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ENVS301: Environmental Case Studies

Fish Farming for a Sustainable Future?
A Case Study of Norwegian Salmon Aquaculture Antimicrobial Practices

Abstract

The world food supply is growing increasingly reliant on aquaculture around the world. Nearly half of the global seafood supply comes from aquaculture, up from 26% in 2000. In order to reduce risk of disease and maintain the health of fish stocks, antimicrobials, specifically antibiotics, are used to combat this issue, but there are significant risks associated with antibiotic use including antibiotic residues and antibiotic resistance. This case study analyzes the unique Norwegian Salmon aquaculture antibiotic practices in comparison to other countries' aquaculture. Norwegian Salmon aquaculture uses virtually zero antibiotics, while other countries' aquaculture, such as Chile, use a concerning amount of antibiotics which can lead to antibiotic residues in the surrounding environment along with antibiotic resistance. This case study will weigh the costs and benefits of aquaculture that minimizes antibiotic use, along with the effects on human health and the environment.

Norwegian Salmon Aquaculture

Today, Norway's seafood industry, consisting mainly of salmon aquaculture, is 2.3% of Norway's GDP, up from 1.5% in the early 2010s, and employs over 80,000 people. More than 837 million salmon are kept by the industry, which is equal to about 1.5 million tons of fish. This makes salmon the most farmed animal in the country by far. The amount of salmon produced by Norway accounts for over half of the world's total production of Atlantic salmon. Other countries with high salmon production, and thus competitors of Norway, include Chile, Britain, and Canada.

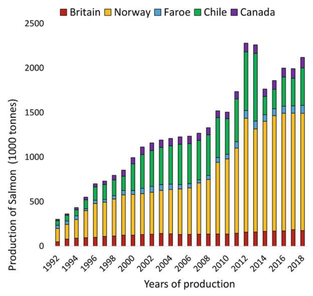


Figure 1: Norway is the world leader in salmon aquaculture production, followed by Chile, Britain, and Canada

Norway's salmon aquaculture companies are under strict regulation to ensure a high quality end product. Each farm must obtain a license to operate, and the location of the farms are important to be granted a license from the Norwegian government. Farms must be located far enough away from maritime traffic areas, and be in open water, so lakes and ponds are off-limits. Fish space is important as well. Norway allots at least 97.5% water to every 2.5% salmon.

After being approved for a license, farms are regularly monitored to ensure correct protocols are followed. For example, farms must space out their farming cycles in order to preserve the natural seabed underneath. This rest period allows for some natural regeneration of the seabed ecosystem that can be disturbed from fish feces and chemicals used in operations. The amount licenses granted by the government are also closely monitored: less than 750 farms can operate on the 29,000 kilometers of coastline available for aquaculture.

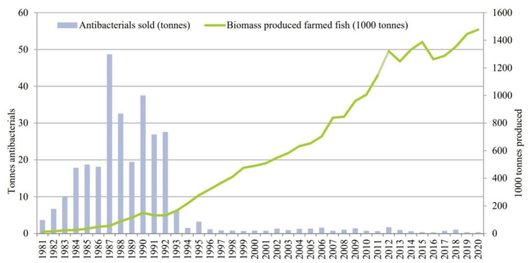


Figure 2: Since 1994, Norwegian salmon farmers have prioritized the limited use of antibiotics in order to maintain the healthiest fish stocks possible while also combatting the modern pervasive issues of antibiotic resistance and antibiotic residues

Figure 3: A large Norwegian salmon aquaculture operation in a fjord

Figure 4: A scientist examines a farm raised salmon off the coast of Norway

Antimicrobial Use

Despite Norway's rigorous controls for salmon farming, keeping an unnaturally large amount of fish in one place can easily and quickly spread bacteria, parasites, and other pathogens that increase fish mortality. Most nations that export significant amounts of Atlantic Salmon, notably Chile, Britain, and Canada, primarily use antibiotics to prevent and treat disease. Norwegian salmon aquaculture is unique in that since the 1990s, Norway has used a fraction of the antibiotics that other nations use while also producing the most Atlantic salmon. In 2019, only 16 prescriptions were issued for Norwegian salmon farming, the lowest ever recorded. In 2019 and 2020, 99% of salmon produced in Norway were produced without any antibiotic treatment.

This is possible due to alternative antimicrobial methods, specifically oil-adjuvanted vaccines. This type of vaccine uses an oil-in-water base and is injected into the salmon at a young age to induce lifelong immunity from furunculosis.

Oil-Adjuvanted Vaccines for Furunculosis

Furunculosis is a main cause of mortality in salmon farming because it is a highly contagious disease affecting fish of all ages and life cycles. This trait makes furunculosis extremely dangerous for farmed salmon, which live in close quarters and are prone to outbreaks. "Horizontal transmission occurs via the water column, but also through direct fish-to-fish contact and animal vectors" such as birds and invertebrates like sea lice. Additionally, "non-salmonids may become infected," which means that fish near contaminated farms could become infected and spread the disease to the natural ecosystem. Even fish surviving disease outbreaks are considered carriers who may continue to infect the remaining population without showing signs of infection. Signs of infection include damaged mucous and skin in the form of boils, lesions, and hemorrhages, among other symptoms. All of these symptoms are life-threatening; within days of contracting this disease, salmon can suddenly die or show effects, including lethargic swimming, swimming just below the surface, loss of appetite, and respiratory distress leading up to death.

Without oil-adjuvanted vaccines, farmers use other methods of prevention and treatment, most notably antibiotics. This is an effective prevention and treatment method, but it requires multiple treatments and can lead to antibiotic resistance in the salmon and exposed organisms, along with antibiotic residues in the surrounding ecosystem.

Issues with Oil-Adjuvanted Vaccines

Oil-adjuvanted vaccines are highly favorable to antibiotics because they have less negative environmental effects and only need to be administered once during a salmon's lifetime. Despite its positive attributes, these vaccines are known to impair growth and reduce carcass quality. Additionally, active immunization requires several potentially harmful procedures on the salmon, including handling, anesthesia, and injection of other substances. The vaccine injection sites can become inflamed, and additional pigmentation can occur. According to a study examining vaccine administration and growth rates in salmon, the highest daily growth rates were recorded in unvaccinated fish. Specifically, in one site, salmon injected with an oil-adjuvanted vaccine saw a significant reduction in growth, 23% after 15 months. This impaired growth was attributed to lesions found inside the abdominal cavity from the vaccine. Other unidentified factors coinciding with vaccination may have varied results in this study, but the findings are clear that vaccines can harm salmon growth. In turn, negative effects on salmon growth can subsequently affect salmon farmers' profit margins due to a slower-maturing fish population.

Cleaner Fish for Sea Lice

Another antimicrobial method used in Norway is cleaner fish. Cleaner fish are small fish that feed off salmon parasites, most notably sea lice. Sea lice attach to a fish host, the salmon, and feed on the fish's skin and blood to survive. This causes open wounds and lesions on the salmon, making them unmarketable. Cleaner fish are used as another alternative antimicrobial method, and it is seen as a more environmentally friendly approach towards sea lice treatment because the approach does not involve introducing foreign chemicals into the natural ecosystem that could disrupt other organisms' live cycles.

Issues with Cleaner Fish

Cleaner fish are better natural alternatives to other methods of combating sea lice, but there are a few issues with this method. To begin, cleaner fish are generally used as "a disposable tool in salmon production." While this is helpful for farmers, environmentalists are concerned with the ethicality of using cleaner fish. Environmentalists cite the near 100% mortality rate of these fish. Moreover, "in 2022, 36.2 million cleaner fish were used in Norwegian fish farms." Additionally, cleaner fish are not fully effective at treating salmon for sea lice. This means that additional treatments are needed to combat this issue. To completely eradicate sea lice, which have the potential to destroy entire salmon farms, farmers resort to using harsh chemicals to kill off the lice — these additional treatments cause the treated salmon to have reduced appetite and overall growth. Salmon cannot be sold for several weeks after treatment. Furthermore, resistance can be built up in sea lice to the major classes of chemicals being used. Combined with these chemical treatments potentially contaminating surrounding ecosystems, treating salmon for sea lice is a harsh and difficult process with significant negative effects.

Stakeholders

1. Farmers
2. Government Regulatory Agencies
3. Consumers
4. Environmental NGOs
5. Feed Manufacturers

Conclusions

- By limiting the use of antibiotics as a means to prevent and treat disease in their salmon populations, Norway can avoid the far-reaching negative consequences of antibiotic use: antibiotic resistance and antibiotic residues.
- Chile, the second largest farm-raised salmon producer in the world, should increase the research and development of vaccines to roll out the use of them in the near future. The Chilean government must play a vital role in expediting this process through legislation and educational programs.
- Smaller producers of Atlantic salmon could also follow suit, such as Britain and Canada.
- Antimicrobial methods will have to be tailored to fit the needs of each country and even each farmer to reach the effectiveness needed to produce healthy salmon.

As salmon farming is rapidly becoming a major player in feeding the growing world population, it must be done as sustainably as possible to ensure the long-term health of humans and our environment. Although Norwegian salmon aquaculture practices are not perfect, they are at the forefront of sustainability in the industry, and other producing countries should consider implementing similar practices.

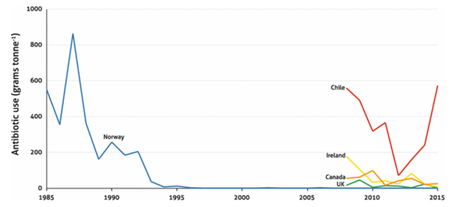
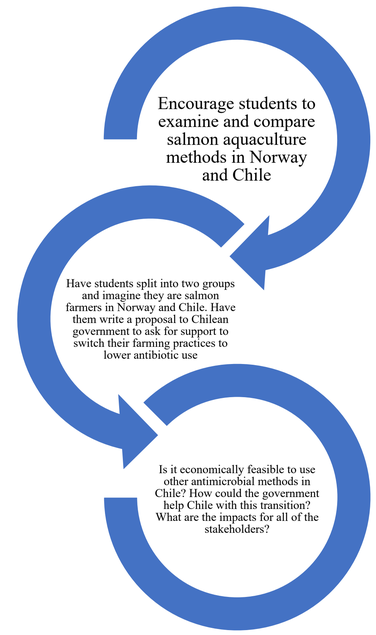


Figure 5: This chart shows the varied use of antibiotics in salmon aquaculture from 2003 to 2017. Note that antibiotic use in Norway is virtually zero. It can be seen that Chilean antibiotic use has fluctuated but remains one of the countries that use the most in their farms.

In Class Activity



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