fair fish

34 fish-facts
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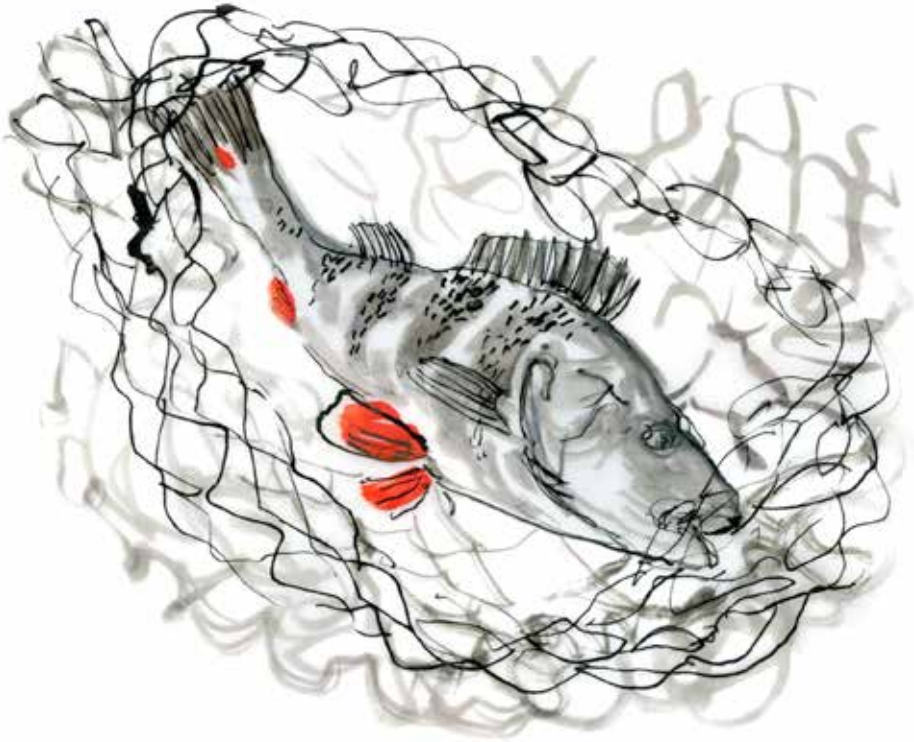

Edible Fish Consumption

Development of a concept for the conversion of global fish production into edible parts, with side glances to Swiss consumption and to fisheries feeding aquaculture.

Ashly Krummnacher

Content

About the author

Ashly Krummenacher studied business at the University of Applied Sciences and Arts of Northwestern Switzerland. For her bachelor thesis she chose a task with the fair-fish international association: to develop a method in order to estimate—on the basis of the sometimes incomplete statistics available—the true weight of fish consumed per capita, on both a global and a Swiss level, as well as the proportion of the global catch weight used for feeding animals, mainly in aquaculture. We are proud to publish a shortened version of her pioneering thesis in our "fish-facts" series and hope to encourage further use of the model presented.

fair fish international

Imprint

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Live fish, Gilthead seabream (Tony Hisgett/Wikimedia)

Edible Fish Consumption

Development of a concept for the conversion of global fish production into edible parts, with side glances to Swiss consumption and to fisheries feeding aquaculture.

Introduction

To be a fish is not easy, especially not in the age of man. Fish are rarely considered to be cute, and humans have limited empathy for them since they cannot read their eyes, and therefore they seem to be alien to our world. However, recent research has demonstrated that fish are capable of feeling pain [1] and thus clearly are sentient beings [2].

Fishing goes back to prehistoric times, so at least 40,000 years [3]. However, its practice has very much evolved ever since, especially in the last few centuries. It is very unlikely that the first fishermen intended to catch all the fish in the ocean, which to them must have seemed endless. They invented tools to catch and process fish out of shells and stones, and later on built spears and harpoons [4]. It was not until the invention of drift nets in the medieval times that fishing became extensive [5]. A substantial shift from consumption of freshwater fish to seawater fish took place at that time [6]. In the rich European population of the 11th century, the demand for fish ran high [7]. People were eating them for protein, for prestige or through religious obligation. And as fishing vessels started to cross oceans in the 16th century, there was a whole new world to conquer.

Whole fish, gutted, head and tail on (Thomas Schwager/fair-fish)

Fish means labour for many

Today, almost 60 million people are engaged in the primary sector of capture fisheries and aquaculture (farming of aquatic organisms). The total number of fishing vessels worldwide is estimated to be around 4.6 million. However, of the roughly 96.4 million tons of wild fish caught annually (data for 2018), only two-thirds are biologically sustainable [8], and only 14% of global production was certified with a label in 2015 [9].

One of the 17 Sustainable Development Goals [39] of the United Nations Organisation focuses on oceans, seas, and coastal areas, which play an essential role in the ecosystem. Over three billion people depend on marine and coastal resources for their livings [8]. In 2017 roughly 17% of animal protein was globally consumed as seafood [8]. But oceans are not only crucial for global food security and human health, they are also the primary regulator of the global climate by absorbing CO_2 from the atmosphere. A process which is compromised when the marine ecosystems do not function properly.

Over 170 million tonnes per year

The FAO reported a total global seafood production (fishes, molluscs, and crustaceans) by fisheries and aquaculture of 171 million tonnes for 2016 [10] and 179 million tonnes for 2018 [8]. Roughly 88% have been allocated to human consumption in both periods. Over the past six decades, this share has sharply increased. In 2018, human seafood consumption was estimated at 21 kg per capita per year as compared to only 10 kg back in 1960 [11].

Of the total reported global production, around 22 million tonnes are caught for "non-food" uses, mainly for the production of fish meal and fish oil [8]. Fish meal is known to be particularly rich in protein, it has a high proportion of essential amino acids, is easy to digest, and contains no substances that impair animal nutrition. However, an average of 4.5 kg

Fish fillets, fresh (Studer/fair-fish)

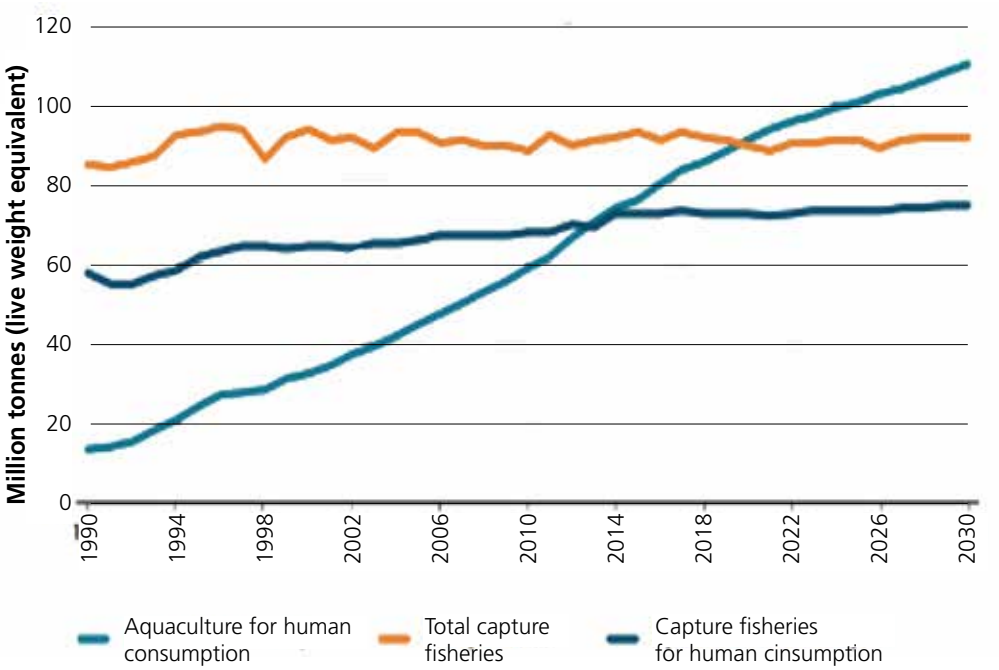


Figure 1: Global Fisheries and Aquaculture Production from 1990 to 2030 (projection [10]), including fishes, molluscs, and crustaceans.

of fish is needed for 1 kg of fish meal [12]. Fish oil is even more concentrated than fish meal, more than 20 kg of fish is needed to produce 1 litre of fish oil. From 1948 to 2000, the percentage of global fish meal production used in aquaculture increased from under 8% up to 35% [13] [14] [15]. This increase is primarily due to the change in farming practices of carnivorous species and to new practices for omnivores, such as shrimp. Other sources declare that the majority of the world's fish meal production (75%) is used in fish farming. Of the forage fishes used in aquaculture, 90% are previously reduced to fish meal or oil, and only the mere rest is fed to animals directly [16] [17].

Fishing for aquaculture

In recent years it was estimated that almost 17 million tonnes of forage fish are utilized in aquaculture [18]. Forage fish are small- and intermediate-sized pelagic fish such as sardines, anchovies, and mackerels, swimming in massive schools and feeding on plankton. Not only is it easier for animal predators to capture agglomerated fish, but also for humans, resulting in lower fishing costs [16]. The tendency in catching forage fish is rising dramatically. They account for over a third of global landings of marine fish annually, and it is widely known that the effects of their removal on ecosystems is grave and manifold [19] [20] [21]. The most ecologically evident

Food and Agriculture Organization of the United Nations

Coordination Working Party on Fishery Statistics (CWP)
Handbook of Fishery Statistics
Cach Concept: Diagrammatic Presentation

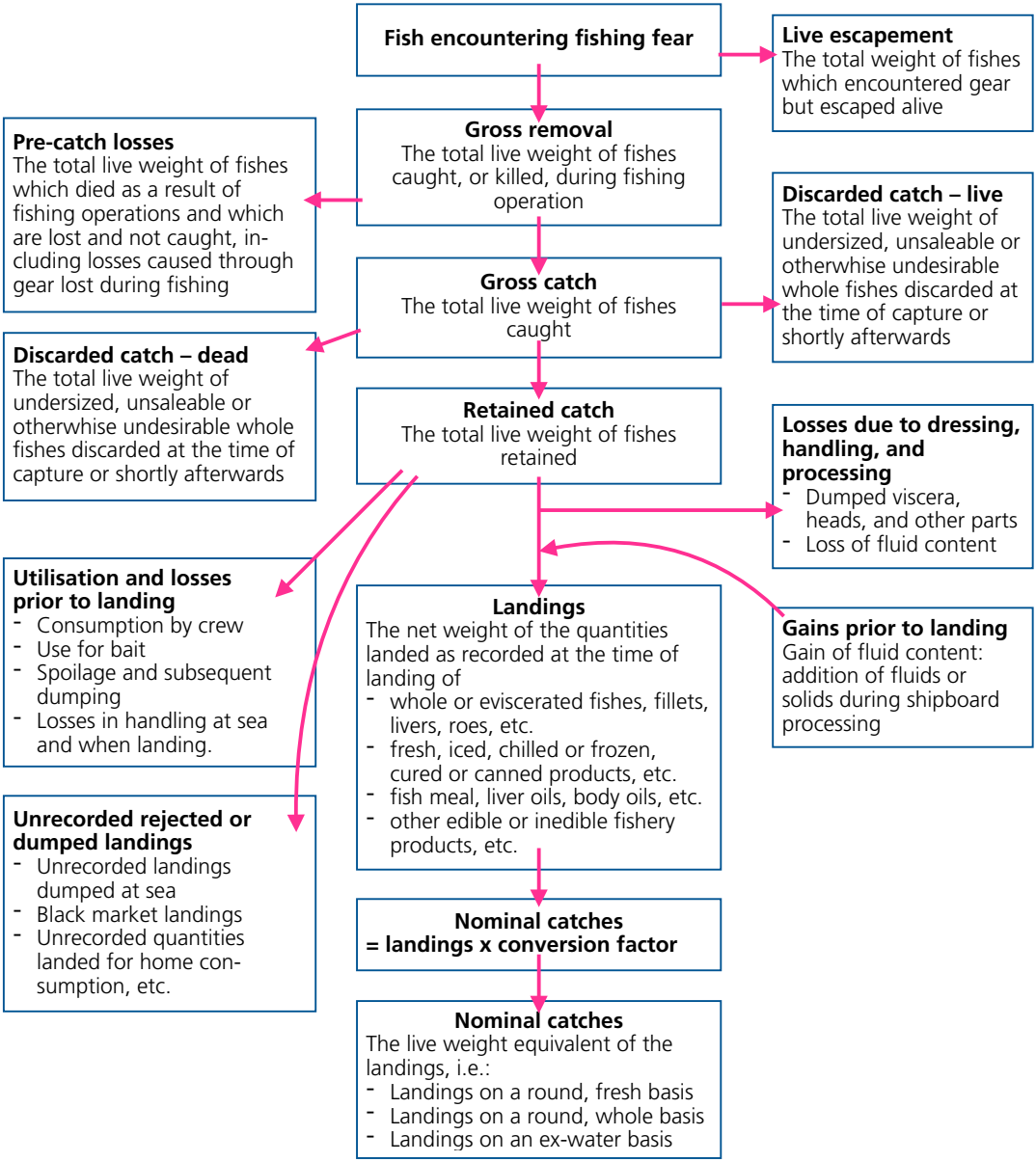


Figure 2: Diagrammatic Presentation of Catch Concepts [25]

effect is the destabilisation of the marine food chain, removing a substantial mass of nutrition for the species in higher trophic levels, and reducing the consumption of the organisms in lower trophic levels. Though the effects go way beyond. The reduction into fish meal is the source of persistent organic pollution (such as dioxin) [22], and in many countries with low-income communities living by the coast, fisheries of forage fish are essential for local food security [23].

Nowadays, 52% of global seafood production for human consumption [8] originate from aquaculture, which has just recently outpaced the wild catch, as illustrated in ***figure 1***. Asia is expected to continue dominating this sector with an estimated share of almost 90% of global aquaculture in 2030. Latin America and Africa also show an increasing trend [10].

Fisheries statitics: tricky waters

For global catch statistics, countries are requested to report fishery production to the FAO [37] in live weight equivalents, which are called "nominal catches". To this day, the terms "catch" and "landings" are not described in national publications with the same meaning as defined in the Coordinating Working Party (CWP) Handbook of Fishery Statistics. When landings are processed, a conversion factor is applied to transform the numbers into the actual "landings": the weight of the organism when it was removed from the water. However, the weighing results have a high potential of being inaccurate. They are depending on the technology used, and on the experience of the observer or inspector, who makes a mere visual assessment of the volume and composition of a catch. None of which can be reliably consistent. Therefore, these numbers most probably conceal the true values. The maintenance of the conversion factors is done by the FAO by the best of ability. Its frequency is regular but does not get applied and published every year [24]. Their concept of catch and landings is illustrated in ***figure 2*** on the previous page [25].
An even more significant concern in fisheries is the dark figure in illegal, unreported, and unregulated fishing (IUU). Agnew et al. have estimated this figure to be between 11 and 26 million tonnes yearly worldwide [26].

Fishes lost along the value chain

Furthermore, it is important to clarify that the numbers labelled as "consumption" are not equal to the quantity of actual food intake and only indicate an average of food available for global consumption [10]. Along the food supply chain, from production to consumer, there are five potential hot spots for loss and waste [27]:

- Agricultural production (i.e. primary production): Losses refer to discards during fishing. There are numerous reasons why fishes are dumped back, such as lack of market opportunities, damaged fish, fish with wounds or cuts that are infected by parasites, and undersized or non-commercial marine life. Researchers expose that roughly 10% of the global catches in the last decades have

been discarded due to poor fishing practices and management [42]. One could fill around 4,500 Olympic size swimming pools with the dumped fish each year.

- Post-harvest handling and storage: Losses refer to spillage and degradation during cooling (higher risk of spoilage in tropical climates), packaging, storage, and transportation after landing.
- Processing: Losses refer to industrial processing such as filleting, canning or smoking.
- Distribution: Losses and waste in the market system, e.g., wholesale markets, supermarkets, retailers, and wet markets.
- Consumption: Losses and waste at the household level, due to food traditions and consumer habits.

Wasted are also the fish that manage to escape through sorting grids and trawl meshes, since they are often injured, stressed and weak [40]. Accounting for all the above, a total of 35% of global catches are lost or wasted according to an estimation [27].

Broad variety of fish producs

In recent decades, the processing of fish has evolved strongly. Through improved cooling and transportation more product forms are being commercialised. According to the FAO [10], processing is classified into five forms:

- Live, fresh, or chilled
- Frozen
- Prepared or preserved
- Cured (smoked, salted, pickled, etc.)
- Non-food purposes

Even though there is a sharp rise in the commercialisation of frozen fish in developing countries (from 3% in the 1960s to 26% in 2016 [10] and an increasing share consumed in a prepared or preserved form (9%), local people still consume slightly over half of the share in a fresh form. Developed countries, on the other hand, retail their fish largely as frozen (doubled from the 1960s to 58% in 2016), prepared or preserved (26%), and cured or smoked (12%).

Frozen fish fillet

Methods

In this current study, we are interested in a further step of conversion of catch, in order to make an estimation of actual food intake by humans globally. We use "edible fish" to refer to the actually consumed parts of fish. How many tonnes of fish are really consumed worldwide? And in relation to the global consumption, what does the situation in the example of Switzerland look like?

The data source for our model of conversion was a publicly available data base by the FAO [28]. The FAO collects, validates, and disseminates data and information related to food and agriculture on a global level. The data collection is received via FAO questionnaires and hosted in a data base of aquatic species caught by country, by species, by FAO major fishing areas, and by year. The live weight of wild fishes caught in commercial fishing and aquaculture are both included, whereas discards are excluded. This FAO's Fisheries and Aquaculture statistics can be accessed using the software FishStatJ (Version 3.05.1, May 2019) by the FAO. Although data of the production go back to 1995, only the recent annual data (2017) was examined.

Concentrating on fin-fish species

A filter has been applied to the data set in order to include only fish species and therefore neglect crustaceans, molluscs, other invertebrates, and plants. Some countries group their catches, which does not provide an entirely accurate assessment of all species. The weights of fish are sometimes listed by single species categories (for example pink/humpback salmon), by multi-species categories (such as salmonoids nei) or in generic categories without species information (like freshwater and diadromous fish). The reliability of the data evidently decreases from the species level to the family level, and even further when considering only the generic categories.

Regarding the yield of edible meat per aquatic species, the FAO's Yearbook of Fishery Statistics, Catches and Landings [29] was consulted. The list of fish species was narrowed down to the commercially more important ones (exceed an annual global catch of 100,000 metric tons). The data in this Yearbook originated from published as well as a from some unpublished material. Many of the selected values are considered provisional or tentative, and are listed in square brackets.

Fillet yields are not always clearly known and sometimes are assumed to include skin. It is assumed that meat yields can be considered as equal to fillet yields. When fish skin is mentioned with the data provided, an average of 5% of the fillet yield is subtracted. This coarse mathematical formula is not very precise, since the thickness of the skin can vary strongly depending on the fish species. It was adopted nevertheless, and an esti-

mated range of a lower and a higher yield of edible meat was obtained for a total of 1326 entries. ***Table 1*** illustrates a reliability ranking through own assessment of the information from the software FishStatJ and the FAO [29].

Ranking Methods	
1	Single-Species Categories
2	[Single-Species Categories]
3	Species Classes
4	[Species Classes]
5	Average Yield of Species (Family)
6	Average Yield of Generic category
7	Average Yield Over All Species

Table 1: Reliability Ranking for the Data Source Used to Estimate Meat Yield.

The Swiss example

After the FAO data had been analysed, the Swiss foreign trade statistics for the year 2018 were consulted in order to investigate the actual fish consumption in Switzerland. Only the import of fish species was considered, and the roughly 5% produced in Switzerland by professional fisheries (decreasing) and the aquacultur sector (increasing) will be added to the total [30]. Switzerland mainly imports processed fish, such as fillets, but also whole (gutted or ungutted), smoked (with or without tail or head), and cured. The Swiss foreign trade statistic treats fresh and frozen the same way, and the conversion gets neglected. It should be noted that in comparison to the data of FAO, the processed fish has been converted to the live equivalent weight.

In the year 2010, fair-fish had investigated the yield (fillet/whole fish in per cent) of the 20 most common fish species consumed in Switzerland, based on data provided by the German Federal Institute for Agriculture and Food (BLE) [45]. German consumer behaviour being sufficiently similar to that in Switzerland, this data was considered to be representative for local Swiss consumption as well. From the data set, conversion factors were obtained that can translate the weight of a fillet to the weight of the whole fish. A cross-species average of 35.27% fillet yield was determined.

Results and Discussion

The estimated range between lower and higher yield of edible meat across all species, species groups, and generic categories worldwide turns out to vary between 39.34% and 52.35% of live weight. Hence, for the 156.4 million tonnes reported by the FAO in 2018 [10] as utilized for human consumption, only 59.5-79.2 million tonnes have actually been consumed. The reported 20.3 kg/year "per capita apparent consumption" would need to be adjusted to 8.0-10.6 kg/year per capita consumption of edible fish meat.

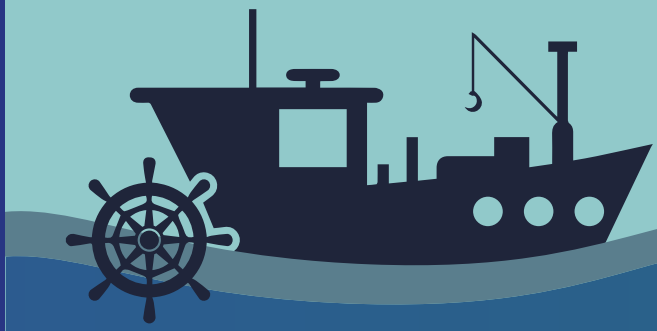
As a comparison, edible fish consumption per capita in Switzerland in the same year (2018) was 6 kg per year (***Table 2***). Over 49,000 tonnes of edible fish were imported into Switzerland in 2018. An additional 5% of consumed fish originated from Swiss aquaculture production [30]. The table does not embrace the recreational freshwater fish captured in Switzerland, which account for an additional roughly 2% of local consumption.

In comparison with the global estimate of 8.0-10.6 kg per capita, Swiss consumption is about one third below the global average. However, the calculated average of 35.27% fillet yield is substantially below the global estimates of 39.34-52.35%, indicating a higher loss during processing, reflecting on a more choosy, fillet-oriented Swiss consumer behaviour.

Designation of Heading (Swiss tariff number)	Weight (t)
Fish, living (0301)	218
Edible fish, fresh or chilled (excl. fish fillets and other fish) (0302)	3,061
Edible frozen fish (excl. fish fillets and other fish meat) (0303)	963
Fish fillets and other fish meat, whether or not minced, fit for human consumption, fresh, chilled or frozen (0304)	18,312
Edible fish, dried, salted or in brine; smoked, whether or not cooked before or during smoking; flours, meals and pellets of fish (0305)	5,187
Prepared or preserved fish and caviar and caviar substitutes prepared from fish eggs (1604)	21,273
Subtotal Edible Fish Consumption without Swiss Catches and Aquaculture	49,015
Total Edible Fish Consumption (incl. local production)	**51,594**
Swiss Population in 2018	8,542,300
Edible Fish Consumption Per Capita in Switzerland, in 2018	**6.0 kg**

Table 2: Edible Fish Consumption in Switzerland in 2018

Edible Fish Consum



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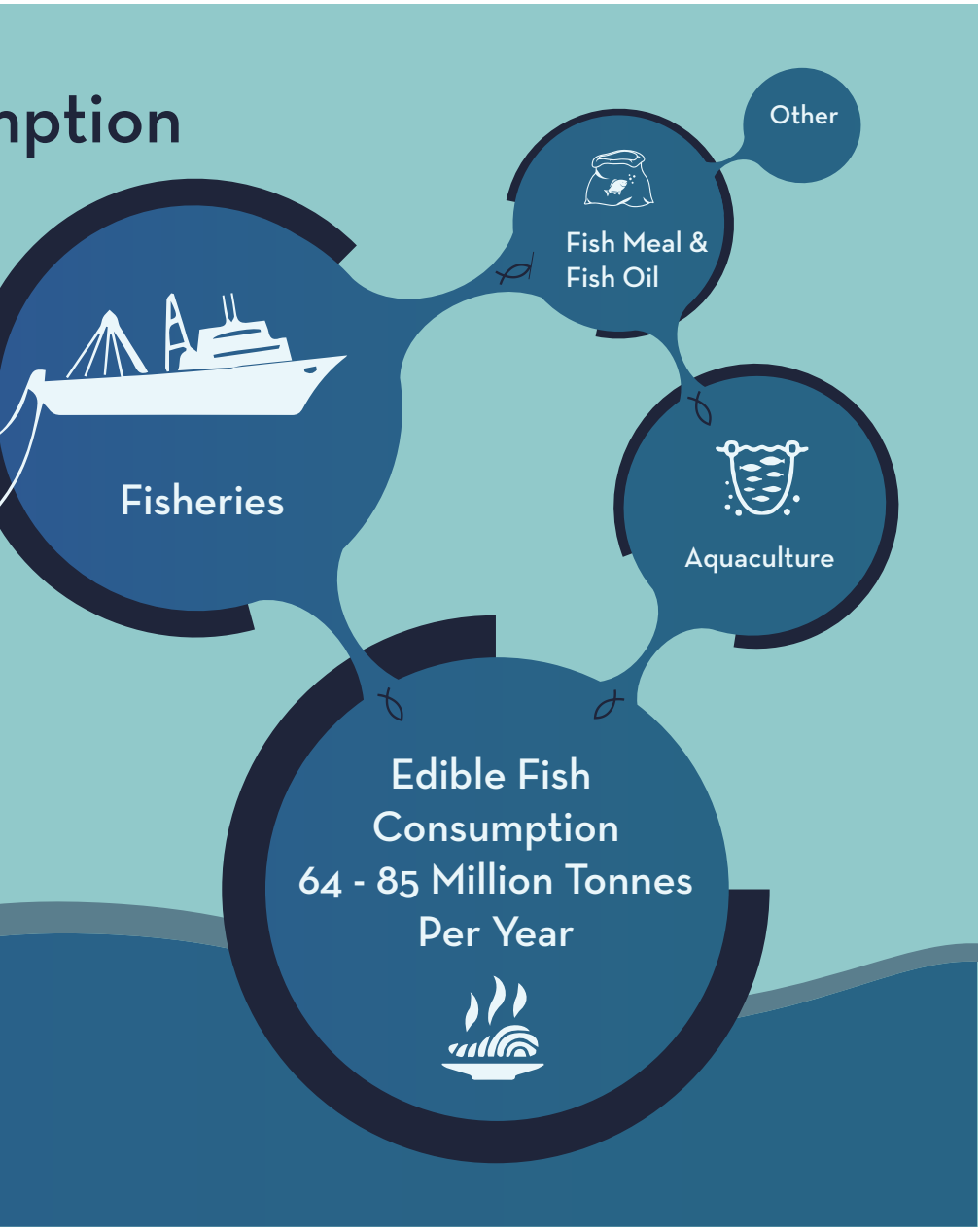


Figure 3.
Global Consumption of "Edible Fish", Recapitulation for the year 2017 [28].

Figure 3 depicts a summary of the actual global edible fish intake by humans in 2017. Using the concept presented here, annual estimation of global fish consumption can be estimated for any year. Furthermore, the scope and focus can be changed. Species or families could be selected and investigated individually. Values from Chefs Resources Inc. [31] can also be a valuable source for comparative data.

Many fishes were not clearly identified in the collected data. The category "Marine fishes not identi-fied" accounts with almost 10 tonnes for the highest catch within the data set. It would be interesting to find out why they could not be identified and how to decrease this number.

When working with the data sets many assumptions had to be made, and the following main varia-bles affected the estimates most:

- **Conversion:** Even though live, fresh or chilled fish account for the largest share of fish (44%) utilized for direct human consumption [8], a substantial mass needs to be converted ino its live weight equivalent. Variation can be high, and future change might occur (net mesh size, overfishing, climate change).
- **Source of yield:** Possible discrepancies between sources.
- **Yield per fish categories:** Reliability is lower on the category level than on the species level.
- **Rounded numbers:** The values are mostly indicated and calculated by millions. Each rounding has an impact on the result.
- **Size:** Most fish are thought to be substantially smaller than the published size, resulting in an overestimation of yield.

The size of fish may strongly vary due to different factors, such as geographical region, water depth, seasons, effects of fishing on population demography, and other environmental conditions. A recent paper [32] has nicely illustrated how temperature drives spatial and temporal changes in fish body size. Observed changes were not at all consistent for all species. Apart from possible unexpected impacts on ecosystem restructuring, this makes estimations of edible flesh yield even harder.

Perspective

In no other meat industry are waste and loss as high as in fisheries. Not only is less than half of the live weight of an animal actually consumed as we presented here, but there is a very substantial amount of harvest discard and unwanted by-catch. Fish being thrown back into the water due to lack of market opportunities, harvest limitations, ill animals, and unwanted size or species. It should also be taken into account all the fish that die due to injuries, stress, or exhaustion before being processed and therefore do not meet quality standards and will not end up on someone's plate.

The waste of biomass is massive, and the numbers recorded by the FAO are not even reflecting the entire picture and the real amount of fish being pulled out of the sea.

The dark number of illegal, unreported or unregulated fisheries (IUU) has been estimated to be in the order of 11 to 26 million tonnes per year [26]. With discards at an estimated 10% of reported landings [33], we get the following calculation for the year 2018:

100 x
(96,4 m t reported landings
+ 11-16 m t unreported landings
+ 9,6 m t discards**)**
: 96,4 m t reported landings
= 121-137%

When we include unreported landings and harvest discard, 21-37% have to be added to the total fisheries production worldwide [42]. This implies that the reported 96.4 million tonnes of total global capture in the year 2018 [8] need to be corrected to numbers in the order of 117-132 million tonnes.

Rising demand for fish

And the demand for fish is still rising with an increasing human population and an increasing appetite for

Smoked fish (SandisterTel/Wikimdia)

fish. The trends of the last decades is depicted in ***Figure 4***, a graph taken from the FAO annual report 2020 [8]. The average annual increase in global seafood consumption of 3.1% overtook the population growth of 1.6%.

As shown in ***Figure 1***, the trend of a rise in aquaculture is even steeper. Aquaculture seems to provide a possible solution for increased consumption, yet the picture is very deceptive. Increased aquaculture will also need increasing amounts of feed, which as of now mostly originates from fish meal supply by specialised fisheries, since fed aquaculture has outpaced non-fed aquaculture [8].

How to lower fish meal and fish oil

Countries with large fish meal supplies use fishery bycatch as direct feed in aquaculture (without reduction into fish meal and fish oil) [23]), and an estimated 25-35% of the total volume of fish meal and fish oil are currently made of by-products [10]. An increase in this share would be a more responsible way to handle waste and to decrease the amount of live catch for aquaculture.

Alternative feeds could also provide a promising solution. Multi-ingredient feeds are more balanced and may lead to better growth rates and animal health. Soya is a plant-based source which currently dominates the fish meal replacement market. However, fish feed containing soya alone cannot provide a maintenance of high growth rates, and meat producers risk higher disease levels and lower meat quality [23] [34]. Furthermore, the soybean cultivation has mostly negative impacts on the environment. The

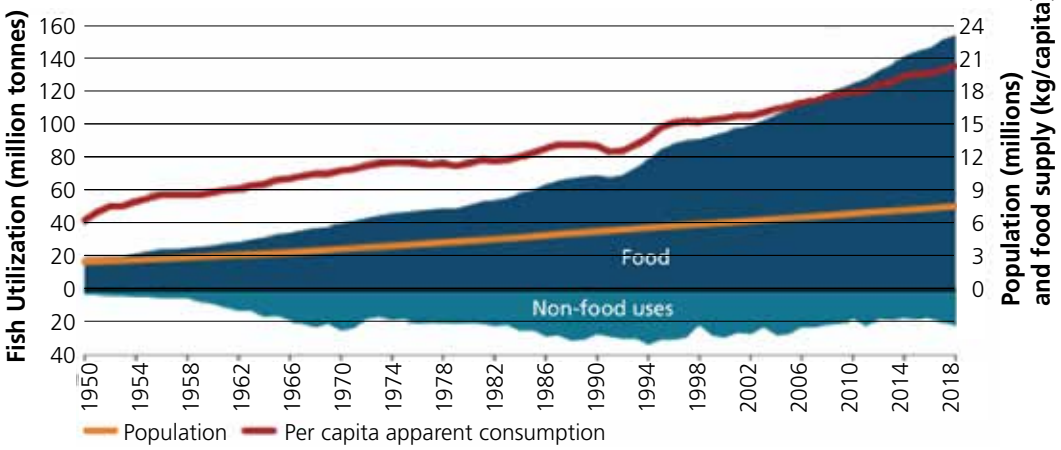


Figure 4: World Seafood Utilisation and Consumption 1950-2018 [8]

production of algae oil may then be a promising solution. Algae are part of the diet of numerous marine species [34], they are highly enriched in DHA (longest chain omega-3 fatty acid—that's where the fishes get it, by the way), and their production is sustainable and waste-free [35]). Canola-based and invertebrate-based feeds could be promising as well [34], or a combination of all these. More effort needs to go into research and development in this field.

Ecological problems of fish farming

But the problems do not end there. Environmental pollution is a serious concern with open net cages connecting the cultured populations to the surrounding ecosystem. Often special strains are used, and consequently the DNA of wild conspecifics is compromised due to inbreeding with net cage escapees over time.

High density and genetic homogeneity facilitate parasitism, and the diseases spread easily from the cultures to the adjacent wild populations. A short-term solution is often the use of antibiotics, but with antibiotic resistance on the rise, alternative strategies will be needed. Ideally density should be regulated at a limit, population should be genetically diverse, and the system should be closed in order to prevent the waste from polluting the adjacent environment. Also, for all naturally migrating species, or for species with natural home or depth ranges beyond dimensions aquaculture can cope with [36], being in captivity is completely against their natural needs and behaviour. Besides, many species do not reproduce naturally in captivity, eggs and sperm must therefore be removed manually, and often the use of hormones is necessary to induce fertility.

Fish stocks need a break to recover

Excessive fishing results in alarming crashes in fish stock, which can only recover if less fishing takes place in the future. As Rainer Froese [41], co-founder of FishBase, likes to remind us: "It is stupid to pull more fish out of the ocean than can grow back." Of course, that seems quite logical. Yet, for this to happen, and for fish stocks to recover, public understanding and awareness must grow, and a much more sustainable consumer behaviour needs to establish itself. We need to find our way back to a sustainable balance between contributing to human food security and poverty alleviation on the one hand and the preservation of marine ecosystems on the other. As fair-fish puts it since 2011 already: "Fish once a month max—the sea won't yield more!", see also page 18.

MARCO EBERLI

Conclusions for consumers

by Billo Heizpeter Studer

According to the most current data (FAO, 2018 [10]), the annual seafood consumption (including fishes, molluscs, and crustaceans, from fisheries and aquaculture) reaches 20,5 kg per human being, which is twice as much as mankind consumed only two generations ago, as this study underlines.

If we consider only the edible meat of just fishes, we are talking about 64 to 85 million tonnes consumed each year according to this study (figure 3), which means 8 to 11 kg per human being (see page 11).

Can fish consumption on such a high level carry on in a sustainable way? Or, to put it more tangible: Will your children and your grandchildren be able to still eat as much fish? In the richest countries, perhaps, but what about the big rest of the world, let alone the many developing countries whose populations depend on fish in their diet much more than you or I do?
Fisheries biologists who are independent from the industry, like e. g. Rainer Froese or Daniel Pauly, tell us that the fishing pressure should be reduced by 50 percent until the fish stocks have fully recovered, whereas "fully" does not refer to the first sign of recovery but to the abundance known until the end of the Second World War. They assert that with fully recovered stocks, fishing efforts per tonne will decrease while the yearly catch volume will increase by up to 60 percent compared to today—and remain so, provided that unsustainable fishing practises and fishing for feed are banned. [45] [46]
Fishing 60 percent more than today would also mean that mankind could do without the bulk of aquaculture, mainly without farming species which need fish components in their feed and/or have a low potential of experiencing welfare in captivity, according to the FishEthoBase [36]. What an amazing perspective for the last big wild food source on this planet we profit from yet!

To fully recover, pelagic species like herrings, mackerels, sardines etc. need 4 to 5 years, whereas bottom living (cod, flat fishes, etc.) and deep sea species need more time, depending on the depth and the higher age in which they reach sexual maturity to contribute to their stock's recovery.

Reducing the fishing pressure by 50 percent means, in plain words: eat 50 percent less fish. Overfishing is not just caused by some "evil" fishermen. As Daniel Pauly once put it straight out when asked where all the fish had gone: *"We simply ate it!"*

So, let's calculate:
1) We ought to reduce the consumption of wild fish by 50 percent.

Fish consumption per capita and year	Lower estimation: 8 kg *(see page 11)*	Upper estimation: 11 kg *(see page 11)*
Wild fish	50% of 8 kg/2 = 2.0 kg	11 kg/2 x 50% = 2.75 kg
Farmed fish	80% of 8 kg/2 = 3.2 kg	80% of 11 kg/2 = 4.4 kg
„Allowed" consumption	5.2 kg = 34 meals of 150 g	7,1 kg = 47 meals of 150 g
Farmed, Western market	0% of 8 kg/2 = 0,0 kg	0% of 11 kg/2 = 0,0 kg
„Allowed" for Westerners	2.0 kg = 13 meals of 150 g	2,75 kg = 18 of 150 g

Table 2: Calculation of the "allowed" fish consumption

2) As for aquaculture, we ought to avoid fishing to feed farmed fishes. The current average global need of fish in feed across all species, including herbivores and omnivores, is estimated to be about 200 g of fish in feed to gain 1 kg of farmed fish [18]. Thus, reducing the consumption of farmed fish down to 80% could help abandon the use of wild fish in feed.
3) Thus, **on a global scale**, mankind should reduce the consumption of wild fish (half of the fish on the market) down to 50% and that of farmed fish (the other half) down to 80%.
4) On the **Western market**, however, the demand in farmed fish concentrates on carnivorous species (salmons, trouts, seabream, seabass, and many more) whose feed is estimated, as an average, to contain 1 kg wild fish to gain 1 kg farmed fish [18]. We Westerners, as a matter of fact, should renounce at farmed fish alogether.
5) With respect for populations that highly depend on fish, the lower estimation (Table 3) is rather the one to follow.
Hence fair-fish's golden and easy to memorise rule for populations who do not depend on seafood [38]:

"fish once a month max."

What is the alternative to fish?
Should I eat more crustaceans, molluscs or more fish oil? Rather not! The problems with overfishing and aquaculture are pretty much the same.
Or should I eat more meat? Again, bad solution! Today's meat consumption causes heavy problems for the environment, the climate, and not least for the poor animals kept in their vast majority under insupportable circumstances. Let alone the health issues ordinary meat eaters encounter, and its financial consequences for the society.

Should you fear…
… a loss of protein intake: do as your grandparents did: there's much protein in a clever plant based diet.
… a lack of the daily intake of long-chain fatty acids (Omega-3 EPA and DHA) your doctor may have recommended to you: ask your health food shop or retailer for "fish" oil produced on the basis of microalgae—that's exactly from where fishes, along the marine food chain, get their more or less high content of Omega-3.

Reference List

[1] Braithwaite, V. (2010). Do Fish Feel Pain? Oxford University Press.

[2] Balcombe, J. (2016). What a Fish Knows. The Inner Lives of Our Underwater Cousins. One-world Publications, England.

[3] Hu Y, Shang H, Tong H, Nehlich O, Liu W, Zhao C, Yu J, Wang C, Trinkaus E and Richards M (2009) „Stable isotope dietary analysis of the Tianyuan 1 early modern human" Proceedings of the National Academy of Sciences, 106(27).

[4] Guthrie, D (2005) The Nature of Paleolithic Art. University of Chicago Press.

[5] Barrett, J.M., Locker, A.M. & Roberts, C.M. (2004a). The origins of intensive marine fishing in medieval Europe: The English evidence. Proceedings of the Royal Society B 271.

[6] Barrett, J.M., Locker, A.M. & Roberts, C.M. (2004b). Dark economics revisited: The English fishbone evidence AD 600-1600. Antiquity 78.

[7] Hoffmann, R.C. (1999). fish and man: Changing relations in medieval central Europe. Beiträge zur Mittelalterarchäologie Österreich 15.

[8] FAO (2020). The State of World Fisheries and Aquaculture—Meeting the sustainable development goals. Food and Agriculture Organization of the United Nations. Rome, Italy

[9] Potts, J., Wilkins, A., Lynch, M. & McFatridge, S. (2016). State of sustainability initiatives review: standards and the blue economy. International Institute for Sustainable Development (IISD), Winniped, Canada

[10] FAO (2018). The State of World Fisheries and Aquaculture. Organization of the United Nations. Rome, Italy

[11] Guillen, J., Natale, F., Carvalho, N., Casey, J., Hofherr, J., Druon, J., Fiore, G., Gibin, M., Zanzi, A. & Martinsohn, J. T. (2019). Global seafood consumption footprint. Ambio, 48 (2), 111-122. https://doi.org/10.1007/s13280-018-1060-9

[12] Boyd, C.E. (2015). Overview of aquaculture feeds: Global impacts of ingredient use. Feed and Feeding Practices in Aquaculture. Woodhead Publishing Series in Food Science, Technology and Nutrition

[13] Macer, C. T. (1974) Industrial fisheries. p. 193-221. In: Harden-Jones, F. R. (ed). Sea Fisheries Research. Elek Science, London

[14] Campbell, B., Alder, J. (2006). Fish meal and fish oil: production trade and consumption, p. 47-66. In: Alder, J., Pauly, D. (eds.) On the multiple uses of forage fish: from ecosystems to markets. Fisheries Centre Research Reports 14(3). Fisheries Centre, University of British Columbia.

[15] Chamberlain, A. (2011). Fishmeal and fish oil: the facts, figures, trends, and IFFO's responsible supply standard. London, Marine Ingredients Organisation.

[16] Watson, R., Alder, J., Pauly, D. (2006). Fisheries for forage fish, 1950 to the present, p. 1-20. In: Alder, J., Pauly, D. (eds.) On the multiple uses forage fish: from ecosystems to markets. Fisheries Centre Research Reports 14(3). Fisheries Centre, University of British Columbia

[17] Pikitch, E. K., Rountos, K. J., Essington, T. E., Santora, C., Pauly, D., Watson, R., Sumaila, U. R., Boersma, P. D., Boyd, I. L., Conover, D. O., Cury, P., Heppell, S. S., Houde, E. D., Mangel, M., Plagányi, É, Sainsbury, K., Steneck, R. S., Geers, T. M., Gownaris, N. & Munch, S. B.: The global contribution of forage fish to marine fisheries and ecosystems: FISH and FISHERIES, 2014, 15, 43–64.

[18] Tacon, A. G. J. & Metian, M. (2008). Global overview on the use of fish meal and fish oil in industrially compounded aquafeeds: Trends and future prospects. Aquaculture, Volume 285(1-4), 146-158.

[19] Fischer, J., Haedrich, R.L. & Sinclair, P.R. (2019) Interecosystem Impacts of Forage Fish Fisheries. Proceedings of the Forage Fishes in Marine Ecosystems Alaska Sea Grant College Program. Conference paper.

[20] FAO (2003) Fisheries impact on the Ecosystem. In: The ecosystem approach to fisheries. http://www.fao.org/3/Y4773E/y4773e05.htm

[21] Morton, T. & Gordon, J. (2019) Forage Fish, Vital to Ecosystem and Economy, Would Gain Protections Under House Bill. Pew Trust Organization. https://www.pewtrusts.org/en/research-and-analysis/articles/2019/04/11/forage-fish-vital-to-ecosystem-and-economy-would-gain-protections-under-house-bill

[22] Zeller, D., Booth, S., Lam, V., Lai, S., Close, Ch. & Pauly, D. (2006) Global dispersion of dioxin: A spatial dynamic model with emphasis on ocean deposition. In: Alder, J., Pauly, D. (eds.) On the multiple uses forage fish: from ecosystems to markets. Fisheries Centre Research Reports 14(3). Fisheries Centre, University of British Columbia

[23] Alder, J., B. Campbell, V. Karpouzi, K. Kaschner & Pauly, D. (2008). Forage Fish: From Eco-systems to Markets. Annual Reviews in Environment and Resources. 33, 153-166

[24] FAO. (2005b). Conversion factors. Retrieved from http://www.fao.org/cwp-on-fishery-statistics/handbook/capture-fisheries-statistics/conversion-factors/en/

[25] FAO. (2017b). Catch and landings. Retrieved from http://www.fao.org/cwp-on-fishery-statistics/handbook/capture-fisheries-statistics/catch-and-landings/en/

[26] Agnew, D.J., Pearce, J., Pramod, G., Peatman, T., Watson, R., Beddington, J.R. & Pitcher, T.J. (2009). Estimating the Worldwide Extent of Illegal Fishing. PLOS One 4(2), 1-8.

[27] Gustavsson, J., Cederberg, C., Sonesson, U., van Otterdijk, R. & Meybeck, A. (2011). Global food losses and food waste—extent, causes and prevention. Study conducted for the international Congress Save Food! Düsseldorf, Germany. 16-17 May 2011. FAO. Rome, Italy.

[28] FAO (2019) Fishery and Aquaculture Statistics. Global production by production source 1950-2017 (FishstatJ). FAO Fisheries and Aquaculture Department [online]. Rome, Italy. Updated 2019

[29] FAO (1989). FAO Yearbook of Fishery Statistics—Catches and Landings, Volume 64. Re-trieved from http://www.fao.org/3/T0219E/T0219E01.htm

[30] Rod, R. (2019, March 20). Swiss made – Fische aus Aquakulturen. Retrieved from https://www.petriheil.ch/swiss-made-fische-aus-aquakulturen/

[31] Chefs Resources Inc. (2014). Finfish Butchering Yield. Retrieved from https://www.chefs-resources.com/seafood/seafood-yields/

[32] Audzijonyte, A., Richards, S.A., Stuart-Smith, R.D., Pecl, G., Edgar, G.J., Barrett, N.S., Payne N & Blanchard J.L. (2020). Fish body sizes change with temperature but not all species shrink with warming. Nature Ecology & Evolution 4, 809-814.

[33] Kelleher, K. (2005). Discards in the world's marine fisheries: an update. FAP Fisheries Technical Paper No. 470. FAO, Rome

[34] Rubicon Resources. (2018, January 29). 3 Promising Alternative Feeds for Aquaculture. Re-trieved from https://medium.com/sustainable-seafood/3-promising-alternative-feeds-for-aquaculture-2742c011e3cc

[35] Corbion. (2019, June 13). AlgaPrime™ DHA—Feeding Your Needs. Retrieved from http://algaprime.com/

[36] For natural needs and behaviour of various fish species, see FishEthoBase: http://fishethobase.net/db

[37] FAO. (2017a). Capture fisheries statistics. Retrieved from www.fao.org/cwp-on-fishery-statistics/handbook/capture-fisheries-statistics/en/

[38] fair-fish's Fish Test: www.fishtest.net

[39] https://sdgs.un.org/goals

[40] Suuronen, P., Perez-Comas, J.A., Lehtonen, E., Tschenij, V. (1996). Size-related mortality of herring (Clupea harangues L.) escaping through a rigid sorting grid and trawl conned meshes. ICES Journals of Marine Science. 53(4), 691-700

[41] The Guardian (2020). Supertrawlers 'making a mockery' of UK's protected seas. Retrieved from https://www.theguardian.com/environment/2020/jun/11/supertrawlers-making-a-mockery-of-uks-protected-seas

[42] Zeller, D., Cashion, T., Palomares. M., Pauly, D. (2018) Global marine fisheries discards: A synthesis of reconstructed data. Fish and Fisheries. Volume 19, Issue 1: 30–39. Retrieved from https://doi.org/10.1111/faf.12233

[43] Leibniz Institut für Gewässerökologie und Binnenfischerei (LGB). (2019). Fischmehl. Retrieved from http://www.aquakulturinfo.de/index.php/fischmehl.html

[44] Personal communication from Bundesanstalt für Landwirtschaft und Ernährung (BLE), Bonn (spreadsheet).

[45] Rainer Froese (2016), Vortrag «Fischerei oder Aquakultur?» www.fair-fish.ch/media/filer_public/1e/eb/1eeb4b52-552d-49ee-a97c-926ebb282338/froese.pdf

[46] Rainer Froese et al. (2018). Status and rebuilding of European fisheries. Marine Policy 93 (2018) 159–170. https://doi.org/10.1016/j.marpol.2018.04.018

Fish meal (Phu Thinh Co/Wikimedia)

fair fish international

fair-fish: who? and what for?

The fair-fish international association (fair-fish.net) was founded in 2010, ten years after the Swiss association fair-fish.ch. Both want to help animal welfare in fish achieve a breakthrough, especially in the case of edible fish, and at the same time takes into account the criteria of sustainability and fair trade.

fair-fish international develops the scientific basis for its own projects as well as for those carried out by its partners. Examples:

- The world's first ***fishery guidelines***—developed in practice together with artisanal fishermen in ***Senegal***—that reduce animal suffering (short catch duration, immediate stunning and killing), establish a fair trade with fish, and ensure sustainable fishing and marine environment protection.
  fair-fish.net/en/where/senegal/fishery-project/

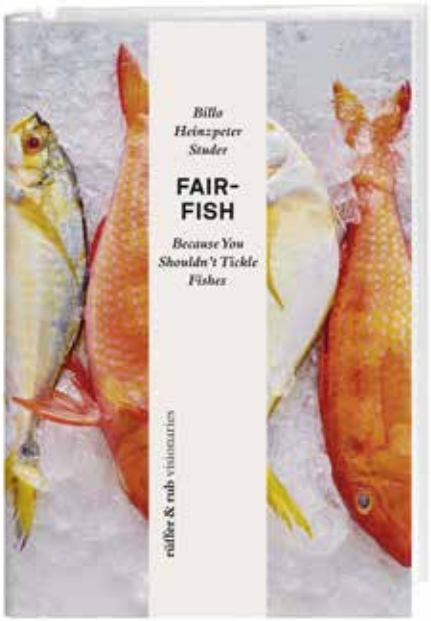
- The ***FishEthoBase***, the first database worldwide which presents the knowledge about the needs and behaviour of species kept in aquaculture—a basis for fish welfare advice and further research by our ***Fish Ehology and Welfare Group.***
  fishethobase.net · fishethogroup.net

- The ***Fish Test*** helps concerned consumers (and retailers and chefs) with quesrions like: which fish may I eat? and how often?
  www.fishtest.net

fish-facts, our quarterly

Each fish-facts issue contains in-depth information on specific subjects such as overfishing, fish welfare in aquaculture, fair-trade with fish, etc. So far, the magazine is published in German, with a first exeption of the issue at hand.
All issues can be downloaded here:
fair-fish.ch/feedback/mehr-wissen/

For general information from fair-fish in English see: https://fair-fish.net/en/
or get our newsletter here:
fair-fish.net/en/newsletter/



All about fair-fish in a book

The founder of fair-fish had been invited by the Swiss publisher rüffer&rub to tell the story of more than twenty years of fair-fish in a book. It has been translated into English and is available in a printed edition or as e-book:
fair-fish.net/en/what/book/