Case study for measuring food loss

Aquaculture and Fisheries sector case study (salmon)

This study analyses food losses in the aquaculture sector of salmon in Norway, a case study led by NORCE.
The salmon case methodology builds on the existing systems used to register and count production losses in salmon farming mandated by Norwegian authorities. Specifically, loss counting is a regulation tied to the salmon production license. Food losses are measured using various metrics, including the number of fish lost and the size of biomass loss (in kilos).
For gaining qualitative insights, 9 interviews were conducted with Norwegian conventional salmon producers, Norwegian Veterinary Institute, Norwegian Directorate of Fisheries, SINTEF Ocean, and Norwegian Food Safety Authority. Identifying organic salmon farmers proved more challenging, as there are very few active producers in the market due to high production costs and thin market conditions. These barriers have led some producers to exit the market altogether. Nevertheless, interviews with two organic fish farmers were conducted, one based in Ireland and the other in Denmark.

Food Loss information	
Commodity	Salmon
Quantification	The use of registries and interviews
Timing	Primary production: pre-harvest and harvesting losses

General information	
Policies	No policy for food loss specifically, but for production losses generally that are linked to fish health and welfare.
Challenges	One of the greatest challenges has been adapting the framework of food loss definitions to the singularities of the salmon case and obtaining access to farm specific data.
Technology	The records were obtained from measurements carried out by a wide range of companies using very diverse methods: from sensors that identify, count, and weigh discarded salmon, to the manual counting of salmon, recorded in specialized software that produce monthly reports for the public authorities.
Destination	Mainly intended for bioenergy applications and pet food.
Benefits	To comply with the legal requirements for reporting losses to the competent authority in Norway.
Operations	Salmon farmers invest in equipment to pump dead fish from the pens to the surface and go on daily inspections on farms for collecting dead fish. However, this activity is an integrated part of fish health and welfare management at the farm.

During the period of reporting, the puzzle of different approaches to the problem of salmon food losses has been completed, as detailed below:

1. Aggregate losses. Data in this part are shown as number of fish lost, i.e., not as ratios. The purpose here is it show patterns of mortality over grow-out cycle, how patterns differ regionally, and what are the main causes of losses. (This pathway was already captured in the previous reporting period, so no further details are provided.)

2. Categories of food losses. The official data collected by the Norwegian Directorate of Fisheries lump losses into four categories: Dead fish, escapees, discards, and other. AquaCloud data, which is a private collaborative data collection initiative, brings a much more granular classification of losses. This is useful in understanding why food losses arise in salmon farming.

   This level of data granularity allows, for example, the analysis and comparison of the main causes of salmon discard from the start of rearing to slaughter (production loss + food loss) (Figure 1) and their comparison with the reasons for losses in salmon weighing 3 kilograms or more (food loss) (Figure 2).

   Figure 1 clearly shows that the losses in these categories tend to be seasonal and stochastic. Some categories cause larger losses in the winter (e.g. “Winter ulcers”, “Handling damage”, “Wounds caused by not specified bacteria”, “Snout and head ulcers”), other in summer (“Non-medical treatment”), and other in the fall (“Complex gill disease with unknown cause”). Other categories do not follow any clear seasonal pattern (i.e., “Cardiomyopathy syndrome”).

   The shift in loss composition for fish above 3kg reveals that physiological/disease factors (particularly CMS) become more prominent in market-size fish, while handling-related losses decline proportionally as larger fish undergo fewer routine interventions (Figure 2). This life-stage dependency of driver profiles suggests that loss prevention strategies must adapt throughout the production cycle, with disease management emphasized for market-weight fish and handling optimization prioritized for younger cohorts.

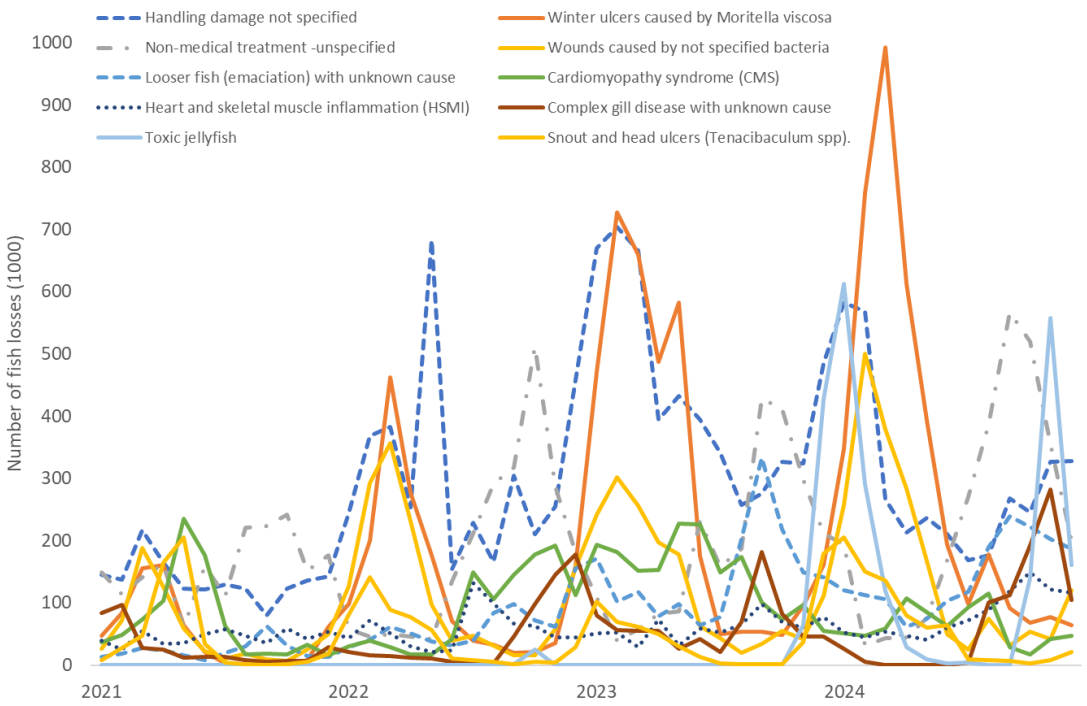

Figure 1. Top ten causes of production and food losses in Norwegian salmon during 2021-2024 period (AquaCloud)

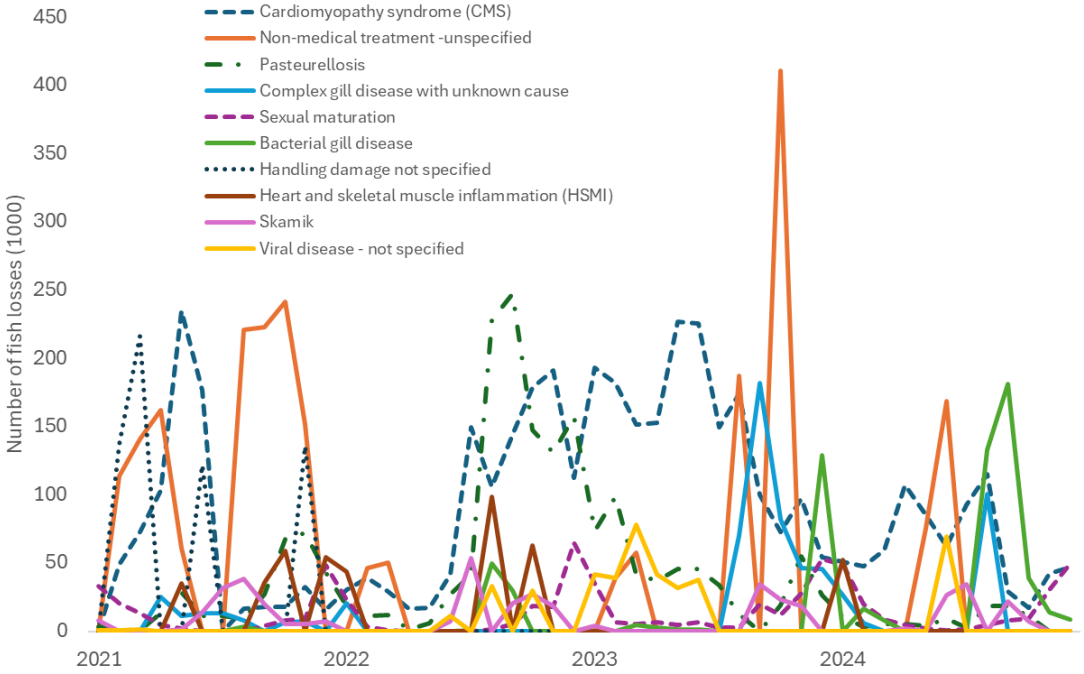

Figure 2. Top ten causes of food losses in Norwegian salmon during 2021-2024 period (AquaCloud)

3. Mortality patterns by production zones and individual farms. Another, more granular level is related to aquaculture production zones along the Norwegian coast (Figure 3), where production and food loss volumes/percentages can be observed by area, along with their main

associated causes, adding an additional layer of information on top of the aggregated data from the higher levels.

Figure 3. Norwegian aquaculture production zone. Source: Norwegian Directorate of Fisheries

Looking at the monthly average mortality rates across production zones, Figure 4, shows that the salmon mortality ranges from approximately 1% to 4% in the salmon farms along the Norwegian coast. Regional variation in these loss patterns particularly reflects differential exposure to environmental driver categories along Norway's coastline. Northern zones benefit from environmental conditions (colder waters) that naturally suppress disease proliferation and sea lice development, reducing both biological and treatment-related drivers. Mid-coast and Southern zones face intensified treatment requirements due to higher infection pressure. These geographic differences demonstrate that loss reduction strategies cannot be uniform, northern operations to a larger degree require management optimization, while South and mid-coast farms must prioritize disease prevention and treatment refinement.

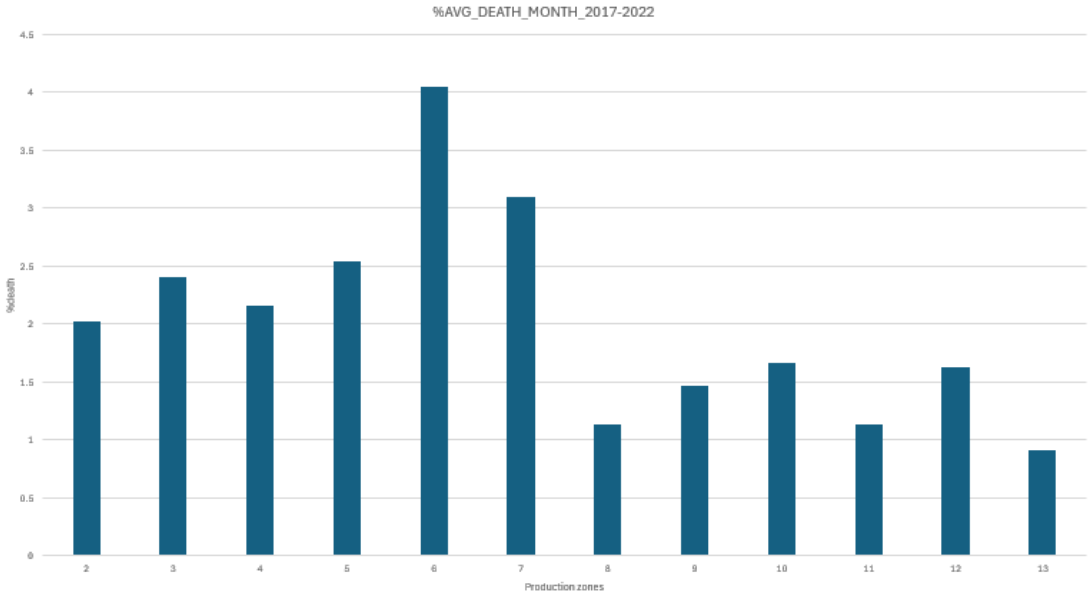

Figure 4. Average monthly salmon mortality rate across production zones

In addition to regional and farm differences, mortality rates can also vary within the same farm across different seasons. Figure 5 shows losses for a salmon producer that farms both organic and conventional salmon. The producer has provided us with data on losses for four generations of salmon production cycles in the grow-out stage, as shown in the figure. The final generation was not completed (i.e., not been harvested yet) at the time the data was shared. As can be seen there is considerable variation between each generation in when and why losses occur.

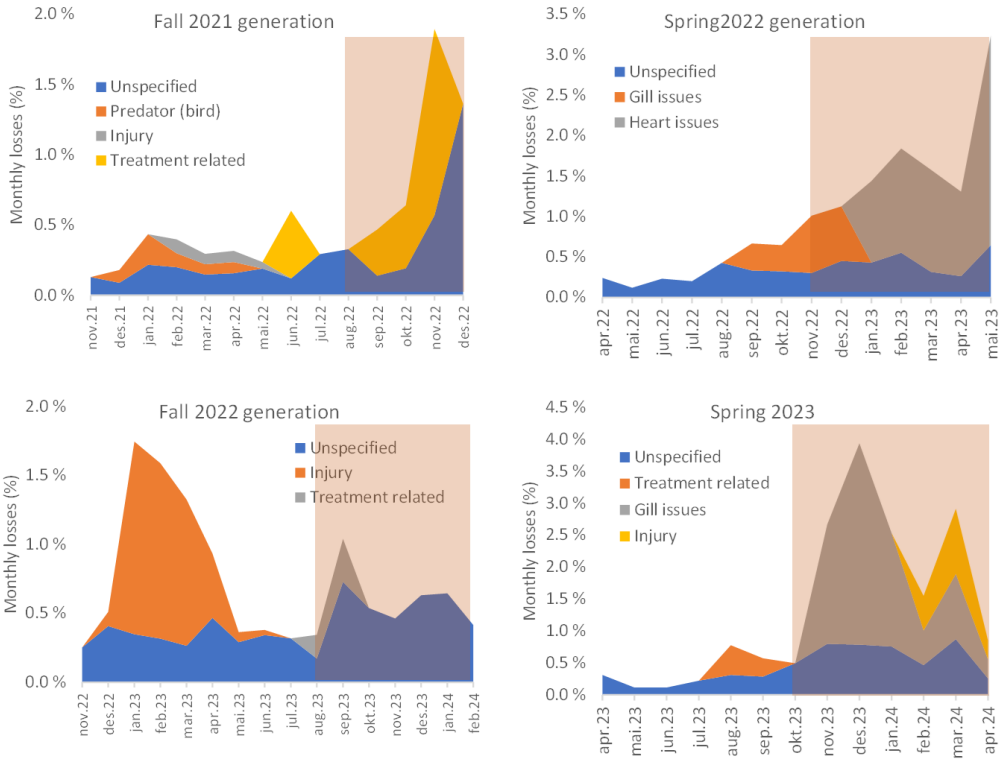

Figure 5. Losses in the production cycles of four generations of organic salmon (note: Spring 2023 generation production cycle not completed). The pinkish area represents food loss based on a cut-off weight of around 3 kilos. (Individual producer, anonymous)

As a conclusion from this analysis across different approaches, scales, and perspectives, it can be inferred from all the data provided that infectious diseases and their treatment are a major contributor to salmon mortality, a finding also confirmed by interviews with Norwegian salmon farmers.