CHAPTER HIGHLIGHTS – FEED SUSTAINABILITY

Efficient – with recent gains in efficiency of feeding and growth, BC farm-raised salmon now produce more high-quality marine protein than they consume.

It takes about 1.15 to 1.2 kilograms of feed to produce 1 kilogram of farm-raised salmon.

Fish meal and oil – once the primary ingredients in Atlantic salmon feed, have been mostly replaced with plant and land-animal ingredients.

All fish trimmings used in BC for Atlantic salmon feed come from sustainably managed Alaskan pollock and Pacific hake fisheries, landed in Canada and the United States.

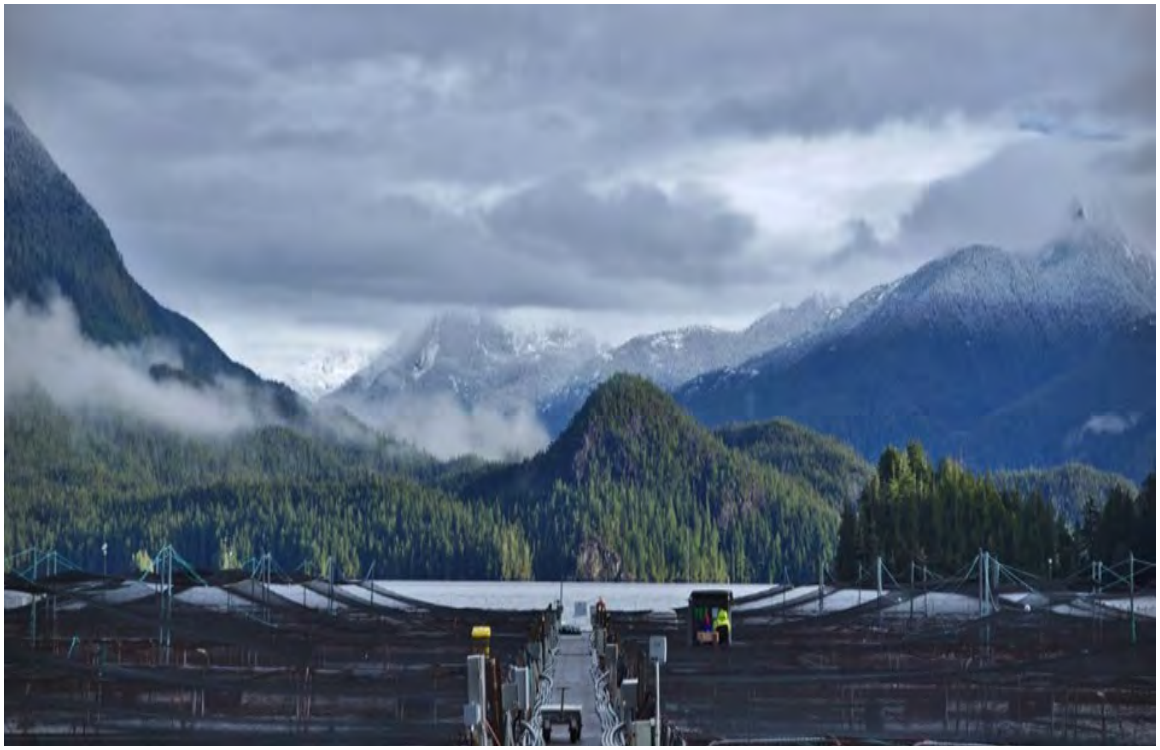
75-80% of the fish meal and oils used to feed farm-raised Chinook salmon are derived from the by-products of the BC herring and hake fisheries.

Feed is formulated to optimize salmon health – there are no added steroids or hormones in farm-raised salmon feed.

Feeds are locally made in BC – with an average of about 80% of the ingredients coming from Canada and the United States. The remaining is sourced globally from sustainable sources.

Much lower carbon footprint – it requires much less feed to grow a kilogram of salmon compared to chicken, pork, and beef.

Ranks #1 for sustainability – on the Coller FAIRR Protein Producer Index compared to other farmed animal proteins.



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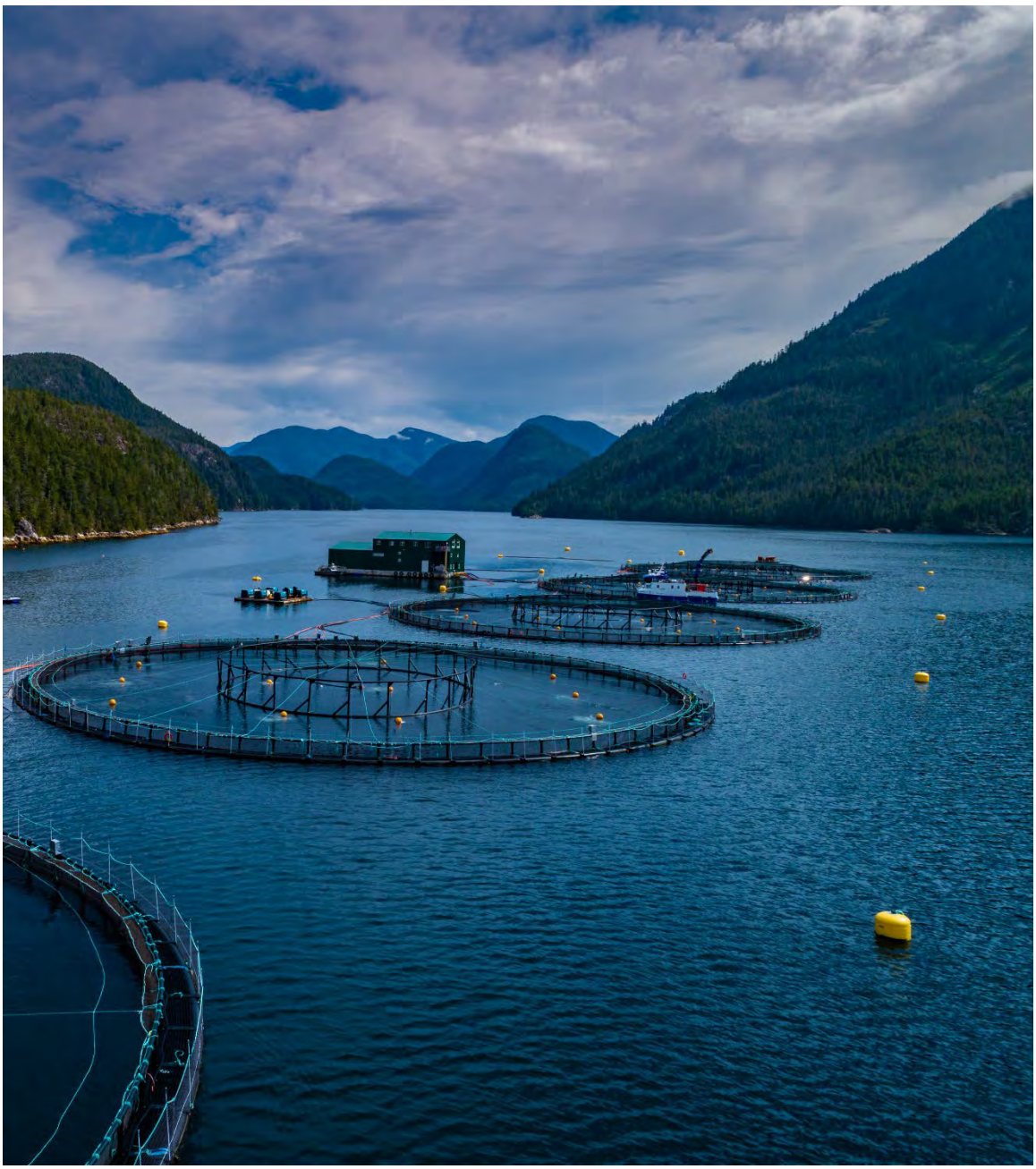


INTRODUCTION

Salmon farmers hear the concerns of First Nations and members of the public that salmon feeds may contain high levels of marine ingredients, creating sustainability challenges. We understand the importance of ensuring that salmon farming is part of the conservation solution for the world's oceans. This includes careful and sustainable practices for sourcing and utilizing marine proteins.

WHAT DO FISH EAT?

In the wild, some fish are herbivores, eating only aquatic plants; others are carnivores, eating only other aquatic animals; and some are omnivores, consuming both plants and animals. All salmon are naturally omnivores, eating varying amounts of plants and animals at different stages of their lives. Salmon need both components to be healthy, to grow and reproduce. Farm-raised salmon are no different; they need correctly balanced, nutritious food, and this comes from both plant and animal sources.

WHAT IS IN FARM-RAISED SALMON FEED?

In British Columbia, there are three main Atlantic salmon farming companies, MOWI Canada West, Grieg Seafood BC, and Cermaq Canada; there is one Chinook salmon farming company, Creative Salmon.

Farm-raised salmon feed typically comes as an extruded pellet. Pellets are sized and formulated to meet the fish's dietary needs at various life stages and are species-specific.

Feed components include proteins, fats, carbohydrates, vitamins, minerals, and the pigment astaxanthin. There are no added steroids or hormones in farm-raised salmon feed.

Although proportions and ingredients vary with life stage and by company, in general, Atlantic salmon feed is composed of (ranges provided by BC feed suppliers):

- 30-45% alternative proteins (e.g., plants, poultry)
- 12-20% alternative oils (e.g., flax, canola)
- 2-16% fish meal
- 10-15% binders and carbohydrates
- 10-15% fish oil
- 2-5% water
- 4-6% micronutrients (e.g., vitamins and minerals)

Salmon feeds are nutritionally dense and highly digestible to meet the needs of this high-efficiency, cold-blooded fish and reduce the amount of waste as much as possible.

WHERE IS SALMON FEED MADE?

All salmon feeds used in British Columbia are locally made in BC. Two companies in BC supply Atlantic salmon farms, Cargill Aqua Nutrition Canada/EWOS feeds in Surrey and Skretting in Vancouver. Taplow Feeds in Chilliwack supplies feed to steelhead, arctic charr and Chinook salmon.

Each salmon farming company has its feed formulated to its own specifications. The ingredients and proportions are not the same for each company. For example, Creative Salmon has organic certified feed produced by both Taplow Feeds and Cargill Aqua Nutrition Canada/EWOS Feeds.

WHERE DO FEED INGREDIENTS COME FROM?

BC feed companies estimate that on average, about 80% of raw sourced materials for Atlantic salmon feeds come from Canada and the United States; this percentage varies between companies, availability and quality of ingredients. The remaining 20% is sourced globally from sustainable sources.

Farm-raised Atlantic salmon feed ingredients are sourced from terrestrial and aquatic plants and animals. Common plant-based protein sources include, but are not exclusive to, wheat and corn gluten, and sunflower. Plant-based oils are mainly from canola and flax. Plant-derived carbohydrates are typically from wheat, beans, and pea flour. Some feeds may contain oil derived from algae.

According to BC feed suppliers, many of the animal-derived ingredients are by-products from fish and poultry processing. Atlantic salmon feeds commonly contain poultry meal and oil, feather meal and blood meal by-products.

Fish and crustacean meal are a common by-product from wild fisheries used in farm-raised salmon feeds to provide high-quality protein and oil.

All of the fish trimmings used in BC for Atlantic salmon come from Alaskan pollock and Pacific hake fisheries landed in Canada and USA.

As in all domesticated animal production, salmon farmers must ensure that the feed meets the nutritional and welfare needs of the fish under their care. Feed companies have nutritionists on staff to strive to understand the needs of the fish and develop optimal diet recipes. Diets are continuously updated as new ingredients become available and nutritional requirements change.

Farm-raised organically certified Chinook salmon feeds do not contain the same ingredients or proportions as Atlantic salmon feeds because of the fish's dietary needs and the product's organic status. For organically certified Chinook salmon, feed must be as close to that found in nature as possible. As such, they contain a higher proportion of marine products than Atlantic salmon feeds, and these products are sourced as locally as possible.

According to feed suppliers, currently, 75-80% of marine meals and oils in organically certified Chinook salmon feed are derived from the by-products of the BC herring and hake fisheries, with smaller amounts from other BC fisheries. Substitutions of marine meals and oils are difficult for organically certified Chinook salmon can't tolerate alternative ingredients such as soy or pea protein.

Photo by Brian Kingzett

DO FEED COMPANIES CARE WHERE THEIR INGREDIENTS COME FROM?

Yes. Modern feed companies have policies and principles they follow to ensure feed ingredients are responsibly sourced. Companies have criteria for sourcing marine-derived ingredients such as meals and oils, and many follow the FAO Code of Conduct for Responsible Fisheries. (1)

Companies have their own policies and guidelines for ingredient sourcing. All BC Atlantic salmon farms require proof of relevant certification for all raw ingredients. Feed companies also have their own guidelines for ingredients to ensure they are sourced responsibly. For example, Nutreco/Skretting and Cargill have developed marine and soy and palm oil sourcing guidelines. Both Cargill/EWOS and Skretting/Nutreco feed companies are committed to responsible sourcing of raw ingredients used in their feeds.

Detailed descriptions of these goals and policies are publicly available on their respective websites and in key documents such as the Cargill Aqua Nutrition Sustainability Report (2) and Skretting/Nutreco Responsible Sourcing (3) as well as Skretting/Nutreco Sustainability Report (4).

Taplow feed ingredient sourcing adheres to the Canadian Organic Aquaculture Standard and requirements for good manufacturing practices.

HOW IS IT SUSTAINABLE TO FEED WILD FISH TO FARMED FISH?

Salmon farmers are keenly aware that both the amount of feed ingredients used, and the sources of proteins and oils must be sustainable. As such, the Atlantic salmon farming sector has and continues to invest in research to decrease the amount of marine-derived ingredients, maintain fish health, and utilize ingredients (both marine and terrestrial) from ethical sources.

The good news is that even with a growing global Atlantic salmon farming sector, the amount of wild-sourced proteins and oils has decreased in recent years. This reduction in wild-sourced fish meal and oil has been possible by substituting and adding new ingredients, including oils from algae or marine microbes and plant-derived ingredients such as yeast, rice, and peas (e.g. Skretting responsible sourcing) (3).

Based on information from BC feed suppliers, over the last few decades, the composition of Atlantic salmon feed has changed from one primarily based on fish meal and oil to one with a major composition of plant ingredients.

In BC, Atlantic salmon feed suppliers have reduced the amount of fish meal used to approximately 15% and fish oil to 11%. Some companies have proportions as low as 2.3% fish meal and 7% fish oil.

ARE WILD FISH CAUGHT TO MAKE SALMON FEED?

Yes. Fish meal and fish oil are sourced from both wild-caught fisheries and by-products from these fisheries. Wild sources of fish meal and oil are typically fish species that are short-lived and exceptionally oily. Examples of these species include sardines, menhaden, herring, pilchard, and mackerel.

BC farm-raised salmon are highly efficient. They now produce more marine protein than they consume.

According to BC feed suppliers, fish meal and oil are also derived from seafood processing by-products. Over 40% of fish meal and more than 50-72% of fish oil in Atlantic salmon feed is now sourced from trimmings and by-products of wild capture fisheries.

DOES FARMING ATLANTIC SALMON USE MORE WILD FISH THAN THEY PRODUCE?

No. Farmed Atlantic salmon are efficient at converting food to body mass. On average, BC farm-raised Atlantic salmon need 1.15 to 1.2 Kg of food, all ingredients combined, to gain 1 Kg of body mass. Farm-raised Atlantic salmon are now net producers of marine proteins. That is, they create more marine protein than they consume.

Although highly efficient, farm-raised Atlantic salmon do need to eat some fish and fish components to be healthy. The amount needed has decreased dramatically by substituting other ingredients such as land plant and animal products and incorporating trimmings from wild-caught fish. Fish trimmings are not used to feed the same species (i.e., salmon are not fed to salmon).

It is important to fish health that the amount of omega-3s, especially EPA and DHA, are at optimal levels in salmon feed to meet the requirements of the fish.

WHY DO YOU HAVE TO USE WILD FISH TO FEED FARMED FISH?

Salmon need fish meal and oil components to grow and develop properly. These products contain about 40 essential nutrients, and they provide essential amino acids and fatty acids that salmon require. Fish oil is particularly important in providing healthy omega-3 fatty acids for both the salmon and the humans that eat them. These fatty acids are essential, and salmon cannot make it themselves.

To maintain a sustainable and growing global Atlantic salmon farming industry, researchers have been working to reduce the reliance on wild-sourced fish meals and oils by finding healthy alternatives, including plants and potentially insects. For example, Skretting is working with a seed development company, Nuseed, in the production of Aquaterra Advantage Omega-3, a canola-based source of DHA and EPA to aid in reducing the amount of wild source omega-3 oil (5).

IS HARVESTING FISH FOR AQUACULTURE FEED SUSTAINABLE?

Yes, wild fish products used to produce salmon feed come from sustainably managed stocks. There are two general types of fisheries from which these ingredients are sourced, targeted pelagic fisheries and by-products of wild capture fisheries.

Targeted fisheries are directed fisheries for small pelagic species such as herring, sardine, and menhaden. They are highly valuable sources of oil and meal and have many uses, including baitfish for commercial fisheries, human nutritional supplements, pet food ingredients, and terrestrial livestock diets. The largest end user, however, remains the aquaculture industry, with shrimp culture taking 25% of aquaculture fishmeal use and salmonids approximately 14% (6).

These fisheries are considered successfully managed as they can be fished without long-term depletion of stocks. An outcome of this successful management is that the world harvest of pelagic species has remained relatively constant over the last 20 years. Additionally, 30% of the world's fish meal and 51% of total fish oil production comes from fishery by-products (7).

Salmon feeds also incorporate by-products from sustainable wild capture fisheries, and in BC, these are typically Pacific hake and pollock by-products. There is a directed fishery for Pacific hake and pollock for human consumption, by-products from these fisheries not destined for direct human consumption are used in salmon feeds.

Feed suppliers are working hard to reduce reliance on targeted pelagic fisheries by sourcing by-products from capture fisheries and increasing the use of terrestrial ingredients when possible.

WHY CAN'T YOU SUBSTITUTE ALL FISH OIL AND FISH MEAL IN SALMON DIETS?

The Atlantic salmon farming sector has come a long way in reducing the amount of fish oil and fish meal in salmon diets and will continue to source novel ingredients to reduce it even more. There are several considerations when developing new formulas, even if a substitute ingredient is a good replacement on paper. Ingredients must be palatable to the salmon. If they don't taste good, the fish will not eat it. If the fish do eat it, the new ingredient must be digestible, or the fish won't utilize the nutritional benefits.

In Canada, all ingredients must meet the health and safety requirements of the Canadian Food Inspection Agency. We must also consider if the new ingredient is sustainable and if it can be produced in large enough volume and quality to be a viable substitute. For example, some plant ingredients may not be able to be sustainably grown or have a large carbon footprint. Ingredients such as insect meals may not be available in large enough quantities to readily be incorporated into feeds.

Another consideration is whether the new ingredient causes any other negative effects, such as increased waste production or the need for increased feed consumption to produce the same amount of fish.

Finally, before an ingredient can be substituted in a feed formulation, the quality and availability at a reasonable price must be ensured. Supply chain reliability and global inflation have become significant concerns for all feed ingredients.

WHY ARE FARM-RAISED SALMON PINK?

Wild and farm-raised salmon have pink flesh because of their food. Salmon, both in the wild and those farm-raised, consume foods with carotenoids. Carotenoids are pigments, as well as antioxidants (8). Many carotenoids have been shown to directly improve the immune system aiding in disease resistance and improved growth, survival, and egg quality.

Wild salmon consume species such as krill, which are high in carotenoids, particularly astaxanthin and canthaxanthin. Farmed Atlantic salmon fish pellets are supplemented with naturally sourced and synthetic astaxanthin. Certified organic farmed Chinook salmon feed is supplemented with a natural astaxanthin pigment to maintain compliance with the certification. All salmon flesh is pigmented pink as a result of consuming carotenoids.

IS THERE A LOT OF FOOD AND FISH FECES ROTTING UNDER SEA CAGES?

No. There are many reasons why uneaten food and fish feces is not building up under salmon farms. Regulations limit the amount of organic waste, either uneaten food or fish feces, that can accumulate under salmon farms.

In BC, sea floor monitoring of salmon farms is regulated federally by Fisheries and Oceans Canada (DFO) through the Aquaculture Activities Regulations (AAR) (9). Monitoring requirements are available in the monitoring standard (10). Under the AAR, salmon farm companies must submit sea floor monitoring reports to DFO at their production peak when the biomass is highest. If fish are on-site continuously, monitoring must occur every 2 years.

Farms cannot be restocked until they meet the sea floor requirements in the monitoring standard. Results of sea floor monitoring are publicly available. Image below was captured during benthic monitoring as required by AAR. See "Chapter 8 – Caring for the Environment – Protecting Biodiversity" for more information.

Salmon feed is the most expensive part of growing farm-raised salmon. No company wants to waste feed. If the fish do not eat the food, they won't grow, and the money spent on feed is wasted. Much research and technology goes into feeding fish - the right type and amount of food at the right time to minimize waste in terms of uneaten food, feces, and money.

Feeds are specially sized, highly digestible and formulated for the life stage of the fish, as well as how fast or slow the pellets will fall through the water column. Feed quality is tightly monitored and traced to ensure freshness and palatability.

Technology is used to deliver the feed to the fish, including automatic feeders and underwater cameras to monitor consumption. Companies have feeding regimes to ensure all fish in a cage have access to feed to minimize competition. Underwater cameras allow farmers to see if the fish are full and food is unwanted so that feeding can be stopped.

- BC Atlantic salmon farms use automatic feed delivery systems to distribute feed evenly throughout the sea cage at specified times.
- Overfeeding is unlikely to occur as feeding is monitored via underwater video, in real-time. At some farms, the video is analyzed by pellet detection software and the feed operator is notified if too many pellets have fallen past the camera.
- Underwater video is also used to monitor feeding behaviour and measure biomass. These data can be utilized to inform machine learning models, artificial intelligence (AI), and deep learning to integrate feeding information with environmental monitoring sensors. This allows farmers to decide how to optimize feeding given farm conditions and fish behaviour.

Companies are beginning to invest in remote feeding centres. MOWI Canada West has developed two such centres, one in Port Hardy and another in Klemtu. These centres allow fish on multiple farms to be fed from a centralized on-land location. Three main reasons for this are to enhance on-farm staff safety in highly exposed areas, 2) to allow new training opportunities for staff who are good at feeding, and 3) to provide employment opportunities for residents who can't travel to the farm.

HOW SUSTAINABLE BY COMPARISON?

For 2021, MOWI and Grieg Seafood, two international companies operating most of BC's Atlantic salmon farms, ranked number 1 and 2, respectively, on the Coller Fairr Protein Producer Index, which ranks publicly traded companies (11). These companies are the only publicly traded Atlantic salmon farming companies in BC. This index measures 10 environmental, social and governance risk and opportunity factors aligned with the Sustainable Development Goals (Figure 1).

The index assessed 60 of the world's largest protein-producing companies, including meat, dairy and aquaculture companies. Seven of the top ten companies ranked for 2021 were aquaculture companies MOWI and Grieg Seafood rated the top 2 with overall "Low Risk" scores. Salmon farming companies performed better than animal protein producers on all risk factors, particularly deforestation, biodiversity, and antibiotics.

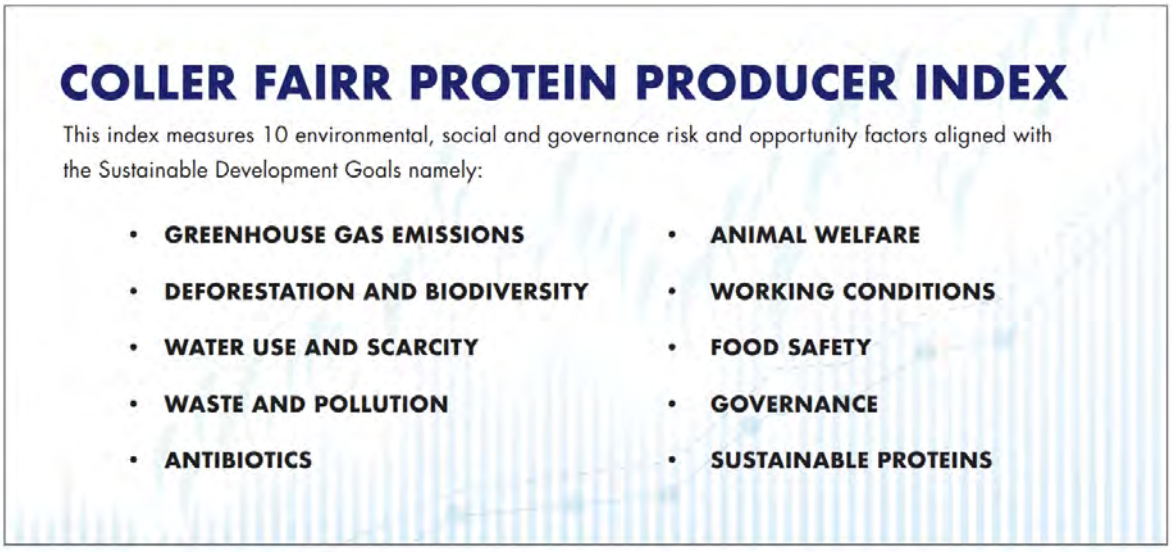


Figure 1. List of metrics evaluated by Coller Fairr Protein Producer Index to compare the world's top listed animal protein producers.

WHAT IS THE CARBON FOOTPRINT OF SALMON FEED AND FARMED SALMON?

Carbon footprint can be calculated in many different ways. It is typically defined as the total greenhouse gas emissions caused directly and indirectly by the production of a product. Carbon footprint is calculated and publicly reported for Atlantic salmon feed and farmed salmon compared to other animal proteins.

For example, feeds produced by Skretting in Canada have, compared to Chile and Norway, shown to have a lower carbon footprint (12). Cradle-to-gate calculations, that is ingredient production (including land use change), transportation to feed facility, feed manufacturing, packaging and packaging end of life is 1.6 kg CO_2e/

kg feed in Canada compared to approximately 2.2 in Norway and 2.4 in Chile. This lower footprint for feeds produced in Canada is because many of the main ingredients are sourced locally. Protein sources are to a large extent from animal by-products with low raw material footprint, and vegetable-based proteins and oil ingredients are locally sourced.

When comparing the carbon footprint of BC farm-raised salmon to other agricultural proteins, farm-raised salmon (all species) have the lowest average carbon footprint compared to chicken, pork and beef as measured as kilograms of CO_2 per typical 40g serving (Figure 2) (13).

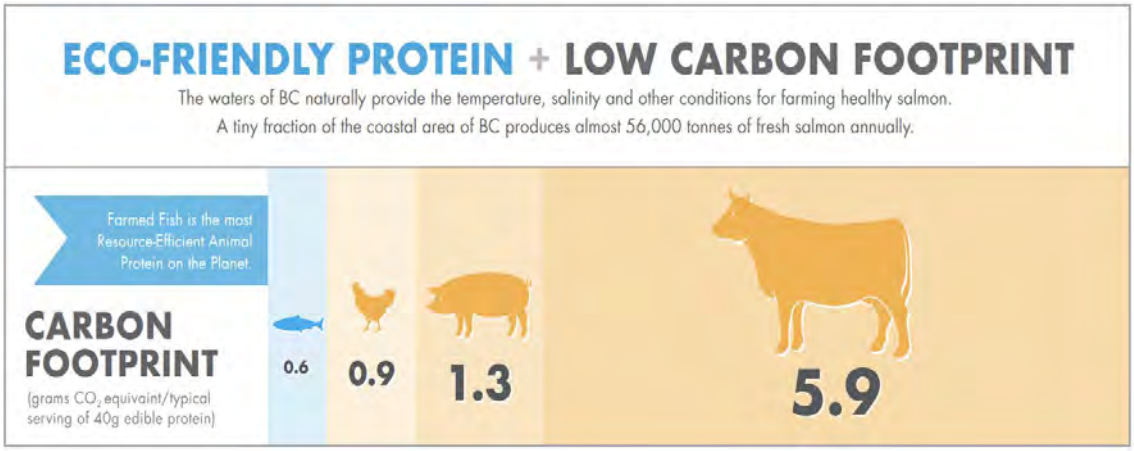
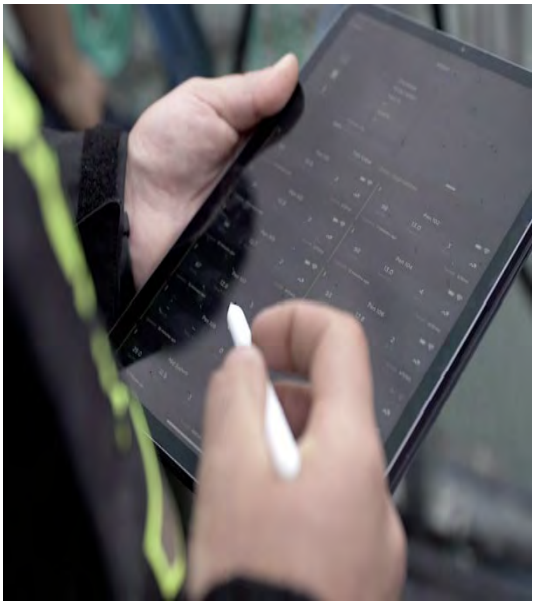


Figure 2. Comparison of the carbon footprint of farm-raised salmon to chicken, pork and beef.

CERTIFICATION PROGRAMS

There are many certification programs relevant to fish feeds and farm-raised salmon. In general, they endeavour to ensure that raw feed ingredients are sourced from environmentally and socially sustainable sources and that farm-raised salmon are reared in a similarly social and environmentally sustainable manner.



In terms of certifying Atlantic salmon farms in BC, there are two main standards, Aquaculture Stewardship Council (ASC) and Best Aquaculture Practices (BAP) (14, 15). All Atlantic salmon farms are currently BAP certified; some are also ASC certified. Creative Salmon's Chinook salmon farms are all organically certified according to the Canadian Organic Aquaculture Standard (16).

Part of BAP certification of Atlantic salmon includes compliance to feed standards. BAP Mill Standards encourage feed mills to actively favour responsibly managed and independently assessed marine ingredients. They also state that when available, terrestrial ingredients such as soy and palm oil are from certified sources, including any ingredients containing protein from the same genus as the species which will consume the feed. So, by-products of Atlantic salmon processing such as trimmings in Atlantic salmon feed is prohibited.

Farms that are ASC certified, among other things, source their feed from ASC certified feed mills. The ASC Feed Standard ensures that all feed ingredients are sustainably sourced. The Standard requires that ingredients that make up more than 1% of the feed (including fish meal and fish oil) must be traceable and responsibly sourced, that is environmentally sustainable as well as socially responsible.

All companies work with their feed suppliers to ensure that the company standards and certification standards are met for all feed ingredients.

WHAT'S NEXT FOR FEED SUSTAINABILITY?

BC salmon farmers will continue to improve feed sustainability by:

- working together with feed suppliers to optimize the use of sustainable raw ingredients,
- increasing efficiency in feed production (decreasing carbon footprint), and
- continuing to innovate feed delivery systems.

Companies continue to research new, more sustainable ingredients that can meet the needs of the fish, including their health and wellbeing, are available on a commercial scale, and are economical. We recognize the importance of and responsibility to strive to reduce our reliance on marine products.

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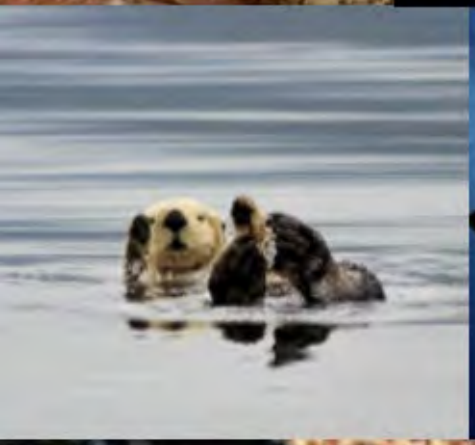
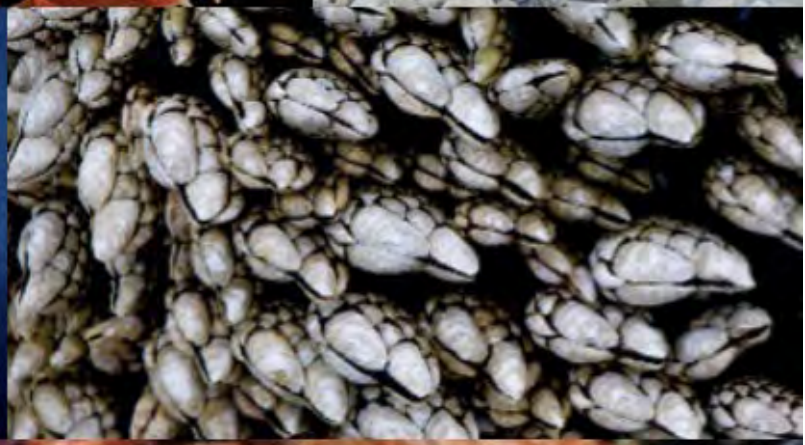
CHAPTER 8

CARING FOR THE ENVIRONMENT

PROTECTING BIODIVERSITY





This chapter describes important measures salmon farmers take to protect biodiversity and discusses what is known about effects to the sea floor beneath the cages and along the shoreline

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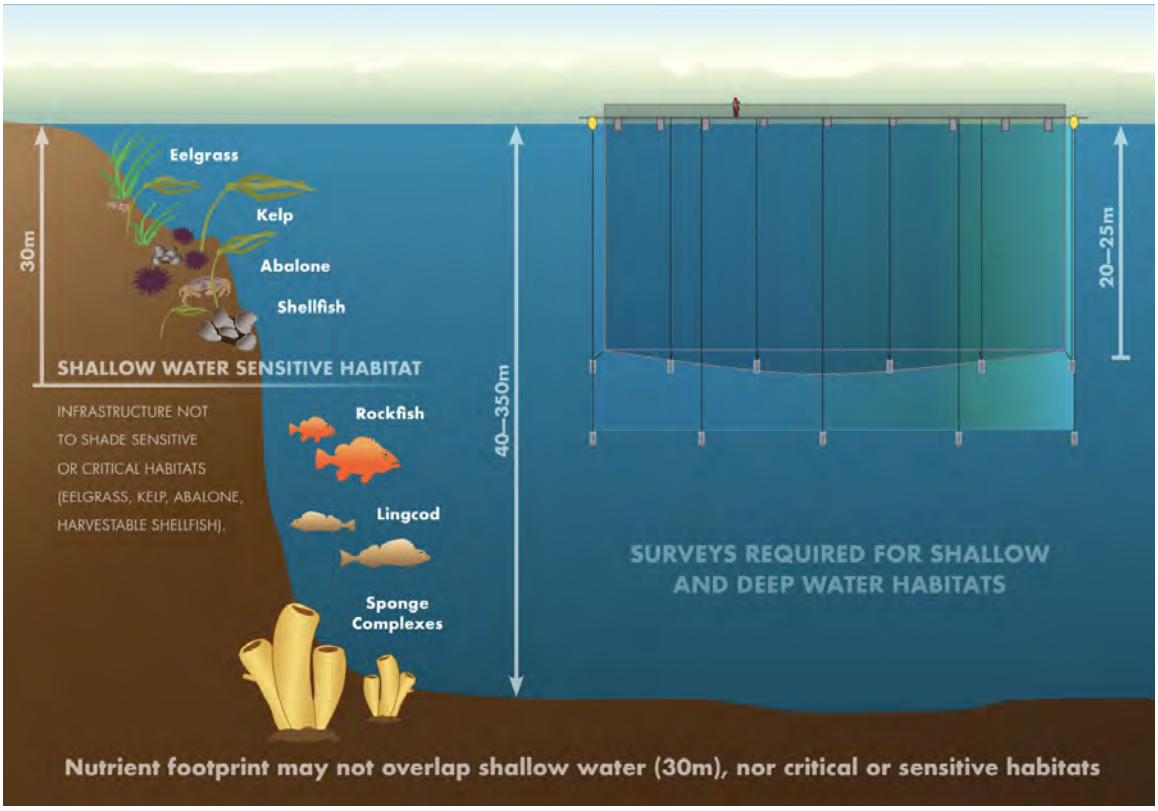
CHAPTER HIGHLIGHTS – PROTECTING BIODIVERSITY

Protecting biodiversity is at the core of sustainable development. 100% of farm-raised salmon in BC is raised in partnership with local First Nations, who provide oversight and guidance on farm locations and operations.

Finding suitable places for salmon farms is a complex process that takes years. Federal, provincial and local governments have legislation and processes that protect wildlife and biodiversity. Farms must meet all of the criteria in order to be approved.

Once operational, farms must follow all laws to protect fish, fish habitat and wildlife. In particular, each farm must demonstrate that its operations meet the requirements of the Aquaculture Activities Regulation. This includes monitoring the footprint beneath farms.

The nutrient footprint is one of the primary drivers determining how many fish can be grown at a site and when a site can be used. On average, 86% of farms in BC met seafloor thresholds each year from 2011 – 2022 and required no additional monitoring prior to restocking. Farms typically recover within a three-month fallow. About 1 to 1.5 million pounds of salmon per hectare are grown in each crop, which is an incredibly efficient and sustainable way to grow food.



The use of medicines at sea sites is strictly controlled in BC. Only products that are registered under the Pest Control Products Act (regulated by the Pest Management Regulatory Agency) and the Food and Drugs Act (regulated by the Veterinary Drugs Directorate of Health Canada) can be used and only under the authority and supervision of a licensed veterinarian. See "Chapter 11 – Caring for Fish Health" for more information.

Medicines prescribed by licensed veterinarians might deposit in the near field of farms, typically within the nutrient footprint (with the feed). On average, between 2016 to 2021, florfenicol was used at 47.8% of active sites each year, primarily to treat yellow mouth infections in newly smolted Atlantic salmon. This antimicrobial is water soluble and was not detected in a recent survey of farms across Canada.

Oxytetracycline was administered (on average) 9.7% at active salmon farms between 2016 to 2021. It has been found in low concentrations in sediments at several farms in BC; however, it is considered to have low toxicity to crustaceans (for example, it can be safely used to treat bacterial infections in lobsters).

On average, 52% of BC Atlantic salmon farms were treated with the sea lice medicine, emamectin benzoate (SLICE®), each year between 2016 and 2021. It is administered via medicated feed pellets on average about 1.2 times per growing cycle. Ultra-low concentrations of emamectin benzoate have been detected at sea sites for more than a year; however, the concentrations have been below levels known to be harmful to BC crustaceans tested in laboratory exposure trials.

Hydrogen peroxide (Interox®Paramove®50) baths were applied to an average of 22% of active Atlantic salmon farms from 2016 to 2021. Hydrogen peroxide is water soluble and rapidly degrades to its components of water and oxygen following release from well boats.

No farm-raised Chinook salmon were treated for sea lice from 2016 to 2021 in BC. Creative Salmon, who specialize in raising organic Chinook salmon, have never treated for sea lice in the 34 years they have grown Chinook salmon in BC.

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