SALMON: THE PINK BOMB OF AN EXHAUSTED FOOD SYSTEM

SEASTEMIK

Seastemik is an NGO created in 2023 by a group of optimists concerned about the state of the Ocean, the primary source of life on Earth. By raising awareness among civil society and engaging the responsibility of the State and intermediate actors (large-scale distribution and collective catering), our mission is to drive a transition towards a healthy, accessible, and sustainable food system that respects the Ocean, human societies, and animals.

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EXECUTIVE SUMMARY

THE OCEAN IS THE PRIMARY SOURCE OF LIFE ON EARTH

The Ocean is the primary source of life on Earth: a major oxygen producer, this blue lung is a great climate regulator and home to millions of animal species. More than 3 billion humans depend on it for their livelihood[1]. However, marine ecosystems are being devoured by the current food system. Marked by unsustainable overfishing and intensive aquaculture, it deepens social inequalities and endangers marine life. This is the case for the Atlantic salmon, which, like the emperor penguin, joined the IUCN Red List in late 2023.

In this context, the salmon industry is an ecological and social bomb. Its intensive farming practices lead to disastrous consequences: ecosystem pollution, greenhouse gas (GHG) emissions, animal cruelty, ecological imbalances, resource plundering of Southern countries, and the exacerbation of overfishing.

Despite this, salmon production, dominated by a handful of multinationals, has experienced hyper-growth on a global scale over the past few decades. This situation is likely to worsen as the world leader, Norway, aims to triple its annual production by 2050, notably by increasing its production capacity through new ultra-energy-intensive and impactful technologies (land-based and offshore farming). Far from addressing environmental concerns, the salmon industry minimises and hides its ecological and human impacts through heavy greenwashing and marketing techniques such as eco-labels, and by creating the illusion of contributing to global food security and human health through the provision of omega-3 (DHA/EPA).

France, the biggest European salmon consumer and the fourth in the world, is a major player in the sector and bears particular responsibility for directing practices. However, depending on the type of omega 3 (DHA/EPA or ALA), 89% to 99% of the French population have omega-3 deficiencies. Therefore, despite the high consumption of salmon in France, the needs of a large majority of the population are not being met. This finding calls into question the value of our overconsumption of salmon and highlights the urgent need to transform our food systems.

This report shows that it is urgent to mitigate the harmful effects of unsustainable food production methods such as the salmon industry, which threatens the most fragile marine, terrestrial, and human ecosystems already under pressure due to the current climate emergency. Today, it is unjustifiable to allow this industry to continue producing salmon that meets no necessity—neither in terms of global food security nor human health. Protecting the Ocean, life on Earth, and future generations requires the collective adoption of a diet that, all the while remaining delicious, is more respectful of the environment and societies.

Marine ecosystems are being devoured by the current food system. Marked by unsustainable overfishing and intensive aquaculture, it deepens social inequalities and endangers marine life.

KEY MESSAGES

1

Food is the most powerful lever to preserve the Ocean and achieve the United Nations Sustainable Development Goals and the Paris Agreement. Transforming the food system must address the need to feed all humans equitably while respecting planetary boundaries, animal health, and human health.

2

A systemic approach is necessary for this transformation to succeed, which must be based on the **co-responsibility** of businesses, the State, and civil society, as well as multi-level and **multi-sector action**. It should primarily focus on reducing fish consumption, investing in low-trophic aquaculture, and promoting education on planetary health.

3

Gradually abandoning destructive industries such as carnivorous fish farming (salmon) is essential to move towards a sustainable food system.

“ The Atlantic salmon (Salmo salar) can journey up to 3,000 kilometres from the coast on their marine migrations. In late 2023, its status on the IUCN Red List shifted from minor concern to near threatened.”

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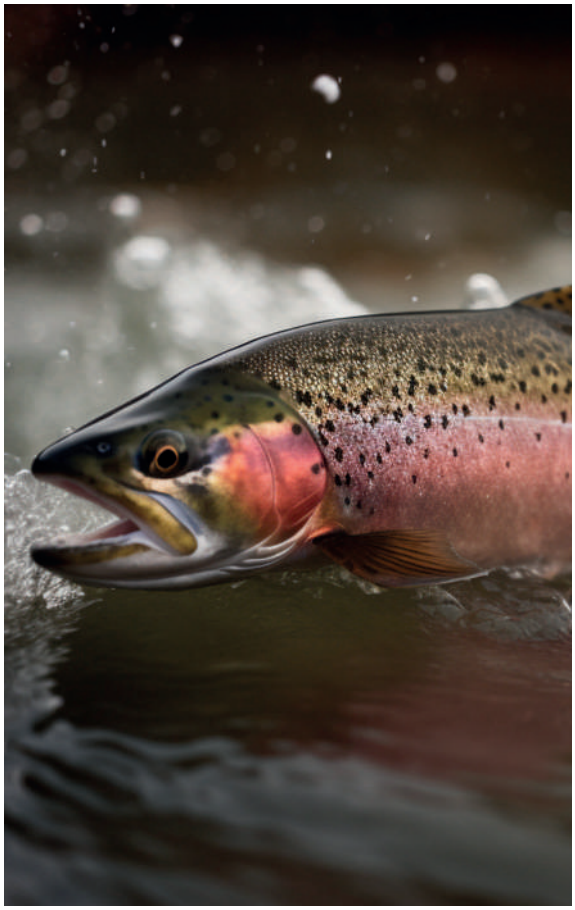
CHAPTER 1

THE DISAPPEARANCE OF *WILD SALMON*

A migratory fish, salmon is a fascinating creature that splits its life between freshwater and saltwater. It starts its journey in rivers, moves to the sea, and then returns to its birthplace to reproduce. Salmon can cover immense distances, leap over 3 metres high, dive more than 900 metres deep, and seems to navigate using the Earth's magnetism and their highly developed sense of smell. Among the various salmon species, some travel thousands of kilometres during migration. For example, the Atlantic salmon (*Salmo salar*) can journey up to 3,000 kilometres from the coast, migrating from northwestern Spain to Greenland[2]. As carnivores, salmon feed on insects, juvenile invertebrates, small fish, and crustaceans[3].

The Salmonidae family includes two genera: Oncorhynchus, which encompasses five main species (chinook, sockeye, coho, pink, chum), and Salmo, represented by the Atlantic salmon (*Salmo salar*)[4]. Although its natural environment is vast—spanning the North Atlantic from Hudson Bay to the Baltic—the Atlantic salmon is an endangered species. In late 2023, its status on the IUCN Red List shifted from «minor concern» to «near threatened.» In Europe, several local populations of Atlantic salmon have even more dire conservation statuses[5] («threatened» or «critically endangered»). Overall, the wild Atlantic salmon population declined by 23% between 2006 and 2020[6]. The species has largely vanished from North American rivers where it was once abundant a century ago. Atlantic salmon are considered extinct in several countries, including the Netherlands, Belgium, Poland, Slovakia, and Switzerland, and have had to be reintroduced in Germany and parts of Canada, with varying levels of success. Significant population declines are also recorded in France and Scandinavian countries. The collective memory of millions of salmon swimming upstream is now just that—a memory.

This decline in wild salmon populations has multiple causes: overfishing at sea, the degradation of freshwater habitats, the construction of numerous migration barriers, and the effects of climate change. Farming activities are also identified as one of the most significant threats. On one hand, farmed salmon transmit diseases to wild salmon through water diffusion. On the other hand, when farmed salmon escape, "genetic disruptions" due to crossbreeding between different genetic pools increasingly render wild salmon unable to survive in their natural habitat. At the same time, salmon production and consumption have seen explosive growth in recent decades.



“ Salmon production surged to 3 million tonnes in 2021, which translates to the farming and slaughtering of 600 million salmon. Today, four countries alone account for 90% of global salmon production. ”

02

CHAPTER 2

A CONCENTRATED SALMON PRODUCTION *IN HYPER-GROWTH*

A true upheaval has taken place in the Ocean over the past century: global consumption of fish and seafood has increased ninefold[7]. Several factors explain this transformation. The first is undoubtedly the dramatic increase in fishing capabilities over the century, particularly the development of large industrial fishing fleets in the decades following World War II. At the same time, the fresh and canned food markets expanded, and dietary habits changed. In more recent times, aquaculture and the development of processed products (frozen, ready-made meals, etc.) have taken over.

Globally, per capita[8] fish reached 20 kg in 2023. In 2021, in France, it reached 30.4 kg per capita, with 23% of this being shellfish and crustaceans. Among fish, tuna is the most consumed species (4.7 kg per person per year), followed closely by salmon (4.4 kg per person per year), with 99% of the latter being imported[9].

Salmon production has seen unparalleled development. Almost non-existent 30 years ago, it surged to 3 million tonnes in 2021[10], which translates to the farming and slaughtering of 600 million salmon.

Global Aquaculture Production of *Salmo salar*

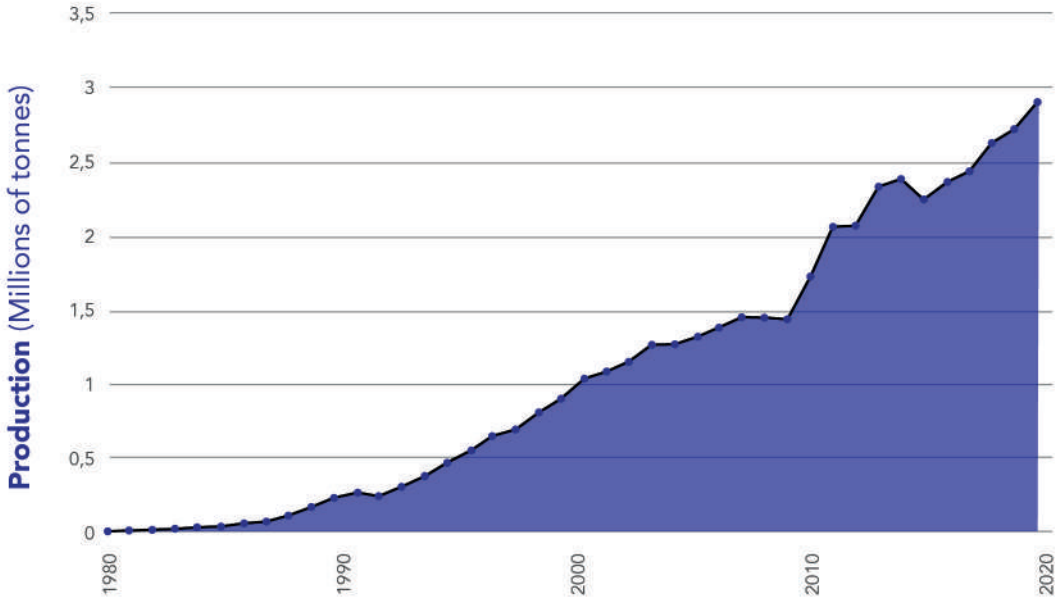


Figure 1: Global Aquaculture Production of *Salmo salar* (Atlantic Salmon). *Source : FAO.*

Over the last 20 years, there has been an acceleration of this trend, accompanied by a dual concentration: of companies in the sector and of the species of salmon farmed.

AN INDUSTRIALISED PRODUCTION, DOMINATED BY A FEW COMPANIES

Small artisanal salmon productions quickly gave way to industrial farming: initiated in Norway in the 1960s, these farms then spread to the few countries with natural conditions suitable for aquaculture. Today, four countries alone account for 90% of global salmon production. In 2021, Norway led the sector with 39% of total production[11], followed by Chile (23%), UK and Canada.

In just a few decades, the market has become dominated by a handful of multinationals. Among the five largest producers, three are Norwegian (Mowi, SalMar, Lerøy Seafood Group), one is Japanese (Cermaq, owned by Mitsubishi Corporation), and the last is Chilean (AquaChile).

	MOWI	SALMAR	LERØY	CERMAQ	AQUACHILE
Country of origin	Norway	Norway	Norway	Japan	Chile
Production volume in tonnes	472 000	194 000	152 000	171 000	138 000

Figure 2: Top 5 salmon producers worldwide in 2022.

Mowi, formerly known as Marine Harvest, dominates the sector. The company operates in 25 countries, including Chile and Canada, and markets its products in 70 countries, primarily in Western Europe and North America[12]. Mowi's strategy is characterised by vertical integration of the value chain—a marked trend in the sector that involves controlling all stages of salmon production, from eggs to final processing.

As a result, Mowi is the global leader in Atlantic salmon farming and smoking. It also ranks fourth in fish feed production, behind Skretting, EWOS (Cargill), and BioMar. These major industries focus their production goals on a single species: *Salmo salar.*

A PRODUCTION REDUCED TO A SINGLE SPECIES OF SALMON: THE *SALMO SALAR*

Atlantic salmon, *Salmo salar*, has been established as the primary species for aquaculture.

Several factors seem to explain this preference. First, there was already a dietary tradition of consuming wild salmon, considered a festive and luxury product, which aquaculture has made widely accessible in just a few years. Additionally, the ability to mass-produce this species in cages attracted the industry, while its pink colour and boneless flesh appealed to consumers for their aesthetic qualities[13]. Furthermore, its high fat content and omega-3 levels are frequently highlighted for their nutritional benefits, often overshadowing the toxic elements[14] present in the fish's flesh.

To continue making *Salmo salar* a staple of global consumption, the industry has developed production techniques based on the intensive farming model: open net pens farming and land-based closed tank farming.

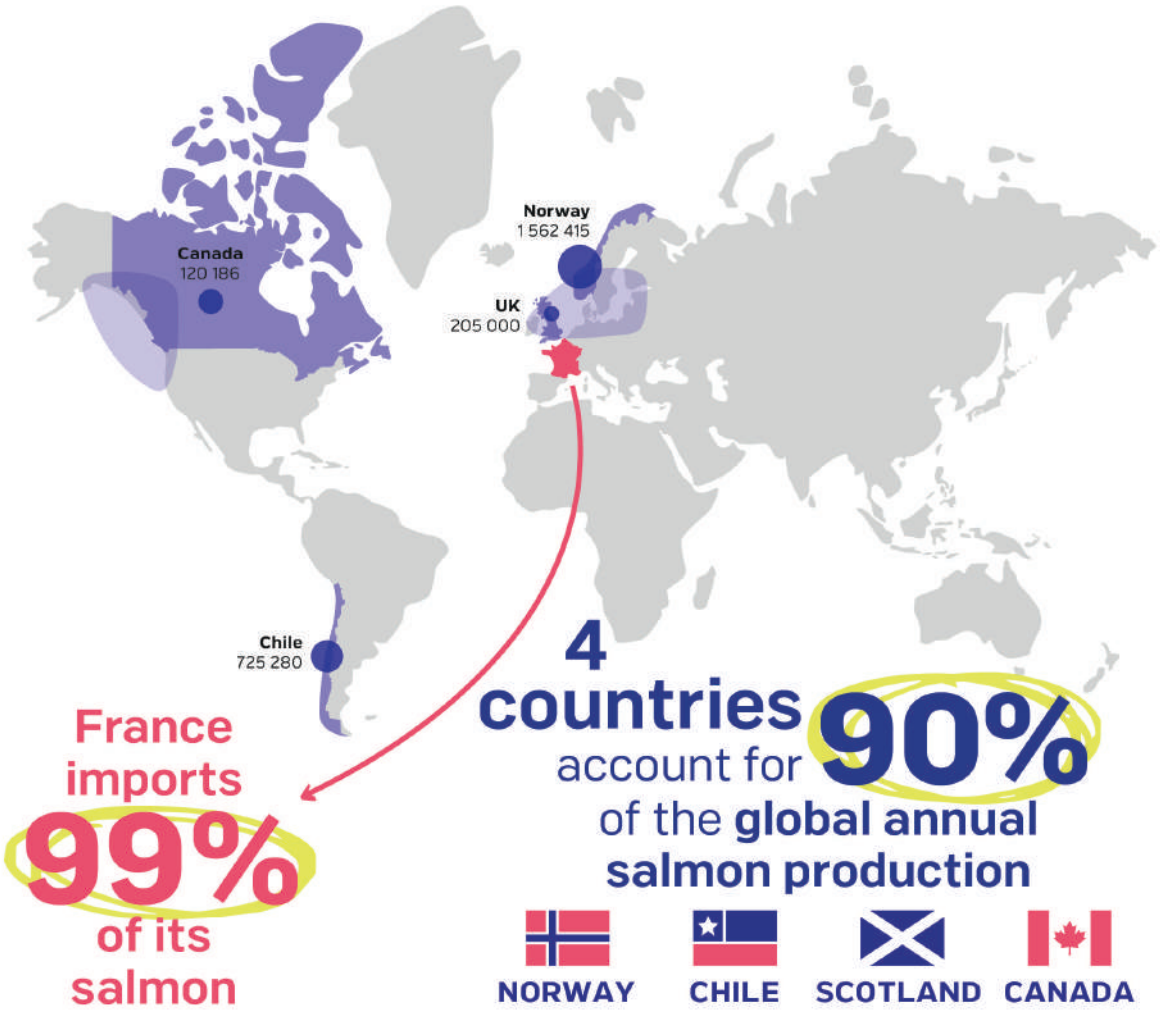
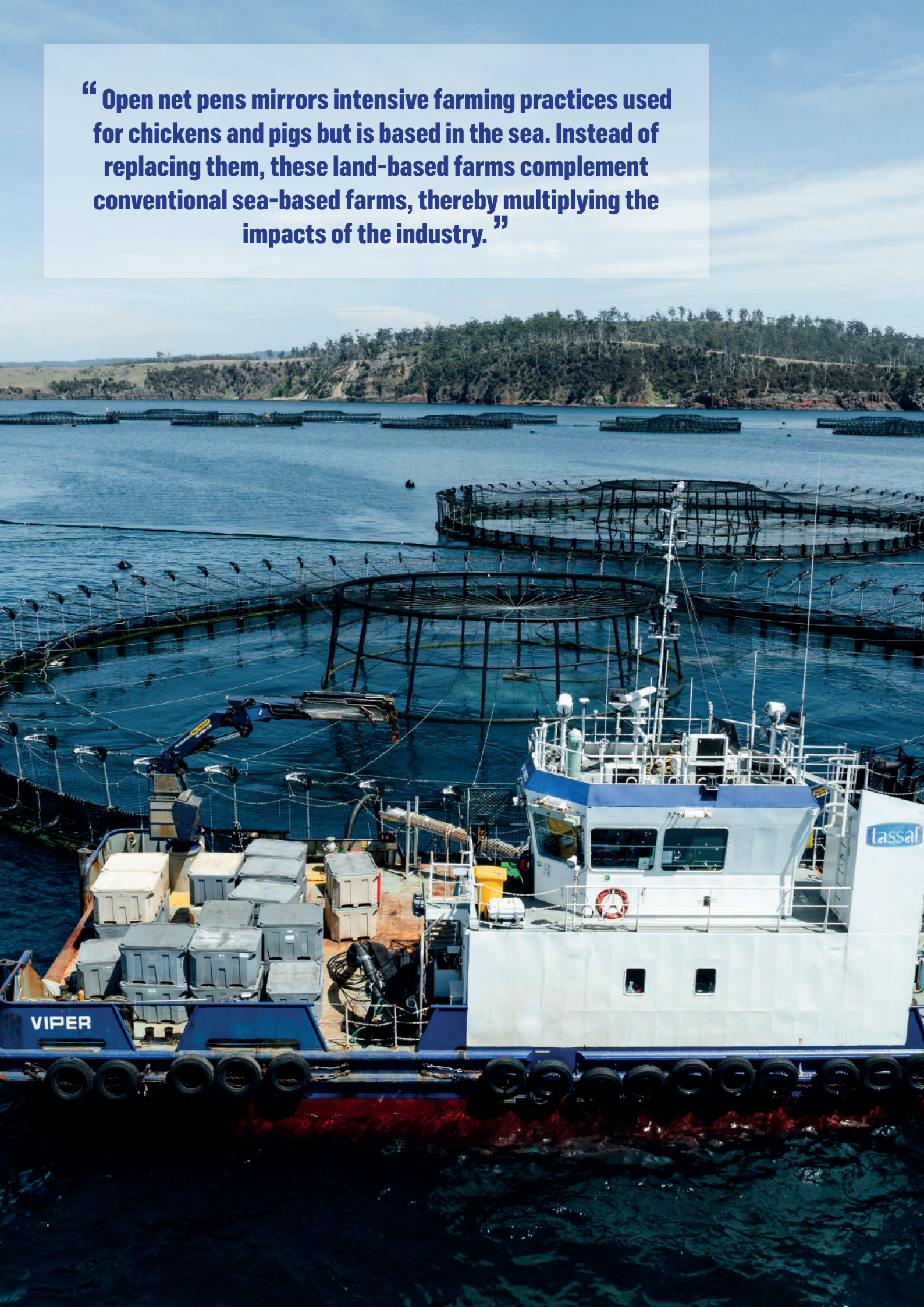


Figure 3: Distribution of Global Annual Atlantic Salmon Production in 2021 (in tonnes)
Based on FAO 2024. World aquaculture production. Fisheries and Aquaculture. Rome.

> “Open net pens mirrors intensive farming practices used for chickens and pigs but is based in the sea. Instead of replacing them, these land-based farms complement conventional sea-based farms, thereby multiplying the impacts of the industry.”



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CHAPTER 3

AT SEA OR ON LAND, *INTENSIVE FARMING-BASED PRODUCTION METHODS*

The transformation of the salmon farming industry, shifting from numerous small and medium-sized enterprises to a concentration of stakeholders, has been accompanied by changes in production methods. These new companies have also followed a trend towards optimising and increasing production, resulting in a multitude of negative environmental, social, health, and animal welfare impacts. Based on the model of intensive agriculture, two production techniques are now favoured: so-called 'conventional' open net pens and land-based farming in closed tanks.

OPEN NETS PENS: THE CRITICISED "CONVENTIONAL" FARMING METHOD

Atlantic salmon is a migratory species that reproduces in freshwater: two phases of fish farming are required before transferring salmon to the open sea. The salmon are born in hatcheries where they transition from the egg stage to juvenile fish (alevins), and then they grow in nurseries until they reach smoltification, a stage where biological processes prepare them to live in a marine environment.

Salmon are then concentrated in moored or floating cages, equipped with nets suspended below, near the coast. Fattening a salmon to a sufficient size for slaughter, typically between 3.5 and 5 kg, generally requires a minimum of two to three years. Throughout this farming period, salmon are fed with fishmeal, indirectly exacerbating overexploitation of wild fish and ecosystem degradation (cf. Chapter 4).

Open net pens mirrors intensive farming practices used for chickens and pigs but is based in the sea: hyper-concentration of production in a very limited space, extensive use of antibiotics, vaccines, and chemical treatments (pesticides for managing sea lice), genetic modification, manipulation and genetic selection, mechanisation, growth acceleration techniques, additives in feed composition, etc.

The deterioration of marine ecosystems is a major issue with this type of farming. Leftover food and salmon feces lead to eutrophication, similar to the green algae issue in Brittany. Excessive nutrient inputs (nitrates and phosphates) into the water cause plant proliferation (algae), oxygen depletion, and ecosystem imbalance. Additionally, chemical treatments against sea lice mean escaped farmed salmon become formidable predators to surrounding species. These factors transform areas once rich in biodiversity into dead zones, deprived of oxygen, leading to severe incidents such as the 2016 red tide in Chile[15]. This has prompted the industry to consider other farming methods like land-based intensive farming—a method that has added to the problem rather than solving it.

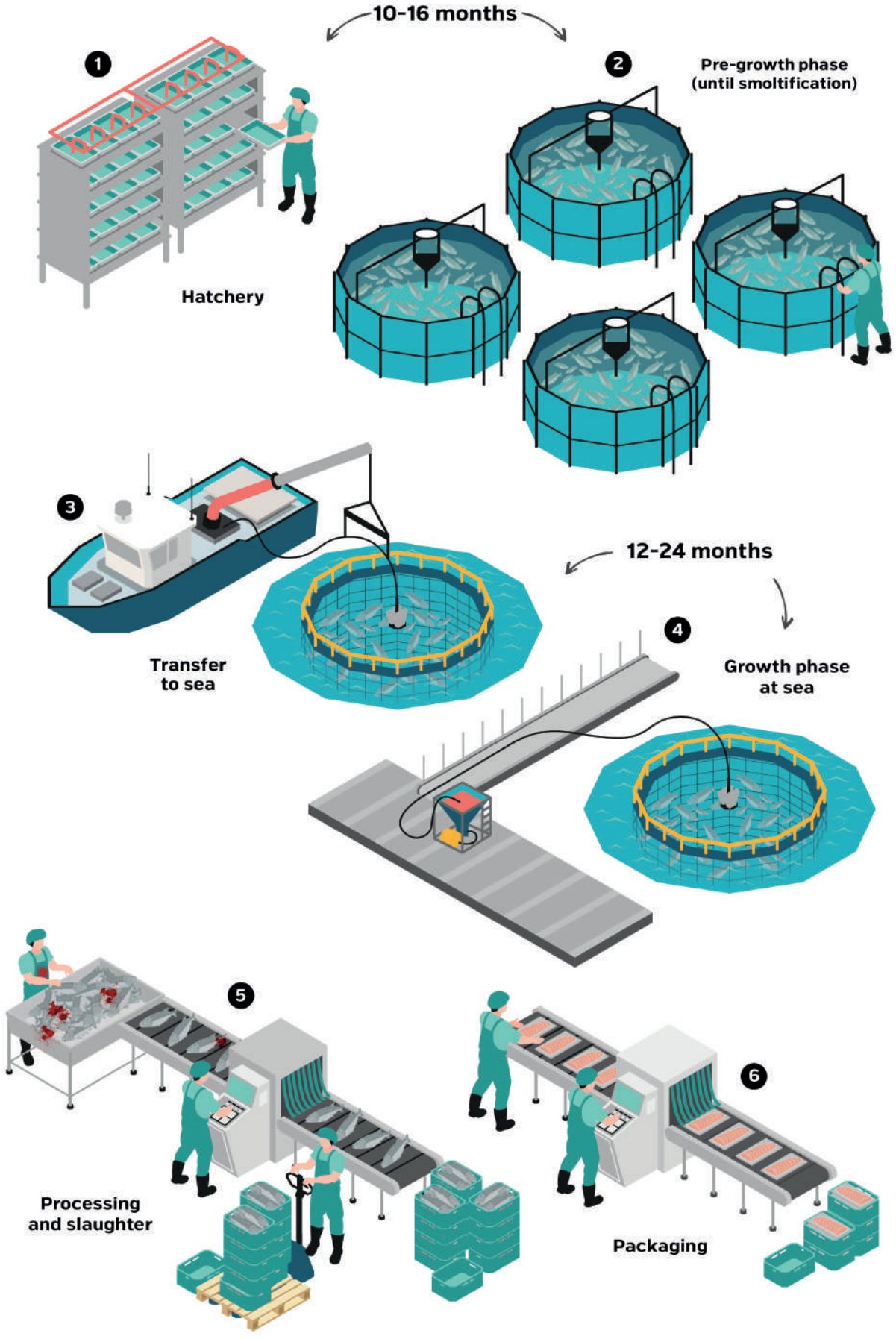


Figure 4: Production and Processing Cycle of Farmed Salmon
Source: Inspired by Mowi, Salmon Farming Industry Handbook 2019.

LAND-BASED INTENSIVE FARMING IN CLOSED TANKS: A RED HERRING

Under the guise of proposing an alternative solution to sea-based farming, the salmon farming industry has developed Recirculating Aquaculture Systems (RAS), aimed at increasing production capacities.

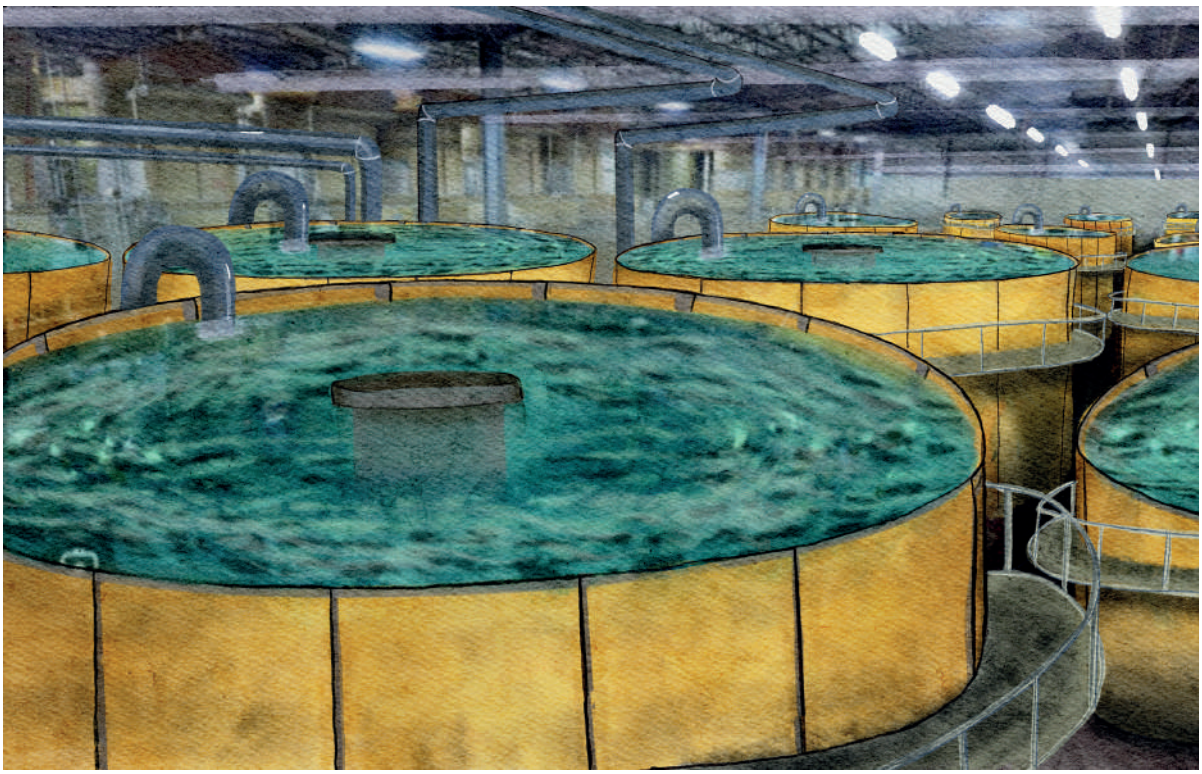
Instead of replacing them, these land-based farms complement conventional sea-based farms, thereby multiplying the impacts of the industry.

Land-based salmon farming in closed tanks relies on continuous water treatment. Fish waste is captured, water is filtered using various water treatment technologies, and then reintroduced into the farming system[16]. A small percentage of water is pumped and discharged daily (1 to 10%).

Currently, RAS technology is primarily used for early stages of salmon farming (hatcheries and pre-growing) before the fish are transferred to marine cages – as elaborated in section 3.1 above.

However, companies like Pure Salmon and Atlantic Sapphire aim to generalise this land-based farming method throughout the salmon's entire life cycle. They are part of a general trend of increasing salmon production, marked by Norway's goal to triple its annual production by 2050 to reach 5 million tonnes per year[17]. In France, several RAS development projects are currently under study or in the pre-installation phase.

Although farming salmon in closed systems theoretically prevents escapes, marine pollution, and genetic contamination of wild salmon, as well as reduces the need for antibiotics, significant issues persist. If the system is compromised due to technical failure, poor water quality, or disease, it can lead to accidents and mass mortalities.



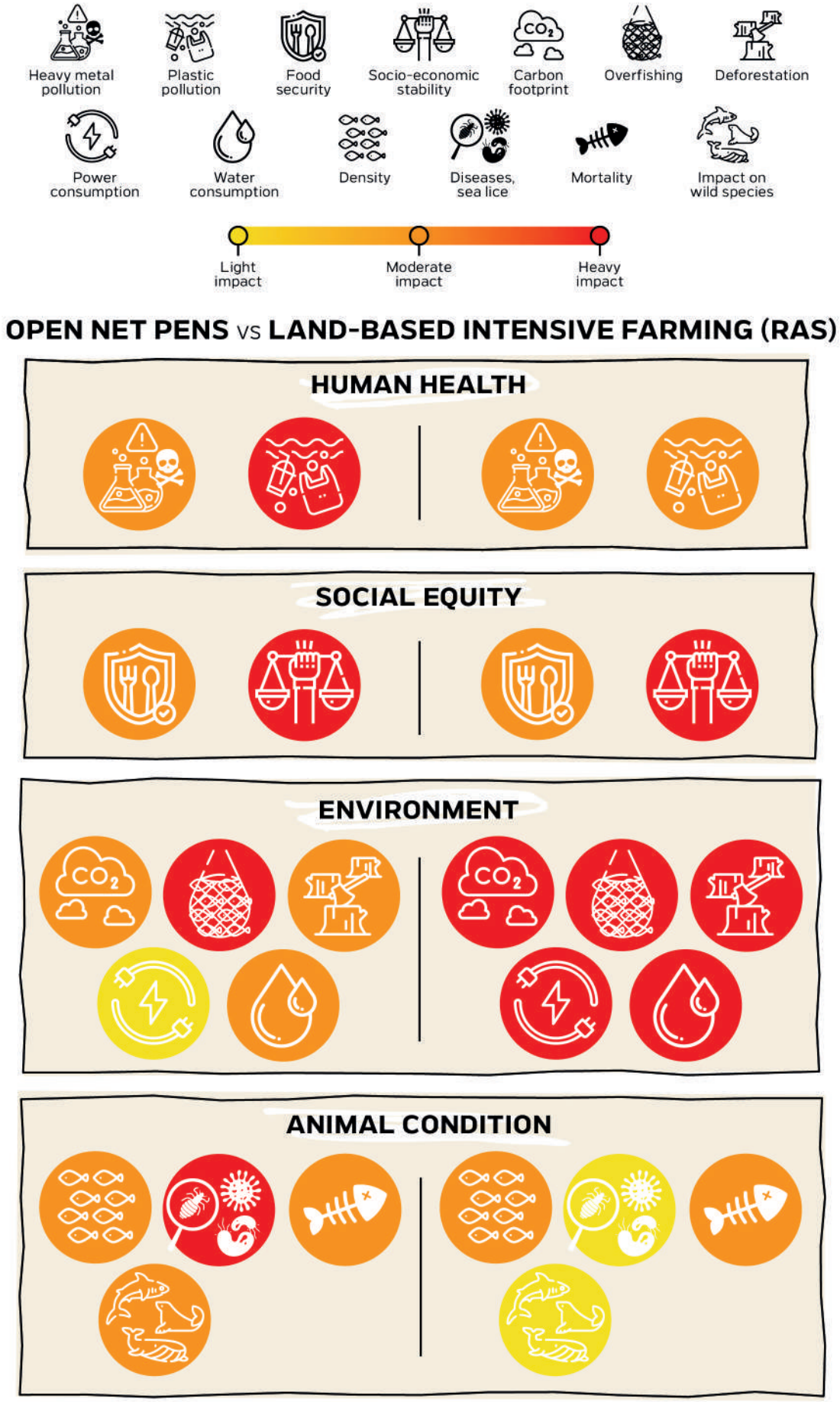


Figure 5: Comparison of salmon production techniques and their impacts.

Indeed, the technology is far from perfected. Scientific literature and specialised press have recently documented numerous malfunctions in water treatment equipment leading to air and water pollution, as well as extremely high and frequent mortality rates due to water quality issues. Furthermore, animal welfare is not adequately addressed[18], with fish densities ranging from 70 kg to 150 kg per cubic metre of water, equivalent to 14 to 30 salmon of 5 kg per cubic metre. Thus, RAS poses significant challenges regarding fish welfare given such stocking densities, necessary to offset the costs of the technology and improve profit margins.

In addition to this major problem, the environmental impact of feeding salmon has not been resolved.

On the contrary,

this type of farming only increases environmental pressures by boosting fishmeal consumption, thereby exacerbating overfishing, marine ecosystem imbalance, and resource plundering in the Global South associated with the farming of carnivorous fish.

Additionally, RAS farming is extremely energy-intensive[19] and consumes large amounts of water and electricity[20]. A 10,000-tonne farm consumes 100,000 MWh per year, equivalent to the energy consumption of a city with over 39,000 inhabitants[21]. The carbon footprint indicator for land-based RAS farming is not yet stabilised, varying from 2 to 14 kg CO_2/kg[22] depending on the energy mix used (coal, solar, wind, nuclear, hydro, etc.). Therefore, in a context of energy sobriety and transition, it seems pertinent to consider absolute values by analysing the additional annual electricity consumption needed to operate this type of farming.

The pursuit of profit that drove technological advancements, unfortunately, did not include investments in research and development aimed at better addressing the environmental and health impacts of aquaculture, let alone animal welfare.

Warnings from scientists and civil society have also fallen on deaf ears, as industry leaders favour a techno-solutionist approach with marginal restrictions, without questioning the intensive farming methods of carnivorous fish or considering planetary boundaries.However, this quest for infinite growth is neither sustainable nor desirable, as evidenced by its disastrous impacts on the environment, animals, and society as a whole.

> “ The collective imagination surrounding salmon intended for human consumption has managed to mask the numerous detrimental effects of the salmon farming industry: ecological disasters, ressource grabbing from certain southern countries, threats to human health and animal suffering. ”

04

CHAPTER 4

PLANET, ANIMALS AND HUMAN SOCIETIES: *THE VICTIM OF AN INDUSTRY WITH DEVASTATING EFFECTS*

Marketed as a cornerstone of a healthy diet, salmon is actually one of the animal species whose farming has the most harmful impacts from a multisectoral perspective. The collective imagination surrounding salmon intended for human consumption has managed to mask the numerous detrimental effects of the salmon farming industry. As detailed in the following pages, feeding salmon leads to ecological and social disruptions, their farming conditions cause suffering and economic losses, and their flesh, contaminated by a polluted ocean, poses threats to human health.

FEEDING SALMON; ECOLOGICAL DISASTERS AND RESSOURCE GRABBING FROM CERTAIN SOUTHERN COUNTRIES

Salmon are carnivorous fish: while their diet now includes plant proteins, animal meal is also widely used. The so-called fishmeal fishery, which supplies salmon farms with small fish for feed, decimates wild fish populations and exacerbates food insecurity in certain regions. Soy protein, used as a partial substitute for fish meal, poses serious ecological problems due to the deforestation of the Amazon rainforest. In both cases, the salmon industry downplays these ecological and social justice concerns behind self-created ecolabels or highly criticised certifications such as the Marine Stewardship Council (MSC) or the Aquaculture Stewardship Council (ASC)[23].

Fishmeal fisheries and animal meal: between biodiversity decline and food insecurity

To feed and raise a single farmed salmon, up to 440 wild fish need to be caught[24]:

A significant volume with severe consequences, inducing overfishing in sensitive areas and undermining food sovereignty in many countries, particularly in West Africa.

Overfishing in Antarctica and West Africa

The concept of overfishing might suggest that some portion of industrial fishing could be sustainable. This approach is problematic as only 7% of fish species are currently fished within biologically sustainable limits, while 92% are either fully exploited or overfished. Aquaculture significantly disrupts ecosystem health through fishmeal fisheries, an unsustainable practice targeting small forage fish, which are a crucial link in the food chain for predators like tuna, salmon, and sharks. Globally, catches by industrial fleets represent 20 to 30 million tons of fish, accounting for a quarter of global fish catches and a vast majority of small pelagic fish catches.

In West Africa, for example, pelagic fish such as sardines, sardinella, horse mackerel, mackerel, and anchovies are targeted by the industry because they are highly nutritious for carnivorous fish and thus constitute the main source of fish used in the production of fish meal and fish oil. Overfishing these fish not only threatens marine ecosystems but also contributes to bycatch—the incidental capture of species that prey on these fish, which then get trapped in the nets. Approximately 300,000 dolphins and small whales, 250,000 turtles, and 300,000 seabirds are killed each year[25], levels of mortality that sadly add to the imbalance of the ecosystem.

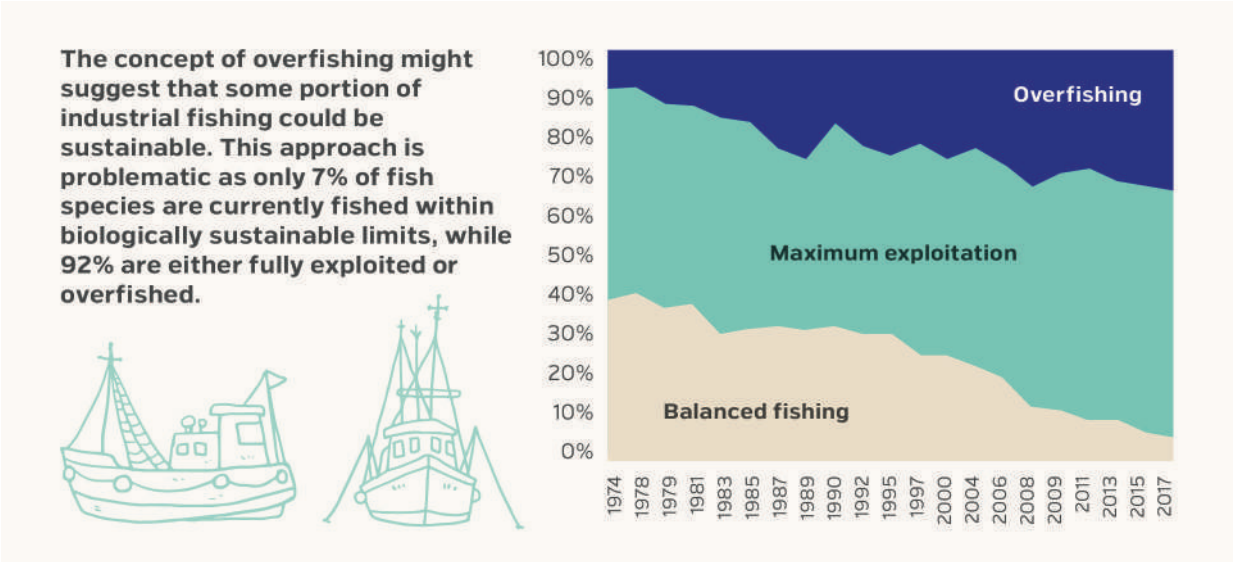


Figure 6: State of overfishing in global fish catches.
Source : FAO, The State of World Fisheries and Aquaculture 2022.

In Antarctica, krill fishing is not without its own issues. Antarctic krill is a tiny shrimp-like pelagic crustacean that grows to no more than 4 cm and feeds on phytoplankton. It is the cornerstone of the Antarctic ecosystem. Krill plays a crucial role in the food chain, serving as essential food for many animals like whales, seals, and squids that depend on it—krill covers 96% of the caloric needs of seabirds and marine mammals[26]. Additionally, krill plays a role in atmospheric carbon regulation and storage through its faeces and moulting, which sequester carbon and transport it to the ocean floor.

However, Antarctic krill is harvested in significant quantities each year by factory trawlers to produce krill meal, which is used as a feed additive in aquaculture and to colour farmed salmon. Krill contains a natural pigment, astaxanthin, which is used in the diets of farmed salmon to give their flesh a pink hue. On average, it takes about 6.5 tons of krill to produce one ton of krill meal[27].

"Krill contains a natural pigment, astaxanthin, which is used in the diets of farmed salmon to give their flesh a pink hue."

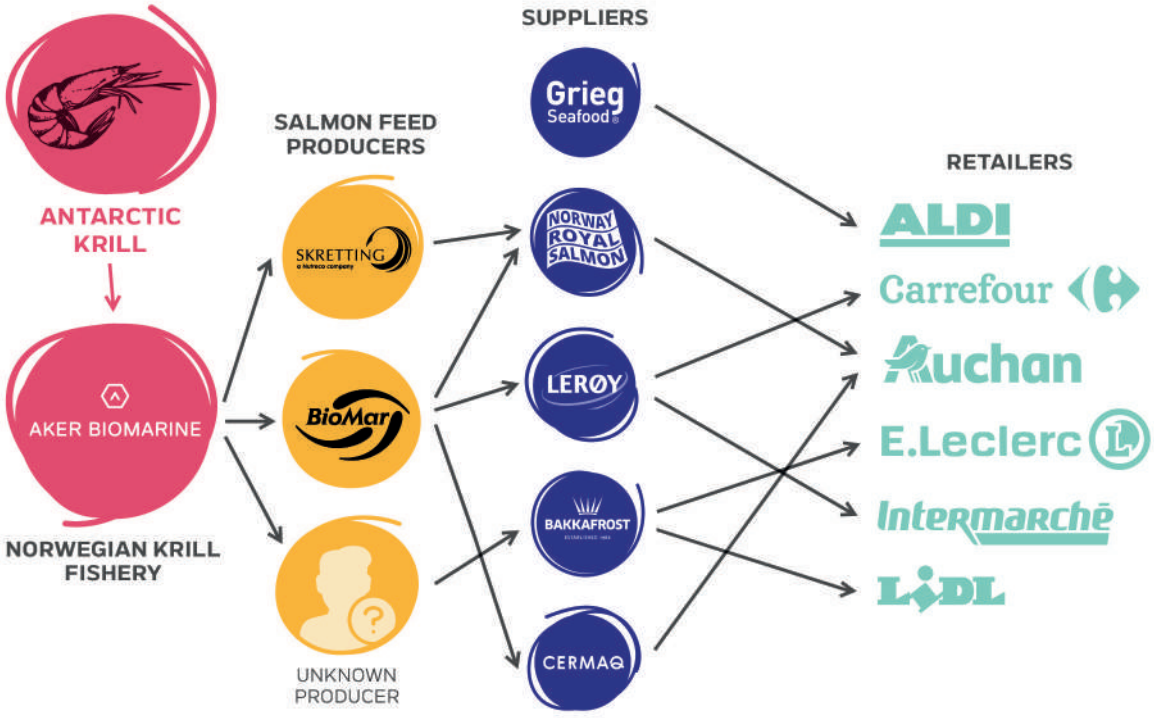


Figure 7: Krill meal supply chain.
Source : Based on Changing Markets, Krill baby krill - The corporations profiting from plundering Antarctica, 2022.

Targeted krill fishing, concentrated in specific areas already under pressure, exacerbates the threats to krill and its predators, creating competition between fishing vessels and key species like penguins and seals in their feeding grounds.
Studies suggest that limited krill availability compromises the reproduction of female fur seals28 and forces crabeater seals to turn to alternative prey or embark on longer foraging trips.

The study conducted by the Changing Markets Foundation highlights the inherent unsustainability of the krill fishing industry, which endangers the Antarctic ecosystem29. Beyond the fishing industry, retail, fish farms, and fish feed manufacturing plants, 16 major supermarket chains in Europe are also involved30, regularly selling farmed salmon products fed with krill without adopting policies to exclude this practice.

In the context of climate emergency, continuing to fish Antarctic krill at the expense of the essential ecosystem services it provides actively contributes to biodiversity decline and global warming, the consequences of which are exacerbating social inequalities.

Different regions of the world are not impacted equally by climate change. Africa is the most severely affected continent[31], facing not only climatic challenges but also socio-economic turmoil, further exacerbated by the weakening of food sovereignty caused by the salmon farming industry.

Food hypocrisy in the North, cycle of impoverishment in the South

While claiming to help feed a growing global population, aquaculture companies often export valuable resources from certain Southern countries to high-income markets, displaying a stark hypocrisy and ignoring the socio-economic realities of these nations.

Firstly, the incorporation of crops such as soy, which could be directly used for human consumption, represents an inefficient use of resources[32]; the same applies to fish destined to be processed into fishmeal for aquaculture. According to scientists, 90% of the fish captured through fishmeal fisheries could be used to directly feed humans[33].

The fishmeal fisheries required by the salmon farming industry, along with the waste of millions of tonnes of fish that are typically crucial food resources for some West African populations, lead to diminished livelihoods, intensified malnutrition, and disrupted socio-economic balances in countries like The Gambia, Senegal, and Mauritania.

In Senegal and The Gambia, pelagic fish provide 65% of the populations' animal protein needs. This nutritional contribution is deteriorating, with fish consumption in Senegal alone decreasing by 50% between 2009 and 2018 due to a reduction in the availability of small pelagic fish[34], caught mainly to feed farmed salmon that the Senegalese population will never see, as the markets are mostly in the West.

Indeed, for its salmon farms, Norway fishes or imports 2 million tons of wild fish annually, of which 123,000 to 144,000 tons come from West African waters[35].

This volume could meet the annual nutritional needs of 2.5 to 4 million people in the region,

More than the population of The Gambia (2.7 million) and nearly the total population of Mauritania (4.7 million).

Dozens of fishmeal factories have been built over the past twenty years, particularly in Mauritania and Senegal, and are now taking catches from local small-scale fisheries. This development has undermined the fish processing and valorization sector (notably drying and smoking), which employed thousands of women. France, being the first European consumer of salmon and the fourth in the world, is significantly contributing to this overfishing and the weakening of food sovereignty in West African countries.

In these geographical areas, affecting the right to access food, to which the salmon farming industry contributes, causes multiple socio-economic issues. By seizing the food resources of already food-insecure populations, the industry exacerbates and contributes to the cycle of impoverishment[36] that primarily affects women and children.

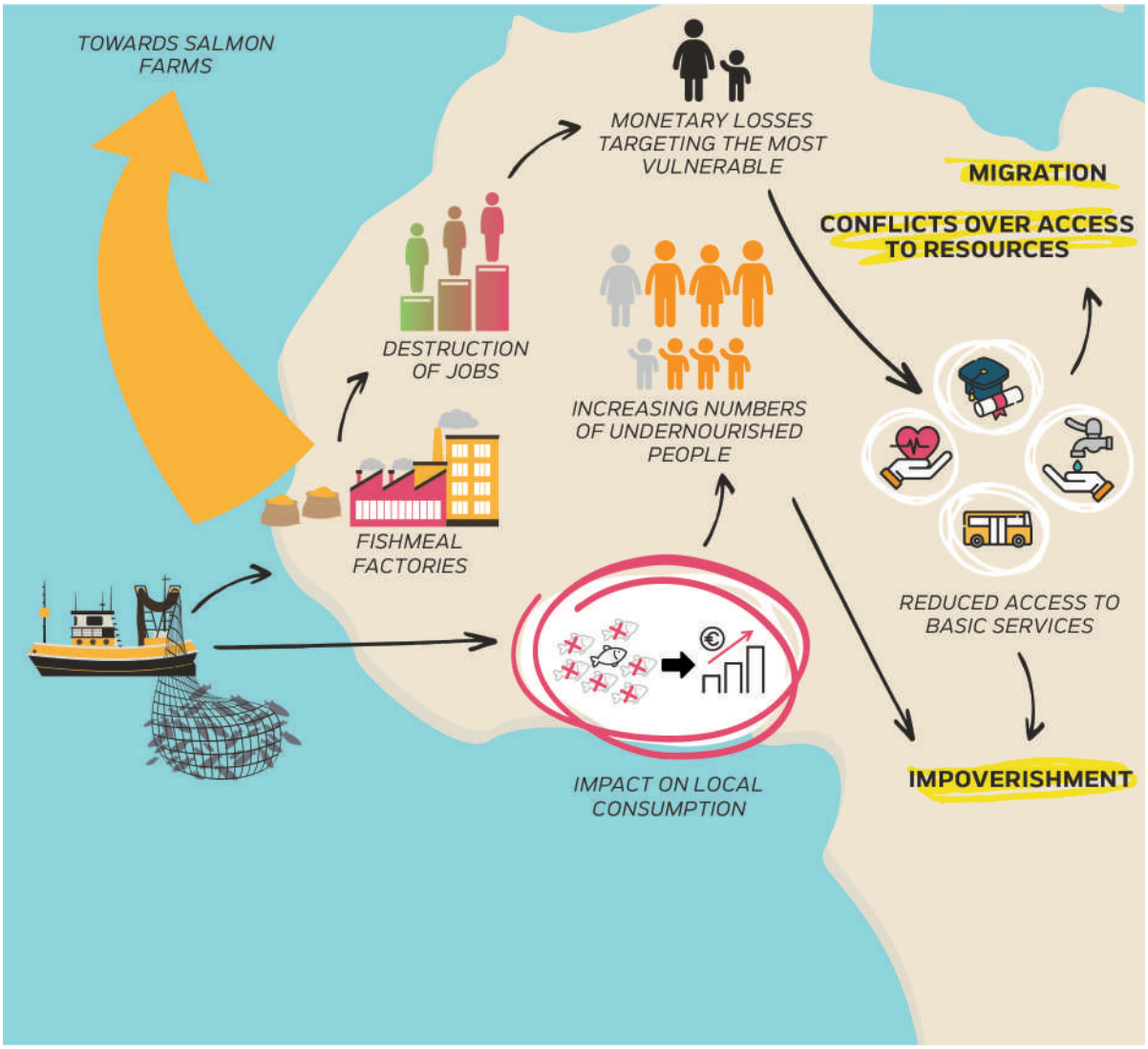


Figure 8: Cycle of impoverishment in certain West African states.

- The very high global demand for fishmeal for aquaculture is driving up the prices of forage fish.
- The decline of migratory fish in West Africa is increasing fish prices.
- The reduction in fish consumption contributes to nutritional challenges.
- The number of undernourished people is rising, with negative effects on health and education.
- Economic losses and job displacement in traditional fishing and fish processing are emerging, particularly affecting women.
- Prolonged unemployment and lack of income pose dangers.
- The right to food is being affected, leading to conflicts.
- Overfishing disproportionately impacts local fishing communities.
- The induced pauperization contributes to migration and conflicts.
- The decline in fish populations disrupts ecosystem functions and directly impacts predators (fish, mammals, and seabirds).
- Dietary shift to protected mammal species[37].

To counter the decline in fish populations caused by fishmeal fishing, the salmon farming industry has chosen to increase the share of plant proteins in salmon feed by expanding soybean cultivation in the Amazon.

Plant-based meal at the cost of deforestation in the Amazon

To reduce dependence on wild-caught fish for feeding farmed salmon, fish feed production companies are substituting fishmeal with soy protein, thereby reducing the marine component of the ingredients from 90% to about 30%[38]. The aquaculture industry is thus strongly linked to the Brazilian soy industry.

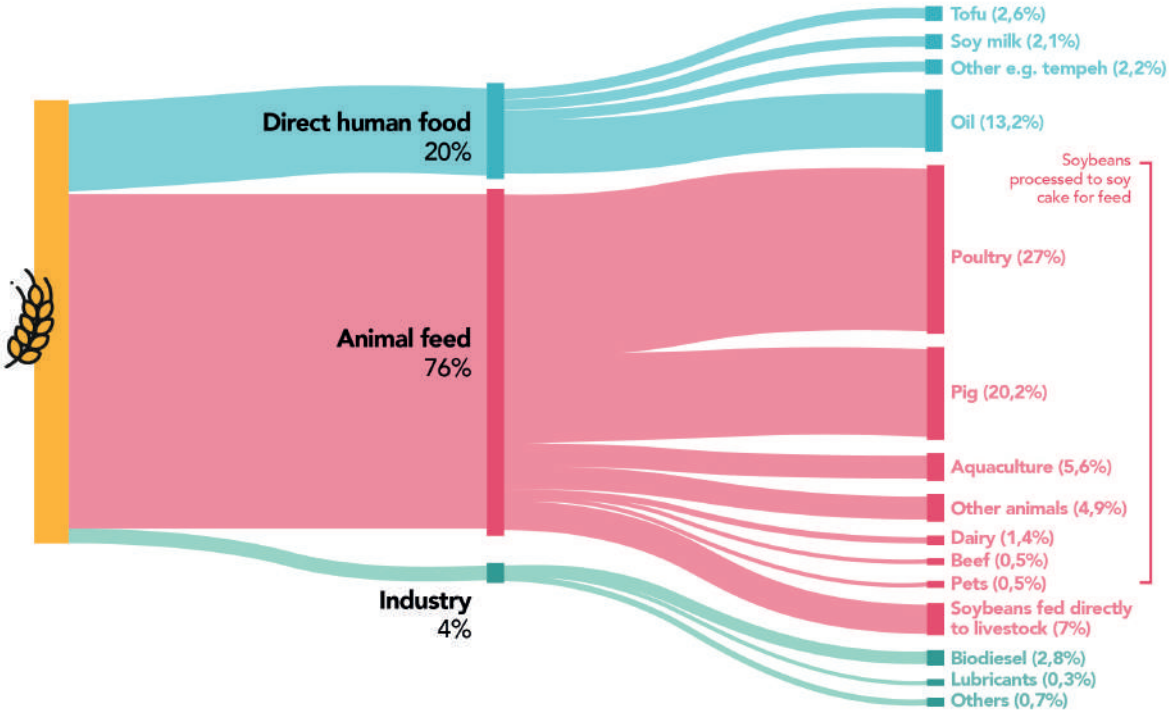


Figure 9: Who is the world's soy going to?
Source : Food Climate Resource Network (FCRN), University of Oxford, USDA PSD Database.

This poses major challenges in terms of deforestation[39], ecosystem degradation, land grabbing from indigenous peoples, resource depletion, and greenhouse gas emissions, which are further exacerbated by central Amazon fires associated with soy cultivation expansion. Previous studies based on life cycle assessments (LCA) demonstrate that fish feed is the primary contributor to environmental impacts within the Norwegian aquaculture industry[40].

Yet, soy – Soy Protein Concentrate (SPC) – has become one of the main components of fish feed used in Norway. According to WWF, for a 100g salmon fillet, 95g of soy were used in 2020[41], making salmon the second-largest consumer of soy after chicken (96g for 100g of chicken). The expansion of soy production in Brazil, necessary for the manufacture of soy protein concentrate imported to Norway, covers more than 2,500 km² of agricultural areas[42]. Most of the salmon production sources its soy from the ProTerra certified program, which ensures that the soy does not come from recently deforested areas – a certification that does not exclude dual sourcing from suppliers and therefore, indirect deforestation[43], as explained by Rainforest Foundation Norway.

This expansion of soy cultivation leads to both legal and illegal deforestation, promoting forced labor[44], irregularities in pesticide use, the encroachment of soy cultivation on indigenous lands, and causing globally significant ecosystem losses[45] as well as increased deterioration of the vulnerable Amazon habitat[46]. Deforestation directly impacts five sustainable development goals[47].

Faced with the lack of transparency throughout global supply chains, the European Union has decided to act. Starting January 1, 2025, the regulation against

imported deforestation will come into effect. It prohibits placing products on the market or importing them from the European market if they have contributed to deforestation or forest degradation after December 31, 2020[48].

However, the situation in the Amazon remains very problematic.

Since 2010, the world's largest tropical forest has been producing more CO_2 than it absorbs[49], contributing to the worsening climate crisis.

Deforestation continues at varying levels depending on the government in power; under Jair Bolsonaro, it increased by 22% in just one year. In Brazil, protection and compensation mechanisms are failing. Soy producers, livestock farmers, and timber merchants find ways to circumvent agreements and legislation[50], making it nearly impossible to guarantee soy that is not derived from deforestation.

The salmon farming industry, in addition to contributing to Amazon deforestation and overfishing, is also a major vector of CO_2 emissions.

A pink carbon bomb

Currently, sea farming produces an average of 10 kg CO_2 per kg of salmon produced[51]. As for land-based farming, its carbon footprint varies depending on the energy mix considered in the calculation methodology, ranging from 2 kg CO_2 to 14 kg CO_2 per kg of salmon produced[52]. In comparison, broiler chicken production ranges from 7 to 10 kg CO_2 per kg produced[53].

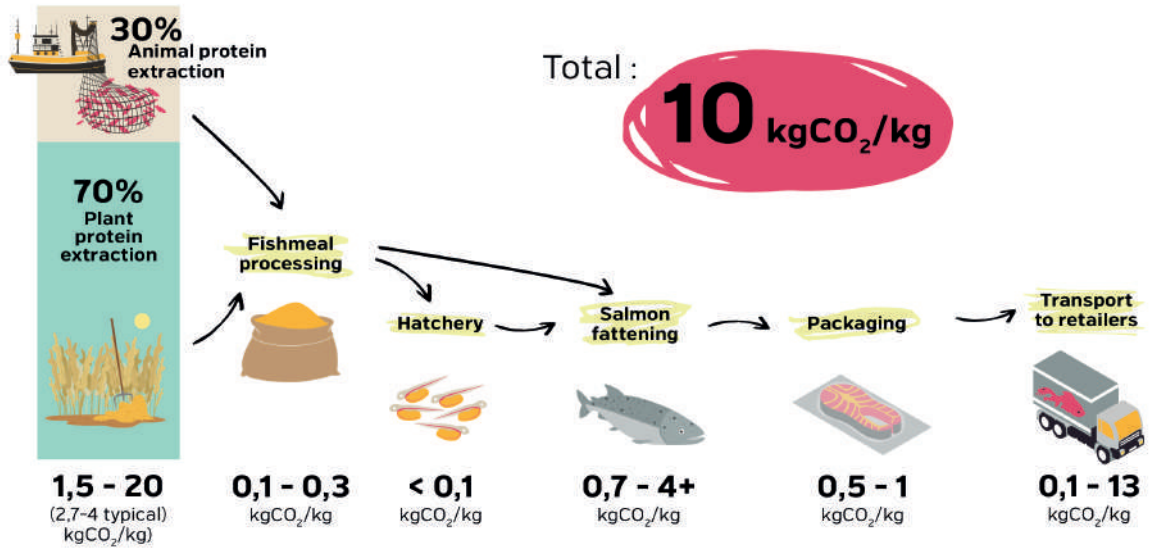


Figure 10: GHG emissions in farmed salmon supply chains
Source: Inspired by Emily Moberg, Katherine Pan, Juliet Liao, Alex Paul-Ajuwape, WWF, Measuring and Mitigating GHGs: Salmon, 2022.

Salmon feed, which is composed on average of 30% marine products (fish meal and oil or krill) and 70% plant-based products (mainly soy), is the primary driver of GHG emissions in salmon production, regardless of the farming type (79.6%)[54]. For sea farming, salmon feed production contributes to more than 80% of the impacts in terms of ozone depletion, global warming potential, acidification, and ecotoxicity[55].

Transportation accounts for only 8.4% of the GHG emissions in salmon production. Therefore, contrary to what some industry players advocating for land-based farms in France suggest, producing salmon locally and reducing transportation does not mitigate the sector's GHG emissions.

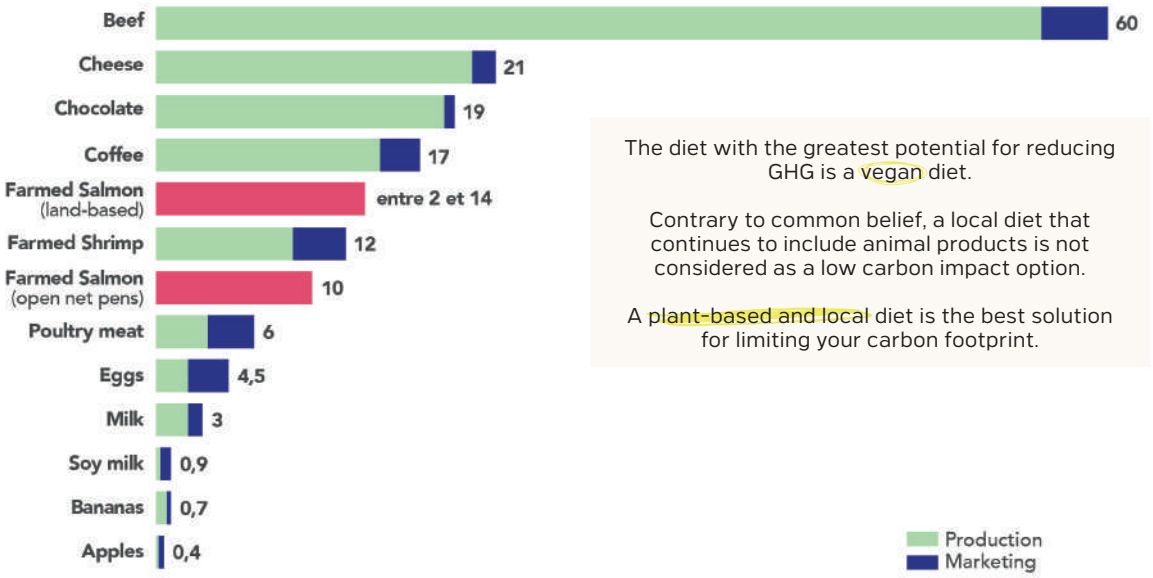


Figure 11: GHG emissions in food choice supply chains
Source : based on the Poore and Nemecek (2018) infographic. Reducing food's environmental impacts through producers and consumers. Adapted into French by Maxime Allibert (@BonPote). For sea-farmed salmon, we used the most recent source cited above, WWF, Measuring and Mitigating GHGs: Salmon, 2022.

Among the environmental pressures exerted by salmon farming[56], 69% are related to their feed[57]. Furthermore,

Contrary to common belief, a local but carnivorous diet (fish and meat) has a higher carbon footprint than a plant-based diet, even when the latter involves more transportation.

Thus, a local plant-based diet is the preferred solution for reducing one's carbon footprint. While the feed for farmed salmon causes significant ecological and social damage, the farming conditions and practices used are also problematic, both for the animals and for the societies bearing the economic costs incurred.

THE HIDDEN SIDE OF INTENSIVE FARMING CONDITIONS: ANIMAL SUFFERING AND ECONOMIC COSTS

Beyond slaughter practices, the farming conditions of salmon lead to significant suffering and high mortality rates for both the fish in cages and the neighbouring species around the farms. These poor practices also incur substantial economic costs.

From marine cages to the Ocean: polluted marine habitats and threatened neighbouring species

Open net pens salmon farms have significant impacts on water quality and, more specifically, on the marine ecosystems in which they are located. They are therefore a source of ecological imbalance, threatening many wild aquatic species.

The main sources of water and habitat pollution include:

- Waste from uneaten food and excrement
- Treatments for diseases and sea lice[58]
- Escapes of farmed salmon

Massive nutrient discharges contribute to high levels of nitrogen and phosphorus in the local environment, stimulating phytoplankton *blooms*[59]. The risks of eutrophication and oxygen depletion increase with rising water temperatures and can lead to mass mortality events for salmon and other aquatic species.

Various chemical treatments for diseases and parasites, whose effectiveness relies on relatively high concentrations[60] and are incorporated into salmon feed or dispersed in the water, lead to unavoidable pesticide discharges into the sea[61]. Among the insecticides toxic to aquatic life, deltamethrin[62] is still widely used by both conventional and organic farms. It causes high mortality rates in shrimp and is highly toxic to lobsters within a radius of up to 39 square kilometres around the farm[63]. In Australia, the maugean skate, an endemic species of Tasmania, is on the brink of extinction due to farms established in its natural habitat[64].

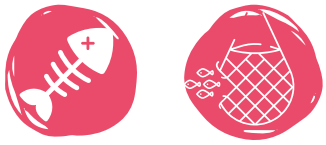
In addition to water degradation, surrounding wildlife is also threatened by escapes of farmed salmon[65] and lethal predator control policies. For example, in Scotland, 1,956 seals have been shot since 2011 to protect farmed salmon. Escapes of farmed salmon promote hybridization and the spread of lice and bacterial, viral, and fungal diseases, leading to increased mortality of wild fish. In Norway, it is estimated that lice from farms kill 50,000 wild salmon annually[66], a species that has been nearly threatened since 2023. The conclusion is clear: escapes of farmed salmon reduce the genetic diversity of wild salmon populations, thereby decreasing their survival capacity. This is one of the factors explaining why the number of salmon and trout returning to rivers is steadily decreasing. Globally, it is estimated that the presence of salmon farms leads to an average decrease of 12 to 29% in the number of adult wild salmon[67].

“escapes of farmed salmon reduce the genetic diversity of wild salmon populations, thereby decreasing their survival capacity”

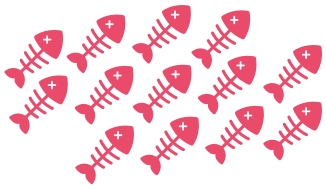
Diseases, stress and mortality in cages : suffering salmon from egg to plate

From 2010 to 2019, the 10 largest multinational companies were responsible for the loss of 100 million salmon, either dead or escaped[68]. This situation has worsened, as just in 2023 in Norway[69], 100 million salmon died[70], with a 16.7% mortality rate in marine cages[71], the highest ever recorded. In Scotland, this rate averaged 24% between 2012 and 2017[72].

100 MILLION
SAMON DIED
FROM 2010 TO 2019
IN THE WORLD



100 MILLION
SALMON DIED
IN 2023 IN NORWAY



Globally, in 35% of cases, the main cause of mortality is sea lice, followed by diseases and algal blooms, which are due to pollutants[73]. Various factors contribute to these high mortality rates in salmon farms, primarily high stocking densities that inherently cannot respect animal welfare. Poor living conditions result in deformities, disease being spread, fish stress, sea lice proliferation, and predator attacks.

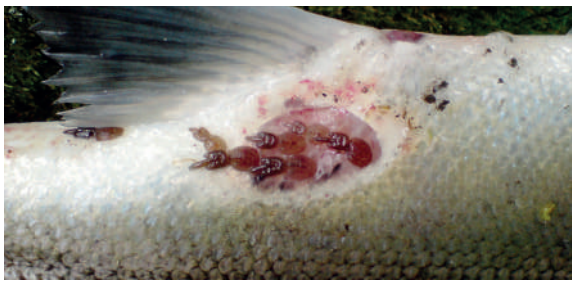
Sea lice are parasites that, once attached to salmon, feed on the mucus, skin, and tissues of the fish. They cause open wounds that, by reducing immune capacity, can lead to death[75].

In Norway, the two main causes of salmon mortality in sea farms are heart attacks and «non-medicinal» methods used to prevent these parasites[76]. These methods include cleaner fish, hot or cold water baths, or high-pressure water jets. These practices are ineffective, inadequate, and cruel, causing suffering and mortality for both salmon and cleaner fish[77], as well as wild fish[78].

Salmon also fall victim to predator attacks from which they cannot escape. Major threats include seals, tuna, and jellyfish, which cause severe burns and high mortality rates. In Scotland, 500,000 salmon die each year directly from predators or indirectly from the stress they cause[79]. The increase in mortality also stems from the warming seas[80] and the fact that most viable sites have already been exploited, leading to a shortage of suitable coastal areas for marine cage farming[81].

However, Article 13 of the TFEU recognizes fish as sentient beings[82]. To date, there is scientific evidence based on physiological, behavioural, and neuro-anatomical studies showing that fish can feel pain and emotions, and therefore can suffer[83].

Despite this, there are still no regulations addressing these animal welfare imperatives in the salmon farming industry. Besides causing animal cruelty, these intensive farming conditions also result in economic costs that burden society.



The economic cost of poor farming techniques

The poor farming conditions for salmon have significant economic costs, particularly affecting the economies of the four main salmon-producing countries (Chile, Norway, Canada, and Scotland[84]).

Since 2013, salmon mortality and escapes have incurred an estimated cost of $15.5 billion. Contributing factors include ocean warming, algae blooms, parasites, diseases, and associated treatments.

Specifically, the cost of sea lice control technology alone amounts to 4 billion dollars a year: the high densities required for increased productivity increase the risk of contamination .

Beyond environmental and social impacts, the feed based on fishmeal and fish oil from wild fish costs $8 billion annually. This amount is expected to rise due to the pressure on declining fish populations.

Therefore, refusing to participate in and invest in the most destructive practices of the current food system would not only avoid unnecessary costs burdening society but also protect human health from exposure to toxic substances that heavily contaminate fish flesh.

OCEAN POLLUTION, CONTAMINATED FISH, AND HUMAN HEALTH UNDER THREAT

Salmon is the second most consumed fish species in France. Recommended for its omega-3 content, salmon is one of the fish species with the highest levels of pollutants, known as persistent organic pollutants (POPs), such as PCBs[86] and PFAS[87], primarily due to its fat content. Additionally, salmon are not immune to the numerous microplastics that pollute aquatic habitats.

A duo of omega-3s and toxic products

While fish flesh contains omega-3s, essential fatty acids for the human body that it cannot synthesise without external intake, it is also loaded with toxic elements, notably POPs. These organic substances are persistent (slow to degrade in the environment), mobile (transported over long distances), bioaccumulative (accumulate in living organisms), and toxic (carcinogenic and neurotoxic, they can also cause immune and reproductive system disorders).

Among these are PCBs and PFAS, chemical compounds formerly used in various industrial or agricultural activities and now widespread in the environment. They accumulate in the fatty tissues of animals, especially fatty fish who have come in contact with contaminated sediments or food, and their concentration rises the higher up the food chain you go.

The accumulation effect on top trophic level carnivorous fish, which consume already contaminated fish, makes salmon one of the species most loaded with toxic products. Consequently, humans who consume them are also exposed to POPs.

In general, regular fish consumption presents risks. The European Food Safety Authority indicates that high fish flesh consumption could lead to exceeding the acceptable weekly mercury intake by six times[88].

POPs enter salmon in two main ways. Firstly, through the chemical treatments used during farming to manage parasites and diseases (see section 2 of chapter 4 on animal health), and secondly, through the ingredients in salmon feed. The pellets fed to salmon consist of vegetable proteins made from soy—a crop reliant on pesticide use—and marine animal proteins that bioaccumulate PCBs present in water, plankton, and the entire food chain.

For example, PBDEs, flame retardants used to slow the ignition and spread of fires, are endocrine disruptors whose concentration increases with fat content. Salmon, along with mackerel, anchovy, sea bass, and sardine, exhibit high average contamination levels[89].

Paradoxically, the idea that eating organic is healthier proves false in the case of salmon. Organic AB or “Label Rouge” certified salmon contains the most PCBs. To understand this paradox, one must look at its feed: “Label Rouge” requires 51% marine-based ingredients, leading to a greater bioaccumulation effect.

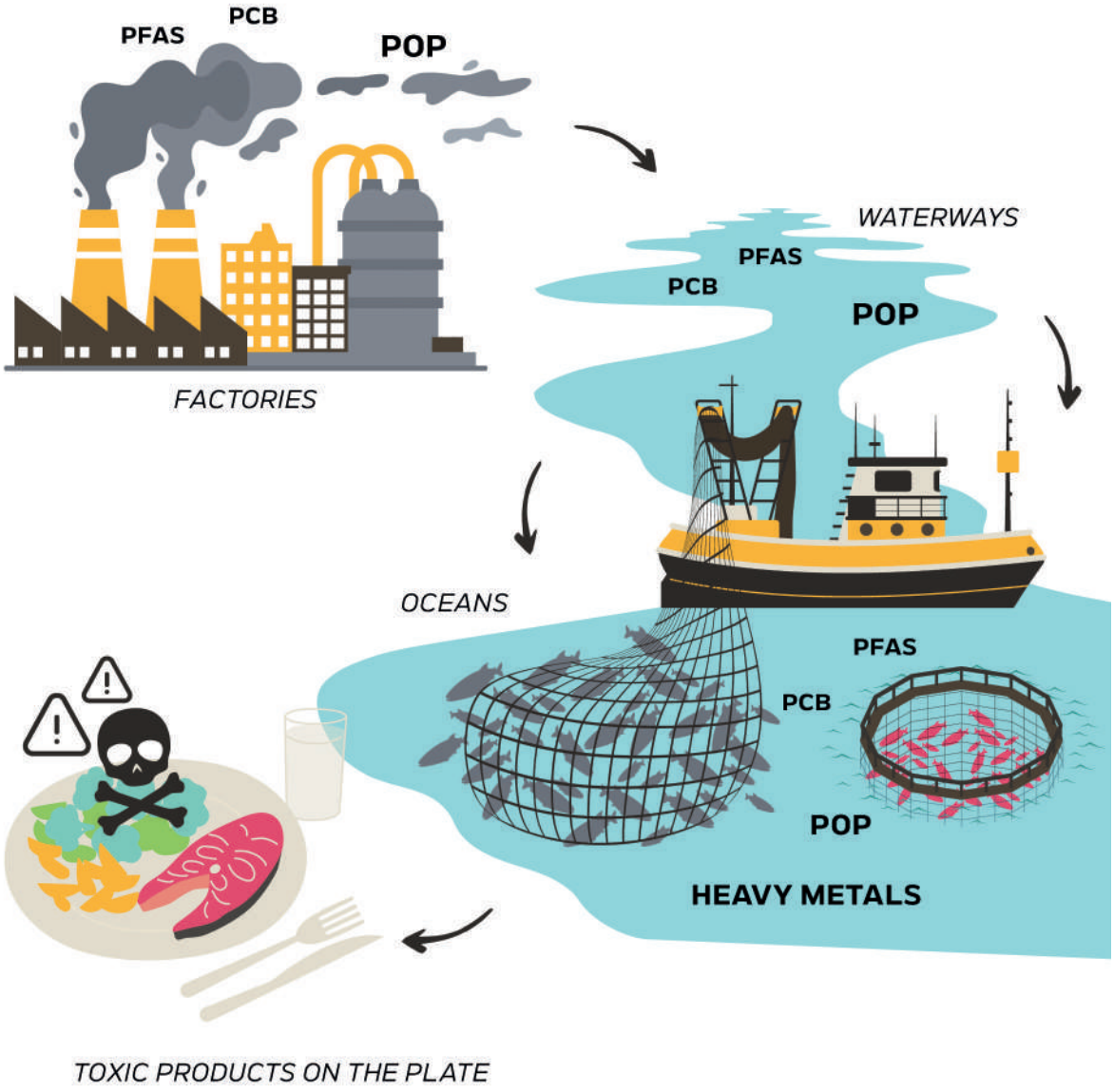


Figure 12: How eternal pollutants find their way to the table

More recently, PFAS have been identified as highly present in fish flesh. The European Food Safety Authority (EFSA) estimated in 2018 that fish and other seafood accounted for up to 86% of dietary PFAS exposure in adults[90]. Norwegian scientific studies[91] linked high PFAS concentrations in women of childbearing age to their salmon consumption.

In addition to toxic elements like PFAS and PCBs contaminating salmon destined for human consumption, microplastics are omnipresent in aquatic habitats. These microplastics also carry numerous chemical contaminants ingested by fish and, consequently, by people who consume them.

Microplastic contamination: a plague for salmon, the environment, and humans

Transported through the water cycle, microplastics, originating from the degradation of larger plastic products, now impact nearly all aquatic habitats. They are easily ingested by a wide variety of aquatic organisms, including fish[92]. Microplastics have been proven to have numerous negative effects on both wildlife and human health, including digestive, respiratory, immune, and reproductive issues[93].

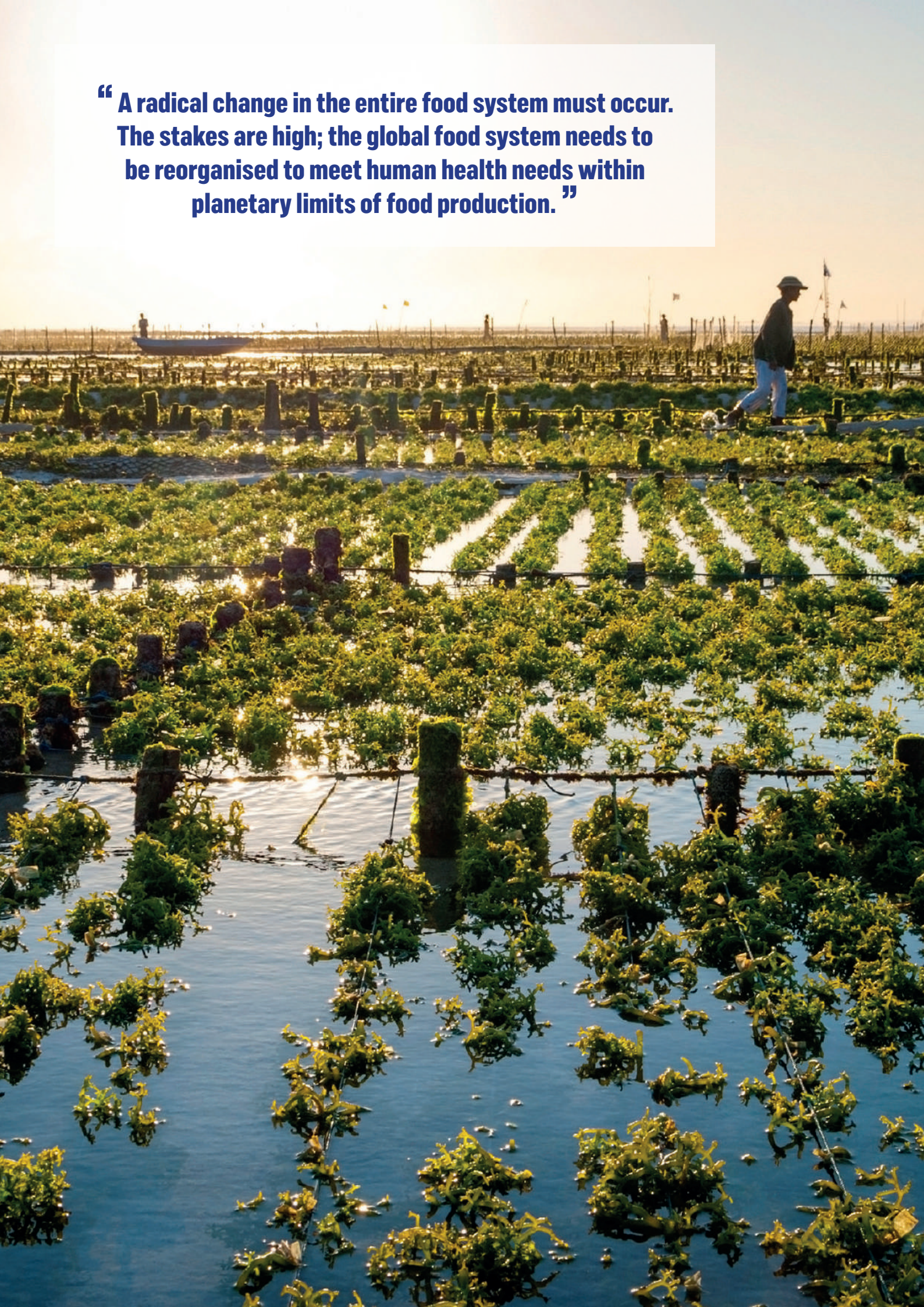
A recent study estimates that over 300 million microplastic particles are released into the ocean annually by marine aquaculture alone[94]. Their presence has been detected in the liver and muscles of both farmed and wild salmon[95]. Fish and seafood are among the main sources of human microplastic consumption, ranking fifth[96] after bottled water, alcohol, air, and tap water.

Two phenomena explain the accumulation of plastics in salmon: bioaccumulation, similar to heavy metals and other toxic elements mentioned earlier, involves the accumulation of pollutants up the food chain each time one species eats another. Secondly, the lipophilicity (or hydrophobicity) of plastics, meaning that plastics attract fatty substances. Farmed salmon, which are much fatter than wild salmon — three times as fat in Norway[97]— and live in a plastic-rich environment, are particularly impacted by microplastic contamination. Indeed, farming installations are mostly made of plastic, including cages, buoys, pontoons, and nets. The abrasion and wear of these elements release large quantities of microplastics into the environment.

These hydrophobic particles absorb many other pollutants, such as POPs, often from the pesticides present in salmon feed. As mentioned earlier, POPs are persistent, bioaccumulative, toxic, and mobile organic substances, whose adsorption by plastic amplifies both their toxicity and mobility. A study published in 2022[98] showed that microplastics found near salmon farms can adsorb the POPs contained in the feed given to salmon and transport them into the marine environment, further exacerbating the environmental and health impacts of salmon farms.

Therefore, fish consumption, particularly salmon, is one of the main sources of human exposure to persistent organic pollutants and microplastics. To reduce human exposure to these substances, plant-based omega-3 fatty acids are an accessible option with lesser environmental impacts.

> **“A radical change in the entire food system must occur. The stakes are high; the global food system needs to be reorganised to meet human health needs within planetary limits of food production.”**



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CHAPTER 5

TOWARDS HEALTH, ACCESSIBLE, *PLANET-FRIENDLY FOOD CHOICES*

It is undeniable that a radical change in the entire food system must occur. The stakes are high; the global food system needs to be reorganised to meet human health needs within planetary limits of food production.

The objective is to ensure healthy diets through sustainable production structures capable of feeding nearly 10 billion people by 2050.

Removing salmon from food production systems is a crucial first step in initiating this movement. This transformation relies on shared responsibility and multi-level action.

Leading the way, governments have the responsibility to implement public policies for food system transition, improving the availability and accessibility of healthy foods and investing in public health information. Alongside them, collective catering and large-scale distribution bear a primary responsibility, as their economic choices guide consumption patterns.

The French government, French businesses, and citizens can be part of the solution and have the privilege of driving a change that meets sustainability and social justice imperatives.

Food, an environmental action lever

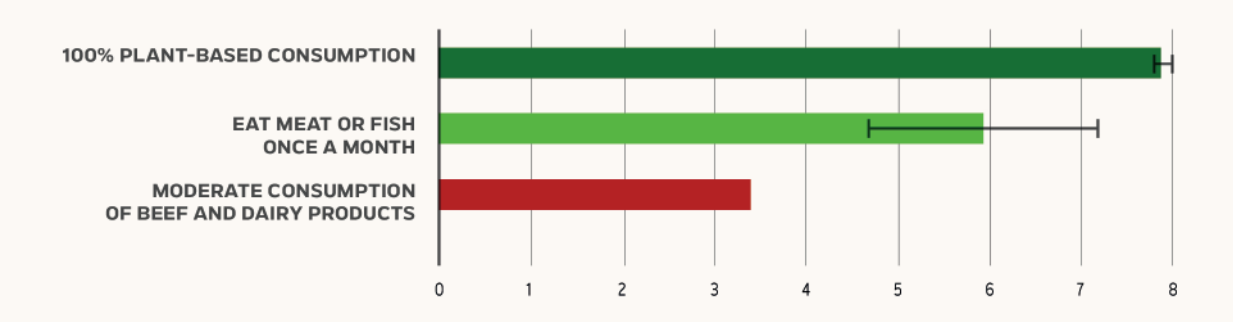


Figure 13: GHG mitigation potential of different diets (gigatonnes of CO^2 equivalent per year)
Source : IPCC.

25 to 30%

Current food systems contribute to greenhouse gas emissions[99].

In France, the share of food in 24%[100] total greenhouse gas emissions is

(making it the second largest contributor after transportation).

The IPCC unequivocally states that the dietary pattern with the greatest potential for reducing greenhouse gas emissions is a vegan diet, followed by a heavily plant-based diet, where meat or fish is consumed no more than once a month[101]. Locavore diets, which emphasise consuming locally sourced and seasonal products but still include animal products, are not considered low-carbon options.

Unlike the agri-food system, which threatens both human health and climate stability, these diets promote equitable resource sharing and adhere to principles of healthy and sustainable diets promoted by WHO and FAO. By reducing pressure on global natural resources, adopting «planetary health diets» protects the planet and improves the health of billions of people[102].

At the national level, Solagro proposes a food transition scenario to be implemented by 2050. Among the main recommendations of the «Afterres 2050» scenario is a significant reduction in meat and fish consumption. Solagro recommends an 85% reduction in annual consumption of fish and seafood[103], with particular attention to species from carnivorous fish aquaculture such as salmon. This transition involves changes in dietary choices and redirecting public funding towards the least impactful practices while phasing out the most destructive ones.

TO PRIORITISE

- Seaweed culture
- Development of plant-based Ocean-friendly food

TO BAN

- Destructive fishing practices and their subsidies: deep-sea trawling
- Consumption of carnivorous fish (cod, tuna, salmon)

Food, a lever for planetary health

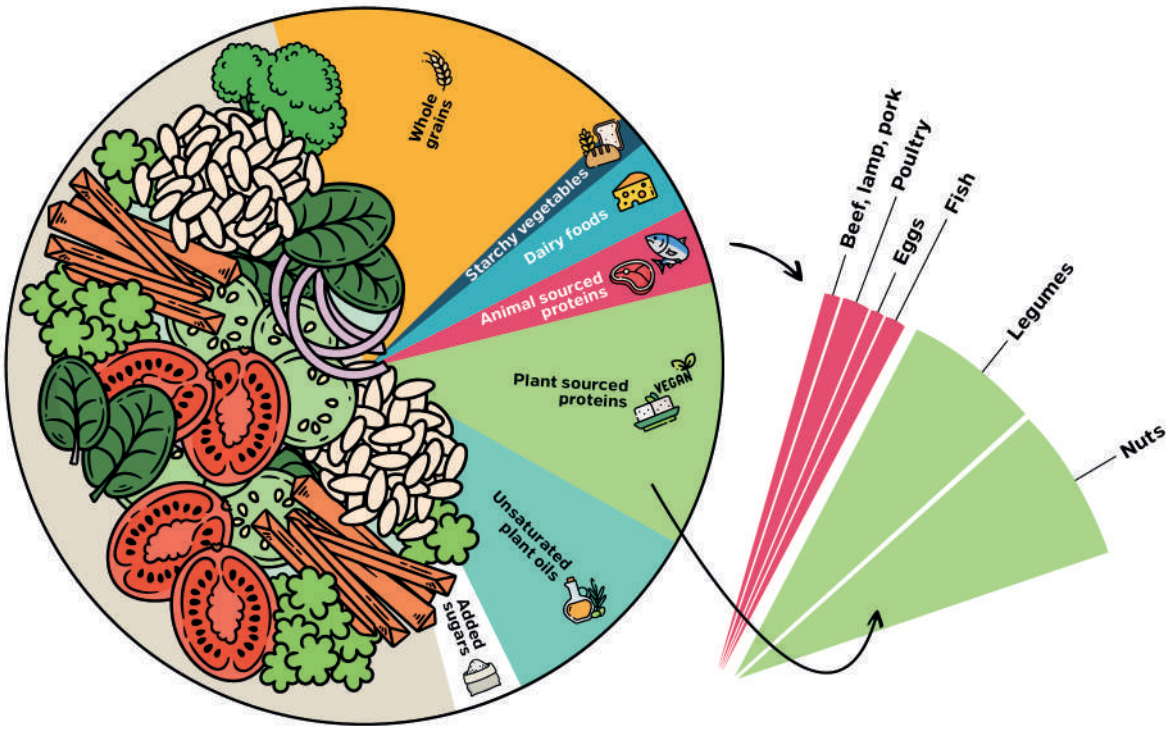


Figure 14. The composition of a "planetary health" plate
Source : Based on the EAT-Lancet Commission summary report

The French College of General Medicine recommends adopting a diet that is 90%[104] plant-based by increasing the consumption of vegetables, fruits, whole grains, legumes, nuts and seeds, and oils rich in omega-3 (canola, walnut, olive). Regarding omega-3 (ALA, DHA, EPA) intake, regularly consuming flaxseed or canola oil, walnuts, flax seeds, and chia seeds can meet the requirements for ALA[105], an essential fatty acid (not synthesised by the body) necessary for the proper functioning of the retina, brain, nervous system, and cardiovascular system. DHA and EPA intake can be achieved in two ways: either synthesised by the body from ALA, but with a conversion rate of less than 1%[106]; or through dietary sources from animal products (fish, poultry, eggs). However, according to the latest ANSES report from 2015[107], 99% of adults have insufficient daily ALA intake, and 89% are at risk of insufficient combined daily intake of EPA and DHA. Indeed, consuming a salmon fillet (110 g) daily does not even meet the recommended daily intake for a man[108]. Therefore, despite the high consumption of salmon in France, the needs are not met for a large majority of the population. Omega-3 supplementation, if not necessary, seems advisable as a precaution to more easily reach ANSES recommendations: in this case, plant-based supplements are the best alternative. They are affordable, healthy - free of PCBs and heavy metals - and do not have adverse environmental impacts (industrial fishing, krill fishing), unlike fish oil supplements[109].

Therefore, it is entirely possible to reduce salmon consumption, without switching to other animal-based foods, and by increasing the plant-based portion to improve ALA intake.

Meat and fish consumption, a source of inequality

Increasing social inequalities : 39% of the global population suffers from obesity[110] (2023) compared to 29.3% facing moderate or severe food insecurity (2021)[111]. Unhealthy diets take various forms, ranging from nutrient-poor diets causing hunger and micronutrient deficiencies—affecting low-income populations in particular—to those high in fats, sugars, and salt but low in whole fibres, fruits, and vegetables, leading to non-transmissible diseases affecting people worldwide..

Towards a responsible and committed private sector

From the culinary world to large-scale distribution, including the hotel industry and large corporations, everyone has a role to play in establishing a healthy, sustainable, and predominantly plant-based food system.

French and European initiatives exist and deserve support from the collective catering and large-scale distribution sectors. Among them, we can note:

· **Greening menus:** Like Alain Ducasse, the world-renowned Michelin-starred chef, who is setting the pace and calling on his colleagues to reverse the proportions to achieve a ratio of 80% plant-based products and 20% animal proteins[112].

· **Removing endangered species from plates:** Like the 21 "Relais & Châteaux" chefs on the association's International Tables Committee, who decided in October 2023 to support the protection of European eels by approving the immediate suspension of eel dishes from their restaurant menus. Similar to the Atlantic salmon now on the IUCN red list, the European eel, found on countless restaurant menus[113] worldwide, is now critically endangered.

· **Guiding sustainable consumption:** Price parity involves reducing the prices of plant-based products to make them accessible by listing them at the same price as their animal equivalents. For example, Lidl Germany decided to reduce the price of plant-based products by 20%, an initiative followed by Lidl Hungary and the Salling Group in Denmark[114].

The conclusion is clear: food is the most powerful lever to improve both human health, environmental sustainability, and social justice. It represents a potential catalyst for achieving the Sustainable Development Goals and meeting the Paris Agreement requirements. In France, we have the privilege to be a part of the solution. The key to transforming our food system lies in co-responsibility and multi-level action. Every individual, every company, and every ministry, especially the Ministry of Agriculture and Food, has a role to play.

So, let's do it: let's change the tide, collectively and sustainably.

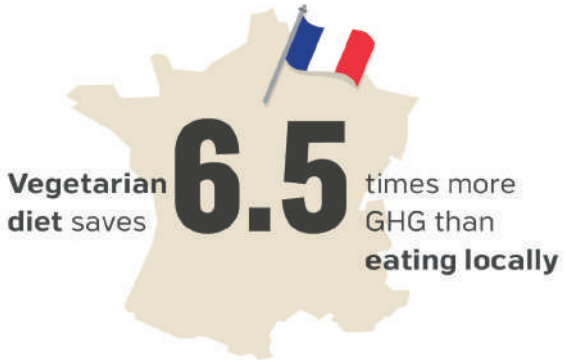
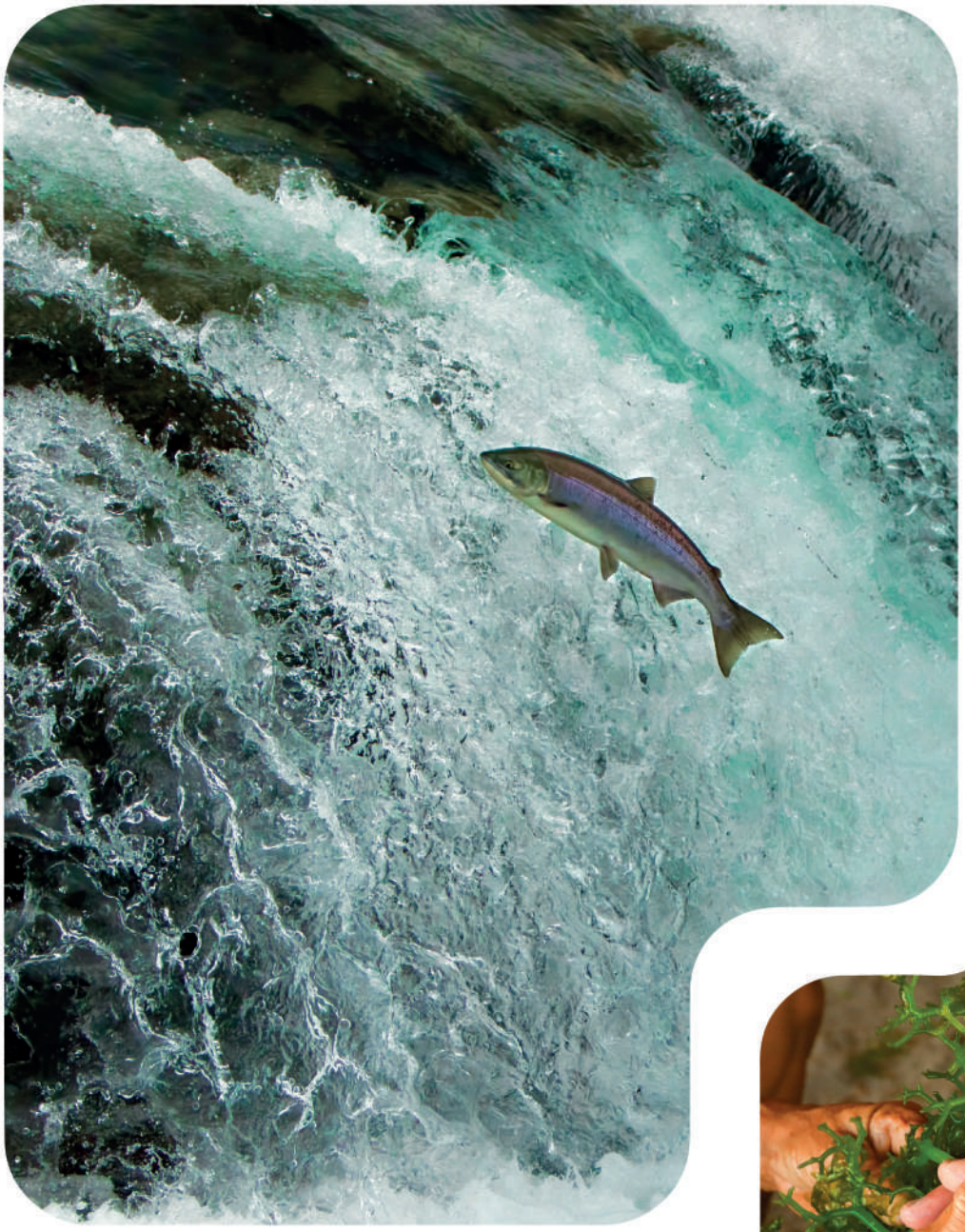


Figure 15: CO_2 footprint: eating vegetarian or eating local?
Source : Based on Do your bit ?, Carbone 4, 2019.



FOR A LIVING OCEAN

LIST OF ABBREVIATIONS

ACV
Life Cycle Analysis

ANSES
French Agency for Food, Environmental and Occupational Health & Safety

EFSA
European Food Safety Authority

GHG
Greenhouse gas

IPCC
Intergovernmental Panel on Climate Change

FAO
Food and Agriculture Organization

SDGs
Sustainable Development Goals

UN
United Nations

PBDE
Polybrominated Diphenyl Ethers

PCB
Polychlorinated Biphenyls

POPs
Persistent Organic Pollutants

PFAS
Per- and Polyfluoroalkyl Substances

RAS
Recirculating Aquaculture System

TFUE
Treaty on the Functioning of the European Union

IUCN
International Union for Conservation of Nature

LISTE OF FIGURES

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