Measuring and Mitigating GHGs: Tuna

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There are millions of farms and fishing vessels globally, each using a unique set of practices to cultivate or harvest their products. Thus, for any commodity, there are many thousands of different production systems and many thousands of different sources of greenhouse gases (GHGs). The relative GHG emissions of producing the same product may differ drastically depending on how and where it is grown. To fully understand how to mitigate emissions and on which producers to focus mitigation efforts, we need a better grasp of the variations and gaps in data.

The authors do not think all the information to quantify GHG emissions from the tuna value chain exists — at the very least, not in one place. This document is our attempt to collate currently available information. This is a working draft; debate, discussion, and comments are welcomed to advance the understanding of this topic. WWF will be producing similar pieces on other key food commodities to stimulate similar discussions. All comments should be justified with evidence and data and sent to Emily Moberg at GHGcommodities@wwfus.org.

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ABOUT TUNA

Tuna are large pelagic fish that are popular seafood. Tuna stocks have been heavily fished, and stock health receives international attention. There are seven types of tuna fished globally, with a total catch of about 4.3 million tonnes (Mt) per year (average from 2006 to 2010)[1] and up to 4.9 Mt in 2021. Almost 60% of tuna caught are skipjack; about 27% are yellowfin. Tuna represent a major portion of the global fish catch.

TUNA SUPPLY CHAINS

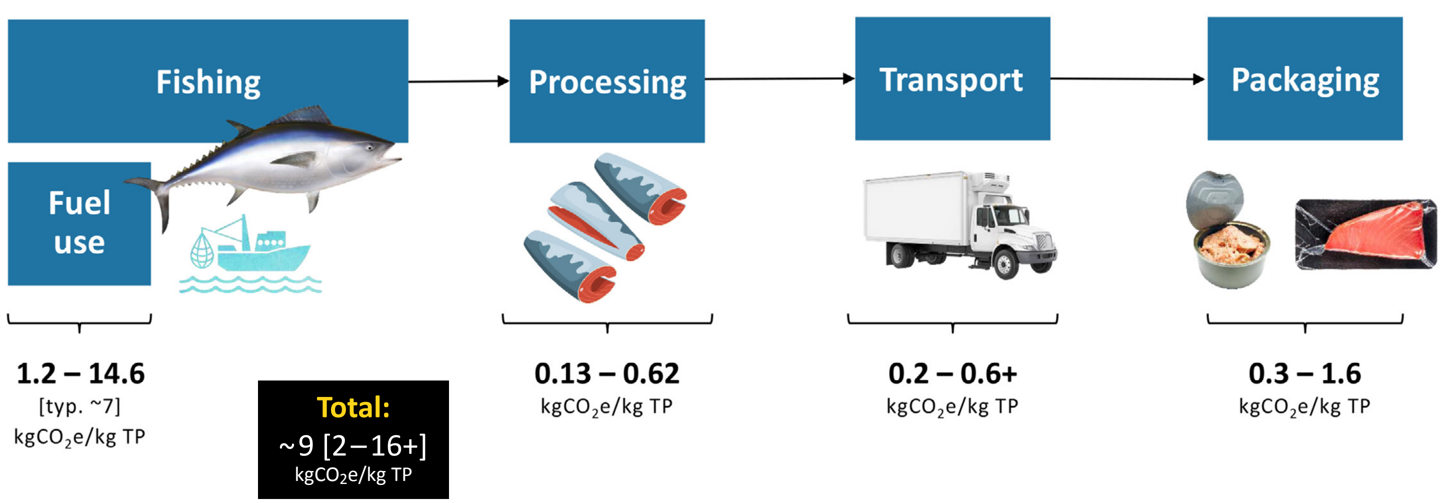
Tuna are wild-caught using multiple methods. Most tuna are harvested using purse seines — large nets that can encircle a school of fish. Most bluefin, yellowfin (65%), and skipjack tuna (76%) are caught using purse seines. In total, purse seining represents 65% of tuna catch (2006–2010 Food and Agriculture Organization [FAO]; 68% in 2019, according to the International Seafood Sustainability Foundation [ISSF]). Longlining is the next most prevalent catch method. Longlines have a long near-surface main line that has short lines with bait and hooks attached. It is the predominant fishing method for albacore, bigeye, and southern bluefin tuna. It represents about 10% of the global tuna catch (13% [2006–2010] FAO, 9.4% 2019 ISSF). Longline fishing has a high rate of bycatch, including animals like dolphins and seabirds. Trolling represents about 1.6% of tuna catch, while pole and line is about 9%. Some artisanal methods are also used more rarely.

Tuna are then brought to port, where initial processing occurs. For canned tuna, the meat is then shipped to a canning facility (this may be in another country) before being shipped to retail.

About 58% of global tuna products (TPs) were transported frozen; 40% were preserved, and the remaining 2% were chilled or live.[2]

GHG EMISSIONS FROM WILD-CAUGHT TUNA SUPPLY CHAINS

Figure 1: Range of GHG emissions from wild-caught tuna supply chains



Fisheries and aquaculture production (to farm gate or to dock) likely contribute between 435 and 866 $MtCO_2e$/yr, which is about 0.8%–1.7% of global net emissions. Wild-caught fish account for about 40% of these emissions. Of this, **tuna contribute about 15% of total wild-caught emissions.**[3]

Emissions from the tuna value chain arise from four main processes: fishing, processing, transport / storage, and packaging. Fuel use from fishing tends to be the dominant source of emissions. Across its value chain, tuna typically emits about 8–9 $kgCO_2e$/kg edible weight (EW) or per kg tuna product (TP).

There is variation in each stage of production, particularly in fishing fuel use and transport. These ranges (in $kgCO_2e/kg$ TP) are shown below, with the typical range highlighted in darker orange.

Fishing

Fishing vessels use fuel. These fuels release GHGs (primarily carbon dioxide [CO_2]) when burned. The total amount of GHGs emitted per tonne of tuna is thus a function of how much fuel is used to catch each tonne of tuna. This fuel use intensity is typically expressed in liters (L) of fuel per tonne of tuna caught. The range is about 1–14.6 $kgCO_2e/kg$ tuna EW with a mean of 7.6.[4] For context, this is much higher than for small pelagic fish (whose emissions from fishing are about 10 times lower) but smaller than for many wild-caught crustaceans.[5]

How fish are caught (longline vs. purse seine, etc.) is the largest determinant of emissions.[6]

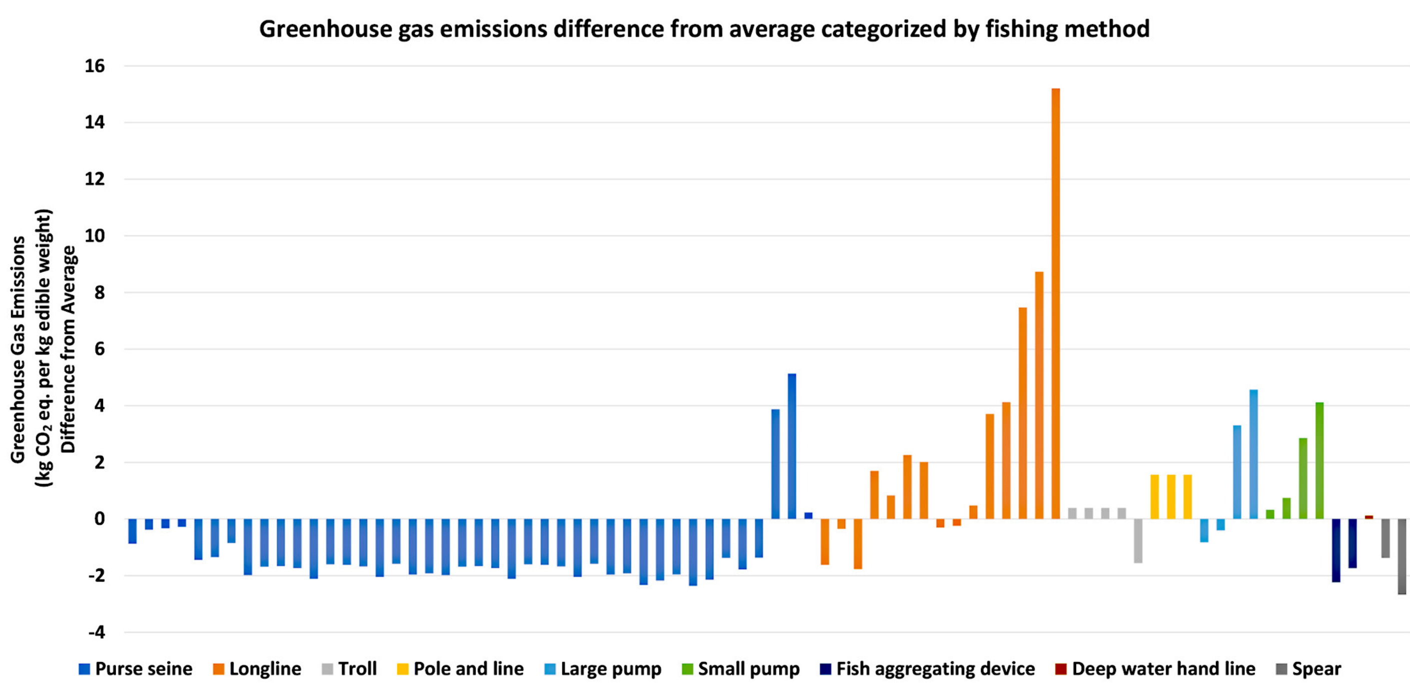
- **Purse seine:** Purse seining has among the lowest fuel use intensity (~16[7]– 459[8] L/t), corresponding to a fishing footprint of **1.7 – 4.1 $kgCO_2e/kg$ EW**[9], although the typical values are likely closer to 2.3 – 3 $kgCO_2e/kg$ EW.[10]

- **Longline:** Longlining has a much higher fuel use intensity than purse seining (300[11] – 1,124[12] L/t), which results in a higher carbon footprint: **3.1 – 12.5 $kgCO_2e/kg$ EW**.[13]

- **Troll:** Trolling has highly variable fuel use efficiency, with reported ranges from 351[14] to 3,896[15] L/t, or **3.7 – 11.4 $kgCO_2/kg$ EW**.[16]

Other fishing practices, like the use of fish aggregating devices, seem to exert a smaller effect on emissions than between major practices. Vessel efficiency within these fishing methods seems to be the major driver of different fuel amounts.

Figure 2. Distribution of GHG emissions difference from average, color-coded by fishing method. Data from Avadí et al. (2015), Hillborn et al. (2006), Hospido et al. (2006), Hospido and Tyedmers (2005), Minami et al. (2004), Parker et al. (2014), Poovarodom et al. (2011), Tan and Culaba (2009), Tyedmers and Parker (2012), and Asian Development Bank (2009).



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Processing

The processing of tuna, in particular for canned product, can be GHG-intensive, primarily from heating the product. Few studies reported on these emissions. The range reported was **0.13 – 0.62 $kgCO_2e/kg$ EW**.[17]

Transport of Product

The mode of transport and distance determine the emissions from transport. Reported emissions from transport ranged from **0.2 to 0.6 $kgCO_2e/kg$ EW**.[18] Some tuna may also be transported by air, although the proportion of tuna transported this way is unknown (and assumed to be for sushi-grade or other fresh product, which is only about 2% of total product). For other fish, air transport can result in emissions in excess of 10 $kgCO_2e/kg$ EW.[19]

Packaging

Most tuna is sold in tins or pouches. The GHG impacts of producing this packaging are a major source of emissions.

- **Metal can:** Emissions for the can are **about 1.6 $kgCO_2e/kg$ EW (tuna).**[20] For smaller fish (sardines, etc.) emissions from cans are often higher (2.3 – 2.6 $kgCO_2e/kg$ fish[21]), likely because of smaller tin sizes per unit of product.

- **Retort pouch:** Emissions for retort pouches are lower at **about 0.32 – 0.58 $kgCO_2e/kg$ EW**.[22] This is in line with plastic packaging per kilogram of fish for salmon and cod (0.2 – 0.5 $kgCO_2e/kg$ fish).[23]

Retail

No studies on retail emissions for tuna were found. Other meats, including fish, have retail emissions of about 0.3 $kgCO_2e/kg$ EW.[24] Canned tuna likely has a lower footprint similar to shelf-stable foods (~0.04 $kgCO_2e/kg$ EW[25]).

PRODUCTION SYSTEMS

The aforementioned production practices are sometimes grouped into particular "production systems." For tuna, the region where fishing occurs (which stock is being harvested) is how fisheries typically are categorized. While there is some difference in emissions across regions (e.g., 2.3–3.0 $kgCO_2e$/kg tuna across basins for purse seine fleet)[26], these differences are small relative to the differences among fishing methods.

For processing and packaging emissions, the electrical grid in the location of the processing facility is most critical. The GHG intensity per kilowatt hour can vary by over tenfold depending on the source. Coal-heavy grids tend to have much higher GHG emissions per unit of electricity, while renewable-heavy grids will be much lower.

OUTLIER EMISSIONS SOURCES

The variability in emissions per kilogram of edible tuna highlights the large mitigation potential that exists across current practices. Here we highlight the "low hanging fruit," or practices that drive unusually high emissions intensity. These practices may be good targets for initial screening for improvement.

- **Inefficient fishing:** Longline fishing can be very fuel-intensive per unit of catch. The emissions from some vessels can be 10 times higher per unit catch than others.

- **Air transit:** When fish are transported by air, emissions can exceed 10 $kgCO_2e$/kg EW, which exceeds typical transport emissions by 10–100 times.

MITIGATION

Mitigation options for wild-caught fisheries are currently limited, especially for individual vessels. However, there are mitigation strategies that are appropriate at multiple organizational and time scales.

- **Rebuild stocks:** Abundant fish are easier to catch With higher catch-per-unit-effort, the emissions from fuel could be dramatically lowered. While there is a long-term benefit financially, the short-term lowered catch and problem of free-riding are major impediments. There is also likely a strong ecological benefit to rebuilding fish stocks. Modeling work suggests that rebuilt stocks could result in a 50% lower GHG footprint from fishing.[27]
- **Employ low-fuel fishing:** Longlining often has higher GHG emissions than purse seining (and the emissions are more variable). Switching more catch to purse seining or to less GHG-intensive longlining could greatly mitigate the emissions from fuel use. However, attention should be paid to make sure these changes do not come at the expense of bycatch. Modeling work suggests that low-fuel fishing methods could result in an over 50% decrease in emissions from fishing.[28]
- **Streamline packaging:** Reduced emissions from packaging may be a critical tool for lowering emissions in the near term. Using greater recycled content, thinning the packaging, or changing packaging may all be viable ways to reduce its emissions.
- **Reduce air freight:** Tuna that is shipped on planes has a much higher GHG footprint than tuna shipped over land or water. Reducing the proportion of tuna shipped by air will decrease overall emissions.
- **Reduce loss and waste:** About 35% of seafood is estimated to be lost or wasted.[29] This loss and waste also "wastes" the embedded emissions to harvest, process, and transport the product. Changes in packaging or storage, as well as consumer engagement, can be powerful tools in reducing loss and waste.

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Table 1: Contribution of seafood to different categories of GHG emissions (relevant categories for tuna are highlighted)

	Total emissions ($GtCO_2e/yr$)	Seafood's contribution ($GtCO_2e/yr$)
Agriculture-driven LUC	4.9	0.13–0.24[30] (aquaculture feed)
Agriculture	6.2	
Non-agriculture, forestry and other land use (AFOLU) food emissions	2.6–5.2	**?**
Maritime fuel use	**1.1[31]**	**0.18–0.38[32] (capture fisheries' fuel)**
Aquatic biogenic	?	? pond emissions 1.47 (trawling)[33]
Global total	52	0.435–0.866 (aq. and w.c. to dock)

TOOLS AND DATA AVAILABILITY

There are relatively few studies and tools available for GHG assessment in seafood. There are fewer still focused on tuna specifically. The table above summarizes the contribution of seafood to different categories of GHG emissions. Because seafood is rarely considered, its emissions are essentially "hidden" in other categories.

Within these contributions remains a great deal of uncertainty, particularly regarding contributions of post-dock emissions from seafood and from biogenic emissions related to fishing. Because tuna are pelagic, it is unlikely that emissions from bottom trawling are produced.

Seafood is also poorly represented in global food and climate models, so the trade-offs between increased seafood consumption relative to terrestrial foods are not well characterized. However, we do know that the emissions intensity of seafood must decrease regardless of the balance of what proportion of diets it comprises. In 2019, the global emissions intensity for food was about 75 tCO_2e/t of protein. If the per capita protein consumption stays the same but the population increases, a 30% reduction of GHG intensity will be required to keep overall emissions the same as they are today. Protein production must decline to 14 tCO_2e/t protein to reduce emissions to about 4 $GtCO_2e/yr$, which is what current modeling[34] suggests the food sector needs to be limited to by 2050. ***This suggests the maximum emissions intensity from seafood will be about 14 tCO_2e/t protein, which is at least double the current intensity of tuna.***

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