

The Environmental Cost of Aquaculture Mortality: How Reducing Fish and Shrimp Deaths Lowers GHG Emissions

Executive Summary

Aquaculture is the world's fastest-growing food production sector, yet the industry faces a largely underappreciated sustainability challenge. Persistently high mortality rates systematically inflate the sector's greenhouse gas (GHG) emissions, **leading the Food and Agriculture Organization (FAO) of the UN to cite mortality reduction as one of the most critical levers for reducing total emissions in aquaculture.**

Aquaculture generated an estimated 263 million tons of CO₂ equivalent in 2017, roughly 0.49% of total anthropogenic GHG emissions, a footprint comparable in scale to that of the global sheep industry.¹ Feed production dominates this footprint, accounting for approximately 57% of total aquaculture emissions when including crop feed material, fishmeal production and transport, with the remainder arising from on-farm energy use and aquatic nitrogen cycling. Shrimp and prawns alone generate 21% of aquaculture's GHG emissions despite representing only 10% of production volume.²

Industry research estimates that disease alone results in an average loss of 40% of global shrimp production, the single largest driver of pre-harvest mortality in the sector. In salmon, annual mortality rates of 15–20% are commonly reported across major producing regions. Beyond these high-value species, mortality remains a pervasive challenge across the sector: tilapia farms experience disease-driven mortality averaging 23%, carp polycultures—the backbone of global freshwater production—face average losses of 10% during disease outbreaks, and sea bass and sea bream in marine farming systems report average mortality rates of 15–20%.

These losses represent not just billions of dollars in recoverable value, but also millions of tons of CO₂ equivalent emissions that could have been prevented. When a farmed fish or shrimp dies before harvest, every kilogram of feed consumed, every kilowatt of electricity used to aerate its pond, and every ton of CO₂ equivalent embedded in its rearing becomes a pure emissions loss. The animal never enters the food system, and yet the planet has already paid the climate cost of raising it to the point at which it died.

The Mortality Challenge

Shrimp Production

Shrimp farming is afflicted by some of the most extreme mortality rates in any livestock sector. Disease alone accounts for an average loss of 40% of global shrimp production,² and when all causes of pre-harvest mortality are included, total losses may average approximately 50%—meaning that roughly 450 billion shrimp are raised each year with significant resource inputs only to die before harvest.³ Acute disease events can occasionally cause near-total mortality; Early Mortality Syndrome (EMS), for example, has caused regional production declines of this magnitude. However, the routine high mortality from endemic diseases represents the more persistent and widespread challenge to the sector.

The economic and environmental costs of this routine mortality are substantial. From a financial impact perspective disease losses across all aquaculture sectors are estimated to exceed USD 6 billion annually,⁴ with shrimp

accounting for a disproportionate share. From a climate perspective, this means that the feed consumed, energy expended, and emissions generated to raise these 450 billion shrimp are wasted resources that never translate into food production, a direct loss of efficiency and a significant contributor to aquaculture's overall GHG footprint.

Salmon Production

Atlantic salmon aquaculture also faces significant mortality challenges globally, with annual mortality rates typically ranging from 15–20% across major producing regions. In Norway, the world's largest salmon producer, data from the Norwegian Veterinary Institute indicates that between 14% and 17% of all salmon placed in sea farming are lost before harvest during the sea phase, with rates of 16% recorded in 2023 before declining to 15% in 2024 and 14% in 2025.⁵ While these recent Norwegian figures suggest an improving trend, a 2024 study published in *Scientific Reports* documented that the frequency and scale of mass mortality events increased across Norway, Canada, and the UK between 2012 and 2022—indicating that the sector's broader structural challenge remains acute even as certain individual producing nations make incremental progress.⁶

Tilapia Production

Tilapia is one of the most widely farmed freshwater fish globally, with disease-related mortality representing a significant challenge across producing regions. Research indicates that disease-driven mortality in tilapia aquaculture averages approximately 23% when disease events occur, meaning that hundreds of millions of tilapia are raised annually with substantial resource and feed inputs, only to die before reaching market size and entering the food system. In major producing regions like Bangladesh, the estimated annual economic loss from disease-driven mortality exceeds USD 875 million,⁷ underscoring the scale of the problem and the wasted emissions embedded in these losses.

The Higher the Mortality, the Higher the Emissions

The link between mortality and GHG emissions flows from a fundamental principle of life cycle assessment (LCA): all emissions incurred during the production of a food product must be allocated to its eventual output.⁸ If producers need to raise two shrimp for every one shrimp that lands on a consumer's plate, or five salmon for every four that make it to market, the total emissions per KG of food produced increases accordingly.

Consider a shrimp pond scenario where 100,000 juvenile shrimp are stocked for grow out. Feed is delivered, electricity powers aerators, and the biological processes of rearing generates nitrous oxide releases. With an average mortality of 40% across the production cycle, 40,000 of those shrimp die before reaching harvest. All of the feed consumed, all of the electricity used, and all of the associated emissions to rear those 40,000 dead shrimp yielded no food for consumers. The surviving 60,000 shrimp must now, in effect, carry the emissions burden of the entire cohort, inflating their carbon footprint accordingly. Losses incurred at later, heavier growth stages carry the greatest accumulated emissions burden, as more feed and energy have already been invested, underscoring the importance of early disease detection and intervention.¹⁰

And the impact of disease on increasing GHG emissions goes even further. Disease outbreaks themselves can generate huge spikes in GHG emissions. A 2026 study on Asian seabass aquaculture found that disease outbreaks causing 30% mortality resulted in daily CO₂ emissions that were 15 times higher than daily emissions under normal production conditions, with similarly elevated methane and nitrous oxide levels.¹¹ Disease-infected shrimp farms have been shown to generate substantially higher environmental impacts across multiple categories, including GHG emissions, with disease presence negatively affecting feed conversion and increasing energy use and overall emissions intensity.¹² Similar patterns have been documented across other major farmed species including tilapia, milkfish and carp.

It is for all of these reasons that the Food and Agriculture Organization (FAO) has spotlighted the reduction of mortality as one the four most critical levers for reducing overall greenhouse gas emissions in aquaculture (alongside improved feed efficiency, enhanced system management, and technological innovation).⁹

Quantifying the Relationship: What the Data Suggest

The data establish a clear, quantifiable relationship between mortality levels and overall GHG emissions per KG of final product produced. This relationship, where lower mortality equals lower emissions, is consistent across all major aquaculture species.

Just how much do reductions in mortality lower emissions? A baseline reduction percentage, which conservatively disregards emissions spikes during high-disease periods and looks just at the lower number of animals needed to produce the same amount of final product, can be calculated using the following formula:

$$0.5 \times [(m1 / (1 - m1)) - (m2 / (1 - m2))] / [1 + 0.5 \times (m1 / (1 - m1))]$$

where $m1$ = original mortality rate, and $m2$ = improved mortality rate

Note that the figure of 0.5 used in the formula assumes that mortality is somewhat evenly distributed across early and late stages of the grow out period, which research by the FAO and others suggests is often roughly the case (though with wide variation on a case-to-case basis).^{13 14} The actual percentage of emissions reduction may be higher or lower if mortality is concentrated early or late in the grow out period.

For an example of this formula in practice, consider a tilapia farm that suffers from 50% mortality. For each one tilapia raised to slaughter and moved into the food system, a second tilapia dies early (we will estimate halfway through the production cycle) and is discarded. Thus there is approximately 1.5 tilapia's worth of emissions (one tilapia that lives a full life and enters the food system, one tilapia that lives half of a life cycle and dies and is discarded) for each 1 tilapia that enters the food system. Moving from 50% mortality to 0% mortality would therefore reduce emissions per harvested tilapia from 1.5 tilapia's worth of emissions to 1 tilapia's worth of emissions—a 33.3% reduction, as the formula above would calculate.

Here are examples of mortality reductions and their corresponding reduction in GHG emissions per KG of final product:

Mortality goes from 50% → 40%: 11.1% reduction in GHG emissions per KG final product

Mortality goes from 50% → 25%: 22.2% reduction in GHG emissions per KG final product

Mortality goes from 30% → 20%: 7.4% reduction in GHG emissions per KG final product

Mortality goes from 20% → 10%: 6.2% reduction in GHG emissions per KG final product

Mortality goes from 15% → 5%: 5.7% reduction in GHG emissions per KG final product

As is evident from the above, a rough rule of thumb is as follows:

- For farms with high mortality, every one percentage point reduction in mortality generates approximately one percentage point reduction in GHG emissions.

- For farms with low mortality, every one percentage point reduction in mortality generates approximately one half percentage point reduction in GHG emissions.

Implications for Climate Strategy in Aquaculture

The quantifiable link between mortality and emissions intensity carries significant implications for how the aquaculture industry should approach climate performance. The most underappreciated lever available to reducing total GHG emissions footprint is one that also improves profitability: lowering mortality rates across the production cycle. High mortality is not simply a production problem. It is a climate problem. Every animal that dies before harvest represents a lost opportunity to convert embedded emissions—from feed, energy, and pond management—into food.

When farms invest in disease prevention, biosecurity, water quality monitoring, and early pathogen detection, they are not only protecting their revenue; they are also reducing the carbon intensity of their production. This reframing opens pathways to green finance, sustainability-linked lending, and ESG-aligned investment that might not previously have been associated with animal health programs. Similarly, technology solutions targeting mortality reduction, including probiotics, disease diagnostics, genetics, vaccines (where applicable), and biosecure pond design, carry a dual climate-and-welfare value proposition that deserves to be surfaced explicitly in sustainability communications.

For aquaculture input providers—particularly feed producers, equipment manufacturers, and health service providers—supporting on-farm mortality reduction represents a powerful value-add opportunity. By providing technical guidance, improved feed formulations, disease monitoring tools, and best-practice support to their customers, input providers can help farms achieve measurably lower mortality rates. This benefits all stakeholders: producers realize improved profitability through higher yields and reduced resource waste, input providers strengthen customer relationships and differentiate themselves as essential partners in sustainability, and the broader aquaculture sector gains competitive advantage through demonstrably lower emissions. These efforts directly contribute to meaningful climate impact—reducing global aquaculture GHG emissions significantly and helping input providers and their customers meet their own corporate climate and sustainability commitments.

Sources

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