Fishing for Catastrophe:

How global aquaculture supply chains are leading to the destruction of wild fish stocks and depriving people of food in India, Vietnam and The Gambia

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: Aquaculture's paradox 11

BOX 1.1: Oceans on the brink 13

2. Stripping the ocean bare: Findings from India, Vietnam and The Gambia 15

2.1. India 17

2.2. Vietnam 31

2.3. The Gambia 41

BOX 2.1: Gambian–Chinese relations 42

3. Risks for the aquaculture industry and retailers 51

3.1. Overview of the aquafeed industry 51

3.2. FMFO in aquaculture and retail supply chains: a controversial link 53

3.3. Main risks facing companies due to their reliance on wild-caught fish for feed 61

BOX 3.1: Supply shocks: Peru's role in fishmeal price volatility 64

BOX 3.2: IFFO certification and membership: a sustainability smokescreen? 66

BOX 3.3: Producers with IFFO certification or membership implicated in unsustainable practices 68

4. Conclusion 69

Recommendations 71

Glossary of terms and abbreviations 74

References 76

Executive summary

Overview

Based on findings from on-the-ground investigations carried out in India, Vietnam and The Gambia in mid-2019, this report presents damning evidence that the production of fishmeal and fish oil (FMFO) for use in global aquaculture supply chains is precipitating the collapse of fish stocks, compromising food security, and destroying the social and economic fabric of communities living adjacent to historic fishing grounds at a time when the oceans are being pushed to the brink by the impacts of climate change, pollution and overexploitation. Using information gathered from in-depth supply-chain research, the report, which is the first to map FMFO supply chains from fishery to fork, also establishes links between unsustainable – and often illegal – FMFO sourcing practices in the countries investigated and among major European aquafeed companies and retailers.

FMFO is mainly used as an ingredient in feeds for aquaculture and agriculture.[1] Almost one-fifth of the world's annual wild-fish catch is taken out of the ocean for this purpose.[2] Roughly one-third of FMFO goes to the agricultural sector (5% to chickens, 23% to pigs[3]), but aquaculture became the dominant user of 'reduction fisheries' (which supply fish for FMFO, rather than for direct human consumption)[A] in the early 2000s.[4] In 2016, 69% of fishmeal and 75% of fish-oil production went to seafood farming.[5] Global demand for FMFO is mainly driven by China's huge aquaculture sector,[6] but export-oriented sectors, such as salmon farming in Norway and Scotland and prawn farming in Asia, are also significant consumers.

The biggest reduction fishery, typically representing 30–35% of world production of FMFO,[7] is Peruvian anchoveta. However, other regions are also important suppliers of the global market and, as such, require close scrutiny. In Asian countries, where a broader diversity of fish species is used than in South America and northern Europe,[8] locally produced FMFO often supplies domestic seafood farms with direct or indirect links to overseas retail markets. Our investigations found that in two of the region's key FMFO- and aquaculture-producing countries, India and Vietnam, collapsing fish stocks and the economics of the FMFO industry are pushing fishing vessels to systematically plunder the oceans for species that have not previously been used for FMFO production, as well as juvenile fish, which should be left in their natural environment to reach maturity and ensure a stable fish population.

Increasing demand in major markets – notably China – has also spurred growth in West African FMFO production; according to UN Comtrade figures, in 2016, it produced 7% of the world's fishmeal. Some countries have experienced a particularly steep rise in production; for example, half of Mauritania's fish catch is used to produce fishmeal.[9] Shockingly, in The Gambia, where GDP was a mere $1,700 per capita in 2018[10] and people rely on fish as a staple food, our investigation found that the combined catch of just one of the country's FMFO plants accounted for approximately 40% of the country's total reported fish catches in 2016. Gambia's fish catch is turned into fishmeal at a rate of 5 kilos of fish for 1 kilo of fishmeal and exported abroad, mainly to China.

A 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/).

Failures of governance and links to the global market

Using information gathered through detailed supply-chain research and analysis, this report identifies links between unsustainable fisheries for FMFO in Africa and Asia and major players on the global market, including aquaculture companies, aquafeed producers, seafood processors and retailers. It also highlights failings in oversight and governance of the sector, both at regulatory level and on the part of the FMFO trade association and certification body, The Marine Ingredients Organisation (IFFO). We found that FMFO and aquafeed plants with proven links to highly unsustainable fishing practices are certified by, or are members of, IFFO, which has a clear conflict of interests due to its double-hatted role. Our research also found that IFFO membership and certification are used as marketing tools at multiple stages of the supply chain; however, it is clear from our findings that they provide a sustainability smokescreen, preventing further probing by downstream customers of FMFO producers regarding the true impacts of using wild fish to feed farmed seafood. The report concludes that IFFO is wholly unfit to serve as a certification body, and that retailers and aquafeed companies need to stop taking its assurances at face value.

Our research finds that aquafeed companies with unsustainable and illegal sourcing practices are supplying seafood farms exporting to the global market – and, in turn, many of the biggest seafood processors and retailers in the world. **This means that aquafeed companies, aquaculture producers, seafood processors and major retailers are complicit by association in the socioeconomic and ecological damage our investigators encountered.** While our analysis focused on European retail supply chains, we would expect the picture to be broadly similar in other high-income markets, based on the knowledge that the same aquafeed companies and seafood exporters supplying the European market are also exporting to other markets in the Global North, including the US and Canada.

While all the markets we looked at were characterised by a surprising lack of traceability and transparency regarding the origin and supply chain of farmed seafood products, we were able to establish that numerous European retailers are sourcing products from aquafeed companies and seafood processors linked to unsustainable FMFO supply chains. These retailers include:

- **UK:** Sainsbury's, ALDI, Lidl, Co-op, Tesco, Asda, Iceland, Morrison's, Waitrose, Marks & Spencer
- **France:** Auchan, Groupe Casino, Leclerc, Monoprix, Système-U
- **Germany:** ALDI Nord, ALDI SÜD, REWE, Lidl, EDEKA
- **Netherlands:** Albert Heijn, Lidl, Plus
- **Spain:** Mercadona

Summary of key findings from India, Vietnam and The Gambia

Our findings show that FMFO production, driven by demand from the global aquaculture sector, is visibly accelerating the decline of fish stocks in India, Vietnam and The Gambia that marine fisheries for human consumption have already pushed to breaking point. Local fisherpeople and communities are clear-eyed about the consequences for them; they see the slump in catches they are currently experiencing as a precursor to the inevitable destruction of the fisheries that sustain them. However, they feel powerless against the economic might of the industry.

Case study: India

The investigation focused on two regions:

- **The Mangalore-Karwar belt on the West Coast of India:** Mangalore harbour, Malpe harbour, Gangoli harbour and Betul port; fishmeal plants (Ullal Fishmeal plant consortium) and aquaculture operations.
- **Andhra Pradesh on the South East Coast of India:** A region of major production and exportation of prawn, largely dominated by small-scale farmers. Our investigators also visited Vishakhapatnam Port.

Key findings

- Indian fishmeal plants have presented opportunities to monetise juvenile catch, damaged catch or species not previously targeted for fishing. Fisherpeople say that that contrary to these companies' public statements about not using juveniles, they 'take everything', so now 'everything' is being hauled in and ground into FMFO.
- Fish stocks of species traditionally used for FMFO (such as sardines) have collapsed, and new species are appearing in catches, suggesting dramatic changes and imbalances in the ocean ecosystem.
- Some FMFO plants are not operating because of the shortage of fish.
- Fishing bans designed to give marine ecosystems an opportunity to recover are being violated.
- FMFO plants generally bypass traditional auctions and secure a fishing vessel's entire catch with upfront payment, which locks fisherpeople in and encourages unsustainable fishing practices.
- Significant quantities of 'food' rather than 'trash' fish are being diverted to the fishmeal plants. Local people rely on locally caught fish for their protein needs, and it is becoming harder for them to compete within the new system.
- Communities are affected by air and water pollution from FMFO production. Locals who speak out are intimidated.
- The entry of non-traditional fisherpeople looking for short-term returns has changed dynamics in the sector: even skilled artisanal fishermen are being pushed into overfishing, which goes against traditional practices.

Indian supply-chain links

Norwegian company Skretting is sourcing fish oil from a number of Indian FMFO companies in Ullal district, several of which are members of IFFO. Many of these companies present their IFFO membership within a 'certification' context, which is potentially misleading.

One of the FMFO plants our investigators visited in Ullal, which confirmed it accepted 'all fish' for FMFO processing, supplies a number of global aquafeed companies, including Skretting, Mitsubishi Corporation, Godrej Agrovet Limited, Cargill India Pvt. Ltd, Uni-President Feeds, Toyota Tsusho Corporation, CP Aquaculture India Pvt Ltd (part of Thai multinational Charoen Pokphand Group) and Grobest Feeds.

Case study: Vietnam

The investigation team visited three ports in the south of Vietnam which are important fishmeal production hubs:

- **Tac Cau port, Kiên Giang Provincez**
- **Song Doc port, Cà Mau Province**
- **Phuoc Tinh port, Bà Ria-Vũng Tàu Province**

Key findings

- Significant underreporting of catches is enabling overfishing to continue unchecked. Catches destined for fishmeal factories are not being reported to authorities.
- Unauthorised transshipment (the transfer of catch from one vessel to another at sea) of both market and 'trash' fish for fishmeal production occurs regularly.
- Fish stocks are in decline; for example, fishermen in Vũng Tàu Province reported their lowest catches ever in 2018, due to overfishing for fishmeal.
- Lack of fish is leading to widespread fishing in foreign waters, which stokes regional tensions.
- Highly unsustainable fishing techniques are being used, and fishing is indiscriminate, targeting species not traditionally used for FMFO.
- Owners of fishing vessels depend on financial loans from fishmeal factories and middlemen to keep their boats running. These loans tie them into exclusive supply agreements. As a result, fisherpeople feel trapped in a vicious cycle.
- Pollution from fishmeal production is blighting communities' lives.
- There are widespread fears in Vietnam that the EU will ban ('red card') Vietnamese seafood imports due to the continued prevalence of illegal, unregulated and unreported (IUU) fishing.

Vietnamese supply-chain links

Investigations at Tac Cau port found IUU fishmeal from Phuc Ngoc fishmeal plant to be entering the supply chain of Vinh Hoan Corporation, a large aquafeed producer and leading Vietnamese pangasius exporter to the EU. This fishmeal is also entering the supply chain of CP Vietnam, the feed subsidiary of global giant CP Foods, part of Thai multinational conglomerate Charoen Pokphand Group.

Investigation at Song Doc port found IUU fishmeal from Bich Khai fishmeal plant to be entering the aquafeed supply chain of leading feed producer, Grobest, which supplies to Vietnam's largest prawn exporter, Minh Phu – a company that exports significant amounts of seafood to the EU and US, including Europe's leading prawn supplier, Heiploeg International. Heiploeg is owned by Dutch fishing giant, Parlevliet & Van der Plas.[B]

Investigations at Phuoc Tinh Port found that IUU fishmeal from Phuc Loc fishmeal plant was entering the aquafeed supply chain of CP Vietnam, also part of Charoen Pokphand Group.

B Parlevliet & Van der Plas states on its own website: 'The fish caught by the vessels of Parlevliet & Van der Plas is solely intended for human consumption. It is not meant for conversion into fishmeal.' (see: https://www.pp-group.nl/fishing)

Case study: The Gambia

Our investigation covered all three operational FMFO plants in The Gambia, which are located along a 30-kilometre stretch of coastline in the villages of Sanyang, Gunjur and Kartong, just over the border from Senegal.

Key findings

- The combined fish catch of just one of The Gambia's FMFO plants accounted for approximately 40% of the country's total reported catches in 2016, revealing the massive scale of this new industry in the country.
- FMFO destined for human consumption is being exported without legally required food-safety certificates.
- Pollution from FMFO production is damaging The Gambia's budding ecotourism industry.
- At least one Gambian plant sells most of its fishmeal to Vietnam; it is then relabelled on the black market for re-export to China, the world's largest aquafeed producer. This circumvents more stringent Chinese food-safety controls and the absence of a fishmeal export agreement between The Gambia and China.

Gambian supply-chain links

Neither the FAO nor the government has records of Gambian FMFO production or exports, even though fishmeal plants have been operating in the country for some years.

However, our investigation found that all three plants have been exporting FMFO illegally. They transport these products in large containers that are shipped abroad by major international logistics companies, including Maersk, according to the Gambian Food Safety and Quality Authority – which only discovered this after our investigators questioned them. Our questioning prompted the government to temporarily halt their exports.

From May 2017, the three plants had been exporting their FMFO destined for human consumption and feed without securing the required food-safety certificates, potentially avoiding export fees and falsifying food-safety certificates – meaning the FMFO did not undergo any food-safety controls or inspections. This reveals serious gaps in international oversight on food security and product traceability, putting consumers' safety at risk.

A shroud of secrecy surrounds the FMFO plants' international clients. Nonetheless, an entry in the Oceans Disclosure Project database shows that Danish aquafeed company, BioMar, sourced round sardinella from The Gambia in 2018.[11] Export data also reveals shipments to Vietnam, Thailand, Saudi Arabia, Tunisia, Mauritania and Chile – a number of which are hubs for aquafeed production with strong supply links on to North America and Europe. Our investigation confirmed that one of the main importers of Gambian fish oil is Chilean company, TRIO S.A., which would have been importing fish oil from The Gambia without proper food-safety certificates. This company is part of a conglomerate, TRIOGROUP, which exports to the US and the UK, among other international markets.

Golden Lead – The Gambia's main FMFO plant, which is responsible for most of the environmental crimes the industry is committing – has exported fishmeal to one company that is a member of IFFO and another, in Vietnam, which serves as a black market conduit to the Chinese market.

The future of feed

On the basis of this evidence, this report analyses the risks that irresponsible sourcing of feed raises for companies throughout aquaculture supply chains. It finds that the sector's continued dependence on wild fish for use in aquafeed represents a systemic threat for companies, with FMFO and aquafeed producers being particularly vulnerable. Through their increasing reliance on farmed seafood fed using FMFO, other sectors – such as seafood processing and retail – are also exposed to these risks, which include disruption of supply, rising costs of raw materials and reputational damage.

The report concludes that, given soaring demand from the aquaculture sector, endemic ecological and social problems in FMFO supply chains, and global fish stocks dwindling to historic lows, FMFO from whole wild fish has no place in the future of feed.

Alternative solutions that make it possible to produce aquafeed without using wild-caught fish need to be scaled up and rolled out across the industry. It is critical that these alternatives are truly sustainable, and do not disrupt and destroy natural habitats and ecosystems. In addition, the current model of carnivorous fish-rearing needs to give way to greater breeding of omnivorous and herbivorous fish, or species that require no external inputs, coupled with a substantial reduction in consumption of unsustainable farmed seafood.

Workers offloading "waste" fish, juvenile and other assorted species at Ullal, Karnataka

Fishing for Catastrophe

1. Introduction: Aquaculture's paradox

Since time immemorial, human beings have lived and thrived off the bounty of the sea. For most of history, humanity's needs have been met without compromising the health of marine ecosystems. However, as this report goes to press in late 2019, decades of industrial fishing have subjected our planet's fish stocks to such pressure that ocean ecosystems are now critically depleted, and marine biologists worry they may soon reach the point of no return.

Against this grim backdrop, aquaculture is often presented as the solution – not only to the ecological damage unsustainable fishing techniques are wreaking under the surface of our oceans but also as a rapidly scalable source of protein for communities vulnerable to food insecurity and malnutrition. The notion that seafood farming can both feed the world's poor and relieve pressure on wild-fish stocks, giving delicate ecosystems the opportunity to bounce back, is a seductive one and makes intuitive sense. However, in reality, the aquaculture industry continues to extract precious finite resources from the very oceans it claims to protect.

Every year, in an extremely inefficient process, billions of edible fish caught in the wild are diverted from direct human consumption and used to feed the voracious aquaculture industry instead, through the production of fishmeal and fish oil (FMFO). In FMFO production hubs across the Global South, fish catches are turned into fishmeal at a rate of 5 kilos of fish for 1 kilo of fishmeal and exported abroad. A report published in July 2019 found that the Scottish salmon industry alone uses roughly the same quantity of wild-caught fish to feed its salmon as the entire adult population of the UK purchases in one year, and that it will require a further 310,000 tonnes of wild fish per year to meet its ambitions to double in size by 2030.[12] While these so-called 'reduction fisheries' have existed for centuries, and ground-up fish have historically been put to a wide variety of uses, including as fertiliser for crops and inputs for animal feed, aquaculture is rapidly displacing other applications and now accounts for 70% of FMFO consumption.[13]

The types of fish destined for reduction fisheries are mainly species lower down the marine food chain, which 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. They include not only small pelagic[C] 'forage' fish (such as anchovy, sardine, herring and mackerel) but also invertebrate species (such as krill). 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. Overfishing down food webs is therefore unsustainable, and can have large impacts on the ecosystem.[14] These fish are also a major source of protein for millions of people living in poor coastal communities, especially in West Africa, where the FMFO industry's demand for small fish competes with demand for direct human consumption; today, almost 70% of landed forage fish are processed into FMFO, representing roughly 20% of the world's total catch of wild fish.[15]

C 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).

Demand for fish is growing more rapidly than the human population, and is outpacing demand for meat.[D] Aquaculture currently accounts for roughly half of world fish consumption,[16] and is projected to rapidly grow even further; farmed species are expected to contribute to an increasing share of global fish consumption, reaching about 60% of the total in 2030.[E]

As this report will show, with stocks of traditional species used to make FMFO increasingly prone to collapse in major production hubs, the industry is becoming less discriminate in its selection of 'raw materials', which now frequently include juveniles and rare and endangered species that were not previously used for this purpose. According to a report commissioned by The Marine Ingredients Organisation (IFFO) regarding the FMFO industry in Vietnam and Thailand, 'As well as catching undersized/juvenile fish, at-risk species such as turtles, stingrays and sharks, are also taken as a feed-fish'.[17] As will be demonstrated, these practices are not confined to these two countries alone.

With the global aquaculture sector expanding at such a rapid pace, it is time to consider whether fish farming's benefits are being overstated and the risks associated with current industry practices underplayed. A slew of recent reports[18] have documented multiple troubling aspects to this industry, suggesting it could be causing more harm than good. This report will focus on the destructive practice of feeding wild fish to farmed seafood, reviewing the evidence to critically assess the industry's claims that it is acting responsibly, and will show that a sea change is required to ensure fish farming is fit for the future on a dangerously resource-constrained planet.

Our findings show that FMFO production driven by demand from the global aquaculture sector is visibly accelerating the decline of fish stocks in India, Vietnam and The Gambia, which marine fisheries for human consumption have already pushed to breaking point. While each country we visited has specific characteristics, a number of common themes emerge, including: localised decline or collapse of target fish stocks fuelled by rampant illegal, unregulated and unreported (IUU) fishing; the industrialisation of fishing practices and bypassing of local markets at the expense of small-scale operators and local consumers, whose livelihoods and access to food are affected; the indiscriminate nature of fishing for FMFO, with factories willing to buy whatever boats land, and fishermen dumping the fish when plants are at overcapacity; corruption, bribery and weak enforcement of regulations; and territorial clashes when dwindling stocks in one country's fishing grounds provoke incursion into foreign waters. Our investigators did not have to dig deep to uncover shocking evidence of how this industry is trashing the oceans, but the full scale of its impacts is concealed from public view due to lack of transparency in, and poor regulatory and government oversight of, fisheries and FMFO supply chains.

The relentless economics of the industry leave fishing communities with no option but to take part in supplying FMFO factories for onward export to the global market. However, our investigations found that fisherpeople in all three countries we investigated are clear-eyed about the consequences for them; they see the current slump in catches as a precursor to the inevitable destruction of the fisheries that sustain them. The collapse of local economies that, for centuries, have been built around the sea seems an intolerably heavy price to pay to ensure wealthy consumers in high-income countries are able to enjoy uninterrupted access to premium seafood products, such as salmon, which is fast becoming a weekly staple in diets across the Global North and, increasingly, China.[19]

Beyond the disturbing social and ecological problems thrown up by FMFO production, the evidence presented

D 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, both combined (2.8%) and individually, except poultry (4.9%). See: FAO (2018) *The state of world fisheries and aquaculture, 2018: Meeting the sustainable development goals*. Licence: CC BY-NC-SA 3.0 IGO. Rome: FAO.

E FAO projections show that combined world capture fisheries and aquaculture production will reach 200 MT (LWE) by 2030, up from just under 100 MT 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. See: FAO (2018) *The state of world fisheries and aquaculture, 2018.*

in this report should also be a red flag to regulators, investors and any companies involved in aquaculture supply chains. Risks for business include disruption of supply, rising costs of raw materials and reputational damage.

Put simply, the economics of the FMFO industry are broken, and this poses a systemic threat to the aquaculture sector as a whole. Depending on how soon the market wakes up to this reality, the knock-on effects for other sectors will be felt more or less keenly. However, with marine ecosystems currently at breaking point, the main question must be: Can we move fast enough to prevent the collapse of the ecosystem, as well as the inevitable collapse of the FMFO sector? If action is taken now to accelerate the transition to sustainable alternatives to FMFO, we can hope both to save fisheries that play a critical role in marine ecosystems from destruction and to contain any economic disruption that would entail, safeguarding vulnerable people's livelihoods. Conversely, the collapse of these ecosystems as a result of our failure to act would spell disaster and have damaging economic, social and ecological consequences far beyond what any of us can imagine today.

As a paper published in the scientific journal Nature Sustainability noted in 2018: 'As the fastest growing food sector in the world, fed aquaculture demand will eventually surpass ecological supply of forage fish, but when and how best to avoid this ecological boundary is unclear'.[20] The evidence presented in this report suggests we could be on course to crossing the ecological boundary faster than previously calculated. This should give us all serious pause for thought about the direction in which aquaculture is headed, and make us radically rethink the way we feed farmed fish.

BOX 1.1: **Oceans on the brink**

The oceans cover over 70% of the Earth's surface and play an important role in the global food system. Fish and seafood provide about 17% of the world's animal protein, and millions of people worldwide depend on fishing economies for their livelihoods.[21] However, current scientific knowledge indicates they are under more pressure now than ever before in history. A study published in May 2019 by the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) – a UN body that assesses the state of biodiversity and ecosystem services – reports that, to date, 66% of marine environments have been 'severely altered' by human actions.[22]

The evidence presented in the IPBES report highlights the dire state of the oceans as a result of chronic overfishing and ocean pollution. Industrial fleets employing rapacious fishing practices currently roam over half (>55%) of our ocean area. The study estimates that one-third of the world's reported fish catch comes from IUU fishing, making it very difficult to rely on official catch statistics for an accurate picture of world fisheries. To make matters worse, 93% of marine-fish stocks have been fished to their limits or overfished.[F,23] According to the United Nations Food and Agriculture Organisation (FAO), the proportion of stocks that are unsustainably fished continues to grow.[24] Climate change compounds pressure from overfishing: The September 2019 IPCC Special Report on the Ocean and Cryosphere in a Changing Climate notes that the maximum amount of fish that can be sustainably caught could decrease by up to a quarter by the end of the century.[25]

According to the UN, without significant changes, we are at risk of pushing more than half of our planet's marine species to the brink of extinction by the year 2100.[26] The collapse of fish stocks is already visible among some of the pelagic fish species, which are used to feed the global aquaculture sector – from crashing oil sardine stocks off the west coast of India[27] to the decline of bonga in Gambia (see Chapter 2). In Europe, Baltic cod stocks are on the verge of collapse, partly as a result of the overfishing of their key food

F This figure is from 2015, when it was estimated that 33% of stocks were harvested at unsustainable levels, while 60% were maximally sustainably fished.

source, sprat, to feed the Norwegian salmon industry.[28]

Despite this bleak outlook, the FMFO industry, which takes billions of wild fish out of the ocean every year to supply seafood farms and multinational aquafeed companies, often defends the sustainability of its business model by referring to wild fish as a 'renewable resource'[29] or 'sustainable raw material'. Peter Johannessen, director general of IFFO, recently stated: 'It's a perfectly sustainable raw material. It's the most certified natural raw material available. I think it would be rather unsustainable to try to move away from that knowing that we need more sustainable raw materials.'[30]

But the science is clear: Owing to the scale and extractive methods of world fisheries today, exacerbated by the impacts of climate change, global fish stocks are in grave danger. In addition, intensifying pressure on pelagic fish stocks to feed the fast-growing aquaculture industry will have further knock-on effects on other marine life (including marine mammals and seabirds) and marine ecosystems.[31] As a recent scientific study on avoiding the ecological limits of forage fish put it: 'The global limit of wild-caught fish, the rapidly increasing production of fed aquaculture and international advice to increase fish consumption for human health and nutrition will create a tipping point of feasible seafood supply, driven by limits to forage fish production'.[32]

In conclusion, there aren't enough fish in the sea to feed the voracious FMFO industry. Protecting and conserving fish stocks and ecosystems, e.g. through the creation of marine reserves, should be the priority in responding to the ocean crisis – that is, if we want to be able to rely on marine ecosystems for food and livelihoods in the future.

Shoal of anchovies (©iStock)

2. Stripping the ocean bare: Findings from India, Vietnam and The Gambia

India, Vietnam and The Gambia play a key role in global aquaculture supply chains in several ways:

1. by fishing the raw materials (wild fish) that are used for feed;
2. by processing these into fishmeal and fish oil (FMFO); and
3. in the cases of India and Vietnam, occupying a leading place in export-oriented aquaculture production.

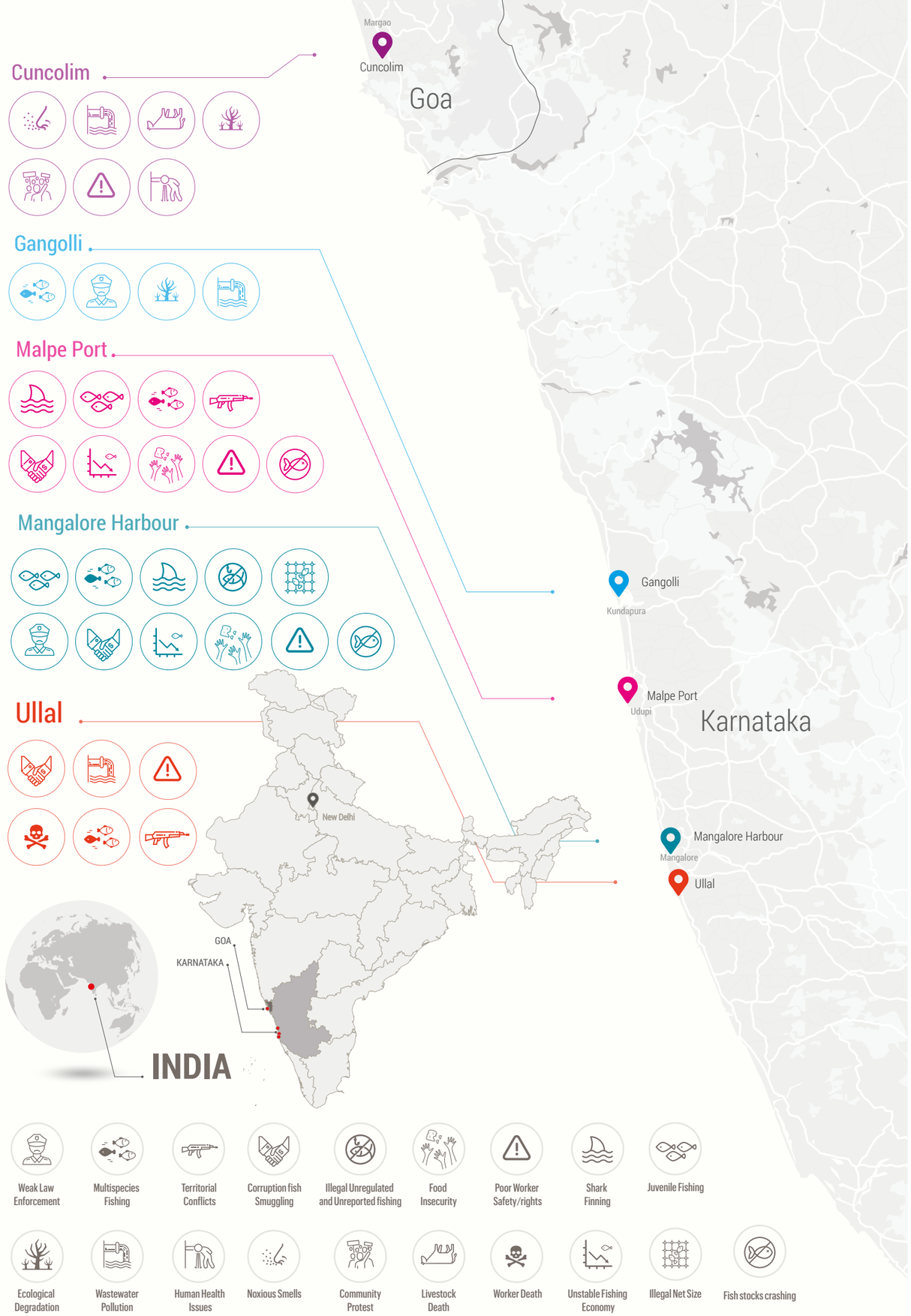
They therefore provide a good insight into how the global FMFO industry operates.

In this chapter, we provide a detailed account of on-the-ground impacts of FMFO production, based on field trips undertaken in all three countries between May and July 2019. The objective of these trips was to show the workings of the FMFO supply chain, from sea to factory to export. This was done by documenting environmental, economic and social impacts, conducting informant interviews and, where possible, gathering visual evidence. During the initial research phase, we gathered secondary evidence on violations of government regulations and pollution at these sites through an in-depth review of media reports and government announcements. The supply-chain analysis aimed to follow both direct and indirect FMFO flows:

- **Direct:** The field teams sought links from illegal, unregulated and unreported (IUU) vessels to port to fishmeal plant, and then tracked FMFO exports from these plants or their parent companies to (high-income) markets via desk research.
- **Indirect:** Where the field teams established links between vessels and aquafeed manufacturers, they investigated whether any of these companies sold aquafeed to high-income markets in the Global North, or to local aquaculture farms that export to these high-income markets.

The evidence from the ground clearly shows that FMFO production is an extractive and highly destructive process, which is leading to the indiscriminate plundering of life below water (including for species previously left in the oceans) and threatening food security in some of the poorest regions of the world. While each country we investigated has different characteristics, common themes emerge. In particular, our findings demonstrate that FMFO production in India and Vietnam is driving IUU fishing, resulting in the collapse of fish stocks, destroying ecosystems and threatening food security and livelihoods.

The findings detailed here should only be considered a 'snapshot' of a hugely complex and opaque sector. The fact that, within a relatively short period on the ground, the investigation teams were able to find conclusive



evidence of IUU in India and Vietnam, and problematic supply chains leading to the Global North in all three countries, indicates the scale of the problem within this sector. It also suggests the FMFO industry is based on a broken business model, and that its voracious practices are wiping out the very resources required to sustain it in the future.

2.1. India

2.1.1. India's FMFO industry

India is one of the world's leading aquaculture producers (after China and Indonesia)[33] and holds a dominant role in global fisheries, owing to its approximately 7,517 km of coastline and 195,210 km network of rivers and canals.[34] According to the National Fisheries Development Board, in India, 'more than 50 different types of fish and shellfish products are being exported to 75 countries around the world'.[35] While carp production is likely to remain the biggest share of fish production,[36] India is also the world's second-biggest exporter of prawns (after Ecuador); it sells significant volumes to the US and China, and was the second-biggest exporter of prawns to the EU in 2018 (pulling in front of Vietnam, which now occupies third place).[37] Andhra Pradesh, the heart of Indian aquaculture production, is the country's largest aquafeed-consuming state.[38]

The Indian oil sardine (Sardinella longiceps Valenciennes) is the most important single-species marine-fishery resource landed along the Indian coast, in volume terms. It accounts for approximately one-fifth of total marine-fish landings in India, the majority of which take place along the country's southwest coast in the states of Kerala, Karnataka and Goa.[39] Oil sardine is a staple food throughout southwestern India, and is also highly prized by the FMFO industry. The state government aims to ensure the conservation of fish stocks during the breeding season by imposing seasonal restrictions (i.e. fishing bans) on fishing by mechanised vessels. On the west coast, the fishing ban is in force from June to July; in the east, it begins in April and ends May.

The abundance of oil sardine off southwestern India has resulted in the establishment of numerous FMFO processing plants along the region's coast, especially in the state of Karnataka. More recently, a number of multinational aquafeed giants have also decided to set up business there. In 2018, Skretting (Nutreco) formed a joint venture with local partner West Coast Group, through which the companies will build a feed-production facility in west India in 2020.[40]

The growth of the Indian FMFO industry has also been partly facilitated by the trade spats between China and the US, which led to tariffs being applied to multiple seafood items in both countries, and China strengthening links with India. In 2018, the two countries signed a protocol on the export of Indian FMFO to China.[41]

However, the outlook for India's FMFO industry is looking increasingly uncertain. In recent years, several Indian states have experienced a 'sardine crash' as a result of overfishing.[42] In 2012, Kerala experienced a severe collapse of stocks, prompting state authorities to institute a ban on fishing juvenile sardines. Demand from expanding FMFO plants (mainly located on the west coast) and fishmeal plants (on the east coast) is one factor that has been blamed for driving overfishing of sardines. This was acknowledged in the Ministry of Agriculture's 2017 National Policy on Marine Fisheries in India:

> *Use of low-value fish species in fish feed industry is becoming a matter of concern as it can lead to overfishing of such species and by-catch, and could undermine the integrity of the marine ecosystem. The spread of fish meal plants in some coastal States and their overwhelming demand for small pelagics (e.g. oil sardines) has led to overfishing, resulting in reduced stocks of small pelagics in some parts of the country. The government will address this issue by taking steps to control and regulate proliferation of fish meal plants.*

With declining oil sardine populations on the west coast, our investigators were told that many companies are moving their plants to the east coast of India or investing in new factories overseas.

In 2017, India's aquafeed market was valued at $1.20 billion. Its domestic feed mills have the capacity to produce 2.88 million metric tonnes (MT),[43] and, with aquaculture production booming, global feed giants are eyeing India as a land of opportunity. Announcing the inauguration of Cargill Aqua Nutrition's first dedicated fish-feed

Fishmeal plant at Ullal, Karnataka

plant in Andhra Pradesh in 2018, the company's CEO said: 'India presents great opportunities for Cargill and plays an important part in our aqua nutrition growth strategy in Asia'.[44] Our investigation found evidence that Indian FMFO plants are supplying these multinational aquafeed companies, including players based in Europe, Canada and Japan.

2.1.2. Overview of investigation

The investigation took place during low season in May and June 2019, following general elections in India. It coincided with the fishing ban on the east coast and directly preceded the ban on the west coast. Fieldwork during high season would likely paint an even starker picture.

The field trip focused on two regions:

1. **The Mangalore-Karwar belt,** stretching across 270 km on the west coast of India. Significant fishmeal production and reduction fisheries take place in this region. Our investigators visited a number of harbours (Mangalore harbour, Malpe harbour, Gangoli harbour and Betul port), FMFO plants (including the Ullal Fishmeal plant consortium) and aquaculture operations.

2. **Andhra Pradesh** on the southeast coast of India, a region of major production and exportation of prawns, largely dominated by small-scale farmers who have converted their farms into ponds. While this region is also home to some fishmeal plants, our investigators found they were difficult and risky to access, and were therefore unable to investigate them. Our investigators also visited Vishakhapatnam Port.

2.1.3. Findings on the ground

2.1.3.1. Evidence of ecological impacts and threats to marine ecosystems

The proliferation of 'non-fishermen'

"This is the last generation in fisheries"

- Mangalore fisherman.

Assorted "waste" fish catch being offloaded at Mangalore port to be sent to fishmeal plants

The sudden monetisation of 'trash fish'[G] brought about by the FMFO industry has resulted in the entry of so-called 'non-fishermen' into the sector. At Mangalore harbour, investigators learned a slew of fishing licenses have been granted in the last few years, which has opened up the port's operations to an unskilled workforce from outside the state.

A representative of a Mangalore-based fishermen's association told our investigators that fishing is no longer a profession of skilled, artisanal fishermen. Since the establishment of the FMFO industry, everyone wants short-term returns. In the competition for already-scarce resources, local fishermen have also started overfishing and disregarding the preservation of juveniles, going against traditional prac-

G The term 'trash fish' is (rather regretfully) used throughout this report as shorthand for bycatch, which may be understood to cover a huge variety of small pelagic fish, edible fish, juveniles of many species, fish eggs and the smaller ocean organisms that would, if left in the waters, provide protein for other parts of the food chain. Local Vietnamese fishermen refer to this product using their own term: 'fertiliser fish'. 'Market fish' refers to all fish sold for human consumption from the trawler catch.

tices. The representative said people will continue to fish until the stocks have completely collapsed: 'We are not getting any catch generally, so when we get a catch - small or big fish, we go for it. It is a matter of survival; whatever fish we get we catch it.' He added: 'This is the last generation in fisheries'.

This concern was echoed by a government official from Gangoli, who said local resources in India have been adversely impacted because of the FMFO plants. According to him, ocean conservation and FMFO industries do not go hand in hand, and there has been a massive commercialisation of fisheries: 'Fishermen have ethics. They used to get dolphins, sharks and turtles in their nets but would release them. These people are getting everything, non-fishermen, and, seeing them, even the fishermen are getting into such behaviour.'

Indiscriminate plundering of the oceans to fuel FMFO production

In both Mangalore and Malpe ports, the investigators found that by-catch mainly consisted of juvenile and extremely damaged fish. The team was informed that most of the juvenile catch comes from trawlers, gets damaged during fishing and is therefore diverted to FMFO production. The investigation team observed a clear difference between handling fish for FMFO and handling fish for human consumption. Fish destined for human consumption (e.g. food-grade fish oil from sardines) have to be treated hygienically and maintained as freshly as possible, meaning iced and transported quickly; but fish destined for FMFO do not need to be well-preserved, and consist of a multitude of different species.

Juvenile mackerel and cuttlefish to be sent to fishmeal plants

Close-up of "waste" fish being offloaded at FMFO plant at Ullal, Karnataka

At both harbours, the investigation team found several piles of pelagic fish, including pomfret, juvenile mackerel, juvenile cuttlefish and silverfish, all of which had signs of belly burst. According to available research, belly burst in fish occurs due to enzymatic reactions because of poor preservation practices after they are caught.[45] Fish with belly burst are considered poisonous and unfit for human consumption, and are therefore ground down into FMFO. A fisheries economist expert from Mangalore explained that belly burst can also occur as a result of poor preservation techniques during night-time LED-light fishing, meaning the huge haul of belly-burst fish found at the ports could have come from this illegal practice.

According to the same expert, about 30–40% of catch in Karnataka goes to FMFO plants. This includes fish species traditionally destined for human consumption. This practice was also recorded by investigators at Malpe port, where the agent set aside fish seemingly fit for human consumption for FMFO plants, explaining that they were too small to fetch a good price on the local market.

One of the reasons for the exceptionally high quantity of juveniles landed is the mesh size and shape of the nets used by the fishing boats. While the government has approved the use of 35 mm square-shaped nets, most boats were still found using smaller-mesh-size, diamond-shaped nets, which restrict the escape of juvenile fish. Trawl boats routinely use small-mesh-size dragnets, which is illegal in Karnataka.

Shark finning at Mangalore port - although shark fishing is not banned in India, export of dried shark fins is prohibited by law.

Alarmingly, shark-finning activities were observed at both Mangalore and Malpe ports. Although shark hunting is not banned in India, the law prohibits export of dried shark fins.[46] However, the team was informed that dried shark fins are routinely exported to Thailand, demonstrating the culture of lenient law enforcement.

Investigators were told that fishermen on the east coast use less-wasteful practices. A representative of the Network for Fish Quality Management and Sustainable Fishing (NETFISH), a society formed under the Marine Products Export Development Authority, said that, at Machilipatnam and Nizampatnam ports, trawl boats salt their catch on board - including trash fish - to prevent wastage. As a result, the trash-fish landing is allegedly very limited and goes as feed to crab farms, while about 40–50% of the dried fish is used for human consumption. Fishermen from the Boat Association at Visakhapatnam port stressed that there were no fishmeal plants in the area, no trash fish was brought to this port and by-catch was dumped back in the sea.

FMFO plants take 'everything', including juvenile fish caught illegally

It is clear that, at the next stage of the supply chain, FMFO plants indiscriminately accept fish from the southwestern ports the team visited - including juvenile fish caught with illegally sized nets. A representative of a Malpe fishermen's association told us that, contrary to these companies' public statements about not using juveniles, they take everything. The team visited a plant in the Ullal district that supplies a number of global (aqua)feed companies, including Skretting. The representative of the fishmeal plant said: 'We prefer more sardine but when sardine is not there then we take all fish'. Investigators saw at least five species of fish in the mix processed into FMFO, including lizardfish, eels, leatherjacket, red-toothed triggerfish, flying fish and cephalopods. According to local sources, this practice is typical of all FMFO plants in Ullal.

Workers offloading "waste" fish, juvenile and other assorted catch at FMFO company at Ullal, Karnataka

Fish waste at a FMFO plant in Ullal

Lax enforcement vs. growing awareness among fishermen

The representative of the Mangalore fishermen's association confirmed that government enforcement is very weak in the region and there is rampant use of illegal nets.[H] There is no monitoring or imposition of penalties, and there are frequent violations of the seasonal fishing ban in Karnataka, Kerala, Goa and Maharashtra.

There is growing awareness among fishermen in India that lax enforcement is jeopardising the future of their catch – and, therefore, their livelihoods. A fishermen's association representative and a government official revealed that fishermen on the east and west coasts have been demanding a change in the net-mesh size and subsidies for bigger nets. Nets that allow juveniles to escape ensure a lighter and higher-value catch, and a better catch the following year. *'We need fish in the ocean for the future. That's why we need to start saving now'*, the fishermen's association representative stressed. On the east coast, fishermen's associations are further calling for controls on licenses for new boats, restrictions on boats' engine capacity, enforcement of the ban on LED lights for fishing and implementation of the ban on ring seine nets.

'We need fish in the ocean for the future. That's why we need to start saving now'

- Fishermen's association representative.

Decreasing fish stocks and shift in species extracted for FMFO

Unsustainable fishing practices and the indiscriminate approach to fishing that the FMFO industry is driving have resulted in a staggering decline of fish stocks in India. While sardine stocks used to be abundant on the west coast, the investigation team observed hardly any at the ports. In June 2019, media outlets reported that the drastic decline in sardines has left Kerala's fishermen in crisis and is affecting food security in the region.[47] Further north, at Mangalore and Malpe harbours, locals complained that the sardine catch has plummeted this year. In Mangalore, fishermen reported they were only able to find sardines for two months during the entire fishing season, and in Malpe the catch was only about 10% of the normal catch. According to the representative of Malpe Fish-workers Association, even the quantity of trash fish has gone down; in the past, roughly 10 tonnes of trash fish would be caught in a 10-day expedition, but this has now dropped to 500–900 kg.

According to the representative of the Mangalore fishermen's association, due to the lower availability of fish, only 3–4 of the existing 14 FMFO plants were operating in nearby Ullal district at the time of the investigation. As a result, many companies are moving their plants to the east coast of India and overseas.

> *Fifteen or twenty years back we were complaining that there is not enough fish production, there is not enough freezing capacity, not enough storage capacity... those were the demands. Now everything is there, but no fish.*
>
> **– A representative of the Mangalore fishermen's association**

With vanishing sardine stocks, there has been a shift in the type of species being caught. For example, in Mangalore, our investigators observed 'massive' catches of leatherjacket and red-tooth triggerfish, which sell for Rs 11-14 (less than €0.2) per kg. The team was informed that these fish are not used for local consumption and go directly to the FMFO plants. These reef fish are considered of lesser quality than oil sardine, and are traditionally not found on the Karnataka coast, suggesting boats may be venturing to off-limits reef systems. A government official confirmed that huge quantities of red-tooth triggerfish are also landed at Gangoli port. Data from the Central Marine Fisheries Research Institute shows there has been a steady increase in catches of leatherjacket over the years and fluctuations in the catch of other species.[48,49,50,51,52,53]

H It should be noted that laws regarding net types and mesh sizes differ from state to state within India, with some states being more proactive on phasing out unsustainable fishing gear (Tamil Nadu and Maharashtra, for example, have banned purse seine fishing entirely), although bans continue to be violated.

Fishworker sorting through redtooth triggerfish and leatherjacket fish at Mangalore fishing harbour

The fisheries economist expert our team spoke to emphasised that fishermen consider excess catch of triggerfish to be a bad sign:

> *"This trigger fish is supposed to be kind of a bad omen. It's an indication of an ocean drought or famine that is going to occur in the coming years."*

Territorial conflicts

Rapid decline in the overall catch – primarily due to unsustainable fishing practices, compounded by the impacts of climate change – has been pushing fishermen to fish in other countries' territorial waters. In 2017, The Hindu newspaper reported that Sri Lanka had taken measures to stop bottom trawling by Indian fishermen.[54] This is a particularly destructive industrial fishing method, consisting of a large net with heavy weights being dragged across the seafloor and scooping up everything in its path. However, according to the fishermen's association representative, fishermen supplying Malpe harbour are still entering the waters of the neighbouring states of Gujarat and Maharashtra because of the shortage of good catch on the Karnataka coast.

Pollution

While visiting Ullal FMFO plant cluster (20 km south of Mangalore on the west coast), which is home to 14 FMFO plants, the investigation team heard reports of severe pollution linked to FMFO and aquaculture production facilities. They were informed that only four of these are currently operating – including United Marine Products (UMP) and Bawa Fishmeal & Oil Co. – due to the shortage of fish.

The plants are located on the coast, separated from the sea only by a narrow road and a line of stonewall, suggesting they are in violation of the Coastal Regulation Zone (CRZ) laws in India.[I] A local activist who has been fighting pollution from these FMFO plants said that, despite violating CRZ laws, factories (most recently, FMFO exporter Blueline) continue to obtain permits to set up in this location, which could reflect a corporate-political nexus between the companies and regulatory agencies.

I It should be noted, however, that the CRZ laws themselves are being diluted, and, with the latest amendments in the Act proposed, these plants may become regularised.

Contrary to statements on company websites – such as Blueline[55] and UMP's[56] assurances that their manufacturing plants are *'state of the art'* and *'environmentally-friendly'* – these plants looked old and decaying, and emitted a strong stench of rotting fish. UMP, an international FMFO exporter that supplies Skretting, was among several FMFO companies in Ullal to receive a fine in 2016 after it was alleged they were causing 'water pollution, air pollution, stench, and violation of CRZ rules'.[57] At the time of their visit, our investigation team experienced first-hand the strong stench, resulting in nausea, headaches and difficulty breathing. According to the local activist, the stench was even worse in the past, when all the plants were operating.

The team observed FMFO being produced at one of the district's plants, which lists Skretting, Mitsubishi Corporation, Godrej, Cargill India, Uni-President Feeds, Toyota Tsusho Corporation, CP Aquaculture India (part of multinational conglomerate Charoen Pokphand) and Grobest Feeds among its customers. While fish were checked for metal objects, there was no procedure to check for plastics in the mix. Pieces of fishing net were observed moving through the entire process without being separated out, leading to likely contamination of the final product. After fish oil and fish paste were extracted, the remaining wastewater, called stickwater, was dumped into the backwaters adjoining nearby mangroves. The unit visited did not have a wastewater-treatment plant. Stickwater – which is composed of (among other things) undissolved protein, residual oil and amines/ammonia[58] – is foul-smelling and polluting, and should not be released into waterways.[59]

Aquaculture farms at Gangoli mangroves, Kundapur, Karnataka

The local activist revealed that most factories in Ullal release wastewater into the local river through underground pipes. As a result, groundwater, surface water and local lakes are completely contaminated, and people have stopped using them. According to the representative of the Mangalore fishermen's association, FMFO plants in Ullal have invested in pollution control but only use it when the pollution control boards visit for inspection.

> Water is contaminated, the wastewater from the plants is left in the river and after that there *is an oily layer on the sand and in the lakes and waterbodies nearby. It also smells bad.* No one uses that water for drinking, the water is so badly spoilt.
>
> **– Local activist**

Effluent outlets from aquaculture plant near Gangoli Mangroves, Kundapur, Karnataka

Front gate of United Marine Products factory at Cuncolim Industrial Estate, Cuncolim, Goa

Similarly alarming conditions were found at Cuncolim Industrial Estate, stretching across 240 acres of land in the South Goan district of Cuncolim. The estate is home to more than 100 industrial units, including UMP, chemical factories, foundries and rolling mills,[60] many of which the regulatory agencies have now closed because of pollution.

The UMP plant has been at the centre of pollution scandals, and the Goa State Pollution Control Board has served it several notices for violating environmental standards.[61,62] According to local communities, the plant is extremely polluting but uses pollution from other industries in the estate to conceal this fact. Locals report noxious odours from the plants during rainy season. They allege that UMP dumps its effluent into local water bodies, and also channels some into bore wells within its premises, thereby contaminating the local aquifer. Locals no longer use their wells.

In conversations with a medical doctor and Cuncolim residents, our investigators heard that toxic effluents released from the factories into the local canal have wiped out the area's ecological diversity. They no longer find frogs, fish or snakes, which were previously endemic to this region. Locals report massive fish kills and said the skin of cows, buffaloes and sheep peels off after they come into contact with the polluted water from the industrial estate. The media has also covered the severe pollution by the fishmeal facilities in the industrial estate.[63]

Compounding the negative impacts of India's FMFO industry, ecosystems are also being destroyed by irresponsible practices in the aquaculture sector. The team drove along the west coast, past the mangrove forests at Gangoli and Kundapura, and saw that large segments of these had been cleared for aquaculture farms, which is a clear violation of the law. Effluent pipelines could be seen draining into the backwaters of the mangroves. The conditions the team witnessed clearly indicate a lack of law enforcement, which allows aquaculture facilities to be established in ecologically sensitive and protected sites.[64] The team was told there are many such illegal 'ghost' aquaculture plants in India. The buyer companies do not hold direct ownership of these plants, using them only as a source of supply, to avoid being held responsible for the environmental damage they cause.

"Waste" fish for fishmeal plants being loaded onto a truck at Malpe fishing harbour

Bypassing traditional auction processes and lack of traceability

The full scale of the aforementioned problems is masked by the lack of traceability within FMFO supply chains. At Mangalore and Malpe harbours on the west coast, agents from fishmeal plants were seen supervising the unloading of pelagic fish from the boats and loading them onto unmarked trucks, clearly bypassing the traditional auction process. It was not possible to ascertain which companies the agents represented; the investigators later found out that the truck drivers did not know their destination until the trucks were loaded. Only then were they informed which local or out-of-state factory to take the catch to.

According to the fisheries economist expert, no agency – including the Central Marine Fisheries Institute, which is the nodal agency to record fish catch – has details of the quantity of fish bypassing the auction process. In short, if the fish has by-passed the auction process, no one knows its diversity, quality or quantity.

2.1.3.2. Impacts on people and local economy

Fishermen locked into supplying FMFO factories through loans

The investigation found that margins within the FMFO industry in India are tight for all parties involved – fishermen, boat owners and agents – and profits are falling across the sector as catch quality declines.

At Mangalore port, boats catching fish for the FMFO industry can earn 3–4 lakhs (€3,750–5,000), whereas boats with catch destined for human consumption can earn about 6–7 lakhs, according to a local researcher. The boat owners get locked into a loan system, through which agents from the FMFO plants cover the costs upfront at the beginning of the year and the boat owner pays the agent back in fish throughout the season. This system by-passes the traditional auction process, and means boat owners have to sell their catch for less money than might be obtainable at auction. A representative of the Malpe fishermen's association said boat owners have been incurring losses for the last three years, and, according to the representative of the fishermen's association in Mangalore, almost 80% of the fishermen are losing out financially. This system, in turn, becomes another motive for boat owners to plunder the oceans for resources, including trash fish and by-catch, so they can stay financially afloat.

Fishmeal plant agent showing "waste" fish he bought for the fishmeal plant

Women fishworkers at Malpe fishing harbour, Karnataka

Left: dried mackerel for human consumption

Food security

Outside the Mangalore port premises, investigators observed several areas where fisherwomen dry and package fish for human consumption, including dried anchovies and mackerel. Fish drying is a traditional and effective way of minimising fresh-fish losses and an important source of income for these families, as dried fish is a prime source of affordable animal protein for poor communities. Since the arrival of FMFO plants in the region, much of the fish that would previously have been dried for human consumption is being diverted to the plants.

Workplace safety and exploitation of foreign workers

The investigation team discovered that Indian FMFO factories frequently bring in workers from other states, and that hardly any attention is paid to their safety or workers' rights.

At Old Mangalore port, located at Bunder, the investigators witnessed a group of migrant women workers and children from Assam unloading fish at the dock and sleeping at the landing site. Conversing with them, investigators learned that most of the migrant workforce come in groups of 10–12, and are brought in by contractors. The workers had hardly any protective gear, such as rubber gloves, boots or coveralls. Similar conditions were witnessed at Malpe harbour, 60 km north of Mangalore port.

According to the representative of the fishermen's association in Mangalore, the harbours and the wider industry employ workers from outside the state (including Tamil Nadu, Odisha, Andhra Pradesh, Jharkhand, West Bengal and Assam). The same phenomenon was observed at fishmeal plants; in Ullal district, migrant workers from Bihar and Assam were seen handling various tasks without any basic protective gear, and investigators found dormitories within the premises of the UMP factory in Goa housing workforce from outside Goa. They were informed that companies avoid hiring local residents, primarily because they demand high wages and often unionise, and to ensure workers do not mingle with local residents and pass on any information about operations or working conditions at the facility.

Migrant women fishworkers take a break at the Mangalore harbour

According to the local activist, there have also been reports of deaths inside the factories, and cases of companies bribing locals to keep quiet. He disclosed: 'There have been episodes where workers have fallen into effluent tanks, legs got amputated'. Sharing information he had obtained from the local police station under the Right to Information Act,[J] he added: 'One factory had two deaths, another factory also has had workers die'. According to him, locals who speak out are intimidated and, in some cases, may be forced from their land: 'Some people earlier came and told me that "these companies are very powerful and they will have you killed", but I told them that one day all of us have to die, so why should I worry?'

Health issues

The rampant pollution recorded around FMFO plants, especially the UMP plants located in Ullal district and South Goa, has taken its toll on communities living in the vicinity of the factories.

The local activist told our team that the pollution in Ullal district has been linked to incidents of asthma and skin and reproductive disorders. He said it is hard to link pollution to one single company, as all of them are polluting and destroying the environment and affecting the health of local residents. However, many locals attribute pollution to UMP. Furthermore, a medical doctor disclosed that pollution in South Goa is linked to severe health impacts in the area, including a rise in lung cancer, kidney problems, and skin and respiratory problems.

Corruption

The fact that India's FMFO industry continues to operate with impunity seems to stem from a deep-rooted industry-political nexus. Local residents around UMP in Goa believe the FMFO plants in the area exercise strong control over politicians, and one of our sources commented that it is common to bribe politicians for favours.

2.1.3.3. Supply-chain links

In terms of supply-chain connections, it was documented that all the Ullal FMFO plants on the west coast of India obtain fish from Mangalore and Malpe harbour, where the investigation found a direct link to unsustainable fishing practices, including juvenile fish caught with illegally sized nets (see Section 2.1.3.1). All customers of Ullal FMFO operations can therefore be said to produce product associated with illegal and unsustainable fishing practices documented at these ports. Ullal district itself is at the centre of severe pollution scandals linked to FMFO operations; it is linked to serious health incidents in the region, and even reported deaths of workers inside the factories.[65]

Furthermore, one of the FMFO plants in Ullal visited during the investigation – which confirmed it accepted 'all fish' for FMFO processing, and was found dumping untreated wastewater into local waterways – supplies a number of global (aqua)feed companies, including Skretting, Mitsubishi Corporation, Godrej Agrovet Limited, Cargill India Pvt Ltd, Uni-President Feeds, Toyota Tsusho Corporation, CP Aquaculture India Pvt Ltd (part of multinational conglomerate Charoen Pokphand) and Grobest Feeds.

Norwegian company Skretting is sourcing fish oil from a number of Indian FMFO companies located in the notorious Ullal district, including Bawa Fishmeal and Oil Co[66] (fish oil in 2018) and Yashaswi Fish Meal and Oil Co[67] (fish oil in 2017), as well as from Janatha Fish Meal & Oil Products[68] (fish oil in 2017) in Kota. Skretting, including Skretting Canada[69] and Skretting Japan, is also sourcing FMFO from UMP Ullal,[70] which has been at the receiving end of government and local allegations regarding pollution and poor working conditions.

J Under the provisions of the Act, any citizen of India may request information from a 'public authority' (a body of government or 'instrumentality of State'), which is required to reply.

Several of the Indian companies that supply Skretting are members of The Marine Ingredients Organisation (IFFO),[71] including Bawa Fish Meal & Oil Co., Janatha Fish Meal and Oil Products, UMP, and Yashaswi Fish Meal and Fish Oil Company. It is notable that many present their IFFO membership (rather than IFFO Responsible Supply certification) within a 'certification' context, which is potentially misleading. Yashaswi Fish Meal and Oil Co., Janatha Fish Meal & Oil Products and Bawa Fish Meal & Oil Co. are also approved by the European Commission's Directorate-General for Health (DG Sanco), which allows them to export to the EU.[72] Concerningly, two producers which source from investigation fisheries, Raj Fishmeal and Blueline Foods, are suppliers to Trio S.A., a Chilean company which hold's IFFO's highest supply certification, IFFO Responsible Supply Chain of Custody..[73,74,75,76] Bawa Fish Meal & Oil Co. are also suppliers to The Scoular Company in the US,[77] which also holds IFFO RS CoC certification.

> Investigation on the west coast of India found IUU-fished FMFO to be entering the supply chain of Skretting, Mitsubishi Corporation, Godrej Agrovet Limited, Cargill India Pvt Ltd, Uni-President Feeds, Toyota Tsusho Corporation, CP Aquaculture India Pvt Ltd (part of multinational conglomerate Charoen Pokphand) and Grobest Feeds.
>
> *Retailers associated with this supply chain include REWE, ALDI SÜD, ALDI Nord, Lidl and Système-U. There is also a possible connection to Asda (see Chapter 3).*

The links between the local catch and aquaculture plants in Andhra Pradesh were not as clear. The government official from NETFISH stated that the aquaculture plants in the region import their fishmeal from abroad to control the quality in their inputs and ensure standardised output. He gave examples: CP, which sources fishmeal from Thailand; and companies like Grobest, Avanti and Waterbase, which source from Taiwan and Vietnam. Godrej has linked up with a Taiwanese company according to his information. He informed us that aquaculture companies – particularly in Andhra Pradesh (Nellore, West Godavari and East Godavari districts) – additionally source raw fish from Chennai harbour to feed the prawns in their aquaculture farms, including farms operated by CP and Waterbase.

Since 2016, the US, Vietnam and China have been the main markets for Indian prawn.[78] Japan and the EU have also been among the dominant markets, but, according to the same government official, there has been a shift due to strict regulations in both countries. Companies in the region treat the prawns with sodium tri-poly-phosphate, which is banned in Japan. At the same time, Indian aquaculture farms are heavily reliant on antibiotics, which the EU has strict regulations on. However, import data shows that the EU and its neighbours continue to import significant volumes of prawns from India. For example, in 2017, India accounted for 18% of the total volume of warm-water prawn imports in the EU, exporting 52,756 tonnes worth €420 million.[79]

Norway imported 339,338 kg of prawn from India in 2018.[K] Our source indicated that the markets are gradually shifting to the US, but that even the US market is moving towards stricter regulations.

K Norwegian import statistics from SSB, category 03061700 (shrimp, excluding cold water shrimp, frozen). [ONLINE] Available at: https://www.ssb.no/statbank/list/muh.

2.2. Vietnam

2.2.1. Vietnam's FMFO industry

Vietnam is a fast-growing market for fisheries and FMFO production. According to the United Nations Food and Agriculture Organisation (FAO), Vietnam is the third-largest exporter of fisheries worldwide (after China and Norway).[80] Overall fisheries production from both capture fisheries and aquaculture has grown steadily, from 5.6 million MT in 2011 to 7.7 million MT in 2018. In 2018, marine-capture fisheries accounted for approximately 43.5% of the country's fisheries production.

Vietnam has 28 coastal provinces with a total coastline of 3,260 km. The country's fishing fleet stands at around 110,000 vessels,[81] the majority of which are small vessels fishing inshore and coastally.[82]

According to FAO[83], trash fish (often referred to as fertiliser fish) landings represented one-third (33%) of total marine-fish landings in 2005. Reporting on trash-fish landings is inconsistent, which makes it difficult to estimate its full scale. In 2014, the trash-fish proportion in pair and otter trawl catches in a Vietnamese province was reported to be over 50% of the catch.[84] Southern Vietnamese fisheries had the highest proportion of trash fish, averaging around 60% of the catch, compared to 5% in central and 14% in northern regions.[85]

Vietnam is one of the world's leading fishmeal producers.[86]According to IFFO, a 2017 survey of known fishmeal operations based in Vietnam identified 96 fishmeal factories, 86 of which were in the southern region, 6 in central Vietnam and 5 from Hue to the Chinese border. Eighty-one of these factories nominated sea fish as their source of raw material, and of these, 20 reported a production capacity totalling 450,506 MT. This equates to almost 2 million MT of whole fish - nearly as much as Vietnam's entire 2016 marine catch of 2.186 million MT - 'suggesting that processing capacity is far higher than the wild resources can sustain'.[87]

According to official statistics - which, based on IFFO's findings (highlighted in the previous paragraph), are likely to be highly conservative - Vietnam's fishmeal production has grown steadily since 2013, and is calculated to reach 460,000 MT in 2019 (see Table 2.1). Fishmeal from saltwater fish still accounts for 70% of total production, but the production of fishmeal from freshwater fishes is growing, and more than doubled between 2013 (just over 57,000 MT) and 2017 (just over 127,000 MT).

Table 2.1: Vietnam's fishmeal production (MT)

	2013	2014	2015	2016	2017	2018*	2019*
Saltwater fishmeal production	324,942	319,170	319,501	308,260	306,275	305,000	300,000
Freshwater fishmeal production	57,607	78,341	103,386	120,812	127,137	145,000	160,000
Total fishmeal production	**382,549**	**397,511**	**422,887**	**429,072**	**433,412**	**450,000**	**460,000**

*Source: GSO Note: * Post estimates and forecasts*

Our investigators were told that the price for trash fish currently ranges from 4,000–8,000 VND/kg (€0.14–0.30/kg), depending on quality. A vessel-maintenance worker said: 'fertiliser fishes [are sold] to recover the expense of fuel and ice. Profit is from the big fishes.' The price is based on how fresh or rotten the trash fish is, and/or on

how high the protein content is, which is determined by the dominant species among the trash fish (for example, anchovies have a higher protein content, and so are more valuable). Additional factors in determining price are how much trash-fish supply is in the port and how much demand there is from the fishmeal plants at any one time. It is generally a buyer's market, since the catches are already deteriorating when brought in and continue to do so until they eventually become unsaleable.

2.2.2. Overview of investigation

The fieldwork took place in May 2019 – a significant moment for Vietnam's fishing industry, which was awaiting imminent inspection by EU authorities, following the European Commission's issuance of a yellow card against the country's fisheries sector in October 2017 due to concerns about the prevalence of IUU fishing.[88] The impact of the yellow card on sector trade has been significant.

The Vietnamese government responded to the yellow card by swiftly drawing up a new and comprehensive Fisheries Law in November 2017.[89] The law was trialled in various ports (including Tac Cau, which the team visited); however, it was only officially launched in January 2019. Inevitably, such a wide-ranging structural change will take time to implement, particularly given the scale of the problems and the size of Vietnam's fishing fleet.

An EU inspection scheduled for January 2019 was pushed back several times during the year due to slow implementation of the Fisheries Law – and to the knowledge of this report's authors, at the time of writing, has still not taken place. At a conference in Hanoi in April 2019, the deputy director of the Ministry of Agriculture and Rural Development's Directorate of Fisheries acknowledged that, if 'the country fails to have instituted controls on fishing and tracing origins, it will likely get a "red card" warning – which means a complete trade ban on fisheries export to European markets'.[90] The stakes are therefore very high, and the team was consequently operating in a somewhat febrile environment, encountering heightened sensitivities around the ports and a visible reluctance of some in the sector to speak to outsiders. Nonetheless, the team was able to gather plentiful first-hand witness accounts that IUU fishing is taking place in each port they visited, along with evidence of the ecological impacts and threats to marine ecosystems that these practices bring. Given the sensitive nature of the information shared, to protect individuals' identities, most of the statements reported in this section have been anonymised.

The investigation team visited three ports in the south of Vietnam. These locations were selected following preliminary research that established they are important hubs for fishmeal production:

1. **Tac Cau port, Kiên Giang Province:** Fish landings in Kiên Giang Province account for 16% of Vietnam's entire marine-capture production, and over 40% of that of the Mekong Delta. Between 2015 and 2017, landings grew significantly (from 493,824 to 765,275 tonnes). The province is also home to at least 12 fishmeal-processing plants, most of which are located in the Tac Cau industrial zone, which has the biggest fishing port in Vietnam. Kiên Giang's Provincial Department of Trade and Industry estimates that, in the first 11 months of 2016, the province's FMFO production accounted for 109,485 tonnes (roughly 25%) of Vietnam's total FMFO production.[91]

Workers at Song Doc Port

Ba Ria port

Fishing vessels at Tac Cau Port

2. **Song Doc port, Cà Mau Province:** Cà Mau is the southernmost province of Vietnam and plays a key role in prawn farming and export. Cà Mau makes up 40% of the country's prawn-farming area;[92] in 2016, it accounted for one-third of Vietnam's prawn export, with a value of nearly $1 billion. The province is home to Vietnam's biggest prawn exporter, Minh Phu Seafood Company JSC, which was ranked among the world's 50 biggest seafood companies in 2018.[93] Song Doc port industrial zone includes three seafood-processing plants and nine fishmeal factories, and is known to be an environmental 'black spot' owing to air and water pollution from the factories.

3. **Phuoc Tinh port, Bà Ria-Vũng Tàu Province:** Bà Ria-Vũng Tàu Province (hereafter 'Vũng Tàu Province') is located northeast of the Mekong Delta, 100 km from Ho Chi Minh City. In 2018, it was reported[94] that the province's fisheries were facing many difficulties due to the decline in fishery resources, more restricted fishing grounds and an increase in the number of fishing vessels. In 2015, fishmeal accounted for 24% of the province's fishery processing for export of 110,000 tonnes.[95] The province has 15 fishmeal-processing plants, 10 of which are located in Tan Hai commune of Tan Thanh district, 4 in Dat Do district and 1 in Bà Ria city.[96] In late 2015, Vũng Tàu People's Committee put forward a plan to close the province's fishmeal factories due to pollution.[97] In 2015, it was reported that fishers in Phuoc Tinh fishing village were selling 50–70% of their catches to fishmeal-processing companies[98].

2.2.3. Findings on the ground

2.2.3.1. Evidence of ecological impacts and threats to marine ecosystems

Lack of fish is leading to widespread fishing in foreign waters

A wide range of informants confirmed that Vietnamese boats are regularly fishing in Malaysian and Indonesian waters, which is prohibited. This practice stokes regional tensions between Vietnam and its neighbours, and carries significant risk for the fishers, as it frequently leads to clashes at sea and can even result in their imprisonment. For example, a vessel owner and captain at Phuoc Tinh told the team the Indonesian authorities have impounded one-third of the pair trawlers from this port: 'Before there were 1,000 pairs like this, but Indonesia arrested 300, so only 700 left'. Indonesian authorities have particularly focused on enforcing penalties against

Vessel at Ba Ria

Vietnamese boats, as they have started to see the impact of punitive measures. According to a 2019 Bloomberg report, Indonesia's '[f]ish stocks in the third quarter of 2018 increased to 6.2 million tons, from 5.4 million tons in same period of 2015. The campaign against illegal fishing has resulted in the sinking of 503 foreign vessels since October 2014.'[99]

Nevertheless, the practice continues. A fisherman at Tac Cau confirmed to the team that his transshipment vessel collects trash fish from fleets fishing in Indonesian waters who have 'contracts'. He said transshippers make less profit than the trawlers, but have less risk.

The primary driver of fishing in foreign waters is the lack of fish in Vietnamese fishing grounds. At Song Doc, a water-taxi driver said local waters have no fish: 'There is no fishes. Cannot even recover the cost for the vessel. So they are forced to go stealing [fishing overseas].' Similarly, some fishermen in Vũng Tàu Province reported their lowest catches ever in 2018. A trawler captain in Phuoc Tinh told the team he caught around 40–50 tonnes of trash fish in Vietnamese waters on his last trip, whereas in the past he would have been able to catch double this amount.

One vessel owner the team spoke to acknowledged that her boat was catching juvenile fish, and that this was contributing to the problem of overfishing the sea. However, in contrast to countries where fishers receive government support for pausing fishing during certain periods of the year, she said: 'If we don't go fishing, we are hungry. We go fishing all year around, so the resource is exhausted.'

Underreporting of catches

The team heard several reports that no official assessment is made of catch volumes at the ports investigated. While there is currently no legal obligation on the part of the authorities to monitor and quantify trash-fish cargos (quota systems are being introduced as part of the new Fisheries Law), there is evidence that the lack of scrutiny is leading to significant underreporting of catches, which is enabling overfishing to continue unchecked.

In Tac Cau, the team was told that local transshipment boats collect trash fish from the trawlers near the shore and sail it straight up the river to deliver to the fishmeal plants' docks. When asked if trash-fish catches needed to be reported to the port authorities at Kiên Giang prior to being taken to the fishmeal plants, they were told: 'They bring it there to sell directly, no need to go through the port'.

One informant at Tac Cau port said his transshipment vessel did need to report when going in and out of the port. However, the authorities do not appear to keep a close watch on things. Describing how he reports to the Fisheries Surveillance Force, he said: 'If I have 10 tonnes, I say 5 tonnes they will also let go'. In other words, he underreports his catch by 50%.

Unsustainable fishing techniques

The team heard numerous accounts of unsustainable fishing techniques, including widespread fishing using very small net mesh, which enables trawlers to catch small fish species, juvenile fish and even fish eggs.

Various species of fish destined for fishmeal

Fishing net on a trawler at Phuoc Tinh port

At Phuoc Tinh port, the team was shown a net from an offshore pair trawler which consisted of three layers, of which the interior mesh was the smallest; at 1–2 cm, not even a small anchovy would be able to escape. This particular boat transhipped around 20 tonnes of trash fish on one fishing trip. According to the new Vietnamese Fisheries Law, 12–15m trawlers are prohibited from using trawl nets with mesh size below 34 mm, and trawlers of 15m upwards are prohibited from using nets with mesh size below 40 mm[100].

A trawler captain at Phuoc Tinh port told the team: '*In general, [I catch] whatever the trawler can catch. Big or small, [I] catch all, not skipping any fish ... Even as small as the toothpick. If they come in the net, we catch all.*' According to a Vũng Tàu fishery official, the ratio of juvenile fishing is high: 30–40%.

"Even as small as the toothpick"

According to local fishermen, a large variety of fish species - including sardine, mackerel, moonfish, prawns, tuna, anchovies, cowfish, gobies and shark - are being landed at all three ports visited. One informant said: 'They catch all they can. They don't let anything go. They catch them and classify, the big ones are iced carefully to sell for exporting, the small ones are used as fertiliser fishes [trash fish for fishmeal production].'

'Trash fish' including sardines and mackerels are sold to fishmeal factories in Ca Mau

An industry source told the investigation team that the fishmeal plants' demand for trash fish is insatiable, and that there was considerable competition among them to buy the landed trash fish; the fishmeal plants at Tac Cau port sourced from as far away as Song Doc port. They directly linked overfishing to the plants' trash-fish demand.

2.2.3.2. Impacts on people and the local economy

Economics of fishmeal production

The large majority of fishing vessels are owned independently rather than by fishmeal or feed companies. However, the vessel owners depend on financial loans from factories and middlemen to keep their boats running, and these loans tie them into exclusive supply agreements. The boats can be out at sea for 3–5 months at a stretch, with transshipment vessels coming out regularly to collect their catches.

It is generally understood that the fleet size has to be reduced, as it is unsustainable at its present size, and that other sources of employment need to be found for fishing communities. One problem mentioned by informants at Phuoc Tinh and elsewhere is that boat owners' assets are tied up in their vessels, which nobody now wants to buy.

This applies particularly to the smaller fishing trawlers owned by coastal and inshore fishermen. A vessel owner told the team: 'Now there is no fish. Now they want to sell [their vessels] ... but no one buys. ... Trawling [fishing] only get [makes a] loss.'

Pollution from fishmeal production

For over a decade, Tac Cau port has been a hot spot for environmental pollution. In 2014, a national media outlet cited a local environmental official, who said: '11 fishing factories in the area have built waste water treatment systems, but they are only used when inspections take place'.[101] The factories include both seafood- and fishmeal-processing factories.

In 2017, Cà Mau authorities fined several seafood- and fishmeal-processing companies in the vicinity of Song Doc port for violations related to environmental and water pollution.[102]

FMFO plant at Kien Giang

At Song Doc, many people spoke to the team about the intolerable smell that comes from the fishmeal factories when the wind blows in their direction. A staff member working at Cà Mau airport reported that the smell from the processing factories is so strong and unpleasant they have to keep the building doors closed, even though the plants are several kilometres away. One person claimed the Phuc Ngoc fishmeal company bribes the authorities to avoid being prosecuted.

Trash fishes unloaded at Phuc Ngoc fishmeal factory

The team spoke with local resident Mrs Dung at Tan Hai about pollution from the surrounding factories. It seems the fishmeal plants are more responsible for the smells than the seafood ones (she reported that many people in her village suffer from rhinitis). The team also spoke with a family who live on the river opposite the Phuc Ngoc and other fishmeal plants on the river at Tac Cau. The family told them local people had complained to the authorities many times, but nothing had ever been done because the companies have protection. For six months of the year, the wind blows towards their side of the river, carrying the smell from the factories. When asked why they did not move, they explained that no one would want to buy their properties.

Taking fish away from people

The team visited a floating fish farm on the Cha Va River in Long Sàn commune, a few kilometres away from Phuoc Tinh port. Cobia, pomfret and seabass (all carnivorous species) are farmed there and exported or sold on domestic market. They are fed on CP Vietnam Tilapia feed; the team also witnessed fresh fish being brought onto the farm in crates and ground down in a machine before being fed to the fish.

The owner explained that he buys one tonne of this fish per day at a cost of VND 11,000–12,000/kg (€0.40) to feed his farmed fish. Asked if this was 'fertiliser' fish (trash fish), the team was told: 'No. These fishes are type for human consumption, but we use it for [feeding fishes]. This one is mackerel... And this one is yellow-stripe scad.' At this farm, and many others, the fish are being fed not only aquafeed but also fresh pelagic fish, fit - and commonly sold - for human consumption. This is a clear illustration of the problematic link between aquaculture and food security. It should also be reiterated that a high proportion of fish sold to fishmeal plants as trash fish is equally fit for human consumption, if not brought to shore rotten and if allowed to grow to maturity.

Grinding fish for use on smallholder farms

Small fishes being sold to floating fish farm at Phuoc Tinh port

2.2.3.3. Supply chain: Who is producing/buying the fishmeal?

The investigation uncovered supply links between problematic FMFO producers in southern Vietnam and several major companies with global reach, including Vinh Hoan Corporation, a large aquafeed producer and leading Vietnamese pangasius exporter to the EU; CP Vietnam, the feed subsidiary of global giant CP Foods, part of multinational conglomerate Charoen Pokphand; and Minh Phu, Vietnam's largest prawn exporter, which exports significant volumes to the EU and US. Grobest, a major producer of prawn feed with its own aquaculture farms and processing facilities across Asia, is supplied by all three of the problematic fishmeal companies studied in this report.

Tac Cau fishing port, Kiên Giang Province

> Investigation at Tac Cau port found IUU fishmeal from Phuc Ngoc fishmeal plant entering the supply chain of Vinh Hoan Corporation, a large aquafeed producer and leading Vietnamese pangasius exporter to the EU. This fishmeal is also entering the supply chain of CP Vietnam, the feed subsidiary of global giant CP Foods, part of multinational conglomerate Charoen Pokphand.
>
> *Our investigation found Dutch retailer Plus to be implicated in this supply chain (see Chapter 3).*

Most of the fishmeal produced in Kiên Giang is sold to domestic aquafeed companies and some joint stock companies, such as Tom Boy, Nutreco (Skretting Vietnam), Uni-President (Taiwan) and Thang Long. Less than 10% of fishmeal production is exported to Japan, China and Hongkong.[103]

At Tac Cau port, Kiên Giang Province, the team received confirmation from two sources that the fishmeal businesses owned by the Chau family were receiving IUU trash fish from both Malay and Indonesian waters.

In a face-to-face meeting with one of our researchers posing as a buyer, Mrs Chau Cam Le, the owner of Phuc Ngoc (one of the Chau family fishmeal factories), disclosed that Phuc Ngoc supplies fishmeal for aquafeed to all the CP Vietnam aquafeed plants, as well as to Proconco, Thang Long, Vinh Hoan, Tongwei, Uni-President and Cargill. These companies are among the largest aquafeed providers in Vietnam, feeding a wide range of farmed fish and prawn destined for the US, EU and many other international markets.

Song Doc port, Cà Mau Province

> Investigations at Song Doc port found IUU fishmeal from Bich Khai fishmeal plant entering the aquafeed supply chain of Grobest, a leading feed producer that supplies Vietnam's largest prawn exporter, Minh Phu – a company that exports significant amounts of seafood to the EU and US.
>
> *Retailers associated with this supply chain include ALDI SÜD, ALDI Nord and Lidl in Germany (see Chapter 3).*

Weighing and unloading trash fishes on a transhipment vessel in Ca Mau

At Song Doc port in Cà Mau, the team witnessed trash fish being transshipped from a large transshipment vessel to a smaller barge for delivery to Bich Khai fishmeal plant. The fishermen on the larger vessel confirmed they had been sent to the territorial borderline to collect IUU catch from trawlers fishing over the border in Malay waters, so our team decided to investigate this company.

The owner of Bich Khai confirmed to the investigator, who was posing as a buyer, that he exclusively uses wild-caught fish, and that his principal buyer is Grobest. Minh Phu claims that Grobest is its exclusive prawn feed provider. Minh Phu is Vietnam's largest prawn exporter and sells to the EU and the US, as well as globally (see below).

At Song Doc port, the fishmeal plants are located along the side of the main road that leads to the port. Behind the plants runs the river. The team hired a boat taxi to take them onto the water, and looked for any transshipment boats coming in from the sea to unload catches at fishmeal-plant docks. During the trip, the taxi captain – a former fisherman – told them Bich Khai is one of the big trash-fish buyers, buying from Kiên Giang vessels that come down to the south. He also described bribing port authorities at this port: 'The border defence station, all the vessels going out will be called in that station, no matter big or small. They check the paper works, and checking around the vessels, one person goes, giving them 500,000VND and go. Easy.' Another source explained that the owner of Bich Khai locks trawlers into supply agreements via loans, as detailed earlier in this report.

The team witnessed workers unloading trash fish onto the deck of their smaller transshipment barge from a larger transhipper, and discussed with the crew how the boat had gone to the territorial border with Malaysia.

Mr Khai, owner of the Bich Khai fishmeal plant, told the researcher he lends money to hundreds of fishing vessels to secure supply: 'investing in one pair of vessels is 500–700 million [€19,500–27,400]. They go [fishing] and they sell all their catches to me.' During the conversation, he told the investigator he takes 20–30% of all trash fish from the port, while acknowledging that local boats are involved in IUU fishing by fishing inshore, bribing the authorities and fishing in foreign waters.

The Bich Khai plant is one of the larger factories at the port. Its usual intake of raw materials is 100–200 tonnes/day, rising to 200–300 tonnes/day on 'high days': 'I run 24/24, 20 days per month. On average, I process >1,000 tonnes [finished fishmeal per month],' said Mr Khai. According to him, in 2018, Grobest purchased 'between 700–1,000 tonnes/month'; they have slightly reduced their purchasing this year, but are still buying 70–80% of the product. He also sells to CP Vietnam, although they mainly buy a lower-grade (60% protein) fishmeal, which is used for animal feed. He told the investigator that Grobest buys the high-protein-content feed (63–65%), which is 50% anchovy and costs VND 30,000/kg (€1.18/kg), buying 7,000–10,000 tonnes/yr. The company has 'papers to satisfy Grobest's requirement on quality standard', and in the past Grobest used to send supervisors to the plant to oversee the production.

Bich Khai fishmeal factory

Baskets of trash fish at Vung Tau

PROFILE: MINH PHU SEAFOOD CORPORATION

Minh Phu is the largest prawn exporter in Vietnam, accounting for around 20% of sector exports. In 2016, its prawn exports were valued at $530 million. Japanese company Mitsui recently bought a 35% share in the equity, with the aim of growing Minh Phu's market share.[104] Its products are certified by the Aquaculture Stewardship Council (ASC).[105]

Minh Phu processing plant in Cà Mau buys from around 10,000 local prawn farmers, who supply 5–10 tonnes per farm per season. The company has an integrated supply chain, and its website indicates its supply farmers use Grohmin prawn feed, which is a brand name of a Grobest/Minh Phu joint feed venture.[106] When the team visited the region where the prawn farms are located in Cà Mau, it was evident that Minh Phu was the primary – if not virtually the monopoly – buyer in the area; so much so that the market price for prawn is whatever the Minh Phu price is set at.

The team was able to speak with two different prawn farmers, although generally farmers were very reluctant to talk for fear of upsetting their big buyer. Neither of the farmers used Grobest prawn feed, however, and the picture was more nuanced than Minh Phu's website might suggest.

The fish farmers said that they are tied to aquafeed dealers via loans: 'The feed dealer invests [lends money] everything [infrastructure of the prawn farm]. We only have to buy the breed [breeding stock]. Other things are invested by the dealer.' Once their prawns are ready to sell, they will sell to whichever 'trader offer better price, I will sell'. Having initially said they don't sell to Minh Phu, they went on to explain that their relationship is only with the middleman trader, from whom Minh Phu buys more or less all the stock in the area: 'Now only Minh Phu is the monopoly'.

Bà Ria/Phuoc Tinh port, Vũng Tàu Province

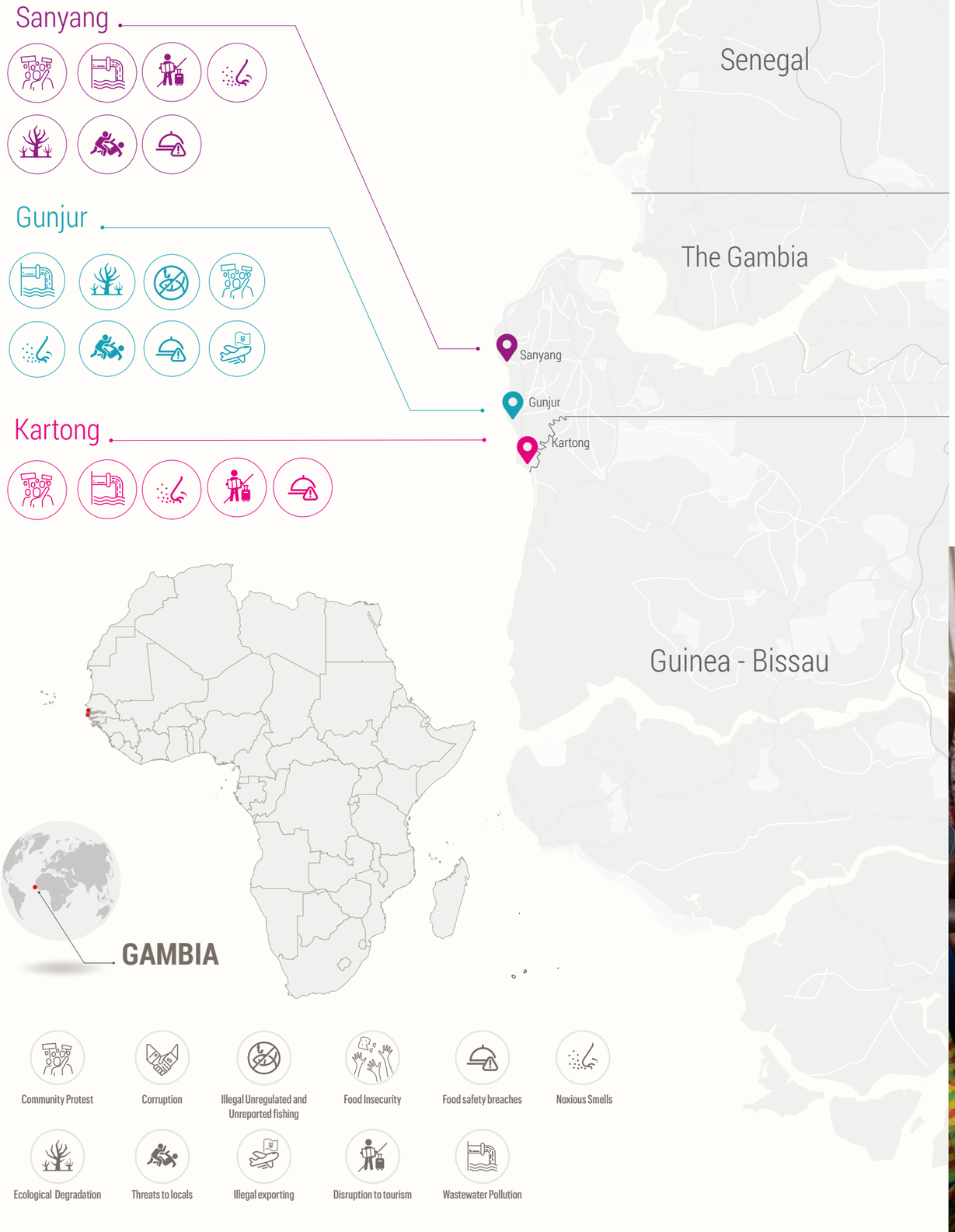
> Investigation at Phuoc Tinh port found IUU fishmeal from Phuc Loc fishmeal plant entering the aquafeed supply chain of CP Vietnam, part of multinational conglomerate Charoen Pokphand.

On its website, Phuc Loc lists its feed-producer partners as CP Vietnam, ANT Group, American Feed Company (Gold Coin Group), GreenFeed and Grobest. A factory worker told the investigator that CP and GreenFeed are the largest buyers, with CP signing weekly contracts for around 500 tonnes of fishmeal per week.

At Bà Ria port, the team spoke with fishermen who confirmed that they had fished illegally inshore and supplied the Phuc Loc fishmeal company, so a researcher visited the company posing as a buyer. They received confirmation from plant workers that the trash fish there was sourced from foreign waters in Malaysia and Indonesia, and witnessed a trash-fish truck being unloaded. Phuc Loc supplies to aquafeed companies CP Vietnam, Grobest, Cargill and others, and is fully qualified for European and other global export. Mr Phuc told the investigator the company has a complete chain of custody for supply, with full traceability back to the ocean.

A conversation between the researcher and a factory worker may also indicate the presence of inshore trawl catch in the factory supply chain. An informant described vessels going into the Vũng Tàu coastal area at night and coming back the next morning with large trash-fish catches: 'Normally they would have to go for a week before they return. But now they go this morning and come back next day evening.' This could imply these boats are trawl fishing in the banned area close to the coast, since coastal waters no longer contain large catches.

Mr Phuc, the manager of the company and son of its owner, acknowledged that almost all the fishing at the port – where they are one of the primary buyers – is using trawling, and told the researcher: 'Trawlers are accused of causing extinction. EU does not allow that.' While he claimed that port authorities and the Department of Fisheries monitor catches and 'check a lot of things', the current inadequacy of these monitoring and checking processes is unfortunately clear to see, given that workers inside the plant confirmed the presence of IUU fish in the factory supply.



2.3. The Gambia

2.3.1. The Gambia's FMFO industry

The Gambia is Africa's smallest nation, and one of its poorest, with debts of around 130% of GDP[107] and a poverty rate of 48%. Since transitioning from dictatorship in 2016, The Gambia has attempted to attract foreign investment to kickstart a bankrupt economy. As such, it is one of many African states to have formed close ties with China (see Box 2.1).

One of The Gambia's key natural resources is the abundant fisheries that lie off its coast. The country's fishing grounds contain large stocks of pelagic (mid-ocean) fish, such as sardinella and bonga, which migrate up and down the West African coast and provide a vital source of protein for 50% of the population,[108] as well as providing jobs for 200,000 people (out of a population of 2.1 million).[109] Gambians consume 25 kg of fish per capita, compared to a African average of 8.2 kg.[110]

Despite possessing some of the world's richest fishing grounds, the nation's food insecurity rate has risen from 5% to 8% over the past five years,[111] in part due to fluctuating populations of bonga fish (also known as shad), which experienced a crash of 40% between 2013 and 2014 according to FAO data.[112] This drove prices up by 50% – something already keenly felt in the local fish markets our investigation team visited. A saleswoman, Sulayman Bah, said: 'three years ago the market was good, we had lots of fish but there's much less now. The price of fish was cheap but now it's three times more expensive because it's just not so available.'

Local woman selling fresh fish, the same type as are sent to the FMFO factories

BOX 2.1: **Gambian–Chinese relations**

The Gambia formed ties with China as part of the Belt and Road Initiative. The agreement promises a $33 million development grant and a further $4 million for the military, and in 2017 China cancelled $14 million of debt accrued in the 1980s.[113]

China's domination of global aquaculture, and closer ties with African countries through the Belt and Road Initiative, has given it unprecedented control over the continent's fisheries and access to new markets for its farmed fish. As fish stocks have dwindled, China has started flooding African markets with its own domestically farmed fish, undermining local fisherpeople and making communities reliant on imported frozen fish.[114]

China is playing a key role in developing The Gambia's fisheries and fishmeal sector. Chinese investors fully or partially control all of the country's three fishmeal plants, and most of the fishmeal produced ends up in China. All three Gambian plants have strong links to China: Chinese-owned Golden Lead started processing fish in early 2016, followed by joint Mauritanian–Chinese JXYG (based in nearby village Kartong) in early 2017, and Mauritanian-owned and Chinese-run Nessim in early 2018.

Chinese owned Golden Lead FMFO factory in Gunjur

Against this backdrop of volatility, the country's National Development Plan 2018–2021 aims to increase fisheries as a percentage of GDP from 6.4% to 15%, while increasing total production of fish resources from 53,719 to 75,000 over the same period, with the FMFO industry playing a key role.[115]

The FMFO industry in West Africa as a whole is expanding; in 2016, it already represented 7% of global production,116 putting further pressure on already overexploited local fisheries' resources. A recent Greenpeace study found 50 operational FMFO factories in the region; in Mauritania alone, there are an estimated 33 active fishmeal plants,[117] and half of the fish catch is already being used for fishmeal.[118] Similarly, there are three FMFO plants in The Gambia, and we have calculated that the combined catch of just one of them accounts for approximately 40% of the country's total reported catches, revealing the massive scale of this new industry in the country. Despite this, little official information is available about the volumes of fish used for FMFO or their species composition.

More specifically, according to the Gambian fisheries ministry, total fish catches (by both industrial and artisanal fleets) were 66,849.98 tonnes in 2016 (see Table 2.2). This would mean just one of the country's three fishmeal plants – Golden Lead – caught the equivalent of 40% of all reported catches that year, since it reported producing 5,430 tonnes of fishmeal. This is equivalent to 27,150 tonnes of fish catches, since some 5 kilos of fish are required to produce every kilo of fishmeal, although there is little official information available about their species composition.

Table 2.2: Gambian fish catches (tonnes)

	2016	2017	2018
Industrial fleet	8,588.40	14,451.06	13,029.89
Artisanal	58,261.58	53,580.63	54,402.26
TOTAL	**66,849.98**	**68,031.69**	**67,432.15**

Source: *Gambian Ministry of Fisheries and Water Resources (data gathered by Changing Markets)*

FMFO processing plants pay local fisherpeople cash upfront for their catch (unlike local fishmongers, who buy on credit), and even buy spoilt fish, making it extremely attractive to sell directly for fishmeal. These plants compete for the same fish species that local communities eat, processing the fish into fishmeal for export abroad.

With domestic production still in its infancy, there are three plants operational in the country. These are located along a 30-kilometre stretch of coastline in the villages of Sanyang (Nessim), Gunjur (Golden Lead) and Kartong, just over the border from Senegal (JXYG). The Gambian fisheries minister, James F. Gomez, told our investigation team that a government feasibility study carried out before the country transitioned to democracy in 2016 concluded that an additional two plants could be developed, which he recently reaffirmed at the national assembly.[119] He added that 'the scientific data from the yearly acoustic survey on pelagic resources such as Bonga and Sardinella in Gambian waters can accommodate the establishment of five fishmeal factories even though only three of such factories are in operation'. However, a senior UN fisheries official – who wished to remain anonymous due to his work in The Gambia – said this was not true, and that virtually no scientific fisheries studies have been undertaken in The Gambia.

Aerial view of Gunjur showing local pirogue fishing vessels

A smokehouse in Gunjur processing bonga fish for local markets

In any case, concerns over food security and a series of environmental scandals relating to existing plants have made the ministry wary – at least for now – of pursuing further expansion of this industry, which provoked a temporary shutdown in 2018.

2.1.1. Overview of investigation

Our investigation took place in May 2019. It comprised primary research, obtained through on-the-ground field visits and interviews with activists and locals; secondary research, consisting of interviews with academics, journalists and ministers; and an in-depth review of official statistics, media reports and supply-chain data. The aim of the investigation was fourfold: to establish whether the three operational fishmeal plants continue to cause serious social and environmental damage to the region; to understand any food-safety implications of FMFO production in The Gambia; to identify the ownership structure of the plants and uncover their place in the international supply network; and to investigate the food-security implications of the FMFO industry for the local population.

2.1.2. Findings on the ground

2.1.2.1. Evidence of ecological impacts and threats to marine ecosystems

The evidence from the ground shows that Gambian fishmeal plants continue to be involved in social and environmental scandals, despite repeated government assurances that they now operate safely and respect existing regulations.

In May 2017, Golden Lead was accused of dumping industrial wastewater directly into the sea and the nearby

Lagoon at a local nature reserve turned red due to pollution

protected Bolong Fenyo Wildlife Reserve, destroying the local ecosystem and prompting local activists to sue the company (the case is currently underway). The National Environment Agency (NEA) temporarily shut down this factory, but reopened it after assurances that wastewater discharged in the sea was being treated and instead dumped 350 metres into the sea, not in the lagoon.

Tourists step over wastewater pipe from Nessim FMFO plant dumping effluent into the sea

However, evidence that local activists shared with Changing Markets shows the lagoon turned red on 23 May 2019, indicating that the plant had again been discharging industrial wastewater. Plant operators prevented activists from testing the effluent; one activist later received a death threat, and another five were arrested. Our investigation team also discovered that the Nessim plant at Sanyang was in breach of wastewater regulation, dumping its industrial effluent just 50 metres out to sea – in full sight of the beachfront hotels – as the pipe that was supposed to discharge wastewater some 350 metres into the sea immediately drifted horizontally and ran along the beach. To make matters worse, noxious smells from the three factories are still severely impacting the local ecotourism industry that has developed all along the coast. According to Lamin Jawla, owner of the popular Rainbow Lodge in Sanyang, their sales have slumped since the fishmeal plant opened, mainly because of this problem:

> *Customers come and order food, but then the plant starts operating and the smell is unbearable, so they stand up and leave. You feel the smell 200 metres away from the plant where we're right now, but also as far as 3 kilometres away, depending on the wind.*

Dead fish dumped on Sanyang beach

The local tourism industry is a key employer in the area, but the smell is driving visitors away from Sanyang beach, resulting in a significant drop in sales. An even larger reduction in reservations was reported at Kartong, where the JXYG factory is located. Many tourists are drawn to The Gambia by the prospect of fishing expeditions – an opportunity that has also been jeopardised by the damage to fish stocks caused by fishing for FMFO.

The team also found huge quantities of dead fish dumped over several kilometres along Sanyang beach. According to locals, this is the work of Senegalese fishermen on lucrative short-term fixed-price contracts for the FMFO factories; these fishermen are the main suppliers to these plants, and they discard the fish they cannot sell or store. The Gambian fisheries minister told Changing Markets they were investigating this incident, but

admitted they were unable to stop Senegalese fishermen from dumping their surplus catch due to a reciprocal fisheries agreement between Senegal and The Gambia, as well as the absence of surveillance capabilities. Local fisherpeople also accuse the Golden Lead plant – protected by UK security firm G4S – of using their own trawlers, which are fishing illegally, using small nets that are wiping out juvenile fish stocks and further contributing to overfishing of pelagic fish.[120]

2.1.2.2. Impacts on people and local economy

Economic impact

It is clear that the presence of polluting and extractive FMFO factories is incompatible with a prosperous, locally run tourism industry. However, a lack of alternative sources of income and government neglect mean that many people support these plants – despite the social and environmental problems they generate – because they create indirect jobs and stimulate the local economy; for example, the Senegalese fishermen contracted to fishmeal plants rent rooms and houses in the local communities.

In addition, some locals credit the factories with bringing in people and boats, and thus a greater number of fish landings for local consumption. Fishmeal plants also directly contribute money to the local communities; through village elders and the so-called Village Development Committees, they fund projects ranging from clinic upgrades to the purchase of a funeral car and improving football pitches, although these payments only amount to a few thousand dollars a year.

Beach front tourist facilities at Sanyang

On the other hand, fishmeal plants generate very few direct jobs for the locals. Since the processing of fish for fishmeal is a simple operation, the average plant does not employ more than 30 people, many of whom are foreigners, who undertake the more specialised jobs.[121] What is more, the majority of raw material is provided by Senegalese fishing boats on Chinese contracts rather than native Gambian boats, which are generally smaller and not equipped for industrial-scale fishing. Even most of the people carrying fish from the boats to the fishmeal plant come from neighbouring countries – such as Burkina Faso, Mali and Sierra Leone – desperate to find work; they are paid some 25 dalasi ($0.50) for every basket they carry, and flock to greet any incoming boats.

Basket carrier taking fish to the FMFO plant in the village of Kartong

This is provoking anger among many traditional Gambian fishermen, who use smaller boats than their Senegalese counterparts and are finding it increasingly difficult to find fish to sell in the market. Standing next to a pile of dead fish dumped on the beach by Senegalese fishermen, who had been unable to sell them to the local Nessim FMFO plant, a fisherman called Bubacarr Sanyang told our investigation team: 'The plant attracts boats from south Senegal, they come here and fish. They dump the fish they cannot sell at the plant. You see all these big boats? They're for the Chinese. I feel I'm in the slave trade, I don't have any rights.'

Further diminishing the economic case, our investigation revealed the FMFO plants pay very few taxes; they are exempt from turnover and corporate taxes, benefit from duty waivers for imports and a VAT waiver, and are exempt from capital allowance taxes for their first 10 years of operations. The Gambia Investment & Export Promotion Agency – a national agency established in July 2010 to promote private-sector investments into the country – confirmed that these initiatives are part of a foreign-investment promotion scheme for companies that export more than 80% of their production.

Illegal operations and shady supply links

Deepening the scandal over social and environmental degradation, our investigation also exposed that all three plants have been exporting FMFO illegally. They have been transporting these products in large containers, which are shipped abroad by major international logistics companies like Maersk, according to the Gambian Food Safety and Quality Authority (which only discovered this after our investigators questioned them). Specifically, from May 2017, they have been exporting their FMFO destined for human consumption and feed without securing the required food-safety certificates, and potentially avoiding export fees. This means they did not undergo any food-safety controls or inspections, revealing serious gaps in international oversight of food security and product traceability, and ultimately putting consumers' safety at risk.

Maersk vehicle used to transport illegal shipments

The food-safety agency told our investigation team they only have records of FMFO exports for Golden Lead factory, and only from March 2016 (when the plant started operating) to May 2017 (when it temporarily shut down after an NEA investigation). There are no records for the other two fishmeal plants – JXYG and Nessim – which started operating in early 2017 and early 2018 respectively.

Scrutiny by the Gambian authorities, and initial orders to cease exports, fell on deaf ears; drone footage obtained by our investigation showed at least one of the plants continuing to flout restrictions, though exports were later allowed to resume. The plants have promised to declare their exports from now onwards, but the food-safety agency has still not been able to find out how much FMFO they had exported, or its final destination. A senior government official told Changing Markets these companies had been faking food and safety certificates to enable them to export their products.

A shroud of secrecy also surrounds the FMFO plants' international clients. Export data reveals shipments to Vietnam, Thailand, Saudi Arabia, Tunisia, Mauritania and Chile – a number of which are hubs for aquafeed production with strong supply links on to North America and Europe. Our investigation confirmed that one of the main importers of Gambian fish oil is Chilean company, TRIO S.A., which would have been importing fish oil from The Gambia without proper food-safety certificates. This is despite TRIO S.A. highlighting that it is 'committed to the principle of sustainable development in its every activity, as well as socially and ethically responsible policies',[122] and its certification as IFFO Responsible Supply Chain of Custody.

TRIO S.A. belongs to a conglomerate called TRIOGROUP Holding, which consists of three companies that operate independently but are under the same management. These companies are TRIO S.A. (which has IFFO Responsible Supply Chain of Custody certification – IFFO RS CoC), BIOILS SpA and Natural Oils Chile S.A. (also possessing IFFO RS CoC)[123] and includes the US, UK and France among its export markets.[124]

Fishmeal laundering

A further dark cloud hangs over the industry. A senior industry source informed Changing Markets that at least one Gambian plant sells most of its fishmeal to Vietnam, and that this fishmeal is then relabelled on the black market for re-export to China, the world's largest aquafeed producer. This would enable the company to avoid existing Chinese food-safety controls and potentially evade paying taxes, circumventing the absence of a fishmeal export agreement between The Gambia and China.

Piles of fish ready for grinding at Kartong

In the case of fish oil, the source added that most of the product is shipped to Chile, where it enters as animal feed but is then changed by intermediaries into fish oil for human consumption, thereby avoiding more stringent food-safety controls. Worryingly, the source added that these fishmeal-laundering practices are commonplace across many African countries, including those from neighbouring Senegal and Mauritania, as well as Angola, with Vietnam a known hub for smuggling other illegal African products into China.125 IFFO inspectors were also reported to have visited The Gambia recently with the aim of potentially providing certification for local fishmeal plants, despite these plants' involvement in environmental and social scandals.

When contacted, neither the Gambian nor Chilean authorities showed any interest in pursuing these allegations. Overall, this suggests feeble government and industry oversight in a sector that emphasises sustainability as a key driver behind its growth. This also partly contradicts IFFO's claim that 'over 45% of the global production of fishmeal and fish oil is now independently certified as being safe and environmentally responsible, including in its sourcing of raw materials'.[126]

Supply-chain links

Golden Lead

Based on the records available for Golden Lead, the plant produced 5,430 tonnes of fishmeal in 2016 and 442 tonnes in 2017 (until it was forced to stop operating), all of which was shipped to Vietnam.

Golden Lead also exported 2,320 tonnes of fish oil, one-third of which (734 tonnes) was shipped to Nouakchott, the capital of Mauritania. This shipment was recorded over a single day, on 19 September 2016. Interestingly, UN Comtrade data identifies 729 tonnes of fish-oil imports into Mauritania for 2016, which coincides with the amount shipped by Golden Lead.

According to information a government source shared with Changing Markets, Golden Lead's clients include three Vietnamese companies – Thien An,[L] Long Hai[M] and Viet Hoa[N] – and one company based in Nouadhibou, Mauritania[O] (a rapidly-expanding FMFO production hub):

L Thien An Co. Ltd, No 104 Mac Dinh Chi Street, Ka Long Ward, Móng Cái City, Quảng Ninh Province, Vietnam.

M Long Hai Trading, Transportation-Sea Product Processing JSC, Tiân Phong Village, Hai Binh Commune, Tinh Gia District, Thanh Hoa Province, Vietnam.

N Viet Hoa Aquatic Food Joint Venture Company Ltd, Lot 6B-Dien Nam Dien, Ngoc Industries Zone, Quảng Nam Province, Vietnam.

O Veiga International Trade Inc., Omaurcisa Nouadhibou P/C., Nouadhibou, Nouachott, Mauritania.

Aerial view of the Golden Lead plant at Gunjur

- **Thien An Company, Móng Cái City, Quảng Ninh Province, Vietnam:** This plant is located on the border between Vietnam and China. Our research indicates that Thien An is importing fishmeal from Golden Lead to re-export to China.
- **Long Hai Company, Tinh Gia Village, Thanh Hoa Province, Vietnam:** Long Hai appears in a European Commission list of companies authorised to export fishery products to the EU.[127] Investigations revealed that Long Hai is lending its name to a Vietnamese fishmeal producer, Ngoc Son Company, to export fishmeal to China, mainly to a Chinese buyer called Mr Liang based in Guangxi Province. Liang is allegedly the biggest Chinese buyer of fishmeal from Vietnam and one of the top distributors of fishmeal in China. According to our information, Long Hai's name was also used to import fishmeal from Africa to Vietnam for the same Chinese buyer. In 2018, Mr Liang imported 3,000 tonnes of fishmeal from The Gambia to Vietnam. The consignment was then exported on to China, with Vietnam indicated as its country of origin.
- **Viet Hoa Company, Ngoc Industries Zone, Quảng Nam Province, Vietnam:** Viet Hoa – which is owned by China's Guangdong Evergreen Feed Industry Co., Ltd – is an aquafeed supplier and does not operate any fishmeal plants. It is likely that the import of fishmeal from The Gambia is arranged directly by the mother company.
- **Veiga International Trade Inc., Nouadhibou, Mauritania:** A company called Veiga International Trading Inc., based in Spain, is listed as a member of IFFO.[128] Both appear to be the same company; online sources state that Veiga International Trading Inc. has operations in Morocco and Mauritania,[129] and there is no reference anywhere to Veiga International Trade Inc. The company is also incorporated as a Sociedad Anonima in Panama.[130]

JXYG

JXYG told Changing Markets it produced 1,500 tonnes of fishmeal in 2018 – equivalent to 7,500 tonnes of fish catch – as well as 500 tonnes of fish oil. Almost all its fishmeal is shipped to Vietnam, and the rest to Thailand and Saudi Arabia. Ninety per cent of its fish oil is shipped to Chile, and the rest to Vietnam and Malaysia.

Further international supply connections

Interestingly, The Gambia did not record any exports of fish oil to Chile, according to UN Comtrade.[131] However, according to the same source, Chile did record large imports of fish oil from The Gambia in 2017 (212 tonnes) and 2018 (1,204 tonnes), coinciding with the time the JXYG and Nessim plant started operating.

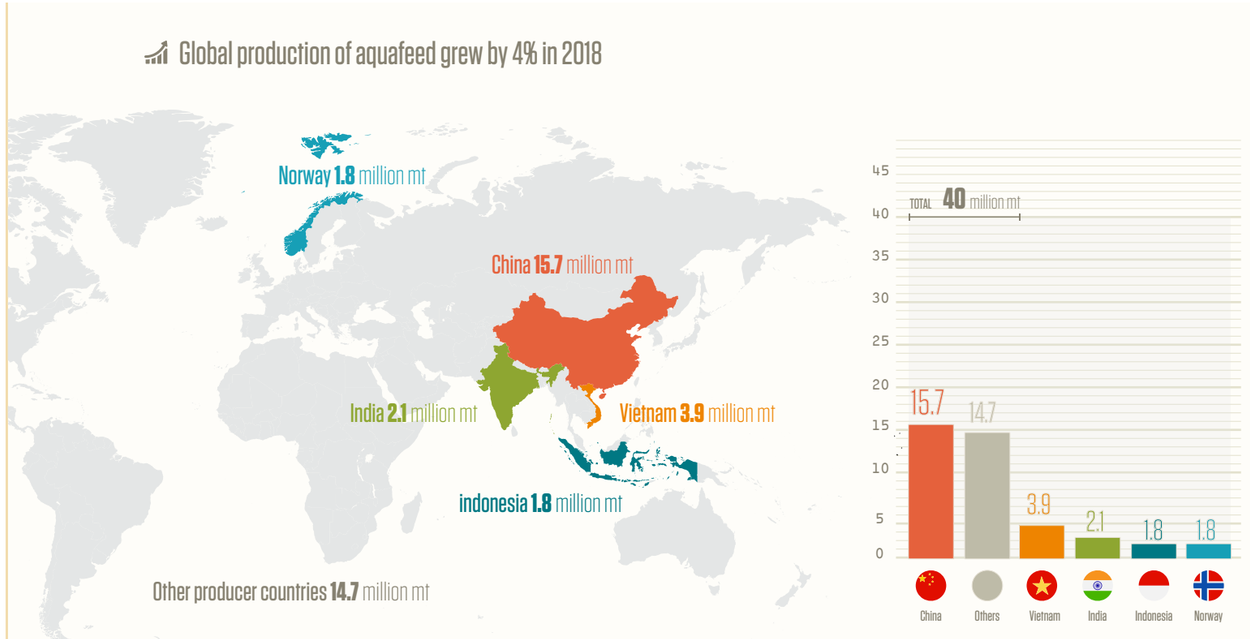
> In 2018, aquafeed giant BioMar was reported to have sourced from The Gambia.[132] BioMar, in turn, supplies aquafeed that feeds farmed seafood in the supply chains of Tesco and Marks & Spencer in the UK, and ALDI and REWE in Germany.

3. Risks for the aquaculture industry and retailers

3.1. Overview of the aquafeed industry

Rapidly rising global seafood consumption[133] and booming aquaculture production have played a crucial role in fuelling the growth of the aquafeed industry, which is projected to continue its upward trend in the coming decades. The aquafeed sector is frequently presented as an attractive investment opportunity, based on the fact that it underpins the fastest-growing food-production sector in the world. Half of today's global aquaculture production takes place in systems requiring the use of feed.[134] Farmed species that are given aquafeed include naturally carnivorous fish, such as salmon and tuna, as well as non-obligate carnivores, such as prawns and carp.[135]

Global production of aquafeed grew by 4% in 2018 to reach more than 40 million metric tonnes (MT).[136] Estimates of the aquafeed industry's market value vary, but all analysts predict huge growth over the coming decade. One source valued the market at $107 billion in 2017 and predicted it will grow to 172 billion by 2022,[137] while another forecast predicts the industry will double in size to surpass a staggering $215 billion by 2024.[138] The growth of the sector has been predominantly driven by China, Southeast Asia and a few European countries. Asia Pacific is the world's largest feed-producing region, and China is the biggest aquafeed producer globally, with 15.7 million MT of aquafeed produced in 2018.[139] After China comes Vietnam, with 3.9 million MT in 2018, followed by India (2.1 million MT), Norway and Indonesia (both 1.8 million MT).[140]



Europe, which is home to several of the world's largest aquafeed producers, is a growing market for aquafeed. Norway is Europe's largest producer, contributing 45% of the region's total aquafeed production (1.83 million MT), followed by Turkey.[141] Both of these countries experienced strong growth in 2018, while Spanish production grew by a substantial 31% in the same period.[142]

Some of the biggest aquafeed companies on the global market were established in the 19th century and have roots in the animal feed industry (e.g. Skretting[143] and Cargill[144]). It was only in the second half of the 20th century, when aquaculture production started to take off,[145] that these companies ventured into aquafeed and others entered the sector: BioMar in the 1960s[146] and Marine Harvest (now Mowi) in 2012.[147] The industry generates high returns: In 2017, four of the leading European aquafeed producers had combined sales of $3.3 billion, including the Norway-based companies Cargill Aqua Nutrition/EWOS ($2.19 billion, estimated),[P] Skretting ($742 million) and Mowi ($371 million), and Denmark's BioMar ($2.6 million).[148]

Commercial aquafeeds vary in their composition, but are likely to include fishmeal and fish oil (FMFO) as their major source of dietary protein, along with vegetable oil, vegetable proteins (e.g. soy and corn) and grain products.[149] The FMFO market is highly volatile,[150] due to its reliance on unstable and rapidly diminishing finite resources (i.e. wild fish), combined with the vulnerability of these to the impacts of climate change and weather patterns, such as El Niño,[151] as shall be examined at the end of this chapter.

The United Nations Food and Agriculture Organisation (FAO) projects that, in 2030, fishmeal production will be 19% higher than in 2016, with 54% of the growth deriving from improved use of fish waste, cuttings and trimmings obtained from fish processing[152,Q] and the rest, presumably, from the use of whole fish. This means the industry's future growth is predicated on the continued extraction of marine resources that should be left in the ocean or prioritised for human consumption. Even where the industry claims to be taking action to minimise its impact on marine ecosystems, these actions have been limited, and do not account for the projected growth of the sector that has so far not been able to decouple its production from wild-fish stocks. The reality is that, if the industry continues with the 'business as usual' approach, it will exert increasing pressure on finite marine resources in the coming decades. The future growth of the aquafeed industry therefore hinges on its ability to reduce its reliance on FMFO and to embrace sustainable innovation, especially the use of novel feed ingredients. Despite numerous alternatives and innovations in the aquafeed market today, companies have made only limited progress in this direction, with current growth strategies still reliant on the exploitation of scarce marine resources.

A number of global aquafeed companies state they aim to increase the inclusion of marine 'by-products' in their feeds as a way of limiting their reliance on forage fisheries.[153] However, in light of the widespread unsustainable and illegal fishing practices described in the previous chapter, it is likely that, in some cases, the FMFO industry and aquafeed companies may classify edible fish which could be consumed directly as by-products. The lack of transparency within the sector raises questions as to how they ensure 'by-products' truly are waste products that are not driving further pressure on wild-fish stocks. As shown by our on-the-ground investigations, in many cases, fish fit for human consumption were diverted to FMFO processing. According to FAO, by-products currently account for 25–35% of the total volume of FMFO produced,[154] but there is significant regional variation; for example, a study funded by The Marine Ingredients Organisation (IFFO), and cited by FAO, states that by-product use in Europe is 54%, while in South America it is a mere 16%.[155] Globally, fishmeal produced from fish by-products is projected to represent 34% of world fishmeal production in 2030, compared to 30% in 2016.[156] However, it is important to note that there is considerable statistical uncertainty when it comes to calculating future trajectories, and that even the models the industry uses rely on incomplete data sets.[157] As the findings from our investigations in Vietnam, India and The Gambia highlight, it is highly likely that, at the global level, significant volumes of fish catches for FMFO production are going unrecorded, and will therefore not be captured by official statistics. Significant efforts to improve traceability and transparency across the sector are required to improve accountability and ensure that by-products represent genuine waste from fish caught for human consumption that would otherwise be discarded.

In recent years, several alternatives to FMFO have emerged on the market, including omega-3 oil from algae (produced by Veramaris), which is used by Skretting[158,159] insect-based feed ingredients (utilised by companies including BioMar)[160] and plant-based alternatives to fish oil (used by Cargill[161]). One major project, backed by the European Commission, is currently examining the use of blue mussels farmed in the Baltic as a replacement for imported fish and soybean meal.[162] In addition, for the third year running, the F3 Fish-Free Feed Challenge – a collaborative effort between NGOs, researchers and private partnerships to accelerate innovation to reduce aquaculture's demand for forage fish – has challenged companies to produce seafood-free aquaculture feed. This year, the competition is focusing on accelerating alternative diets for prawns, salmonids and carnivorous fish, which are the largest consumers of FMFO.[163] Some of these alternative feed sources might present a way for companies to provide sought-after omega 3 content in aquafeed while reducing the pressures on marine ecosystems, although it is critical to ensure that they do not give rise to other social and ecological problems.

While some of the alternative approaches seem to be taking off faster than others, there is a lack of determination and urgency among aquafeed companies to fully embrace the transition towards sustainability. Feed remains aquaculture's biggest cost, accounting for some 70% of companies' business expenditure, but multi-million-euro companies that dominate the market – such as Skretting, which has been linked to some of the most irresponsible FMFO production practices in this report, – argue that they cannot afford to finance the cost of alternatives.[164] Other arguments put forward are extremely tenuous; for instance, in an effort to counter the argument that marine ingredients are finite and need to be replaced, the president of IFFO, Eduardo Goycoolea, recently said: 'It is possible to replace fishmeal and fish oil totally in the diet of the salmon, but if you take these ingredients out of the food, you end up selling a vegetable product, which stops being a fish'.[165]

The aquafeed industry's general claim remains that it produces sustainably sourced feed from renewable or sustainable marine resources. However, in the case of FMFO production from whole fish, these claims are clearly indefensible. As seen earlier in this report, our oceans are on the brink; continued production of FMFO using whole fish will push target fish stocks and key marine ecosystems beyond the point of no return, exposing the FMFO industry, aquafeed suppliers and retailers to risks that these companies must urgently address. To better understand the threats facing the sector, the following sections will examine the origins of FMFO in aquaculture and retail supply chains, and the risks for aquafeed and aquaculture companies of pursuing a 'business as usual' approach.

3.2. FMFO in aquaculture and retail supply chains: a controversial link

3.2.1. Highly complex supply chains

Global aquaculture supply chains are interwoven and highly complex. While the aquafeed sector itself is quite concentrated, and dominated by a handful of large corporations, the whole supply chain from fishery to fork can involve as many as eight different stages: fishery, FMFO plant, aquafeed producer, aquaculture farms, seafood processor, distributor, retailer and many middlemen in between.[166] For example, according to a 2018 report com-

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

Q 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.

missioned by the US-based Ocean and Seafood Markets Initiative, the majority of prawn farms in Southeast Asia, India and China are highly disaggregated, family-operated production units serviced by an informal network of traders and brokers who, in turn, supply hundreds of processors.[167] On the other hand, some companies have a highly integrated value chain, with operations across several different activities: FMFO production, aquafeed manufacturing, fish farming and seafood distribution. One such example is Mowi, which is both the world's biggest salmon producer[168] and a leading aquafeed supplier. According to the company, which is aiming to become 100% self-sufficient in feed during the course of 2019, 'Vertical integration is to result in more stable earnings and unlock future growth'.[169]

This complexity, combined with a lack of transparency and corporate accountability across the sector, makes comprehensive external scrutiny impossible, and masks the full scale of social and environmental problems in aquaculture supply chains from the consumer. Retailers often rely on thin assurances of sustainability from seafood processors and aquaculture and aquafeed producers, who, in turn, hide behind one of the many certification schemes for marine products, such as GlobalG.A.P., the Aquaculture Stewardship Council (ASC) or IFFO (see Section 3.3.4 and Box 3.2 for a discussion of the shortcomings of this approach).[170]

Based on our on-the-ground investigations in The Gambia, Vietnam and India, and in-depth supply chain research in the UK, France, Spain, Germany, the Netherlands, Norway and Denmark, we attempted to untangle this knotty supply network. While incomplete, the information we gathered reveals the globalised nature of FMFO and aquafeed trade, and makes it possible to draw links between consumption of farmed fish and seafood in the Global North and extractive and unsustainable reduction fisheries in the Global South.

Our findings show that aquafeed producers' assurances of responsible supply are dubious at best. Similarly, any sustainability claims made by retailers regarding their farmed-seafood supply chain should be closely scrutinised.

3.2.2. Global reach of aquafeed companies

The complexity of the aquafeed value network is compounded by the global reach of the industry's key players, whose operations span continents. Unable to rely on any one source of FMFO as a result of the inherent volatility of supply171 (see Section 3.3.2), aquafeed companies must source from multiple countries to ensure access to the required volumes of raw materials. In addition, all the major global aquafeed players operate regional subsidiaries and joint ventures, which not only facilitate the supply of raw materials but also ensure access to markets for aquafeed.

FMFO sourced from these hubs goes into aquafeed for farmed seafood destined for overseas retail markets. Our research and investigations revealed that Skretting, for example, sources FMFO from not only India, Vietnam and West Africa but also fisheries in Europe and South America.[172] This is in spite of its commitments to sustainability and to developing alternative ingredients.[173] Another major player is Danish aquafeed giant BioMar – to give a sense of scale, according to their own figures, one out of every five farmed fish in Europe, South and Central America is fed with BioMar feed.[174] BioMar sources FMFO from West and North Africa (The Gambia, Senegal, Mauritania and Morocco),[175] South Africa and Angola,[176] as well as from South American and European fisheries.[177]

3.2.3. Clear links to unsustainable practices

Our investigations and research have enabled us to draw direct and indirect links between unsustainable and ecologically damaging practices as a result of FMFO production and the handful of multinationals that control the majority of global aquafeed trade:

- In **India** (see Section 2.1) – where crashing fish stocks, indiscriminate use of species (including reef species), catching of juvenile fish, wastewater contamination, human health and food-security issues were discovered – FMFO is supplied to Skretting, Trio S.A. (Chile), EWOS/Cargill and CP Foods (part of multinational conglomerate Charoen Pokphand), with export markets including the US, Europe, China, Japan, Taiwan, Thailand and Vietnam.
- In **Vietnam** (see Section 2.2) – where there is widespread illegal, unregulated and unreported (IUU) fishing, threats to the marine ecosystem, FMFO plant pollution, unsustainable fishing techniques and use of mixed species – FMFO is produced for markets in Western Europe, the US, China, Japan and Australia, with direct and indirect clients including CP Foods (part of the Thai Charoen Pokphand conglomerate), EWOS/Cargill, Nutreco/Skretting, seafood-processing giant Minh Phu Seafood, Grobest and BioMar-Tongwei.
- In **The Gambia** (see Section 2.3) – where our investigators reported ecological degradation from waste water, socioeconomic and food-security issues, food-safety concerns and fish dumping – FMFO is supplied to Vietnam, China, Chile, Tunisia, Thailand and Saudi Arabia, as well as to aquafeed giant BioMar. Additionally, Skretting and Mowi source from Mauritania, where FMFO production has led to serious food-security concerns and community backlash.[178]

3.2.4. Retailers in the spotlight

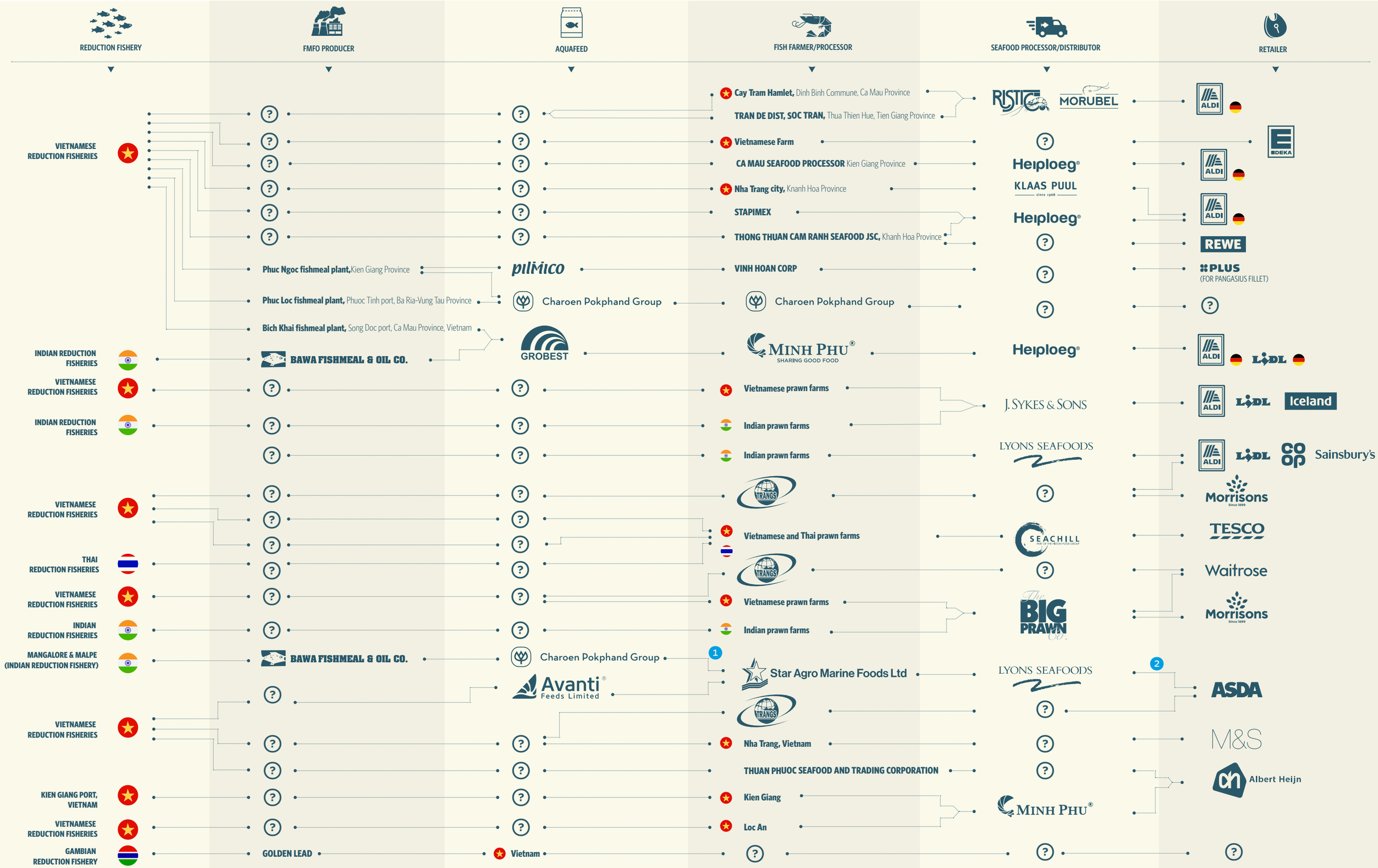
Our supply-chain research focused on salmon and prawn products supplied to retailers in Europe, and their direct and indirect links to FMFO production. Information was gathered in mid-2019 through desk research, interviews with industry experts and in-store visits. We also sent letters to retailers in the UK, France, Germany and Spain requesting information about their sourcing policies and practices in the first half of 2019. The responses we received were disappointing – almost all retailers failed to disclose details about the origin or content of aquafeed in their farmed-seafood supply chain. Commendable exceptions were French retailer Système-U (which told us its salmon products are fed using feed manufactured by Skretting and EWOS) and UK retailer Tesco (which provided details of its seafood processors and aquafeed suppliers, but asked us not to share the information publicly). With the exception of the information supplied by Système-U in its response to our letter, all of the information provided below and in Table 3.1 is from our independent research.

While all the markets we looked at were characterised by a surprising lack of traceability and transparency regarding the origin and supply chain of farmed-seafood products, we were able to establish that numerous European retailers are sourcing products from aquafeed companies and seafood processors linked to unsustainable FMFO supply chains. These retailers include:

- **UK:** Sainsbury's, ALDI, Lidl, Co-op, Tesco, Asda, Iceland, Morrison's, Waitrose, Marks & Spencer
- **France:** Auchan, Groupe Casino, Leclerc, Monoprix, Système-U
- **Germany:** ALDI Nord, ALDI SÜD, REWE, Lidl, EDEKA
- **Netherlands:** Albert Heijn, Lidl, Plus
- **Spain:** Mercadona

European retailer links to reduction fisheries - prawn

The information displayed here was obtained from a variety of publicly accessible sources, in-store visits, interviews and our country investigations. It must be noted that without total traceability and transparency, it is impossible to establish an exact chain of custody of a given quantity of raw fish through FMFO production to aquafeed and then seafood farm based on data available in the public domain. In cases where we have been able to establish that a FMFO plant is supplying a specific aquafeed company and that that aquafeed company supplies a fish farm or retailer, this is indicated for illustrative purposes to demonstrate the concerning implication of European retailers and aquafeed companies with highly unsustainable practice at the fisheries level.

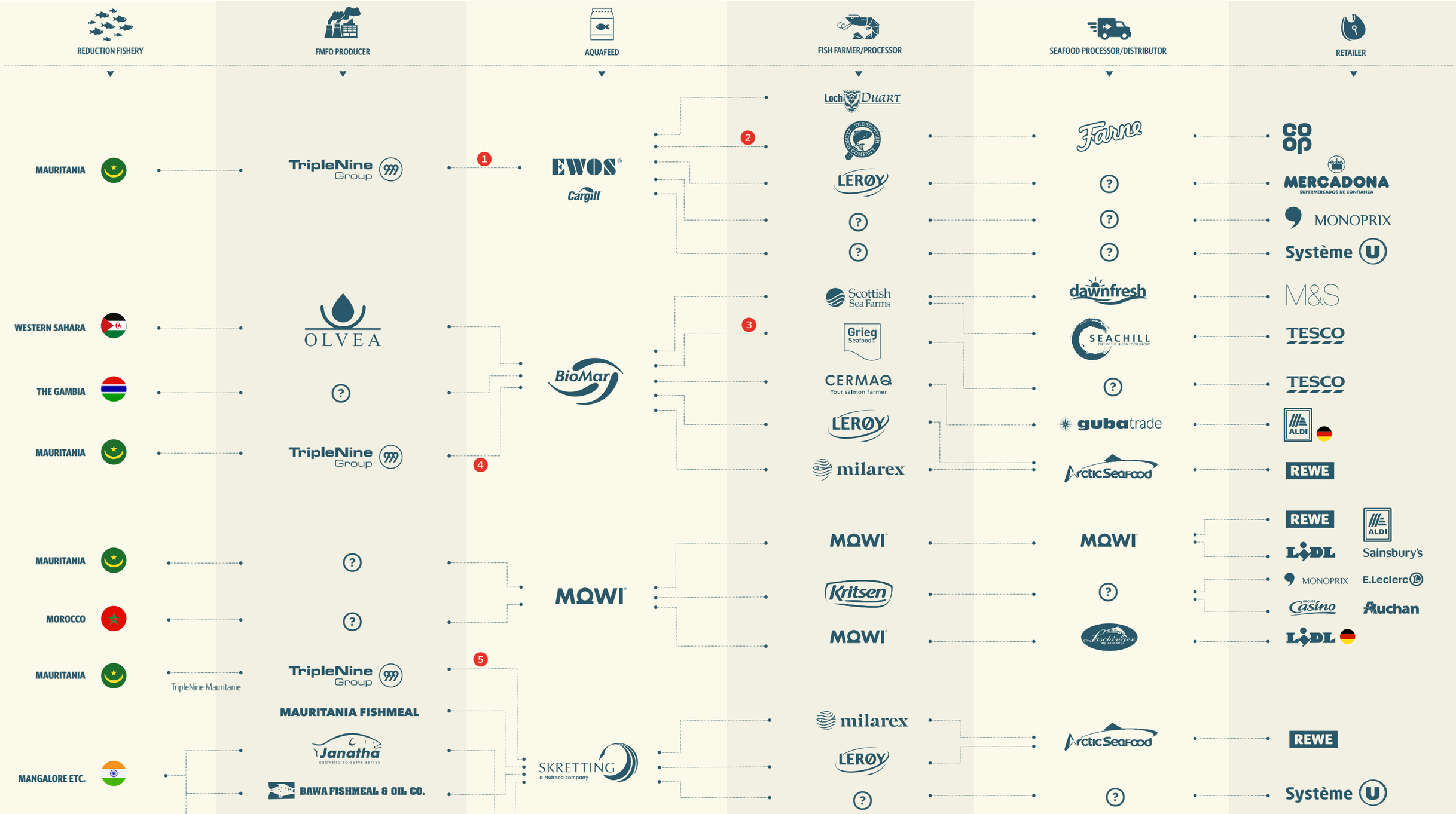


1 CP Foods > Star Agro: This comes from a 2014 corporate presentation obtained by Changing Markets but could easily have changed over the past five years

2 Star Agro > Asda: industry news articles strongly suggest ASDA use Lyons for its own-brand shrimp supply. In June 2018 it ended it's contract with Young's and signed with Lyons according to industry sources, and one report stated that it is "understood that whitefish and prawn own-label work is involved in the contract."

European retailer links to reduction fisheries - salmon

The information displayed here was obtained from a variety of publicly accessible sources, in-store visits, interviews and our country investigations. It must be noted that without total traceability and transparency, it is impossible to establish an exact chain of custody of a given quantity of raw fish through FMFO production to aquafeed and then seafood farm based on data available in the public domain. In cases where we have been able to establish that a FMFO plant is supplying a specific aquafeed company and that that aquafeed company supplies a fish farm or retailer, this is indicated for illustrative purposes to demonstrate the concerning implication of European retailers and aquafeed companies with highly unsustainable practice at the fisheries level.



CAVEATS

1, 4, 5 TripleNine to Cargill: Previous research was able to identify that EWOS, BioMar and Skretting were customers. Other connections to BioMar include the fact that the Chairman of the Board of TripleNine since 2016, Torben Svejgaard, was CEO of BioMar from 2008 to 2014. However, we have found no up-to-date evidence of this company currently operating in Mauritania. There are no online references, and no factories listed under this name.

2 Cargill to Scottish Salmon Company: The companies have directorship links (Douglas Low, Philip Smith) and Companies House records for SSC register a charge with EWOS (repaid 2018).

3 BioMar to Grieg Seafoods: There are directorship links - Asbjørn Reinkind is on the board of both companies. UK Companies House records for Greig Seafood Shetland also register a charge with BioMar in the late 1990s and early 2000s.

3.2.5. Prawn

European retailers import substantial volumes of warm-water prawns from Central America and Asia. After Ecuador, India and Vietnam are major suppliers to the EU market. In 2017, India accounted for 18% of the total volume of this species' imports into the EU, exporting 52,756 tonnes worth €420 million. Vietnam followed, accounting for 12% of the total volume of EU imports of warm-water prawns, with 34,793 tonnes worth €324 million.[R] Imports from India and Vietnam are mostly destined for the UK, Netherlands and Belgium, which not only have large domestic markets but also act as important hubs for re-exporting prawns to the rest of Europe.[179]

Our supply-chain research demonstrates the highly complex and opaque supply chains bringing warm-water prawns to Europe. Traceability is a particular concern for farmed prawn in the regions we investigated; both farms and FMFO producers are highly disaggregated, often distributed among hundreds of companies and smallholdings with little regulatory oversight.[180] Small farms typically sell to a bigger market player that aggregates supply for export to global markets (e.g. in the case of Vietnam, Minh Phu). This can make tracking the true origin of farmed-seafood products difficult, and the origin of FMFO and aquafeed used to cultivate them even more complex.

Analysis of packaging from a range of farmed seafood available in supermarkets we visited during the course of our research threw up a number of supply-chain connections, which make it possible to link farmed prawns available to European consumers with irresponsible fisheries and FMFO production in India and Vietnam (see Table 3.1).

In several cases, we found retailers sourcing prawns from seafood processors in Cà Mau Province – home to numerous fishmeal factories and one of the world's largest seafood processors, **Minh Phu Seafood Corporation** (as documented in the previous section). Our investigation found that Minh Phu sources aquafeed from Grobest, which is linked to the **Bich Khai fishmeal plant** in Song Doc port, Cà Mau. Grobest is also linked to Indian FMFO producer **Bawa** in Ullal.

According to our research, Minh Phu supplies Heiploeg International B.V., Europe's leading prawn supplier,[181] which is owned by Dutch fishing giant Parlevliet & Van der Plas (P&P). In July 2019, it was reported that P&P is investing tens of millions of euros in expanding Heiploeg, in the face of 'increasing demand for [its] shrimp products'.[182] With turnover of nearly €300 million,[183] Heiploeg products can be found at retailers across the EU, including the UK and Republic of Ireland.[184] We found that Heiploeg sources from other Vietnamese seafood suppliers, one of which is located in Kiên Giang Province, home to numerous fishmeal plants. Heiploeg supplies a variety of prawn products originating in Vietnam to ALDI Nord and ALDI SÜD in Germany.

A 2017 investigation of Vietnam–Denmark prawn supply chains found links between Minh Phu and major Danish retailers and importers. These importers were Nordic Seafood, Planets Pride, Crown Seafood, Lauge Food Selection, Seamaid, Sepio, World Seafood and Butler's Choice. Danwatch found that all of Denmark's major supermarkets – Salling Group, Co-op and Reitan Group – sell vannamei prawns sourced from Vietnam. Minh Phu was one of the suppliers.[185]

We also discovered a link between **Phuc Ngoc fishmeal plant** (in Tac Cau port, Kiên Giang) and the EU retail market through **Vinh Hoan Corp**, a seafood processor that supplies pangasius fillets to Dutch retailer Plus.

R Vietnamese prawn exporters see the EU market as presenting a strong opportunity for the sector, with the removal of tariffs on EU prawn imports from Vietnam in 2020 under the terms of the EU–Vietnam free trade agreement (see: http://seafood.vasep.com.vn/seafood/50_13231/eu-market-looks-bright-for-vietnamese-shrimp-producers.htm).

3.2.6. Salmon

Only around 16% of salmon consumed in the EU is produced by Member States,[186] with the UK (primarily Scotland) being the largest producer. 187 However, it is important to note that many of the salmon farms in operation in Scotland are in fact owned by foreign companies such as Norwegian giants Grieg Seafood and Mowi and Swiss majority owned The Scottish Salmon Company, which lean heavily on their adopted Scottish provenance for branding.

Salmon is a carnivorous fish and salmon farming is highly dependent on the use of FMFO. 60% of fish oil used in aquaculture goes into salmon and trout ('salmonid') feed.[188] A recent study by the UK-based campaign group Feedback found that the Scottish salmon farming industry currently uses roughly the same quantity of wild-caught fish to feed its salmon as the entire adult population of the UK purchases in one year. What is more, if the Scottish salmon industry wants to meet its expansion targets of doubling in size, it will need 310,000 tonnes more wild fish every year for feed alone. [189]

Norway is the primary exporter of salmon to the EU[S] and has significant future growth ambitions for the sector.[190] Intensive farming of Atlantic salmon accounts for more than 80% of total Norwegian aquaculture production and is hugely resource-intensive when it comes to feed, especially FMFO. While Norway produces large volumes of FMFO itself, it is also a major importer, predominantly from Denmark. Norway is also home to a number of large aquafeed companies which supply the salmon farming industry, including Skretting, Cargill Aqua Nutrition/EWOS and Mowi.[191]

Our retailer investigations and supply-chain analysis show links between many of the world's largest aquafeed producers and seafood processors supplying farmed salmon to major retailers in the UK, Germany, France and Spain (see Table 3.1). All of the identified aquafeed suppliers (Skretting, Mowi, BioMar and EWOS/Cargill) use significant quantities of FMFO in their feeds, sourced from countries including The Gambia, Mauritania, Morocco and Senegal. For example, the Marine Harvest (Mowi) Integrated Annual Report 2018 shows the company sourced 8,147 tonnes (22.6% of total) of fish oil from Mauritania.[192]

3.3. Main risks facing companies due to their reliance on wild-caught fish for feed

In investor circles, soaring consumer demand for seafood, coupled with the depletion of wild-fish stocks from overfishing, is often perceived as creating opportunities for the aquaculture sector, making it an attractive target for investment.

This perception is encouraged by shrewd positioning by the industry. For example, Skretting, which produced 2.5 million tonnes of aquafeed in 2017,[193] states that with 'negligible scope for capture fisheries to increase their harvests, aquaculture needs to bridge the gap between the long-term supply and demand, while doing all it can to also reduce the pressure on wild-caught fisheries', before claiming: 'Without question, [aquaculture] is best positioned to address the considerable imbalance that exists between the amount of water available to us as a planet and its contribution to the human diet: currently, oceans provide just 2% of the food that we eat despite occupying 70% of the Earth's surface'.[194] Mowi uses strikingly similar language: 'With wild-capture fisheries under increasing pressure, it is important that aquaculture bridges this gap, assuming an increasingly greater role in providing food security for the planet'.[195] Biomar also claims that '[t]he oceans are underexploited', and even sees a pioneering role for aquaculture in other food sectors: 'Aquaculture is a renewable source of food and globally,

S 795,307 tonnes in 2018, worth NOK 49,421 million (see: https://www.ssb.no/statbank/table/09283/)

aquaculture has the knowledge, production methods and technology that can be adapted by other farmers and to other forms of food production'.[196]

However, as our findings and analysis show, the aquaculture industry is exposed to numerous risks. Investment in the sector can therefore carry a significant downside.

Based on the findings presented in this report, our analysis is that the aquaculture sector's continued dependence on billions of wild fish for use in aquafeed represents a systemic risk for companies, with FMFO and aquafeed producers being particularly vulnerable. Through their increasing reliance on farmed seafood fed using FMFO, other sectors – such as seafood processing and retail – are also exposed to these risks. This section will examine some of the specific risks, posed by the sector's continued reliance on FMFO, to different actors in farmed-seafood supply chains.

3.3.1. Resource risk: with soaring growth of the aquaculture industry, FMFO demand will outstrip supply

In June 2019, the Farm Animal Investment Risk & Return (FAIRR) initiative – an investor network representing companies with $19 trillion of assets under management – examined a variety of environmental, social and governance risks that could have a significant impact on the future growth and financial performance of aquaculture companies. Noting that the industry is 'heavily dependent on wild stocks of certain fish for future growth', FAIRR warned that 'demand is set to outstrip supply', and stated that 'aquaculture is not a full solution to depleting fish stocks until this dependence is severely reduced'.[197]

Aquafeed companies acknowledge the problems raised by their dependence on FMFO, and are at pains to highlight that the proportion of FMFO used in aquafeed has declined over time. For example, Cargill states: 'in our salmon feed business, … we have decreased our use of marine raw materials [sum of FMFO] by half, from 55% in 2005 to 27% in 2015, despite a large increase in annual feed production over the same period' (emphasis added).[198] While at first sight this might look like an impressive reduction, it is important to note that a relative reduction in FMFO inclusion per unit of product does not equate to an aggregate reduction in demand for FMFO across the sector as a whole, as hinted at in the second part of Cargill's statement. Marine scientists have also highlighted that FMFO use in aquafeed has increased overall despite lower proportional inclusion rates of FMFO in aquafeed.[199]

In numerous regions of the world, the rapid expansion of the aquaculture industry is leading to growth in demand for FMFO. One industry expert estimates that there will be an additional 500,000 MT of new fishmeal demand in the coming five years: According to the 'conservative' model used to calculate this, 200,000 MT of this demand will come from the prawn sector and 300,000 MT from the growth of Chinese coastal aquaculture.[200] In addition, as noted in a 2019 report by the FAO, in Peru, FMFO demand is growing[201] whereas supply remains limited and highly variable. This has a significant impact on FMFO prices (see following section). The same report notes: 'The processing of SPF [small pelagic fish] for fishmeal, boosted by global market demand, is … showing a marked tendency to increase in the CCS [Canary Current System]' off the coast of West Africa.[202]

Despite higher demand for FMFO for aquafeed, the supply of fish has remained relatively constant, and has recently declined to a lower proportion of global landings.[203]. In fact, since the mid-1990s, the sector has witnessed a long-term decline in the global supply of fishmeal.[204] Supply will also continue to be influenced by the impacts of climate change. The declining trend of raw materials to sustain the FMFO sector was strongly evidenced by our investigation findings and media reports in India, Vietnam and The Gambia, where fishermen involved in the FMFO industry themselves acknowledge that key pelagic fish stocks are collapsing and some recognise that they are likely to be the last generation involved in fisheries. Finite wild-fish supplies combined with growing demand for FMFO carry the risk that demand will outstrip supply and – as is already being seen – lead to increased costs.

3.3.2. Increasing cost/rising price of FMFO

The FMFO market is inherently volatile, reflecting the vulnerability of its target (mainly pelagic) fisheries to sudden collapse. This volatility is exacerbated by the preponderant role played by a handful of countries in supplying the global market – foremost among them Peru, which produced on average 835,000 tonnes of fishmeal annually between 2012 and 2015,[205] but whose marine fisheries catches are subject to extreme variability as a result of El Niño. This variability has a significant impact on the global market, which is illustrated in box 3.1.

Against this backdrop, the overall picture for FMFO prices over the past several decades is one of a sustained upward trend, with the FAO and OECD predicting that the price will increase by 58% for fishmeal and 83% for fish oil (compared to 2005 levels) by 2028.[206] This phenomenon was noted in a European Commission impact assessment a decade ago: 'The growth of aquaculture creates increased demand and higher prices for fishmeal and fish oil, as this resource is limited'.[207] The higher prices in combination with stagnation of FMFO production limits the further growth and profitability of the aquaculture industry. Increased demand for FMFO is not just a function of increased production of farmed seafood; choices about the type of fish we cultivate also matter, because the farming of more high-value species (such as salmon) place upwards pressure on FMFO demand and prices.[208] Higher FMFO prices are felt keenly by fish farms, as feed represents a significant share of production costs. Countries that farm fish but do not produce fishmeal may be at a relative disadvantage compared to their competitors.[209]

Increased costs are also of concern to fish feed manufacturers.[210] They acknowledge the risk that volatility (in terms of both price and availability) presents to their business. For example, Cargill states: "Fishmeal has long been the most important ingredient in commercial feed formulations, but fluctuations in price and availability makes it important for Cargill Aqua Nutrition to adapt a flexible and more rational use of marine proteins."[211]

The FAO's analysis (from 2016) is that, '[i]n general, the fishmeal and oil sector remains vulnerable due to its limited supply sources, with not much progress being made in this regard as demand continues to increase. … in the long term, prices will not revert back to lower levels.'[212] According to Dutch banking and financial services company Rabobank, fishmeal will no longer be a commodity in the long term, as falling supply and rising demand is making it a "high-price strategic marine protein."[213]

BOX 3.1: **Supply shocks: Peru's role in fishmeal price volatility**

Peru is the world's biggest producer of FMFO, but also the global market's most volatile source of supply.[214] This variability has a significant impact on the global FMFO market.

The collapse of Peruvian anchoveta stocks in 1972 (resulting from El Niño and overfishing) likely contributed to a rise in prices due to a combination of decreased supply of catch for FMFO production and the growing demand of FMFO for aquaculture production. [215]

FMFO prices steadily decreased into the 1990s as Peruvian anchoveta recovered. However, since the late 1990s, prices for fish for FMFO have steadily increased. This is likely attributable to the combination of a decrease in global marine fisheries' catch and supply, increased demand from aquaculture expansion and increasing fuel costs.[216]

The FAO reports that, from 2017–18, there was a 90% year-on-year increase in global production of FMFO.[217] This growth was mainly driven by Peru's soaring output, which rose from 735,000 tonnes in 2017 to 1.4 million tonnes in 2018 and led to higher global fishmeal supply in 2018.[218] This had a visible impact on fishmeal prices, which, according to the FAO, 'began to normalize with a soft downward trend, fundamentally due to [the] Peruvian bumper harvest'.[219]

Although the fishery has normalised and a price correction occurred, this is a short-term trend. In the long-term, climate change models suggest a severe reduction in maximum revenue potential in Peru by 2050 as a result of climate change impacts on fisheries.[220]

On the global level, the long-term trend is reflected in International Monetary Fund (IMF) commodity price data, which shows that, between 1990 and 2018, the world price of fishmeal more than doubled – from $651 to $1,350 per tonne.[221] World Bank Data to September 2019 shows that the average price of fishmeal during the first eight months of 2019 was $1,488.36 (see Figure 3.1).[222] Fish oil prices have also followed an upward trend. Data from Oil World and the FAO's GLOBEFISH project shows that fish oil prices in The Netherlands have followed an overall upward trend, rising from just over $400 per tonne in January 1984 to over $2,000 per tonne in January 2017.[223]

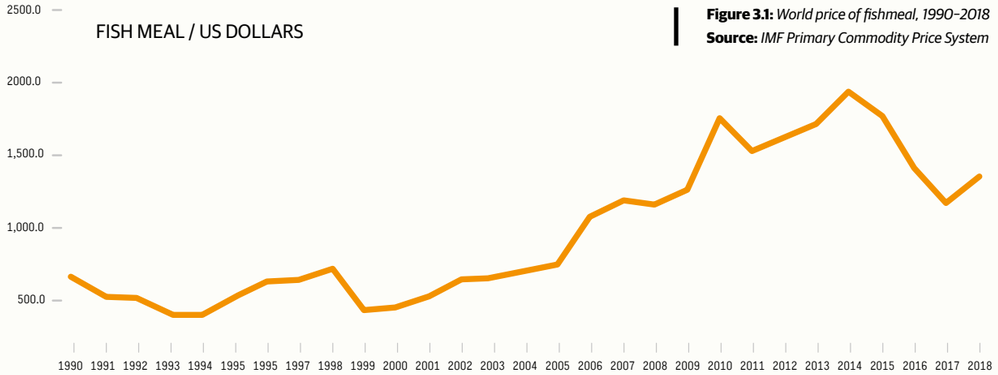


Figure 3.1: *World price of fishmeal, 1990–2018*
Source: *IMF Primary Commodity Price System*

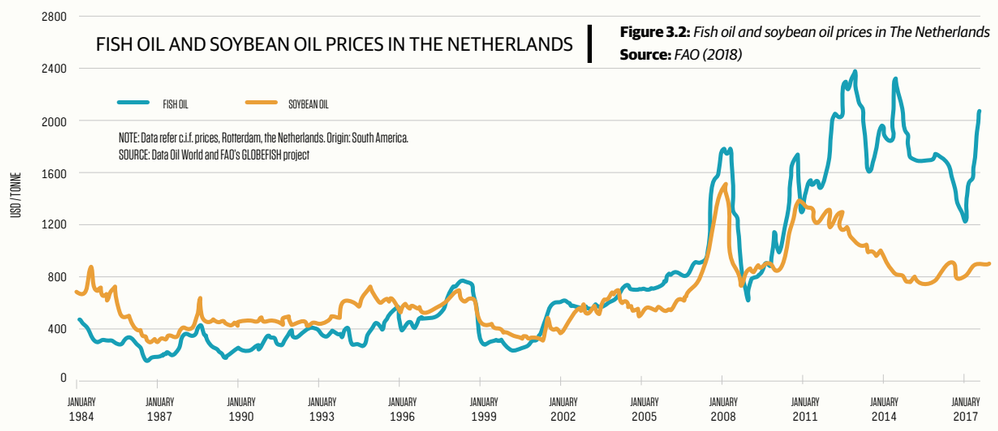


Figure 3.2: *Fish oil and soybean oil prices in The Netherlands*
Source: *FAO (2018)*

3.1.1. Reputational risk

In addition to legal risks, direct or indirect association with the exploitation of scarce marine resources for FMFO throws up a serious reputational risk – particularly for consumer-facing companies, such as retailers. Aquafeed companies could also suffer from knock-on effects if retailers take steps to limit their exposure to risky FMFO supply chains. It is worth noting that reputational considerations are not just confined to consumer attitudes; policymakers' perceptions (partly reflecting and overlapping with consumer concern) are also key, and may act as a spur to legislative action. As the European Commission notes, 'consumer protection, animal welfare and environmental considerations are crucial for the image of aquaculture and possible demarcation of its products (labels) in the minds of European citizens and consumers, and also for the way this industry is seen by the public authorities' (emphasis added).[224]

Consumers are increasingly concerned about the provenance and sustainability of their food, including fish and seafood. In recent years, this has led to the proliferation of sustainability certifications and labels; for example, supply of certified-sustainable wild catch has grown ten times faster than conventional seafood production, accounting for 20% of global wild catch in 2016.[225] When it comes to farmed species, the ASC has experienced rapid growth off the back of the expanding aquaculture industry, and a group of the world's leading farmed-salmon suppliers aims to achieve ASC certification across 100% of their farms.[226] For FMFO, the industry trade body, IFFO, which launched a certification scheme in 2009, now certifies over half of the world's production of marine ingredients.[227]

Reacting to consumer demand, major retailers have embraced certification as a way of ensuring sustainability in wild- and farmed-seafood supply chains. However, the rigour and independence of seafood certification is increasingly called into question, and recent analysis of major schemes – including the Marine Stewardship Council (MSC), ASC and IFFO – casts doubt over their effectiveness in curbing unsustainable fishing and seafood farming practices.[228] Many of the unsustainable practices witnessed during investigations in India, Vietnam and the Gambia, have received a stamp of approval by one or more of these certification schemes (see box 3.2). According to our analysis, none of these schemes offers companies a meaningful way of mitigating against the reputational risk of exposure to destructive fishing practices in their supply chains. In addition, issues such as rampant pollution around FMFO plants, related health incidents among local communities and even reported deaths among workers in the industry, are likely to provide additional cause for consumer concern and media scrutiny, further exacerbating reputational risks.

Compliance issues within the supply chain

Rising FMFO prices due to rising demand for a scarce and volatile resource encourage IUU fishing. According to one observer, 'higher commodity prices can create incentives for overfishing in poorly regulated fishing regions (such as the South China Sea) and economically marginal fisheries. In this sense, unless appropriate substitutes [to FMFO] are found, aquaculture stops being a solution to overfishing and starts contributing to it, turning it into a risk for natural marine ecosystems.'[229] This observation is borne out by the findings from our investigations, which show that IUU fishing for FMFO is rampant in Asia and Africa. IFFO also reports that the FMFO industry in Vietnam and Thailand is catching at-risk species such as turtles, stingrays and even sharks, to process into fish feed.[230]

In the case of the South China Sea – a hotly contested zone – increased IUU fishing for FMFO has potential geopolitical implications. There are disputes as to the ownership of the waters, with China, Taiwan, Brunei, Malaysia, the Philippines and Vietnam all laying claim to various islands, rocks and reefs around the sea.[231] According to our research, within this context, the Vietnamese government has been using Vietnam fishing vessels to further strategic interests.[T] These kinds of problems are not limited to Asia; in West Africa, fishing for FMFO production

T According to a European Parliament analysis: 'The government … encourages Vietnam's fishing fleet to sail out into disputed waters and provide a maritime defense function as part of a fishing militia'. See: European Parliament (2018), *Research for PECH Committee: Fisheries in Vietnam.* [ONLINE] Available at: http://www.europarl.europa.eu/RegData/etudes/STUD/2018/629175/IPOL_STU(2018)629175_EN.pdf, p.11.

has also resulted in tensions between Senegal and Mauritania, and there are reports that dozens of fishermen caught up in disputes over access to fishing grounds have been killed.[232]

The presence of IUU fishing in FMFO supply chains should be of grave concern to all corporate actors directly or indirectly exposed, given that it presents serious compliance issues. Companies should take meaningful action to address this; for example, by conducting thorough due diligence and opening up their supply chains to external scrutiny through enhanced transparency.

3.1.2. Competitive risk

Aquafeed companies reliant on FMFO will lose out to competitors that make the switch to sustainable alternatives. With the fast-growing aquaculture sector on one side, and stagnant, even declining supply of FMFO, in combination with rising prices on the other side, the industry needs to move fast to make the shift to more ecological and – at scale - more economical feed ingredients.[233] Without taking action to avoid systemic bottlenecks, such as the decline of global fish stocks, companies will eventually hit the wall.

Companies that lead the way are likely to gain in the long term if they consider their triple bottom line and understand the benefits of: a) Moving away from FMFO dependency; b) Considering resource utilisation and efficiency in the choice of species they farm by discontinuing farming of carnivorous species, such as salmon, which is putting upward pressure on FMFO demand; and c) Ensuring they are part of the solution to global food security issues and the planetary environmental catastrophe that is increasingly recognised. As underlined by the UN paper on Blue Economy, aquaculture offers huge potential for the provision of food and livelihoods, but if the industry is to be sustainable and maintain its viability and growth it must actively reduce fish protein and oil in fish feed.[234]

BOX 3.2: **IFFO certification and membership: a sustainability smokescreen?**

Faced with the precipitous growth of aquaculture production, and the projection that farmed species will account for 62% of the seafood we consume by 2030,[235] sustainability is understandably a major concern for the industry. Several certification schemes cover the aquaculture sector, including GlobalG.A.P., the MSC and the ASC, but the international standards for FMFO were established by IFFO, which offers the IFFO Responsible Supply (RS), IFFO RS Chain of Custody (CoC) and IFFO RS Improver Programme certifications.

Our investigations revealed that FMFO and aquafeed plants with proven links to highly unsustainable fishing practices are certified by, or are members of, IFFO. These include Trio S.A., which has IFFO RS CoC certification yet sources from plants identified in our Gambian and Indian investigations; Köster Marine Proteins and Olvea (both IFFO RS CoC),[236] which were embroiled in a scandal involving a blocked shipment from Western Sahara in 2018;[237] CP Vietnam, Thai Union and TripleNine, which are IFFO RS certified; and others that use IFFO membership as a proxy for certification, such as Bawa Fishmeal and Oil Co. and Janatha Fishmeal.[238] Danish FMFO producer, FF Skagen, proudly declares its IFFO RS certification but sources from Alfa Service Ltd. in Mauritania, where there are no IFFO RS certified sites.[239]

This 'certification' is used as a marketing tool at multiple stages of the supply chain, and appears to be taken at face value by aquafeed producers and retailers. However, it is clear from these examples that IFFO certification (or simply membership) is being used as a diversion, preventing downstream customers from further probing FMFO producers regarding the true impacts of using wild fish to feed farmed seafood.

According to IFFO, 45% of the world's FMFO supply is IFFO RS-compliant,[240] and its members account for over 50% of FMFO production worldwide.[241] Documents obtained by Changing Markets show the industry's ambitions to explore certification of FMFO production in West Africa and Asia,[242] both regions with high output but low certification coverage. Their studies tally with our own research in revealing widespread overfishing and failings in fisheries management. The risk is that extending IFFO certification to these regions will create the illusion that reduction fishing is consistent with responsible fisheries management, and will detract attention from the food-security implications of diverting edible fish towards industrial aquaculture. Given the depleted state of global fish stocks, it is incorrect to present taking any wild-caught fish for FMFO processing to farm high-value seafood destined largely for wealthy countries as responsible, let alone sustainable.

Who is IFFO?

IFFO was officially formed in 2001, but its origins as a trade association representing fishmeal producers go back to 1959. Since then, it has become the preeminent trade body for the FMFO sector, systematically promoting FMFO in new markets and for new uses while using its influence and lobbying power to defend the industry from years of accusations of unsustainability. Reputation management takes up a significant part of its budget and, according to IFFO, is 'likely to remain a major priority in the future'.[243] Both IFFO and IFFO RS are industry-funded, the former though membership fees and the latter through certification fees.

IFFO is overseen by a board of directors, consisting of 13 FMFO producers, and a secretariat that includes the CEO and Technical Director. The nominally separate IFFO RS certification scheme is overseen by a governing board and a technical advisory committee consisting of representatives of the FMFO industry, seafood processors, traders, aquafeed producers (many of whom are IFFO members), retailers and environmental NGO representatives, as well as IFFO's own Technical Director.

IFFO has highlighted the need for more raw materials and that demand is outstripping supply, even suggesting the exploitation of mesopelagic or deep-sea fish to satisfy growing demand.[U]

In this context – and given the presence of industry with a strong vested interest in ever-increasing FMFO supply in IFFO's governance structures – the chances for conflict of interest are high. With the organisation's dual function and structures so inextricably linked, it is impossible for IFFO RS to hold the industry to account in a way that ensures sustainable fisheries into the future.

Why does IFFO persist in presenting fish as a 'renewable' resource?

IFFO highlights its commitment to the UN Sustainable Development Goals, including Responsible Consumption and Production, Reduced Inequalities and Life Below Water.[244] It asserts that fish are a 'naturally renewable resource'[245] – a statement that is woefully out of touch with the reality of the world's fish stocks, 93% of which are fully or overexploited.[246] Once a fish stock has been depleted, it takes decades to recover, and may not ever fully do so.[247] In addition, research on the wider ecosystem impacts of overfishing forage fish shows that depletion of the fish stocks used for FMFO production can have 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.[248] To justify the systematic destruction of global pelagic fish stocks on the basis that they are technically renewable is akin to justifying rampant deforestation with the notion that the trees could theoretically be replanted.

In addition, there is a key distinction between 'responsible' and 'sustainable' in FMFO supply. Responsible management does not necessarily take into account the principles of Maximum Sustainable Yield, nor the wider ecosystem and food-security risks of removing vast amounts of pelagic and juvenile fish from marine food webs.[249] And, while many major industry players recognise the need to move to alternative feed ingredients,[250] IFFO staunchly defends the extraction of forage fish, maintaining that FMFO is primarily produced from fish 'unwanted by the market'[251] – despite multiple independent investigations, including our own, finding that local markets are often outbid for fish by FMFO producers, and that the very presence of an FMFO market means fishers have an incentive not to preserve fish for direct consumption.

The results of our investigations call into serious doubt the effectiveness of IFFO's oversight. Supply from overfished and highly unsustainable fisheries goes to FMFO plants that are members of IFFO or IFFO certified. Critically, IFFO RS certification is limited to the FMFO factory as a unit, and does not extend to the sources of raw material at fishery level.252 At best, it accepts MSC fishery certification as a proxy; but this is problematic and no guarantee of responsible supply.[253] The MSC has been the subject of heavy criticism for certifying a number of fisheries in a 'compartmentalised' approach, which means a vessel and crew can use their nets to catch tuna 'sustainably' (receiving MSC certification), and then – on the same day, using the same equipment – haul in tuna along with protected species: a practice that is unsustainable and therefore non-certified.[254] Although the MSC is reviewing its practice of compartmentalisation, at the time of publication no decisive action had been taken.[255]

U In 2016, the Director General of IFFO, Andrew Mallison, was quoted as saying: 'The industry is certainly in need of more raw material – demand exceeds supply and demand is forecasted to continue growing as global aquaculture (and feed) increases. However, these deeper water fish will be more costly to harvest, and there would have to be a good set of science based harvest control rules to satisfy any environmental or ecosystem impact concerns. If the science indicates a potential sustainable fishery with a reasonable yield, there are several IFFO member companies who could look at the economics of fishing effort and return.' Frontiers in Marine Science (2016) A dark hole in our understanding of marine ecosystems and their services: Perspectives from the mesopelagic community. [ONLINE] Available at: https://www.frontiersin.org/articles/10.3389/fmars.2016.00031/full.

BOX 3.3 **PRODUCERS WITH IFFO CERTIFICATION OR MEMBERSHIP IMPLICATED IN UNSUSTAINABLE PRACTICES:**

IFFO Member

- Bawa Fish Meal & Oil Co. (India)
- Blueline Foods (India) Pvt.Ltd.
- Janatha Fish Meal and Oil Products (India)
- Raj Fishmeal & Oil Company (India)
- United Marine Products (India)
- Yashaswi Fish Meal and Fish Oil Company (India)
- Alfa Service Limited (Mauritania)
- Grobest Holdings Limited (China)
- Guangdong Evergreen Feed Industry Co., Ltd. (China)
- BioMar (Denmark)
- Skretting (Netherlands)
- Cargill Aqua Nutrition (Norway)
- Charoen Pokphand Foods Public Company Ltd (Thailand)
- Scottish Sea Farms Ltd (UK)
- The Scottish Salmon Company (UK)
- Veiga International Trading Inc. (Spain)

IFFO Responsible Supply

- Bawa Fish Meal & Oil Co. (India)
- TripleNine (Denmark)
- Laayoune Protein (Morrocco)
- MOWI (Norway)
- Thai Union (Thailand)
- C.P. Vietnam (Vietnam)

IFFO Responsible Supply Chain of Custody

- Natural Oils Chile S.A. (Chile)
- Trio S.A. (Chile)
- Köster Marine Proteins GmbH (Germany)
- TripleNine (Denmark)
- Olvea Fish Oils (France)
- IQI B.V. (Netherlands)
- The Scoular Company (US)

4. Conclusion

This report has brought to light widespread – and often illegal – unsustainable practices linked to the production of FMFO for use in global aquaculture supplying markets in Europe and other regions of the Global North. Evidence gathered at fishing ports and fishmeal and fish oil (FMFO) production plants in India, Vietnam and The Gambia clearly demonstrates that the FMFO industry poses a serious threat to marine ecosystems and global food security and that, by continuing with extractive and unethical practices, it will be the architect of its own downfall.

Contrary to companies' claims – the aquaculture industry is not fulfilling its promise of providing a sustainable, scalable source of food that relieves pressure on the world's oceans and wild-fish stocks. This will remain the case for as long as it continues to depend on wild-caught fish. Our investigation findings from India, Vietnam and The Gambia show that fishing for FMFO to supply the global aquaculture industry is accelerating the collapse of local fish stocks in all three countries; driving illegal, unregulated and unreported fishing where fish stocks are already depleted; plundering the oceans for juvenile fish, fish eggs and other species that were previously disregarded; and wreaking environmental damage around production sites. Moreover, the industry is depriving people of food by depleting fish stocks and competing with (and often outbidding) markets destined for human consumption. In other words, the FMFO industry is an extractive industry that is stripping our oceans bare and taking protein away from where it is most needed in order to feed it to commercially more-attractive fish, which is mainly sold in high-income markets. For these reasons, the aquafeed industry must stop relying on FMFO from whole wild-caught fish.

Our investigations, which should only be considered a 'snapshot' of a hugely complex and opaque sector, show that the industry's assurances of responsible production and supply chains are unfounded. Considering the lack of transparency and regulatory oversight, it is difficult to assess the full scale of unsustainable practices at the global level but it is likely to be staggering. While many aquafeed producers say their objectives are to limit their impact on wild fisheries by reducing the proportion of FMFO they use in their products, without a switch to viable alternatives, the rapid expansion of the aquaculture sector will only continue to drive up demand for FMFO from whole wild-caught fish. One industry expert offers a 'conservative' estimate that growth in the farmed prawn sector and Chinese coastal aquaculture alone will add an extra 500,000 MT of demand for fishmeal in the coming five years[256], which is equivalent to one-tenth of current global supply, or more fishmeal than Vietnam produces in one year. If the industry does not start moving away from the use of wild-caught fish to provide omega-3 content or scale up alternative sources of omega-3 for feed, the reality is that it will continue to push target fish stocks and key marine ecosystems towards the point of no return.

While European aquafeed and aquaculture industries seek to set themselves apart from producers in Asia and Africa, our research and investigations have established that the leading European aquafeed companies source significant volumes of FMFO produced through highly destructive practices in the Global South. Furthermore, feed containing this FMFO is ending up in seafood sold by major European retailers in the UK, Germany, France, Spain and The Netherlands. Multinational companies based in Europe are therefore complicit in some of the

most extractive and environmentally destructive practices in the modern food system. They must be closely scrutinised and held to account for their actions.

Alarmingly, these practices and end products are sanctioned by certification schemes, such as The Marine Ingredients Organisation (IFFO) Responsible Supply (RS), that retailers and consumers take at face value. These create complacency within the industry and enable the negative impacts of FMFO production to go unchallenged by players further along the supply chain. IFFO is fundamentally a trade association representing the interests of the FMFO industry, and it argues that the 'majority of wild-caught fish is responsibly sourced'.[257] Its certification programme, IFFO RS – nominally a separate entity, yet governed by several industry representatives – certified several companies our investigation showed are linked to extractive and environmentally destructive practices. It is therefore failing in its stated objective to guarantee responsibly sourced marine ingredients, and cannot credibly hold the industry to account. Considering the state of the oceans and the inherently unsustainable nature of FMFO from wild fish, certification emphatically does not provide a solution to the risks associated with FMFO production and consumption.

The world's leading experts on biodiversity are unanimous in warning that we face unprecedented loss of species and marine ecosystems over the coming decades, and that this crisis demands unequivocal action at every level. It is therefore hard to justify any industrial model that puts additional pressure on declining fish stocks, particularly with the growing and unpredictable effects of climate change on ocean ecosystems. With its reliance on a finite and rapidly dwindling resource, the FMFO industry is heading towards the point at which demand outstrips supply. In light of this, the questions are: How long can the aquaculture industry sustain its current reliance on FMFO? Will the industry shift to sustainable alternatives in time to adapt, or will it collapse along with global fish stocks? Simply put, the FMFO industry as it stands is not viable in the long term – and as long as they remain reliant on FMFO from whole wild-caught fish, aquafeed and aquaculture companies, as well as retailers, will also be exposed to significant business risks. Eventually, companies reliant on FMFO will lose out to competitors that make the switch to sustainable alternatives.

For the aquaculture industry to play a net positive role in feeding a growing world population, it needs to stop taking food away from people and ensure that aquafeed and farmed seafood are produced within planetary boundaries. The evidence presented in this report shows that it is currently failing on both counts. Aquafeed producers, aquaculture companies and retailers therefore need to move away from using FMFO in their products. The use of processing waste (offcuts and trimmings) might, in some cases, be an alternative solution – as long as it genuinely represents real waste from fish caught for human consumption that would otherwise be discarded. However, considering the reality of FMFO production witnessed on the ground and proclaimed sustainable by industry players further down the supply chain, and the lack of transparency and traceability regarding the quantity and type of raw materials going into FMFO, it is questionable how the industry could provide credible guarantees on this. Transparency and accountability would need to be significantly improved throughout the entire FMFO supply chain for waste to be considered a solution.

Above all, alternative solutions, which make it possible to produce aquafeed without the use of wild-caught fish, need to be scaled up and rolled out across the industry. It is critical that these ingredients are truly sustainable and do not disrupt and destroy livelihoods and natural habitats and ecosystems, creating new problems in their wake. A transition to responsible aquaculture must consider adverse effects on ecosystems and food security in a more holistic and innovative way to avoid creating or exacerbating negative environmental and social impacts. In addition, the current model of carnivorous fish-rearing needs to diversify to greater breeding of omnivorous and herbivorous fish, or species which require no external inputs, coupled with a substantial reduction in consumption of unsustainable farmed seafood in the Global North.

Recommendations

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

Aquafeed industry

- Switch from using wild-caught fish for feed to more sustainable alternatives. While some companies are taking initial steps towards reducing their reliance on fish in a selection of their aquafeed products, the use of fishmeal and fish oil (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 alternative feed sources do not give rise to other social and 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 soybean and palm-oil production, which are currently not sufficiently addressed by any existing sustainability initiatives.[v]

Aquaculture industry (fish farms)

- The industry should prioritise cultivating species that do not require feed (e.g. shellfish), that require fewer inputs (e.g. tilapia) or that can be fed an entirely vegetarian diet (e.g. carp). For species that require feed, it should push aquafeed producers to provide genuinely sustainable alternatives to aquafeed containing FMFO. The aquaculture industry must be willing to share the additional cost that sustainable alternatives may entail.

Certification schemes

- Reduction fisheries should not be certified. Certifying reduction fisheries gives a false impression that exploiting wild-caught fish for use in fishmeal and fish oil (FMFO) can be sustainable. Wild-caught fisheries certification schemes, such as the Marine Stewardship Council, 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 FMFO from whole wild-caught fish.

V 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.

Retailers

- Provide full transparency about farmed seafood supply chains – from the identity of their suppliers and processors, to aquafeed companies, fishmeal and fish oil (FMFO) producers, and the location of reduction fisheries.
- Commit to avoiding seafood reliant on FMFO inputs from whole wild-caught fish. 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.

Policymakers

- Implement stricter regulations on due diligence and transparency in aquafeed supply chains. Governments and policymakers should strengthen governance frameworks to eliminate illegal, unregulated and unreported fishing and slave labour, prevent overfishing, and enhance transparency and reporting in global fisheries supply chains.
- Develop guidelines for sustainable feed ingredients. Policy should support the development of alternative feed industries and provide incentives for a transition to more sustainable ingredients. Policymakers should encourage a range of alternatives to whole wild-caught fish that do not result in the destruction of natural habitats and ecosystems, as well as other innovative and truly responsible approaches.
- Governments should support the phase-out of whole wild-caught fish for use in aquafeed. Furthermore, aquaculture that relies on wild-caught fish should not receive any subsidies or other public support measures.

Consumers

- Diversify consumption of seafood to include fewer species reliant on feed containing FMFO – especially carnivorous farmed species, such as salmon and prawns. 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 species not cultivated using FMFO and reducing consumption of unsustainable farmed seafood products.
- Show companies that they care by contacting retailers and seafood farmers and spreading the word.

Glossary of terms and abbreviations

Aquaculture: The farming of aquatic species, including molluscs, crustaceans and fish, both on land and in the sea (also known as **mariculture**)

Aquafeed: A range of products used to feed aquatic organisms. It can be made from animal-derived sources, such as FMFO and insects; from plant-based sources, such as soy; and from new alternatives, such as microalgal oils.

ASC: Aquaculture Stewardship Council

By-catch: Fish or other aquatic species that are caught unintentionally in addition to the target catch. By-catch can be discarded at sea or landed and used.

CCS: Canary Current System

CoC: Chain of Custody

CRZ: Coastal Regulation Zone

FAIRR: Farm Animal Investment Risk & Return

FAO: United Nations Food and Agriculture Organisation

Fertiliser fish: 'Trash fish' that is used for fertiliser in agriculture

Fish oil: An oil derived from mincing, cooking and pressing fish tissue, containing omega-3 fatty acids. It is used in the manufacture of aquafeed for aquaculture.

Fishmeal: A commercial product made from fish that has been minced, cooked and ground into a powder. Its high-calorie and -protein content makes it desirable in the manufacturing of aquafeed and animal feed in agriculture.

FMFO: Fishmeal and fish oil

Food security: A measure of the availability of enough safe, healthy, nutritious food to an individual or population

Food web: The complex natural network of feeding relationships within an ecosystem

Forage fish: Small, schooling, pelagic (open water) fish preyed upon by larger predators, such as carnivorous fish, seabirds or marine mammals. They play an important function in marine ecosystems by converting energy from lower trophic levels, such as plankton, into food for species higher in the food chain.

IMF: International Monetary Fund

IPBES: Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services

IUU: Illegal, Unreported and Unregulated fishing, including fishing in the waters of another country without permission, illegal fishing methods that jeopardise fish stocks (such as small mesh nets, LED fishing or blast fishing) and the underreporting of catch.

Juvenile fish: Fish that have not yet reached full size or sexual maturity. They are often caught as by-catch, or with illegal small mesh nets, posing a risk to the ability of fish stocks to produce future generations of fish.

Maximum Sustainable Yield: The maximum level at which a natural resource, such as fish stocks, can be exploited without long-term depletion

MSC: Marine Stewardship Council

MT: Metric tonnes

NEA: National Environment Agency

Otter trawl: Trawl towed on the seabed, held open by a pair of otter boards (trawl doors). There are a wide variety of otter trawl varieties depending upon the nature of the ground to be fished and the target species.

Overfishing: The removal of fish species at a rate at which they cannot be replenished, with the result that they become seriously depleted

P&P: Parlevliet & Van der Plas

Pair trawling: A variation of trawling whereby two vessels tow a very large net stretched between them, often at high speed, to pull the net mesh tighter and thus catch more fish

Pelagic fish: Fish living predominantly in the pelagic, or open water, zone of the ocean. They include small forage-fish species, such as herring and sardine, as well as larger species, such as mackerel and some species of tuna.

Reduction fisheries: Fisheries that 'reduce' their catch by processing it into FMFO, rather than for direct human consumption

SPF: Small pelagic fish

Sustainability: The ability of an activity or process to be sustained indefinitely and within planetary boundaries, avoiding the depletion of natural resources and maintaining ecological balance

Transshipment: The transferring of catches between two vessels at sea. Although it can be legal when done under strict observation, it is often used as a way to 'launder' fish, by mixing legally and illegally caught fish, and to avoid port inspections. When illegal transshipment occurs, it makes traceability almost impossible.

Trash fish: A misleading term referring to fish used for the production of FMFO that covers a wide variety of small pelagic fish, edible fish, juveniles of many species, fish eggs and the smaller ocean organisms that would, if left in the oceans, provide protein for other parts of the food chain. Renowned marine biologist Daniel Pauly notes that the emergence of trash fish resulted from a combination of growth overfishing (which removed most of the older representatives of large species, leaving only the juveniles) and of ecosystem overfishing characteristic of trawling in Southeast Asia.[258]

Trawling: An industrial fishing method in which a vessel tows a large bag-shaped net to catch fish, either in open water or through bottom trawling

UMP: United Marine Products

References

1 Naylor, R. L., Goldburg, R. J., Primavera, J. H., Kautsky, N., Beveridge, M. C. M., Clay, J., Folke, C., Lubchenco, J., Mooney, H. and Troell, M. (2000) Effect of aquaculture on world fish supplies. Nature, 405(6790): 1017–1024. [ONLINE] Available at: *https://www.ncbi.nlm.nih.gov/pubmed/10890435.*

2 Cashion, T., Le Manach, F., Zeller, D. and Pauly, D. (2017) Most fish destined for fishmeal production are food-grade fish. Fish and Fisheries, 18(5): 1–8. [ONLINE] Available at: https://www.bloomassociation.org/wp-content/uploads/2017/02/Cashion_et_al-2017-Fish_and_Fisheries-1.pdf.

3 Bachis, E. (2017) Fishmeal and fish oil: A summary of global trends. Washington: 57th IFFO Annual Conference. [ONLINE] Available at: http://www.iffoevents.com/files/iffo/2.IFFO%20Washington%202017_1.pdf.

4 Cashion, T., Le Manach, F., Zeller, D. and Pauly, D. (2017) Most fish destined for fishmeal production are food-grade fish.

5 Bachis, E. (2017) Fishmeal and fish oil: A summary of global trends. Washington: 57th IFFO Annual Conference. [ONLINE] Available at: *http://www.iffoevents.com/files/iffo/2.IFFO%20Washington%202017_1.pdf.*

6 Naylor, R. L., Hardy, R. W., Bureau, D. P. et al. (2009) Feeding aquaculture in an era of finite 617 resources. Proceedings of the National Academy of Sciences of the United States of America, 106: 15103–15110. [ONLINE] Available at: *http://doi.org/10.1073/pnas.0910577106.*

7 IFFO (2009) The production of fishmeal and fish oil from Peruvian anchovy. Datasheet. [ONLINE] Available at: *http://www.iffo.net/system/files/67_0.pdf.*

8 Holmyard, N. (2019) Driving change in South East Asian trawl fisheries, fishmeal supply, and aquafeed: Summary report for IFFO, The Marine Ingredients Organisation and the Global Aquaculture Alliance (GAA). [ONLINE] Available at: https://www.iffo.net/system/files/SEA%20Report_Short%20version.pdf.

9 DW (2018) Foreign appetite for fish meal threatens West Africans' livelihood. DW, 5 July. [ONLINE] Available at: *https://www.dw.com/en/foreign-appetite-for-fish-meal-threatens-west-africans-livelihood/a-44506336.*

10 World Bank (2019) Country data: The Gambia. [ONLINE] Available at: *https://data.worldbank.org/country/gambia.*

11 Ocean Disclosure Project (n.d.) BioMar Norway. [ONLINE] Available at: *https://oceandisclosureproject.org/companies/biomar.*

12 Feedback (2019) Fishy business: The Scottish salmon industry's hidden appetite for wild fish and land. [ONLINE] Available at: *https://feedbackglobal.org/wp-content/uploads/2019/06/Fishy-business-the-Scottish-salmon-industrys-hidden-appetite-for-wild-fish-and-land.pdf.*

13 Bachis, E. (2017) Fishmeal and fish oil: A summary of global trends. Washington: 57th IFFO Annual Conference..

14 Smith, A. D. M., Brown, C. J., Bulman, C. M., Fulton, E. A., Johnson, P., Kaplan, I. C., Lozano-Montes, H., Mackinson, S., Marloff, M., Shannon, L. J., Shin, Y.-J. and Tam, J. (2011) Impacts of fishing low-trophic level species on marine ecosystems. Science, 333(6046): 1147–1150. [ONLINE] Available at: *https://doi.org/10.1126/science.1209395.*

15 Cashion, T., Le Manach, F., Zeller, D. and Pauly, D. (2017) Most fish destined for fishmeal production are food-grade fish. Fish and Fisheries, 18(5). [ONLINE] Available at: *https://doi.org/10.1111/faf.12209.*

16 FAO (2018) The state of world fisheries and aquaculture, 2018: Meeting the sustainable development goals. Licence: CC BY-NC-SA 3.0 IGO. Rome: FAO.

17 Holmyard, N. (2019) Driving change in South East Asian trawl fisheries, fishmeal supply, and aquafeed: Summary report for IFFO, The Marine Ingredients Organisation and the Global Aquaculture Alliance (GAA). [ONLINE] Available at: *http://www.iffo.net/system/files/SEA%20Report_Short%20version.pdf.*

18 Feedback (2019) Fishy business; Greenpeace (2019) A waste of fish: Food security under threat from the fishmeal and fish oil industry in West Africa, June 2019. [ONLINE] Available at: https://storage.googleapis.com/planet4-international-stateless/2019/06/56fbee4b-a-waste-of-fish-report-en-high-res.pdf; FAIRR (2018) Shallow returns? ESG risks and opportunities in aquaculture. [ONLINE] Available at: *https://www.fairr.org/article/shallow-returns-esg-issues-in-aquaculture/.*

19 Pauly, D. (2019) How the global fish market contributes to human micronutrient deficiencies. Nature, 25 September. [ONLINE] Available at: *https://www.nature.com/articles/d41586-019-02810-2*; Tencent, Q. Q. (2019) [In China salmon ushers in a new style of consumption: 80% of Hema users buy to eat at home]. [ONLINE] Available at: *https://new.qq.com/omn/20190710/20190710A0N0CX00.html.*

20 Froehlich, H. E., Jacobsen, N. S., Essington, T. E., Clavelle, T. and Halpern, B. S. (2018) Avoiding the ecological limits of forage fish for fed aquaculture. Nature Sustainability, 1: 298–303. [ONLINE] *Available at: https://www.nature.com/articles/s41893-018-0077-1.*

21 IPCC (2019) The ocean and cryosphere in a changing climate: Summary for policymakers. [ONLINE] Available at: *https://report.ipcc.ch/srocc/pdf/SROCC_FinalDraft_FullReport.pdf.*

22 IPBES (2019) Nature's dangerous decline 'unprecedented'; species extinction rates 'accelerating'. News Release. [ONLINE] Available at: *https://www.ipbes.net/news/Media-Release-Global-Assessment.*

23 IPBES (2019) Nature's dangerous decline 'unprecedented'; species extinction rates 'accelerating'.

24 FAO Commission on Genetic Resources for Food and Agriculture (2019) The state of the world's aquatic genetic resources for food and agriculture assessments. [ONLINE] Available at: https://reliefweb.int/sites/reliefweb.int/files/resources/CA5256EN.pdf.

25 Plumer, B. (2019) The World's Oceans Are in Danger, Major Climate Change Report Warns, New York Times,

25 September [ONLINE] Available at: *https://www.nytimes.com/2019/09/25/climate/climate-change-oceans-united-nations.html?action=click&module=Top%20Stories&pgtype=Homepage*

26 UNESCO (2015) Facts and figures on marine biodiversity. [ONLINE] Available at: *http://www.unesco.org/new/en/natural-sciences/ioc-oceans/focus-areas/rio-20-ocean/blueprint-for-the-future-we-want/marine-biodiversity/facts-and-figures-on-marine-biodiversity/.*

27 Chandrashekhar, V. (2019) Rattled by sardine stock crash, India begins regulating its fisheries. Mongabay Environmental News, 11 July. [ONLINE] Available at: *https://news.mongabay.com/2019/07/rattled-by-sardine-stock-crash-india-begins-regulating-its-fisheries/.*

28 Hivert, A.F. (2019). Le cabillaud au bord de l'effondrement en mer Baltique. Le Monde, 26 July. [ONLINE] Available at: *https://www.lemonde.fr/planete/article/2019/07/26/le-cabillaud-au-bord-de-l-effondrement-en-mer-baltique_5493603_3244.html;* ICES (2019) Sprat (Sprattus sprattus) in subdivisions 22–32 (Baltic Sea). [ONLINE] Available at: *http://www.ices.dk/sites/pub/Publication%20Reports/Advice/2019/2019/spr.27.22-32.pdf.*

29 IFFO (2019) IFFO responds to the Changing Markets report, 18 April. [ONLINE] Available at: *https://www.iffo.net/press-release/iffo-responds-changing-markets-report.*

30 Evans, J. (2019) Skretting CEO on feed alternatives: 'We cannot afford to finance the cost'. IntraFish. [ONLINE] Available at: *https://www.intrafish.com/aquaculture/1798014/skretting-ceo-on-feed-alternatives-we-cannot-afford-to-finance-the-cost.*

31 Smith et al. (2011) Impacts of fishing low-trophic level species on marine ecosystems; Deutsch, L.M., Gräslund, S., Folke, C., Troell, M., Huitric, M., Kautsky, N. and Lebel, L. (2007) Feeding aquaculture growth through globalization: Exploitation of marine ecosystems for fishmeal. Global Environmental Change, 17: 238–249.

32 Froehlich et al. (2018) Avoiding the ecological limits of forage fish for fed aquaculture.

33 Statista (2018) Major aquaculture producers worldwide 2018. [ONLINE] Available at: *https://www.statista.com/statistics/755857/major-aquaculture-producers-worldwide/.*

34 Ray, P. (2019) Aquafeed market study for 2019 to 2024 providing information on key players. Reports Go [ONLINE] Available at: *http://reportsgo.com/aquafeed-market-trends.*

35 National Fisheries Development Board (2016) About Indian fisheries. [ONLINE] Available at: *http://nfdb.gov.in/about-indian-fisheries.htm.*

36 Msangi, M. and Batka, M. (2019) 'Chapter 8: The rise of aquaculture.' The role of fish in global food security [ONLINE] Available at: *https://www.ifpri.org/sites/default/files/gfpr/2015/feature_3087.html.*

37 FAO (2018) Globefish highlights: A quarterly update on world seafood markets. October. [ONLINE] Available at: *http://www.fao.org/3/ca2830en/CA2830EN.pdf.*

38 Mordor Intelligence (n.d.) India aquaculture feed market: Segmented by type – Growth, trends, and forecast (2018–2023). [ONLINE] Available at: *https://www.mordorintelligence.com/industry-reports/india-aquaculture-feed-market.*

39 Central Marine Fisheries Research Institute (2019) CMFRI special publication no.130: Engimatic oil sardine eprints. [ONLINE] Available at: *https://www.researchgate.net/publication/330134865_CMFRI_Special_Publication_No130_Enigmatic_Oil_Sardine_Eprints.*

40 Skretting (2018) Nutreco enters joint venture with West Coast Group to build production. Skretting, 6 June. [ONLINE] Available at: *https://www.skretting.com/en/news/news/nutreco-enters-joint-venture-with-west-coast-group-to-build-production/1577739.*

41 India Export News (2018) China to import fish meal and fish oil from India. 18 December. [ONLINE] Available at: *http://indiaexportnews.com/detail_news.php?newsid=2635&cat_id=7&pageid=2.*

42 Chandrashekhar (2019) Rattled by sardine stock crash, India begins regulating its fisheries.

43 Mordor Intelligence (n.d.) India aquaculture feed market.

44 Cargill (2018) Cargill opens first dedicated fish feed plant in India, tripling fish feed capacity for farmers. 24 January. [ONLINE] Available at: *https://www.cargill.com/2018/cargill-opens-first-dedicated-fish-feed-plant-in-india.*

45 FAO (n.d.) Biological aspects. [ONLINE] Available at: *http://www.fao.org/3/V3630E/V3630E02.htm.*

46 Chatterjee, B. (2019) Shark, 15 other fish species along Maharashtra coast under threat: Study. Hindustan Times, 12 June. [ONLINE] Available at: *https://www.hindustantimes.com/mumbai-news/shark-15-other-fish-species-along-maharashtra-coast-under-threat-study/story-txTfPVvgAtut0uesJjJcGJ.html.*

47 Mathrubhumi (2019) Sharp decline in availability of sardine, Kerala fisherfolk in crisis. 22 June. [ONLINE] Available at: *https://english.mathrubhumi.com/news/kerala/sharp-decline-in-availability-of-sardine-kerala-fisherfolk-in-crisis--1.3894121;* Chandrashekhar (2019) Rattled by sardine stock crash, India begins regulating its fisheries.

48 CMRFI (2017) Karnataka 2017. [ONLINE] Available at: *http://www.cmfri.org.in/karnataka2017.*

49 CMRFI (2016) Karnataka 2016. [ONLINE] Available at: *http://www.cmfri.org.in/karnataka2016.*

50 CMRFI (2015) Karnataka 2015. [ONLINE] Available at: *http://www.cmfri.org.in/kn2015.*

51 CMRFI (2014) Karnataka 2014. [ONLINE] Available at: *http://www.cmfri.org.in/kn2014.*

52 CMRFI (2014) Marine fish landings in India 2013–14. [ONLINE] Available at: *http://www.cmfri.org.in/uploads/divfiles/Landings-FY-2013-14_final.pdf.*

53 CMRFI (2013) Karnataka 2013. [ONLINE] Available at: *http://www.cmfri.org.in/KN.*

54 The Hindu (2017) India acts against bottom trawling. 14 October. [ONLINE] Available at: *https://www.thehindu.com/news/national/india-acts-against-bottom-trawling/article19863478.ece.*

55 Blueline (n.d.) About the studio. [ONLINE] Available at: *https://bluelinefoods.in/about-the-studio/.*

56 United Marine Products (n.d.) Infrastructure. [ONLINE] Available at: *http://unitedmarineproducts.com/infrastructure.html.*

57 Daiji World (2016) Green Tribunal imposes hefty fine on fishmeal companies in Ullal. 14 July. [ONLINE] Available at: *https://www.daijiworld.com/news/newsDisplay.aspx?newsID=404068.*

58 FAO (n.d.) The process. [ONLINE] Available at: *http://www.fao.org/3/x6899e/X6899E04.htm.*

59 FAO (n.d.) Pollution abatement. [ONLINE] Available at: *http://www.fao.org/3/x6899e/X6899E05.htm.*

60 Goa Industrial Development Corporation (n.d.) Cuncolim information. [ONLINE] Available at: h*ttp://goaidc.goa.gov.in/?page_id=1064.*

61 Goa Herald (2013) GSPCB tells Cuncolim plants to fall in line [ONLINE] Available at: h*ttps://www.heraldgoa.in/Goa/The-Sunday-Roundtable/gspcb-tells-cuncolim-plants-to-fall-in-line/69248.html.*

62 Times of India (2012) Board issues notice to marine plant in Cuncolim. 14 November. [ONLINE] Available at: *https://timesofindia.indiatimes.com/city/goa/Board-issues-notice-to-marine-plant-in-Cuncolim/articleshow/17221335.cms.*

63 India Environment Portal (2012) Inspection confirms dumping of hazardous waste at Cuncolim. [ONLINE] Available at: *http://www.indiaenvironmentportal.org.in/content/367879/inspection-con-firms-dumping-of-hazardous-waste-at-cuncolim/?page=; ItsGoa (2016) Common effluent treatment plant to solve Cuncolim issues? 31 August.* [ONLINE] Available at: *https://www.itsgoa.com/common-effluent-treatment-plant-to-solve-cuncolim-issues*; India Environment Portal (2019) Cuncolkars adamant on shutting down polluting fish meal plants. [ONLINE] Available at: *http://www.indiaenvironmentportal.org.in/content/455099/cuncolkars-adamant-on-shutting-down-polluting-fish-meal-plants/.*

64 Coastal Aquaculture Act (2005) Sections 8 (a) and (b), p.29. [ONLINE] Available at: *http://www.caa.gov.in/uploaded/doc/Act-English.pdf.*

65 The Hindu (2011) Malpe fishmeal company accused of polluting rivulet. October 25. [ONLINE] Available at:*https://www.thehindu.com/news/cities/Mangalore/malpe-fishmeal-company-accused-of-polluting-rivulet/article2570511.ece.*

66 Bawa Fishmeal and Oil Co (n.d.) Profile. [ONLINE] Available at: *http://www.bawafishmealandoilco.com/profile.html.*

67 Yashaswi Fish Meal and Oil Co (n.d.) Homepage. [ONLINE] Available at: *http://www.fishmealoil.com/.*

68 Janatha Fishmeal (n.d.) Homepage. [ONLINE] Available at: *http://janathafishmeal.com/.*

69 Panjiva (2019). Supply chain intelligence about: United Marine Products. [ONLINE] Available at: *https://panjiva.com/shipment_search/company?permanent_id=28726817&type=us_imports.*

70 Panjiva (2019) Supply chain intelligence about: United Marine Products.

71 IFFO (2019) List of All IFFO Members (Public) [ONLINE] Available at: *https://www.iffo.net/members-list.*

72 EU Sanco (n.d.) Country section: India processing plants. [ONLINE] Available at: *https://webgate.ec.europa.eu/sanco/traces/output/IN/ABP-FSB_IN_en.pdf.*

73 Raj Fishmeal (n.d.) About Us. [ONLINE] Available at: *http://www.rajfishmeal.com/about-us/*

74 Panjiva (n.d.). [ONLINE] Available at: *https://panjiva.com/Raj-Fishmeal-And-Oil-Co/43462005*

75 Pet Food Industry (n.d.) Directory of Suppliers. [ONLINE] Available at:*https://www.petfoodindustry.com/directories/347-directory-of-suppliers/listing/11529-trio-sa*

76 IFFO (2018) Natural Oils Chile S.A Certificate 2018-2021 [ONLINE] Available at:*https://www.iffors.com/sites/iffors/files/2018-*04/COCIFFO119%20Natural%20Oils%20Chile%20S.A%20Certificate%202018-2021.pdf

77 Panjiva (n.d.). [ONLINE] Available at: *https://panjiva.com/Bawa-Fishmeal-And-Oil-Co/36575017*

78 FAO (2018) Globefish highlights.

79 EUMOFA (2018) The EU fish market. [ONLINE] Available at: *https://www.eumofa.eu/documents/20178/132648/EN_The+EU+fish+market+2018.pdf*

80 European Parliament (2018) Research for PECH Committee: Fisheries in Vietnam, p.8. [ONLINE] Available at: *http://www.europarl.europa.eu/RegData/etudes/STUD/2018/629175/IPOL_STU(2018)629175_EN.pdf.*

81 Fisheries Information Centre (Vietnam Directorate of Fisheries) (2018) Hội nghị sơ kết 6 tháng đầu năm ngành Thuỷ Sản [ONLINE] Available at: *https://www.mard.gov.vn/Pages/hoi-nghi-so-ket-6-thang-dau-nam-nganh-thuy-san.aspx*

82 Stop Illegal Fishing (2018) EU set to lift 'yellow card' on Vietnam fisheries next year. 27 June. [ONLINE] Available at: *https://stopillegalfishing.com/press-links/eu-set-to-lift-yellow-card-on-vietnam-fisheries-next-year/.*

83 FAO (2005) FAO fishery country profile: The Socialist Republic of Vietnam. [ONLINE] Available at: *http://www.fao.org/fi/oldsite/FCP/en/vnm/profile.htm*

84 De Mitcheson, Y. S., Leadbitter, D. and Law, C. (2018) History, profiles and implications of feed fish and fishmeal supply from domestic trawlers in the East and South China Seas. [ONLINE] Available at: *https://portals.iucn.org/library/sites/library/files/resrecrepattach/FINAL%20BIOMASS%20REPORT%20June%2011th%202018%20pp.131%20upload.pdf.*

85 FAO (2005) FAO fishery country profile: The Socialist Republic of Vietnam.

86 Seafish (2019) Fishmeal and fish oil facts and figures 2018. [ONLINE] Available at: *https://www.seafish.org/media/publications/Seafish_FishmealandFishOil_FactsandFigures2018.pdf.*

87 Holmyard (2019) Driving change in South East Asian trawl fisheries, fishmeal supply, and aquafeed.

88 European Commission (2017) Commission warns Vietnam over insufficient action to fight illegal fishing. Press Release. [ONLINE] Available at: *http://europa.eu/rapid/press-release_IP-17-4064_en.pdf.*

89 Vietnam Directorate of Fisheries (2019) New points in the 2017 Fisheries Law takes effect from January 1, 2019. 28 January. [ONLINE] Available at: *https://tongcucthuysan.gov.vn/en-us/vietnam-fisheries/doc-tin/012252/2019-02-15/new-points-in-the-2017-fisheries-law-takes-effect-from-january-1-2019.*

90 Viet Nam News (2019) Drastic measures needed to lift yellow card. 24 April. [ONLINE] Available at: *https://vietnamnews.vn/society/519066/drastic-measures-needed-to-lift-yellow-card.html#EwO7dJM7DwhCz1le.97.*

91 [ONLINE] Available at: *https://www.kiengiang.gov.vn/trang/TinTuc/61/1407/Tinh-hinh-kinh-te---xa-hoi-thang-11-va-11-thang-nam-2016.html*

92 Vietnam Plus (2019) Ca Mau builds brands for agro-forestry-fishery staples. 22 February. [ONLINE] Available at: *https://en.vietnamplus.vn/ca-mau-builds-brands-for-agroforestryfishery-staples/146985.vnp.*

93 Vietnam Net (2018) Minh Phu now one of world's largest seafood companies. 25 September. [ONLINE] Available at: *https://english.vietnamnet.vn/fms/business/209062/minh-phu-now-one-of-world-s-largest-seafood-companies--to-list-on-hsx.html.*

94 VASEP (2018) Bà Ria: Vũng Tàu đối mặt với nhiều khó khăn trong khai thác. [ONLINE] Available at: *http://m.vasep.com.vn/Tin-Tuc/1214_53864/Ba-Ria-Vung-Tau-doi-mat-voi-nhieu-kho-khan-trong-khai-thac-hai-san.htm.*

95 VASEP (2016) Vũng Tàu: Sản lượng thuỷ sản nuôi đạt gần 17000 tấn. [ONLINE] Available at: *http://vasep.com.vn/Tin-Tuc/1112_43131/Ba-Ria-Vung-Tau-San-luong-thuy-san-nuoi-dat-gan-17000-tan.htm*

96 VASEP (2016) Vũng Tàu: Sản lượng thuỷ sản nuôi đạt gần 17000 tấn.

97 VTV News (2015) Bà rịa – Vũng Tàu sẽ xoá sổ nghề chế biến bột cá. [ONLINE] Available at: *https://vtv.vn/trong-nuoc/ba-ria-vung-tau-se-xoa-so-nghe-che-bien-bot-ca-20151215153356937.htm*

98 VTV News (2015) Bà rịa – Vũng Tàu sẽ xoá sổ nghề chế biến bột cá.

99 Rahadiana, R. (2019) Indonesia sinks 13 Vietnamese boats in war on illegal fishing. Bloomberg, 5 May. [ONLINE], Available at: *https://www.bloomberg.com/news/articles/2019-05-05/indonesia-sinks-13-vietnamese-boats-in-war-on-illegal-fishing.*

100 List of fishing occupations and gears banned from use in commercial fishing (provided in APPENDIX II of Circular 19/2018/TT-BNNPTNT, 15 November 2018).

101 Vietnam News (2014) Kien Giang tackles pollution at major fishing port. 10 February. [ONLINE] Available at:*https://vietnamnews.vn/environment/250901/kien-giang-tackles-pollution-at-major-fishing-port.html*

102 Bao Moi (2017) Cà Mau: Phạt nhiều nhà máy chế biến bột cá, thủy sản vi phạm về môi trường [Cà Mau: Imposing a lot of factories for processing fishmeal and aquatic products that violate the environment]. 19 July. [ONLINE] Available *at: https://baomoi.com/ca-mau-phat-nhieu-nha-may-che-bien-bot-ca-thuy-san-vi-pham-ve-moi-truong/c/22791373.epi.*

103 Nguyen, T. (2015) Study on trawl fishery socio-economics and supply chains in Kien Giang, Vietnam. Cà Mau [ONLINE] Available at: *http://www.rebyc-cti.org/countries-profiles/doc_download/309-study-on-trawl-fishery-socio-economics-and-supply-chains-in-kien-giang-viet-nam.*

104 Ramsden, N. (2019) Mitsui agrees to $150m deal for 35% stake in Vietnam's Minh Phu. Undercurrent News, 16 May. [ONLINE] Available at: *https://www.undercurrentnews.com/2019/05/16/mitsui-agrees-deal-for-35-stake-in-vietnams-minh-phu/.*

105 ASC (2019) Find a supplier. [ONLINE] Available at: *https://www.asc-aqua.org/what-you-can-do/take-action/find-a-supplier/.*

106 Minh Phu (n.d.) Responsible and end-to-end value chain of shrimp. [ONLINE] Available at: *http://minhphu.com/en/operation/.*

107 Gbadamosi, N. (2018) Gambia's tolerance for Chinese fish factories tested as Beijing courts poor African nation with deals. The Pulitzer Center, 16 September. [ONLINE] Available at: *https://pulitzercenter.org/reporting/gambias-tolerance-chinese-fish-factories-tested-beijing-courts-poor-african-nation-deals.*

108 FAO (2018) The state of world fisheries and aquaculture.

109 UNCTAD (2014) The fisheries sector in The Gambia: Trade, value addition and social inclusiveness, with a focus on women. [ONLINE] Available at: *https://unctad.org/en/PublicationsLibrary/ditc2013d4_en.pdf.*

110 FAO (2007) Republic of Gambia fishery profile. [ONLINE] Available at: *http://www.fao.org/fishery/docs/DOCUMENT/fcp/en/FI_CP_GM.pdf.*

111 WFP (2018) The Gambia country brief, September. [ONLINE] Available at: *https://docs.wfp.org/api/documents/WFP-0000101157/download/?_ga=2.179227492.1782577258.1559719392-2011303021.1559719392.*

112 Gbadamosi, N. (2018) Gambians fight Chinese fishmeal factory as fish prices soar, stocks fall. Pulitzer Center, 12 July. [ONLINE] Available at: *https://pulitzercenter.org/reporting/gambians-fight-chinese-fishmeal-factory-fish-prices-soar-stocks-fall.*

113 Gbadamosi, N. (2018) Gambia's tolerance for Chinese fish factories tested as Beijing courts poor African nation with deals.

114 Dijkstra, A. (2019) Chinese imports 'driving fishermen to despair'. BBC News, 21 March. [ONLINE] Available at: *https://www.bbc.co.uk/news/business-47611076.*

115 The Gambia National Development Plan (2018–2021). [ONLINE] Available at: *https://www.theeverywoman.org/images/PDF/Gambia_National_Development_Plan-2018_2021.pdf.*

116 UN (2019) UN Comtrade Database. [ONLINE] Available at: *https://comtrade.un.org/data/.*

117 Greenpeace (2019) A waste of fish: Food security under threat from the fishmeal and fish oil industry in West Africa.

118 DW (2018) Foreign appetite for fish meal threatens West Africans' livelihood. DW, 5 July. [ONLINE] Available at: *https://www.dw.com/en/foreign-appetite-for-fish-meal-threatens-west-africans-livelihood/a-44506336.*

119 Af Touray, K. (2019) Gambia: '411 Gambians employed as fisheries deck hands' Fisheries Minister. AllAfrica, 18 September. [ONLINE] Available *at: https://allafrica.com/stories/201909190320.html.*

120 Singhateh, S. (2018) Gambia: Fishermen accuse Chinese fishmeal company of hijacking catches. AllAfrica, 24 July. [ONLINE] Available at: *https://allafrica.com/stories/201807250516.html.*

121 Summers, H. (2019) Chinese fishmeal plants leave fishermen in the Gambia all at sea. The Guardian, 20 March. [ONLINE] Available at: *https://www.theguardian.com/global-development/2019/mar/20/chinese-fishmeal-plants-leave-fishermen-gambia-all-at-sea.*

122 TRIO S.A. (n.d.) Who we are. [ONLINE] Available at: *http://www.triosa.cl/en/quienes-somos.*

123 Natural Oils Chile S.A. (n.d.) Homepage. [ONLINE] Available at: *http://www.naturaloils.cl/.*

124 Natural Oils Chile S.A. (n.d.) Mercados. [ONLINE] Available at: *http://www.naturaloils.cl/mercados.html.*

125 Traffic International (2019) Reducing illegal timber exports from Cameroon and Viet Nam. [ONLINE] Available at: *https://www.traffic.org/what-we-do/projects-and-approaches/promoting-sustainable-trade/reducing-illegal-timber-exports-from-cameroon-and-viet-nam/.*

126 IFFO (2017) IFFO responds to the Fish Free Feed (F3) challenge. Press release, 4 October. [ONLINE]. Available at: *http://www.iffo.net/press-release/iffo-responds-fish-free-feed-f3-challenge.*

127 EU Sanco (2019) Country section: Viet Nam fishery products. 15 May. [ONLINE]. Available at: *https://webgate.ec.europa.eu/sanco/traces/output/VN/FFP_VN_en.pdf.*

128 IFFO (2019) Members list. *https://www.iffo.net/system/files/List%20of%20All%20IFFO%20Members%20%28Public%29_198.pdf.*

129 -List.org (n.d.) Veiga International Trading Inc. [ONLINE] Available at: *https://www.company-list.org/veiga_international_trading_inc.html.*

130 Open Corporates (2019) Veiga International Trading, Inc. [ONLINE] Available at: *https://opencorporates.com/companies/pa/696048.*

131 UN (2019) UN Comtrade Database. (The HS code for fishmeal is HS 230120 and for fish oil is 150420.)

132 Ocean Disclosure Project (n.d.) BioMar Norway [ONLINE] Available at: *https://oceandisclosureproject.org/companies/biomar.*

133 European Commission (2018) How much fish do we consume? First global seafood consumption footprint published. 27 September. [ONLINE] Available at: *https://ec.europa.eu/jrc/en/news/how-much-fish-do-we-consume-first-global-seafood-consumption-footprint-published.*

134 FAO Commission on Genetic Resources for Food and Agriculture (2019) The state of the world's aquatic genetic resources for food and agriculture assessments.

135 Froehlich et al. (2018) Avoiding the ecological limits of forage fish for fed aquaculture.

136 Gibson, D. (2019) Alltech: Global aquafeed production hit 40m tons for the first time in 2018. Undercurrent News, 31 January. [ONLINE] Available at: *https://www.undercurrentnews.com/2019/01/31/alltech-global-aquafeed-production-hit-40m-tons-for-the-first-time-in-2018/;* Globe Newswire (2019) Global aquafeed market trends: Share, size, growth, opportunity and forecast 2018–2019 and 2024. 26 April. [ONLINE] Available at: *https://www.globenewswire.com/news-release/2019/04/26/1810368/0/en/Global-Aquafeed-Market-Trends-Share-Size-Growth-Opportunity-and-Forecast-2018-2019-2024.html.*

137 Markets and Markets (2017) Aquafeed market worth $172.56 billion by 2022. Press release. [ONLINE] Available at: *https://www.marketsandmarkets.com/PressReleases/aquafeeds.asp.*

138 Global Market Insights (2018) Aquafeed market will witness above 12% CAGR from 2018 to 2024. Press release, 23 October. [ONLINE] Available at: *https://www.globenewswire.com/news-release/2018/10/23/1625210/0/en/Aquafeed-Market-will-witness-above-12-CAGR-from-2018-to-2024-Global-Market-Insights-Inc.html.*

139 Gibson, D. (2019) Alltech: Global aquafeed production hit 40m tons for the first time in 2018.

140 Gibson, D. (2019) Alltech: Global aquafeed production hit 40m tons for the first time in 2018.

141 Alltech (2019) Alltech 2019 global feed survey. [ONLINE] Available at: *https://www.alltech.com/feed-survey.*

142 Aquafeed.com (2019) 2019 Alltech global feed survey. Press release, 30 January. [ONLINE] Available at: *http://www.aquafeed.com/news/headline-news-article/8468/2019-Alltech-Global-Feed-Survey/.*

143 Skretting (2017) We are proud of our long history in the aquafeed industry. [ONLINE] Available at: *https://www.skretting.com/en/about-us/history/.*

144 Cargill (2019) Cargill animal nutrition: Livestock feed & fish feed. [ONLINE] Available at: *https://www.cargill.com/animal-nutritio.*

145 European Commission (2016) A short history. [ONLINE] Available at: *https://ec.europa.eu/fisheries/cfp/aquaculture/aquaculture_methods/history_en; FAO (2018) The state of world fisheries and aquaculture, p.26*

146 BioMar (2014) BioMar history. [ONLINE] Available at: *https://www.biomar.com/en/denmark/about/biomar-history/.*

147 Mowi (2019) About – Mowi. [ONLINE] Available at: *https://mowi.com/about.*

148 IntraFish (2018) The future of aquaculture feed: The supply trends and alternatives driving tomorrow's industry, p.17.

149 FAO (2009) Fish as feed inputs for aquaculture – practices, sustainability and implications: A global synthesis. In M. R. Hasan and M. Halwart (eds) Fish as feed inputs for aquaculture: Practices, sustainability and implications. FAO Fisheries and Aquaculture Technical Paper, 518: 1–61. [ONLINE] Available at: *http://www.fao.org/3/i1140e/i1140e01.pdf.*

150 Rabobank (2018) Alternative feed ingredients in a world of volatile fishmeal supply. [ONLINE] Available at: *https://www.feedproteinvision.com/wp-content/uploads/2018/03/Day-2-Beyhan-de-Jong.pdf.*

151 Green, M. (2018) Ocean Shock: The climate crisis beneath the waves, Reuters. October 30. [ONLINE] Available at: *https://www.reuters.com/investigates/section/ocean-shock/*

152 FAO (2018) The state of world fisheries and aquaculture.

153 e.g. Cargill (2019) Sustainable aquaculture feed & ingredients. [ONLINE] Available at: *https://www.cargill.com/sustainability/aquaculture/aquaculture-feed-ingredients;* Skretting (2018) Sustainability report 2018. [ONLINE] Available at: *https://www.skretting.com/siteassets/global-files/nutera/sustainability-report-2018/skretting-sustainability-report-16-july.pdf.*

154 FAO (2018) The state of world fisheries and aquaculture.

155 Institute of Aquaculture, University of Stirling And IFFO (2016) Project to model the use of fisheries by-products in the production of marine ingredients, with special reference to the omega 3 fatty acids epa and DHA. [ONLINE] Available at: *https://www.iffo.net/system/files/Report%20IoA%20IFFO%20project%20Final_0.pdf.*

156 FAO (2018) The state of world fisheries and aquaculture.

157 Institute of Aquaculture, University of Stirling And IFFO (2016) Project to model the use of fisheries by-products in the production of marine ingredients.

158 Evans (2019) Skretting CEO on feed alternatives: 'We cannot afford to finance the cost'.

159 Skretting (n.d.) Bridging the raw material gap [ONLINE] Available at: *https://www.skretting.com/en/sustainability/ingredients/novel-raw-materials/omega-3-from-marine-algae--an-innovative-solution-for-increased-protein-production/*

160 IntraFish Media (2019) BioMar sees promise with insect feed. 24 April. [ONLINE] Available at: *https://www.intrafish.com/aquaculture/1764461/biomar-sees-promise-with-insect-feed.*

161 Cargill (2019) Cargill's sustainable plant-based alternative to omega-3 fish oil approved for US cultivation [ONLINE] Available at: *https://www.skretting.com/en/sustainability/ingredients/novel-raw-materials/omega-3-from-marine-algae--an-innovative-solution-for-increased-protein-production/*

162 Keep.EU (n.d.) Project: Initiation of full scale mussel farming in the Baltic Sea. [ONLINE] Available at: *https://keep.eu/project/17950/initiation-of-full-scale-mussel-farming-in-the-baltic-sea.*

163 Einstein-Curtis, A. (2019) F3 organization launches feed challenge for carnivorous fish. Feed Navigator, 10 September. [ONLINE] Available at: *https://www.feednavigator.com/Article/2019/09/10/F3-organization-launches-feed-challenge-for-carnivorous-fish.*

164 Evans (2019) Skretting CEO on feed alternatives: 'We cannot afford to finance the cost'.

165 Garcés, J (2019) Marine ingredients 'don't make salmon unsustainable'. Fish Farming Expert. [ONLINE] Available at: *https://www.fishfarmingexpert.com/article/marine-ingredients-dont-make-a-salmon-unsustainable.*

166 Changing Markets Foundation and Compassion in World Farming (2019) Until the seas run dry: how industrial aquaculture is plundering the oceans. [ONLINE] Available at: *http://changingmarkets.org/wp-content/uploads/2019/04/REPORT-WEB-UNTILL-THE-SEAS-DRY.pdf*

167 California Environmental Associates (2018) Shrimp Aquaculture Landscape. [Online] Available at: *https://www.sustainablefish.org/Media/Files/SR-Documents/Shrimp-Aquaculture-_-Asia-Farmed-Shrimp-SR.*

168 Adams, L. (2019) Salmon farming giant Mowi probed over chemical use. BBC News, 20 May. [ONLINE] Available at: *https://www.bbc.com/news/uk-scotland-48334029.*

169 Mowi (2018) Integrated annual report 2018. [ONLINE] Available at: *http://hugin.info/209/R/2239765/882920.pdf.*

170 Changing Markets (2018) The false promise of certification. [Online] Available at: *https://changingmarkets.org/wp-content/uploads/2018/05/False-promise_full-report-ENG.pdf.*

171 FAIRR (2018) Shallow returns? ESG risks and opportunities in aquaculture.

172 ODP (2018) Skretting profile. [ONLINE] Available at: *https://oceandisclosureproject.org/companies/skretting.*

173 Skretting (2018) Feed ingredients used for the production of farmed fish and shrimp [ONLINE] Available at: *https://www.skretting.com/en/sustainability/reports/sustainability-report-2018/ingredients/feed-ingredients-used-for-the-production-of-farmed-fish-and-shrimp/*

174 BioMar (2018) BioMar raises EBIT guidance for 2018. Press release, 12 November. [ONLINE] Available at: *https://www.biomar.com/en/global/press-releases/press-releases/q3-2018-results/#.*

175 Ocean Disclosure Project (n.d.) BioMar Norway.

176 BioMar (2018) BioMar sustainability report 2018. [ONLINE] Available at: *https://www.biomar.com/globalassets/.global/pdf-files/biomar-group-sustainability-report-2018.pdf*

177 BioMar (2018) BioMar sustainability report 2018.

178 Standing, A. (2017). The growth of fishmeal production in Mauritania: The implications for regional food security. Coalition for Fair Fisheries Arrangements. [ONLINE] Available at: *http://cape-cffa.squarespace.com/new-blog/2017/2/23/the-growth-of-fishmeal-production-in-mauritania-the-implications-for-regional-food-security.*

179 EUMOFA (2018) The EU fish market.

180 California Environmental Associates (2018) Shrimp aquaculture landscape.

181 Heiploeg (2019) Heiploeg International. [ONLINE] Available at: *https://www.heiploeggroup.com/en-us/company/heiploeg-companies/heiploeg-international-bv.*

182 Undercurrent News (2019) Heiploeg puts millions into expansion at shrimp plant. Press release, 9 July. [ONLINE] Available at: *https://www.undercurrentnews.com/2019/07/09/heiploeg-puts-millions-into-expansion-at-shrimp-plant/.*

183 Heiploeg (2019) Some facts and figures. [ONLINE] Available at: *https://www.heiploeggroup.com/en-us/company/some-facts-and-figures.*

184 Seafish Directory (2019) Heiploeg Group. [ONLINE] Available at: *http://www.seafishdirectory.com/directory/2009/heiploeg-group/.*

Fishing for Catastrophe

185 Erin-Madsen, C. (2018) The journey from Vietnam to Danish supermarkets. Danwatch, 13 September. [ONLINE] Available at: *https://danwatch.dk/undersoegelse/rejens-rejse-fra-vietnam-til-danske-supermarkeder-2/.*

186 EUMOFA (2018) The EU fish market.

187 Seafish (2015) Responsible sourcing guide: Farmed Atlantic salmon. [ONLINE] Available at: *https://www.seafish.org/media/1403303/_2_atlantic_salmon_rsg_-_cocker_04-15kg.pdf*

188 European Market Observatory for Fisheries and Aquaculture products – EUMOFA (2019) Monthly Highlights [ONLINE] Available at: *http://www.eumofa.eu/documents/20178/148316/MH+4+2019+EN_final.pdf/#page=23*

189 Feedback (2019) Fishy business.

190 Norsk Industri (n.d.) Roadmap for the Aquaculture Industry [ONLINE] Available at: *https://www.norskindustri.no/siteassets/dokumenter/rapporter-og-brosjyrer/veikart-for-havbruksnaringen---kortversjon_eng.pdf*

191 Changing Markets Foundation and Compassion in World Farming (2019) Until the seas run dry: how industrial aquaculture is plundering the oceans. p.40

192 Mowi (2018) Integrated annual report 2018, p.25.

193 Skretting (n.d.) Company facts. [ONLINE] Available at: *https://www.skretting.com/en/about-us/company-facts/.*

194 Skretting (n.d.) Why is aquaculture important? [ONLINE] Available at: *https://www.skretting.com/en/faq/why-is-aquaculture-important/.*

195 Mowi (n.d.) We are leading the Blue Revolution. [ONLINE] Available at: https://mowi.com/sustainability/.

196 BioMar (n.d.) Is fish farming sustainable? [ONLINE] Available at: *https://www.biomar.com/en/uk/sustainability/is-fish-farming-sustainable/.*

197 FAIRR (2018) Shallow returns? ESG risks and opportunities in aquaculture.

198 Cargill (2019) Sustainable aquaculture feed & ingredients.

199 Naylor et. al. (2009) cited in: Tai et. al. (2017) Ex-vessel fish price database: disaggregating prices for low-priced species from reduction fisheries. OceanCanada Working Paper #2017-02 [ONLINE] Available at: *https://www.oceancanada.org/ocp/wp-content/uploads/2014/11/TAIetal_PriceDB-Manuscript_20170515_v1.pdf*

200 Harkell, L. (2019) Rabobank's Nikolik: Long-term market outlook still rosy for fishmeal producers, Undercurrent News. March 11. [ONLINE] Available at: *https://www.undercurrentnews.com/2019/03/11/rabobanks-nikolik-long-term-market-outlook-still-rosy-for-fishmeal-producers/*

201 FAO (2018) Impact on climate change on fisheries and aquaculture, p.331

202 FAO (2018) Impact on climate change on fisheries and aquaculture, p.171.

203 Cashion et al. (2017) Most fish destined for fishmeal production are food-grade fish.

204 Rabobank (2018) Alternative feed ingredients in a world of volatile fishmeal supply [ONLINE] Available at: *https://www.feedproteinvision.com/wp-content/uploads/2018/03/Day-2-Beyhan-de-Jong.pdf*

205 Green, M. (2018) Ocean Shock: The climate crisis beneath the waves, Reuters.

206 Godfrey, M. (2019) IFFO head: Aquaculture growth portends bright future for marine ingredients industry. Seafood Source, 27 September. [ONLINE] Available at: *https://www.seafoodsource.com/news/aquaculture/iffo-head-aquaculture-growth-portends-bright-profitable-future-for-marine-ingredients-industry*.

207 European Commission (2009) Building a sustainable future for aquaculture: A new impetus for the Strategy for the Sustainable Development of European Aquaculture – Impact assessment. Commission staff working document. Brussels, SEC(2009): 43. [ONLINE] Available at: *http://discomap.eea.europa.eu/map/Data/Milieu/OURCOAST_085_UK/OURCOAST_085_EUROPE_UK_Doc4_EU-CommunciationSustainableAquacultureIA.pdf*

208 FAO (2009) Impact of rising feed ingredient prices on aquafeeds and aquaculture production. [ONLINE] Available at: *http://www.fao.org/3/i1143e/i1143e.pdf.*

209 European Commission (2009) Building a sustainable future for aquaculture.

210 European Commission (2009) Building a sustainable future for aquaculture.

211 Cargill (2019) Sustainable aquaculture feed & ingredients.

212 FAO (2016) Fishmeal and fish oil: Analysis of 3rd quarter 2015. 24 February. [ONLINE] Available at: *http://www.fao.org/in-action/globefish/market-reports/resource-detail/en/c/384232/.*

213 Villegas, A. (2015) Fishmeal will move from being commodity to 'high price', strategic marine protein. Undercurrent News. June 9. [ONLINE] Available at: *https://www.undercurrentnews.com/2015/06/09/fishmeal-will-move-from-being-commodity-to-high-price-strategic-marine-protein/*

214 Rabobank (2018) Alternative feed ingredients in a world of volatile fishmeal supply

215 Tai et. al. (2017) Ex-vessel fish price database: disaggregating prices for low-priced species from reduction fisheries.

216 Tai et. al. (2017) Ex-vessel fish price database: disaggregating prices for low-priced species from reduction fisheries.

217 FAO (2019) Promising fishing season in 2019. 25 June. [ONLINE] Available at: *http://www.fao.org/in-action/globefish/market-reports/resource-detail/en/c/1199564/. I*

218 FAO (2019) Globefish highlights: A quarterly update on world seafood markets. January. [ONLINE] Available at: *http://www.fao.org/3/ca4185en/ca4185en.pdf.*

219 FAO (2019) Promising fishing season in 2019.

220 FAO (2018) Impact on climate change on fisheries and aquaculture p.331

221 IMF (2019) Primary commodity price system: Fish meal / US dollars. [ONLINE] Available at: *https://data.imf.org/?sk=471DDDF8-D8A7-499A-81BA-5B332C01F8B9&sId=1393552803658.*

222 World Bank (2019) World Bank commodity price data (The Pink Sheet), 2 October. Excel spreadsheet. [ONLINE] Available at: *https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=2&ved=2ahUKEwjEnZSX4tXkAhWNUxUIHXP5AO4QFjABegQIARAC&url=http%3A%2F%2Fpubdocs.worldbank.org%2Fen%2F561011486076393416%2FCMO-Historical-Data-Monthly.xlsx&usg=AOvVaw2GedGhCvf-gImbBuS1bI24U.*

223 FAO (2018) The state of world fisheries and aquaculture.

224 European Commission (2009) Building a sustainable future for aquaculture.

225 Potts et al. (2016), cited in Changing Markets (2018) The false promise of certification.

226 Global Salmon Initiative (2019) What is the GSI? [ONLINE] Available at: *https://globalsalmoninitiative.org/en/what-is-the-gsi-working-on/sustainability-certification-asc-standard/*

227 Changing Markets and Compassion in World Farming (2019) Until the seas run dry.

228 Arnold, S. and Roebuck, K., 2017. What's behind the label? Assessing the impact of MSC and ASC certifications in Canada. [ONLINE] Available at: *http://www.seachoice.org/wp-content/uploads/2017/09/Seachoice-ASCMSC-Report-On-line.pdf; Changing Markets (2018) The false promise of certification; Changing Markets (2019) Until the seas run dry.*

229 Hongzhou, Z. (2018) Can aquaculture solve the fishing problems in the South China Sea? The Diplomat, 26 March. [ONLINE] Available at: *https://thediplomat.com/2018/03/can-aquaculture-solve-the-fishing-problems-in-the-south-china-sea/.*

230 IFFO (2019) Driving change in South East Asian trawl fisheries, fishmeal supply, and aqua-feed[ONLINE] Available at: *http://www.iffo.net/system/files/SEA%20Report_Short%20version.pdf*

231 Poling, G. B. (2019) Illuminating the South China Sea's dark fishing fleets. 9 January. [ONLINE] Available at: *https://ocean.csis.org/spotlights/illuminating-the-south-china-seas-dark-fishing-fleets/.*

232 Daniels, A. (2018) 'Fish are vanishing': Senegal's devastated coastline. BBC News, 1 November. [ONLINE] Available at: *https://www.bbc.co.uk/news/world-africa-46017359.*

233 Tai et. al. (2017) Ex-vessel fish price database: disaggregating prices for low-priced species from reduction

fisheries.

234 UN (2018) Blue Economy Concept Paper. Online] Available at: *https://wedocs.unep.org/bitstream/handle/20.500.11822/11129/unep_swio_sm1_inf11_blue_economy.pdf?sequence=1&amp%3BisAllowed=*

235 FAO (2013) Fish to 2030: Prospects for fisheries and aquaculture. [ONLINE] Available at: *http://www.fao.org/3/i3640e/i3640e.pdf.*

236 IFFO RS (2009) IFFO RS CoC certified sites. [ONLINE] Available at: *https://www.iffors.com/iffo-rs-coc-certified-sites.*

237 Western Sahara Resource Watch (2018) Fishmeal from occupied Western Sahara now being unloaded in Germany. 19 July. [ONLINE] Available at: *https://www.wsrw.org/a105x4225.*

238 Bawa Fishmeal & Oil Co. (n.d.) Certifications. [ONLINE] Available at: *http://www.bawafishmeal.com/indian-fish-oil-certifications.php.*

239 FF Skagen (2019) Quality. [ONLINE] Available at: *https://ffskagen.dk/en/quality.*

240 IFFO RS (n.d.) About. [ONLINE] Available at: *https://www.iffors.com/about.*

241 IFFO (n.d.) FAQs. [ONLINE] Available at: *https://www.iffo.net/faqs.*

242 IFFO (2019) The first overarching study for the South-East Asian fishmeal industry provides recommendations to move forward in achieving a sustainable supply chain. Press release, 26 April. [ONLINE] Available at: *http://www.iffo.net/press-release/first-overarching-study-south-east-asian-fishmeal.*

243 IFFO (2009) International Fishmeal and Fish Oil Organisation 50th anniversary. [ONLINE] Available at: *http://www.iffo.net/system/files/50-year-history-booklet.pdf.*

244 IFFO (n.d.) Annual report 2018. [ONLINE] Available at: *http://www.iffo.net/es/system/files/IFFO-2018-report-ENGLISH.pdf.*

245 IFFO (n.d.) Raw material. [ONLINE] Available at: *http://www.iffo.net/raw-material.*

246 FAO (2018) The state of world fisheries and aquaculture.

247 Heffernan, O. (2009) No more fish in the sea. Nature, 460(956). [ONLINE] Available at: *https://www.nature.com/articles/460956a.*

248 Smith et al. (2011) Impacts of fishing low-trophic level species on marine ecosystems.

249 MSC (2015) Ensuring sustainable aquaculture feed ingredients. Discussion for SAR workshop 7–8 October. [ONLINE] Available at: *https://www.mcsuk.org/media/seafood/SAR_Feed_Policy_paper_21_Sept_2015.pdf.*

250 Nutreco (2010) Sustainability report 2010. [ONLINE] Available at: *https://www.nutreco.com/globalassets/nutreco-corporate1/publications/sustainability/2011/nutreco-sustainability-report-2010.pdf?id=1227103.*

251 IFFO (2016) IFFO's response to 'How vital fish stocks in Africa are being stolen from human mouths to feed pigs and chickens on Western factory farms.' Letter to the Editor, The Independent, 19 September. [ONLINE] Available at: *http://www.iffo.net/press-release/iffos-response-%E2%80%98how-vital-fish-stocks-africa-are.*

252 MSC (2015) Ensuring sustainable aquaculture feed ingredients.

253 IFFO RS (2015) Statement of purpose of the IFFO RS Standard. [ONLINE] Available at: *https://www.iffors.com/sites/iffors/files/2017-06/IFFO%20RS%20Board%20Statement%20of%20Purpose%20-%20Final.pdf.*

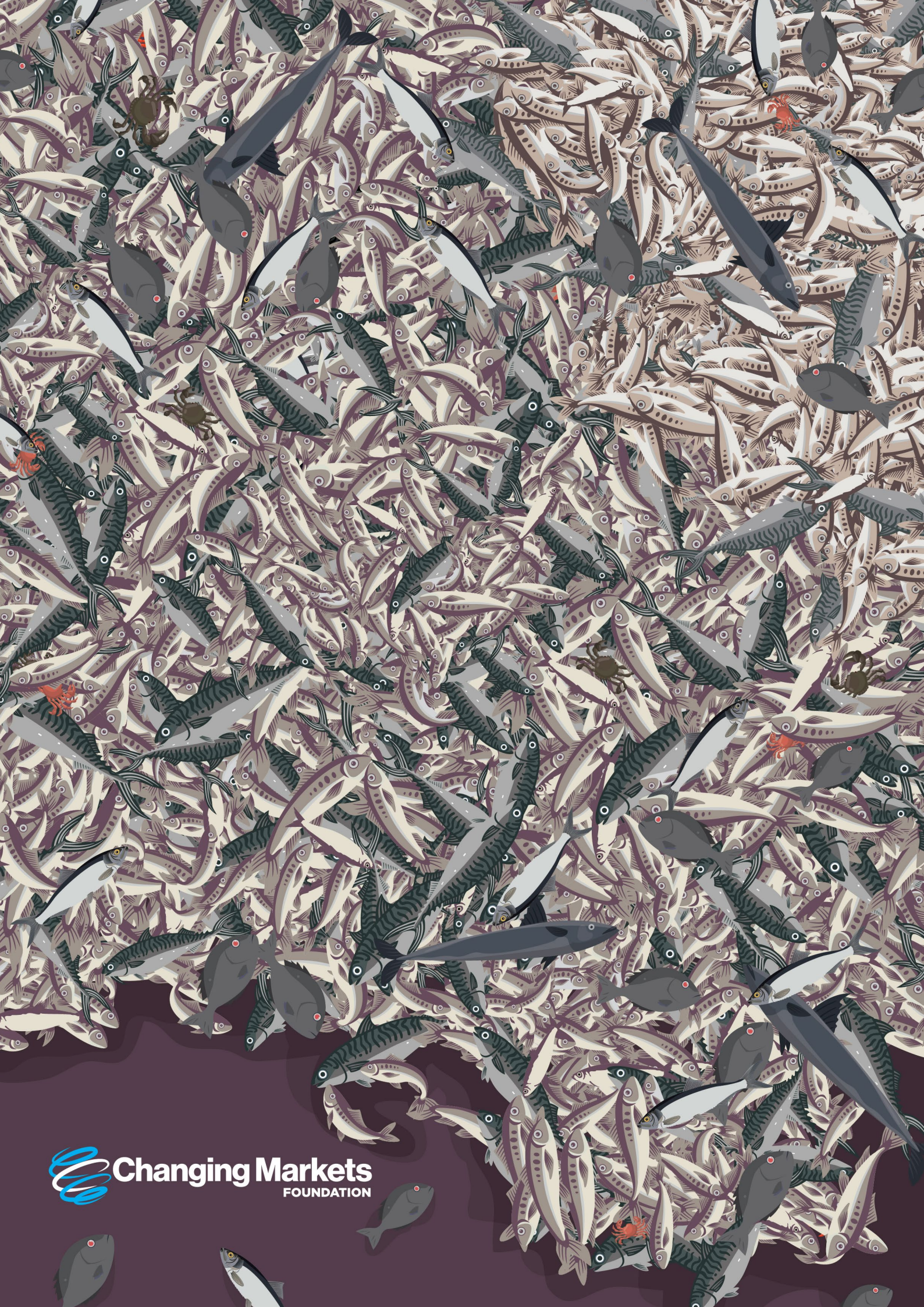
254 Changing Markets (2018) The false promise of certification.

255 MSC (2019) MSC opens consultation on unit of assessment and shark finning. Press release, 4 March. [ONLINE] Available at: *https://www.msc.org/media-centre/press-releases/msc-opens-consultations-on-compartmentalisation-and-shark-finning.*

256 Harkell, L. (2019) Rabobank's Nikolik: Long-term market outlook still rosy for fishmeal producers, Undercurrent News.

257 IFFO (2019) IFFO responds to the Changing Markets Report. Press release, 18 April. [ONLINE] Available at: *https://www.iffo.net/press-release/iffo-responds-changing-markets-report.*

258 Pauly, D. (2019) Vanishing Fish: Shifting Baselines and the Future of Global Fisheries Canada: Greystone Books Ltd.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