U.S. Farmed Finfish Per Capita Consumption

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Summary

In this write-up we will estimate 90% subjective confidence intervals (SCIs) of

- The number of farmed finfish[1] deaths that food consumption in the U.S. is responsible for per year per capita
- The number of years these finfish spend in farms

The main calculation can be found in this Guesstimate model. The following text explains the most important parts of the calculation.

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[1] A finfish is a bony fish (such as a salmon) in contrast to a shellfish (such as a shrimp or oysters). We decided to exclude shellfish in this writeup because we are unsure about their degree of sentience relative to finfish.

Relevant species

We use the National Fisheries Institute's list of 10 most consumed seafoods to select the species for which we will do a detailed calculation. According to the list, Americans ate 14.9 pounds of seafood per capita in 2016—only 1.44 pounds of which belongs to species outside of the top 10 list. Out of the 10 species in the list, three are shellfish. We decided to exclude shellfish in this writeup because we are unsure about their degree of sentience relative to finfish. What is more, cod, pollock, and tuna are rarely farmed—they are mostly wild caught from the ocean.[2] This leaves us with four species: salmon, tilapia, Pangasius and catfish. These compose the vast majority of the farmed finfish consumed in the U.S. For the sake of simplicity, we exclude all the other farmed finfish species from our detailed calculations and only take them into account by subjectively increasing our estimate in the end.

The primary purpose of this writeup is to estimate the impact of dietary consumption of farmed fish. Consequently, this estimate does not include baitfish[3] and ornamental fish. It also does not include fish who are used for feed of farmed finfish, because they are not farmed themselves.

Imports

First we calculate how many imported finfish Americans consume. The National Fisheries Institute's Imports and Exports of Fishery Products Annual Summary, 2016 reports product weights in metric tons. Almost all of the imports of each of the four species were either in the form of "fillets and steaks" or "whether or not whole." Products like fillets exclude some parts of the fish (e.g. head, guts, and bones) and use anywhere between 25% and 95% of the total fish weight. To calculate how many farmed fish were slaughtered to create these products, we first need to convert these product weights to whole weights

[2] According to Fisheries and Aquaculture Department, 1,696 tons of Atlantic cod and 4,253 tons of Atlantic bluefin tuna were harvested globally in 2014. For comparison, the global harvest of Nile tilapia in the same year was 3,670,259 tons. No other cod, pollock, or tuna species are listed in the FAO list of cultured aquatic species fact sheets. Counting Animals' article The fish we kill to feed the fish we eat also excludes cod, pollock, and tuna from calculations about fish farming.

[3] Baitfish appear to be mainly sold to recreational fishermen. This article claims that "six billion bait minnows—predominantly golden shiners, fathead minnows, and goldfish—are raised in Arkansas each year and shipped throughout the country." That would be nearly 19 minnows per capita, more than all the finfish farmed for food. The article also states that "Arkansas leads the nation in the farming of bait and feeder fish, providing sixty-one percent of the value of all cultured baitfish in the country." However, the sources of these claims are unclear.

(the "whole weight" is the weight of the whole animal). Then we divide these whole weights by the estimated mean whole weight of the finfish. We do these calculations separately for each of the four species:[4]

$$finfish\ consumed\ annually\ per\ capita\ (imports)\ =$$

$$\frac{(Imports_{\ fillets} \times CF_{\ fillets} + Imports_{\ \text{"whether or not whole"}} \times CF_{\ \text{"whether or not whole"}}) \times Proportion\ of\ meat\ that\ comes\ from\ aquaculture}{Mean\ edible\ weight\ per\ individual \times U.S.\ population\ (2016)}$$

where:

$Imports_{\ fillets}$ is the total weight of the imports under the "fillets and steaks" category minus the re-exports of the same category

$CF_{\ fillets}$ is the "fillets and steaks" weight to whole weight conversion factor (for example, if a fillet on average has half of the weight of the whole fish, the conversion factor is 2)

$Imports_{\ \text{"whether or not whole"}}$ is the total weight of the imports under the "whether or not whole" category minus the re-exports of the same category

$CF_{\ \text{"whether or not whole"}}$ is the "whether or not whole" weight to whole weight conversion factor

When examining more detailed trade data, we noticed that there are no entries for steaks of salmon, tilapia, Pangasius, or catfish. Consequently, we assumed that most of the products in the "fillets and steaks" category were fillets. We found different fillet weight to whole weight conversion factors for each of the species on various websites, but we primarily relied on the FAO of the UN's Indicative Factors for Converting Product Weight to Live Weight for a Selection of Major Fishery Commodities. Since different sources provided different values, we used 90% subjective confidence intervals[5] for each of the conversion factors. See the Guesstimate model for more details.

[4] The National Fisheries Institute's list of 10 most consumed seafoods has separate entries for catfish and Pangasius. This can be a bit confusing because technically Pangasius is a type of catfish. The annual summary combines Pangasia and catfishes that are grown in the U.S. into one category simply called "catfish." However, Pangasius and channel catfish that are farmed in the U.S. have very different mean weights. To improve the accuracy of our estimate, we did calculations for them separately (just like the list of most consumed seafoods), using the trade data from the National Fisheries Institute database. In this report we refer to all non-Pangasius catfishes simply as catfishes—but the vast majority of them are channel catfishes.

[5] An SCI is a range of values that communicates a subjective estimate of an unknown quantity at a particular confidence level (expressed as a percentage). We generally use 90% SCIs, which we construct such that we believe the unknown quantity is 90% likely to be within the given interval and equally likely to be above or below the given interval.

It's unclear what kind of products are in the category "whether or not whole." If all the fish were whole, the conversion factor would be 1. As a result, we used 1 as the lower bound of the 90% subjective confidence intervals (SCIs) of the "whether or not whole" weight to whole weight conversion factor. It is also possible that most of the products in this category contained only edible meat. As a result, we used the same upper bounds we used for filet weight to whole weight conversion factors.

Mean whole weights and proportions of meat that come from aquaculture were taken from various sources. See the Guesstimate model for more details.

U.S. aquaculture

Similarly, we calculate how many U.S.-farmed finfish Americans consume:

$$finfish\ consumed\ annually\ per\ capita\ (U.S.\ aquaculture) = \frac{Total\ whole\ weight\ farmed\ in\ the\ U.S. - Estimated\ whole\ weight\ used\ for\ exports}{U.S.\ population\ (2015) \times Whole\ weight\ per\ individual\ fish}$$

We did these calculations separately for each of the four species. Values for total whole weights farmed in the U.S. were taken from the table "Estimated U.S. aquaculture production, 2010–2015" in the Fisheries of the United States 2016 report.[6] We estimated whole finfish weights that were used for exports using the same sources and conversion factors we used for imports.

Combined estimate

To get the full estimate, we sum the counts for both imported finfish and finfish farmed in the U.S. We also multiply the counts of consumed finfish by their average lifespans to calculate how many years of life in aquaculture is required annually per capita. Please see the Guesstimate model for sources of lifespans.

Species	Farmed fish consumed annually per capita (U.S. aquaculture)	Farmed fish consumed annually per capita (imports)	Farmed finish consumed annually per capita (combined)	Farmed finfish years required annually per capita
Salmon	0.008–0.014	0.2–0.38	0.21–0.39	0.39–0.9
Tilapia	0.017–0.053	1.8–5.16	1.8–5.24	1.1–3.7

[6] Note that we use 2015 data for the U.S. aquaculture and 2016 data for imports. This is because the U.S. aquaculture data lags one year behind the rest of the data from the National Fisheries Institute.

Pangasius	0	0.72–2.1	0.72–2.1	0.54–1.65
Catfish	0.43–1.3	0.045–0.15	0.48–1.56	0.77–2.7
Total	**0.47–1.35 finfish**	**3.2–6.9 finfish**	**3.93–7.8 finfish**	**3.7–7.24 years**

Note that the bounds of the confidence intervals on the totals in the table above may not match the sums of the bounds for the individual species. This is because we are summing probability distributions instead of constants. Guesstimate uses Monte Carlo simulations. Monte Carlo simulations involve some randomness, which can cause the values in our Guesstimate models to be slightly different upon each reload of the model.

Mortality

So far we haven't taken into account the fact that some farmed fish die prematurely. We gathered mortality data for each of the four species from various sources that can be seen in the Guesstimate model.[7] We calculated the number of deaths that happen before the planned slaughter using this formula:

$$farmed\ finfish\ deaths\ prior\ to\ slaughter\ per\ year\ per\ capita\ =$$

$$\frac{finfish\ consumed\ annually\ per\ capita\ *\ proportion\ of\ finfish\ who\ die\ prior\ to\ slaughter}{1-proportion\ of\ finfish\ who\ die\ prior\ to\ slaughter}$$

We estimate that in total there are 0.9–4.2 premature farmed finfish deaths per year per capita. To calculate how many years these finfish spend in farms prior to their death, we guess that on average deaths occur when the fish have lived 5–35% of their planned lifetime. This guess is based on limited evidence,[8] but it is subjective. After taking premature deaths into account, our 90% SCI for farmed finfish

[7] It is debatable at what stage of their development fish become sentient. This uncertainty is somewhat reflected in our 90% SCIs for the proportion of finfish who die prematurely: we tried to include "fry" mortality for the upper bounds but not for the lower bounds. The term "fry" refers to a recently hatched fish who has reached the stage where their yolk-sac has almost disappeared and their swim bladder is operational to the point where the fish can actively feed themselves. This inclusion of fry mortality has a non-negligible impact on our final estimate of finfish deaths. According to our estimates, deaths prior to slaughter account for 0.78–4.5 deaths per year per capita, and many of these deaths happen during the early stages of fish development.

[8] Our SCI is mostly based on the following evidence:

- Mortality and fish welfare claims that "mortality rate typically reduces as fish develop and increase in size."

- A 1989 article "Tank Culture of Tilapia" by James E. Rakocy claims: "the highest mortality of the production cycle (about 20 percent) occurs during the fry rearing stage. Much of this is due to predation. As the fish grow and become

deaths per year per capita becomes 5–11.3, and our 90% SCI for the amount of time these finfish spend in farms becomes 3.9–7.7 years. The full details of the calculation can be seen in the Guesstimate model.

Other considerations

In this report we use data from the years 2015 and 2016. Due to the fact that the aquaculture sector is growing, we may have underestimated the number of farmed finfish. What is more, we haven't yet taken into account less popular species of farmed fish consumed in the U.S., such as bass and trout.[9] To account for all these concerns, as well as the possible inaccuracies in the data used, we increase the upper bounds of our confidence intervals by 15%.[10] Our 90% SCI for the number of farmed finfish that the U.S. is responsible for per year per capita now becomes 5–13 fish. Our 90% SCI for the number of years all these finfish combined spend in farms becomes 3.9–8.9 years.

hardier, mortality decreases significantly at each stage so that no more than 2 percent of the fish are expected to die during final growout." Fry rearing stage is near the very beginning of fish life.

- The article Effects of Fry Age-at-Stocking on Growth and Survival of Channel Catfish also claims that "rearing catfish fry to fingerlings stage is probably the least efficient phase of catfish production."

[9] It seems unlikely that the final estimates would be much higher if detailed calculations were made for the other species. Salmon, tilapia, Pangasius, and catfish are the only commonly farmed finfish species that are on the list of 10 most consumed seafoods. As mentioned earlier, Americans ate 14.9 pounds of seafood per capita in 2016, 13.46 pounds of which belongs to the 10 most consumed species. According to the article The fish we kill to feed the fish we eat, the remaining 1.44 pounds is mainly composed of sardines, oysters, scallops, and lobsters. Of these, sardines are the only finfish—but sardines are not farmed.

In the table "Estimated U.S. aquaculture production, 2010–2015" in the Fisheries of the United States, 2016 report, we can see that in 2014 the four species also made up 87.7% of all the weight of aquacultured finfish in the U.S. The remaining 12.3% are large fish (trouts and striped basses). Because of their high average weight, taking them into account would not significantly change the final estimate of the number of farmed finfish.

[10] Note that the extent to which we increase these intervals is based on our intuitions.

Key resources

Fowler, Lynsee. (2017). Top 10 List Highlights Seafood Consumption Progress. *National Fisheries Institute.*

National Oceanic and Atmospheric Administration Fisheries. (2017). Imports and exports of fishery products annual summary, 2016. *U.S. Department of Commerce.*

National Oceanic and Atmospheric Administration Fisheries. (2017). Fisheries of the United States, 2016 (Report). *National Oceanic and Atmospheric Administration.*

Sethu, Harish. (2015). The fish we kill to feed the fish we eat. *Counting Animals.*

Archived reports

2014 Fish Consumption Report