



Eating up the ocean

A call to shift our seafood consumption towards ocean-friendly diets

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EXECUTIVE SUMMARY

The growing impact of global seafood consumption

As the worldwide production and consumption of seafood keeps rising, we catch more fish than what the oceans can sustainably provide. As oceans reach their limits, aquaculture has boomed, and today provides more of our seafood than fisheries. But this comes with a hidden impact: many farmed species – carnivores in particular – rely on fish meal and oil derived from marine fish such as sardines and anchovies. Not only does this increase pressure on wild fish populations, worsening loss to marine biodiversity, but it also poses a threat to livelihoods and food security in regions dependent on these fish.

Switzerland's taste for farmed fish at the top of aquatic food chains

Our analysis shows that in Switzerland, seafood consumption heavily favours carnivorous species such as salmon and trout. Two thirds of our imported fish are carnivores, half of which come from farms and need large inputs of marine feed (up to 4.5 times their weight in wild fish). As for Swiss aquaculture, carnivores account for 98% of our production. To feed the 30'000 tonnes of farmed fish we consumed in a year, up to 96'000 tonnes of wild marine fish were caught. This is especially wasteful as most of the fish caught for feed are perfectly edible and nutrient-rich, and important sources of food for marine predators and for people.

A need to shift to less and better seafood choices

There is an urgent need to reduce our seafood consumption and especially that of high impact carnivorous species. Adopting more plant-based diets and diversifying our seafood choices towards lower-impact species further down the food chain are key to reducing our impact on the oceans. There are ocean-friendly and nutrient-rich seafood alternatives: these include farmed filter feeders (mussels, clams and other bivalves), small marine fish (sardines, anchovies, herring), and whitefish such as catfish and carps that require little or no marine feed.

All hands on deck

To achieve this shift from high impact carnivorous seafood species towards lower impact alternatives, action is needed on all levels: from policymakers, producers, retailers and food service providers, to consumers. Efforts should focus on promoting plant-based ingredients and low-impact aquatic species, offering more diverse and appealing alternatives, and reducing demand for high-impact species like salmon.

1. INTRODUCTION

Global context

Global seafood consumption keeps rising, while marine fisheries have reached their limit. Globally we catch more fish than the oceans can sustainably provide: the proportion of overexploited stocks has reached 38% of the world's commercial fisheries [1].

Meanwhile, aquaculture – the farming of fish, seafood and aquatic plants – has boomed, with production reaching 94 million tons in 2022, four times more than in the 1990s [1]. Aquaculture has become central to global fish and seafood production, and today provides more of our seafood than wildcatch fisheries [1].

Aquaculture's overlooked impact

Aquaculture has been presented as an alternative to wild fisheries, and a means to improve food security while lessening the over-exploitation of wild fish populations [2, 3, 4].

However, the farmed species particularly favoured in high income countries, such as salmon, trout, seabream and seabass, are carnivorous species at the top of aquatic food chains (high trophic level) [5]. They require feed containing wild-caught marine fish [6, 7].

Our hunger for these species increases the pressure on the oceans, driving the overexploitation of wild populations of small, nutrient-rich marine fish such as sardines and anchovies [6, 8, 9, 10]. **22% of the marine fish caught worldwide is reduced to fishmeal and fish oil** [1], destined mainly to aquaculture [6]. This voracious industry diverts important sources of food from other marine animals, destabilizes marine food webs, and threatens food security and livelihoods in other parts of the world [11, 12, 13, 14].

The impacts of fishing for feed can often be overlooked compared to more visible issues in aquaculture, such as polluting outflows of excess feed, faeces or chemicals, damage to marine and coastal habitats, and the spread of disease and invasive species to wild populations [15, 16, 17, 18].

Aquaculture production – and especially that of carnivorous species – is predicted to increase by 10% in the next ten years [1]. But with capture fisheries already at their limit, this expansion cannot be sustained. There is therefore an urgent need to **reduce our consumption of carnivorous species and embrace lower impact alternatives**.

Swiss seafood consumption

In landlocked Switzerland, **we import 97% of the fish and seafood we consume from over 100 countries** [19, 20]. Therefore, the everyday consumption choices we make here have far reaching effects on marine, coastal and freshwater ecosystems in other parts of the world.

In this study, we aimed to understand our contribution to the global issue of fishing wild fish to feed aquaculture. We use import statistics, retail sales and domestic production data to analyse our preferences for high vs. low impact seafood species based on their trophic level. We also estimate our feed-print, or the quantity of wild fish caught to produce the farmed seafood we consume in Switzerland. Finally, we call for a shift to lower-impact alternatives.



2. A STRONG TASTE FOR FISH AT THE TOP OF THE FOOD CHAIN

Carnivorous species

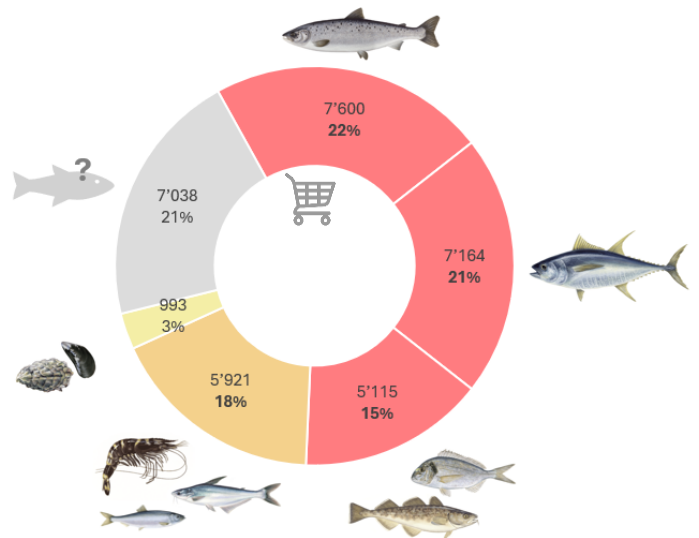
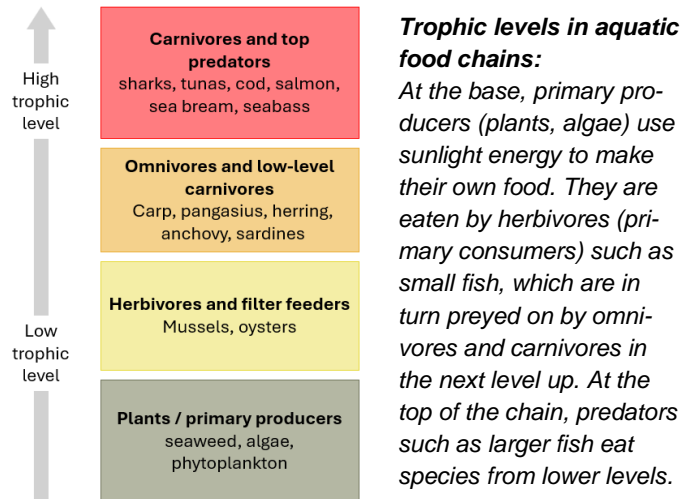
Species such as tuna, salmon, cod, and seabream are carnivorous species: at the top of aquatic food chains (high trophic-level species). They prey on other species lower in the chain and play a key role in balanced ecosystems by keeping prey populations in check. Many top predators are slow growing and vulnerable to overfishing. When farmed, carnivorous species require feed that contains wild-caught marine fish. For these reasons, fishing and farming high-trophic level species come with greater environmental impact [15] and a higher demand on Earth's ecosystems [21] compared to species lower in the food chain.

How prevalent are high-trophic level species in the seafood preferences of Swiss consumers?

We buy a majority of carnivores

Our analysis of Swiss retail sale volumes (Proviande data) shows that **nearly two thirds of the seafood we purchase are species at the top of the food chain, either wild-caught top predators or farmed carnivorous fish**. Of the 33'831 tons of seafood sold in retail in 2023, 57% were carnivorous species with salmon (22%) and tuna (21%) the most consumed species.

Figure 1: Seafood sold in Swiss retail in 2023 according to trophic level (tons). Source: volume data from Proviande, categorised according to trophic level (see Methodology). *Undefined species: Proviande categories "other fish", "other seafood" and "fish sticks/-Knusperli".



Methodology: Exploring Switzerland's seafood preferences

To examine seafood preferences in Swiss supermarkets, 2023 retail sale volumes by species (obtained from Proviande) were grouped in broad categories according to the species trophic level (TL) [22]: "Plants/Primary producers", "Herbivores and filter feeders", "Omnivores and low-level carnivores" and "Carnivores and top predators". Swiss aquaculture production data for 2023 (obtained from the Swiss Aquaculture Association [23]) were grouped according to the same categories.

Trade data were obtained from the Swiss Federal Office for Customs and Border Security (FOCBS) for the year 2022 [20]. Fish and seafood imports were identified by tariff numbers (TN) 03, 1604 and 1605. Data were recategorized into species groups by collating corresponding TN subheadings (e.g. tuna imports are captured under several TN codes: 0302.xx (fresh or chilled), 0303.xx (frozen), 0304.xx (fillets) and 1604.xx (prepared or preserved)). We estimated the proportion of imports from aquaculture and fisheries using national production data for each exporting country [24] (note: countries exporting to Switzerland may be intermediate processing rather than producing countries, potentially affecting estimates of farmed versus wildcatch volumes using national production data).

We import a majority of carnivores, half of which are farmed not fished

To reflect our fish and seafood consumption habits, both in retail and out-of-home (restaurant, food services), we examined all seafood imported into Switzerland (Figure 2), which represent 97% of our fish and seafood consumption [19].

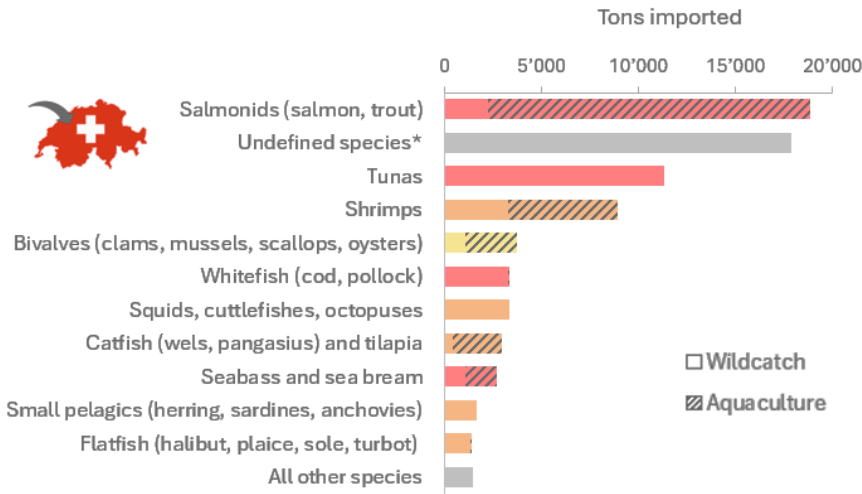


Figure 2: Seafood species groups imported into Switzerland in 2022, by trophic level and production type (source: 2022 trade statistics [20] and calculations in Methodology Box).

*“Undefined species” include breaded fish fillets, unspecified fresh, chilled, or frozen fillets (or meat of fish), and prepared or preserved fish, caviar, crustaceans, molluscs.

The Squids etc and Flatfish groups include both carnivores and low-level carnivores, not shown on the plot.

At least 61% of our imported seafood (for which the species was specified) are carnivores, including salmon, tuna, cod, seabass and seabream.

For almost ¼ (23%) of imported fish and seafood the species was not defined in trade data. The group likely includes wild-caught carnivores such as cod (e.g. in “breaded fish fillets”) and European perch among others (in “fillets”).

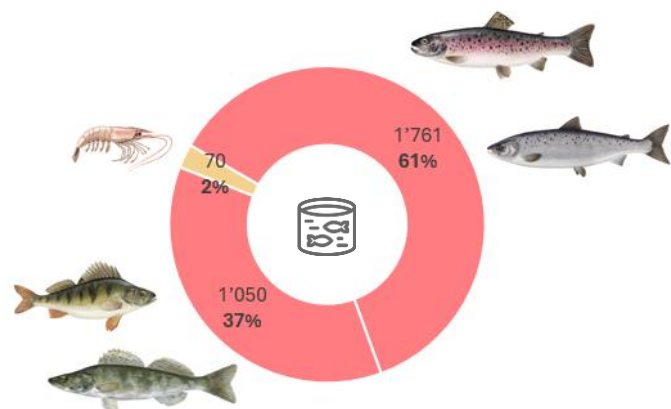
¼ of imports are salmon and trout: In 2022 salmonids accounted for 24% of all our imported seafood (77’282 tons). We estimate that 88% of these are farmed, not fished (see methodology).

Seabass and seabream are also largely farmed. Combining these groups, **51% of imported carnivores came from aquaculture farms that require fish feed inputs.**

We farm almost only carnivores

Fed carnivorous species accounted for **98% of Swiss aquaculture production**, with farmed trout accounting for 50% (1’431 tons) of production (Figure 3). Other prevalent, fed carnivorous species include European perch (*Perca fluviatilis*, 696 tons), Atlantic salmon (*Salmo salar*, 320 tons) and pike perch (*Sander lucioperca*, 224 tons).

Figure 3: Seafood species groups produced in Swiss aquaculture farms in 2023 (tons). Source: volume data by species from the Swiss Aquaculture Association (SAV), trophic level categorisation as described in Methodology Box.



3. THE FEED-PRINT OF THE FARMED SEAFOOD WE EAT

How much marine fish is caught to feed the farmed fish we consume?

The feed used in aquaculture is composed of fishmeal, fish oil and other ingredients including plant-based proteins, such as soy. The reliance of aquaculture on captured fish can be estimated using the Fish In: Fish Out metric (see FIFO box).

To feed the 29'000 tons of farmed seafood we import annually into Switzerland, an estimated 37'800 to 95'700 tons of wild fish were caught for the production of fishmeal and oil.

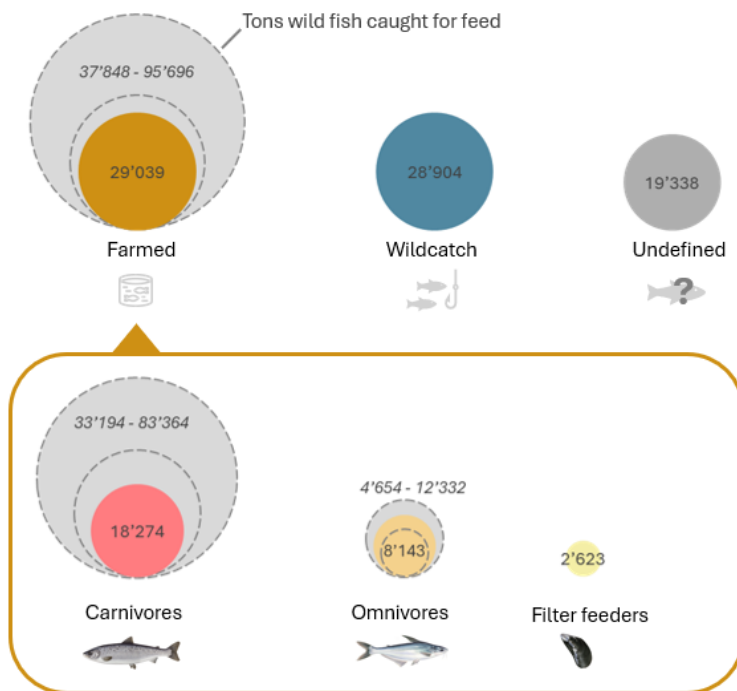


Figure 4: Seafood imported into Switzerland and the feed-print of aquaculture products (2022 import data [20], calculated as described in FIFO box and using Roberts et al. values [6]). Bubble sizes indicate quantities (tons) of farmed, wild-caught and other undefined seafood. Grey bubbles surrounding farmed imports represent estimated quantities of marine fish caught for feed, with lower and upper estimates shown as dashed lines.

A wasteful use of wild fish in feed

Carnivorous species account for most of our marine feed-print: to farm these species, it takes 1.8 to 4.5 times more wild-caught fish. This is especially wasteful when considering that 90% of the fish caught and reduced into fishmeal and oil is in fact fit for human consumption [11].

Improvements in feed formulations have reduced the proportion of wild fish used in fish farming [25], but fish meal and especially fish oil remain essential components in the feed of carnivores such as salmon [9, 10]. Our choices of high versus low trophic-level species directly impact our global marine feed-print: the more we favour farmed carnivores, the greater our indirect impact on wild fish populations.

Fish In: Fish Out (FIFO)

The Fish In: Fish Out (FIFO) metric indicates the quantity of wild fish required to produce a given quantity of a farmed fish. This ratio varies according to the oil content of the forage fish, the extraction process of fish meal and oil, and the feed requirements of the farmed species [25, 26].

There is a severe lack of transparency in the composition of aquaculture feed, and the quantity of wild fish included [6, 10].



Here we estimate the feed-print of Switzerland's fish imports (97% of our consumption) using lower and upper bound values of FIFO ratios estimated by Roberts et al. [6].

The lower bound estimate reflects industry-reported values assuming low inclusion of fish meal and oil in feed, an optimum oil extraction process and excludes fish parts considered discards of fish processing activities ("trimmings"). The upper bound value more conservatively accounts for higher oil and meal content in feed, extracted less efficiently from wild fish, and with the inclusion of trimmings.

For example, according to Roberts et al. [6], a 1 kg output of farmed Atlantic salmon requires between 1.82 and 5.57 kg of wild fish inputs, while carp requires 0.02 – 0.16 kg. The numbers may be even higher because the capture of marine fish for feed also causes bycatch and discards of other fish [6].

An obsession for farmed salmon...

The salmonid group, and especially salmon, is the most imported and consumed seafood in Switzerland, with farmed imports estimated at around 16'000 tons. As a carnivore with high feed requirements, salmon is the main driver of our Swiss marine feed-print.

Once considered a luxury, salmon is now an affordable and popular product, ever-present in supermarkets, restaurants, media and recipe books. In 2023 we imported nine times more smoked salmon than 30 years ago (Figure 5).

... and other carnivorous fish

But salmon is not the only carnivorous fish consumed in Switzerland. Seabream and seabass account for 6% of our farmed imports. Every kilogram produced requires up to 4 kg of small wild fish [6]. Tuna farms require up to 25 kg of wild fish input to every kg of tuna [6, 27].

As for the most produced species in Switzerland's farms (Figure 3) we estimate 3 kg of fish input per kilogram output (using industry values for European perch and pike perch that possibly underestimate the true values (see FIFO box).

An added burden for the oceans

Farming carnivores and the need for marine-sourced feed increases the pressure on wild fish populations, at a time when the world's fisheries have already been pushed to their limit [6, 28].

Species targeted for fish meal and oil are important sources of food for other marine animals and their depletion can disrupt marine ecosystems [29, 30, 31, 32]. These same species are also often a staple food for low

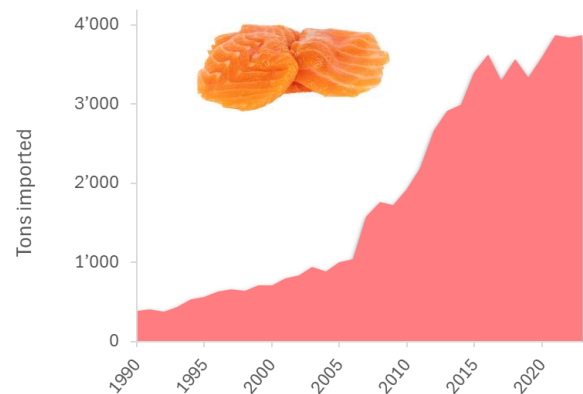


Figure 5: Imports of smoked salmon (TN code 0305.4100) into Switzerland from 1988 to 2023.

Source: FOCBS – Swiss-Impex online data query

income groups and coastal communities in many parts of the world, and redirecting their use to aquaculture threatens food security [33, 28, 34, 35]. (see also Box “Why is fed aquaculture a problem”).

If global seafood production and consumption continue to grow at the predicted rate [1], fed aquaculture as we know it cannot be sustained [10, 36, 37, 38].

An urgent need for change

There is an urgent need to reduce our consumption of high impact carnivorous species. Adopting more plant-based diets and diversifying our seafood choices towards lower-impact species further down the food chain are ways to reduce our marine feed-print and our impact on the oceans [9, 21, 39, 40].



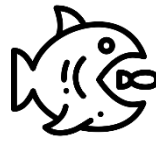
Why is fed aquaculture a problem?



Fisheries pushed to their limit

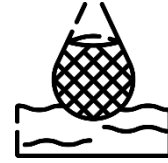
We catch more fish than what the oceans can sustainably provide [41, 42, 43].

Today 38% of the world's commercial fish stocks are overexploited - harvested faster than they can reproduce to maintain their populations [1] and overfishing threatens marine biodiversity and the ocean's resilience to climate change [44].



High-impact farmed carnivores

Farming of carnivorous aquatic species, or fed aquaculture, represents 73% of global aquaculture production. The demand for these species is growing, especially in high-income countries [1, 5]. Salmon farming alone uses 60% of the world's fish oil [10]. Meeting the needs of this voracious industry comes at a significant environmental cost.



Extracting fish from the base of aquatic food chains

Each year 17 million tons of fish is caught for the fish meal and oil industry, representing 22% of the world's marine catch [1].

Industrial fisheries target small open-ocean fish such as anchovies, herring, pilchard, and sardines [7, 10]. At the base of marine food webs, they are vital prey for predators including larger fish, marine mammals and seabirds [28, 45, 46].



Chasing after new sources at the expense of the Southern Ocean

Antarctic krill is at the base of the food chain in the Southern Ocean, a critical food source for fish, whales, and seabirds [47, 48] but is now increasingly targeted for fish oil.

In 2024, a key conservation measure expired, allowing up to 620,000 tonnes to be caught annually in critical Antarctic hotspots [49]. Combined with climate change, this concentrated fishing impacts humpback whales pregnancies [47] and penguin populations [48] due to food shortages.



Impacts on land as well

Aquafeed contains plant-based ingredients such as soy, with an estimated 0.95 kg of soy for every kilogram of salmon consumed in Switzerland [50].

Large scale cultivation of soy for animal feed is linked to deforestation and habitat destruction, biodiversity loss and increased carbon emissions [51].



Threatening food security

The small fish used to produce fish feed and oil are among the most nutrient-dense wild fish in the world [10]. They are rich in omega-3 fatty acids, micronutrients and proteins and key diet components in many regions [8, 11].

Reduction fisheries in West Africa exploit important food sources, usually consumed locally, threatening food security and disrupting the local processing sector traditionally led by women [8, 10, 13].

4. LOWER IMPACT SEAFOOD ALTERNATIVES

Less and better: eating lower in the food chain

The environmental impacts of our seafood consumption can be drastically reduced by shifting away from the most consumed carnivorous species such as farmed salmon, trout, seabass and seabream. By consuming more plant-based foods and diversifying our seafood consumption towards species that are lower in the food chain, we can provide the ocean with urgently needed relief.

Below are examples of such species groups. Species that require little or no marine feed include filter feeders such as mussels and clams as well as farmed omnivores and herbivores such as carps and catfish. Wild-caught small pelagic fish such as sardines, anchovies, herring could be consumed directly rather than being reduced to aquaculture feed.

Farmed oysters, mussels and clams

These species filter their food from the water and do not need to be fed. They are generally grown in suspension on ropes, trays or poles, with minimal impact on the surrounding marine ecosystem [15]. Farmed bivalves are among the lowest impact seafood choices (unlike wild-caught bivalves, that are typically harvested with dredges destructive to the seabed and should be avoided). They are also rich in omega-3 fatty acids, iron, selenium, and zinc [52, 53].

Catfish, carp, tilapia and herbivorous white fish

Carp, catfish and tilapia farming has a limited impact on wild fish populations because these species have low dietary dependency on fishmeal and fish oil [6]. Carp can thrive on plant-based feeds, while catfish are primarily fed grain- or soy-based diets. Rearing these species in closed recirculating systems generally has low impacts on the environment.

Small pelagic fish

Small oily fish such as sardines, anchovies and herring are nutrient-rich [9, 53, 54, 34] and should be prioritised for direct consumption over feeding farmed carnivores. They are rich sources of essential nutrients such as omega-3 fatty acids, calcium, iron and zinc.

Low impact choices exist from selected, well managed stocks, although many stocks targeted by reduction fisheries are not healthy or well managed [32]

Marine plants

Marine plants, particularly seaweeds, require minimal inputs, provide ecological benefits, and serve as nutritious food options [55]. Supporting the cultivation and consumption of these plants helps reduce pressure on overexploited fish stocks [56].

Quick guide to making better seafood choices

for more details, consult the [WWF Seafood Guide online](#)



Marine plants: algae, seaweed



Filter feeders: mussels, oysters, clams

- ✓ from aquaculture or collected by hand
- ✗ fished using dredges



Low impact white fish: carp, catfish, tilapia

- ✓ organic (Bio certified)
- ✓ from European recirculation aquaculture systems (RAS)
- ✗ red-rated sources in WWF Seafood Guide



Small pelagic fish: sardines, anchovies, herring

- ✓ MSC and green-rated sources in WWF Seafood Guide
- ✗ red-rated sources in WWF Seafood Guide

5. RECOMMENDATIONS

Switzerland's consumption preference for farmed carnivorous fish species indirectly contributes to the overexploitation of marine fish populations. As a high-income importing country, we have a responsibility to ensure that our seafood is produced in a way that keeps seas healthy and full of life and does not threaten the stability and the security of other regions.

A shift to lower impact seafood choices is key to reducing our impact on the world's oceans and requires efforts from market actors in the seafood industry, public policy and consumers. Nutritious and ocean-friendly alternatives exist but are currently less popular and less known compared to strongly marketed salmon products. There is a need to increase public awareness of the impacts of fed aquaculture species, enhance the appeal of low impact alternatives and improve the availability of convenient products based on low impact ingredients. We call on efforts from all stakeholders to enable and support this shift:

Policy makers: Incentivise low-impact seafood and push for transparency

- **Dietary guidelines:** In a positive development, Swiss dietary guidelines recently integrated environmental considerations for fish and seafood, including advice to diversify species choices towards lower impact species [57]. This must now be implemented and taken up by actors of the private and public sector, to further promote plant-based and lower impact alternatives.
- **Imports:** We import 97% of our seafood, but there are no environmental (or social) regulatory standards for imported seafood, except for ensuring that wild-caught marine products come from legal sources. No such criteria exist for farmed seafood, which makes up 51% of our imports. Additionally, species information was missing for 23% of all imported seafood. There is a clear need for more complete and transparent information on seafood imports, along with restrictions on the import of seafood from sources with high environmental and/or social impacts.

Industry: Innovate and develop a low-impact offer

Consistent efforts are needed from all parts of the seafood industry to shift towards production and uptake of lower-trophic level species, to develop appealing products using lower-impact ingredients and meet the growing demand for environmentally friendly seafood. This requires innovation and bold trials of new recipes and ingredients, as well as (re)discovering species that are already popular in neighbouring countries, such as carp, sardines and mussels.

- **Producers:** Aquaculture must reduce its reliance on capture fisheries for feed. Producers are key to this transition, as they can choose to farm lower trophic species that need less fishmeal and oil in their feed. Additionally, they must push for improvements in both the transparency and composition of feed, with the goal of reducing the amount of marine-sourced ingredients and increasing the uptake of alternative sources of proteins and oil (e.g. algae, insect, fungi, etc).
- **Seafood traders and processors:** Innovate to make plant-based alternatives and lower-impact species more appealing and available to restaurants, food service providers and retailers. Develop a range of convenient and affordable products as alternatives to the ever-present, high-impact salmon, tuna and cod.
- **Retail sector:** Retailers exert a strong influence on our choices through the food environment in which we shop [58]. They can support this shift by making low-impact choices more prominent, convenient, appealing, and affordable, instead of promoting and discounting high trophic level species such as salmon. Additionally, they should work with their suppliers to increase transparency and improve the composition and origin of the feed used in farmed seafood.
- **Restaurant and food service providers:** In Switzerland, about 50% of our seafood consumption occurs out-of-home (estimate based on exchanges with industry experts). Food service providers and restaurants can play a pivotal role to showcase and elevate the appeal of plant-based and low impact seafood alternatives, by incorporating them into flavourful dishes and popular menu options.



Public procurement: Show the way

- Public procurement can and must set expectations for public spending on low-impact food. Cities for example can play a key role by encouraging schools, hospitals and staff canteens to adopt more plant-focussed menus and prioritise low impact seafood preparations.

Consumers: Eat less and better seafood

- A reduction in seafood consumption is urgently needed, particularly in high income countries such as Switzerland, where consumers are not dependent on fish as a protein source and have access to an abundance of protein- and nutrient rich plant-based products.
- Choose ocean champions and try new recipes: Select a diverse range of species lower in the food chain to reduce pressure on high-impact, widely consumed options, and encourage the growth of a low-impact offering.

Food for thought



Wakame salad (seaweed)



Moules frites (mussels)



Fried panga (catfish)



Pasta alla puttanesca (anchovies)



Grilled carp



Vegetarian sushi (seaweed)

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Our Mission

Together, we protect the environment and create a future worth living for generations to come.

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