Global Salmon LCA
AQUACULTURE PRODUCTION

The environmental impacts of salmon aquaculture begin before the fish farm. Production, transport, and milling of aquaculture feed, as well as salmon farm operations, all contribute to life-cycle salmon aquaculture performance.

In this study, we compare the environmental performance of salmon aquaculture production systems in Norway, the UK, Canada (British Columbia), and Chile. We examine scenarios for more efficient practices and alternative feed formulations, and we quantify environmental costs by contribution to global warming potential (greenhouse gas emissions) and several other measures of global environmental impacts.

Key Findings

- The global environmental performance of salmon aquaculture production is dominated by the impacts of aquaculture feeds and influenced by feed use efficiency.
- Fish- and livestock-derived aquafeed ingredients account for the highest proportional environmental costs of production.
- The fish farm stage of production is a significant contributor to only one of the quantified impacts: eutrophying emissions.
- Impacts of salmon production are highly variable between regions, indicating substantial scope for environmental performance improvement in the industry as a whole

Our Analysis

We compiled a life-cycle inventory of inputs and emissions per live-weight tonne of salmon produced in each of the major salmon aquaculture regions: Norway, the UK, Canada (British Columbia), and Chile. We examined production, processing, and transport of feed inputs, energy use for feed milling, production and transport of smolts, on-farm feed and energy use, and farm-level emissions. Data was collected directly from salmon feed and farming companies; and feed inputs were modeled following a consistent, ISO-compliant methodology. We found that in 2007 the production of feed accounted for over 92% of salmon aquaculture's energy use, biotic resource use, greenhouse gas emissions, and acidifying emissions.

The nutritional requirements of farm-raised salmon may be satisfied with a variety of feed formulations. Feed producers currently source raw materials from diverse fish, crop, and livestock sources globally, each with characteristic resource dependencies and environmental impacts. We calculated weighted-average feed composition by ingredient for all salmon feeds milled by the surveyed companies. Across each of five impact categories, fisheries-derived ingredients were, on average, the most environmentally costly; however, low-impact fishery ingredients like menhaden meal outperformed high-impact crop ingredients like wheat gluten meal.

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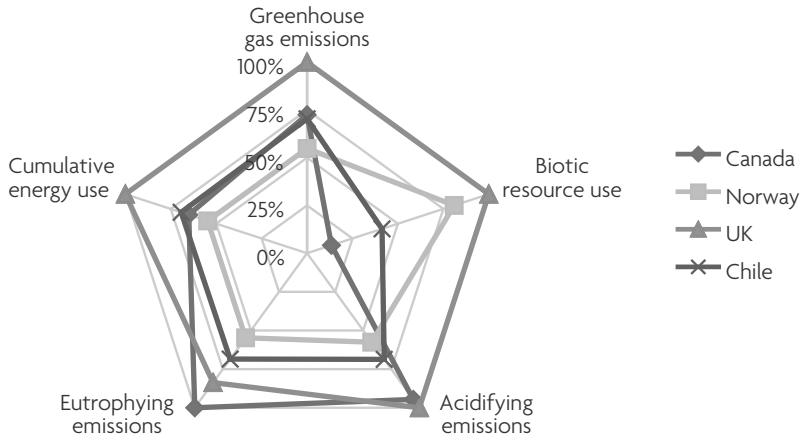
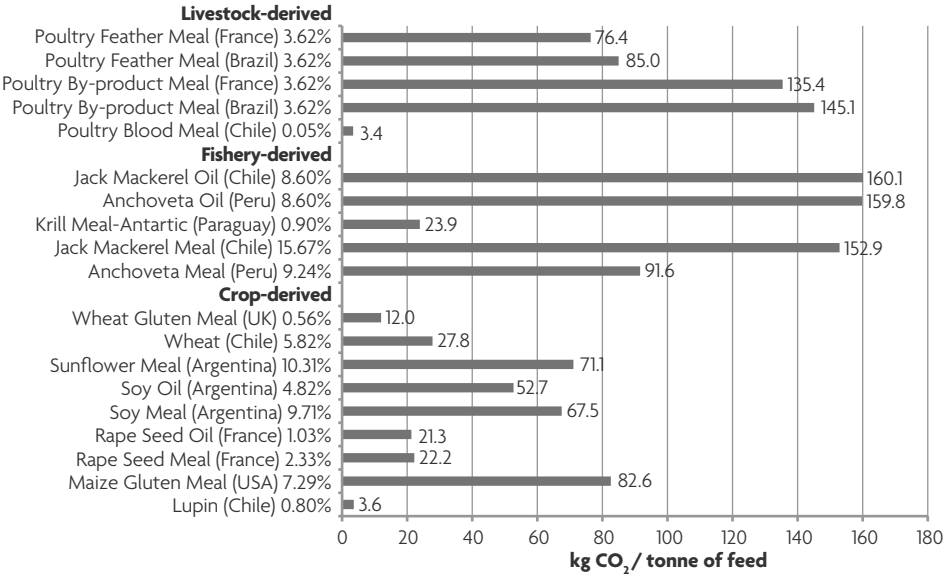
ENVIRONMENTAL PERFORMANCE OF SALMON AQUACULTURE IN THE FOUR MAJOR PRODUCING COUNTRIES



We assessed 2007 life cycle salmon aquaculture impacts up to the salmon farm gate in each of the four major producing countries, according to five measures of global environmental performance: greenhouse gas emissions, biotic resource use, acidifying emissions, eutrophying emissions, and cumulative energy use. With the poorest performer set to equal 100% in each impact category, this diagram maps the relative performance of the four countries. Norwegian operations were found to be the most efficient in each category except biotic resource use, in which Canadian operations performed best.

Exploring alternative scenarios, we found that replacing all fishery-derived ingredients with menhaden in 2007 Norwegian salmon production would have reduced the industry's greenhouse gas emissions by 57%, and that improving 2007 feed conversion rates around the world to equal those of Norway's, the industry leader, would have reduced greenhouse gas emissions across the three other countries' industries by 10%. Utilizing a previous data set from British Columbia, we found that substituting organic for conventional crop ingredients would have resulted in an 11% reduction in its aquaculture industry's greenhouse gas emissions. Important factors like nutritional equivalency were not accounted for in our scenarios, which would need to be complemented by a more comprehensive suite of considerations.

CONTRIBUTIONS OF CHILEAN FEED INGREDIENTS TO GREENHOUSE GAS EMISSIONS, PER TONNE OF FEED



In each of the major aquaculture production regions, we assessed total contributions of each aquafeed ingredient to each of five environmental impact categories. Chilean feed ingredient contributions to global warming potential are compared here as an illustrative example. Ingredients are sourced globally, with large differences in impacts. The country of origin for each ingredient is indicated in parentheses, followed by its rate of inclusion.

Opportunities for Action

Feed Producers:
Seek opportunities to improve feed use efficiency and substitute ingredients that improve global environmental performance.

Influencers:
Note that other aquafeed ingredient substitutions may be more effective than organic crop ingredients at improving global environmental performance.

For Further Reading

Pelletier N. and P. Tyedmers. 2007. Feeding farmed salmon: Is organic better? *Aquaculture.*

Pelletier, N., P. Tyedmers, U. Sonesson, A. Scholz, F. Ziegler, A. Flysjo, S. Kruse, B. Cancino, and H. Silverman. 2009. Not All Salmon Are Created Equal: Life Cycle Assessment (LCA) of Global Salmon Farming Systems. *Environmental Science & Technology.*

Winther, U., F. Ziegler, E. Skontorp Hognes, E. Emanuelsson, V. Sund, and H. Ellingsen. 2009. Carbon footprint and energy use of Norwegian seafood products. SINTEF Fisheries and Aquaculture.

About the Global Salmon LCA Project

The Global Salmon LCA project is the first worldwide life-cycle assessment of a single food product. LCA provides a systematic framework for calculating inputs and outputs at each stage of a product life cycle. Utilizing this framework, we examine the salmon fillet, icon of the global food system, and compare alternative methods of production and distribution. We evaluate global environmental impacts and expand on a traditional LCA to consider additional impacts specific to nearby ecosystems and social welfare. This analysis allows us to identify opportunities for improved performance in both aquaculture and capture fisheries — while building a more robust understanding of sustainable food systems.
Please visit www.ecotrust.org/lca to sign up for updates.

Global Salmon LCA Factsheets

A Life Cycle of Foods
Salmon Ecosystems
Capture Fisheries
Aquaculture Production
Closed-Containment Aquaculture
Products and Transport
Social Dimensions
A Globalized Food System

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