

# Fish Health Report

2025



*Ichthyobodo* parasites (Costia) and blood cells on a salmon gill (magnified 12,000 times). The image was captured using an electron microscope and colourised. Photo: Jannicke Wiik-Nielsen, Norwegian Veterinary Institute

# Norwegian Fish Health Report 2025

Norwegian Veterinary Institute Report no 5b/2026

## The Norwegian Veterinary Institute's annual review of the fish health in Norway

### Authorship

Authors are credited for each chapter. With the exception of Chapter 11.5 "Water Quality", written by employees of the Norwegian Institute for Water Research (NIVA), Chapter 5 "Climate and Fish Health" co-authored by employee of NOFIMA and Chapter 8.8 "Mycobacteriosis" co-authored by employees of Pharmaq Analytic AS, all authors are employees of the Norwegian Veterinary Institute.

Chapter 6.4 "Nutrition and fish welfare", 6.8 "Experimental fish in 2024" and 7.6 Viral hemorrhagic septicemia (VHS) and infectious hematopoietic necrosis (IHN)" have not been translated into English; please refer to the Norwegian report.

*The Fish Health Report 2025 is mainly written without references in the text. For information about references, please contact the authors of each chapter.*

### Editors

Torfinn Moldal, Jannicke Wiik-Nielsen, Victor Henrique Silva de Oliveira, Julie Christine Svendsen, Asle Haukaas and Ingunn Sommerset

### Suggested citation:

Moldal T, Wiik-Nielsen J, Oliveira VHS, Svendsen JC and Sommerset I. Norwegian Fish Health Report 2025, Norwegian Veterinary Institute Report series #5b/2025, published by the Norwegian Veterinary Institute 2026

Published online in Norwegian 11.03.2026: [www.vetinst.no](http://www.vetinst.no)

Published online in English 16.05.2026

ISSN 1890-3290

ISSN #1893-1480 (online version)

© Norwegian Veterinary Institute 2026

Design: Aksell

### Cover image:

*Ichthyobodo* parasites (*Costia*) on a salmon gill - magnified 12,000x. The parasites inhabit both the gills and the skin and may cause disease in both juvenile fish and market-size fish. They irritate the gill epithelium, which can impair respiration. The parasites are particularly likely to establish in fish that are stressed, held at high stocking densities, or exposed to poor water quality and temperature fluctuations. The image was captured as part of the project "Optimal smolt production for a robust fish at sea" (Optismolt), led by the Norwegian University of Life Sciences (NMBU). The image is photographed with a scanning electron microscope and then colour manipulated.

Photo: Jannicke Wiik-Nielsen, Norwegian Veterinary Institute

# Contents

Are we now moving in the right direction?	5
Summary	7
<b>1 Statistical basis for the report</b>	<b>12</b>
<b>2 Mortality in fish farming</b>	<b>16</b>
2.1 Production Statistics and Trends	17
2.2 Mortality data and analytical framework	22
2.3 Mortality in hatcheries	25
2.4 Mortality at sea sites	30
2.5 Cause-specific classification of farmed Atlantic salmon mortality	47
<b>3 Fish Health Economics</b>	<b>55</b>
3.1 Economic consequences of fish disease	55
3.2 Disease costs	56
3.3 Costs and benefits of different biosecurity measures	59
3.4 Socioeconomic disease burden	60
3.5 Health economics as part of the decisionmaking basis	60
<b>4 Biosecurity</b>	<b>62</b>
4.1 Biosecurity in aquaculture	62
4.2 Disinfection of intake and effluent water	62
4.3 Vaccination as a biosafety measure	63
4.4 Infection risk farmed fish - wild fish (and vice versa)	67
<b>5 Climate and Fish Health</b>	<b>68</b>
5.1 Climate Change	69
5.2 Effects on Fish and Production Systems	71
5.3 Effects on Bacterial Diseases	72
5.4 Effects on Parasitic Diseases	73
5.5 Effects on Algae and Jellyfish	74
5.6 Effects on the Production Environment	75
5.7 Measures and Adaptation Strategies	75
<b>6 Fish Welfare</b>	<b>79</b>
6.1 Welfare indicators	83
6.2 Fish Welfare and Health in Regulations and Public Management	87
6.3 Operations and Methods	91
6.5 Welfare Challenges in Juvenile Production	94
6.6 Welfare Challenges Related to Salmon Lice and Delousing	99
6.7 Slaughter data as a welfare indicator	109

<b>7 Viral diseases in farmed salmonids</b>	<b>116</b>
7.1 Pancreas disease (PD)	117
7.2 Infectious salmon anaemia (ISA)	124
7.3 Infectious Pancreatic Necrosis (IPN)	130
7.4 Heart and Skeletal Muscle Inflammation (HSMI) in Atlantic Salmon and HSMI-like Disease in Rainbow Trout	132
7.5 Cardiomyopathy syndrome (CMS)	136
<b>8 Bacterial Diseases in Farmed Salmonids</b>	<b>140</b>
8.1 Flavobacteriosis	143
8.2 Furunculosis	145
8.3 Bacterial Kidney Disease (BKD)	147
8.4 Winter Ulcer Disease	150
8.5 Pasteurellosis	154
8.6 Yersiniosis	157
8.7 Piscirickettsiosis	161
8.8 Mycobacteriosis	163
8.9 Other Bacterial Infections	165
8.10 Susceptibility to Antibacterial Agents and Antibiotic Use	166
<b>9 Fungal diseases of salmonids</b>	<b>168</b>
<b>10 Parasitic Diseases in Farmed Salmonids</b>	<b>170</b>
10.1 Salmon lice - <i>Lepeophtheirus salmonis</i>	172
10.2 Sea louse - <i>Caligus elongatus</i>	182
10.3 Parvicapsulosis - <i>Parvicapsula pseudobranchicola</i>	184
10.4 Amoebic Gill Disease (AGD) - <i>Paramoeba perurans</i>	186
<b>11 Other Health Problems in Farmed Salmonids</b>	<b>189</b>
11.1 Gill Diseases	191
11.2 Poor smolt quality and runt syndrome	196
11.3 Nephrocalcinosis	201
11.4 Hemorrhagic Smolt Syndrome (HSS) / Hemorrhagic Diathesis (HD)	204
11.5 Water Quality	206
11.6 Algae and Fish Health	210
<b>12 Health and Welfare in Farmed Cod</b>	<b>212</b>
<b>13 Health Status of other Marine Species in Aquaculture</b>	<b>218</b>
<b>14 Health and Welfare of Cleaner Fish</b>	<b>221</b>
<b>Appendices</b>	<b>231</b>
<b>Acknowledgements</b>	<b>246</b>

# Are we now moving in the right direction?

By Ingunn Sommerset

The Norwegian Veterinary Institute's primary purpose is to work for "good health in animals and humans" including aquatic animals. Good animal health also includes good animal welfare. The WHO definition of health is "a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity," an approach also embraced by animal welfare experts. For two decades, the annual Norwegian Fish Health Report has collected and compiled data to provide fact-based knowledge on the health status of farmed fish and wild fish. Since 2024 the wild fish health was split off in a separate status report. A relevant and comprehensive Fish Health Report could not have been made without access to data and information, shared beyond mandatory reporting requirements by the industry and its suppliers. Mutual trust between the aquaculture industry, service industries and the authorities, has been highlighted as a competitive advantage for the Norwegian aquaculture industry in a global context.

The White Paper Report No. 24 (2024-2025) "The Future of Aquaculture – Sustainable Growth and Food for the World" released in spring 2025, presented "a new, comprehensive management system for aquaculture, regulating the industry based on actual and measurable environmental impacts." With an exchange of biomass limitations to a quota system for emission of salmon lice larvae, combined with a proposed mortality related levy, the White Paper represents a revolution more than a reform to the fish farming industry. A Parliamentary majority supported the overall direction of the paper but deferred the most far-reaching measures pending completion of further studies. *Animal Welfare White Paper*, Report to Parliament no. 8 (2024-2025), had already set an ambitious target to reduce mortality for all fish species in aquaculture to around five percent.

If mortality is to be utilised as a regulatory target, it is important that it should be calculated according to



Ingunn Sommerset, head of department. Photo: Asle Haukaas

a common standard. There are many ways of calculating mortality, depending on the questions being asked. If the aim is to understand how mortality development over time and space represents an indicator of fish health, different factors may need to be considered than in, for example, a purely business-economic context. The Norwegian Veterinary Institute has for several years, calculated annual mortality for farmed Atlantic salmon and rainbow trout in the sea phase as one of several indicators of the health situation in Norwegian aquaculture. Mortality as a health indicator is objective (an unambiguous outcome) and robust, but it does not capture nonlethal diseases, functional impairments, or poor welfare not leading to death. For that reason, it is important to combine mortality with other indicators of health and welfare.

There is little doubt that most farmed fish that die before reaching harvest weight have experienced shorter or longer periods of reduced health and welfare. We know the most important drivers – frequent and stressful treatments against salmon lice and infectious diseases that negatively affect each other. Reducing mortality is a good start for improving animal welfare in Norwegian aquaculture.

*“The industry must address the poor reputation that the negative health and welfare situation has led to. The most effective way to achieve this is to clearly demonstrate tangible, measurable improvements.”* The sentences are from the introduction of the Norwegian Fish Health Report 2024. The calculated annual mortality risk for farmed salmon sea was 16.7 percent in 2023, 15.4 percent in 2024 and 14.2 percent in 2025. There were also higher harvest

volumes and a lower share of downgraded fish in 2025 than in 2024 and 2023, and fewer registrations of some infectious diseases like pancreas disease and winter ulcer disease. All together this may indicate that Norwegian farmed salmon overall had better health and welfare status in 2025.

At the same time, the number of lice treatments in 2025 was a record high, likely due to warm sea temperatures into the autumn in southern Norway and there were severe algae blooms in the northern Norway. Climate change cannot easily be slowed, and it will inevitably lead to changes in production conditions for farmed fish along the coast. Periods of warmer seas allow salmon lice and other harmful parasites and microorganisms to reproduce more rapidly and spread to new areas.

Greater vigilance towards emerging health threats will be important going forward, and central to this are the fish health professionals and farm staff who observe the fish and environment on a daily basis. A recent survey of fish health professionals found that only 43 percent felt their professional advice and input were acted upon by aquaculture companies. Such attitudes are not constructive towards development of a sustainable aquaculture industry. We must listen to one another to ensure that risks are identified and prevented in an increasingly complex reality.

The Norwegian Veterinary Institute will also contribute to this, including through our annual assessment of emerging and established health threats in the Norwegian Fish Health Report.

# Summary

By Torfinn Moldal

**The summary highlights some of the most important health challenges in the Norwegian aquaculture industry in 2025. According to monthly reporting, 43.3 million Atlantic salmon, 2.84 million rainbow trout, and 2.44 million Atlantic cod weighing more than 3 grams died in land-based juvenile production facilities in 2025. This represents a decrease for salmon and rainbow trout compared with 2024, while mortality increased for cod. In the sea phase, 54.8 million salmon, 3.2 million rainbow trout, and 2.4 million cod died. Estimated mortality (mortality risk) in 2025 was 14.2% for salmon, 17.0% for rainbow trout, and 20.4% for cod. For salmon and cod, this constitutes a slight decrease compared with 2024, whereas mortality increased for rainbow trout. For all species, non-infectious diseases were ranked as the most important health challenges in the juvenile phase in the survey answered by fish health personnel as well as inspectors and advisors from the Norwegian Food Safety Authority, although infectious pancreatic necrosis (IPN) was ranked relatively high for both salmon and rainbow trout.**

## Mortality in Norwegian Aquaculture

In the farming of Atlantic salmon and rainbow trout, the first part of production takes place in freshwater (juvenile production) before the fish begin the process of adapting to life in seawater (grow-out production). The authorities require monthly reporting of the standing stock of live fish as well as losses and mortality in both the juvenile and grow-out phases. However, it is challenging to link these data and thereby estimate production mortality from first feeding to harvest, because fish groups cannot be traced at group level when fish are moved within facilities and between juvenile and grow-out facilities. In addition, the quality of data in the public registries varies.

The Norwegian Food Safety Authority receives monthly reports from juvenile fish production facilities on the number of dead fish and the standing stock at tank level. In the earliest phase of production in juvenile facilities, a certain level of culling or losses is expected, and the Fish Health Report therefore excludes the 0-3 gram weight class from its calculations. In 2025, the reported number of dead juvenile fish weighing more than 3 grams were 43.3 million Atlantic salmon, 2.84 million rainbow trout, and 2.44 million Atlantic cod. This represents a decrease for salmon and rainbow

trout compared with 2024, while there was a significant increase for cod. Mortality was particularly high for cod in the 36-155 gram weight class, and this may reflect the high production volumes in juvenile facilities. Culling fish with developmental deformities may also be a contributing factor.

Losses of fish in the sea phase are reported monthly to the Norwegian Directorate of Fisheries, and in 2025 these were 67.5 million Atlantic salmon and 3.7 million rainbow trout. The category "dead fish" accounted for the largest losses, totalling 54.8 million salmon, 3.2 million rainbow trout, and 2.4 million Atlantic cod. The number of fish registered under "other" as the cause of loss was approximately at the same level as in 2024 for both salmon and rainbow trout. As in previous reports, the Fish Health Report uses the number of fish in the "dead fish" category when calculating percentage mortality. This is done by calculating monthly mortality rates per site, which, unlike percentages, can be summed up and thus used to estimate the risk of mortality over time intervals longer than one month. The calculated annual mortality risk in the sea phase was 14.2% for salmon, 17.0% for rainbow trout, and 20.4% for cod. This represents a decrease of 1.2 percentage points for salmon compared with 2024, while there was an increase of 2.0 percentage points for rainbow trout. For cod, there was a decrease of 1.8 percentage points compared with 2024, but the level remains far higher than in the years 2021-2023.



Torfinn Moldal (Editor), Scientific coordinator for fish health.  
Photo: Eivind Röhne

As in previous years, there are substantial geographical differences in annual mortality risk. For Atlantic salmon, PA4 had the highest mortality risk at 20.1%, while PA12-PA13, assessed jointly, had the lowest at 9.4%. PA6 showed the largest decrease compared with 2024 and has returned to approximately the same level as in the years prior to 2024. PA9 experienced the largest increase from 2024 to 2025, which may be related to both a higher number of infectious salmon anaemia (ISA) outbreaks and an algal bloom during the previous spring. The calculated mortality risk for salmon production cycles completed in Norway in 2025 was 14.7%, representing a reduction of 0.7 percentage points compared with 2024.

An overview of the main categories of causes of death for farmed Atlantic salmon at sea sites, as recorded by companies that share data through the industry initiative "Aqua-Cloud," was presented for the first time in the Fish Health Report 2023. In 2025, data were recorded from 408 sites, representing nearly half of all sea sites with salmon. At the national level, the main causes of mortality were recorded as "Injuries (trauma)" at 33.5%, "Infectious diseases" at 28.1%, and "Unknown cause" at 27.4%. Compared with 2024, injuries are considered to have had greater importance for mortality in 2025, while infectious diseases and environmental factors are attributed less significance. Among the infectious diseases, heart and skeletal muscle inflammation (HSMI) and cardiomyopathy syndrome (CMS) accounted for a larger share of the registrations in 2025 than in the previous year, whereas winter ulcer caused by *Moritella viscosa* represented a smaller proportion.

According to the Norwegian Directorate of Fisheries, approximately 19 million cleaner fish were stocked in cages with salmonids in 2025, and 12.7 million cleaner fish were recorded as dead. Emaciation, handling, fin erosion, infectious diseases, and non-medicinal delousing methods are ranked as the most important health challenges for wrasse and lumpfish in the survey answered by fish health personnel as well as inspectors and advisors from the Norwegian Food Safety Authority ([Appendices E1 and E2](#)).

## Listed Diseases

Listed diseases in aquatic animals are classified into categories A through G, where diseases in categories A to E are determined by the EU and are laid down in Commission Implementing Regulation (EU) 2018/1882, as amended by

Commission Implementing Regulation (EU) 2022/925 and Commission Implementing Regulation (EU) 2024/216. Diseases in categories F and G are determined by the Norwegian authorities (§ 6 of the Animal Health Regulation) ([Chapter 1](#) Statistical basis for the report). A disease classified in category A or C also belongs to categories D and E. The number of detections of listed diseases for the years 2021-2025 is shown in the table below.

Infectious salmon anaemia (ISA) was confirmed at 18 sea sites in 2025, and in addition, suspicion of ISA arose at three sea sites during the year. A land-based broodstock facility with suspected ISA dating back to January 2024 remained under suspicion at the end of 2025. A substantial proportion of last year's confirmed outbreaks occurred in the Vest-erålen region, where two different virus variants were detected. Presumably infected fish were transferred from one site to another, and in other cases the infection is assumed to have spread between neighbouring sites. Several of last year's outbreaks may be associated with the presence of ILAV HPR0 during the juvenile production phase. Seven outbreaks were confirmed at sites with fish that had been vaccinated against ISA. Approximately 190 million doses of vaccines containing ISA virus were sold in 2025, which is at the same level as in 2024.

There has been a positive development with a reduction in cases of pancreas disease (PD) in recent years. In 2025, 44 cases were detected. All cases last year occurred within the endemic zone, with 31 cases caused by SAV3 in PA3 and PA4 and 13 cases caused by SAV2 in PA5 and PA6. No new cases of PD have been detected in PA2 since 2022, and the restricted zone established following the detection of PD at several sites in PA8 in autumn 2023 was lifted before Christmas last year.

After a relatively high number of outbreaks of bacterial kidney disease (BKD) caused by *Renibacterium salmoniarum* in both 2023 and 2024, only one outbreak was confirmed in 2025. In addition, BKD was suspected at one site. Systemic flavobacteriosis in rainbow trout was detected at two juvenile production facilities last year, while francisellosis was detected in cod at one site. Piscirickettsiosis was listed as a notifiable disease in the summer of 2025. Earlier in the year, piscirickettsiosis was detected in turbot at one site, and suspicion of piscirickettsiosis was reported at three salmon sites during the autumn. None of these suspicions were confirmed.

## Number of sites with listed diseases in farmed fish in Norway.

Disease	Category	2021	2022	2023	2024	2025
<b>Salmonids</b>						
Infectious salmon anaemia (ISA)	C+D+E	25	15	18	13	18
Pancreas disease (PD)	F	100	98	58	48	44
Furunculosis	F	5	2	0	0	0
Bacterial kidney disease (BKD)	F	0	1	12	8	1
Systemic infection with <i>F. psychrophilum</i> in rainbow trout	F	1	4	1	1	2
Piscirickettsiosis*	G					0
<b>Marine species</b>						
Francisellosis	F	0	0	0	0	1
Furunculosis (lumpfish)	F	0	1	0	0	0
Nodavirus infection (VNN/VER)**	G	1	0	0	1	0
Piscirickettsiosis*						1*

\*Piscirickettsiosis was listed in category G in June 2025

\*\*Nodavirus infection (VNN/VER) was reclassified from category F to category G in June 2025

## Non-listed Diseases

The data basis for infectious diseases that are not listed is described in [Chapter 1](#) Statistical basis for the report and is comparable to previous years because of agreements entered into between the Norwegian Veterinary Institute and more than 20 aquaculture companies regarding access to data from investigations conducted at private laboratories. However, a greater number of diseases and disease-causing agents are included in the agreements for 2025 and 2026 than in previous years.

Even though statistics for diseases are presented individually, it is not uncommon for fish to suffer from multiple diseases at the same time. This may include two different viral diseases, co-infections involving several types of bacteria, combinations of infections with viruses, bacteria, fungi, and parasites, or combinations of infectious diseases and production-related disorders.

In juvenile production facilities for salmonids, non-infectious diseases dominate. Nephrocalcinosis, water quality issues, runt (failure-to-thrive) syndrome, and haemorrhagic smolt syndrome are ranked among the most important health challenges in the survey answered by fish health personnel as well as inspectors and advisors from the Norwegian

Food Safety Authority (figure “Top 10 health problems for salmon in juvenile production facilities” and [Appendix A1](#)). For rainbow trout, runt syndrome, nephrocalcinosis, deformities, and infectious pancreatic necrosis (IPN) are ranked highest ([Appendix A2](#)). For cod, poor growth development, various deformities, and intestinal disorders are considered the most important health problems ([Appendix A3](#)).

Gill disease and injuries following delousing are, as in previous years, ranked as the most important health problems in grow-out facilities for Atlantic salmon in the survey (figure “Top 10 health problems for salmon in grow-out facilities” and [Appendix B1](#)). However, heart and skeletal muscle inflammation (HSMI) and cardiomyopathy syndrome (CMS) are attributed greater importance than in previous years, and compiled data show that both diseases were detected at more sites in 2025 than in 2024.

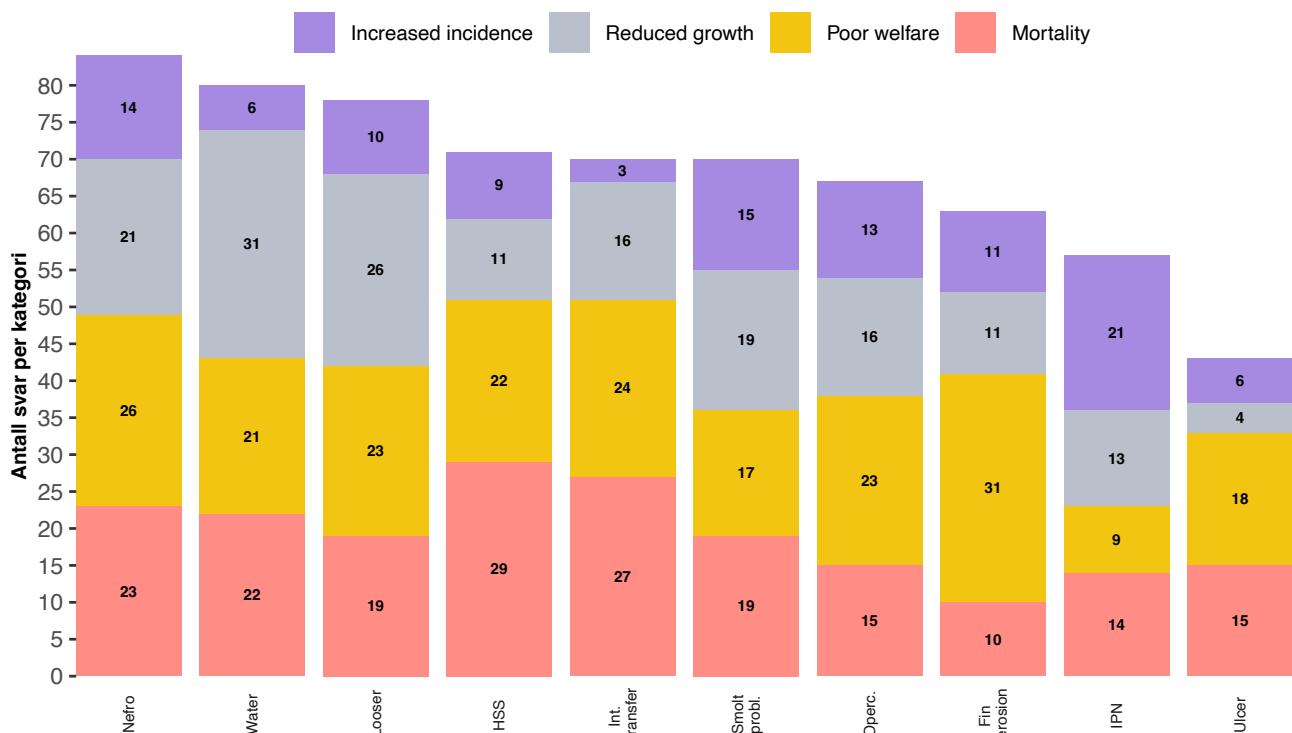
Compared with 2024, there was approximately a threefold increase in the number of detections of infectious pancreatic necrosis (IPN), which is ranked highly in the survey with regard to increasing occurrence in Atlantic salmon in both juvenile production facilities and grow-out facilities. Detection of virus variants has been reported that appear to be

better adapted to fish originating from QTL-selected eggs that are resistant to IPN.

Ulcerative disease affects many sites along the entire coastline each year. When causative agents are detected, various genetic variants of *Moritella viscosa* and/or *Tenacibaculum* spp. are typically identified—often in mixed infections or together with other marine bacteria. In 2025, infection with *M. viscosa* (classical winter ulcer) was detected at 246 sites, compared with 289 sites in 2024. The number of sites with detected infection caused by *Tenacibaculum* spp. (tenacibaculosis/atypical winter ulcers) was 147 in 2025, compared with 165 in 2024. Nearly all Atlantic salmon transferred to the sea in 2025 were vaccinated with a new vaccine containing *M. viscosa*. Compared with previous years, winter ulcer caused by *M. viscosa* is ranked lower in the survey.

There were slightly more detections of *Yersinia ruckeri* in Atlantic salmon last year compared with 2024. As in previous years, most detections occurred at sea sites, and yersiniosis appears to pose the greatest challenges in PA1-PA4. Increased vaccine coverage is assumed to have contributed to fewer outbreaks in PA5-PA7, which were previously heavily affected. Pasteurellosis was also detected at somewhat more sites in 2025 than in 2024. Most detections occurred along the western coast of Norway, but as in 2024, several detections were also recorded in PA7 in 2025.

Runt syndrome, mechanical injuries resulting from delousing, gill disease, heart disorders, and nephrocalcinosis are ranked as the most important health problems for rainbow trout in the sea phase (Appendix A3). For Atlantic cod, intestinal disorders, poor growth development, gill disease, spinal deformities, and *Vibrio* infection are ranked highest (Appendix B4).



Fish Health Report 2025, Norwegian Veterinary Institute

Figure “The ten most important fish health problems in juvenile salmon production”.

Results from the 2025 annual survey among fish health personnel and inspectors of the Norwegian Food Safety Authority. Respondents were asked to indicate the five most important health problems on a list of 28 different problems. The respondents (N = number of people who answered the question) were asked whether the problems were related to mortality (N=60), poor growth (N=59), reduced welfare (N=60), or increased incidence (N=57).

Abbreviations: Nefro = nephrocalcinosis, Water = poor water quality departments with different water qualities, Looser = runt fish, runt syndrome, emaciation, Int transfer = relocation of fish between rearing units with varying water quality, Smolt probl = smoltification problems, Operc = shortened gill covers, Ulcer = skin ulcers and underlying tissues, unspecified cause.

### Salmon Lice and Other Parasites

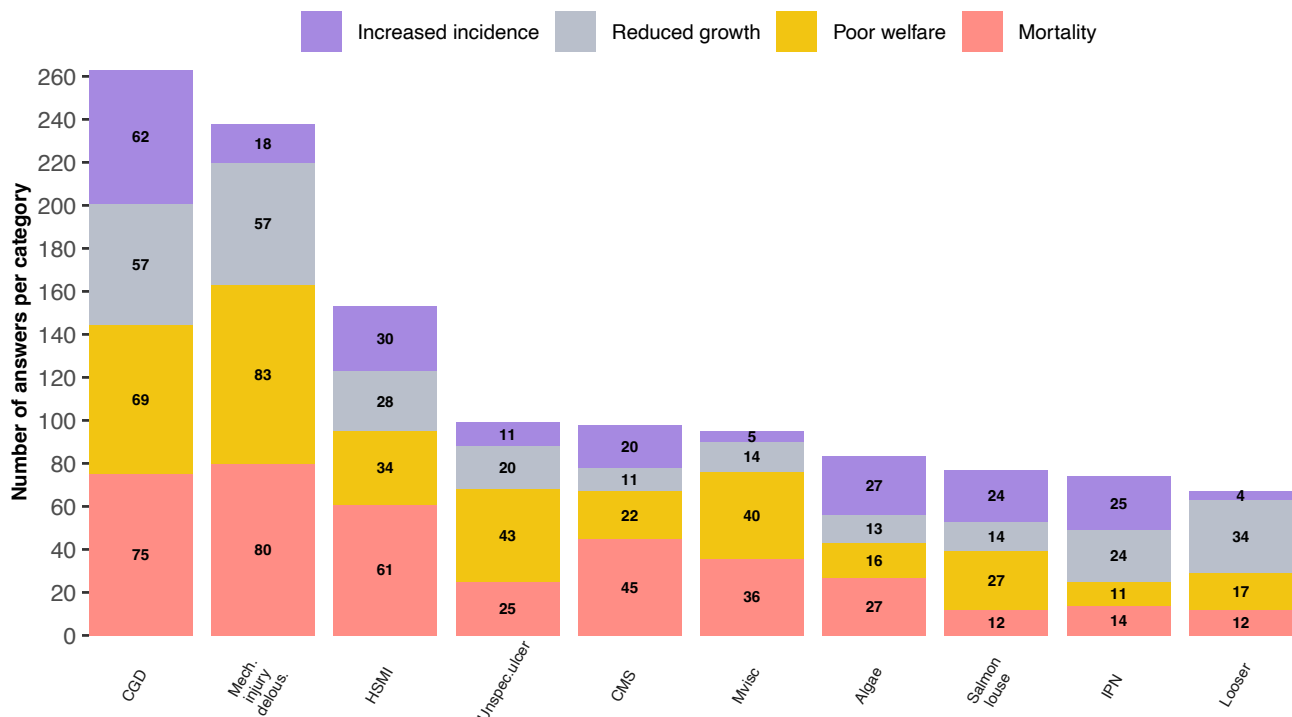
Salmon lice (*Lepeophtheirus salmonis*) remain a persistent challenge in the farming of salmonids. In 2025, there were nearly four thousand treatment weeks involving non-medicinal control measures against salmon lice, representing a substantial increase compared with 2024. Mechanical and thermal delousing, either applied individually or in combination, accounted for well over half of all treatments.

*Parvicapsula pseudobranchicola* continues to cause mortality, poor growth, and reduced welfare in farmed fish in Troms and Finnmark. It is worth noting that parvicapsulosis has also been detected in production areas further south in recent years. Conversely, *Paramoeba perurans*, which causes amoebic gill disease (AGD), has been detected as far north as Troms. The number of detections was far higher than in 2024. Water temperature is a known risk factor for

AGD, and higher water temperatures may result in greater challenges associated with the disease.

### Slaughter Quality

In addition to mortality, slaughter quality can be used as an indicator of animal welfare. In 2025, the proportion of Atlantic salmon classified as superior was 86.9%, representing a significant improvement compared with 2024. Between production areas (salmon only), there was less variation in the proportion of superior-quality fish in 2025 than in previous years; however, there was considerable geographical variation in the reasons for downgrading. The most important reason for downgrading of salmon in 2025 was "Ulcers/injuries," as in previous years. For rainbow trout, the proportion classified as superior was 91.2%, and "Defects" were the most important reason for downgrading. Both slaughter volume and the proportion of superior-quality fish vary throughout the year, and both are highest in the second half of the year.



Fish Health Report 2025, Norwegian Veterinary Institute

Figure "The ten most important fish health problems of salmon in ongrowing facilities".

Results from the 2025 annual survey among fish health personnel and inspectors of the Norwegian Food Safety Authority. Respondents were asked to indicate the five most important health problems on a list of 38 different problems. The respondents (N = number of persons who answered the question) were asked whether the problems were related to mortality (N=119), poor growth (N=116), reduced welfare (N=119) or increased incidence (N=114).

Abbreviations: CGP = gill disease complex/multifactorial, Mech injury delouse = mechanical damage related to delousing, HSMI = heart and skeletal muscle inflammation, Unspec ulcer = ulcers unspecified cause, CMS = cardiomyopathy syndrome, Mvisc = infection with *Moritella viscosa* (classic winter ulcers), Algae = algal bloom, Salmon louse = salmon lice (grazing injuries following infection with *Lepeophtheirus salmonis*), IPN = infectious pancreas necrosis, Past = infection with *Pasteurella* sp. (pasteurellosis).

# 1 Statistical basis for the report

By Victor H S Oliveira, Eve Marie Louise Zeyl Fiskebeck, Trishang Udhwani and Torfinn Moldal

The data in the Fish Health Report are mainly obtained from: official registers (the Directorate of Fisheries, the Norwegian Food Safety Authority, and the Veterinary Medicinal Product Register), the fish health database in AquaCloud, the Norwegian Veterinary Institute and private laboratories, as well as a survey completed by fish health personnel in private companies, and inspectors and advisors in the Norwegian Food Safety Authority. In the individual chapters, the data/information on which the figures are based are specified, followed by the author’s assessment of the situation.

## Official data

Norway implemented new animal health legislation on 28th April 2022, and [Forskrift om dyrehelse](#) covers disease lists and notification obligations. For aquatic animals, the follow-

ing applies: “In the case of suspicion or detection of a listed disease in aquatic animals, as referred to in Annex II to Regulation (EU) 2016/429, or in the national list of aquatic animal diseases in § 6, except for salmon lice, the operator and any natural or legal person shall immediately notify the Norwegian Food Safety Authority.”. Furthermore, the Norwegian Food Safety Authority shall be notified of “increased mortality and other signs of serious disease” in both wild aquatic animals and in cases of abnormal, unexplained mortality in aquaculture animals.

Diseases in aquatic animals that are listed at EU and national level are presented in a simplified form in [Table 1.1](#). These diseases are notifiable and therefore constitute official data.

**Table 1.1. Notifiable diseases listed by the EU and nationally (Norway) for aquatic animals as of 15th June 2025.**

List	Name of listed disease in fish	Category	Species/group of species
EU	Epizootic hematopoietic necrosis	A+D+E	Rainbow trout and perch
	Infectious hematopoietic necrosis (IHN)	C+D+E	Many species, see EEA Agreement's Annex I, Chapter I, Part 1.1, No. 13a (Regulation (EU) 2018/1882)
	Viral haemorrhagic septicaemia (VHS)	C+D+E	Many species, see EEA Agreement's Annex I, Chapter I, Part 1.1, No. 13a (Regulation (EU) 2018/1882)
	Infectious salmon anaemia, HPR-deleted	C+D+E	Atlantic salmon, rainbow trout and sea trout
	Koi herpesvirus disease	E	Carp and Koi
National (Norway)	Bacterial kidney disease (BKD, <i>Renibacterium salmoninarum</i> )	F	Salmonids
	<i>Gyrodactylus salaris</i> infection	F	Atlantic salmon, rainbow trout, Arctic char, North American brook trout, grayling, Canadian char (lake trout) and sea trout
	Furunculosis ( <i>Aeromonas salmonicida</i> subsp. <i>salmonicida</i> )	F	Salmonids
	Pancreas disease (PD, Salmonid alphavirus)	F	Atlantic salmon, rainbow trout and sea trout
	Systemic <i>Flavobacterium psychrophilum</i> infection	F	Rainbow trout
	Francisellosis ( <i>Francisella</i> sp.)	F	Atlantic cod
	<i>Lepeophtheirus salmonis</i> (salmon lice) infection	F	Salmonids
	Viral nervous necrosis (VNN)/Viral encephalopathy and retinopathy (VER), nodavirus	G	Marine fish species
	Piscirickettsiosis ( <i>Piscirickettsia salmonis</i> )	G	Family: Salmonids; marine fish species

The category A disease epizootic haematopoietic necrosis has never been detected in Norway. For an overview of detections of diseases in category C and category F (excluding salmon lice) in farmed fish, see the table in the “Summary” of this report. The figures are based on data from the Norwegian Veterinary Institute, which assists the Norwegian Food Safety Authority in maintaining an updated overview of the listed diseases. The Norwegian Food Safety Authority shall notify the Norwegian Veterinary Institute of listed diseases that are reported as suspected or detected by private laboratories. In principle, the Norwegian Veterinary Institute, as the national reference laboratory (NRL), is responsible for verifying diagnoses for all notifiable diseases. The definition of the term “official data” in the Fish Health Report is the number of new detections at a site after fallowing. This means that the actual number of infected sites may be higher, as infected fish from the previous year may still be present at sea.

In addition to disease data, other official data are used in the Fish Health Report. From the Directorate of Fisheries, the Norwegian Veterinary Institute receives figures from the monthly reporting for marine grow-out sites, including average weight, number of live fish, dead fish, and other categories of fish lost during marine production. From the Norwegian Food Safety Authority, the Norwegian Veterinary Institute receives lice counts and data on lice treatments from the weekly reports, data on prescribed medicinal products, and reports on welfare-related events). In addition, the Norwegian Food Safety Authority provides monthly reports from hatcheries on the number of live, dead and culled fish, as well as average weight at tank level. The Norwegian Veterinary Institute also uses the Directorate of Fisheries’ “Aquaculture Register”, which provides an overview of all aquaculture licences and related information.

### Data from the Norwegian Veterinary Institute

The Norwegian Veterinary Institute receives samples for diagnostic purposes from various fish health services and the Norwegian Food Safety Authority. These are analysed at the Norwegian Veterinary Institute’s laboratories in Harstad, Trondheim, Bergen and Ås. All information on submitted samples is stored in the Norwegian Veterinary Institute’s electronic sample journal system (PJS). Data from PJS has been extracted and sorted so that primarily samples submitted for diagnostic purposes are included in the Fish Health Report. Samples submitted for research projects, ring trials or monitoring programmes are usually excluded.

### Data from private laboratories and compilation

Non-listed diseases are not notifiable. Therefore, data from the Norwegian Veterinary Institute alone cannot provide a complete picture of the national situation. In recent years, agreements have been established with the largest and several medium-sized aquaculture companies in Norway to gain access to data on detections of selected non-listed diseases in farmed Atlantic salmon, rainbow trout and cleaner fish from analyses conducted at private laboratories. The data are obtained from the electronic journal systems of PatoGen AS, Pharmaq Analytiq AS and Blue Analytics AS. All data were verified and approved by the aquaculture companies before use.

Twenty-four aquaculture companies (some with subsidiaries) have shared data on the following diseases and associated causative agents:

- Heart and skeletal muscle inflammation (HSMI) and HSMI-like disease
- Cardiomyopathy syndrome (CMS)
- Infectious pancreatic necrosis (IPN)
- Yersiniosis
- Pasteurellosis
- Classical winter ulcer
- Tenacibaculosis / non-classical winter ulcer
- Parvicapsulosis
- Amoebic gill disease (AGD)
- Infection with lumpfish flavivirus
- Mycobacteriosis
- Flavobacteriosis in species other than rainbow trout
- Systemic spironucleosis
- Infection with ISAV HPR0
- Atypical furunculosis
- Salmon pox
- Epitheliocystis
- Infection with *Salmoxcellia vastator*
- Winter ulcer
- Piscirickettsiosis
- Infection with *Vibrio anguillarum*
- Infection with *Vibrio splendidus*

Although the company structure has changed somewhat due to acquisitions and mergers on the one hand and the separation of sea and land-based production into separate companies on the other, the statistical basis for 2025 can be considered comparable to previous years. The selected

diseases and causative agents occur mainly in the marine phase of farmed Atlantic salmon and rainbow trout, and to some extent in cleaner fish. In addition, disease detections in other fish species and in the aquatic environment, where such information is available, were included.

The coverage of the dataset, i.e. the proportion of active sites included in 2025, is calculated based on reported biomass submitted through the Altinn portal (a government-run digital platform) to the Directorate of Fisheries. A total of 833 sites with Atlantic salmon and 85 sites with rainbow trout (grow-out, broodstock, and research and development sites) were active for at least one month in 2025. The total number of hatcheries in Norway, based on reports to the Norwegian Food Safety Authority, was 134 for Atlantic salmon and 21 for rainbow trout. The compiled data for the above-mentioned non-listed diseases were based on detections from 692 sites and represent fish kept in both freshwater and seawater.

For each disease or agent, the datasets from the different laboratories, including data from the Norwegian Veterinary Institute, have been harmonised so that each site is counted only once per detected disease or agent. In some cases, the same disease or agent may have been detected in the same cohort in both 2024 and 2025, and the overview cannot therefore be used to determine the number of new outbreaks in 2025. The exception is for notifiable diseases (see description above).

In some cases, fish health personnel diagnose non-listed diseases based on characteristic macroscopic findings and detection of the agent alone (for example by PCR). Fish health managers in the companies providing data were asked to report the clinical status ("sick" or "healthy") of the population from which the positive sample was taken. This additional information has been used in several of the chapters dealing with non-listed diseases.

### Data from AquaCloud

The Norwegian Veterinary Institute has established a collaboration with Seafood Norway and AquaCloud on quality assurance of their "fish health database". The database receives daily reports from the aquaculture companies' internal systems, where, among other things, recorded dead fish in sea sites with salmon are classified into standardised cause categories.

The classification system for dead fish was developed by Norwegian University of Life Sciences on behalf of the industry and has also been included in the Norwegian Standard NS 9417:2022. As part of the collaboration agreement, publication of statistics for the six main cause categories (level 1) is permitted for regional areas that ensure the anonymity of aquaculture company sites. Publication of data at more detailed cause categories (levels 2 and 3) must be approved in writing before use in the Fish Health Report. The number of sites reporting to AquaCloud in 2025 was 408 (as of January 2026), corresponding to approximately 49 percent of all marine salmon sites in Norway in 2025.

### Data from the annual survey

As in previous years, the Norwegian Veterinary Institute has used an electronic questionnaire to collect supplementary information from fish health personnel in fish health services, aquaculture companies and breeding companies, as well as inspectors and advisors in the Norwegian Food Safety Authority. In the survey, respondents were asked, among other things, to rank how important they consider various health problems in hatcheries and grow-out sites with Atlantic salmon, rainbow trout and Atlantic cod, broodstock facilities with Atlantic salmon and rainbow trout, as well as lumpfish and wrasses in hatcheries and grow-out facilities for salmonids. The questionnaire also included questions on the effects of lice treatments, various parameters for fish welfare, vaccine effectiveness and water quality. New in the Fish Health Report 2025 were questions on climate change and its impact on fish health. Respondents were also able to provide free text answers within each topic.

The questionnaire was sent to 361 recipients, of whom 265 were in fish health services, aquaculture or breeding companies, or in the category "other", and 96 were in the Norwegian Food Safety Authority. The survey was completed by 143 individuals (40% response rate), the highest number of responses received to date. Of these, 122 were fish health personnel or in the "other" category, and 21 were inspectors or advisors in the Norwegian Food Safety Authority. Respondents who wished to be credited are listed under "Acknowledgements" at the end of the report.

Data from the survey is used under relevant topics in the individual chapters of the report. A combined ranking of different disease and welfare challenges from the survey is presented in [Appendices A-E](#). For salmon in grow-out sites,

the results are presented both for the country as a whole and by production area (PA) for PA1-PA5, PA6-PA9 and PA10-PA13. Respondents with experience from overlapping areas (for example, PA5-PA6 and PA9-PA10) are excluded from the dataset for the area-based presentations. The same applies to rainbow trout broodstock due to the low number of respondents.

### Geographical distribution

Until 2020, the Fish Health Report presented geographical distributions of data at county level. The production area regulation of 15th October 2017 introduced regulation of commercial aquaculture for salmonids in thirteen geographically defined areas, referred to as production areas (Figure 1.1). With few exceptions, this year's edition of the Fish Health Report presents aggregated data by production area (abbreviated PA in the report), rather than by county. As there are relatively few sites in PA1 and PA13, data for these production areas are combined with PA2 and PA12, respectively, when presenting data on non-listed diseases to ensure confidentiality.

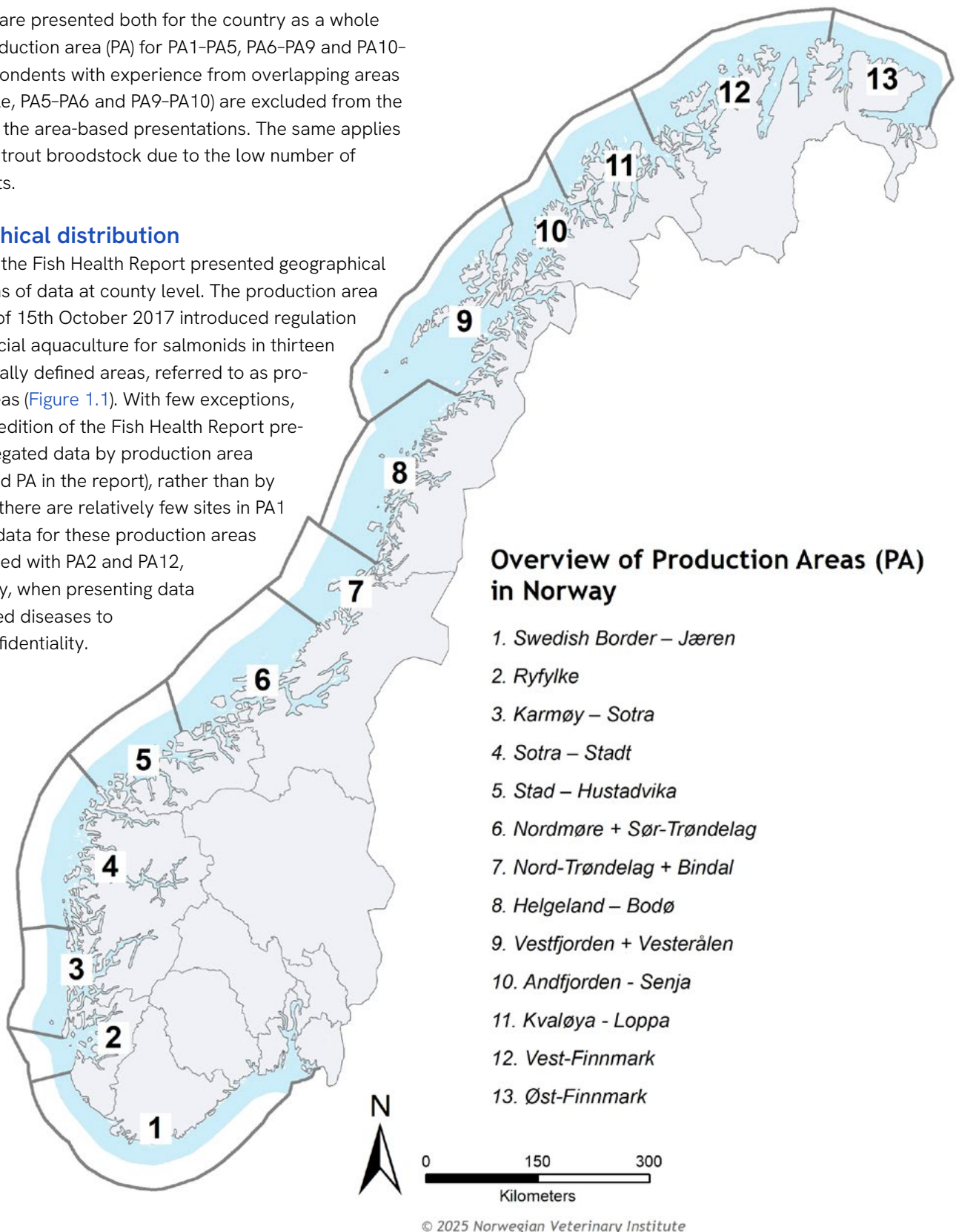


Figure 1.1. The map shows Norway divided into 13 production areas (PA1-PA13) as defined in the production area regulation.

## 2 Mortality in fish farming

By Victor H.S. Oliveira and Ingunn Sommerset

**Mortality in Norwegian aquaculture is an important indicator of fish health, welfare, and overall production conditions. Fish may die because of a wide range of factors, including infectious diseases, adverse environmental conditions, injuries related to handling, or other operational factors. Several of these issues are discussed in more detail in other chapters of this report.**

Mortality in the aquaculture industry has received increasing political and regulatory attention following the publication of the parliamentary white paper on animal welfare (*Meld. St. 8 (2024-2025)*). The white paper, which was presented to the Norwegian Parliament in 2024, provides a status overview of Norwegian livestock production and associated welfare challenges. It also outlines the government's objectives and measures to strengthen animal welfare in Norway, including for aquatic animals such as fish. The government emphasizes that mortality levels in aquaculture are too high and has set a target to reduce mortality across all farmed species to approximately 5%.

Mortality is also addressed in the white paper *"The Future of Aquaculture – Sustainable Growth and Food for the*

*World"* (*Meld. St. 24 (2024-2025)*), which presents a broader regulatory reform of the aquaculture sector. This white paper describes structural and economic policy instruments intended to stimulate improvements in fish health and welfare, including potential mechanisms to reduce mortality, such as economic incentives or fees linked to fish losses.

Due to the strong focus on mortality, the Norwegian Veterinary Institute introduced quarterly reporting of mortality for Atlantic salmon and rainbow trout in 2025 through the [Laksetap app](#). Additional statistics and figures are included in this year's report to enable a broader assessment of mortality in aquaculture.

As in previous years, this chapter covers developments in production trends and mortality across different production phases (juvenile and seawater grow-out). It includes the main species produced or used in Norwegian aquaculture (Atlantic salmon, rainbow trout, Atlantic cod, and cleaner fish species), both at the national level and at the regional level, by county and production area. In addition, causes of mortality at sea sites for Atlantic salmon are presented based on companies' voluntary data sharing with AquaCloud.



Farmed salmon. Photo: Rudolf Svensen

## 2.1 Production Statistics and Trends

By Victor H.S. Oliveira, Katharine R. Dean, Hege Løkslett and Lars Qviller

### Production of Salmonids

The first phase of Atlantic salmon and rainbow trout production takes place in freshwater and is referred to as the hatchery (smolt production) phase. Fertilized eggs (eyed eggs) hatch into yolk-sac larvae, which are subsequently start-fed and develop further from fry to parr before undergoing a physiological adaptation to seawater and becoming smolt. Farmed salmonids generally spend approximately 8–15 months in freshwater production systems before being transferred to sea.

Data from the hatchery phase show that in 2025 there were 134 hatchery facilities producing salmon smolt and 21 hatchery facilities producing rainbow trout smolt (Table 2.1.1). In recent years, there has been an increasing occurrence of fish spending longer periods in hatchery facilities and being transferred to sea at 250 g or more, often referred to as large smolt. Sea transfer may occur throughout the year, but most commonly takes place in spring (mainly April–June) and during the late summer–autumn transition (August–September) (Table 2.1.2). Each transfer event at a site may last several weeks.

**Table 2.1.1** Production data for hatchery fish (Atlantic salmon and rainbow trout) in Norway over the past five years (2021–2025). Data source: Norwegian Food Safety Authority (<https://www.mattilsynet.no>) (February 2026). The data are based on site-level information that is not publicly available.

	2021	2022	2023	2024	2025
<b>Atlantic salmon</b>					
Active hatcheries per year	133	131	129	132	134
Active tanks per year	4766	4914	4841	4949	5013
Active tanks per hatchery (monthly average)	19	19	20	20	20
Active tanks per hatchery (5th–95th percentiles, monthly range)	2–49	2–48	3–51	3–49	3–50
Number of fish per tank (monthly average)	114 475	121 288	130 400	131 154	131 026
Number of fish per tank (monthly 5th–95th percentiles, monthly range)	11 349–299 921	13 282–321 914	14 659–329 261	15 641–341 389	14 976–335 110
Number of fish (<500 g) transferred to sea (millions)*	381.7	461.9	432.8	413.6	405.3
<b>Rainbow trout</b>					
Active hatcheries per year	22	22	19	18	21
Active tanks per year	485	490	503	487	505
Active tanks per hatchery (monthly average)	14	15	15	16	15
Active tanks per hatchery (5th–95th percentiles, monthly range)	1–41	3–42	2–42	3–42	4–36
Number of fish per tank (monthly average)	59 767	62 395	66 191	67 064	62 368
Number of fish per tank (monthly 5th–95th percentiles, monthly range)	8 093–225 143	6 059–249 131	8 433–209 736	7 321–222 475	6 740–204 639
Number of fish (<500 g) transferred to sea (millions)*	20.6	27.9	28.8	29.1	25.1

\*Figures differ from previous reports due to updates in data from the Directorate of Fisheries.

**Table 2.1.2** Total number of sea sites with Atlantic salmon, rainbow trout, or Atlantic cod in Norway during 2021–2025, distributed by the month of first sea transfer. Data source: Directorate of Fisheries (<https://www.fiskeridir.no>) (February 2026). The data may be based on site-level information that is not publicly available.

	Atlantic salmon	Rainbow trout	Atlantic cod
January	66	7	0
February	17	17	0
March	157	23	4
April	261	16	4
May	299	5	5
June	225	8	10
July	177	22	2
August	289	24	1
September	194	18	2
October	143	8	2
November	127	9	4
December	117	10	1

Based on data from the Directorate of Fisheries as of the end of February 2025, approximately 405.3 million Atlantic salmon were transferred to sea in 2025. This represents a decrease of more than 55 million sea stocked salmon compared with 2022, which marked a peak year, but is still about 24 million more than in 2021 (Table 2.1.1).

Similarly, the number of sea stocked rainbow trout declined to 25.1 million in 2025, after reaching a five-year peak of 29.1 million in 2024 (Table 2.1.1).

It is worth noting that discrepancies have been observed between the reported number of fish transferred to sea and the reported number of smolt sold. For example, the most recent available data on sold smolt are from 2024, when 460 million Atlantic salmon and rainbow trout were reported as sold (data as of December 2025), while the total reported number of smolt transferred to sea for these species in the same year was 443 million (data from February 2026). The

magnitude of these discrepancies varies between years, and the number of fish transferred to sea may be either lower or higher than the number sold.

Standing biomass at sea for active salmonid sites is reported at the end of each month (Table 2.1.3). The average monthly biomass in 2025 was approximately 876 000 tonnes for Atlantic salmon and 52 000 tonnes for rainbow trout, representing the highest values recorded during the five-year period for both species.

The harvested biomass of Atlantic salmon in 2025 increased by 11 % compared with 2024, exceeding 1.72 million tonnes (round weight). For rainbow trout, harvested biomass increased by 13 % in 2025 compared with 2024. These are the highest recorded harvested biomass figures for both species during the 2021–2025 period (Table 2.1.3).

**Table 2.1.3** Production data for Atlantic salmon and rainbow trout at sea sites in Norway over the past five years (2021–2025). Data source: Directorate of Fisheries (<https://www.fiskeridir.no>) (February 2026). The data may be based on site-level information that is not publicly available.

	2021	2022	2023	2024	2025
<b>Atlantic salmon</b>					
Active sea sites per year	830	834	816	827	833
Average monthly active sea sites	581	568	570	563	564
Active monthly number of fish per sea site	744 835	774 614	793 889	822 871	803 506
Number of fish per sea site (monthly 5th–95th percentile)	85 013– 1 541 533	79 276– 1 703 965	85 421– 1 698 882	88 734– 1 769 976	89 593– 1 677 545
Total biomass in Norway (tonnes, monthly average)	836 742	814 039	827 651	837 359	875 687
Total biomass in Norway (tonnes, monthly min–max)	772 338– 904 607	750 003– 867 371	764 801– 894 847	760 947– 902 267	834 169– 907 431
Harvest volume (tonnes, round weight)	1 557 255	1 538 646	1 520 726	1 544 395	1 719 781
<b>Rainbow trout</b>					
Active sea sites per year	65	66	78	81	85
Average monthly active sea sites	43	40	49	55	55
Active monthly number of fish per sea site	485 641	522 148	508 940	486 659	455 704
Number of fish per sea site (monthly 5th–95th percentile)	4 283– 1 095 135	8 266– 1 396 446	11 457– 1 218 116	15 440– 1 268 789	3 636– 1 092 855
Total biomass in Norway (tonnes, monthly average)	40 846	37 056	43 577	49 983	51 760
Total biomass in Norway (tonnes, monthly min–max)	36 984– 44 591	33 541– 41 582	35 302– 49 599	43 606– 53 585	49 769– 54 845
Harvest volume (tonnes, round weight)	84 083	76 658	81 1544	95 158	107 745
<b>Atlantic salmon and rainbow trout (combined)</b>					
Grow out production – number of land based sites (freshwater and seawater)	58	58	64	64	66
Number of sites reporting the use of cleaner fish	496	433	355	291	221

## Use of Cleaner Fish

The use of cleaner fish for biological sealice control continues to decline. In 2025, fewer than half of the salmonid sea sites used cleaner fish compared with 2021 (Table 2.1.4).

The number of cleaner fish stocked at sea sites was approximately 19 million in 2025, compared with around 48 million in 2021. In addition, the average monthly number of cleaner fish in 2025 decreased by 40 % compared with 2024.

**Table 2.1.4** Figures for cleaner fish kept at sea sites for use in salmon farming over the past five years (2021–2025). Data source: Directorate of Fisheries (<https://www.fiskeridir.no>) (February 2026). The data may be based on sitelevel information that is not publicly available.

	2021	2022	2023	2024	2025
Number of cleaner fish stocked at sea sites (million)	48.3	36.3	34.0	24.1	18.9
Stock at sea sites - average monthly number (million)	19.8	14.0	12.2	8.5	5.3
Stock at sea sites - monthly range (min-max, million)	16.7-22.0	10.7-17.8	9.2-13.9	5.7-11.4	3.5-7.2

## Production of Cod

The first production phase for cod (Atlantic cod) consists of the egg, larval, and juvenile stages and takes place exclusively in hatchery facilities using seawater. Cod are initially fed live feed such as rotifers or Artemia (brine shrimp), which is gradually replaced by formulated commercial feed before the fish are transferred to sea cages. Cod take longer than salmonids to reach a suitable size for sea transfer and are therefore typically held for longer periods in hatchery facilities.

Cod are usually transferred to sea cages at a body weight of 100–500 g, where they remain until reaching harvest weight. More than half of the sea sites for cod during the period 2021–2025 had first sea transfer between April and June (Table 2.1.2).

Production of farmed cod has increased in recent years (Table 2.1.5 and 2.1.6). Both the number of active sites and total biomass have increased substantially since 2023, often referred to as a “third wave” of cod farming in Norway. Average monthly biomass at sea has also shown marked growth, exceeding 16 000 tonnes in 2025.

Harvest volumes have increased accordingly, from 1 800 tonnes in 2021 to more than 19 000 tonnes in 2025. The number of hatchery facilities increased from six to ten between 2024 and 2025, with a corresponding increase in the number of active tanks (Table 2.1.5). The number of fish transferred to grow-out sites increased by 38 % from 2024 to 2025.

**Table 2.1.5** Production data for farmed Atlantic cod in hatchery facilities in Norway over the past five years (2021–2025). Data source: Norwegian Food Safety Authority (<https://www.mattilsynet.no>). The data may be based on site-level information that is not publicly available.

	2021*	2022	2023	2024	2025
<b>Atlantic cod</b>					
Active hatcheries per year	-	6	6	6	10
Active tanks per year	-	108	141	126	252
Active tanks per hatchery (average)	-	10	12	12	15
Number of fish per tank (monthly average)	-	90 362	81 962	153 413	104 026
Number of fish per tank (5th-95th percentile)	-	9 436- 257 821	9 748- 213 006	29 714- 238 846	8 851- 216 753
Number of fish (100–500 g) transferred to sea (million)†	-	4.1	6.8	6.3	8.7

\*Data for 2021 are not presented due to the limited number of facilities in that year.

†Figures differ from previous reports due to updates to datasets from the Directorate of Fisheries.

**Table 2.1.6** Production of Atlantic cod at sea (posthatchery phase) in Norway over the past five years (2021-2025). Data source: Directorate of Fisheries (<https://www.fiskeridir.no>) (February 2026). The data may be based on site-level information that is not publicly available.

	2021	2022	2023	2024	2025
<b>Atlantic cod</b>					
Active sea sites per year	15	15	17	19	21
Average number of active sea sites per month	10	12	13	14	14
Average monthly number of fish per sea site	368 945	535 524	712 575	763 014	856 681
Number of fish per sea site (monthly 5th-95th percentile)	1 675- 1 507 594	3 980- 1 442 419	4 871- 1 445 036	4 630- 1 741 041	2 014- 1 917 126
Average monthly biomass at sea (tonnes)	4 373	8 945	11 513	14 303	16 294
Average monthly biomass at sea (5th-95th percentile, tonnes)	1 979- 7 148	6 093- 12 715	9 122- 14 376	13 303- 15 804	13 785- 18 718
Harvest volume (tonnes, round weight)	1 812	4 893	11 623	14 416	19 698

## 2.2 Mortality data and analytical framework

By Victor H.S. Oliveira, Lars Qviller, Hege Løkslett and Lars Erik Gangsei

### Presentation and interpretation of mortality data

We present mortality data for the relevant production phases for Atlantic salmon, rainbow trout, cleaner fish, and Atlantic cod. We show several different ways of summarising and visualising these data. Depending on species and production phase, mortality may be presented as monthly summaries (salmon, rainbow trout and cod), cumulative annual summaries (salmon, rainbow trout, cleaner fish and cod), or summaries covering the production cycle period (salmon). Figures in this chapter show results for the past five years. Additional historical data, as well as extended visualisation options for individual species, are available in the [Laksetap app](#).

Mortality is reported in two ways: as “losses”, which indicates the total number of fish lost (including dead fish), and as “mortality”, which is based on calculation methods rooted in established veterinary epidemiological practice, as described in the sections *Production of hatchery fish: data and methods* and *Production at sea: data and methods*. Procedures for processing and calculation are regularly reviewed, and input from stakeholders is welcomed. When scientifically justified, updates may be implemented and documented openly in the Laksetap app during the year.

Mortality results may be presented using different summary measures; median, interquartile range (IQR), mean, and confidence interval for the mean.

The median represents the central value of the distribution and divides all observations into two equal parts. The IQR describes the spread of the middle half of the observations, from the 25th to the 75th percentile. Together, the median and IQR provide an indication of a typical mortality level and the degree of variation among sites, without being strongly influenced by extreme values. One interpretation of the IQR is that a randomly selected site has a 50% probability of having mortality within this range, and consequently a 25% probability of having mortality below the lower interquartile limit and a 25% probability of having mortality above the upper interquartile limit.

The mean, or arithmetic average, is another way to summarise mortality. The mean is more influenced by extreme

values than the median, and for mortality the mean is usually higher than the median, as the mean can be substantially affected by a small number of sites with outlying data, typically high mortality. To express uncertainty, a 95% confidence interval is calculated via the standard error. The confidence interval represents the range that, with 95% probability, covers the true underlying mean mortality. Confidence intervals become narrower when the mean is based on observations from many sites, or when the variation between sites is small. It is important to note that individual sites may have values outside this interval; the confidence interval reflects uncertainty around the overall mean, not the variation among individual observations.

### Production of hatchery fish: data and methods

Monthly losses of salmon, rainbow trout and cod in hatchery production are reported to the Norwegian Food Safety Authority. From 2023 onwards, the Authority began sharing these data via APIs. Losses have been reported exclusively as the number of dead fish, without distinguishing between fish that died naturally and fish that were culled (often referred to as destroyed), and they have been accompanied by information on total stock and average weight. From September 2025, the reporting format was changed so that naturally dead fish and culled fish were to be reported as separate categories. As this was introduced during a transition period and was not consistently adopted by all reporters in 2025, data up to the end of 2025 were harmonised with the previous format to ensure comparability. Due to this transition phase, we had to use two different data sources from the Norwegian Food Safety Authority (old and new API) to ensure that data from all sites were included. From next year onwards, reporting will reflect the new structure, and the methodology will be updated accordingly.

The quality of data from the hatchery phase, as recorded and made available in official databases, is generally lower than for production at sea. Mortality data are reported at the tank level, without the possibility of identifying or following individual fish groups. As the fish grow, they are moved between tanks and often sorted, split, or mixed with other groups. Larger sites may also operate several parallel egg batches throughout the year. In addition, variation in reporting practices, such as multiple reports for the same period or changes in reporting systems over time, necessitates

certain quality assurance steps to ensure consistency. Duplicate or overlapping reports have been harmonised, and missing or incomplete submissions have been excluded in dialogue with the data provider. As a result, the dataset is suitable for describing overall patterns, but there are still limitations in using hatchery data for detailed mortality calculations for specific groups.

The hatchery dataset contains monthly information at the tank level within individual hatchery facilities. After removing duplicate and overlapping reports, three additional exclusion criteria were applied: 1) Tanks with an average weight between 0 and 3 grams were excluded because a certain level of losses (mortality and culling) is expected in this early phase. 2) Tanks with fewer than 5,000 fish were also excluded, as these were assumed not to represent typical commercial production. 3) In addition, we removed records where the reported number of dead fish exceeded the number of fish in the tank.

Before these three final exclusion criteria were applied, the dataset contained observations from 241,946 tanks with salmon, 22,514 tanks with rainbow trout, and 4,942 tanks with cod. In total, records for 106,891 (44.2%) salmon tanks, 10,833 (48.1%) rainbow trout tanks, and 2,333 (47.2%) cod tanks were excluded based on these criteria. Summaries of the final dataset with production data per species, including number of tanks and number of fish per tank, are provided in [Table 2.1.1](#) for salmonids and [Table 2.1.5](#) for cod.

Because suitable data for following individual fish groups from month to month in hatchery production are not available, mortality is calculated and presented by weight group. This approach makes it possible to identify patterns across developmental stages and to highlight which weight classes are most vulnerable to mortality. The dataset includes numbers of live, dead, and culled fish at the tank level. For each month, we aggregated data from all tanks that contained fish within the same site, species, and weight group, and used these aggregated figures to calculate monthly mortality.

Mortality in hatchery facilities was estimated by defining the population at risk as the number of live fish reported at the end of the month, plus half of the number of dead and culled fish recorded during the same period (see Gåsnes et al., 2021). This approach reflects that fish removed during

the month (dead and culled) only contribute to exposure time for part of the period. Based on this “population at risk” estimate, we first calculated the monthly mortality rate as the total number of dead and culled fish divided by the number at risk. We then converted the mortality rate into a monthly mortality risk, which represents the probability that a fish dies during the course of the month. This transformation follows principles described by Toft et al. (2004) and Bang Jensen et al. (2020).

### Production at sea: data and methods

Losses of fish at sea sites – from the first month after sea transfer until harvest – are reported monthly by aquaculture companies to the Directorate of Fisheries. These data include both stock numbers and losses for each site, and losses are classified into four categories: “dead”, “discarded”, “escaped”, and “other”. The category “dead” includes fish that are physically removed from the cage and registered as dead due to various causes. “Discarded” includes downgraded fish that are sorted out at slaughter facilities and considered unfit for human consumption, for example due to sexual maturation, wounds, or deformities. “Escaped” covers fish lost as a result of events leading to escape, while “other” is used for losses that do not fall into any of the three preceding categories.

It should be noted that we do not merge the categories “other” and “counting error”, the latter of which may include negative values, into a single category. This differs from the methodology used by the Directorate of Fisheries in loss overviews for biomass statistics published on their websites. Definitions are available in [About aquaculture statistics](#) (downloaded 5 February 2026).

We present mortality summaries aggregated at three geographical levels: county, production area, and national level. The production areas correspond to the 13 areas defined in the production area regulation (FOR-2017-01-16-61). To safeguard confidentiality, production areas or counties with fewer than five active sites may be merged with adjacent areas/counties or omitted from separate visualisations. Data from such sites are nevertheless fully included in the national summaries.

The reported losses include Atlantic salmon, rainbow trout, various species of cleaner fish, and Atlantic cod, and cover market fish, cleaner fish used in salmonid production,

broodstock, as well as fish held under research, development, or educational licences. Mortality results are summarised and presented in three ways: (i) monthly mortality, (ii) annual cumulative mortality, and (iii) cumulative mortality per production cycle. Calculations of monthly and annual cumulative mortality include data from several licence categories, whereas cumulative mortality per production cycle applies exclusion criteria to include only sites holding market-fish licences. Throughout the report, mortality results are presented as mortality risk (0-100%).

To calculate monthly mortality, the mortality rate is first calculated as the number of dead fish (does not include fish in the discarded, escaped, and other categories) divided by the mean number of live fish during the month, calculated as the mean of the number of fish recorded on the first and the last day of the month. The mortality rate is then converted into a monthly mortality risk, defined as the probability of dying during the month, using a formula that accounts for how risk accumulates over time (Toft et al., 2004; Bang Jensen et al., 2020).

Cumulative mortality risks are calculated on the basis of mortality rates. To calculate cumulative mortality, complete data series are required from the starting month, i.e. January for calculation of annual cumulative mortality and the first month at sea for calculation of cumulative mortality per production cycle.

For annual cumulative mortality, average monthly mortality rates are calculated as the mean of the mortality rates across all sites within the relevant aggregation level for each calendar month. These monthly averages are then summed to obtain a cumulative mortality rate for the entire year, which is subsequently converted into an overall mortality risk (the probability that a fish has died during the year).

Cumulative mortality per production cycle is calculated for sites where the data indicate that a full production cycle has been completed. This requires continuous and complete reporting from sea transfer to final harvest, with a duration of at least eight months and a maximum of 24 months. Cumulative mortality for a given month represents the probability that a fish has died from the start of the production cycle up to and including the current month.

In this year's report, we introduce cumulative mortality per production cycle accumulated month by month. This makes it possible to visualise mortality patterns throughout the entire production cycle and facilitates comparisons within and between production areas, even when cycle lengths vary (for example shorter or longer time at sea). Although production cycles may extend over several calendar years, mortality per production cycle is attributed to the year in which the cycle ends (the harvest year) rather than the year of sea transfer. The latter is often referred to as generation mortality.

### References:

- Bang Jensen B, Qviller L & Toft N (2020). Spatio-temporal variations in mortality during the seawater production phase of Atlantic salmon (*Salmo salar*) in Norway. *Journal of Fish Diseases*, 43, 445-457. doi: 10.1111/jfd.13142
- Gåsnes SK, Oliveira VHS, Gismervik K, Ahimbisibwe A, Tørud B & Bang Jensen B. (2021). Mortality patterns during the freshwater production phase of salmonids in Norway. *Journal of Fish Diseases*, 44, 2083-2096. doi: 10.1111/jfd.13522
- Toft N, Agger JF, Houe H & Bruun J (2004). Measures of disease frequency. In H. Houe, A.K. Ersbøll, & N. Toft (Eds.), *Introduction to Veterinary Epidemiology* (pp. 77-93). Frederiksberg, Denmark: Biofolia.

## 2.3 Mortality in hatcheries

By Victor H.S. Oliveira, Lars Qviller, Lars Erik Gangsei, and Ingunn Sommerset

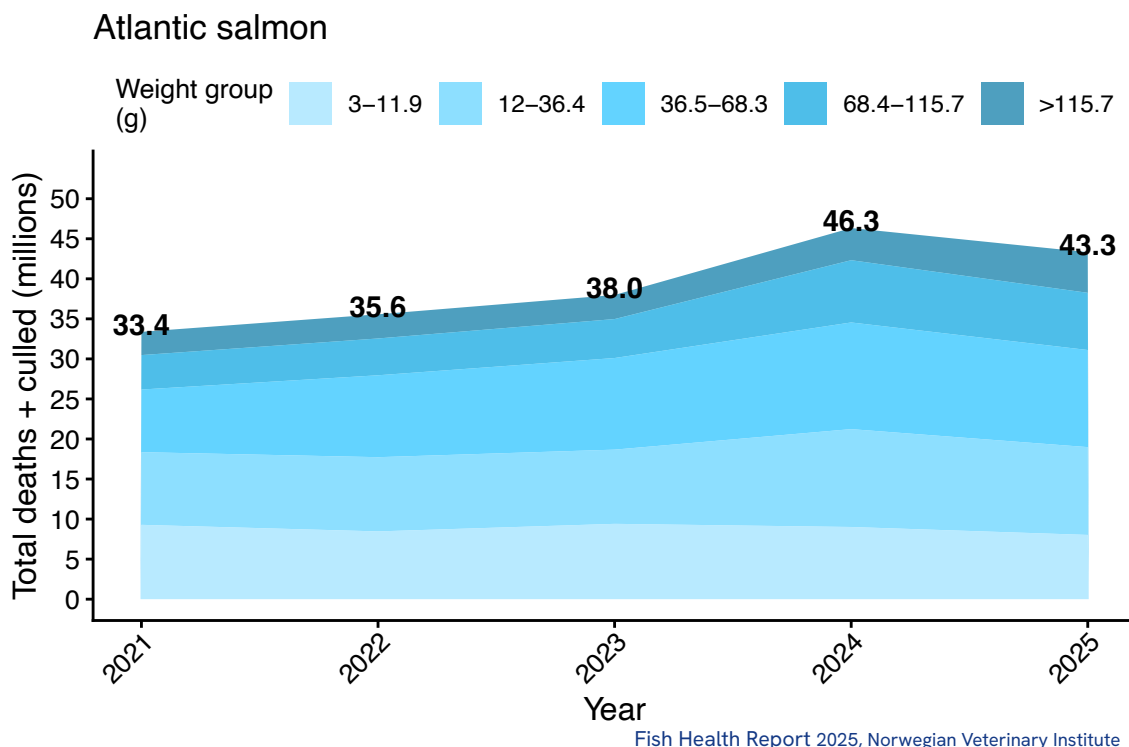
### Total losses

Total losses (dead plus culled fish) in hatcheries for Atlantic salmon during the period 2021–2025 are illustrated in Figure 2.3.1, while losses for rainbow trout smolts are shown in Figure 2.3.2.

In 2025, 43.3 million Atlantic salmon and 2.84 million rainbow trout (above 3 grams) were reported lost during the hatchery phase. This corresponds to a decrease of 6.5% for salmon and 18% for rainbow trout compared with 2024. Compared with 2021, however, losses in 2025 were nearly 30% higher for salmon and 50% higher for rainbow trout. The number of lost salmon increased year by year until a reduction in 2025, whereas figures for

rainbow trout varied considerably over the same period. For salmon, most losses occur in the weight classes 3–68 grams. For rainbow trout, it is more difficult to identify a specific weight class with consistently higher losses due to substantial variation between years.

Losses of cod in hatcheries include data from 2022 to 2025 (Figure 2.3.3). As there were too few active sites in 2021, figures for that year are not included. The increase in the number of cod losses has been substantial from year to year, and the 2.44 million fish reported lost in 2025 represent an increase of more than 250% compared with 2022. Fish in the weight range 36–115 grams account for most reported losses of cod in hatcheries.



Fish Health Report 2025, Norwegian Veterinary Institute

Figure 2.3.1 Number of dead and culled salmon in hatchery facilities reported to the Norwegian Food Safety Authority from 2021 to 2025, distributed by weight group.

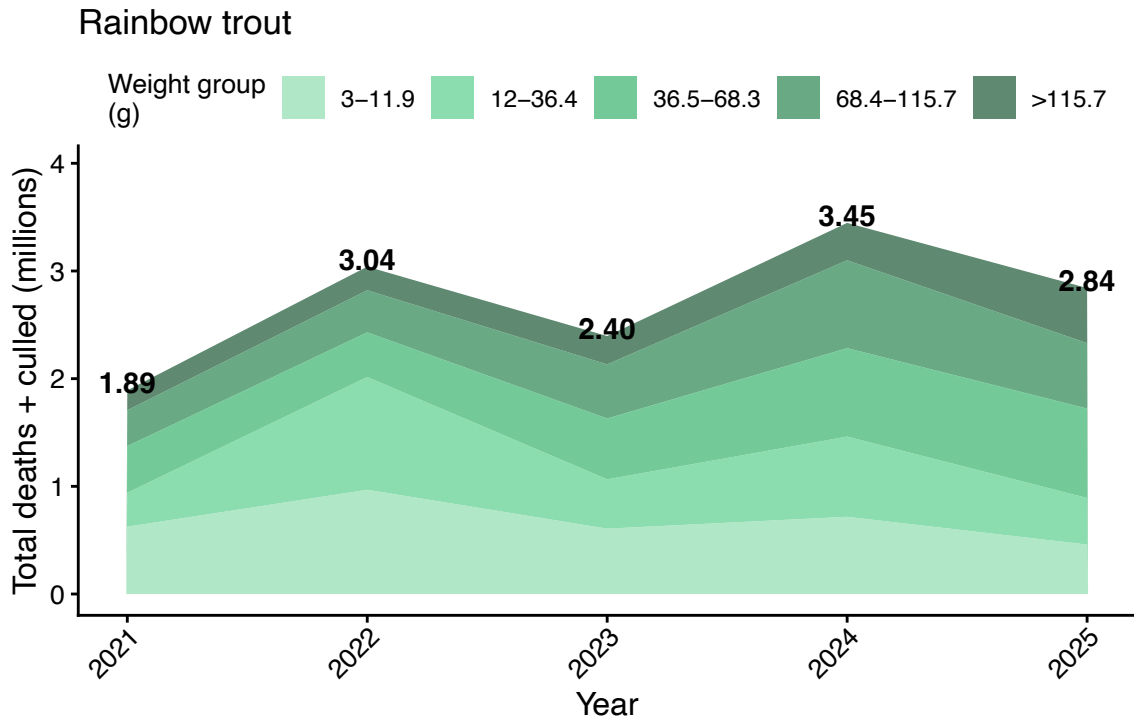


Figure 2.3.2 Number of dead and culled rainbow trout in hatchery facilities reported to the Norwegian Food Safety Authority from 2021 to 2025, distributed by weight group.

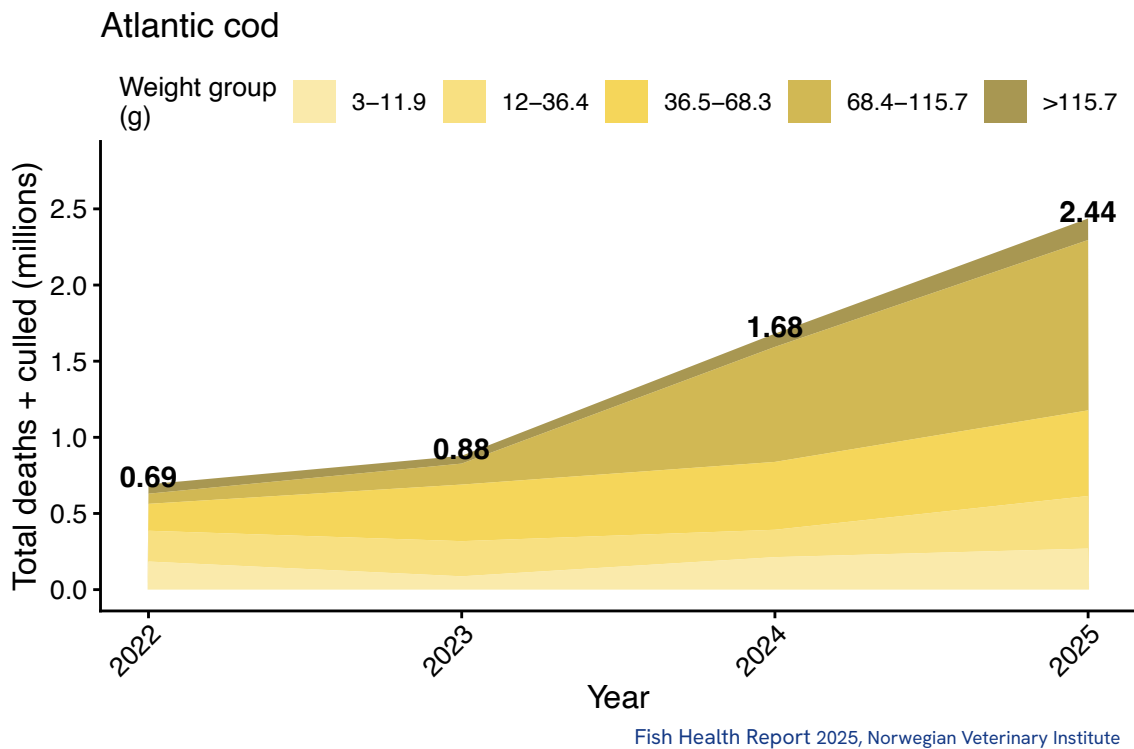


Figure 2.3.3 Number of dead and culled Atlantic cod in hatchery facilities reported to the Norwegian Food Safety Authority from 2022 to 2025, distributed by weight group.

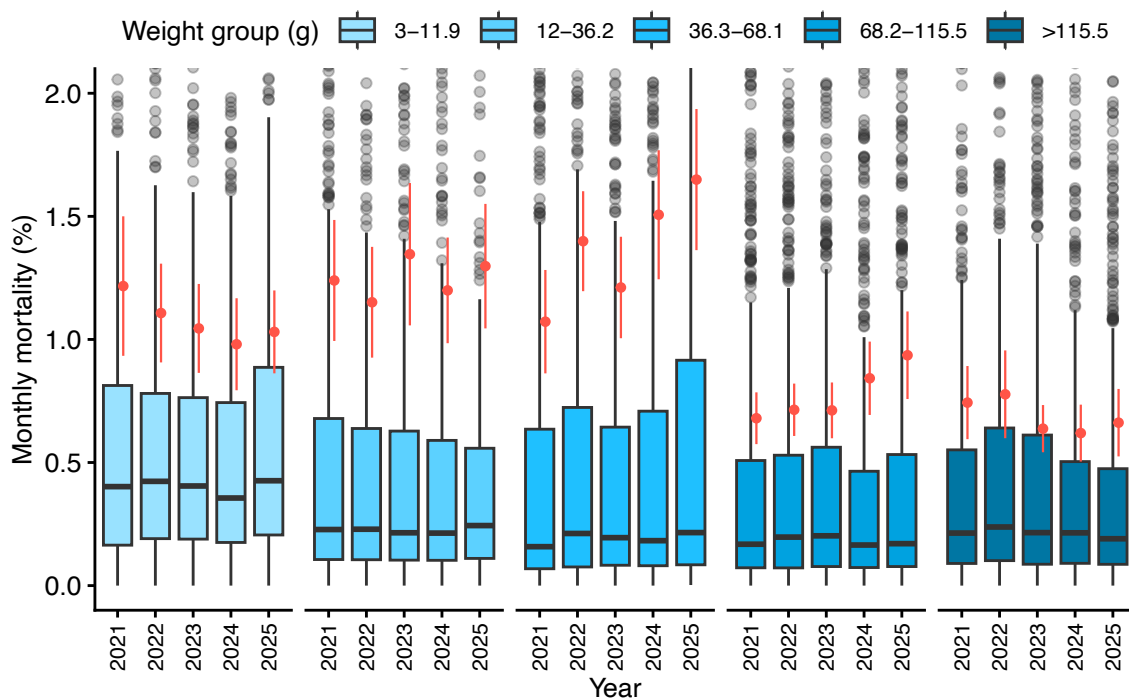
### Mortality stratified by weight class

The lightest weight class for Atlantic salmon (<12 g) typically has the highest median monthly mortality risk, at around 0.4%. The interquartile range spans approximately 0.2-0.9% across years (Figure 2.3.4). As the fish grow, the monthly median mortality decreases, particularly in the 12-68 g weight class.

The mean mortality risk, however, shows a different pattern. Although the lightest weight class has a relatively high mean mortality (around 1.0-1.2%), the highest mean mortality is observed in the 12-68 g group. Thus, the smallest fish consistently have an elevated mortality risk, while individual months or site-specific events with particularly high mortality increase the mean mortality in the 12-68 g weight class.

For the heaviest weight class (>68 g), both the median and mean mortality are lower. The median is around 0.2%, with an interquartile range between 0.1 and 0.6%, and the mean mortality remains below 1%. The heaviest weight class therefore has the lowest overall mortality and fewer, less severe mortality peaks that could otherwise increase the mean.

Mortality for rainbow trout in hatcheries stratified by weight class (Figure 2.3.5) shows a pattern somewhat similar to that observed in salmon smolts, with higher mortality in the smallest weight group (<12 g) and decreasing mortality as the fish grow larger. However, the median mortality in the lightest group (3-11.9 g) is higher than for salmon and generally ranges between 0.5% and 1%. The interquartile



Fish Health Report 2025, Norwegian Veterinary Institute

**Figure 2.3.4** Distribution of monthly mortality (2021-2025) for salmon in hatchery facilities by weight groups. The weight categories (3-11.9 grams, 12-36.7 g, 36.8-68.1 g, 68.2-115.5 g and >115.5 g) were defined using percentile thresholds. The solid line in each box shows the median mortality risk, while the colored boxes show the interquartile range. Black dots mark outlier observations. Extreme values lying outside the axis limits in the figure are not shown, but were included in the calculation of the central mortality measures presented. Red dots show mean mortality risk and the red line indicates a 95% confidence interval based on the standard error.

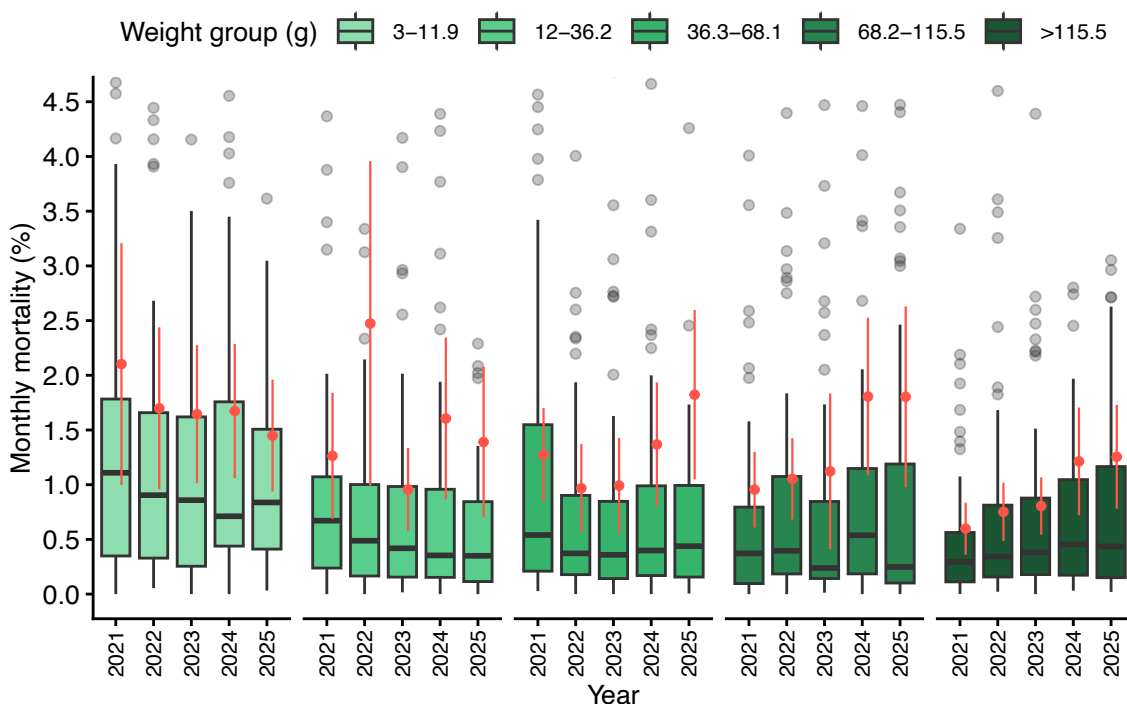
ranges span from 0.4% to 1.7%. For rainbow trout above 12 g, the monthly median mortality is around 0.5% or lower, and the interquartile ranges generally lie between 0.2% and 1% across years.

In contrast to salmon, the mean mortality for rainbow trout often lies close to the upper quartile, indicating more consistent mortality levels among hatcheries and fewer pronounced mortality peaks that would otherwise elevate the mean substantially above the median and quartiles.

Gåsnes et al. (2021), who used hatchery data from 2011 to 2019, described several factors influencing mortality pat-

terns in Norwegian hatcheries for salmonids. They found that mortality was highest during the summer months and lowest during winter. In addition, mortality was higher in hatcheries located in the northern regions than in Southwest Norway.

Monthly mortality in juvenile cod (Figure 2.3.6) is consistently higher than in salmonids, with median mortality exceeding 1%. The weight group 36–115 g had the highest mortality, with a marked year-to-year increase from the first reporting in 2022 through 2025. In 2025, mean mortality in the 36–68 g weight group was close to 6%, while the >68–115 g weight group was around 3.5%. There was also sub-



Fish Health Report 2025, Norwegian Veterinary Institute

**Figure 2.3.5** Distribution of monthly mortality (2021–2025) for rainbow trout in hatchery facilities by weight groups. The weight categories (3–11.9 g, 12–36.7 g, 36.8–68.1 g, 68.2–115.5 g and >115.5 grams) were defined using percentile thresholds. The solid line in each box shows the median mortality risk, while the colored boxes show the interquartile range. Black dots mark outlier observations. Extreme values lying outside the axis limits in the figure are not shown, but were included in the calculation of the central mortality measures presented. Red dots show mean mortality risk, and the red line indicates a 95% confidence interval based on the standard error.

stantially higher variability, both in interquartile ranges and in the uncertainty surrounding mean mortality estimates, for cod. The considerably smaller data volume (number of tanks) for cod compared with salmonids contributes to the increased uncertainty.

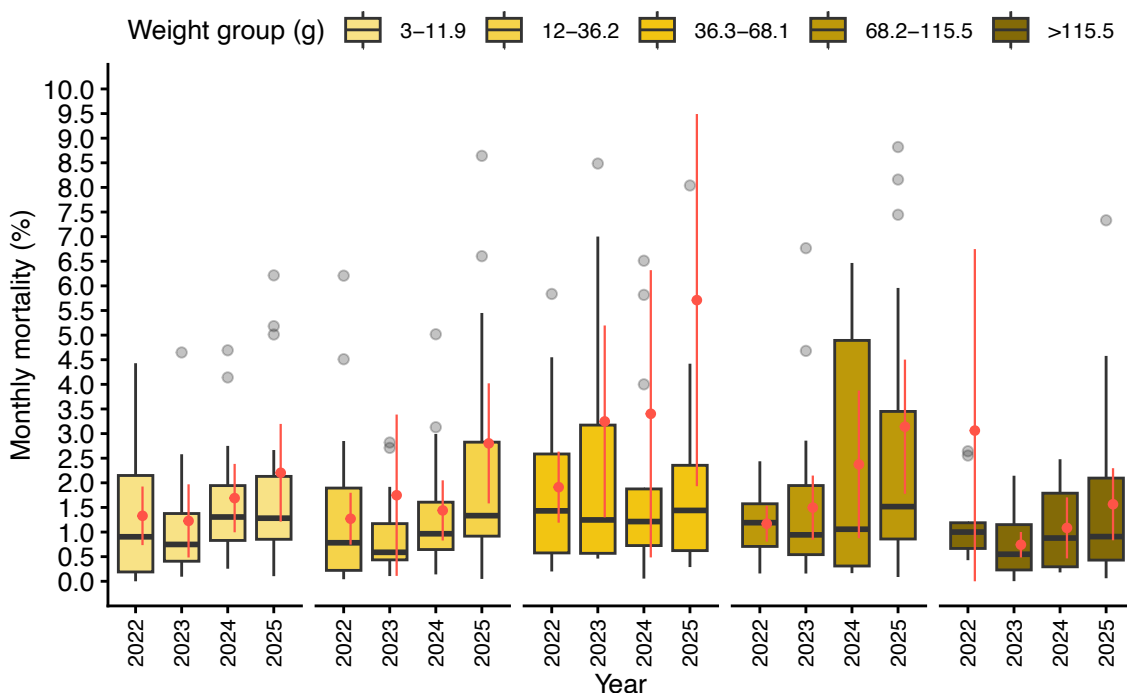
The elevated mortality observed in cod may be a result of the high production volumes in hatcheries. The culling of fish with developmental deformities that are unsuitable for continued production may also be a contributing factor.

**References**

Bang Jensen, B., Qviller, L., and Toft, N. (2020). Spatiotemporal variations in mortality during the seawater production phase of Atlantic salmon (*Salmo salar*) in Norway. *Journal of Fish Diseases*, 43, 445-457.

Gåsnes SK, Oliveira VHS, Gismervik K, Ahimbisibwe A, Tørud B & Bang Jensen B. (2021). Mortality patterns during the freshwater production phase of salmonids in Norway. *Journal of Fish Diseases*, 44, 2083-2096. doi: 10.1111/jfd.13522

Toft N, Agger JF, Houe H & Bruun J (2004). Measures of disease frequency. In H. Houe, A.K. Ersbøll, & N. Toft (Eds.), *Introduction to Veterinary Epidemiology* (pp. 77-93). Frederiksberg, Denmark: Biofolia.



Fish Health Report 2025, Norwegian Veterinary Institute

**Figure 2.3.6** Distribution of monthly mortality (2022–2025) for Atlantic cod in hatchery facilities by weight groups. The weight categories (3–11.9 g, 12–36.7 g, 36.8–68.1 g, 68.2–115.5 g and >115.5 grams) were defined using percentile thresholds. The solid line in each box shows the median mortality risk, while the colored boxes show the interquartile range. Black dots mark outlier observations. Extreme values lying outside the axis limits in the figure are not shown, but were included in the calculation of the central mortality measures presented. Red dots show mean mortality risk, and the red line indicates a 95% confidence interval based on the standard error.

## 2.4 Mortality at sea sites

By Victor H.S. Oliveira, Lars Erik Gangsei, Lars Qviller, Hege Løkslett and Ingunn Sommerset

### Total losses of salmonids

In 2025, the reported losses (in the categories “dead”, “discarded”, “escaped” and “other”) amounted to approximately 67.5 million salmon. This represents a decrease compared to the two preceding years (2023 and 2024), both of which had total losses exceeding 70 million. In 2025, a total of 3.7 million rainbow trout were registered in the loss categories, corresponding to approximately 800,000 more losses than in 2024. Of the reported losses, 54.8 million were registered as dead salmon and 3.2 million as dead rainbow trout, accounting for 81.2% and 86.6% of the total losses for salmon and rainbow trout, respectively.

The total number of lost salmon decreased in 2025 compared with 2024, whereas losses increased for rainbow trout (Table 2.4.1). In the period 2021-2025, most losses were recorded in the category “dead”. Losses recorded under the category “other” have, however, increased markedly in recent years. For salmon, the number in the category “other” increased from 3.4 million in 2021 to approximately 10 million in both 2024 and 2025. For rainbow trout, the number of fish lost in the category “other” increased from approximately 0.26 million (stable between 2021 and 2023) to around 0.36 million in 2024-2025. This may indicate that fish previously classified as dead are now being registered under other loss causes. In 2025, production area (PA) 9, PA10 and PA12 stood out, with more than one million salmon registered in the category “other”, representing between 30% and 40% of the total losses in these regions. Several mechanisms may explain this pattern; nevertheless, the results indicate that the current loss categories and their associated descriptions may require review.

Detailed information on how losses are distributed across the different loss causes over the past five years is available in [Laksetap](#).

### Monthly mortality in salmonids

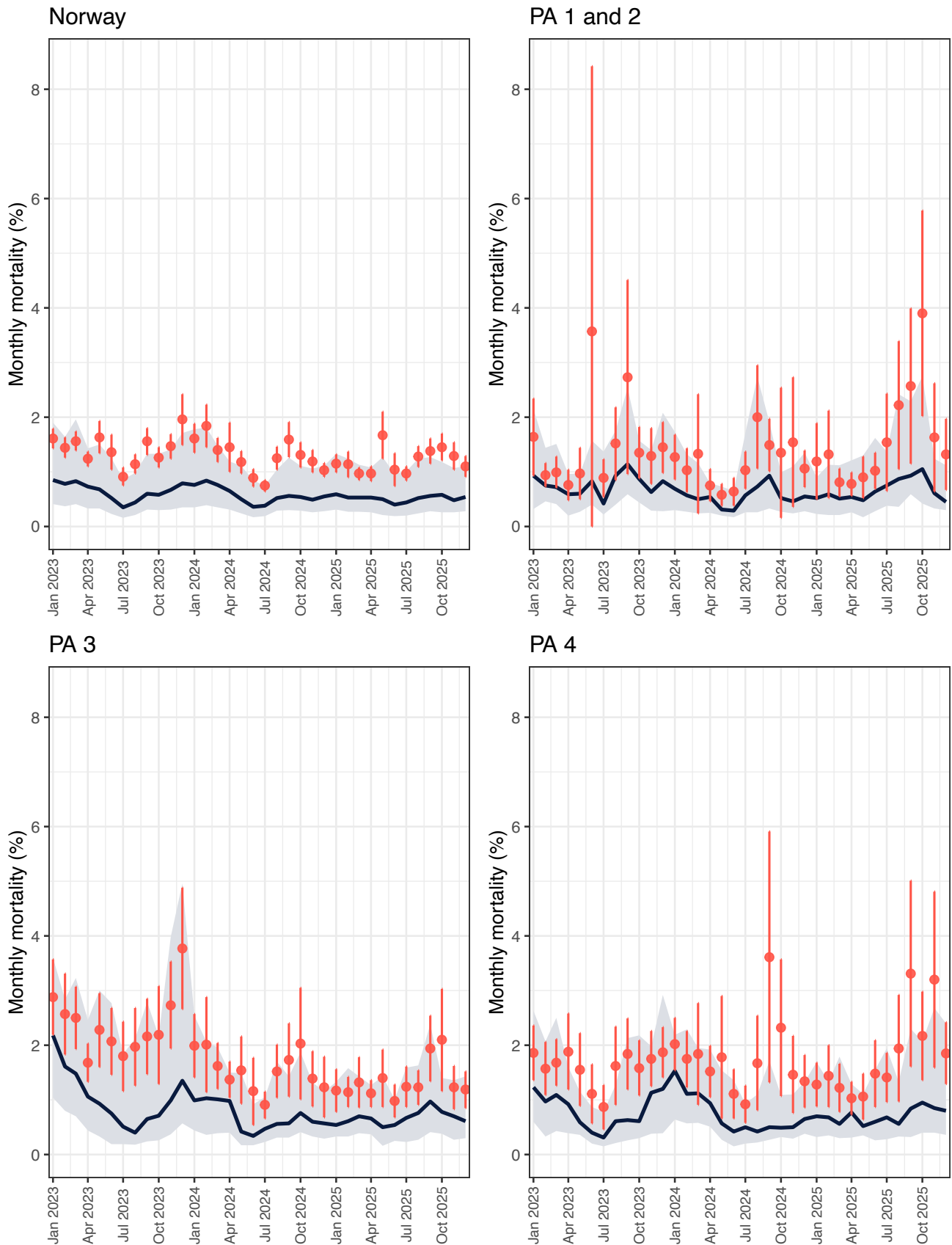
Figures 2.4.1 A-C show the monthly mortality risk for salmon at the national level (Norway) and by production area for the period 2023-2025. The figures illustrate how mortality changes throughout the year and enable identification and comparison of trends, recurring patterns and unusual events. It should be noted that the results for the most

recent months reflect mortality in fish from production cycles that are still at sea.

At the national level, mortality tends to be higher during the winter months and early spring, as shown in Figure 2.4.1 (A). This pattern is also evident when examining historical data further back in time, which are available in [Laksetap](#). In the years preceding 2024, the upper limit of the interquartile range (see explanation in Chapter 2.2 Mortality data and analytical framework) approached 2% monthly mortality in some winter months at the national level. In 2024 and 2025, these seasonal peaks were less pronounced, and the monthly median mortality generally remained at 1% or lower. Seasonal patterns vary between production areas, both with respect to how pronounced the peaks are and which periods of the year have the highest mortality. As shown in Figures 2.4.1 A-C, some distinct mortality peaks occurred in 2025, but at different times depending on the area. For example, PA1-PA2 and PA4-PA5 had mortality peaks in late summer, whereas PA9-PA10 and PA12-PA13 had peaks in spring.

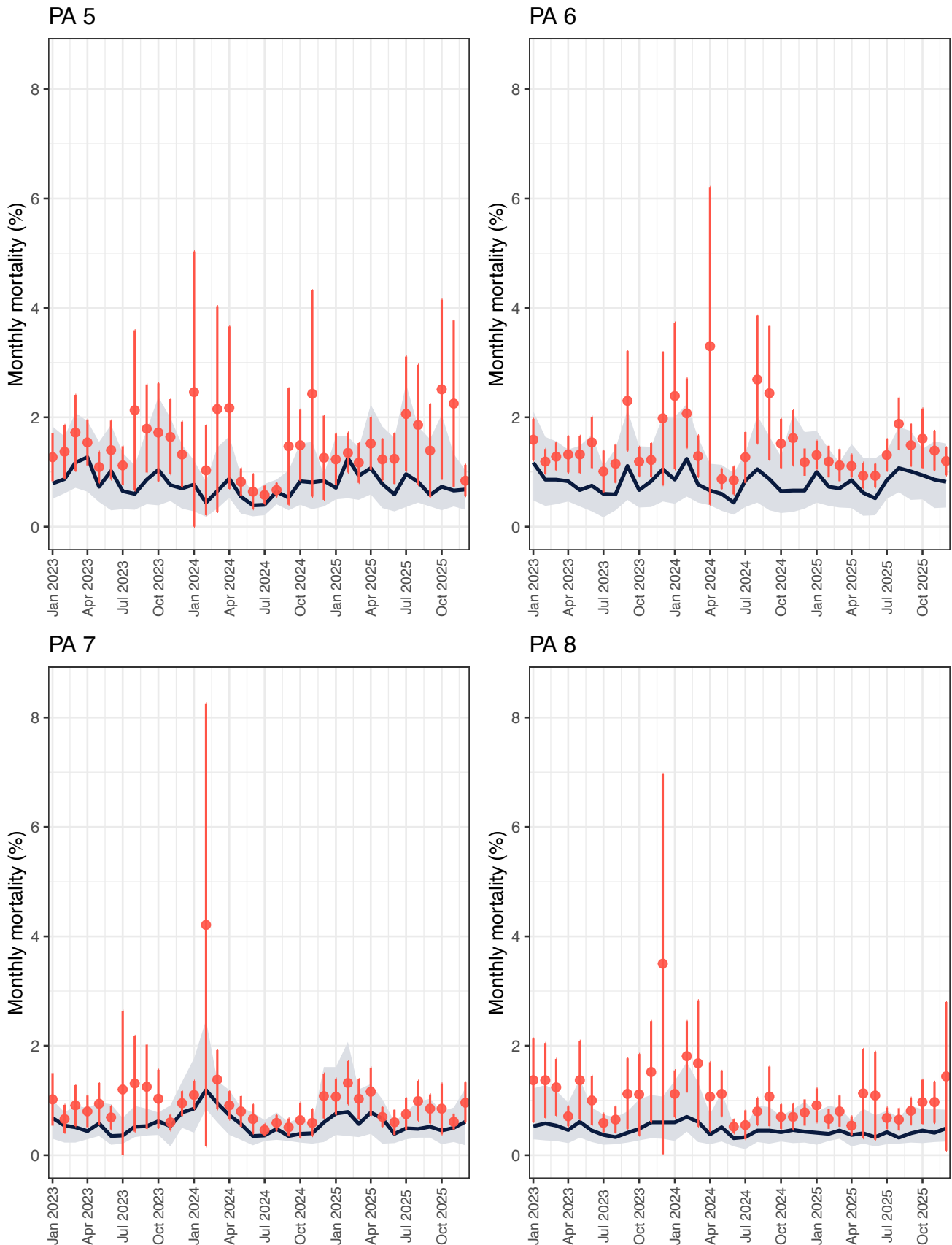
Figures 2.4.1 A-C can also be used to assess variation in monthly mortality between areas. The interquartile range (IQR) around the median (the grey area in Figures 2.4.1 A-C) indicates the extent of variation in mortality between individual sites. For example, PA7 shows consistently low variation between sites, with some exceptions such as February 2024, which is reflected in narrow IQRs and narrow confidence intervals, whereas PA3 has wider IQRs, indicating greater variation in mortality between sites.

Both nationally and within individual production areas, the mean monthly mortality (red dots in Figures 2.4.1 A-C) is noticeably higher than the median (solid black line in Figures 2.4.1 A-C). The confidence intervals (red lines in Figures 2.4.1 A-C) are much narrower at the national level than at the production area level, as many more observations underlie each national level mean. At the production area level, some months stand out with high mean values and wide confidence intervals, for example PA7 in February 2024. Such cases are driven by individual sites with very high mortality in the relevant month (some exceeding 80%). In the specific case of PA7 in February 2024, part of the underlying cause may be attributed to the extreme weather event “storm Ingunn” during the transition from January to February 2024.



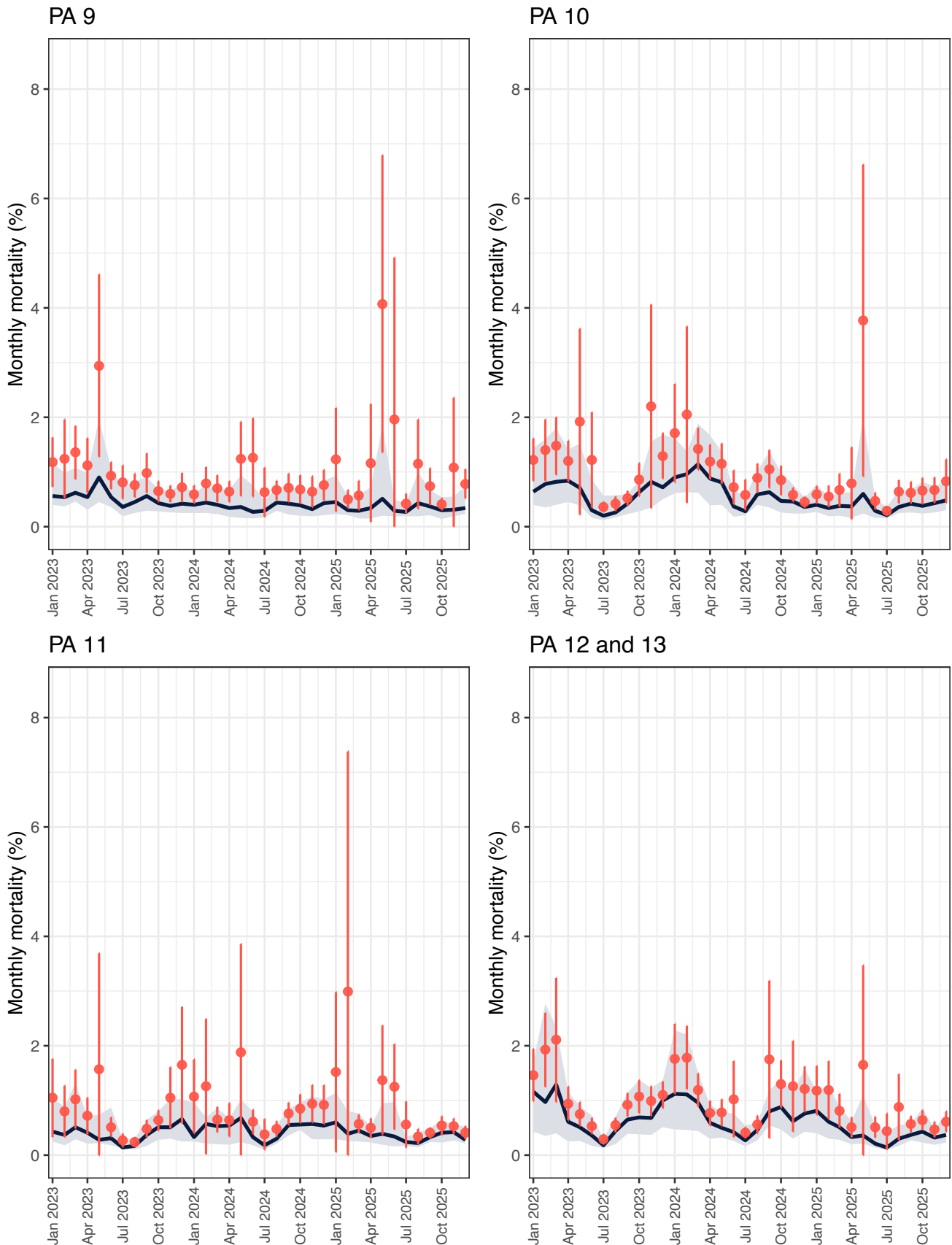
Fish Health Report 2025, Norwegian Veterinary Institute

Figure 2.4.1 (A) Monthly mortality risk (%) in the period 2023–2025 for Atlantic salmon in Norway as well as PA1–PA2 (merged), PA3 and PA4. The black solid line shows the median, and the grey shaded area represents the interquartile range (IQR) for mortality risk. Mean mortality risks are shown as red dots, and the vertical red lines indicate 95% confidence intervals for the mean.



Fish Health Report 2025, Norwegian Veterinary Institute

Figure 2.4.1 (B) Monthly mortality risk (%) in the period 2023-2025 for Atlantic salmon in PA5, PA6, PA7 and PA8. The black solid line shows the median, and the grey shaded area represents the interquartile range (IQR) for mortality risk. Mean mortality risks are shown as red dots, and the vertical red lines indicate 95% confidence intervals for the mean.



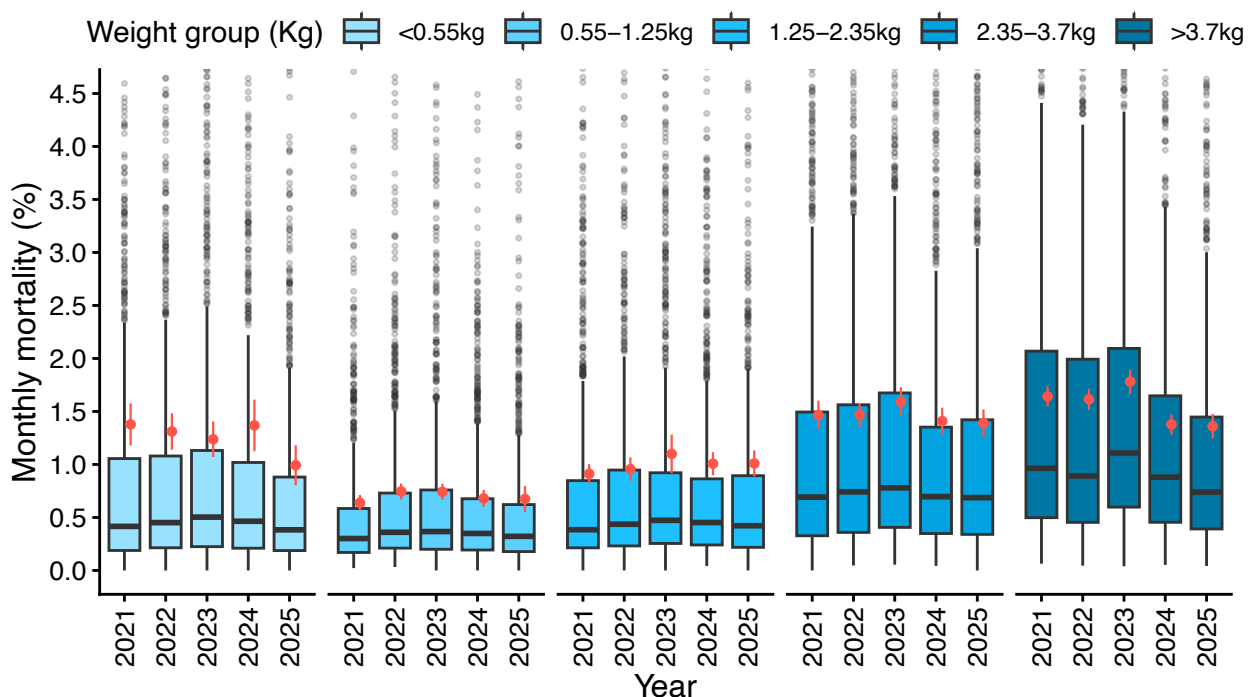
Fish Health Report 2025, Norwegian Veterinary Institute

Figure 2.4.1 (C) Monthly mortality risk (%) in the period 2023–2025 for Atlantic salmon in PA9, PA10, PA11 and PA12-PA13 (merged). The black solid line shows the median, and the grey shaded area represents the interquartile range (IQR) for mortality risk. Mean mortality risks are shown as red dots, and the vertical red lines indicate 95% confidence intervals for the mean.

The relationship between monthly mortality risk and fish weight in the period 2021–2025 is shown in Figure 2.4.2. Mortality in the lowest weight group (below 0.55 kg), corresponding to the first months after transfer to sea, is relatively high. Thereafter, mortality declines somewhat before gradually increasing again from around 1.25 kg and upwards, reaching the highest levels as salmon approach harvest weight (above 3.7 kg). The weight groups with higher mortality also show greater variation in mortality, as illustrated by the interquartile ranges in Figure 2.4.2. The confidence intervals for mean mortality in the lightest group (<0.55 kg) are wider than for the other weight groups. This is due to individual observations with very high mortality (>50% mortality at site level), which are mainly associated with the lightest weight group.

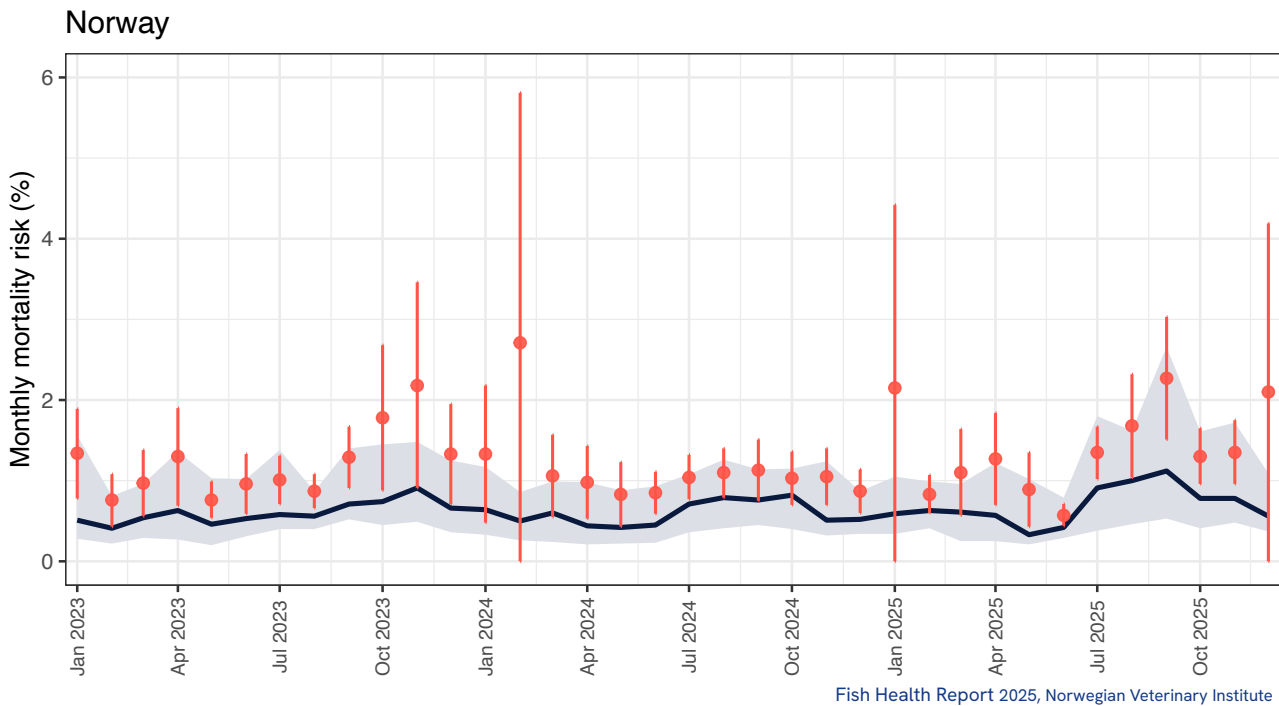
The observed relationships between weight and mortality are consistent with the findings of Oliveira et al. (2021). They also identified other factors influencing mortality in farmed salmon, including different delousing treatments, regional differences, timing of sea transfer, and environmental conditions such as temperature and salinity.

Figure 2.4.3 shows the monthly mortality risk for rainbow trout in Norway from 2023 to 2025. Until May 2025, mortality at most sites was below 1.5%. From July 2025, mortality appears to increase, and the upper limit of the IQR (the 75th percentile) exceeds 2%, indicating a clear peak. Several periods with high mean values and wide confidence intervals are observed, particularly in October and November 2023, February 2024, and January and December 2025. This indicates the presence of individual sites with high mortality.



Fish Health Report 2025, Norwegian Veterinary Institute

**Figure 2.4.2** Distribution of monthly mortality risk by year and weight group for Atlantic salmon in Norway. The figure covers the years 2021 to 2025 and the weight groups <0.55 kg, 0.55–1.25 kg, 1.25–2.35 kg, 2.35–3.7 kg and >3.7 kg. The horizontal black lines show median mortality risk, and the blue boxes represent the interquartile range (IQR). Red dots indicate mean mortality risk, and the vertical red lines show the corresponding 95% confidence intervals based on the standard error. Black dots represent mortality values for individual localities and months exceeding the upper percentile limit, defined as the upper interquartile limit plus 1.5 times the interquartile range. Extreme values that fall outside the axis limits in the figure are not shown but were included in the calculation of the central mortality measures presented.



**Figure 2.4.3** Monthly mortality risk (%) in the period 2023–2025 for rainbow trout in Norway. The black solid line shows the median, and the grey shaded area represents the interquartile range (IQR) for mortality risk. Mean mortality risks are shown as red dots, and the vertical red lines indicate 95% confidence intervals for the mean.

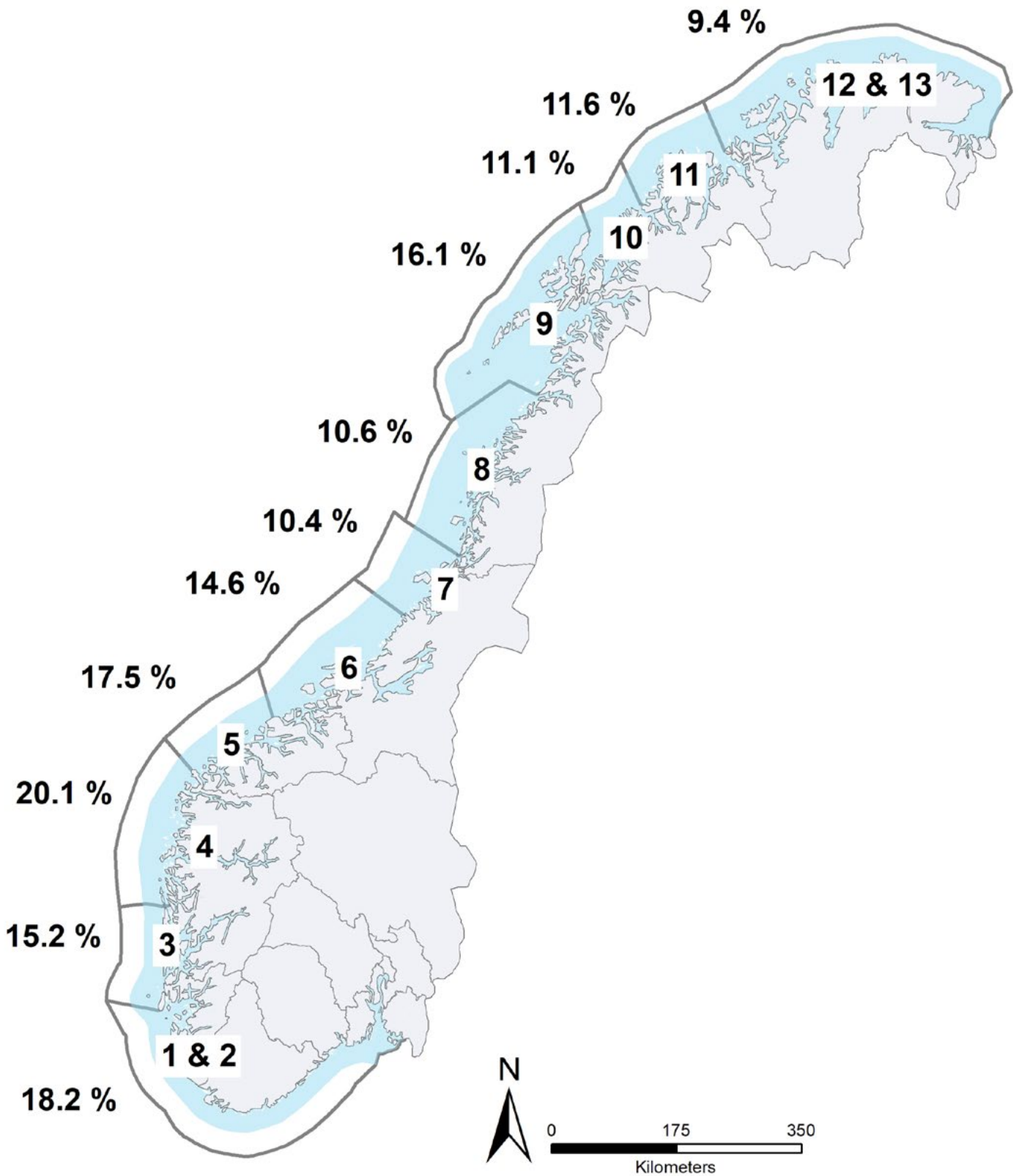
### Annual mortality in salmonids

In 2025, the national annual cumulative mortality risk (based on monthly intervals), hereafter referred to as annual mortality, was estimated at 14.2% for salmon (Table 2.4.1). This corresponds to a reduction of more than one percentage point compared with the previous year and represents the lowest mortality recorded in at least five years.

As in previous years, there was substantial variation in annual mortality of farmed salmon across the different production areas (Figure 2.4.4 for 2025 and Table 2.4.2 for 2023–2025). PA4 had the highest mortality in 2024 at 20.1%, followed by PA1–PA2 (18.2%) and PA5 (17.5%). To prevent possible identification of companies or sites in areas with few producers, PA1–PA2 and PA12–PA13 are combined. The lowest mortality was recorded in PA12–PA13, at 9.4%.

**Table 2.4.1** Total number of dead fish and annual cumulative mortality risk (based on monthly intervals) for sea-transferred salmon and rainbow trout (2021–2025) in Norway. For additional historical data and summaries of mortality by county, see [Laksetap](#).

	2021	2022	2023	2024	2025
<b>Total number dead at sea</b>					
Atlantic salmon (millions)	54.1	56.8	62.8	57.8	54.9
Rainbow trout (millions)	2.8	2.7	2.6	2.4	3.2
<b>Annual mortality</b>					
Atlantic salmon (%)	15.5	16.1	16.7	15.4	14.2
Rainbow trout (%)	14.8	17.1	14.0	15.0	17.0



Fish Health Report 2025, Norwegian Veterinary Institute

Figure 2.4.4 Geographical distribution of annual cumulative mortality risk (based on monthly intervals) for Atlantic salmon by production area in 2025. For historical data and mortality by county, see [Laksetap](#). Figure: Attila Tarpai.

Six production areas had annual salmon mortality above 15% in 2025 (PA1–PA2, PA3, PA4, PA5 and PA9), while five areas had mortality below 12% (PA7, PA8, PA10, PA11 and PA12–PA13). Only PA12–PA13 had mortality below 10% (9.4%). Seven production areas showed a reduction in mortality from 2024 to 2025 (PA3, PA4, PA6, PA7, PA8, PA10 and PA12–PA13). The reduction in PA6 was particularly pronounced, with a decrease of nearly 8 percentage points from 2024. This brought mortality back to levels comparable to previous years, following the unusually high mortality of 22.3% in 2024. Possible causes of the high mortality in PA6 in 2024 were discussed in the Fish Health Report 2024, where challenges related to salmon lice and treatment frequency, gill disease, winter ulcers and jellyfish were mentioned.

In PA3, annual salmon mortality was reduced from 25.7% in 2023 to 15.2% in 2025. This represents a substantial decline and the lowest mortality recorded in at least five years. The reduction has not been accompanied by an increase in losses reported under the category “other”. Mortality accounts for more than 92% of total losses in PA3, indicating a genuine reduction both in reported mortality and in total losses during the sea phase. PA3 is the production area with the highest biomass density ([Chapter 10.1 Salmon lice – \*Lepeophtheirus salmonis\*, Figure 10.1.5](#)) and is among the two PAs most affected by the [Traffic Light System](#).

A reduction in annual mortality during the sea phase does not necessarily imply reduced total mortality over the entire life cycle of the fish (freshwater and sea phases). Production strategies vary, and there is an increasing trend toward extending the freshwater or landbased phase by transferring larger smolt or postsmolt to sea. This results in a shorter production period at sea and a lower proportion of fish in the lightest weight group. As shown in [Figure 2.4.2](#), the lightest weight group has higher average mortality. At the same time, annual mortality is still calculated cumulatively over a 12-month period, without accounting for the distribution of weight groups. In addition, other production factors, such as shorter production cycles and more rapid introduction of new generations at the same site, may affect infection pressure, salmon lice dynamics and other risk factors.

Although developments in PA3 are encouraging, it is important to note that changes in production strategies may influ-

ence mortality in both directions. Some mechanisms may reduce total mortality, while others may increase it, and the overall effect remains uncertain.

The three production areas with the lowest annual salmon mortality in 2025—PA7, PA8 and PA12–PA13—all had mortality around 10%. Historically, the northern production areas have had lower mortality. However, it is unclear whether this pattern is driven by climatic conditions or by generally lower production density in these regions.

PA9 showed the largest increase from 2024 to 2025, with an increase of approximately 7 percentage points in mortality. PA9 therefore ended with an annual cumulative mortality of 16.1% in 2025, despite the area having relatively low biomass density. The area also reported the highest proportion of losses in the category “other” (40% of total losses), indicating that overall losses were substantial in 2025. There were six confirmed outbreaks of ILA and one suspected outbreak in PA9 in 2025 ([Chapter 7.2 Infectious salmon anaemia \(ILA\)](#)). In some cases, ILA can lead to high mortality, and fish removed due to authority mandated measures may be registered under both “dead” and “other”. There were also challenges related to algal blooms in PA9 in 2025 ([Chapter 11.6 Algae and fish health](#)).

There was also a large increase in annual mortality in PA1–PA2, from 13.6% in 2024 to 18.2% in 2025. Mortality in these two production areas was, however, 19.8% in 2023. PA2 has substantially higher production than PA1, and non-medicinal delousing treatments, which are an important driver of mortality, may be a main cause of the mortality pattern observed in the combined PA1–PA2. This is consistent with the observed number of non-medicinal treatments in PA2 ([Chapter 6.6 Welfare challenges related to salmon lice and treatment, Figure 6.6.1](#)).

Mortality in Norwegian rainbow trout production has shown greater year-to-year variation than that observed for salmon ([Table 2.4.2](#)), which is expected given the smaller number of active sites. When fewer sites contribute to national figures, estimates of annual mortality become more sensitive to changes at individual facilities. The national annual mortality in 2025 was 17.0%, representing an increase compared with previous years and comparable to the peak observed in 2022. Among the production areas, mortality in 2025 was highest in PA4, while it was lowest

**Table 2.4.2** Annual cumulative mortality risk (based on monthly intervals) for salmon and rainbow trout in 2023–2025, by production area (PA). For historical data and mortality by county, see [Laksetap](#).

Atlantic salmon				Rainbow trout			
Produksjonsområde (PO)*	2023 % mortality	2024 % mortality	2025 % mortality	Production area (PA)*	2023 % mortality	2024 % mortality	2025 % mortality
PA1 and PA2	19.8	13.6	18.2	-	-	-	-
PA3	25.7	17.5	15.2	PA2 and PA3	16.8	10.5	14.9
PA4	17.8	20.2	20.1	PA4	13.3	16.0	18.3
PA5	16.9	16.7	17.5	PA5, PA6 and PA9	13.3	15.0	12.6
PA6	16.3	22.3	14.6	-	-	-	-
PA7	11.0	14.4	10.4	-	-	-	-
PA8	17.6	11.6	10.6	-	-	-	-
PA9	13.0	9.1	16.1	-	-	-	-
PA10	13.8	12.2	11.1	-	-	-	-
PA11	9.8	10.2	11.6	-	-	-	-
PA12 and PA13	12.1	13.3	9.4	-	-	-	-

\*Mortality is calculated for production areas with more than five active sites. Production areas with fewer than five sites are marked with "-".

when PA5, PA6 and PA9 were considered together. Rainbow trout production is largely concentrated in PA4, where mortality has increased each year since 2023. In 2025, mortality in this area was 18.3%, approximately five percentage points higher than in 2023.

### Mortality in production cycles for salmonids

Mortality in production cycles (continuous and complete reporting from sea transfer to final harvest, with a duration of at least eight months and a maximum of 24 months) is useful for monitoring developments and challenges encountered by sites from sea transfer to harvest. This provides mortality estimates that better correspond to the actual time the fish spend in the sea phase. The data used to report mortality for production cycles are limited to market fish sites; for further details, see [Chapter 2.2](#) Mortality data

and analytical framework. [Table 2.4.3](#) shows the duration of completed production cycles by production area, with median values ranging from 15 to 20 months. Production areas with generally longer production cycles may have higher cumulative mortality, even if the monthly mortality is similar to that observed in areas with shorter cycles. These differences arise because fish in longer cycles are exposed to risk over a longer period. Note that a production cycle may last longer than the lifespan of an individual fish, as farmers often stock fish over several weeks and harvest them over a corresponding period. The distribution of production cycle lengths in [Table 2.4.3](#) provides important context for the interpretation of variation in cumulative mortality and highlights the importance of the time dimension when comparing mortality per production cycle.

**Table 2.4.3** Overview of the duration of completed production cycles in 2025 by production area. Only production cycles with a continuous duration of at least eight months and less than 24 months are included. The median represents the middle value, meaning that half of the production cycles were equal to or shorter than this value, and the other half were longer. The interquartile range (1st-3rd quartile) represents the middle 50% of sites and provides an indication of where most completed production cycles were concentrated.

Production area (PA)	Median (months)	1.-3. quartile (months)	Min. (months)	Max. (months)
PA 1 & 2	17	14-18	9	22
PA3	16	14-18	8	24
PA4	15	13-17	9	21
PA5	16	13-18	10	20
PA6	18	16-20	8	23
PA7	16	12-19	10	22
PA8	17	14-18	8	22
PA9	19	13-21	8	23
PA10	19	15-21	11	23
PA11	18	15-20	11	23
PA12 & 13	20	17-21	10	23
Norway	17	14-20	8	24

Table 2.4.4 shows the median and interquartile range for production-cycle mortality over the past five years in Norway, distributed across the different production areas and nationally. The median mortality for production cycles completed in Norway in 2025 was 14.7%, a reduction from 15.4% in 2024. This is the lowest mortality recorded in the period 2021-2025. Half of Norwegian sites in 2025 had production cycle mortality between 9.3% and 22.6%.

Across production areas, PA4-PA6 had the highest mortality levels for completed production cycles in 2025, all with median mortality above 20%. This represents an increase compared with 2024, and the increase was particularly pronounced in PA5, where mortality increased by approximately 7 percentage points.

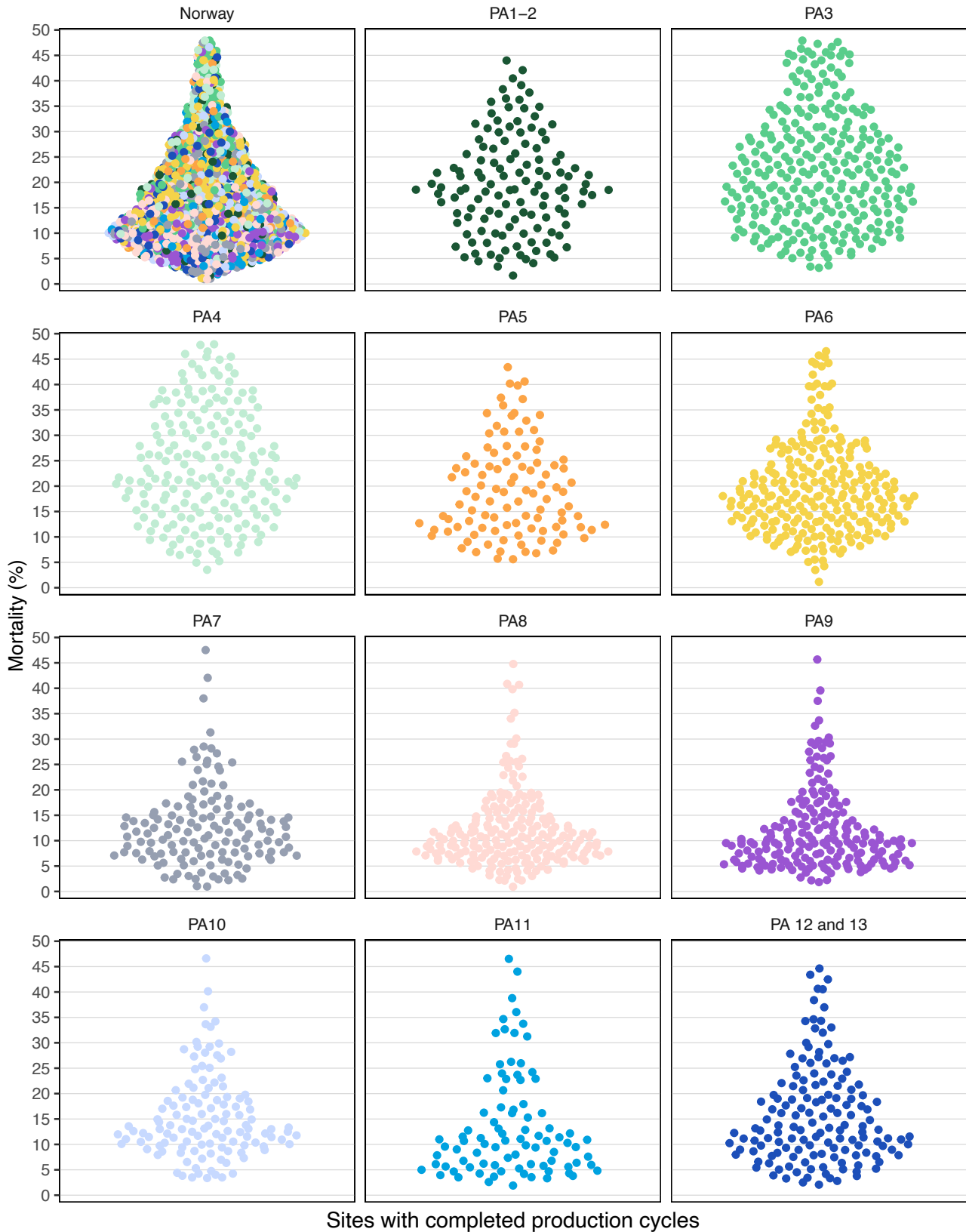
The lowest mortality levels for production cycles were observed in PA8-PA10, with median values at or below 10%. Several production areas showed clear overall reductions in 2025 when developments are viewed in the context of the period 2021-2024. For example, PA3 had its highest mortality in 2023, and PA4 had very high mortality in completed production cycles in 2021. Both areas have seen reductions of nearly 10 percentage points in their most recently completed production cycles. PA3 and PA4 also have similar production cycle lengths, which may be relevant when comparing areas. Another area worth mentioning is PA10, which also showed a reduction of nearly 10 percentage points from 2024 to 2025. PA11 had relatively high mortality in 2021 (18.4%) but has experienced steady reductions in subsequent years.

**Table 2.4.4** Median (1st–3rd quartile) cumulative mortality risk for completed production cycles for salmon, by production area and for Norway overall. Only production cycles lasting at least eight months and no more than 24 months are included. Mortality data for rainbow trout production cycles are available in the [Laksetap](#).

Production area (PA)	2021 % mortality	2022 % mortality	2023 % mortality	2024 % mortality	2025 % mortality
PA1 and 2	19.0 (13.2-25.6)	21.3 (16.1-31.0)	21.2 (15.5-31.8)	19.7 (10.1-29.0)	18.5 (10.1-24.4)
PA3	23.3 (15.2-30.8)	22.0 (14.7-33.2)	26.9 (19.0-37.0)	19.4 (13.5-30.3)	16.6 (9.7-22.5)
PA4	33.4 (21.5-39.2)	22.8 (14.8-30.6)	20.9 (13.3-27.9)	22.9 (13.8-32.0)	23.6 (13.8-34.2)
PA5	14.1 (9.3-23.9)	22.1 (11.8-27.9)	19.1 (16.1-25.7)	13.0 (11.1-19.4)	20.3 (14.3-27.6)
PA6	17.9 (11.6-24.6)	17.9 (12.6-26.7)	20.3 (16.5-27.7)	18.4 (13.7-22.4)	20.8 (14.4-28.7)
PA7	7.4 (5.9-9.9)	12.2 (9.1-15.8)	13.5 (9.1-18.5)	13.2 (8.4-15.2)	12.7 (7.9-16.7)
PA8	9.8 (7.3-12.6)	9.8 (7.4-14.2)	11.6 (8.4-16.0)	11.6 (8.0-16.7)	9.8 (7.0-14.3)
PA9	10.2 (6.0-15.6)	9.3 (5.8-13.9)	9.8 (7.6-15.4)	12.3 (9.5-17.0)	9.6 (6.8-17.6)
PA10	13.7 (9.8-17.1)	14.0 (10.2-18.4)	14.9 (11.7-20.5)	19.5 (12.5-28.1)	10.4 (8.9-14.7)
PA11	18.4 (10.7-25.4)	8.5 (6.0-13.1)	10.2 (5.6-15.9)	7.9 (5.1-11.1)	11.5 (8.0-16.8)
PA12 and PA13	12.6 (7.5-25.1)	10.9 (8.5-16.7)	18.6 (13.3-25.7)	16.9 (10.5-23.9)	14.0 (8.8-18.8)
Norway	15.8 (9.2-26.5)	15.2 (9.4-24.0)	17.8 (11.6-25.9)	15.4 (10.9-24.0)	14.7 (9.3-22.6)

When mortality in production cycles is presented in a scatter plot for the period 2021–2025 (Figure 2.4.5), this illustrates not only differences between production areas but also variation within each area. Each point represents a completed production cycle for a site in the given period. Although all production areas had some sites that completed production cycles with mortality below 5%, Figure 2.4.5 shows that very few achieved this level—fewer than 6% of all plotted production cycles.

The results for cumulative mortality in production cycles presented in Table 2.4.4 and Figure 2.4.4 are based on production cycles of varying duration. Figure 2.4.5 A–B, on the other hand, are designed to show how mortality accumulates month by month, making it easier to compare sites both within and between production areas with different production cycle durations.



Fish Health Report 2025, Norwegian Veterinary Institute

**Figure 2.4.5** Cumulative mortality risk for completed production cycles for sea sites (one dot represents one production cycle at one locality) with Atlantic salmon lasting at least eight months and no more than 24 months in the period 2021 to 2025, distributed by production area or groups of production areas (PA1-PA2 and PA12-PA13). Areas in the figure with a high density of dots (wider spread of the point cloud) indicate clusters of localities with similar mortality per production cycle. Localities where mortality was classified as extreme values are excluded from the figure. Extreme values were defined as observations exceeding the third quartile plus 1.5 times the interquartile range (IQR), where the IQR is the difference between the third and first quartile.

In [Figure 2.4.5 A-B](#), the curves for the median (with interquartile range) and the mean (with confidence interval) are calculated using mortality observations from sea sites that were active for the number of months shown in the embedded bar chart (blue bars). The embedded chart therefore shows how many sites contribute data at each point along the horizontal axis. As expected, the number of contributing sites decreases as the number of months increases: not all sites start production at the same time, and sites drop out of the dataset as production cycles are completed, that is, when harvesting takes place.

It is important to emphasize that the downward trend observed in some of the figures at longer production cycle durations does not imply that longer production cycles have lower mortality. Instead, this pattern reflects the fact that the sites that remain active at these later stages are those that have already experienced relatively low mortality up to that point. Sites that have experienced higher mortality may have completed their production cycles earlier and therefore do not contribute to the far right of the curve. The width of the confidence intervals in [Figure 2.4.5 A-B](#) varies between production areas. For Norway as a whole, the confidence intervals are, as expected, narrower, since the national mean is based on a much larger number of sites than for individual production areas.

Sample sizes, i.e. the number of sites underlying the calculations at each time point, are shown in the inset bar chart. Taking Norway as an example ([Figure 2.4.5A](#)), the number remains constant up to eight months, as only production cycles with at least eight months in the sea phase are included in the dataset. For time periods longer than eight months and up to 24 months, the number of production cycles contributing to the calculations decreases. This is because the number of production cycles with the longest durations declines toward the upper limit of 24 months. This naturally results in smaller sample sizes at longer time spent in the sea phase and wider confidence intervals. This effect is more pronounced in some production areas than in others.

Production areas differ in the underlying variability in cumulative mortality between sites that have been in operation for the same number of months. For example, PA10 and

PA12-PA13 show relatively low variability between sites, whereas PA1-PA2, PA11 and PA6 show substantially greater spread. In some areas, such as PA3 and PA4, variability between sites is low during the early months of production (approximately up to month six), before increasing later in the cycle.

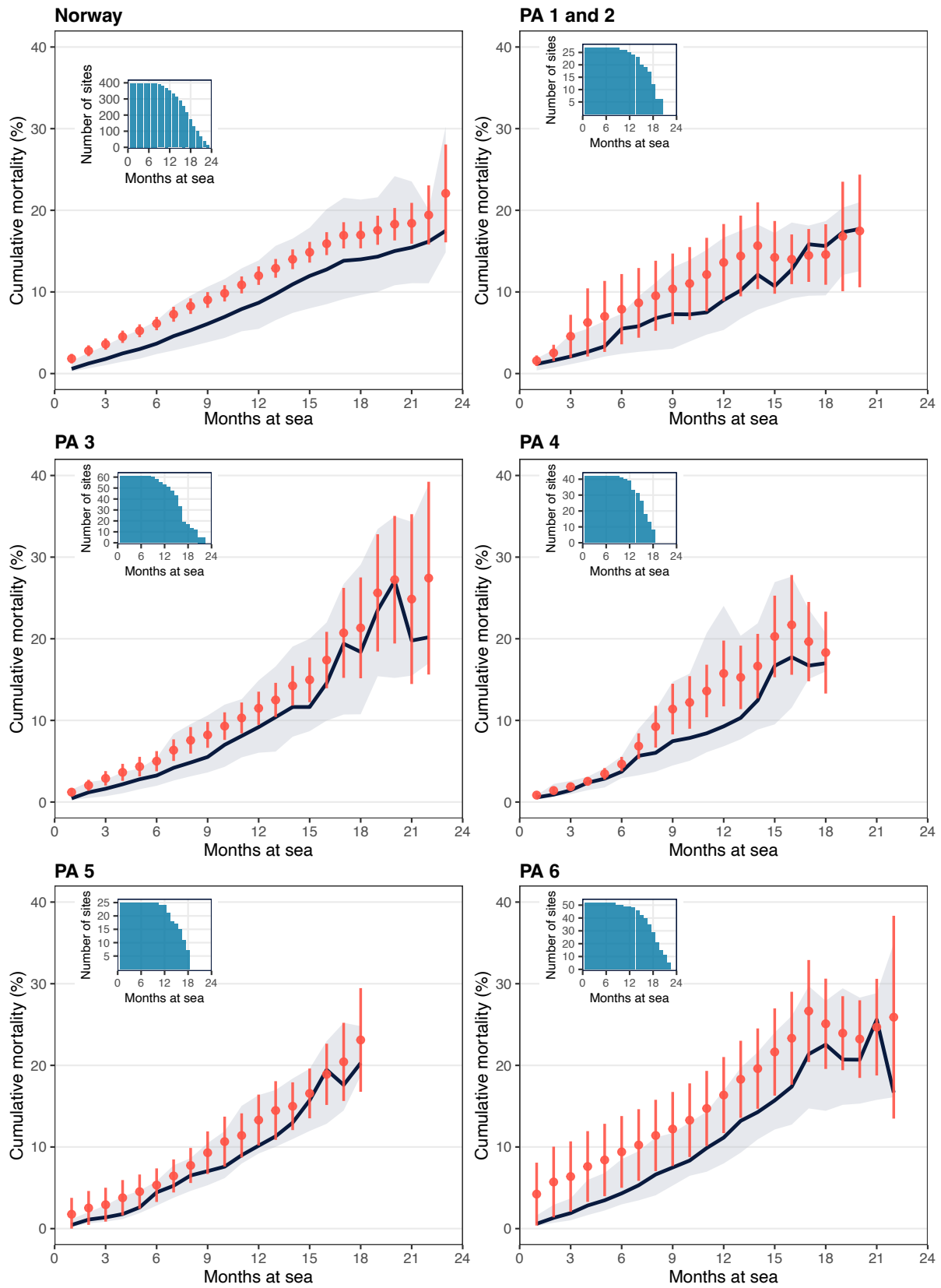
To further illustrate how the curves can be compared between regions at a given point in the production cycle, production areas can be compared using the median length of production cycles in Norway. This was 17 months in 2025. [Figures 2.4.6 A-B](#) show that cumulative mortality varies between production areas at 17 months. For example, PA3 and PA4 show cumulative mortality approaching 20% at this point, whereas mortality in PA10 for cycles extending to 17 months is closer to 10%. These contrasts demonstrate that even when sites operate for the same length of time, the total mortality pressure can vary substantially between production areas.

These regional differences in variability may reflect how homogeneous fish populations are within each production area, both in terms of production practices and exposure to mortality risk factors.

### Mortality in Atlantic cod

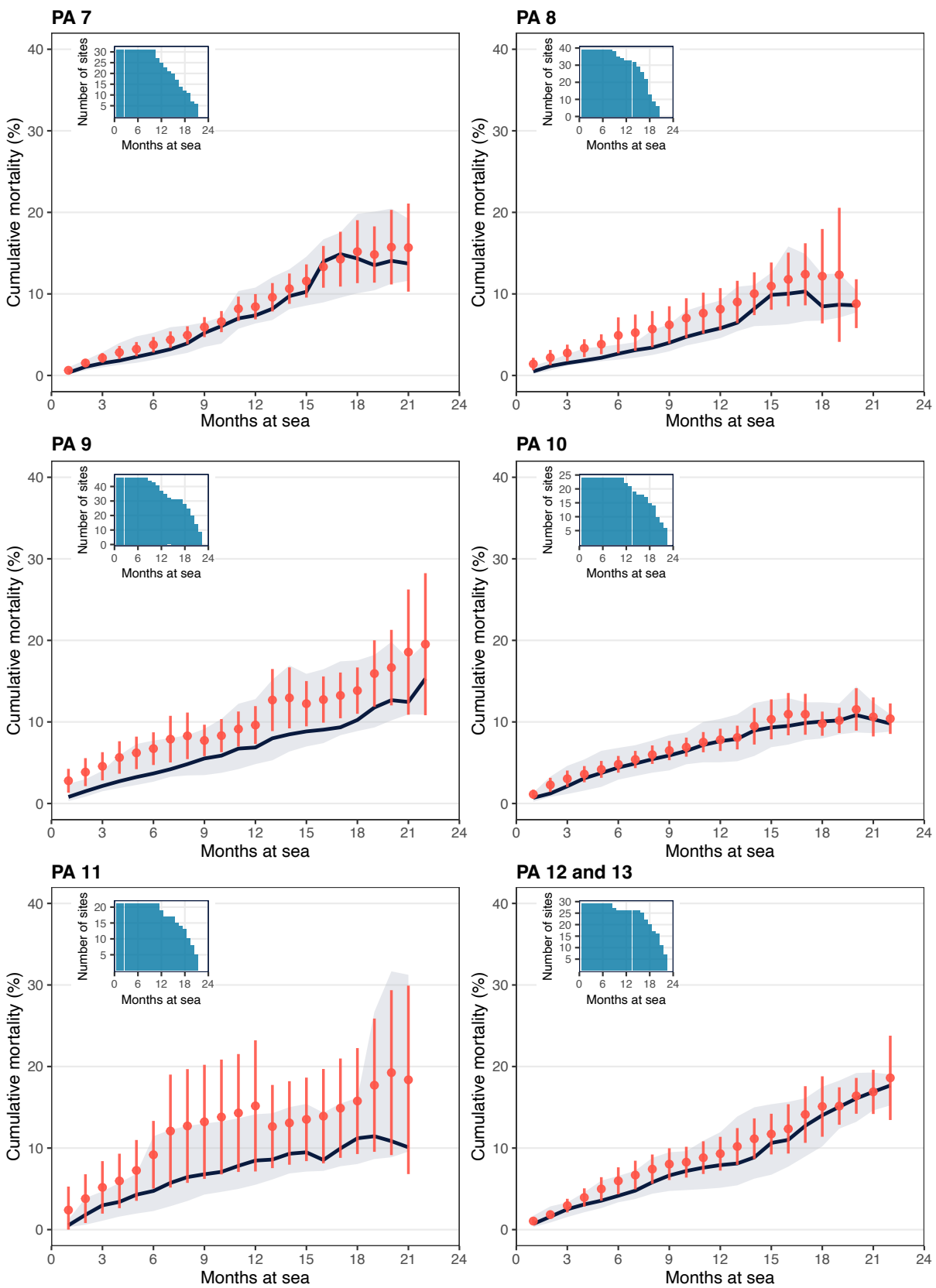
In parallel with the increasing production of cod in recent years, mortality has also increased ([Figure 2.4.5](#)). The monthly mortality risk (median) was consistently below 1% up to May 2024, although some periods showed greater variability ([Figure 2.4.7](#)). Although the number of active cod farms has increased over the past five years, there were nevertheless only 21 active seabased cod sites in 2025, with a monthly average of 14 active sites ([Table 2.1.6](#)). The national average therefore becomes more sensitive to random events and may vary more over years than the national figures for salmonids.

In 2025, the annual cumulative mortality risk was 20.4%, a slight decrease from 22.2% in 2024. Given the expected year-to-year variation when calculations are based on few observations, the mortality level in 2025 can be considered largely comparable to that of the previous year. However, this level is higher than in 2022 and 2023, when annual mortality was approximately 13%.



Fish Health Report 2025, Norwegian Veterinary Institute

Figure 2.4.6 (A) Cumulative mortality risk for production cycles completed in 2025, shown by months at sea for salmon. The subfigures represent Norway, production areas (PA) 1-2 (merged), PA3, PA4, PA5 and PA6. The black solid line shows the median, and the grey shaded area represents the interquartile range (IQR) for the cumulative mortality risk. Mean mortality risk is shown as red dots, with vertical red lines indicating 95% confidence intervals. The inset bar charts show the number of localities contributing data for each month.



Fish Health Report 2025, Norwegian Veterinary Institute

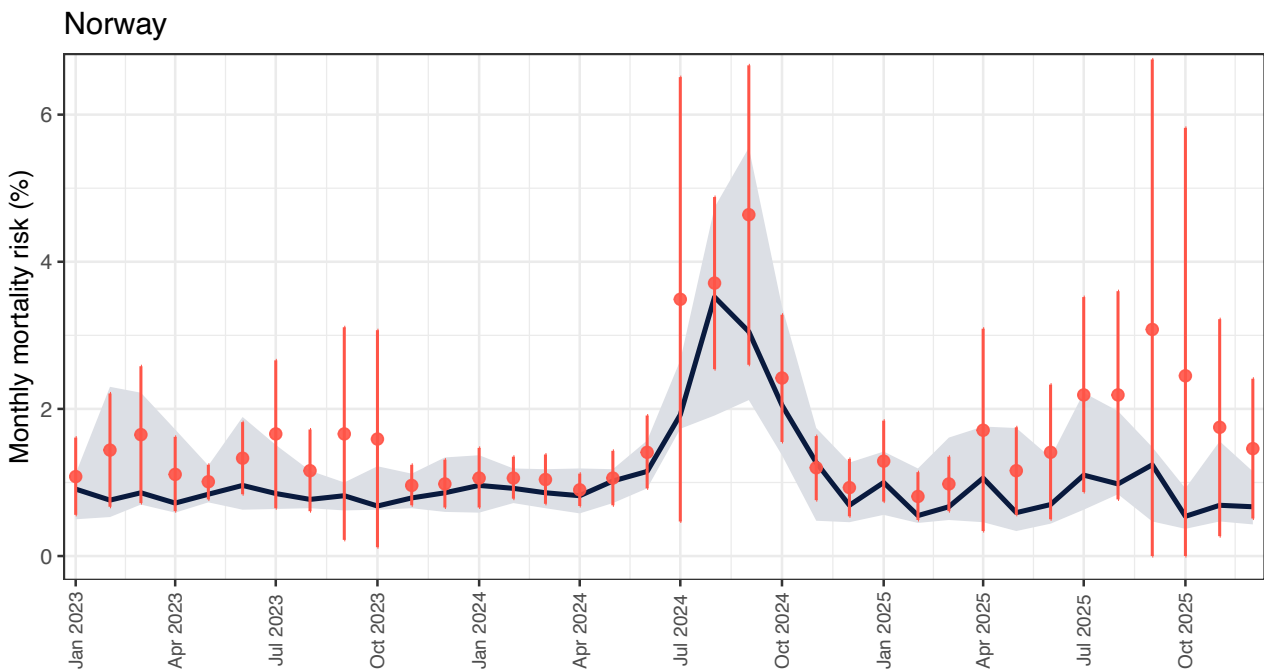
**Figure 2.4.6 (B)** Cumulative mortality risk for production cycles completed in 2025, shown by months at sea for Atlantic salmon. The subfigures represent production areas (PA) 7, PA8, PA9, PA10, PA11 and PA12-13 (merged). The black solid line shows the median, and the grey shaded area represents the interquartile range (IQR) for the cumulative mortality risk. Mean mortality risk is shown as red dots, with vertical red lines indicating 95% confidence intervals. The inset bar charts show the number of localities contributing data for each month.

As in 2024, an increase in mortality during the summer months was also observed in 2025 (Figure 2.4.7). In 2025, this increase was more pronounced in the mean, suggesting that the elevated mortality may have been concentrated at individual sites, as the median and interquartile range (IQR) did not increase to the same extent as the mean. Informa-

tion from fish health personnel indicates that the peaks during this period were associated with a combination of high temperatures, reports of mortality linked to infections with *Vibrio anguillarum*, and complex gill disease caused by multiple agents.

**Table 2.4.5 Annual cumulative mortality risk (%) in Atlantic cod production in Norway (2021-2025).**

	2021	2022	2023	2024	2025
Total number dead at sea (thousands)	484	870	1561	2346	2362
Annual mortality (%)	11.9	13.6	13.3	22.2	20.4



Fish Health Report 2025, Norwegian Veterinary Institute

**Figure 2.4.7 Monthly mortality risk (%) in the period 2023-2025 for Atlantic cod in Norway.** The black solid line shows the median, and the grey shaded area represents the interquartile range (IQR) for mortality risk. Mean mortality risks are shown as red dots, and the vertical red lines indicate 95% confidence intervals for the mean.

## Mortality in cleaner fish

The main cleaner fish species used during the sea phase of salmon farming are lumpfish (*Cyclopterus lumpus*) and various wrasse species. These species have a high mortality risk, mainly due to non-medicinal delousing treatments, handling stress, infectious diseases, fin erosion and emaciation (Appendix E1 and Appendix E2). There are also challenges related to insufficient sorting and loading, stressing cleaner fish prior to medicinal and non-medicinal lice treatments. Health and welfare challenges in cleaner fish are described in more detail in Chapter 14 Health and welfare in cleaner fish.

Unlike salmonids in the sea phase, losses of cleaner fish are not categorized by causes of loss. All fish removed are registered as dead. For example, cleaner fish removed from cages during salmon lice treatments or in connection with harvesting are often registered as dead. In addition, cleaner fish “disappear” from cages for unknown and partly known reasons. Interpretation of loss figures for cleaner fish is therefore difficult, as no distinction is made between cleaner fish that have died because of poor welfare and, for example, cleaner fish that have been physically removed in connection with salmon lice treatment.

From January 2026, data on cleaner fish will be reported using a new reporting form (via a new API or Altinn) developed by the Norwegian Food Safety Authority. The form has been designed to improve data quality for cleaner fish, with more differentiated categories for causes of loss. A distinction will be made between dead fish and fish that have been culled. In addition, the cause of culling will be recorded, as well as fish lost for other reasons and fish that are reused. This will represent a substantial improvement in data quality and will hopefully make it possible to present cleaner fish mortality figures in the coming years.

Table 2.4.6 presents data on the number of dead cleaner fish in Norway during the period 2021–2025. The number of dead cleaner fish at sea decreased from 39 million in 2021 to 12.7 million in 2025. As the number of cleaner fish stocked at sea also declined during this period (from 48 million in 2021 to 18.9 million in 2025), much of the reduction in the number of dead fish likely reflects this decrease in stocking (Table 2.1.2). Due to weaknesses in data quality, it cannot be determined whether this represents a genuine reduction in the proportion of cleaner fish that die.

**Table 2.4.6 Total number of registered dead cleaner fish at sea (millions) in Norway, 2021–2025.**

	2021	2022	2023	2024	2025
<b>Total number of dead at sea (millions)</b>	39.0	31.3	20.0	14.8	12.7

## References

- Bang Jensen B, Qviller L & Toft N (2020). Spatio-temporal variations in mortality during the seawater production phase of Atlantic salmon (*Salmo salar*) in Norway. *Journal of Fish Diseases*, 43, 445–457. doi: 10.1111/jfd.13142
- Oliveira, V.H.S., Dean, K.R., Qviller, L., Kirkeby, C., & Bang Jensen, B. (2021). Factors associated with baseline mortality in Norwegian Atlantic salmon farming. *Scientific Reports*, 11(1), 14702.
- Toft N, Agger JF, Houe H & Bruun J (2004). Measures of disease frequency. In H. Houe, A.K. Ersbøll, & N. Toft (Eds.), *Introduction to Veterinary Epidemiology* (pp. 77–93). Frederiksberg, Denmark: Biofolia.

## 2.5 Cause-specific classification of farmed Atlantic salmon mortality

Hege Løkslett, Victor H.S. Oliveira, Annika Krutto, Katharine Rose Dean og Ingunn Sommerset

**The Norwegian Veterinary Institute has conducted a collaborative project with the Norwegian Seafood Federation (Sjømat Norge) and Aquacloud (NCE Seafood Innovation), with the aim of implementing, reporting, and sharing standardized summaries of causes of mortality at marine salmonid farming sites. A database referred to as the *Fish Health Database* was established, through which companies voluntarily reported daily numbers of dead fish classified according to a standardized set of codes. Data presented in this year's Fish Health Report for the period 2021–2024 have been made available through this collaborative project. In addition, the Norwegian Veterinary Institute has been granted access to data from AquaCloud for 2025.**

The sharing and systematic organization of mortality cause data provide aquaculture producers with an improved foundation for assessing factors that influence fish health, as well as opportunities to facilitate a more coordinated and effective response to shared challenges.

The role of the Norwegian Veterinary Institute in the collaboration has been to support quality assurance and content validation of the reported data, ensuring that the data constitute a reliable information source for descriptive epidemiological analyses related to aquaculture in Norway. With consent from the data administrators (the Norwegian Seafood Federation and AquaCloud) and on behalf of the data

owners (the aquaculture companies), annual summaries can be published in the Fish Health Report. The extent of data sharing is presented first, followed by registered causes of mortality at national and regional levels. There has been a substantial increase in the number of participating companies since the project's inception in 2016. The number of sea sites reporting causes of fish mortality has quadrupled since the start and consists of 408 salmon sea sites in 2025. This represents approximately half of the active aquaculture sea sites (Table 2.5.1).

The classification system was developed by NMBU for the registration and structuring of causes of mortality, but can also be extended to other forms of losses. The system has a hierarchical structure comprising three levels (1–3). Level 1 covers the main categories of causes of mortality, which are subsequently divided into increasingly detailed subcategories (Levels 2 and 3). Level 1 consists of six principal categories: "Infectious diseases (A)", "Environmental conditions (B)", "Injuries (trauma) (C)", "Physiological causes (D)", "Other causes (E)", and "Unknown cause (F)". Level 2, which builds upon the Level 1 categories, comprises 29 distinct categories, while Level 3—the most detailed level—includes 150 underlying cause categories (as of January 2025). Owing to the hierarchical design of the system, new Level 2 and Level 3 categories can be added if needed, for example in response to the emergence of new diseases. It should be noted that Level 3 also includes unspecified categories.

**Table 2.5.1** Number of sea sites that have shared data and the proportion (%) of all sea sites (salmon). Note that historical data are also updated when new companies begin sharing data, and that the proportions therefore represent the current situation rather than the number of participants at earlier points in time.

Year	Number of sea sites	Proportion (%) of sea sites
2021	389	46%
2022	405	48%
2023	397	48%
2024	401	48%
2025	408	49%

Over time, the figures from the database have corresponded well with compiled disease statistics from the Norwegian Veterinary Institute and private laboratories (Chapter 1 Data sources), as well as with the Fish Health Report questionnaire, which is completed by fish health personnel, inspectors and advisors at the Norwegian Food Safety Authority. Increased national coverage through participation by a larger number of companies, together with growing experience and competence in the use of the fish mortality categories, increases the validity of the data. In the following sections, figures calculated from the shared data are presented, based on the quality of the data at the time of reporting. It is important to emphasize the value and potential of such data, both for research and decision support and for producers themselves, particularly in identifying the main causes of loss and mortality so that targeted measures can be implemented in seafood production.

### Distribution of registered dead fish (salmon) at the national level

When national figures are referred to below, this includes all data from salmon sites that have shared data via the *Fish Health Database/AquaCloud*, and not all sites nationwide in Norway. The figures therefore do not represent the true prevalence. When total numbers of dead fish are discussed, this refers to the total number of dead fish recorded in the

*Fish Health Database/AquaCloud*. There may be several explanations for increases or decreases in the proportions across different categories, both related to real changes in the number of dead fish within specific groups and as a result of, for example, changes in registration routines and associated data quality.

As shown in Table 2.5.2, the Level 1 main categories with the highest proportions of dead fish registrations at the national level in 2025 were "Injuries (trauma) (C)" (33.5% of registrations) and "Infectious diseases (A)" (28.1% of registrations). The proportion of deaths registered under "Unknown cause (F)" declined gradually during the period 2021–2024 (21.2% of registrations in 2024), but increased to 27.4% of all registrations in 2025. Nevertheless, this proportion remains substantially lower than in 2021 (43.5%) and can likely be attributed to a calibration period involving training of personnel responsible for registrations at the sites. The proportion of dead fish registered in the category "Environmental conditions (B)" in 2025 has been halved compared with 2024 (from 8.5% of national registrations to 4.3% in 2025). "Physiological causes (D)" remains stable (4.7%), and the proportion of the category "Other causes (E)" has returned to a stable level (2.0%) after increasing somewhat in 2024 (4.8%) compared with previous years.

**Table 2.5.2** The table provides an overview of the proportion of dead fish registrations for salmon within the six main categories (Level 1) per year from 2021 to 2025, as well as for the period as a whole, based on data from the *Fish Health Database/AquaCloud*. \*Note: The figures do not represent the true prevalence of the different categories. The underlying data may change if new companies begin sharing data or if existing companies update historical data, and historical figures may therefore also be subject to change as a result.

Nivå 1	2021*	2022*	2023*	2024*	2025*	2021–2025*
Infectious diseases (A)	22.8%	28.4%	38.4%	33.1%	28.1%	30.6%
Environmental conditions (B)	0.2%	0.4%	2.7%	8.5%	4.3%	3.3%
Injuries (trauma) (C)	24.8%	31.9%	32.7%	26.6%	33.5%	29.9%
Physiological causes (D)	5.7%	4.4%	4.0%	5.8%	4.7%	4.9%
Other causes (E)	3.0%	2.1%	2.3%	4.8%	2.0%	2.8%
Unknown cause (F)	43.5%	32.8%	19.9%	21.2%	27.4%	28.5%
Total	100%	100%	100%	100%	100%	100%

Regardless of main category (Level 1), the three Level 3 causes of death with the highest proportions of dead fish in 2025 were “Unknown cause of death” (15% of all registrations), “Handling injury (unspecified)” (13% of all registrations), and “Nonmedicinal treatment (unspecified)” (11% of all registrations). “Winter ulcer caused by *M. viscosa*” was among the top three in 2024, accounting for 13% of all registrations, but in 2025 this proportion decreased to approximately 4% of all registrations.

When the fiveyear period 2021–2025 is considered as a whole (Table 2.5.2), three conditions within “Infectious diseases (A)” (approximately 31% of all registrations during the fiveyear period) stand out: winter ulcer caused by *M. viscosa* (8% of all registrations during the period), winter ulcer caused by unspecified bacteria (approximately 5% of all registrations during the period), and cardiomyopathy syndrome (CMS) (approximately 4% of all registrations during the period). “Environmental conditions (B)” accounted for approximately 3% of all registrations during the period 2021–2025, with jellyfish being the subcategory with the highest proportion of dead fish registrations. “Injuries (trauma) (C)” accounted for approximately 30% of all registrations during the same period, where “Handling injury (unspecified)” and “Nonmedicinal treatment (unspecified)” were the subcategories with the highest proportions of registrations (approximately 14% and approximately 9% of all registrations during the period, respectively). “Physiological causes (D)” accounted for approximately 5% of all registrations during the fiveyear period, with “Physiological maladaptation (unspecified)” having the highest number of registrations (approximately 2% of all registrations during the period). “Other causes (E)” accounted for approximately 3% of all registrations during the same period, with the majority of registrations recorded under “Other cause, unspecified”. “Unknown cause (F)” accounted for approximately 29% of all registrations during the period 2021–2025.

For 2025, the three subcategories with the highest proportions of registrations within “Infectious diseases (A)” were heart and skeletal muscle inflammation (HSMI), cardiomyopathy syndrome (CMS), and winter ulcer caused by *M. viscosa*. In 2025, there was an increase in the number of registrations for HSMI and CMS compared with 2021–2024. HSMI remained at a stable level during the four preceding years (approximately 6–10% of registrations within category A “Infectious diseases”), but in 2025 showed a marked

increase to 19% of dead fish registrations within category A and thus became the infectious disease category with the highest number of registrations. This is consistent with compiled data from the Norwegian Veterinary Institute and private laboratories, where HSMI in salmon was diagnosed at 167 sites in 2025, compared with 115 sites in 2024 (but lower than in 2023, with 184 sites) (Chapter 7.4 Heart and skeletal muscle inflammation in salmon (HSMI) and HSMIlike disease in rainbow trout).

For CMS, the proportion of dead fish registered in this category was halved in 2024 compared with the previous year (from approximately 13–16% to approximately 8% of dead fish among infectious diseases). In 2025, an increase was observed, returning to levels comparable with earlier years (16% of registrations among infectious diseases). This is consistent with compiled data from the Norwegian Veterinary Institute and private laboratories, where a CMS diagnosis was recorded at 114 sites in 2025 compared with 78 sites in 2024 (10.1.2 Cardiomyopathy syndrome (CMS) – cardiac rupture). In the annual survey, HSMI and CMS moved from being ranked as the eighth and ninth most important health challenges in salmon in 2024, respectively, to the third and fifth most important health challenges in 2025. This is also the first year in which HSMI was assessed as the viral disease of greatest importance for mortality in the annual survey.

Since 2021, there has been a gradual increase in the proportion of dead fish registrations attributable to winter ulcer caused by *M. viscosa*, with a peak in 2024 (approximately 39% of all registrations among infectious diseases). In 2025, however, a marked reduction was observed in the proportion of registrations within this category, accounting for approximately 14% of registrations among infectious diseases. A similar reduction was also observed in the proportion of registrations attributed to winter ulcer caused by unspecified bacteria (from 19% of registrations among infectious diseases in 2024 to 15% in 2025), and the reduction can therefore not be explained by increased registrations within the unspecified category. Although not known with certainty, such a reduction may be linked to the increased use of a new vaccine against *M. viscosa* (Chapter 4.3 Vaccination and measures to reduce transmission). Compiled figures from the Norwegian Veterinary Institute and private laboratories show a moderate decline in the number of diagnoses of classical winter ulcer since 2024 (Chapter 7.4

Winter ulcer), and in the survey, infection with *M. viscosa* is ranked as the fifth most important cause of mortality in 2025, compared with third place in 2024.

Among other bacterial diseases, pasteurellosis has shown a gradual decline in the number of dead fish registrations since 2022 and accounted for only approximately 3% of dead fish registrations among infectious diseases in 2025.

With respect to “Environmental conditions (B)”, which accounted for approximately 4% of all dead fish registrations in 2025, the proportion was halved compared with 2024 (approximately 9% of all dead fish registrations in 2024). Jellyfish were the main contributing factor, accounting for approximately 75% of the dead fish within this category in 2024. Dead fish registrations attributable to jellyfish amounted to just over 1% of the registrations within “Environmental conditions” in 2025. In contrast, there was an increase in the proportion of dead fish registrations attributable to algal intoxication, which accounted for approximately 65% of the registrations within the “Environmental conditions” category in 2025. For comparison, the proportion of dead fish registrations due to algal intoxication was below 1% of registrations in the “Environmental conditions” category during the period 2021–2024. This corresponds well with reports of extensive mortality caused by algal blooms in spring 2025 in Nordland and Troms (Chapter 11.6 Algae and fish health), as well as with feedback from the survey, in which algae shifted from being ranked as the fifteenth most important health challenge in salmon in 2024 to the seventh most important in 2025. Similarly, jellyfish were ranked considerably lower in the survey in 2025 as a cause of fish mortality and reduced welfare compared with 2024, when jellyfish were ranked as the third most important health challenge in market-size fish. A reduction was also observed in the proportion of registrations under “Natural environmental impact (unspecified)” (from approximately 12% in 2024 to approximately 2% in 2025).

The category “Injuries (trauma) (C)” accounted for the largest proportion of registrations in 2025, with approximately 34% of all dead fish registrations that year. Within this category, as in previous years, dead fish associated with “Handling (unspecified)” and “Nonmedicinal treatment (unspecified)” comprised the largest proportions of registrations, accounting for approximately 38% and 34%, respectively, of the registrations within “Injuries (trauma) (C)”.

Among “Physiological causes (D)” (approximately 5% of all registrations in 2025), “Smoltification (unspecified)” accounted for the largest proportion of registrations, representing approximately 38% of the dead fish registrations within this category. This represents an increase compared with 2021 (approximately 12% of dead fish registrations within this category), but is at a level comparable to that observed during 2022–2024. The second most frequent dead fish registration within “Physiological causes” was “Physiological maladaptation (unspecified)”, which accounted for approximately 36% of dead fish registrations among physiological causes.

For “Other causes (E)”, the subcategory “Other cause (unspecified)” was by far the most frequently registered, accounting for approximately 97% of registrations within category E.

For “Unknown cause (F)”, which accounted for approximately 27% of all dead fish registrations in 2025 (an increase from 21.2% in 2024), the subcategory “Unknown cause of death” accounted for approximately 55% of registrations, followed by “Runts/failure to thrive with unknown cause” and “Complex gill disease with unknown cause”, accounting for approximately 21% and approximately 20% of registrations within “Unknown cause (F)”, respectively. The latter category, “Complex gill disease with unknown cause”, shows an increase in the proportion of registrations within this main category compared with previous years (accounting for 3–14% of registrations within “Unknown cause” during the period 2021–2024).

### Distribution of registrations of dead fish (salmon) within groups of production areas

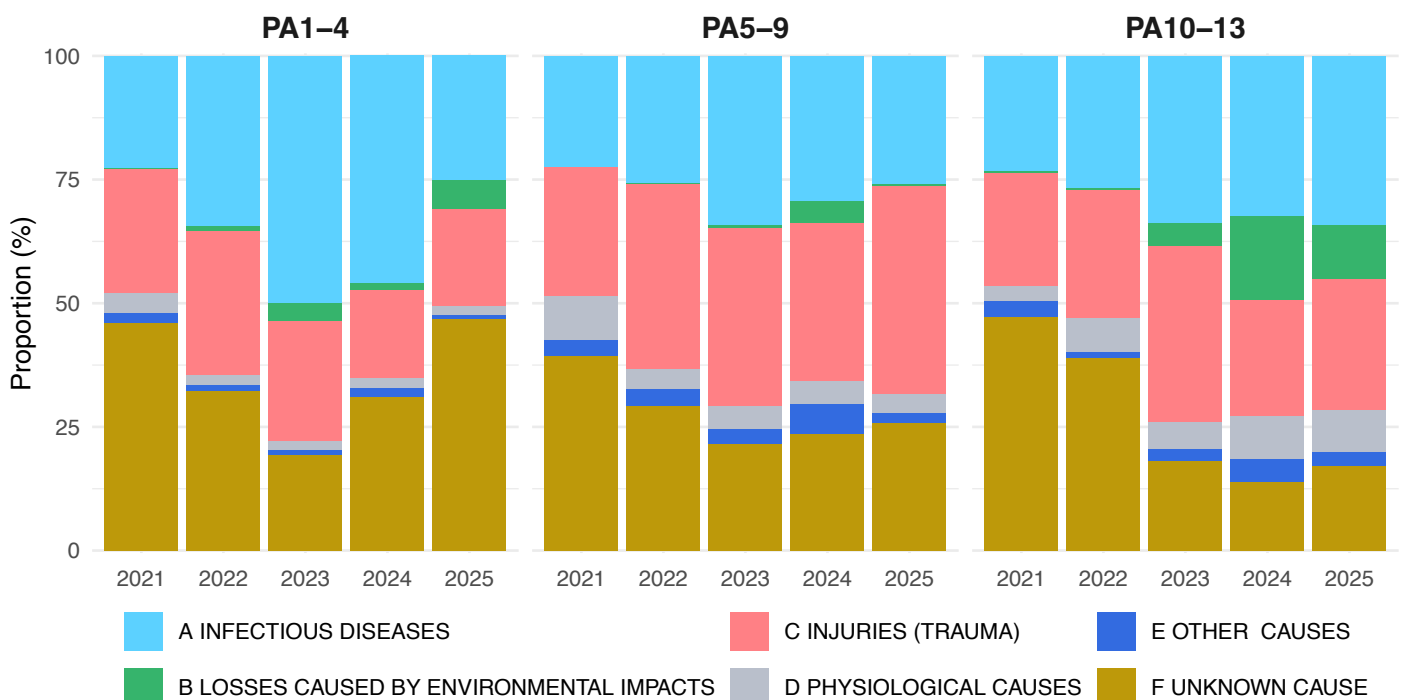
Figure 2.5.1 illustrates the distribution of registered causes of death at Level 1, stratified by three groups of production areas, PO1–PO4, PO5–PO9, and PO10–PO13, for the period 2021–2025. In the following, registered dead fish categories within each of the three production area groups are presented.

#### Production areas 1–4

The majority of dead fish registrations in PO1–PO4 in 2025 were recorded under “Unknown cause (F)” (accounting for approximately 47% of all dead fish in this area) (Figure 2.5.1). Within this category, the subcategory “Unknown cause of death” accounted for the largest proportion of registrations

(approximately 43% of registrations within this category), followed by “Complex gill disease with unknown cause” (approximately 30% of registrations within this main category). “Infectious diseases (A)” accounted for the second largest proportion of registrations in PO1-PO4 in 2025, with approximately 25% of all registrations. This represents approximately a halving compared with 2023 and 2024. “Winter ulcer caused by *M. viscosa*” and “ulcers caused by unspecified bacteria” accounted for approximately half of the dead fish registrations (approximately 24% and approximately 25%, respectively, of the dead fish within this main category) in 2024, whereas in 2025 winter ulcer caused by *M. viscosa* accounted for approximately 3% and winter ulcer caused by unspecified bacteria for approximately 19% of the dead fish registrations in this area. In 2025, CMS was the subcategory with the highest number of registrations among infectious diseases in this area, accounting for approximately 32% of the registrations. This represents an increase compared with 2021-2024, when CMS accounted for approximately 14-20% of the registrations among infectious diseases.

A similar increase was observed in the proportion of dead fish registrations attributed to HSML (approximately 13% of registrations among infectious diseases in 2025 compared with approximately 3% in 2024). The proportion of dead fish registrations attributed to PD has returned to 2021-2022 levels (approximately 14% of registrations) after having been lower during the two preceding years. This does not fully correspond with the reported occurrence of PD during the same period, as the number of PD cases was halved in 2025 compared with 2021 (Chapter 7.1 Pancreas disease (PD)). Bacterial gill disease as a cause of death showed an almost halving in the proportion of registrations among infectious diseases compared with 2024, which itself represented a halving from 2023 (from approximately 29% in 2023 to 16% in 2024 and further down to approximately 9% in 2025). It is possible that some of the observed decline in registrations of bacterial gill disease has been reclassified under complex gill disease, which has increased, although this cannot be confirmed. Dead fish registrations attributed to pasteurellosis remain at a level similar to that observed



Fish Health Report 2025, Norwegian Veterinary Institute

**Figure 2.5.1** Proportion of causes of death registered in the Fish Health Database/AquaCloud for salmon, distributed by main categories A-F (Level 1) for the period 2021-2025, stratified by three groups of production areas: PA1-PA4, PA5-PA9, and PA10-PA13. These are registrations reported by companies that have shared data and do not necessarily reflect the true prevalence at the national level. The data basis will change if the number of participating companies’ changes, and historical data may therefore also be subject to change as a result.

in 2024 (approximately 4% of registrations among infectious diseases).

The proportion of registrations under “Environmental conditions (B)” has increased compared with 2021–2024 (from approximately 1–3% of registrations to approximately 6% of all registrations). The majority of registrations within “Environmental conditions (B)” in 2025 fall under the category “Extreme currents”, which accounted for approximately 73% of registrations, followed by “Nephrocalcinosis”, accounting for approximately 15% of registrations. As shown in [Table 2.5.2](#), there is a notable increase in the proportion of registrations under “Environmental conditions (B)” during the period January–April, during which “Extreme currents” accounted for nearly 95% of registrations within this main category. Periods of very rough weather occurred along the west coast at the beginning of 2025, which may represent a contributing cause of mortality within this category. In contrast to the northern parts of the country, algal intoxication does not appear to have played a central role as a cause of dead fish registrations in this area in 2025, accounting for only just under 1% of registrations within the “Environmental conditions” category.

The proportion of registrations under “Injuries (trauma) (C)” is at a level comparable to that observed in 2024 (approximately 19% of registrations) and is thus lower than during 2021–2023, when the proportion ranged between 25% and 29%. The majority of registrations fall under “Handling injury (unspecified)”, accounting for approximately 41% of registrations within category C, followed by “Thermolicer” (approximately 22% within category C) and “Injury, unspecified/unknown cause” (approximately 17% within category C).

“Physiological causes (D)” and “Other causes (E)” remained stable at approximately 1–2% of all registrations in PO1–PO4.

## Production areas 5–9

The categories “Infectious diseases (A)” and “Injuries (trauma) (C)” accounted for approximately 70% of all dead fish registrations in PO5–PO9 in 2025, with approximately 26% and 42% of the dead fish, respectively ([Figure 2.5.1](#)). The proportion of registrations under “Infectious diseases (A)” has remained relatively stable since 2021, while the proportion of registrations under “Injuries (trauma) (C)” has

gradually increased (from approximately 26% of all registrations in 2021).

The majority of registrations within “Injuries (trauma) (C)” fall under “Nonmedicinal treatment (unspecified)”, accounting for approximately 41% of registrations within this main category, followed by “Handling injury (unspecified)” with approximately 30% of registrations among “Injuries (trauma) (C)”.

Within “Infectious diseases (A)”, the highest proportion of registrations was attributed to HSMI, where the proportion doubled compared with levels observed during 2021–2024 (from 8–13% in 2021–2024 to approximately 23% of registrations among infectious diseases in 2025). The proportion of registrations for CMS is similar to that observed in the previous year (approximately 11%). As for PO1–PO4, a reduction is observed in the proportion of dead fish registrations attributable to winter ulcer caused by *M. viscosa* (from approximately 30% of registrations within this main category in 2023 and 2024 to approximately 21% in 2025). A reduction is also observed in the proportion of registrations within “Winter ulcer, unspecified bacteria”, from approximately 23% in 2024 to approximately 13% in 2025. The proportion of registrations for mouth/head ulcers caused by *Tenacibaculum* spp. increased slightly from approximately 10% in 2024 to 12% in 2025. The proportion of registrations under “Pasteurellosis” appears to be gradually increasing, from no registrations in 2021 to accounting for approximately 5% of registrations among infectious diseases in 2025 in this area. This corresponds with compiled data from the Norwegian Veterinary Institute and private laboratories over the same period, where the occurrence of pasteurellosis appears to be expanding northwards ([Chapter 8.5 Pasteurellosis](#)). The proportion of registrations under “Infectious pancreatic necrosis (IPN)” is approximately 4% of infectious diseases in 2025 and represents an increase compared with previous years.

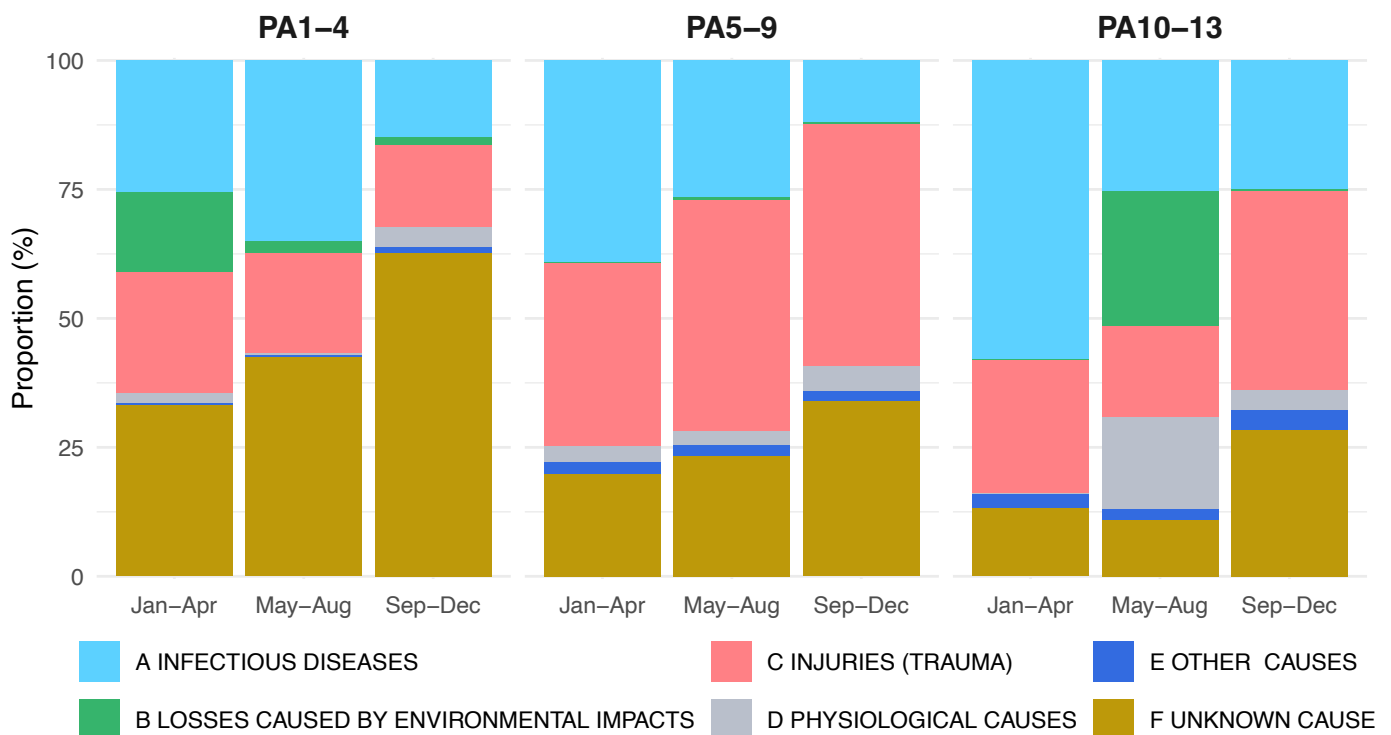
An increase in the proportion of dead fish registered under “Environmental conditions (B)” was observed in 2024 compared with 2021–2023 (accounting for just under 5% of all dead fish in this area in 2024). However, the proportion declined again in 2025 and represents less than 0.5% of all dead fish registrations in PO5–PO9.

The proportion of dead fish attributable to “Physiological causes (D)” has remained stable at around 4% over the past three years, with the majority of registrations under “Physiological maladaptation (unspecified)” and “Sexual maturation”. The proportion of registrations under “Other causes (E)” decreased from approximately 6% of all registrations in PO5-PO9 in 2024 to approximately 2% in 2025. “Unknown cause (F)” accounted for approximately 26% of all registrations in this area, with “Unknown cause of death” as the subcategory with the highest proportion of registrations within category F (approximately 65%).

### Production areas 10-13

In PO10-PO13, the largest proportion of dead fish registrations fell within the category “Infectious diseases (A)”, followed by “Injuries (trauma) (C)”, accounting for approximately 34% and approximately 27% of all dead fish registrations in this area in 2025, respectively (Figure 2.5.1).

Within infectious diseases, a shift is observed compared with previous years, where “Bacterial disease (unspecified)” increased from representing less than 1% of registrations within this main category to becoming the subcategory with the highest proportion of registrations among infectious diseases in 2025 in this area, accounting for approximately 20% of registrations. The period from January to April is when the proportion of dead fish registrations within “Infectious diseases (A)” is highest in this area (accounting for approximately 58% of registrations during this period), and among these, “Bacterial disease (unspecified)” accounts for the largest proportion of dead fish registrations (approximately 17% of registrations) (Figure 2.5.2). Furthermore, the proportion of registrations under CMS increased markedly from less than 1% during the three preceding years to accounting for approximately 16% of registrations among infectious diseases in 2025. Also in this area, an increase was observed in the proportion of registrations for HSML as



Fish Health Report 2025, Norwegian Veterinary Institute

**Figure 2.5.2** Proportion of causes of death recorded in the “Fiskehelsedatabasen”/AquaCloud for Atlantic salmon, categorized by main category A-F (level 1) for the first to third tertials of 2025, stratified into three groups of production areas: PA1-PA4, PA5-PA9, and PA10-PA13. These records are based on data reported by companies that share data and do not reflect the true prevalence at the national level. The underlying data will change if the number of participating companies’ changes, and historical data may therefore also change as a result

a cause of death (from approximately 11% of registrations among infectious diseases in 2024 to 16% in 2025). The proportion of registrations for winter ulcer caused by *M. viscosa* is markedly reduced (from approximately 57% of registrations among infectious diseases in 2024 to only approximately 9% in 2025). By contrast, the proportion of registrations for winter ulcer caused by unspecified bacteria increased (from approximately 9% in 2024 to approximately 17% of registrations among infectious diseases in 2025).

Within "Injuries (trauma) (C)", as in PO5-PO9, "Handling injury (unspecified)" as well as injuries associated with "Nonmedicinal treatment (unspecified)" were the causes of death with the highest proportions of registrations within this main category, with the former accounting for approximately 60% of registrations among injuries and the latter for approximately 25%. There have been challenges associated with increased sealice occurrence in the northern parts of the country since 2024. However, this does not appear to have resulted in an increased proportion of dead fish in the category "Handling injury". By contrast, the proportion of dead fish associated with "Nonmedicinal treatment (unspecified)" has increased compared with 2021-2023. The proportion of registrations under "Thermolicer" has also increased, from less than 1% of registrations within "Injuries (trauma)" during 2021-2024 to approximately 5% of registrations in 2025.

"Environmental conditions (B)" accounted for approximately 11% of dead fish registrations in PA10-PA13 in 2025, repre-

senting a reduction compared with 2024, when this category accounted for 17% of all dead fish registrations due to major challenges related to jellyfish. Mortality attributable to algal intoxication accounted for 94% of registrations within this category in 2025, with the majority of registrations occurring during the period May-August (Figure 2.5.2). It is well established that algae caused challenges particularly in the northern parts of the country in 2025. Jellyfish, by contrast, do not appear to have posed a significant challenge in 2025 (accounting for less than 1% of registrations within "Environmental conditions").

Approximately 9% of all registrations in this area fell under "Physiological causes (D)", with "Smoltification (unspecified)" as the most important contributing factor, with the majority of registrations occurring during the period May-August (Figure 2.5.2). "Other causes (E)" accounted for approximately 3% of all registrations in PO10-PO13, with all registrations recorded under the subcategory "Other cause, unspecified". "Unknown cause (F)" accounted for approximately 17% of registrations in this area.

## References

- Aunsmo, A., Persson, D., Stormoen, M., Romstad, S., Jamtøy, O., & Midtlyng, P. J. (2023). Real-time monitoring of cause-specific mortality and losses in industrial salmon farming. *Aquaculture*, 563, 738969, 1-10. <https://doi.org/10.1016/j.aquaculture.2022.738969>

# 3 Fish Health Economics

By Cecilie Sviland Walde and Bård Misund

**Animal health economics concerns how companies and society, under limited resources, can make decisions to ensure good animal health. Health economic analyses can provide important information on how companies and society can prioritise resources and make informed economic decisions to ensure good animal health in line with societal needs.**

Economics is the study of the production, consumption, and distribution of goods and services, as well as the management of resources, viewed both from a societal perspective (macroeconomics) and from the individual firm's perspective (business economics). Animal health refers to the animal's physiological, behavioural, and mental state and is a central component of animal welfare (Chapter 6 Fish Welfare). Maintaining good animal health involves preventing and treating disease, ensuring adequate nutrition and appropriate living conditions, as well as managing other factors that may affect animal welfare.

## 3.1 Economic consequences of fish disease

The economic consequences of disease can be substantial. Disease naturally has negative consequences for the fish itself through reduced health and, in the worst case, mortality. For fish farmers, disease leads to economic losses through reduced growth, increased mortality, and downgraded slaughter quality, and expenditures related to disease prevention and control. More broadly, fish diseases affect production, consumption, and resource management by reducing production efficiency, lowering food output, and leading to poorer resource utilisation. In addition, disease may generate indirect costs through reduced market demand, trade restrictions, and negative impacts on the environment and wild fish populations. Therefore, in its broadest sense (i.e. from a socio-economic perspective), animal health economics concerns not only farm-level profitability and production costs, but also the broader impacts of poor animal health on society as a whole.

There are several examples of infectious diseases with severe animal welfare consequences that have led to substantial economic losses for both producers and society. During the 1970s, 1980s, and 1990s, infectious bacterial diseases such as vibriosis, cold-water vibriosis, and furunculosis

caused high mortality rates and necessitated extensive use of antibiotics. Mortality levels during certain periods, particularly in the early 1990s, were considerably higher than those observed today. Over time, the development and implementation of effective vaccines against these diseases substantially improved fish health and reduced the direct economic costs associated with these diseases.

Nevertheless, the indirect cost associated with extensive antibiotic use persisted for several decades after antibiotic use had been drastically reduced, particularly through negative reputational effects. Another major disease challenge has been pancreas disease (PD), a viral disease first detected in Norway in the late 1980s. PD has affected the Norwegian aquaculture for several decades and has caused large economic losses. For many years, the annual number of outbreaks was relatively low and limited to Hordaland, before the disease gradually began to spread both northwards and southwards. In 2010, a new viral variant (SAV2) was introduced into Central Norway, where it subsequently became established.

The economic consequences of PD have been substantial. In 2013, a PD outbreak was estimated to cost approximately NOK 55.4 million, corresponding to around NOK 80 million in 2025 prices. During the period 2014-2020, between 140 and 170 new PD cases were reported annually, corresponding to estimated industry-wide losses of NOK 10-12 billion per year. Today, only production area (PA) 1 and the areas from PA7 and northwards are free of PD, although some detections have also occurred further north, most recently in PA8 in the autumn of 2023.

Some of the most striking examples of disease causing severe economic consequences are outbreaks of the viral disease infectious salmon anaemia (ISA) in Chile during 2007-2009 and in the Faroe Islands during 2003-2006. In both countries, ISA led to a near-collapse of the aquaculture industry. In Chile, production fell by 64% from 2008 to 2010, while the number of salmon stocked to sea was reduced by 80% between 2007 and 2009. The combined direct and indirect production losses resulted in a prolonged economic crisis that affected individuals, local communities, and the supply industry. According to the Chilean salmon industry, losses amounted to approximately USD 2 billion in 2010,

and 40% of workers lost their jobs. In the Faroe Islands, production declined by nearly 75% between 2003 and 2006 following the ISA crisis. It took approximately 10 years before production returned to the 2003 level.

### 3.2 Disease costs

The probability of an epidemic caused by a serious infectious disease may be perceived as low, and measures to prevent disease outbreaks can be very costly. However, the risk of extreme events is often underestimated. Furthermore, experience from Norway and other countries shows that epidemics of infectious fish diseases can have major consequences for fish health and welfare, with significant economic repercussions for both producers and society. If a disease becomes established, the long-term consequences may be even more substantial.

It is therefore important that risk assessments are grounded in sound scientific evidence and that health economic analyses are supported by robust epidemiological studies. Such analyses can help quantify the economic consequences of both epidemic outbreaks and endemic disease situations, thereby enabling these costs to be weighed against investments in various biosecurity measures and preparedness. Economic decision theory may further support rational decision-making among producers, regulators, and policy-makers by providing a framework for evaluating trade-offs under uncertainty. This, however, requires decision-makers to have access to reliable estimates of disease-related costs.

Despite the importance of such information, knowledge regarding the economic burden of different diseases in farmed salmon in Norway remains limited. Although individual studies exist that estimate the costs of notifiable diseases such as PD, ISA, and sea lice infestation, both in Norway and internationally, there is limited knowledge concerning the economic impacts of many other diseases, particularly non-notifiable ones. This makes it challenging to rank diseases according to their economic importance and, consequently to prioritise preventive and control measures effectively.

A further challenge is that individual studies are often not directly comparable. Differences in methodological approaches, cost definitions, and analytical perspectives mean that estimates cannot easily be aggregated to calcu-

late total disease costs or combined within broader analyses without risking inconsistencies or double counting.

Through the “Global Burden of Animal Diseases” (GBADs) initiative, the World Organisation for Animal Health (WOAH) has developed a standardised framework for estimating the total burden of animal diseases (<https://animalhealthmetrics.org/gbads-technical-guide/>). The framework is closely related to methods used to estimate the global burden of disease in humans and has gained increasing acceptance over time. The goal is to adapt and implement this framework to estimate the burden of disease in Norwegian aquaculture. Achieving this requires extensive information on a range of factors, including produced biomass, species, production systems, as well as disease prevalence and impacts. Much of this information is already collected as part of the preparation of the Fish Health Report. In addition, detailed economic data are required, including prices, costs, and expenditures related to prevention and treatment, such as the purchase of vaccines and medicines, as well as investments in equipment such as delousing systems.

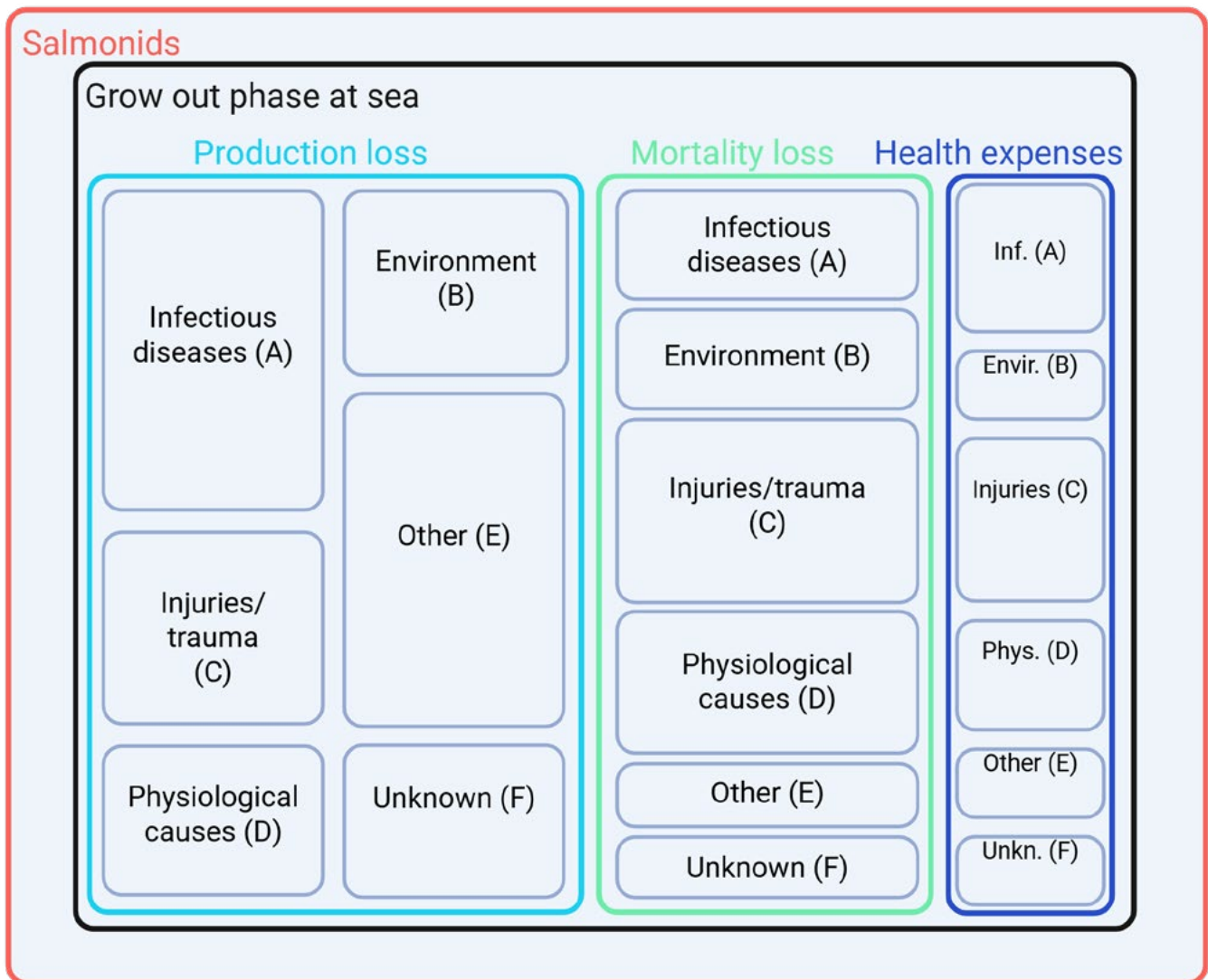
Within the GBADs framework, the total economic burden of disease is initially estimated through a so-called cost envelope approach. This is calculated by determining actual production costs and comparing them with production costs in a “utopian” production system where fish have perfect health. Costs include both direct losses (mortality, reduced growth, and slaughter quality) as well as expenditures related to disease prevention and treatment. In practice, a disease-free state is nearly impossible to achieve, but it nevertheless represents a relevant baseline if the objective is to assign a value to the total disease burden. In aquaculture, one approach to selecting a baseline is to use the economic feed conversion ratio as an indicator to capture the effects of disease on growth and mortality. This method is not perfect and will involve measurement errors, for example by capturing factors not caused by poor fish welfare, such as feed wastage and effects of changes in feed composition.

Once the total cost of disease has been estimated, this cost envelope can be distributed across individual diseases to illustrate how much of the total disease burden is attributable to different conditions. [Figure 3.2.1](#) illustrates the framework for total disease and health-related costs in salmonid

farming (red frame), and how this can further be distributed across different production forms (black frame) and different causes of impaired health and death (Chapter 2 Mortality in Aquaculture). For producers, regulators, and other stakeholders, such analyses provide an important basis for prioritisation and decision-making.

There are several challenges associated with allocating total costs to individual diseases. When the disease profile is complex, such as in cases where two or more diseases

occur simultaneously (comorbidity), it can be difficult to isolate the negative health effects—such as mortality, reduced growth, increased disease susceptibility, and impaired harvest quality—caused by a single disease, as well as its economic impact. For example, fish may undergo a stressful delousing procedure and subsequently die. Examinations may reveal that both cardiomyopathy syndrome (CMS) and gill disease are detected, followed shortly by the development of skin lesions. Determining how each of these factors independently affects mortality, growth, and harvest quality



**Figure 3.2.1** The total cost envelope, or burden, of disease and health related problems in farmed salmonids (red frame) can be allocated across the different life stages, such as the seawater grow out phase (black frame). The total cost comprises production losses, mortality losses, and health related expenditures. These cost components can be further allocated to the different causes of impaired health and mortality, A-F (mortality category level 1). The cost attributable to each individual disease can then be estimated within the individual categories.

requires standardised methods for categorising causes of mortality and robust epidemiological studies.

Such studies are often highly data-intensive and require traceability of fish cohorts. At present, such data are neither publicly available nor easily accessible. In many cases, only individual companies possess the relevant data and knowledge for their own facilities. Publicly available data are largely limited to sea lice counts, delousing treatments, and certain notifiable diseases such as PD and ISA. Ongoing initiatives involving systematic health recording in aquaculture, the development of standardised coding systems for classifying causes of mortality, as well as monitoring and reporting of a broader range of non-notifiable diseases are therefore valuable for estimating the economic burden of disease in Norwegian aquaculture and for prioritising research and control measures.

Preliminary estimates of disease costs per kilogram for Norwegian salmon and trout production are presented in [Table 3.2.1](#). The methodology used to calculate these

figures is described in the NORCE report 41/2022 *Cost Development in Salmon and Trout Farming: What Does Biological Risk Cost?* Since the early 1980s, the Norwegian Directorate of Fisheries' Profitability Survey for salmon and rainbow trout has collected accounting and production data from aquaculture companies. This survey provides a strong indication of levels and changes in production costs. Since 2015, the overview has also included the category "health costs" ([Table 3.2.2](#)), although this category is incomplete. Reported health costs (part of the item "other operating costs") have generally increased since 2015, but the reasons for the increase are not specified, nor is it clear which costs are included under "health costs". There is reason to believe that this category includes direct health-related costs such as expenditure on preventive measures (vaccines) and treatment costs (medicines and delousing equipment), whereas the biological costs associated with mortality, reduced growth, poor feed utilisation (higher feed conversion ratio), and reduced slaughter quality are not captured.

**Table 3.2.1** Estimated production costs related to fish health costs, 2024 (NOK/kg whole fish weight). Source: The Norwegian Directorate of Fisheries' Profitability Survey for salmon and rainbow trout and own calculations (see NORCE Report 41/2022 *Cost development in salmon and trout farming: What does biological risk cost?*).

Cost element	Typical cost presentation (NOK/kg whole weight)	Cost presentation according to the GBADs framework (NOK/kg whole weight)
Smolt	8.40	6.46
Feed	25.67	19.75
Wages	3.72	2.86
Depreciation	0.79	0.61
Other operating costs	16.83	12.95
Slaughtering and transport	4.67	4.67
Capital cost	7.15	5.50
Direct fish health costs	3.65	2.81
Indirect fish health costs ("biological costs")	0	15.28

**Table 3.2.2** Reported health costs. Source: The Norwegian Directorate of Fisheries' Profitability Survey for salmon and rainbow trout.

Year	Reported health costs (NOK/kg, nominal)	Estimated total direct health costs (NOK billion, nominal)
2015	1.83	2.68
2016	2.02	3.25
2017	2.25	3.25
2018	1.59	2.22
2019	2.21	3.14
2020	2.61	3.92
2021	2.49	3.97
2022	2.66	4.39
2023	3.44	5.45
2024	3.65	6.71

### 3.3 Costs and benefits of different biosecurity measures

Cost-benefit analyses can provide important support when choosing measures to eradicate, limit, or prevent disease. A range of biosecurity measures exist to prevent the introduction and limit the spread of infection. One of the most far-reaching measures is compulsory culling (stamping out) following the detection of infectious salmon anaemia (ISA) and pancreas disease (PD) in areas previously declared free of the latter. At the farm, production area, and national levels, several factors influence both the costs and benefits of depopulation as a strategy. These include, among other things, the consequences for fish health, the stage of the production cycle at which the disease outbreak occurs, the effectiveness of depopulation in preventing new outbreaks, the market price of salmon, and so forth. All of these factors involve some degree of uncertainty. Consequently, the implications of depopulation for farms and for the production area as a whole are complex. The cost of taking no action must therefore be compared with the cost of taking action. In addition, the alternatives being compared may differ between production sites and may change over time.

For an individual farm, the short-term economic consequences of depopulation can be very high, depending on how far along the fish are in the production cycle at the time of depopulation. In a cost-benefit assessment of depopulation as a measure to control PD (introduction of SAV2) in production area PO8, preliminary estimates for the area as a whole indicated an expected value of NOK 521 million compared with taking no action. This value is adjusted for the expected cost of depopulating within one month after detection of PD infection. The benefit of this measure declines the longer producers wait before depopulating. If producers wait more than three months before depopulating PD-infected fish, the short-term costs will exceed the short-term benefits. If producers wait as long as six months before depopulation, preliminary estimates indicate that the expected cost for the area is approximately NOK 1.2 billion. The reason for this is an increased risk of transmission to neighbouring sites, resulting in more farms having to depopulate before reaching planned slaughter weight. These are sites that, in principle, could have continued production without disease.

The estimates above apply only in the short term (over a single seaproduction generation) and only to a single production area in a nonendemic region. The benefit of controlling PD through rapid depopulation in nonendemic areas is therefore likely to be much greater in the long term, particularly if several or all nonendemic production areas are included in the analysis. This example illustrates that there is an economic gain at the area level when infected farms depopulate as quickly as possible. At the same time, from the perspective of the infected farm alone, there may be a short-term economic incentive to delay culling, depending on the size of the fish. Such situations are referred to as collective action dilemmas. In this case, a small number of actors bear a substantial cost in order to reduce the collective risk of disease transmission. These situations may be perceived as unfair if losses are not compensated. Collective action dilemmas therefore create challenges both for companies and for authorities when implementing costly measures to prevent disease spread, partly because they require binding cooperation.

### 3.4 Socioeconomic disease burden

In addition to company-level costs related to health-related problems, there are costs borne by society. These may include costs that companies do not account for in their financial statements. In the example above, costs such as poor fish welfare, loss of reputation, and increased risk of disease transmission to wild fish were not considered. Such costs are referred to as negative externalities and can lead to what is known as market failure. Market failure arises when the price of a product does not reflect the true cost of production. Examples include negative environmental impacts from medicinal treatments, increased infection pressure on wild stocks, inefficient resource utilisation, or public concern triggered by media coverage of poor fish welfare in aquaculture. The latter may also lead consumers to purchase less farmed fish, which in turn can reduce demand and, in isolation, lower market prices.

In the longer term, poor fish health may lead authorities to impose stricter requirements for acceptable fish welfare, for example through tighter standards, reduced production capacity, or fees and taxes, which in turn may increase costs for companies. Examples of this can be seen in the ongoing discussion regarding the introduction of taxes on mortality and escaped fish, as well as sea lice quotas. Whether taxes and quotas are effective regulatory instru-

ments for reducing mortality and lowering lice pressure on wild fish must be carefully assessed before they are potentially implemented on a full scale across the industry. In addition, society incurs costs related to the monitoring and management of fish health, including funding for research activities.

Companies are subject to societal demands and expectations, commonly referred to as their social licence to operate. This may influence changes in regulatory frameworks and operating conditions. There is an increasing societal focus on sustainability and animal welfare, which is also reflected in new regulations, access to capital and credit, and reporting requirements. The EU has recently introduced the Corporate Sustainability Reporting Directive (CSRD), which is in the process of being implemented in the Member States and in Norway through new legislation, regulations, and accounting standards (ESRS). A core element of the ESRS standards is that companies covered by the CSRD must report on their impacts on society and the environment, and on how sustainability requirements may affect the company's profitability and development in the short, medium, and long term (the so-called double materiality principle). Animal welfare is one of the issues that may potentially be incorporated into such corporate reporting in the future.

### 3.5 Health economics as part of the decisionmaking basis

Economic decision theory can support rational decision-making and help ensure that resources are managed efficiently. However, it is important to remember that economic analyses are only decision-support tools, not definitive answers. Prioritisation also involves evaluating ethical considerations and broader societal goals. For example, some diseases may appear to have limited economic consequences at an overall level, while still causing severe welfare impacts for affected fish. They may also have serious economic consequences for the affected company or for a small local community that depends on that company. In such cases, purely business-economic calculations may be insufficient.

Considerations related to profitability, the health and welfare of farmed salmon and wild salmon, and negative environmental impacts do not always align and may create conflicts between objectives. This implies that choosing one

objective may come at the expense of another. Companies must balance goals such as economic profitability, sustainable food production, efficient resource use, environmental impact, and societal acceptance. are all goals that companies must navigate.

Companies create important societal value through employment and, in the case of aquaculture, healthy food for a growing middle class. Aquaculture companies, like all businesses, must be profitable in order to survive, but how this profitability is achieved is also important from a societal perspective. In animal production, there is a particular responsibility to safeguard animal welfare. This is an ethical objective that every animal owner should and must take into account when making decisions. A key objective is therefore to ensure the best possible animal health using the resources available.

Without clear objectives, effective governance becomes difficult. Determining which objectives should guide decision-making—profitability, sustainability, or animal welfare—is therefore a fundamental discussion when considering which choices should be made.

# 4 Biosecurity

By Ingunn Sommerset, Sonal Patel, Leif Lukas Löfling, Kristoffer Vale Nielsen, Åse Helen Garseth and Kari Olli Helgesen

**Biosecurity involves systematic measures, routines, and barriers designed to prevent the introduction of infectious agents into an aquaculture facility, their spread within a farm, and their spread to other farms, wild fish, and the environment. The purpose is to ensure good health and welfare, reduce disease incidence, and contribute to sustainable and responsible operations.**

## 4.1 Biosecurity in aquaculture

Biosecurity encompasses prevention, preparedness, and response, and applies to the entire production chain from roe and juvenile fish to slaughter and transport. The principles are risk-based and facility-specific, adapted to species, production method, location, and the infection situation. The regulatory framework is based on laws regulating food production and aquaculture and EU Animal Health Law. The latter regulations, which were introduced in 2022, resulted, among other things, in a requirement that all approved aquaculture facilities must have an approved biosecurity plan. Information about relevant regulations and guidance is available on the Norwegian Food Safety Authority's website, [Biosikkerhetsplan i akvakulturanlegg](#) (in Norwegian).

The aquaculture industry has had an increased focus on biosecurity, and in the spring of 2022 it was decided to establish a top management forum to outline a common path forward toward the main objective: "An industry that operates according to best practice based on biological infection principles - preventing introduction and combating the spread of infectious diseases." The forum sets principles, objectives, and measures throughout the entire production chain. This work is in the process of being operationalized at the national level, and through regional and sub-regional groups in which industry actors and fish health personnel participate. The work on the aquaculture industry's biosecurity process aims to include all stakeholders, regardless of organizational affiliation (Haram 2023). The forum updated the website [Biosikkerhet](#) (in Norwegian) in 2025. This is intended to make it easier for stakeholders to reach common goals and carry out joint measures for improved biosecurity.

## 4.2 Disinfection of intake and effluent water

In connection with the implementation of Animal Health Law, Norwegian Food and Safety Authorities are in the process of revising and updating several national regulations to adapt the wording of the EU regulatory framework. One of these is the "Forskrift om desinfeksjon av inntaksvann til og avløpsvann fra akvakulturrelatert virksomhet", often referred to as the "Vannbehandlingsforskriften" (in English: Regulation on water treatment), which was introduced in 1997 and revised in 2004. Under this regulation, approval of methods and equipment has been delegated to the Norwegian Veterinary Institute. This is now to be revised, with a move toward third-party approval, while the content of the regulatory requirements will be better adapted to modern aquaculture operations. In 2025, the Norwegian Food Safety Authority prepared [guidelines for the operation of disinfection systems in land-based facilities and well boats](#) (in Norwegian), which provides a good foundation and support for industry stakeholders during the operation and control of water disinfection to and from aquaculture facilities.

### Standardization

In 2024, a standardization committee ("[SN/K 625 SN/K Desinfeksjon av inntaksvann til - og avløpsvann fra akvakulturrelatert virksomhet](#)") was established within Standard Norway, with the aim of specifying and creating a common understanding of the technical and biological requirements related to the disinfection of water to and from aquaculture. The committee led by Norwegian Veterinary Institute, consists of members from research, management, and industry, represented by equipment suppliers, producers, analytical laboratories, the well boat industry, and a seafood cluster. Following an initial mapping phase, the committee has worked on developing technical requirements for several of the disinfection methods, sampling protocols, and procedures. The initial mapping revealed significant knowledge gaps, and the field is characterized by a lack of research activity over the past decades.

The FHF-funded research project [WaterSafe](#) (902001), which started in 2025 and is led by the Norwegian Veterinary Institute, aims to address some of the knowledge gaps identified by the standardization committee. This includes, among other things, microbial indicators for measuring the effectiveness of disinfection adapted to the current aquaculture

situation, and the development of standardized methods for sampling, analysis, and effect measurement.

### Technology neutrality and design

Equipment suppliers demonstrate a high level of innovation, both in the development of new methods and in the improvement of existing approved methods. Several salmon producers acknowledge that regulatory requirements regarding dosage for UV and ozone have not been sufficient, and many ensure safety by increasing doses and combining multiple methods for disinfection. At the same time, under the current regulation, only UV and ozone are approved for the disinfection of intake water. This results in facilities having to use at least one of these two approved methods, in addition to new and innovative methods that may be equally effective. Methods such as membrane filtration and chlorination have been tested, and membrane filtration with pore sizes for ultra- and nanofiltration can remove bacteria and, in some cases, most viruses through reverse osmosis (RO) water treatment. Chlorination of intake water can be applied but requires good safety routines to avoid fish being exposed to residual chlorine. The Norwegian Food Safety Authority has indicated that the revised regulation will be anchored in functional requirements that better accommodate innovation and technology neutrality.

One of the greatest challenges is the wide variation in how different equipment suppliers calculate effect doses for their disinfection equipment. Limited knowledge of expected seasonal variation in water quality and future changes in production plans may also affect effectiveness. At present, there are no specific requirements regarding preparatory work prior to the design of an aquaculture facility. This leads to large variation in how thoroughly different actors have mapped relevant factors before commencing with designing the facility. As a result, there is a risk that disinfection effectiveness may be insufficient, for example following changes in water quality after heavy rainfall or during summer seasons with algal blooms. A thorough risk assessment prior to dimensioning and selecting disinfection systems is therefore important.

### Analytical methods

The regulation on disinfection of water in aquaculture § 10, sets a requirement of a 99.9% inactivation rate of the bacterium *Aeromonas salmonicida* ssp. *salmonicida* for intake water to juvenile fish production. However, this applies only

to the approval of the method itself, as the bacterium occurs to a very limited extent in natural water bodies and is therefore not suitable for routine operational monitoring. *Vibrio* spp. are better suited as indicator bacteria for measuring disinfection efficiency in seawater, while total bacterial count or *Pseudomonas* bacteria are used as indicator organisms for disinfection effectiveness in freshwater. The occurrence of these bacteria varies both geographically and seasonally, posing analytical challenges. Laboratories count bacteria following cultivation of samples collected before and after disinfection, and reference is made to standardized methodologies (ISO, EN, NS, NMKL, or equivalent), or the method described by Storset (Norsk Veterinærtidsskrift 1991, 103, no. 11, pp. 1025-1027).

Most standardized methods have been established for measurements in drinking water, whereas other water qualities, microorganisms, and cultivation conditions are relevant for water to and from aquaculture operations. Divergent results have been reported from different analytical laboratories analyzing the same water sample, as well as variations within the same laboratory. Another issue concerns samples taken at facilities or well boats that are located far from the nearest laboratory. In such cases, a long time may elapse between sampling and the arrival of samples at the laboratory, which may affect the degradation or growth of viable bacteria in the sample and thus its quality. It is therefore important to include sampling protocols and storage conditions/time considerations when developing a standardized method for measuring water disinfection.

### 4.3 Vaccination as a biosafety measure

Historically, effective vaccines against important bacterial diseases have contributed, and continue to contribute, to the very low consumption of antibiotics in Norwegian aquaculture compared with other countries and other food-producing animals. For salmonids, there are good and effective vaccines against many diseases, but considerable research and development efforts remain to establish effective vaccines for lower-volume farmed species such as cod, halibut, and various species of farmed cleaner fish. This lack of effective vaccines is reflected in the fact that 75% of the antibiotic prescriptions issued for farmed fish in 2025 were for marine species (94 for halibut, four for cod, and four for cleaner fish). For further details on antibiotic use, see [Chapter 8.10](#).

Where no licensed vaccines with marketing authorisation are available, or where available vaccines have been shown to have insufficient efficacy, autogenous vaccines may be relevant. Autogenous vaccines are based on a pathogen isolated from one or more fish belonging to the same “epidemiological unit.” In each case, permission must be applied for and granted prior to use, and the manufacturer must be accepted by the Norwegian Medicines Agency (NoMA). [Table 4.3.1](#) provides an overview of applications granted by NoMA in 2025 (data received 11 February 2026). Note that this does not provide information on the actual use of autogenous vaccines, i.e. how many fish are vaccinated and deployed at the various sites. NoMA also states the following: “Among approved applications for the right to prescribe

autogenous vaccines, monovalent autogenous vaccines against *Pasteurella (Phocoenobacter)* spp. for Atlantic salmon dominate, with 24 approved applications.”

All pharmacies that sell veterinary medicinal products, and animal health personnel who administer medicinal products obtained from pharmacies to animals, are required to report to the Norwegian Food Safety Authority’s Veterinary Prescription Register (VetReg). Vaccines for fish are classified as medicinal products and must therefore also be reported to VetReg. Statistics on vaccine use in aquaculture can provide information on regulatory compliance, changes in disease threats, and overall biosecurity assessments.

**Table 4.3.1** Autogenous vaccines for fish in 2025. Number of applications approved by NoMA per species. Agents listed may occur in different combinations in the applied-for autogenous vaccines for a species. An agent may therefore also only be mentioned in rejected applications. Data received from the Norwegian Medicines Agency on 11 February 2026.

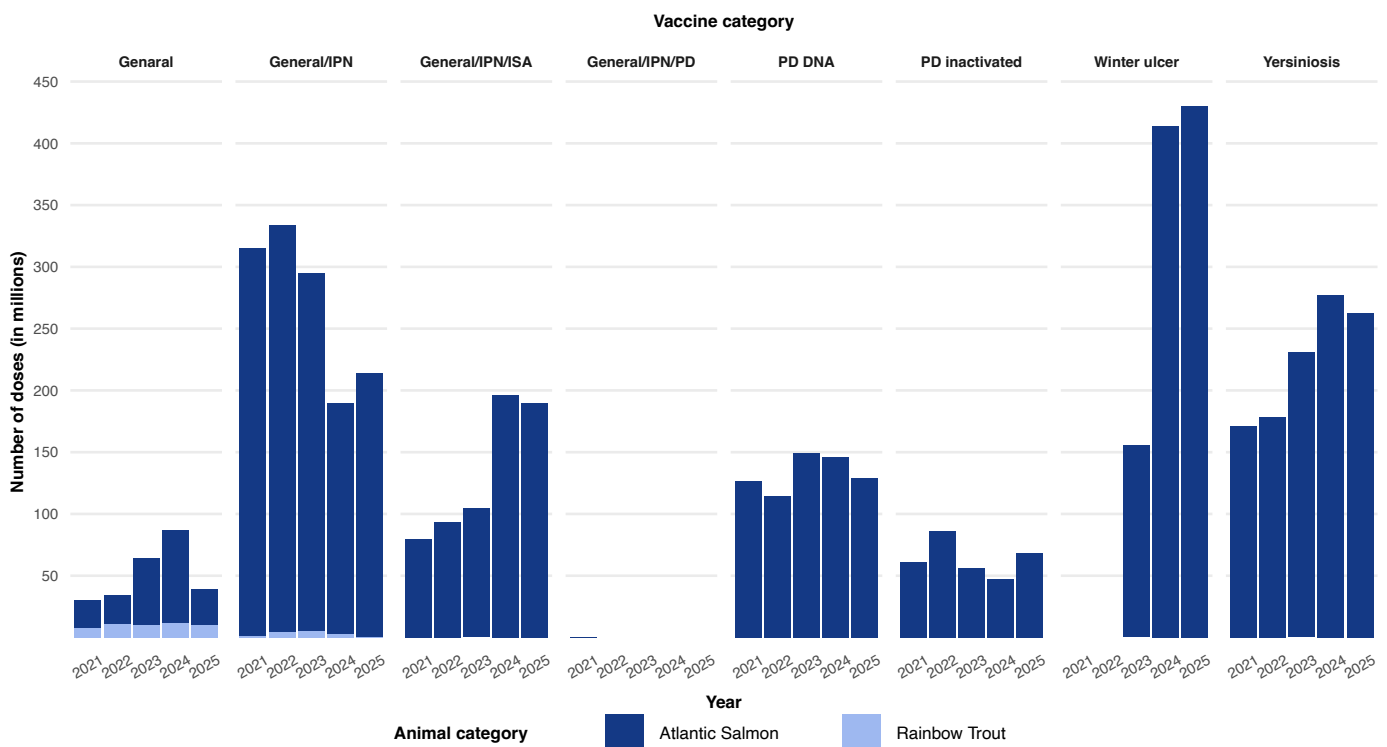
Fish species	Approved applications	Agents
Atlantic salmon	26	<i>Pasteurella</i> sp. <i>Yersinia ruckeri</i> <i>Moritella</i> sp. <i>Flavobacterium psychrophilum</i> <i>Tenacibaculum finnmarkense</i>
Arctic char (freshwater)	1	<i>Aeromonas salmonicida</i> <i>Pseudomonas fluorescens</i>
Halibut	3	<i>Vibrio splendidus</i> <i>Vibrio tapetis</i> <i>Allivibrio logei</i> <i>Tenacibaculum finnmarkense</i>
Turbot	1	<i>Aeromonas salmonicida</i> type II <i>Vibrio (Listonella) anguillarum</i>
Rainbow trout	2	<i>Moritella viscosa</i> <i>Vibrio anguillarum</i> O2a variant <i>Vibrio anguillarum</i> O1
Lumpfish	1	<i>Pseudomonas anguiliseptica</i> <i>Moritella viscosa</i> variant <i>Moritella viscosa</i> klassisk <i>Aeromonas salmonicida</i>
Cod	2	<i>Aeromonas salmonicida</i> <i>Aeromonas salmonicida</i> type III <i>Vibrio (Listonella) anguillarum</i> <i>Vibrio (Listonella) anguillarum</i> O2a <i>Vibrio (Listonella) anguillarum</i> O2b <i>Moritella viscosa</i>
<b>Total</b>	<b>36</b>	

Salmonids are commonly vaccinated during the hatchery phase (freshwater) so that they are immunised against important infectious diseases during the seawater phase. VetReg data contain information only on which hatchery the vaccine is delivered to, not which sea site the vaccinated fish are subsequently transferred to. To measure the effect of vaccination for disease prevention, information on vaccination status would need to be available per sea site, and ideally at cage level. At present, such data are not available in public registers.

Figure 4.3.1 shows the number of doses (in millions) of different categories of licensed vaccines for salmon and rainbow trout delivered to hatcheries during 2021–2025. The data are sourced from the Norwegian Food Safety Authority’s VetReg as of 2 February 2026 and are limited to injectable vaccines. The most common primary vaccination for salmon

is a multicomponent injectable vaccine containing five bacterial antigens and the viral antigen IPN, and optionally also ISA, referred to in the figure as “General/IPN” and “General/IPN/ISA.” The five bacterial components include *Aeromonas salmonicida* subsp. *salmonicida*, *Vibrio anguillarum* serotype O1 and O2a, *Vibrio salmonicida*, and *Moritella viscosa*. Primary vaccination without IPN and/or ISA, referred to in Figure 4.3.1 as “General,” is the most commonly used for rainbow trout.

Vaccination against PD is carried out by administering the PD vaccine as a separate injectable vaccine, either as a DNA vaccine (injected intramuscularly) or as an inactivated PD virus vaccine (injected intraperitoneally). The PD vaccine is usually administered at the same time as the primary vaccine. No PD vaccines were delivered for use in rainbow trout during 2021–2025, although this species can also contract



Fish Health Report 2025, Norwegian Veterinary Institute

Figure 4.3.1 Number of doses of injectable vaccines for fish dispensed from pharmacies to hatcheries from 2021 to 2025, by target diseases: General (against furunculosis, cold-water vibriosis, vibriosis, and for some vaccines also winter ulcer), General/IPN (general plus infectious pancreatic necrosis), General/IPN/ISA (general plus IPN plus infectious salmon anaemia), General/IPN/PD (general plus IPN plus inactivated PD vaccine), PD DNA (DNA vaccine against pancreas disease), PD inactivated (inactivated PD vaccine), winter ulcer, and yersiniosis. Vaccine doses are further divided into doses for Atlantic salmon (dark blue) and doses for rainbow trout (light blue). Data are derived from the Norwegian Food Safety Authority’s Veterinary Prescription Register (VetReg), downloaded on 02.02.2026. Bath vaccines are not included.

PD and shed infectious virus. In total, approximately the same number of PD vaccine doses were prescribed for salmon in 2025 (198 million) as in 2024 (194 million). Vaccination against PD is discussed in more detail in [Chapter 7.1](#) Pancreas disease (PD).

Approximately the same number of fish were vaccinated against ISA in 2025 as in the previous year; 190 million doses were dispensed from pharmacies. Vaccination contributes to reducing disease and virus shedding. In 2025, infectious salmon anaemia (ISA) was confirmed at 18 sites, and at seven of these sites the fish were vaccinated ([Chapter 7.2](#) Infectious salmon anaemia). Among respondents who assessed vaccine efficacy in the survey, 7% considered it poor, 52% moderate, and 40% good.

During 2025, a total of approximately 430 million doses of a new winter ulcer vaccine approved in 2023 (labelled “Winter ulcer” in [Figure 4.4.1](#)) were dispensed. Since approximately the same number of salmon (433 million) got one of the three general vaccines with or without viral components (General, General/IPN, or General/IPN/ISA), this means that nearly all (99.4%) vaccinated salmon were also vaccinated with the new winter ulcer vaccine. In the survey among fish health professionals, vaccine efficacy was assessed as poor

by 8%, moderate by 45%, and good by 47% of those who evaluated the effect of winter ulcer vaccination ([Table 4.3.2](#)).

Approximately 263 million salmon were vaccinated against yersiniosis in 2025. This means that 61% of all vaccinated salmon were also vaccinated against yersiniosis; any dip or bath vaccination is not included. In 2025, the number of registered yersiniosis cases was approximately the same as the previous year ([Chapter 8.6](#) Yersiniosis). Vaccine efficacy was assessed as good by 94% of respondents who evaluated the effect ([Table 4.3.2](#)).

Although the number of vaccine doses prescribed for the various vaccines provides some indication of expected cost-benefit, the actual field efficacy of vaccination, as mentioned above, cannot be quantified based on available data. To obtain qualitative information on perceived vaccine efficacy in the field, respondents to the Fish Health Report survey with experience of vaccination were asked to answer questions regarding the effectiveness of vaccination against specific diseases ([Table 4.3.2](#)).

Follow-up questions allowed respondents to provide additional comments on vaccine efficacy. The free-text responses largely reflect the distribution of responses summarised in [Table 4.3.2](#).

**Table 4.3.2** Summary of responses from the 2025 survey to the question: “How well do you believe the vaccines protect against clinical disease for these diseases?” The numbers show the number of respondents selecting each response option for each disease (ISA, PD, IPN, winter ulcer (*Moritella viscosa*), yersiniosis (*Yersinia ruckeri*), pasteurellosis, and others), while numbers in parentheses show the percentage of respondents selecting the respective response option.

Effect / Disease	ISA	PD	IPN	Winter ulcer	Yersiniosis	Pasteurellosis
Poor	3 (4%)	0	12 (17%)	5 (7%)	0	0
Moderate	22 (32%)	14 (21%)	21 (30%)	28 (41%)	3 (4%)	10 (15%)
Good	17 (25%)	29 (43%)	24 (35%)	29 (42%)	49 (71%)	7 (10%)
Not vaccinated against	15 (22%)	18 (27%)	4 (6%)	1 (1%)	10 (15%)	30 (44%)
Do not know	12 (17%)	7 (10%)	8 (12%)	6 (9%)	7 (10%)	21 (31%)
Number of responses	69	68	69	69	69	68

#### 4.4 Infection risk farmed fish – wild fish (and vice versa)

Since 2022, there have been a number of BKD outbreaks in aquaculture facilities in PA4–PA6. The most recent case was detected in PA6 in January/February 2026. The epizootic outbreak in Central Norway therefore does not appear to be over. In 2024, 8400 salmon (average weight 7.3 kg) escaped from the BKDinfected site Reitholmen. In recaptured fish, the prevalence was slightly over 2% ([Villfiskrapporten 2024](#)). In 2025, the Norwegian Food Safety Authority's health surveillance program for wild salmonids was dedicated to BKD surveillance, with the Norwegian Veterinary Institute responsible for monitoring in freshwater (juvenile fish and returning adult fish) and the Institute of Marine Research responsible for monitoring at sea (outmigrating smolt). The Norwegian Veterinary Institute's surveillance has particularly focused on rivers in Central Norway that had a significant proportion of escaped salmon from Reitholmen, but also some rivers in PA3–PA5.

Among 500 examined salmonids, *R. salmoninarum* has been detected by PCR in one escaped salmon and in two older wild salmon—all caught in the Orkla River. The escaped salmon has been traced back to Reitholmen (Sporbarhet AS). So far, it has not been possible to culture the bacterium from the PCRpositive individuals in 2025 and followup with new investigations will continue in 2026. BKD has previously been detected in wild salmon in the Orkla River: in an outmigrating smolt in 1997 and in two returning adult salmon in 2000. Phylogenetic investigations show that the outbreaks from 2022 onward have at least two different origins, and it is assumed that reservoirs in wild salmonids are the source of the introductions into aquaculture. However, spread within the aquaculture industry leads to a dramatic increase in the number of infected individuals, and thus also increased infection pressure back on wild fish ("spillback"). In this context, the escape of large fish represents a particularly significant risk factor.

When the cod farming industry collapsed in 2012, the bacterial disease francisellosis played a central role, together with competition from wild-caught whitefish and problems related to early sexual maturation. As the industry is once again growing, health problems are being recorded involving both old and new infectious diseases. Among the old diseases, francisellosis has been detected at the same site in Nordmøre in both 2024 and 2025, and in February 2026

suspicion of francisellosis arose at a site in Stad municipality. The disease has an insidious course with many of the same characteristics as BKD in salmonids, where the disease has often been present in the population for a long time before it is detected. Francisellosis is expected to be favored under conditions of increased cod farming and climate change.

The new disease cod pox is caused by a poxvirus. Several sites experienced severe outbreaks during 2025, and new outbreaks have been registered in 2026. The disease causes gill damage and respiratory distress but also occurs in association with severe cardiac symptoms. At present, it is unclear whether the entire symptom complex is caused by the cod pox virus, or by the coexistence of multiple infections. Although wild fish are necessarily a source of and reservoir for the infectious agents, concern about the "spill-back" effect on wild fish is increasing. Access to hosts in large numbers and high density facilitates amplification and spread into the environment. For many of the relevant infectious diseases affecting farmed cod, there is currently little updated knowledge about their occurrence in wild fish.

# 5 Climate and Fish Health

By Elisabeth Ytteborg (NOFIMA), Duncan Colquhoun, Geir Bornø, Jannicke Wiik-Nielsen and Arve Nilsen (Veterinærinstituttet)

**The latest climate report from the United Nations has concluded that global climate change is occurring more rapidly and is more extensive than previously assumed, and that several impacts are already irreversible. Temperature scenarios from the Intergovernmental Panel on Climate Change (IPCC) indicate that the magnitude of climate change will continue to increase toward the middle of this century, and that the consequences may be catastrophic. Rising sea temperatures, ocean acidification, altered ocean currents, sea level rise, and more extreme weather events will affect marine ecosystems worldwide and place significant pressure on coastal industries.**

In Norway, we have in recent years seen some of the extent of the impacts that climate change may have on the aqua-

culture industry, including high summer temperatures, increased sea lice pressure, and the need for more frequent delousing treatments. In the Risk Report for Norwegian Fish Farming 2026, the Institute of Marine Research mentions the influence of climate change on the environment, but indicates that, due to the scale of the issue, a separate assessment with a climate focus will be produced. Climate change has for the first time been given its own chapter in the Fish Health Report (with references provided at the end of the chapter) and is also included in the survey. The high response rate to the annual survey among fish health personnel demonstrates that climate- and environment-related changes are already affecting fish health and operational decision-making ([Figure 5.1](#) and [Figure 5.2](#)). This underscores that climate change has become more visible within



Photo: Shutterstock

the aquaculture industry and that these issues must be given greater prominence.

Climate change affects Norwegian aquaculture through increasing sea temperatures, more frequent extreme weather events, and changes in salinity, oxygen levels, and pH. This leads to a higher occurrence of diseases and parasites, more frequent blooms of harmful algae and jellyfish, as well as increased risk of damage to infrastructure and operations. The marine heatwave that affected the Norwegian coast in the autumn of 2024 clearly demonstrated the wide-ranging ways in which climate change can influence production conditions. Nevertheless, there is still a lack of knowledge regarding how combinations of climate-related stressors, production methods, and production systems affect farmed species. There are substantial knowledge gaps concerning how climate change will affect different regions of the country and what is required in terms of contingency plans and technology to manage future challenges. It therefore remains unclear how well prepared the aquaculture industry is to handle the climate changes we are facing.

Climate change represents a persistent and increasing challenge for Norwegian aquaculture. These risks must be addressed through systematic and knowledge-based adaptation strategies, including strengthened preparedness, area-based management, technological measures, improved understanding of species biology, climate risk management that encompasses the entire value chain, and strategic species diversification where appropriate. Measures must be site-specific, dynamic, and based on continuous monitoring, modelling, and evaluation in order to ensure a robust and future-oriented industry.

We currently lack sufficient experience and data to draw firm conclusions about how climate change will affect fish health and welfare in commercial aquaculture. There is considerable potential for improvement in this area, and the collection of better environmental data would benefit multiple stakeholders. Norwegian aquaculture facilities already record data such as sea temperature, oxygen levels, salinity, and pH. With more than a thousand sites along the coast, the industry represents a unique opportunity to strengthen marine monitoring and to serve as an important supplement to the Institute of Marine Research's eight permanent

national hydrographic stations. Such data collection will contribute to:

- Improved understanding of climate change in the coastal zone
- More detailed climate projections
- Increased knowledge of effects on aquaculture and fish health
- Development of targeted climate adaptation measures

## 5.1 Climate Change

Climate change involves increasing average temperatures, heatwaves, ocean acidification, more extreme weather, increased runoff and ice melt, as well as changes in ocean salinity and circulation. These changes will alter the fundamental environmental conditions for Norwegian aquaculture. While we have good knowledge of climate development in open ocean areas, we know considerably less about the dynamics of coastal zones. Improved environmental data are therefore crucial for understanding climate change in Norwegian coastal areas, particularly where models and downscaled scenarios are currently insufficient.

### Temperature

Long-term measurements show that waters along the Norwegian coast have warmed by 1–2 °C since 1935, and that both surface waters and the underlying Atlantic water masses have become warmer throughout the entire water column.

This temperature increase is not evenly distributed along the coast, and data show large variations both between regions and between nearby sites. As a result, some areas have reached, may reach, or are approaching critical temperature thresholds several decades earlier than others. Warming has increased most rapidly over the past two decades, clearly indicating an acceleration in the rate of warming. It has also been demonstrated that the Arctic is warming significantly faster than the global average.

Some areas in the south and west have already recorded temperatures above 20 °C, which is well above the optimal temperature range for Atlantic salmon. Temperatures above 16 °C may pose challenges for salmon, Atlantic cod experience problems when temperatures exceed 15 °C, and other species have correspondingly different tolerance limits.

Future temperature development depends on global emissions, but models show a clear increase toward the middle of the century. This underscores the need for better local data, enhanced monitoring, and tailored climate adaptation measures.

### Oxygen levels

Warming, altered stratification, and reduced water mass exchange contribute to declining oxygen levels globally and along the Norwegian coast. Globally, oxygen levels have decreased by approximately 2% since 1960, and models estimate further reductions toward 2100.

Along the Norwegian coast, a decline in oxygen levels has also been observed. Several fjords in Western Norway have experienced a reduction in deep-water oxygen of around 15% over the past 30 years. This decline is caused by a combination of factors, including climate effects, nutrient loads, and imbalanced ecosystems. Measurements conducted by the aquaculture industry may contribute to increased understanding of these processes.

### Extreme weather

Increasing extreme weather includes, among other things, heatwaves, floods, and storms. Marine heatwaves can result in prolonged periods of temperatures well above normal throughout the entire water column, not only at the surface. Climate projections from the Intergovernmental Panel on Climate Change (IPCC) indicate that marine heatwaves will increase in duration, extent, and intensity in the coming years.

The marine heatwave in 2024 resulted in temperature increases of up to 5 °C in the northern regions compared to temperatures recorded between 2012 and 2023. Such events increase the risk of sea lice, disease, operational challenges, and capacity constraints. Marine heatwaves may also shift or extend seasons for thermophilic parasites and diseases by elevating temperatures into autumn and winter.

Current knowledge of marine heatwaves is limited, both regarding how they will manifest, how they will affect different marine species, and to what extent environmental pressure from aquaculture and other human activities will amplify these changes. A lack of such knowledge creates

uncertainty and increases the risk of unpleasant surprises for the industry.

Increasing frequency and intensity of storms, floods, and heavy precipitation raise the likelihood of damage to cages, moorings, and land-based infrastructure, thereby increasing the risks of escapes, occupational safety incidents, and operational instability. For example, Storm Hans in 2023 caused damage to infrastructure and hindered fish transport. This and similar events highlight the importance of adaptation and preparedness across sectors. Government initiatives (including Report to Parliament No. 26, 2022–2023) support goals of increased resilience to flooding, landslides, and extreme weather—measures that are also relevant for aquaculture infrastructure and coastal zone planning.

### Currents, ice, and salinity

Climate change affects ocean currents, inflow of Atlantic water, ice conditions, and salinity in Norwegian waters. This influences the Norwegian Coastal Current, which is increasingly supplied with freshwater from precipitation, runoff, and meltwater. These changes may locally amplify or reduce disease and parasite pressure and may also affect the carrying capacity of certain fjord systems.

Ice conditions in northern areas are changing rapidly. Reduced sea ice in the Barents Sea and shorter ice seasons in fjords and coastal zones lead to greater wave exposure, increased coastal erosion, and altered habitat conditions for species dependent on cold water and stable ice conditions.

There is a need for better data and longer time series to understand the impacts of climate change on salinity in Norwegian fjords.

### Ocean acidification

Globally, the ocean has become approximately 30% more acidic since pre-industrial times. The average pH has declined from 8.11 in 1985 to 8.04 in 2024, with a greater reduction in northern marine areas. Ocean acidification affects chemical and biological processes and may have ecological impacts on key organisms in the food web, which in turn may indirectly affect aquaculture.

As with temperature, the degree of ocean acidification follows the level of greenhouse gas emissions in the atmos-

phere. IPCC climate scenarios show that in a pathway consistent with achieving the goals of the Paris Agreement, the average ocean pH will decline to approximately 8.01 by 2100. In a high-emission scenario, the average ocean pH is projected to decline to around 7.67.

These values represent global averages, and pH varies substantially both regionally and seasonally. Monitoring pH in coastal areas will be important for understanding how the ocean is changing, how rapidly these changes occur, and how they may affect fish. Contributions of such data from the aquaculture industry would represent a positive spillover effect from the sector and enhance overall understanding of marine environmental change.

## 5.2 Effects on Fish and Production Systems

The health and welfare of farmed fish are strongly influenced by climate change, and the scope of these impacts is broad. However, there are major knowledge gaps regarding how climate-related stressors affect the different life stages of fish, how they may interact and amplify one another, and how production systems and production methods influence these processes. Climate change will affect all stages of fish production, including land-based aquaculture facilities and sea-based farms, transport systems, feed production and raw material availability, slaughterhouses, and markets. There is limited data analyzing fish health in relation to climate change, and the knowledge currently available mainly concerns traditional open net-pen systems in the sea. New technologies, such as closed containment systems, offshore cages, and land-based facilities, may influence vulnerability during this phase, but how and to what extent remains unclear.

### Land-based facilities

Land-based facilities are affected by climate change through factors such as access to water, water quality, damage to infrastructure caused by floods, landslides, and storms, as well as power supply and energy consumption. Access to sufficient quantities of high-quality water and assurance of stable oxygen supply are critical factors for fish health.

Increased ice melt may lead to greater runoff and higher particle loads in the water, while periods of drought may reduce water availability. Warmer freshwater during early developmental stages may result in faster growth, increased

deformities, and elevated biomass. Increased temperatures in deep-water intakes pose similar challenges for cod and other marine species reared on land.

In recent years, several land-based facilities have been affected by extreme weather or climate-related events, and these effects have been noted in various risk assessments. More systematic recording of climate-related events would contribute to a better understanding of the magnitude of climate impacts on different land-based production systems.

### Sea-based facilities

Rising sea temperatures represent one of the most direct and well-known climate-related effects on farmed fish. Both salmon and cod are cold-water species with a narrow thermal optimum, and increasing temperatures affect physiology, behaviour, health, and the surrounding environment of the farms. The optimal temperature range for salmon is between 8 and 14 °C, while for cod it is between 8 and 12 °C. Other species have different tolerance limits.

When temperatures exceed the optimal range, fish growth slows while metabolic rates increase, energy is allocated to stress responses, and oxygen demand rises. This places salmon in a state of metabolic imbalance and further increases the risk of stress. For farmed fish in northern regions, higher temperatures may lead to faster growth, but this potential benefit must be weighed against drawbacks such as increased sea lice levels, more frequent treatments, higher incidence of infectious diseases, and other potentially negative climate-related effects.

Warmer water holds less oxygen and increases metabolic activity in fish, thereby raising the risk of hypoxia, or oxygen deficiency. Reduced oxygen levels may also increase the risk of disease outbreaks, particularly when elevated temperatures coincide with increased infection pressure. Temperatures outside the fish's normal tolerance range may cause micro-damage to vital organs such as gills and skin. Impaired oxygen uptake or weakened barrier properties of the skin can make fish more vulnerable to infection or environmental stress. At high temperatures, the fish immune system also becomes less effective. Taken together, warm periods may lead to negative consequences for growth, mortality, disease progression, treatment regimes, and the

fish's ability to tolerate handling, as well as increased mortality during warm periods.

Ocean acidification has long been known to have negative effects on the exoskeletons of various calcifying organisms such as crustaceans and plankton species. Recent studies have also shown reduced mineralization in fish scales. As a result, scales become weaker and the protective barrier function of the skin is compromised. In addition, fish behaviour is affected by CO<sub>2</sub> concentration in the water and by pH. The gut microbiota is also influenced by environmental conditions, particularly temperature, and effects of ocean acidification on feed intake have also been demonstrated. Combined effects of temperature and ocean acidification have been little studied.

Biofouling varies between sites and is influenced by local conditions, equipment, and operational practices. Environmental conditions play a key role in the establishment and composition of fouling communities. Fouling growth is linked to temperature and light, with the highest occurrence in spring and summer. Oxygen availability and ocean acidification also affect growth and species composition. Changes in precipitation and runoff may influence nutrient levels in the water column and thereby fouling communities. Storms may impede access to facilities and reduce the ability to clean nets. Collectively, these factors affect fish health, but there remain significant knowledge gaps regarding how future environmental conditions will influence the development of biofouling.

### Extended production chain

Climate change will affect the entire aquaculture production chain, including access to raw materials such as marine resources (e.g. fishmeal and fish oil) and plant-based components such as soy. Increased raw material costs and more unstable supply chains should be incorporated into companies' production planning and climate risk analyses. Certification schemes and new, sustainable protein sources for feed may reduce vulnerability, but there is still a considerable need for knowledge regarding how such production can be scaled up and how well new raw materials can ensure growth and health in farmed fish.

An increase in extreme weather events may lead to more extensive damage to infrastructure and impede daily opera-

tions and transport to and from facilities. This includes everything from feeding and treatment of fish, transport of fish, products, and raw materials, slaughter operations and cooling systems, to export. Disruptions to feeding and treatment in particular may have significant impacts on fish health.

The wide range of responses and overlapping events highlights a strong need for more climate-focused recording of causal relationships and a better understanding of how climate change actually affects fish health and welfare. The effects of rising temperatures will naturally vary depending on geographical location, but it is important to remember that climate change involves more than temperature alone, and that temperature rarely increases without concurrent changes in other environmental factors.

There is much that remains unknown about how salmon will respond to climate change, and the knowledge gap is even greater for other farmed species such as various cleaner fish species, halibut, rainbow trout, and cod. Each species has its own tolerance limits, physiological requirements, and environmental preferences. As environmental conditions in the coastal zone become more variable and demanding, it becomes increasingly important to strengthen knowledge of species biology and environmental requirements in order to ensure good health, welfare, and production.

### 5.3 Effects on Bacterial Diseases

With rising sea temperatures, the balance between fish health, environmental conditions, and the pathogenic potential of different bacteria—the epidemiological triad—may shift. Some bacteria are likely to become more problematic in warmer waters, while others may become less prominent. It is also likely that new infections caused by opportunistic or previously unknown fish-pathogenic bacteria may emerge, or that bacterial species from warmer waters may establish themselves in Norway.

#### Bacteria that may increase in importance

*Vibrio anguillarum*, which causes classical vibriosis, and *Aeromonas salmonicida* subspecies *salmonicida*, which causes furunculosis, have been shown to become more pathogenic at temperatures only slightly above today's "normal" summer temperatures. Both bacteria are present in Norwegian waters and cause disease in wild fish during

periods of high sea temperatures. In farmed salmon and rainbow trout, these diseases are currently well controlled through effective vaccination, but whether vaccine protection will remain equally effective in a warmer ocean is uncertain. A potential increase in the number of outbreaks of these diseases therefore cannot be ruled out.

Several important bacterial fish pathogens grow well at temperatures above what is considered optimal for salmon welfare. It is therefore likely that infections with, for example, *Phocoenobacter* spp., *Yersinia ruckeri*, and *Mycobacterium* spp. may occur more frequently and with greater severity in warmer waters.

*Piscirickettsia salmonis*, which causes piscirickettsiosis, is a highly important pathogen in salmon farming in countries where sea temperatures are often higher than in Norway. In Norway, outbreaks have been rare, but when they have occurred, they have typically been associated with periods of high water temperature. This indicates a high likelihood that this bacterium may cause greater problems for Norwegian aquaculture in the future.

*Tenacibaculum maritimum* causes severe infections in a wide range of fish species in warmer marine regions worldwide. The bacterium is already present in Norwegian waters but has so far only exceptionally been associated with disease outbreaks in Norwegian farmed fish. With a warmer marine environment, however, it is likely that this bacterium may increase in importance and represent a greater challenge in the future.

In cod, *Francisella noatunensis* is a severe pathogen that has recently re-emerged in Norwegian cod farming. It is likely to become more problematic if sea temperatures continue to rise.

Several other bacteria present in Norway, but which have so far not been associated with disease in Norwegian farmed species, may also become relevant pathogens in the future. One example is *Lactococcus garvieae/petauri*, which causes severe disease in several fish species, including rainbow trout, in several other countries. Opportunistic bacteria such as various *Vibrio* spp., *Pseudomonas* spp., and motile *Aeromonas* spp., which are currently mainly associated with

suboptimal operational or environmental conditions, may also increase in prevalence at higher temperatures.

### Bacteria that may decrease in importance

Not all consequences of warmer seas are necessarily negative. Cold-water vibriosis, caused by *Aliivibrio salmonicida* (formerly *Vibrio salmonicida*), occurs only at temperatures around 10 °C or lower, and the disease has already become nearly historical due to effective vaccination. If winter sea temperatures rise further, it may be possible to consider reducing or discontinuing vaccination against this disease in the future.

The same applies to winter ulcers, caused by *Moritella viscosa* and *Tenacibaculum finnmarkense*, which primarily occur at low temperatures. These conditions are likely to decrease in importance in a warmer marine environment.

For some bacteria, the consequences of increased water temperatures remain uncertain. For example, *Flavobacterium psychrophilum* is known to cause disease in salmonids at both low and high temperatures.

## 5.4 Effects on Parasitic Diseases

Rising sea temperatures provide improved living conditions and faster reproduction for many parasites. This is particularly evident for salmon lice, where recent years of increasing temperatures have led to more rapid reproduction and higher lice levels. This negative development has been especially pronounced in northern regions, where lice infestations have previously been a minor problem.

Other parasites may also become more important as sea temperatures increase. The Norwegian Veterinary Institute has recorded both amoebic gill disease caused by the parasite *Paramoeba perurans* and "haustsjuke" caused by the parasite *Desmozon lepeophtheirii* in salmon in Northern Norway. These are new diseases in this region.

A warmer ocean will likely contribute to the introduction of new parasites along the Norwegian coast. A high level of preparedness is therefore required, not only for monitoring known parasitic diseases, but also for detecting emerging parasite-related problems as early as possible.

### Salmon lice (*Lepeophtheirus salmonis*)

Temperature and salinity are important factors influencing the development, reproduction, and life cycle of salmon lice, and infection pressure is expected to increase in the future as a result of rising temperatures. Warmer water leads to shorter generation times and faster development of both larval stages and attached lice. Lice levels are also affected by pH, with lower pH associated with higher lice prevalence. Studies suggest that salmon lice have a high tolerance for the pH values expected toward the end of this century. The spread of lice may also be influenced by extreme weather events, including stronger winds and ocean currents.

### Amoebic gill disease (AGD)

The amoeba *Paramoeba perurans*, which causes AGD, has been a problem in Tasmania since the 1980s but has gradually spread northwards to Europe and was first recorded in Norway at several aquaculture sites on the west coast in 2006. This occurred during a period when sea temperatures were higher than normal. The disease was not observed again until 2012, but since then AGD has developed into a significant problem for the Norwegian aquaculture industry. The disease has also been detected progressively further north in the years following its initial detection in Norway (Chapter 10.4 Amoebic Gill Disease (AGD) – *Paramoeba perurans*).

The two most important risk factors for AGD outbreaks are high sea temperatures and high salinity. Fish infected with AGD have impaired gill function and are also less tolerant of fluctuations in oxygen levels in the water.

## 5.5 Effects on Algae and Jellyfish

As with parasites and bacteria, changes in the marine environment will affect the distribution and blooms of jellyfish and algae. Conditions may also facilitate the establishment of new species. Increased preparedness, improved monitoring of both known and emerging species, and better knowledge of the different organisms will be necessary to manage these challenges.

### Algae

Harmful algal blooms (HABs) are linked to various climate-related stressors, such as storms, temperature, marine heatwaves, ocean acidification, oxygen levels, and salinity.

It is difficult to predict where HABs will occur, as algal blooms are influenced by many environmental factors simultaneously. Nevertheless, there is broad agreement that HABs are increasing in both frequency and geographical extent, and that new species are emerging in areas where they have not previously been recorded.

In Norway, several algal species have caused extensive fish mortality. However, due to the long intervals between events, poor data registration, inadequate detection indicators, and uneven monitoring, it is difficult to identify clear trends. In large ocean areas, it is assumed that HABs will occur more frequently in northern regions as climate change becomes more pronounced. However, there remains considerable uncertainty regarding how the distribution and frequency of HABs will actually develop in coastal zones in the future.

### Jellyfish

Although there is considerable uncertainty regarding how climate change will affect jellyfish populations, there are, as with HABs, documented links between jellyfish distribution and climate-related changes such as storms, increasing temperatures, marine heatwaves, salinity, and oxygen levels. However, knowledge of the overall distribution of jellyfish in Norwegian waters is limited, as is understanding of how climate change will affect the occurrence of different species.

Some jellyfish populations increase under hypoxic conditions, while others decline. Extreme temperatures and heatwaves may influence jellyfish population dynamics, for example through blooms of moon jellyfish (*Aurelia aurita*). In recent years, major problems have been associated with the string jellyfish (*Apolemia uvaria*), and higher sea temperatures combined with altered inflow of Atlantic water have been suggested as possible explanations. General anthropogenic factors influencing jellyfish blooms and distribution include rising sea temperatures, large-scale reductions in global fish stocks, nutrient inputs from aquaculture and runoff in coastal zones, and maritime transport. The effects of ocean acidification on jellyfish remain uncertain and are the subject of ongoing debate.

## New species

The effects of climate change on the marine environment will allow more non-native species to establish and spread in Norwegian coastal areas. Continued observation and registration will be important in order to map new species as they appear and to assess those that may pose a risk to the aquaculture industry.

## 5.6 Effects on the Production Environment

Aquaculture releases nutrients into the surrounding environment, including feed residues and excreta that accumulate on the seabed beneath and around cages. The extent to which these discharges are degraded and dispersed depends on environmental conditions, hydrodynamics, and the composition of benthic communities. Climate- and environment-related stressors affect both the dispersal and accumulation of waste and thus influence the capacity of an area to tolerate such loading. The sinking rate of particles further depends on temperature, salinity, and currents, as well as on particle size and density.

Many Norwegian aquaculture facilities are located in fjords where warming has resulted in reduced oxygen levels, which in turn may impair the environment's ability to break down organic material. Increased precipitation and runoff add further organic material to coastal and fjord areas, and the resulting microbial activity may further reduce overall environmental capacity. In addition, this activity may reduce light penetration in the water column, which in turn affects the total carrying capacity of the area.

Extreme weather events such as storms may also cause greater damage to infrastructure, increase wave heights that pose higher operational risks, and hinder access to and from facilities. In this area as well, there remain substantial knowledge gaps.

## 5.7 Measures and Adaptation Strategies

### Climate adaptation strategies

Climate change may lead to production losses, increased treatment costs, and damage to facilities or critical infrastructure. This may impose a significant economic burden on the aquaculture industry in the years ahead. At the same time, recent analyses indicate that the industry often prioritises short-term operations over comprehensive climate risk

management. This is due, in part, to uncertainty, knowledge gaps, acute challenges, and climate projections with time horizons that may seem too distant. Such factors may delay necessary investments in adaptation.

Examples of climate adaptation measures include:

- **Production methods:** New approaches to treatment strategies, such as strengthened area-based coordination, preventive measures, and contingency strategies that account for warmer seas and increased infection pressure from both known and emerging species.
- **Technology and facility design:** Development and implementation of alternative production methods, such as semi-closed or closed containment systems, submersible cages, or offshore facilities to reduce environmental impact and infection risk, as well as simpler measures such as active oxygenation.
- **Increased knowledge:** Systematic recording of climate-related events and improved monitoring of environmental data and fish responses, enhanced understanding of species tolerance limits, better knowledge of how climate change will affect Norwegian coastal areas, and increased knowledge of climate-related effects on parasites and diseases.
- **Diversification:** The inclusion of multiple species (both fish and low-trophic species such as algae, kelp, and shellfish) is highlighted as a long-term climate adaptation strategy by both national authorities and the Food and Agriculture Organization of the United Nations. Identifying climate-related tolerance limits and assessing climate impacts at relevant sites may support species selection and production strategies in different parts of the country.
- **Spatial planning and regulation:** Planning of new sites should include expected temperature development, local ecosystem dynamics, potential infection and lice pressure, as well as tolerance limits and needs assessments for the species to be established.
- **National frameworks for climate adaptation:** The aquaculture sector must be integrated into national and municipal climate adaptation plans, and cross-sectoral collaboration must be strengthened.

### Maladaptation

Climate change represents an increasingly critical challenge for global seafood production, and the aquaculture industry

faces substantial pressure to develop robust and adaptive strategies. Adaptation is, however, complex, and both action and inaction may have unforeseen consequences.

One of the greatest risks is maladaptation, which occurs when a measure introduced to reduce a negative impact instead exacerbates the situation, increases vulnerability, imposes ecological, social, or economic costs, or weakens the system's long-term capacity to adapt to further climate change. To date, six main areas have been identified where maladaptive strategies may arise in the aquaculture industry:

- Increased greenhouse gas emissions: Some climate measures may unintentionally increase energy use or carbon footprints; for example, land-based facilities generally have higher emissions than traditional open sea cages.
- Negative effects on farmed species: Technological or operational solutions may increase physiological stress or reduce fish welfare, such as new production methods or situations where one species is favoured at the expense of another.
- Environmental consequences: At local, regional, or global scales, including strategies that lead to increased eutrophication, negative impacts on habitats of other species, or other unintended biological consequences.
- Social consequences: Changes in operations or production methods that may affect local communities, the workforce, and/or social sustainability.
- Economic consequences: More expensive strategies or production models may result in reduced profitability for producers, value-chain actors, or markets.
- Reduced adaptive capacity: Measures that reduce flexibility or hinder future improvements, such as investments in costly technologies that do not adequately address the underlying problem and that lock the industry into rigid strategies.

These outcomes may occur across the entire production chain or in specific segments. An important recognition is that maladaptation is often unintended and typically arises when measures are implemented rapidly or without comprehensive, holistic assessment of their consequences. The distinction between successful adaptation and maladaptation is not always clear. A measure that is effective under one climatic or production context may be inappropriate in

another. In addition, the effects of a measure may change over time as climate conditions, production practices, or ecosystems evolve. Climate adaptation should therefore be viewed as a continuous process, in which measures must be evaluated dynamically with regard to direct effects, secondary consequences, and systemic impacts.

To reduce the risk of maladaptation and simultaneously strengthen the aquaculture sector in the long term, the following approaches are proposed for the development of climate adaptation strategies:

- Improved risk assessments prior to the implementation of climate measures
- Increased interdisciplinary knowledge sharing
- Integrated decision-making processes that consider biological, environmental, economic, and social consequences
- Continuous evaluation of climate impacts and the effects of adaptation measures over time

The aquaculture industry must plan for a wide range of possible climate impacts and balance multiple considerations. This is particularly important given the complex interactions between climate, environmental conditions, disease risk, production costs, and market dynamics. For Norwegian aquaculture, this means that climate adaptation must be considered in conjunction with fish health, biosecurity, and overall production management. Measures that strengthen robustness or prevent risk in the short term must be critically assessed to ensure that they do not increase vulnerability at a later stage. Investments in new operating practices, technologies, or feed strategies should always be evaluated for potential consequences for fish welfare, disease occurrence, environmental impact, and sustainability, and be placed within a climate perspective.

Climate change is a very serious challenge and will have a substantial impact on aquaculture in the years to come. All stakeholders must take greater responsibility for reducing greenhouse gas emissions to mitigate the effects of climate change. At the same time, we must increase our understanding of how the unavoidable impacts of climate change will affect production systems and farmed species. Only in this way can we prepare broadly and adapt as effectively as possible.

## The Annual Survey

Out of a total of 141 respondents, 126 answered the two questions addressing climate and environmental issues. The high response rate (89%) indicates that many respondents are already experiencing climate- and environment-related changes that affect fish health, operational decision-making, and the need for treatment and preparedness.

The first question addressed how climate change and environmental impacts are already being observed within the respondents' areas of work (Figure 5.1). Respondents were able to select multiple response options. The most frequently reported factor was an increased need for lice treatments or preventive measures (81%), followed by changes in water quality—such as temperature, oxygen levels, and pH. Several respondents also reported an increase in the occurrence of new infectious diseases (39%). A smaller proportion reported changes in production strategies, while very few stated that they had not observed any

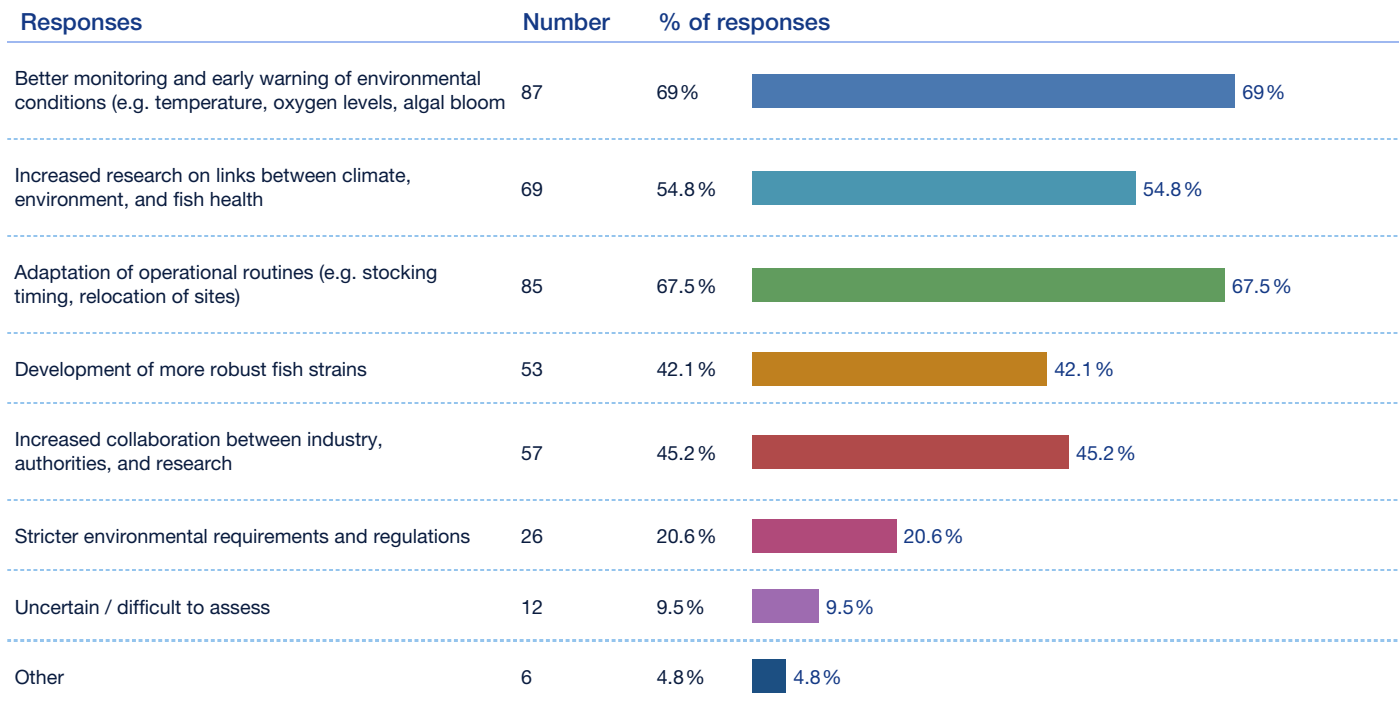
impacts. In the free-text responses, several respondents mentioned an increased occurrence of algae and jellyfish as a possible consequence of climate-related changes.

The second question asked respondents to rank which measures they considered most important for addressing the challenges ahead (Figure 5.2). Many respondents highlighted the need for improved monitoring and early warning systems (69%) and greater adaptation of operations (68%). More than half called for increased research on the relationship between climate, environment, and fish health. In addition, many respondents emphasized the need for strengthened collaboration between industry, management authorities, and research institutions. Free-text responses included references to the need for long-term strategies, operational adjustments such as lower biomass, modified stocking practices, and the use of closed-containment technologies. It was also emphasized that increasing temperatures and emerging diseases require improved preparedness.

Responses	Number	% of responses	
Increased occurrence of infectious diseases	44	34.9%	34.9%
Occurrence of infectious diseases that are new in your area	49	38.9%	38.9%
Changes in water quality (e.g. temperature, oxygen levels, pH)	76	60.3%	60.3%
Increased mortality	40	31.7%	31.7%
Reduced growth	14	11.1%	11.1%
Increased need for sea lice treatments or preventive measures	102	81%	81%
Changes in production strategies (e.g. stocking time, site selection, time of slaughter)	31	24.6%	24.6%
No noticeable impact	2	1.6%	1.6%
Uncertain / difficult to assess	14	11.1%	11.1%
Other	6	4.8%	4.8%

Fish Health Report 2025, Norwegian Veterinary Institute

**Figure 5.1** Results from the Fish Health Report 2025 survey, in which respondents (n = 126) assessed how climate change and environmental pressures affect fish health and fish welfare in their area of work (Report, Nettskjema).



Fiskehelse rapporten 2025, Veterinærinstituttet

**Figure 5.2** Results from the Fish Health Report 2025 survey, in which respondents (n = 126) indicated which measures they consider most important for reducing negative effects of climate and environment related pressures on fish health and fish welfare (Report, Nettskjema).

## Referanser

- Bernie D *et al.* (2010). Influence of mitigation policy on ocean acidification, *Geophys. Res. Lett.*, 37, L15704, doi:10.1029/2010GL043181
- Cai JN, Yan X & Leung PS (2022). Benchmarking species diversification in global aquaculture. FAO Fisheries and Aquaculture Technical Paper No. 605. Rome, FAO.
- Dyrddal AV, Bakke SJ, Hanssen-Bauer I, Mayer S, Nilsen IB, Nilsen JEØ, Paasche Ø, Saloranta T & Årthun M. (redaktører) (2025). Klima i Norge – kunnskapsgrunnlag for klimatilpassing oppdatert i 2025, NCCS-rapport 1/2025, doi:10.60839/4rgq-nn84. Norsk klimaservicesenter, <https://klimaservicesenter.no/>
- Falconer L *et al.* (2025). Marine aquaculture sites have huge potential as data providers for climate change assessments. *Aquaculture*, 595, 741519.
- Falconer L *et al.* (2024). Diversification of marine aquaculture in Norway under climate change. *Aquaculture*, 593, 741350.
- Falconer L *et al.* (2022). Insight into real-world complexities is required to enable effective response from the aquaculture sector to climate change. *PLOS Climate*, 1, e0000017.
- Falconer L *et al.* (2026). Maladaptation to Climate Change Poses a Threat to Future Aquaculture Production. *Reviews in Aquaculture* 18, no. 1 (2026): e70114, doi: 10.1111/raq.70114
- Gonzales S (2025). Drivers of the summer 2024 marine heatwave and record salmon lice outbreak in northern Norway. *Communications Earth & Environment*, 6, 639.
- Halvorsen PS *et al.* (2026). The influence of egg incubation and rearing temperature on heart morphology and function in farmed Atlantic salmon (*Salmo salar*). *Aquaculture*, 617, 743755.
- Hjøllo SS *et al.* (2025). Investigating cumulative impacts: coastal primary production in a warmer, darker, and nutrient-enriched future. *Aquacult Environ Interact* 17:235-250. doi: 10.3354/aei00506
- Husa V *et al.* (2025). *Hardangerfjorden under press*.
- IPCC, 2023: Summary for Policymakers. In: Climate Change 2023: Synthesis Report. Contribution of Working Groups I, II and III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [Core Writing Team, H. Lee and J. Romero (eds.)]. IPCC, Geneva, Switzerland, pp. 1-34, doi: 10.59327/IPCC/AR6-9789291691647.001
- Lee SH *et al.* (2023). The global spread of jellyfish hazards mirrors the pace of human imprint in the marine environment. *Environment International*, 171, 107699.
- Grefsrud ES, Andersen LB, Dunlop KM, Grøsvik BE, Hannisdal R, Husa V, Sandlund N, Skern R, Solberg MF & Stien LH (redaktører) (2026). *Risikoreport norsk fiskeoppdrett 2026*.
- Townhill BL *et al.* (2018). Harmful algal blooms and climate change: exploring future distribution changes. *ICES Journal of Marine Science*, 75, 1882-1893.
- Williams CR *et al.* (2019). Elevated CO2 impairs olfactory-mediated neural and behavioral responses and gene expression in ocean-phase coho salmon (*Oncorhynchus kisutch*). *Glob Chang Biol*, 25, 963-977.
- Ytteborg E *et al.* (2023). Climate change with increasing seawater temperature will challenge the health of farmed Atlantic Cod (*Gadus morhua* L.). *Frontiers in Marine Science*, 10.

# 6 Fish Welfare

By Kristine Gismervik, Kristin Bjørklund, Kristoffer Vale Nielsen, Siri Sollien Gåsnes, Magnus Nygård Osnes and Ewa Harasimczuk

**Animal welfare for aquatic animals is regulated, as for other animals, through the Norwegian Animal Welfare Act (AWA). This law promotes the intrinsic value of animals, with the right to a living environment and handling that ensures good welfare throughout their life cycle. The law applies equally to all farmed fish. AWA §3 states that animals have intrinsic value regardless of their utility to humans. Fish health personnel, research institutions, and governmental agencies have a particular responsibility to promote good attitudes towards fish, including wild fish, both in the industry and in society in general. In 2026, regulatory changes have been initiated, including work on a specific welfare regulation for aquaculture.**

It is important to have a broad approach to the concept of animal welfare, where common approaches such as biological functioning (with good health and normal development), the animals’ own experience (with emphasis on feelings such as safety, fear, and pain), and a life as natural as possible are included. Figure 6.1 summarizes three common definitions of animal welfare. To estimate what fish experience and feel, welfare indicators are used (Chapter 6.1 Welfare

Indicators). Good health is a prerequisite for good welfare. Mortality is a crude, useful, and widely used indicator of welfare, but survival alone does not guarantee good welfare. Both the intensity and duration of pain and discomfort are important when assessing welfare. In practice, combinations of factors such as disease, environmental conditions, nutrition, and operational routines, including handling, will affect welfare.

In 2023, the Office of the Auditor General of Norway published “Document 3:12 (2022–2023) The Public Authorities’ Work on Fish Health and Fish Welfare in the Aquaculture Industry”. They point out that it is criticisable that the authorities have not implemented measures that have been sufficient to reduce disease and poor fish welfare in the aquaculture industry (Fish Health Report 2023 and the Office of the Auditor General). In 2024, a new White Paper on animal welfare was published (Meld. St. 8 (2024–2025)), with an updated knowledge base and a clear objective for aquaculture to reduce mortality towards 5% for all farmed fish species. The White Paper does not specify when the goal is to be achieved, but several processes have subsequently been



**Figure 6.1** Three common definitions of animal welfare (in italics) including references. A broad approach to the concept of animal welfare is important, including the normal understandings such as biological function, animals’ own experience and a natural life.

initiated within regulatory development and management. Included in this work is a new aquaculture management regulation, which has now been circulated for consultation. Governmental-based welfare indicators, so-called GOWIs, can be used to measure and ensure development in the right direction. Such a GOWI framework, with data and threshold values for, for example, the number of non-medicinal delousing treatments and slaughter quality, can contribute to lower mortality, better welfare, and ethical value creation.

The growth-oriented focus must be adjusted and balanced with considerations for fish welfare. To achieve this, animal welfare must be measurable and specified. This can be accomplished through the use of welfare indicators ([Chapter 6.1 Welfare Indicators](#)), improved data quality and preparedness ([Chapter 6.2 Fish Welfare and Health in Regulation and Management](#)), overview of welfare effects of technology and methods ([Chapter 6.3 Operations and Methods](#)), requirements for cleaner fish management ([Chapter 14 Health and Welfare of Cleaner Fish](#)), and better protection against lice. Shielding measures must meet requirements related to fish welfare, the environment, and energy, nature, and sustainability.

### Assessment of Fish Welfare in 2025

Effective management by objectives towards 5% mortality requires knowledge of causes of mortality and specific welfare goals. When overall fish welfare is assessed, it is important to consider indicators in combination. In 2025, a lower mortality risk for farmed salmon in the sea phase is estimated compared with the previous year ([Chapter 2 Mortality in Aquaculture](#)), and slaughter quality has improved compared with 2024, when, among other things, there were several incidents involving jellyfish and extensive wound problems. Nevertheless, 2025 shows the highest number of reported delousing weeks to date. Welfare-related incidents are increasing in number, and the proportion related to non-medicinal delousing is increasing, which is known to have major welfare consequences for farmed fish. In 2025, there was again a warm summer, which may partly explain this development and may represent a new normal. Limiting the number of non-medicinal delousing treatments (IMM) could be a relevant indicator to introduce, as mechanical injuries resulting from delousing are again highlighted as the most important cause of mortality and reduced welfare in 2025. Fish health personnel propose in the annual survey to

set a limit per fish group of three IMMs and one medicinal treatment. In 2025, there are indications that geographical differences in health challenges are decreasing, and this year gill health is also rated relatively highly as an important driver of reduced welfare in northern regions. For improved goal-oriented management towards good animal welfare, a welfare clearance of sites could be a useful tool. In such a clearance, mortality, number of non-medicinal treatments, welfare of cleaner fish, reported welfare incidents, and slaughter quality can be used to operationalise welfare goals.

Welfare indicators must be used to a greater extent. Mortality as a welfare indicator is in the process of being implemented in governmental management. For measurability and targeted measures, additional knowledge is required regarding what fish die from and when. An overview of mortality causes and the classification of more diseases as notifiable are useful tools; for example, listing in category G was introduced in 2025. To obtain good national overviews for the knowledge base, reporting must be mandatory for producers. Regarding mortality, a high proportion of fish is still registered in the category "other", without further specification. For a comprehensive overview of health and welfare status, it is also necessary to specify sick and weakened fish that are euthanised for destruction or emergency slaughtered. The Norwegian Food Safety Authority has established a working group to examine reporting of losses and mortality.

There is increased interest in registering welfare in real time using camera technology. Automatically registered welfare indicators are used to a relatively large extent by fish health personnel, where skin health parameters and salmon lice infestation are considered important indicators. Camera monitoring should be combined with manual inspection and health examinations to achieve a holistic understanding of fish health and welfare status, as the professional intuition and empathy of farm personnel and fish health professionals cannot be directly replaced by technology and artificial intelligence.

Lice problems force the industry to rethink, and implementation of new production systems is likely part of the solution. Several new production systems reduce lice problems, but other challenges may arise. Keeping fish in new systems is more demanding, and many of the problems in open sea-

cages farming also apply to new systems. Developing and mastering a new production system requires a systematic and targeted approach. Good risk management and internal control are appropriate tools. In 2025, the Norwegian Food Safety Authority continued the work with system audits and states on their website that specific animal welfare goals are often lacking and that welfare data are insufficiently used in risk management. It is further described that risk management is fragmented or insufficiently updated, and that deviations yield limited learning.

Within a complex picture of health challenges, focus on fish nutrition is important. At the same time, objectives that feed ingredients should be sustainable and that an increasing proportion should be of Norwegian origin are important conditions for the industry. In this year's chapter on nutrition, a brief summary of recent research on nutrition-related issues is provided.

The entire life cycle of salmon must be considered collectively when welfare and mortality are assessed. Research indicates that a less intensive production of juveniles at lower temperatures and with clear signals towards smoltification, including a winter signal, is positive for subsequent welfare in the sea phase. Optimisation of the production plan entails adapting it to the biological needs of the fish. Official reporting, especially in the juvenile phase, still has considerable potential for improvement. To implement targeted measures based on where in the production process the greatest challenges occur, the use of standardised mortality causes, welfare indicators, and systematic disease registrations must increase. A holistic understanding of production-related challenges for juveniles is necessary. The ranking of health and welfare challenges is relatively similar to 2024, when haemorrhagic smolt syndrome (HSS), nephrocalcinosis, reduced water quality, runt fish, and reduced smolt quality were ranked as important causes of mortality and reduced welfare. Internal transfers between units with differing water quality are ranked higher than in 2024 as an important cause of mortality and reduced welfare. Smoltification problems, on the other hand, are ranked as somewhat less significant, but score highest in terms of increasing occurrence.

In 2025, the Norwegian Veterinary Institute focused, among other things, on large smolt in the survey. The most reported weight of large smolt at sea transfer was between

250–300 grams. A large proportion of respondents are not aware of the average duration of the sea phase following transfer of large smolt, but among those who knows, most respond that the period exceeds 10 months. Regarding whether the transition to large smolt production has provided health and welfare benefits, most respondents believe it is too early to assess or do not know. With regard to serious welfare incidents related to land-based facilities, 284 incidents were recorded in 2025, representing a clear increase compared with 238 incidents in 2024. The introduction of a new reporting solution in ALTINN from October 2024 makes trends somewhat less comparable with previous years. Nevertheless, a large proportion of incidents remain severe and are followed up by the Norwegian Food Safety Authority.

For farmed fish in the sea phase, the number of delousing treatments and the methods used remain a major welfare problem, both for salmonids and for cleaner fish. The survey shows that combination methods, including triple methods, have become even more common. In 2025, the number of non-medicinal delousing weeks (3,918 weeks) increased by 24% compared with 2024 (3,163 weeks). The number of serious welfare incidents increased from 1,385 in 2024 to 1,488 in 2025, with the proportion related to IMM showing the largest increase (44%). This after several years of decline in the total number of incidents and those specifically associated with IMM.

It is important that the practice of using bleeding or slaughter boats alongside sea cages during delousing for emergency slaughter of compromised fish does not increase risk-taking during delousing operations. In addition, the number of fish slaughtered in this manner should be reported and the data made available. This would strengthen the knowledge base surrounding delousing operations and provide background information for assessing changes in overall mortality numbers.

In 2025, there was a marked increase in the total slaughter volume of farmed salmonid fish in Norway, for the first time in several years. Compared with 2024, the volume increase in 2025 was 14% for salmon, 16% for rainbow trout, and 38% for cod. The average slaughter quality for salmonids was also better in 2025 than it has been since 2021.

Although the use of cleaner fish continues to decline, more than 19 million cleaner fish were deployed in 2025 (Chapter 14 Health and Welfare of Cleaner Fish). Health and welfare challenges for cleaner fish persist, and mortality remains too high. Regarding serious welfare incidents reported to the Norwegian Food Safety Authority in 2025, there were 75 incidents involving cleaner fish in sea cages, of which approximately one third were reported as “other”. Nearly as many were reported as “unknown mortality”, and somewhat fewer as “disease”.

In 2024, just over 1.4 million experimental animals were used in Norway, of which 95% were fish. A decline is observed in the use of Atlantic salmon, while the use of marine species such as cleaner fish has increased. The high total number of experimental animals is linked to challenges in the industry related to welfare, health, and the environment, as well as technological development. Norway is the European country that uses the highest number of experimental animals, and it is positive that the government has allocated funds for initiatives to reduce the use of experimental animals, replace animal experiments where possible, and improve welfare.

For cod, the mortality risk in 2025 is approximately at the same level as in 2024 but increased compared with 2022 and 2023. This, together with information indicating that slaughter quality has declined in 2025 compared with 2024, may suggest that some individuals have reduced welfare. Key health challenges for cod are of non-infectious origin, such as runt development and intestinal problems, but infectious diseases such as gill inflammation and vibriosis have increased in importance.

Fish health personnel are engaged advocates for both fish health and welfare and for general biosecurity. Tekna’s survey among fish health personnel in 2025 showed that it remains demanding to work as a fish health professional. It is important that expert advice is followed. For farmed fish, identifying appropriate indicators for achieving welfare goals is essential.

## 6.1 Welfare indicators

By Kristin Bjørklund and Kristine Gismervik

**Welfare indicators comprise all parameters that can be measured or observed and that provide information on the quality of animal welfare, whether good or poor (definition according to LAKSVEL). Welfare indicators describe the extent to which the animals' welfare needs are fulfilled.**

One of the key challenges in the development of welfare indicators is ensuring sufficient knowledge of biological variation, establishing appropriate threshold values, and identifying which indicators truly reflect that fish experience good welfare. A recent publication by Stien et al. (2025) reviewed which welfare indicators included in LAKSVEL have the greatest impact on salmon welfare in the days and weeks following delousing. Injuries to the eyes, gills, and snout are particularly detrimental to salmon welfare, followed by body wounds, operculum damage, and fin injuries. Scale loss and skin haemorrhaging may also have serious consequences, particularly when they are indicative of rough handling that has resulted in internal injuries.

Good welfare encompasses more than the absence of poor welfare. Indicators that confirm positive welfare are often lacking; instead, assessments typically focus on the presence or degree of negative welfare, such as injuries. The ethical standard for what is regarded as "good enough" welfare evolves alongside increasing knowledge and improved methods for assessing fish condition. This progression may influence the threshold values applied to welfare indicators.

An operational welfare indicator is a welfare indicator that can be applied directly at the production site to guide and ensure welfare-oriented practices. Such indicators should reflect welfare status and be easy to record, reproduce, and interpret. If sampling requires laboratory analysis, the measure is no longer considered an operational welfare indicator, but rather a laboratory-based welfare indicator (LABVI). In recent years, there has been increasing interest in using blood samples more actively in fish health monitoring, and non-lethal blood sampling in fish has therefore been discussed. Recent research from the project *Blood chemistry as decision support in aquaculture* (INDIKATOR) (FHF 901771), led by the Norwegian University of Life

Sciences (NMBU) Veterinary School and Aqua Kompetanse, demonstrates that important structures in the caudal region—such as blood vessels, nerves, and the spinal cord—may be damaged during sampling. The study was carried out on relatively small salmon, including parr in freshwater and smolt in seawater, using repeated blood sampling from the caudal vein every second week and monthly (Klykken et al. 2025). The Norwegian Food Safety Authority (NFSA) has clarified that fish must be euthanised after blood sampling under commercial conditions, and that non-lethal blood sampling is permitted only in approved animal experiments ([www.mattilsynet.no](http://www.mattilsynet.no)).

**Automatically recorded welfare indicators**  
**During the parliamentary consideration of the White Paper on animal welfare, the Standing Committee on Business and Industry stated that "automated systems for monitoring animal husbandry can contribute to early warning of welfare challenges and enable improved adaptation of the environment for the animals. Particularly in the aquaculture industry and agriculture, conditions should be created for research and investments in solutions that can enhance animal welfare."**

In the aquaculture industry, camera technology has undergone substantial development in recent years, and its use has increased considerably. The advantages of automated recording of welfare indicators include the ability to monitor a larger number of fish, which can provide a more representative picture of the fish group, depending on camera placement and fish distribution. Monitoring is conducted continuously and in real time, and scoring can be performed in a standardised manner each time, thereby reducing human subjectivity. This requires that the data are representative and accurate, and that any use of artificial intelligence is verifiable and transparent. Automated welfare monitoring is, in itself, a positive measure for improving welfare, as it reduces the need for physical handling of fish.

**For further information on welfare indicators, see the Norwegian Veterinary Institute's fact page (in Norwegian):**

[Velferdsindikatorer hos oppdrettsfisk](#)

Close monitoring of the development of salmon lice is essential to ensure that mitigation measures are implemented at the appropriate time. Registration of salmon lice has increasingly been automated using camerabased systems. Field experience indicates that such registrations may have limitations (Chapter 6.6 *Welfare challenges related to salmon lice and treatment*). It is therefore important that camera monitoring is combined with manual inspection and health assessments, both to validate lice counts and to achieve a comprehensive understanding of the overall health and welfare status of the fish. Technology and artificial intelligence cannot replace the professional judgement, intuition, and empathy of fish farmers and fish health personnel, which are also critical components of a holistic welfare assessment.

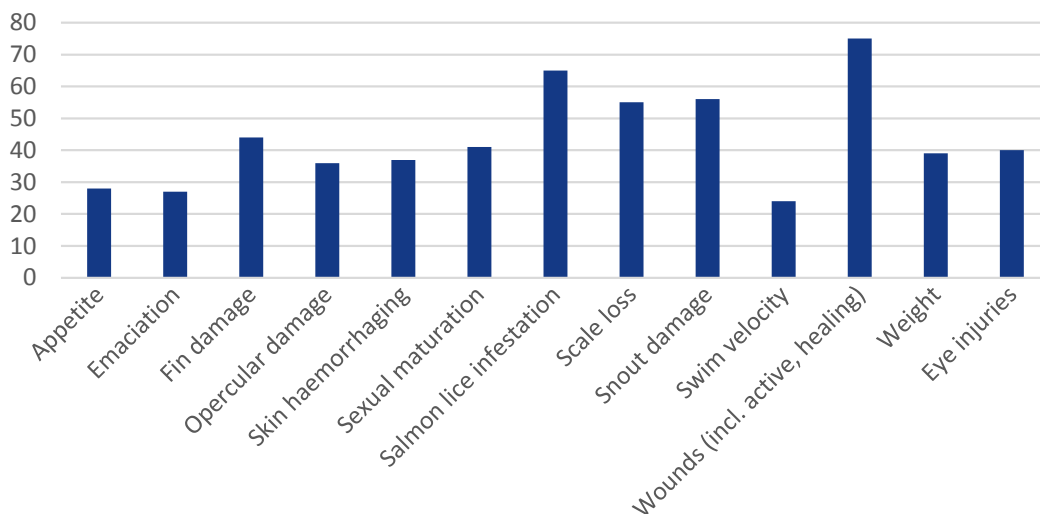
The LAKSVEL protocol is used by several camera suppliers as the basis for the automated recording of welfare indicators. If LAKSVEL indicators are interpreted differently during data collection and by the software, the resulting data may become imprecise or poorly comparable. This issue will be examined in greater detail by the Norwegian Veterinary Institute, in collaboration with other partners, through a new FHF-funded project entitled *Foundation for a common industry standard for automated recording of welfare indicators* (LAKSVELdigital, FHF 910576).

In the TARGEST project (FHF 910576), the Norwegian Veterinary Institute, together with Biosort, NMBU, and SINTEF, is involved in developing a system for identifying and sorting fish that, for various reasons, should be removed during the marine phase. The project also investigates potential uses of the removed fish as raw material within the value chain. The criteria for fish removal are based on three categories of characteristics:

1. welfare—to prevent further suffering of the individual;
2. reduction of infection risk to the remaining population; and
3. technological prerequisites for autonomous sorting of fish.

The indicators identified by the project group as having high relevance across several of these categories include condition factor, spinal deformity, scale loss, wounds, and salmon lice infestation. Other selection criteria may also provide significant benefits, but their implementation depends on further development of knowledge and technology; behaviour-based welfare indicators are one example. Monitoring individual growth over time, and in relation to the rest of the population, would also be valuable. This would require individual identification of fish, and although various solutions are currently under development, such systems have not yet been commercialised.

### Useful camera-recorded welfare indicators



Fish Health Report 2025, Norwegian Veterinary Institute

Figure 6.1.1 Number of respondents indicating which camera based welfare indicators they consider useful (N = 77).

## The Annual Survey

### Automatically recorded welfare indicators

The Norwegian Veterinary Institute's survey among fish health personnel showed that 77 of 127 respondents had experience with camera technology for the automated recording of welfare indicators, 44 had no such experience, and six responded "do not know." Almost all respondents considered wounds to be a useful indicator. Other indicators perceived as useful included salmon lice infestation, snout wounds, and scale loss (Figure 6.1.1). In freetext responses, some respondents also stated that respiratory rate was considered an important indicator.

When asked whether camerarecorded welfare indicators provided substantial support in professional assessments and/or decisionmaking, 63 of the 77 respondents answered "yes," ten answered "no," and four answered "do not know." Respondents were further asked whether they applied threshold values based on camerabased welfare indicators that they considered useful. Several respondents indicated that the skin-health parameters as wounds and scale loss are monitored, and that tracking their development over time is useful. It was also noted that the proportion of fish with wounds is important when determining the risk category assigned to a fish group prior to treatment (for example, delousing). Less than 10% of fish with score 1 wounds is considered low risk during treatment, 0–5% of fish with score 2 wounds represents moderate risk, and more than 5% of fish with score 3 wounds is assessed as high risk during treatment. This categorisation largely corresponds to the Norwegian Food Safety Authority's guidance for fish health personnel; however, the assessment of high risk differs. In the guidance document from NFSA, the presence of score 3 wounds is classified as high risk. It was also reported that the occurrence of wounds and sexual maturation are important parameters when prioritising cages for harvest, and that a weighted welfare index is used as guidance for initiating mitigating measures such as functional feed, increased removal of injured fish (for example using Fishsweep), and slaughter.

In the freetext field for additional comments on camerarecorded welfare indicators and suggestions for improvement, several respondents stated that camera technology is a useful tool but that not all indicators are recorded with the same level of precision and that differences exist between suppliers. Some respondents pointed out that camera regis-

trations can serve as indicators, but that manual registration is required to qualityassure the data. Difficulty in distinguishing between acute, chronic, and healing wounds was given as one example of imprecise registration. It was also noted that some producers do not have cameras installed in all cages, and that cameras are therefore moved between cages to obtain estimates of fish weight prior to harvest. This practice may make it difficult to monitor welfare development over time. Overall, several respondents expressed the view that continued technological development is desirable, as camerabased monitoring would be a valuable tool for fish health personnel and inspectors from the Norwegian Food Safety Authority.

### Mortality as a welfare indicator

Mortality is the most coarse, but also the most widely used, welfare indicator. In the White Paper on animal welfare, a target has been set of reducing mortality towards 5% for all fish species in aquaculture. In the annual survey conducted for the Fish Health Report, there has been strong concordance between factors ranked highly as causes of mortality and those ranked highly as causes of poor welfare in farmed salmon during the sea phase. This supports the use of mortality as a valid welfare indicator. The Norwegian Veterinary Institute, together with the Institute of Marine Research and the Directorate of Fisheries, participates in a working group on mortality data established by the NFSA. One of the objectives of this working group is to ensure that mortality is recorded in a uniform and appropriate manner. To implement the most targeted measures to reduce mortality, detailed knowledge is required of what the fish die from and when. An overview of causes of mortality and the classification of additional diseases as notifiable (for example in category G) may serve as useful tools for implementing targeted measures and monitoring welfare development. This necessitates mandatory reporting by producers, enabling authorities and the industry to obtain comprehensive national overviews to support their knowledge base. For details regarding classification in 2025, see [Chapter 6.2 Fish welfare and health in legislation and management](#) and [Chapter 2 Mortality](#). Among other, more overarching welfare indicators, slaughter quality may also be used, for example to measure progress between production cycles ([Chapter 6.7 Slaughter and slaughter data](#)).

## Regional health and welfare problems

The survey provides valuable information on the health and welfare situation in the aquaculture industry. There are geographical differences with regard to which health problems are assigned the greatest importance for salmon in the on-growing phase (Appendix B2). As some respondents cannot be assigned to a specific geographical area and must therefore be excluded, the results should be interpreted with caution. Common to all regions is that nonlisted diseases rank highly both as causes of reduced welfare and as causes of mortality. Examples of geographical variation include pasteurellosis, pancreas disease (PD), and yersiniosis, which are mainly reported as problems in PA1-PA5, whereas sea lice (*Caligus elongatus*) and parvicapsulosis are of greatest importance in PA10-PA13. A new finding this year is that pasteurellosis is reported as a health problem in PA6-PA9. Gill disease ranks relatively high in PA10-PA13 as a cause of mortality and reduced welfare and is assessed by respondents as the most important parameter, together with salmon lice, showing increasing prevalence. In PA6-PA9, gill disease is assessed by the largest proportion of respondents as the factor with increasing occurrence and by the secondlargest proportion as a cause of mortality and reduced welfare. This may indicate that pasteurellosis and gill disease are emerging diseases progressing northwards along the coast.

Mechanical damage related to delousing ranks highly in all regions as a cause of mortality and reduced welfare. Heart diseases also rank among the three most important causes of mortality in all regions; HSMB is considered most significant in PA6-PA13, whereas CMS is considered most important in PA1-PA5.

Various types of wounds, including winter ulcers caused by *Moritella viscosa*, non-specific wounds, and tenacibaculosis, are assessed as important causes of mortality and reduced welfare in PA10-PA13. Algal blooms are highlighted as important contributors to mortality and as increasing in occurrence in PA1-PA5 (Chapter 11.6 *Algae and fish health*). Grazing damage caused by salmon lice is assessed as an important cause of reduced welfare in PA6-PA13, and in northern regions, sea lice is also highlighted as an important welfare concern. The combination of mechanical damage resulting from delousing, together with gill disease, heart disease, and infection pressure from wound-associated bacteria, may all contribute to poor fish welfare. These factors may interact and influence one another's severity, illustrating that fish mortality is not necessarily caused by a single factor, but rather by the cumulative burden of multiple stressors.

## 6.2 Fish Welfare and Health in Regulations and Public Management

By Kristine Gismervik, Ewa Harasimczuk and Kristin Bjørklund

**The parliamentary white paper on animal welfare (Meld. St 8 (2024–2025)) highlights, among other things, the status of current animal husbandry, key welfare challenges, as well as goals, strategies and measures to improve animal welfare in Norway. To follow up the white paper, including the target of reducing mortality to 5% for all farmed fish species, several regulatory amendments have been initiated.”**

The Norwegian Government states clearly that mortality in the aquaculture industry is too high and that the trend of increasing mortality must be reversed. The White Paper states that “the government believes that clear requirements for continuous improvement must be set. Improvements should take place for each production cycle at each site, based on the starting point of the individual farmer. Regulations and other instruments to achieve improvements must be further developed so that farmers can work systematically to reduce mortality.” The target of reducing mortality to around 5% also applies to cleaner fish, an important clarification since long-term welfare consequences are well documented.

The white paper states that the Norwegian Government want to ‘achieve a better overview of the status and development of animal welfare’. If welfare is to be measured and shown to improve over time, relevant data must be accessible to authorities, researchers, fish farmers and fish health professionals. The Norwegian Veterinary Institute is contributing to increased knowledge on welfare indicators and on how the needs of fish should be safeguarded and prioritised. There is considerable potential in making more systematic use of authority-reported data as governmental-based operational welfare indicators (GOWIs). Available authority-reported data, such as mortality, slaughter quality and lice treatments, can be integrated into a GOWI framework. Work on GOWIs demonstrates substantial variation between individual sites and geographical areas, indicating significant potential for improvements. The use of this type of welfare indicators as functional requirements in regulations and regulatory follow-up may assist both authorities and fish farmers in defining limits for biological impact on fish and establishing specific targets for further develop-

ment. Efforts to improve the data available to authorities is ongoing, in order to provide better national overviews in several areas, including technology, registrations of dead fish and causes of death, culling for destruction and emergency slaughter, slaughter quality, cleaner fish, disease and welfare-related incidents, among others. As part of this work, it has been announced that a dedicated animal welfare regulation for aquaculture will be submitted for consultation in 2026, with planned implementation from 2027. For further details see the Norwegian version of the report.

### Welfare related incidents reported to NFSA

Serious welfare-related incidents are, in accordance with the Norwegian regulations, subject to mandatory reporting to the Food Safety Authority. In October 2024, the reporting form was restructured (ALTINN). Consequently, comparisons with trends from previous years are more uncertain for 2024 and 2025, particularly considering categorisation. In both years, manual efforts have been made to categorise incidents as accurately as possible based on free-text entries or other available information, and some duplicate reports have been identified and removed from the dataset. The total number of serious incidents in the freshwater phase appears to have increased in 2025, after several years of relative stabilisation (Table 6.2.2 and Table 6.2.3). Note that following the revised reporting system, this applies to land-based facilities, which may also influence the results. In sea-cage production, the total number of incidents was 1,488 in 2025, which is higher than in the two preceding years (Table 6.2.2). Serious incidents associated with non-medicinal delousing methods show the greatest increase, accounting for 44% of incidents in 2025 (Table 6.2.4). This coincides with an increased number of delousing weeks in 2025 (Table 10.1.2 in Chapter 10.1 Sea lice (*Lepeophtheirus salmonis*) and Chapter 6.6 Welfare challenges related to salmon lice and treatment). With respect to the jellyfish/algae category, the number of incidents has decreased compared with 2024. The categories ‘unknown mortality’ and ‘other’ have also decreased, but this is most likely due to changes in the reporting structure, including the introduction of a new disease category from 2025. Welfare incidents related to transport are now

reported by email, and a substantial increase in the number of reports has been recorded (70 incidents in 2025) compared with what was previously reported in MATS (10–20 incidents recorded in 2021/2022).

During the period 2018–2024, approximately half (45–54%) of incidents in the freshwater (now land-) phase were categorised as 'other', while 24–47% were classified as mortality of unknown cause (Fish Health Report 2024, Table 5.6.2). A more detailed review in 2023 showed that these incidents

often involved human error, water quality issues, equipment failure, disease and parasites, frequently occurring in various combinations of these categories. In addition, there were a small number of severe incidents involving failures in the use of chemicals, resulting in toxic injury and death, and some incidents were related to the transfer of fish. From 2025 onwards, most incidents have been reported according to a new reporting structure, including more detailed information on causal factors, fish species, mortality and mitigation measures (Table 6.2.3).

**Table 6.2.2.** Serious welfare-related incidents reported to the Norwegian Food Safety Authority. The table is based on data from the Norwegian Food Safety Authority, recorded in MATS during the period 2018–2024 and, from October 2024 onwards, primarily in ALTINN. In addition, 70 reports related to transport were received by email in 2025; these are not included in the table. The data have been compiled by the Norwegian Veterinary Institute, and numbers for 2024 have been updated.

Total number reported serious welfare-related incidents 2018–2025								
	2018	2019	2020	2021	2022	2023	2024*	2025
Hatcheries («land production» from 2024)	58	98	162	204	228	208	238	284
Ongrowing/broadstock fish («sea production» from 2024)	1037	1489	1623	1617	1830	1455	1385	1488

**Table 6.2.3.** Number of reported serious welfare-related incidents submitted to the Norwegian Food Safety Authority, by type of incident categorised under 'Main condition'. The reports concern land-based fish facilities where the incident occurred in 2025. Data from the Norwegian Food Safety Authority are presented as recorded in their reporting system (via ALTINN). The introduction of a new reporting structure in 2025 means that the figures may be less comparable with, and more uncertain for assessing trends relative to, the years 2018–2024 than previously. Some reports are still submitted via MATS and are here combined with 'Other'; species classification then more uncertain (N = 19).

Serious welfare- related incidents reported in land production of fish in 2025				
Main condition	Total, all species	Salmonids	Cleaner fish	Other species
Other	73* (26%)	68	1	4
Human error	26 (9%)	24	0	2
Reduced feed quality/incorrect feeding	4 (1%)	4	0	0
Reduced roe quality	13 (5%)	13	0	0
Reduced water quality	28 (10%)	24	1	3
Disease	56 (20%)	50	3	3
Technical failure	27 (10%)	26	0	1
Unknown mortality	48 (17%)	39	5	4
Vaccination (hatchery phase)	9 (3%)	9	0	0
Total	284*	257	10	17

**Table 6.2.4.** Number of reported serious welfare-related incidents submitted to the Norwegian Food Safety Authority, by type of incident categorised under 'Main condition'. The reports concern seabased facilities where the incident occurred in 2025. Data from the Norwegian Food Safety Authority are presented as recorded in their reporting system (via ALTINN). The introduction of a new reporting structure in 2025 means that the figures may be less comparable with, and more uncertain for assessing trends relative to, the years 2018–2024 than previously. \*Some reports are still submitted via MATS and are here combined under 'Other'; species classification then more uncertain (N = 56).

Serious welfare-related incidents reported in sea facilities in 2025				
Main condition	Total all species	Salmonids	Cleaner fish	Other species
Algae and jelly fish	36 (2%)	33	1	2
Other*	205 (14%)	174	25	6
Delousing- non-medicinal	653 (44%)	652	1	0
Delousing- medicinal	32 (2%)	32	0	0
Human error	2 (0%)	2	0	0
Nature force, -storm etc.	25 (2%)	22	2	1
Predators	2 (0%)	2	0	0
Pumping (sorting/crowding/counting)	79 (5%)	72	4	3
Disease	232 (16%)	213	14	5
Technical failure	17 (1%)	17	0	0
Transport	27 (2%)	21	0	6
Unknown mortality	100 (7%)	74	23	3
Mortality at transfer to sea	78 (5%)	70	5	3
Total	1488	1384	75	29

## Input from the survey on regulations and management

In the survey, a total of 52 free-text responses were submitted under “additional comments on the fish health and welfare situation in the Norwegian aquaculture industry”. Several respondents highlight that the major challenges associated with salmon lice are not compatible with the industry’s growth ambitions (Chapter 6.6 Welfare consequences of salmon lice and treatments). There are calls for authorities to introduce stronger restrictions on the number of fish stocked at sea. One measure proposed is that biomass should be reduced if a site exceeds, for example, three non-medicinal and one medicinal treatment. It is further emphasised that, if mortality is to be reduced, handling-intensive treatments must be avoided. The use of shielding technologies and closed production systems is identified by several respondents as necessary measures. Others

express concern regarding the transition to closed production systems and the effects this may have on fish health and welfare, including the implications of reduced exposure to sunlight.

Several respondents mention that growth should be assessed on welfare and survival, not lice counts. In this context, there are calls for specific thresholds defining acceptable welfare, linked to mortality, the prevalence of runts/emaciated fish, and the occurrence of fish with wounds and injuries. Other welfare parameters mentioned include the registration of dead fish, with a need to improve data quality to enable more targeted measures. Several respondents also point at the potential of reporting automatically recorded welfare indicators, allowing a broader set of indicators to improve measurements of the welfare situation of farmed fish.

Many respondents believe that collaboration and information sharing must be strengthened. Fish health professionals call for greater openness from clients (aquaculture companies) in order to work towards improved welfare, noting that this becomes difficult without a comprehensive regional overview. It is further proposed that requirements should be introduced obliging aquaculture companies to obtain and follow professional fish health advice. It is also highlighted that incidents involving compromised welfare could have

been avoided if companies had paid greater attention to the input of caretakers and operational managers. In addition, several respondents express concern regarding insufficient biosecurity. It is noted that guidelines within area-based coordination routines are not always followed, particularly with respect to fallowing periods and the use of vessels for the transport of smolt or harvest-size fish, as well as for non-medicinal delousing operations.

## 6.3 Operations and Methods

By Kristoffer Vale Nielsen and Kristine Gismervik

**The Animal Welfare Act grants farmed fish the right to good welfare and places requirements on the animal owner regarding which considerations must be taken into account for the fish during the operation of an aquaculture facility. The technology or method used affects, for example, water quality, delousing frequency, handling, mortality, fish health and welfare, as well as growth performance. Suitability of technologies and methods must be documented.**

In the development and improvement of operations and methods, good fish welfare and health are important prerequisites for success. More detailed descriptions of welfare challenges, risk factors and mitigation measures can be found in the fact sheet on Technology and Fish Welfare (<https://www.vetinst.no/fagomrader/dyrevelferd/faktaark/teknologi-og-fiskevelferd>), as well as in the Norwegian Food Safety Authority's Guidance on Fish Welfare in the Development and Use of Methods, Equipment and Technology, etc. in Aquaculture. As of 1 January 2026, the Regulation No. 822 on the operation of aquaculture facilities (Aquaculture Operations Regulation) (§ 40) clarify the requirement that technology must be reported to the authorities in connection with approvals of operational plans. Such regulatory changes can be seen in connection with the fact that an increasing number of fish farmers along the coast are replacing traditional open net pens with alternative production systems in the growout farming of salmonids, and in some cases for postsmolt production. This year, we will take a closer look at these alternative production systems and what is known about fish welfare within them.

The alternative production systems have been developed mainly in response to the industry's challenges related to the management of salmon lice. A key element in the strategy behind alternative production systems is to prevent lice infestation by avoiding direct contact between the parasite and the host. The salmon louse's strategy, acquired over thousands of generations, is that the infective louse stage remains in the upper water layers, where the probability of encountering a host is greatest. In alternative production systems, knowledge of this strategy is utilised by preventing the fish from having direct contact with the upper water layers.

The advantage of reduced salmon lice infestation is not only the avoidance of the direct and negative effects that the parasite has on the fish, but also the avoidance of welfare challenges associated with delousing treatments (Chapter 6.6 Welfare challenges related to salmon lice and treatment). Compared with operation in traditional open net pens, farming in alternative production systems may also offer additional advantages. Depending on the production system, these may include a reduced risk of escape, opportunities for sludge collection, a lower risk of infection with other surface-associated agents, and the possibility of achieving more stable farming conditions, such as water temperature or current conditions.

At the same time, alternative production systems do not offer advantages only. Open netpen aquaculture is based on relatively inexpensive and simple technology that is also operationally reliable and well tested. Fish in open systems also have a relatively greater opportunity to choose an environment that suits them compared with fish in many alternative systems. Alternative production methods require greater investments, often higher energy consumption, larger areas or environmental interventions (particularly landbased systems), more complex technology, higher levels of competence, more monitoring and backup systems. At present, there is a more limited experience base from which to obtain information about these technologies. Operation of alternative production systems is generally more demanding in terms of competence, manpower and equipment, and may therefore entail a higher risk profile.

As is the case for traditional open netpen aquaculture, for alternative production systems there will also be sites that are more suitable than others. From the perspective of fish welfare, it is of primary importance that the site provides a stable and appropriate supply of fresh water, and that used water is effectively removed so that waste products are carried away. Appropriate water temperature and low exposure to infectious agents are also essential for ensuring successful operation. Most infectious diseases that cause problems in open netpen aquaculture may also cause problems in alternative production systems, and smolt quality is just as important in alternative systems as in open net pens (Chapter 6.5 Welfare challenges in juvenile fish production and Chapter 11.2 Poor smolt quality and runt syndrome).

A systematic and efficient buildup of the knowledge base on the operation of alternative production systems will be critically important in the coming years. Effectiveness depends, among other factors, on the sharing of new knowledge and experience for the benefit of the wider community, including avoiding the repetition of the same mistakes. The White Paper on Animal Welfare (Report to the Storting No. 8 (2024–2025), Norway) emphasises “that data from trials of new technology and methods that are of significance for animal welfare can be shared”.

### The Annual Survey

In this year’s survey, several questions were asked about alternative production systems compared with traditional open netpen aquaculture. As definitions of the technologies may be perceived as unclear, the results must be interpreted with caution. This particularly applies to the definitions of “Closed net pen” versus “Semiclosed net pen”, which in the survey are distinguished solely by whether the technology includes water treatment.

Respondents with experience from growout farming of Atlantic salmon (N = 119) and/or rainbow trout (N = 23) in Norway were given the opportunity to answer questions regarding the various alternative production systems. [Table 6.3.1](#) shows the distribution of responses. Subject to uncertainties related to definitions, the experience base may indicate the extent of use within the industry. As some respondents had experience with several types of alterna-

tive production systems for salmon, the total number of responses exceeds 119.

The followup questions aimed to map general experiences with the use of the individual technologies, compared with farming in open net pens. The questions concerned fish welfare, fish health, water quality, growth, number of delousing events, other handling, wound occurrence and mortality. For each technology and each question, the response options were: “increased”, “unchanged”, “reduced” and “don’t know”. The responses are summarised in [Figure 6.3.1](#), excluding the category “Closed net pen (with water treatment)” with only two respondents, as well as the category “Other”. Results of this type, and particularly those partly based on very few respondents, must be interpreted cautiously and only as indications of possible trends. Responses and comparisons will naturally also depend on the individual respondent’s frame of reference.

Among the respondents, there was a strong trend towards agreement that all the mentioned alternative facility concepts for salmon farming contributed to a reduction in the number of delousing events compared with farming in open net pens. Regarding to other handling, the results are very similar to those for the number of delousing events, i.e. a reduction associated with the use of alternative facility concepts. The authors find it unclear why other handling activities are reduced with the use of alternative facility concepts, but contributing factors may include shorter pro-

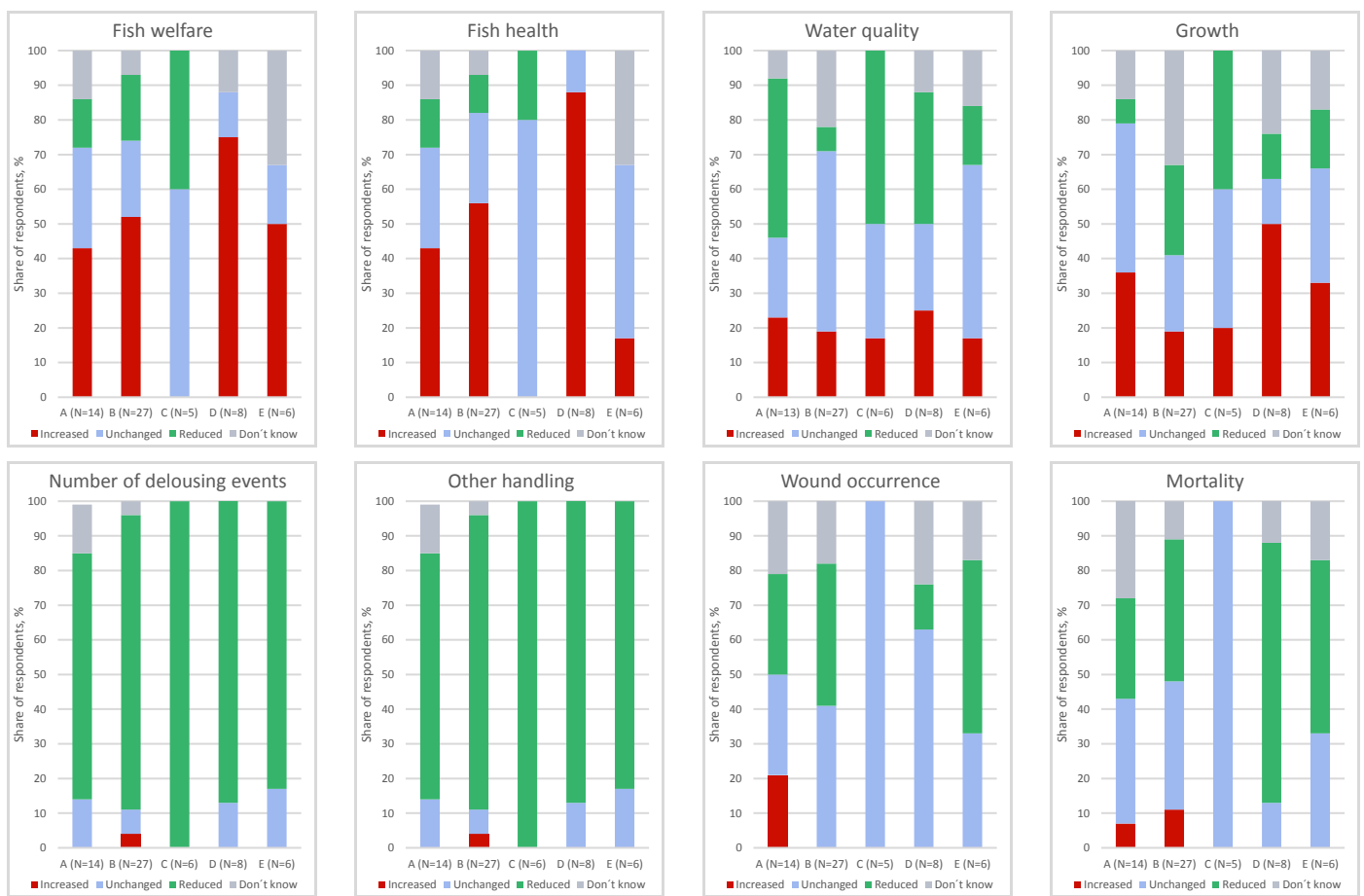
**Table 6.3.1** Respondents’ experience with alternative production systems for growout farming of Atlantic salmon and/or rainbow trout (RT) in 2025. In the category “Other”, one respondent had experience with exposed aquaculture, one with offshore facilities, and one with Preline.

	Salmon, number of responses (N = 119)	RT, number of responses (N = 23)
Closed net pen (with water treatment)	2	0
Semi closed net pen (no water treatment)	14	6
Submerged net pen (with air dome)	27	0
Snorkel net pen	6	0
Land based grow out aquaculture	8	0
Other (specify*)	3	0
No experience with the above	74	17

duction time (postsmolt production), less manual lice counting and welfare scoring. This requires further investigation to be clarified. Fewer delousing events and less handling are in themselves beneficial for animal welfare and are assumed to be part of the explanation for the slightly positive tendency observed in the results for several of the other parameters. Snorkel net pens appear to differ somewhat from the other facility concepts, with somewhat less positive results, but also a greater degree of agreement among respondents (although based on few respondents). Regarding the farming of rainbow trout in alternative production systems, respondents reported experience only with farming in semiclosed net pens. The experience with rainbow trout does not differ substantially from the experience with salmon, as described above.

### Assessment of the Situation

Problems associated with salmon lice are forcing the industry to rethink its practices, and the implementation of new production systems is likely to be part of the solution. Although lice problems are significantly reduced with new production systems, this must not lead to complacency. Operation of new production systems is more demanding, and many of the challenges faced in open netpen aquaculture are also relevant in new production systems. Developing and mastering a new production system requires a systematic and targeted approach. Good risk management and internal control are appropriate tools and are also expected to receive increased attention when the new Aquaculture Management Regulations are adopted. Systematic summarisation and sharing of knowledge and experience will ensure continued progress for the benefit of all parties, including the fish.



Fish Health Report 2025, Norwegian Veterinary Institute

**Figure 6.3.1** Respondents' experiences with different facility concepts, with regard to fish welfare, fish health, water quality, growth, number of delousing events, other handling, wound occurrence and mortality. Facility concepts: A = Semi closed net pen, salmon (no water treatment), B = Submerged net pen, salmon (with air dome), C = Snorkel net pen, salmon, D = Land based grow out aquaculture, salmon, E = Semi closed net pen, rainbow trout.

## 6.5 Welfare Challenges in Juvenile Production

By Kristin Bjørklund, Siri Sollien Gåsnes, and Kristine Gismervik

**The early life stages of Atlantic salmon and rainbow trout take place in freshwater. In the wild, salmon spawn in autumn, and the eggs remain in the river gravel throughout winter, hatching in spring. In modern juvenile production facilities, production begins with eyed eggs, which hatch into yolk-sac larvae. Initial feeding starts once the yolk sac has been fully absorbed. The fish subsequently develop from fry to parr before undergoing smoltification – a physiological transformation that enables adaptation to seawater.**

Current technology in juvenile fish facilities allows for control of most environmental conditions during rearing. Eggs are stocked year-round, and through the use of temperature regulation, light manipulation, selective breeding, and adequate feed availability, farmed salmon grow rapidly during this phase. A farmed salmon typically reaches a weight of 100 grams within six to twelve months in a juvenile production facility. In contrast, wild smolts require between one and eight years to reach a weight of 10–80 grams.

A comprehensive understanding of production-related challenges in juvenile fish is essential. Fish health and welfare can be influenced by temperature, light conditions, water quality, genetics, and smoltification regimes, both during the juvenile phase and later in the marine environment. There remains a substantial need for knowledge in this area, and non-infectious conditions related to production practices represent the majority of health and welfare challenges during the juvenile phase.

**For further information on welfare challenges in juvenile fish production, see the Norwegian Veterinary Institute's fact page (in Norwegian):**

[Velferd hos laks i settefiskanlegg](#)

### Small Fish – A Critical Start

Approximately 25% of total mortality (direct mortality and fish euthanized for destruction) among salmon during the juvenile phase involve fish weighing 0–3 grams. Actual mor-

tality is likely higher, as approximately 45% of the data material has been excluded from the calculations, with the majority of excluded data relating to fish in the 0–3 gram size class ([Chapter 2.2 Mortality and Losses of Salmonids in the Juvenile Phase](#)). There are limited descriptions of mortality causes during this early life stage.

The SMÅFISKVEL report from 2019 describes that high mortality among fish weighing less than 3 grams may be associated with challenges related to the timing of transfer to tanks, stocking density, feed quality, feeding practices, water quality, water flow, tank design, temperature, disease, and malformations. Holm et al. (2025) describe disturbances in yolk sac development in salmonids. The yolk sac serves as the larva's nutritional reserve prior to initial feeding and is therefore critical for normal development. Abnormal appearances of the yolk sac, such as a compact, yellowish structure or the presence of a white mass, haemorrhages, constrictions, or incomplete absorption, may indicate Coagulative Yolk Disease (CYD). However, other non-specific abnormalities in yolk sac development are also observed.

Clinical signs may include uneven development during the hatchery phase and elevated mortality associated with the onset of feeding. Salmonids with yolk sac abnormalities often also exhibit changes in other parts of the body, such as a slender body shape and deformities in the neck and tail regions. In cases of insufficient cranial ossification, protrusion of brain tissue may occur. Concurrent infections with *Saprolegnia* spp. have been described, and removal of affected individuals is important both from a welfare and biosecurity perspective. Fish with disturbances in yolk sac development often die early or are removed during grading, and limited knowledge exists regarding the potential for recovery.

The underlying cause of CYD remains unknown, but environmental factors, including temperature during fertilisation, transport (shock, vibration, and duration), and later conditions in juvenile production facilities, cannot be ruled out. Improved disease diagnostics, systematic evaluation of operational routines, and further research into these conditions may contribute to better understanding of causal mechanisms and the development of effective preventive measures.

## Developmental Rate and Robustness

Recent research indicates that less intensive production at lower temperatures, combined with clear cues promoting smoltification using a winter signal, has positive effects on fish welfare during the subsequent marine phase (Fish Health Report 2024, Table 5.6.1). This is supported by a field study in which a total of 5.4 million smolts aged 15 months or older, produced using cold-water regimes, were stocked at sites in Production Areas (PA) 2-4 in 2022. Control groups consisting of conventionally produced smolts were present at the same sites. The results showed that smolts produced under cold-water conditions outperformed control fish at both the site level and relative to the production area average, with respect to survival, feed conversion efficiency, and the proportion of harvest fish classified as "superior" quality (Klakegg and Sørum, 2025, submitted).

To ensure a successful transition to seawater, fish must be sufficiently smoltified (Chapter 11.2 Poor Smolt Quality and Runt Syndrome). This can be challenging in heterogeneous groups where some individuals are not capable of tolerating the transition. Such fish may experience environmental stress that compromises welfare. Thorough production planning is therefore critical, including consideration of environmental conditions at the time of stocking.

In recent years, the Norwegian Food Safety Authority's appeals unit has processed two cases in which producers were issued administrative fines for stocking smolts at low sea temperatures (<4°C). The fish developed skin lesions, and in one case mortality reached up to 26% at cage level within the first month following stocking. The severity of the mortality was assessed in accordance with the Laksvel protocol, which defines monthly mortality exceeding 2% as very high. In both cases, the appeals unit upheld the fines. In the case described above, the unit further concluded that the maximum fine should have been imposed, as the risks associated with stocking at low temperatures are well known and appropriate measures to safeguard sick and injured fish had not been implemented. The decision underscores the importance of thorough risk assessments and adherence to them.

## Welfare Incidents During the Land-Based Phase

Under current regulations, serious welfare incidents must be reported (Chapter 6.2 Fish welfare and health in regulations and public management). The total number of reported inci-

idents during the juvenile/land-based phase increased substantially from 2018 (58 incidents) to 2021 (204 incidents), after which the number stabilised (Fish Health Report 2024, Table 5.6.2). In 2025, the total number of reported incidents during the land-based phase increased again, reaching 288. The majority of these incidents were classified as serious and required follow-up by the Norwegian Food Safety Authority.

Following the implementation of a new reporting system in 2025, primary causes are now more specifically categorised. The five most frequently reported causes are disease, other, unexplained mortality, reduced water quality, and technical or human failure (Chapter 6.2 Fish welfare and health in regulations and public management, Table 6.2.2). For incidents where disease is listed as the primary cause, the most reported conditions are heart and skeletal muscle inflammation (HSMI), "other," and various wound types (Chapter 6.2 Fish welfare and health in regulations and public management, Figure 6.2.1).

## The Annual Survey

In the survey conducted among fish health personnel and inspectors from the Norwegian Food Safety Authority, respondents were asked to assess which factors they consider most important in causing mortality, reduced welfare, poor growth, and whether the occurrence of these issues is increasing in juvenile fish facilities. As in previous years, the primary challenges are associated with non-infectious diseases and suboptimal production conditions (Chapter 11 Other Health Problems in Farmed Salmonids).

The ranking of health and welfare challenges for salmon in juvenile production facilities is largely consistent with that of 2024. Haemorrhagic smolt syndrome (HSS), nephrocalcinosis, reduced water quality, development of looser fish, and impaired smolt quality are ranked as important contributors to mortality and reduced welfare (Appendix A1). Internal transfer between units with differing water quality is ranked higher than in 2024 as a cause of mortality and welfare reduction. Smoltification problems are ranked as somewhat less important overall but show the greatest increase in reported occurrence. As in 2024, fin erosion is assessed by most respondents as an important contributor to reduced welfare.

For rainbow trout, development of looser fish (runt syndrome) has increased in importance over the past two years

and is now most frequently ranked as a key cause of mortality, reduced welfare, and poor growth (Appendix A2). This is followed by nephrocalcinosis, deformities, IPN, reduced water quality, and internal transfer between units with different water quality conditions.

In the open-text fields, respondents elaborate on both improvements and the complexity of disease and welfare issues during the juvenile phase. For salmon, several respondents identify suboptimal feeding practices as a cause of reduced growth and welfare. Inadequate size grading may result in overfeeding, leading to deteriorated water quality. Feed distribution equipment that fails to deliver feed evenly is also highlighted as a challenge, as are high temperatures and reduced feeding in recirculating aquaculture systems implemented to control elevated ammonium levels. Respondents describe how suboptimal feeding leads to stress and aggressive behaviour, including fin and opercular biting.

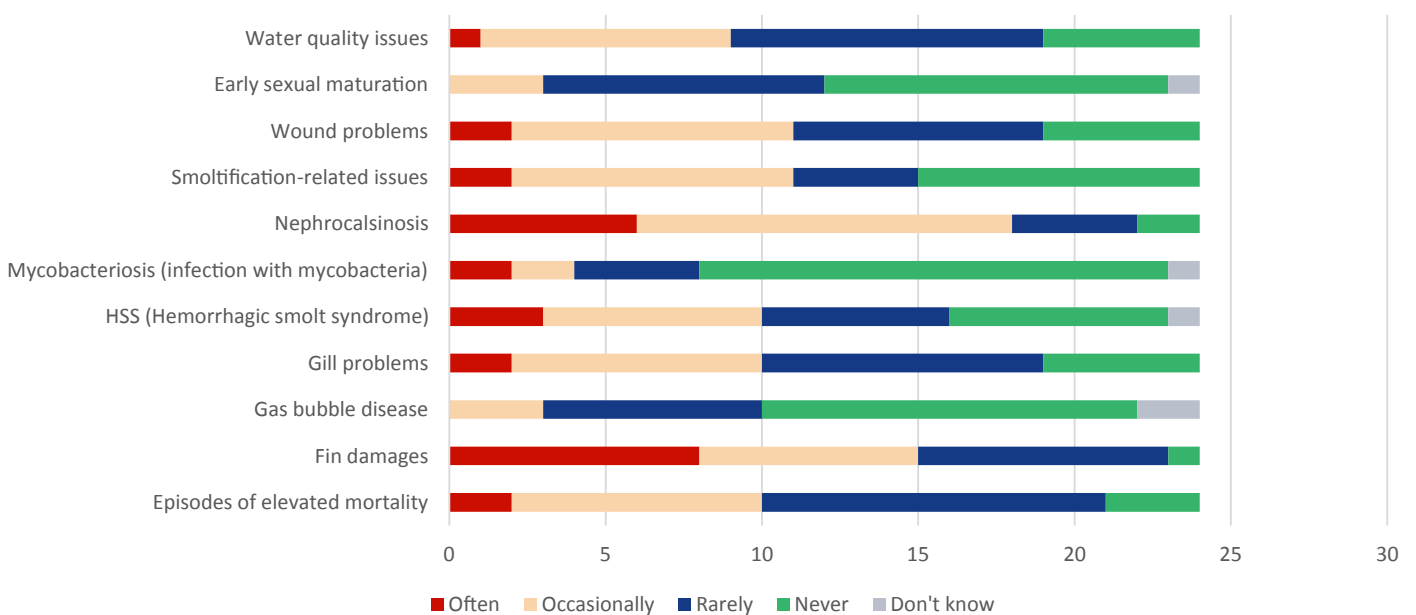
High stocking densities may complicate monitoring and management of fish groups, and insufficient size grading may promote development of looser fish and mortality throughout production. Respondents describe the importance of appropriate size distribution as difficult to quantify and understand, despite being a widespread issue. Poor water quality may also result from delayed smolt delivery, leading to prolonged periods of high stocking density.

Yolk sac coagulation is highlighted as a condition associated with increased mortality in eggs and yolk-sac larvae. Some respondents report positive trends, including a reduction in heart and skeletal muscle inflammation (HSMI), and indicate that overall challenges during the juvenile phase have not worsened but are stable or slightly reduced.

### Rearing of Large Smolts

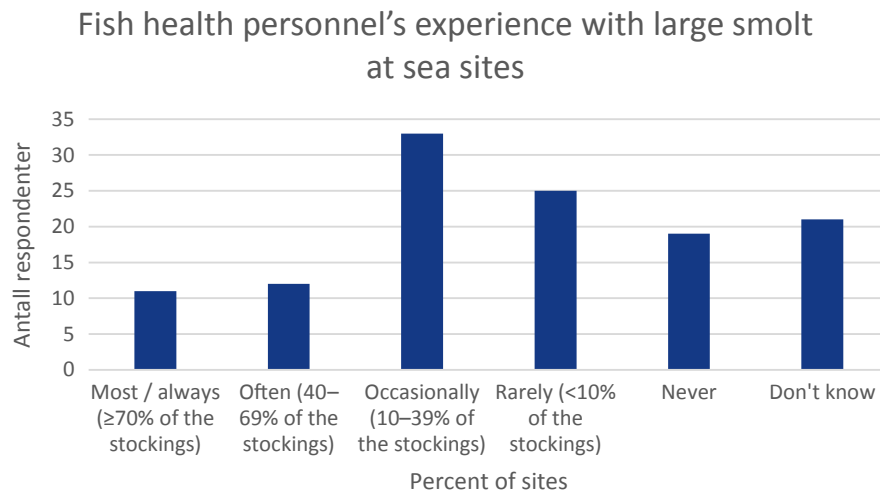
Twenty-four respondents answered questions regarding observed health and welfare challenges associated with the

Large smolt: frequency of welfare and health challenges



Fish Health Report 2025, Norwegian Veterinary Institute

Figure 6.5.1 Respondents' observations of welfare and health challenges in the production of large smolt, based on the survey (N = 24).



Fish Health Report 2025, Norwegian Veterinary Institute

**Figure 6.5.2** Survey respondents' experiences with transfer of large smolt (>250 g) to grow-out sites in marine environments (N = 121).

rearing of large smolts (Figure 6.5.1). Fin damage is the condition most frequently reported as commonly observed, while nephrocalcinosis is the most prevalent when the responses "often" and "occasionally" are combined. Smoltification issues, wounds, HSS, gill disease, and episodes of elevated mortality are also reported as being observed "often" or "occasionally" by up to eleven respondents. Mycobacteriosis, early sexual maturation, and gas bubble syndrome are reported as "never" or "rarely" observed by the majority of respondents, although some respondents also report frequent observations of mycobacteriosis.

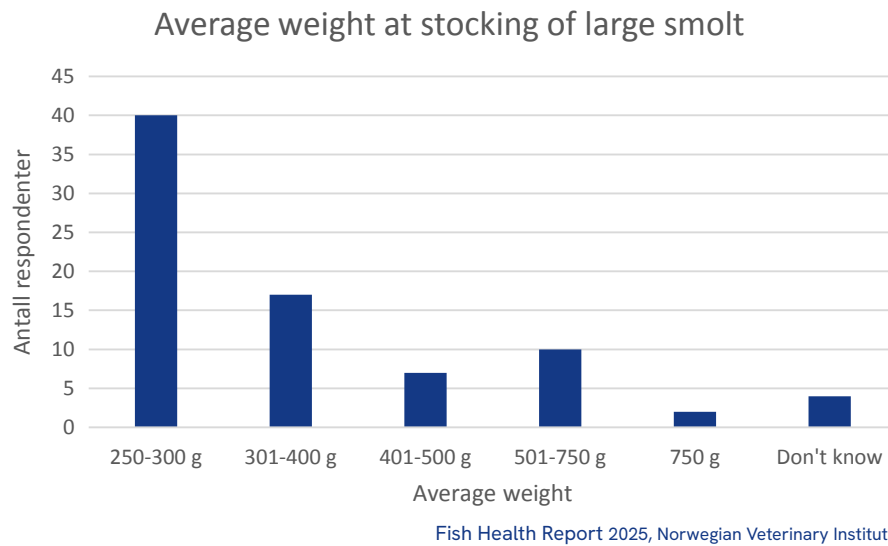
In the open-text responses, respondents note that achieving uniform smoltification can be challenging for large smolts reared in pure freshwater, and an increase in welfare score deficiencies is reported for such fish. Large smolts are also observed to exhibit more fin damage and an increased risk of cataracts and reduced mucus layer integrity. Fin damage is often associated with periods of feed deprivation or high stocking densities prior to delivery. Additional challenges include the occurrence of impact-related injuries, such as fractures and cerebral haemorrhages, during transport and delivery when pipe systems are not adequately dimensioned for large smolts.

### Large Smolts in Seawater

A total of 121 respondents report experience with stocking large smolts at on-growing. Most indicate that only a small proportion of the sites they oversee involve large smolts (Figure 6.5.2).

Among the 80 respondents who reported stocking weights for large smolts, half indicated weights between 250 and 300 grams (Figure 6.5.3). Respondents were also asked to estimate the average duration of the marine phase from stocking to slaughter. Sixteen percent (13 respondents) reported a duration of less than 10 months, 20% (16 respondents) reported 10-12 months, and 20% reported more than 12 months. A substantial proportion (44%, 35 respondents) were unable to estimate the duration.

When asked whether changes in health and welfare challenges are experienced for large smolts in the marine phase, 37% (30 of 81 respondents) reported that they did not know or considered it too early to assess. Twenty-eight percent reported a reduction in challenges following the transition to large smolts, while 14% reported increased challenges. For 21%, the situation was perceived as unchanged.



**Figure 6.5.3** Typical average body weight of large smolt at sea transfer, as reported by survey respondents (N = 80).

Respondents reporting improvements or deterioration elaborated further in open-text comments. Improvements were primarily attributed to reduced time in seawater, resulting in fewer delousing treatments and fewer handling-related secondary infections, which is beneficial for fish welfare. Several respondents noted that large smolts are more robust at stocking and exhibit low mortality related to incomplete smoltification when originating from facilities operating with full or near-full seawater (approximately 35‰ salinity).

It was also reported that large smolts originating from low-salinity systems may be adapted to seawater but are not always sufficiently smoltified or may have undergone de-smoltification, which can result in mortality following stocking. Prolonged land-based rearing of large smolts has been associated with non-specific gill inflammation, possibly linked to increased particulate loads in the facility. Compromised gill health represents a poor starting condition for the marine phase. Additionally, respondents reported that post-smolts may carry 'land-based' diseases into the marine environment, including wounds caused by *Tenacibaculum* spp.

Other respondents highlighted the advantage of being able to stock fish at higher sea temperatures, reporting reduced incidence of tenacibaculosis and winter ulcers under such conditions. Nephrocalcinosis and HSMI were also identified as health challenges affecting large smolts.

### Vaccine Effects and Adverse Reactions

Some respondents reported an increase in vaccine-related adverse effects, manifested as adhesions and melanin deposition within the abdominal cavity. This increase is associated with the use of a new *Moritella* vaccine, and it has been suggested that one contributing factor may be the increased volume of vaccine administered intraperitoneally.

### References:

- Holm H, Faureng E & Thoen E (2025). Forstyrrelser i utvikling av plommesekk hos laksefisk. Norsk Veterinærtidsskrift, 2025(9). [https://nvt.vetnett.no/journal/2025/9/m338/Forstyrrelser\\_i\\_utvikling\\_av\\_plommesekk\\_hos\\_laksefisk](https://nvt.vetnett.no/journal/2025/9/m338/Forstyrrelser_i_utvikling_av_plommesekk_hos_laksefisk)
- Klakegg Ø & Sørum H (2025). Natural cold freshwater temperatures and light regimes in Atlantic salmon smolt production can improve the sea phase performance. SSRN. <https://doi.org/10.2139/ssrn.5132018>

## 6.6 Welfare Challenges Related to Salmon Lice and Delousing

By Kristin Bjørklund and Kristine Gismervik

Widespread resistance to available medicinal treatments against salmon lice has led to the development and extensive use of alternative control methods (including cleaner fish and laser technology), as well as increased emphasis on preventive measures. Non-medicinal delousing methods are based on thermal (hot water), mechanical (various washers and brushes), and freshwater principles. Combinations of methods have become relatively common, and since 2023, the use of triple-method treatments has been reported. The extensive use of non-medicinal delousing methods to control salmon lice and avoid biomass reductions under the Traffic Light System has welfare consequences for farmed fish.

Mechanical injuries associated with non-medicinal delousing have, over the past eight years including 2025, been assessed as the most significant welfare challenge for farmed salmon in the marine phase (Appendix B1). Stress-induced immunosuppression combined with damage to the skin barrier or gills may lead to secondary infections following delousing. An epidemiological study conducted by the Norwegian Veterinary Institute demonstrated, among other findings, a significantly increased risk of pasteurellosis at sites that had carried out thermal or mechanical delousing. No corresponding increase in risk was observed following freshwater treatments. Mechlaoui et al. (2025) investigated the effects of mechanical delousing and identified mild to moderate changes in gills, thymus, and nasal cavities in salmon following commercial delousing. The study discusses whether the observed deterioration after the third delousing was due to cumulative weakening from the previous treatments or other factors, but no definitive conclusion could be drawn.

Damage to fins and skin can heal, but the rate of healing depends on temperature - the closer the temperature is to the optimal range for salmon, the faster the healing process. One study demonstrated that regeneration of a new epidermal layer can take 6-12 hours at 4 °C, compared to 4-6 hours at 10-14 °C. Stress caused by repeated crowding, low temperatures, high stocking density, or suboptimal feeding can slow or even halt wound healing (Virtanen et al., 2023).

Complex gill disease was ranked as the second most important cause of mortality by respondents in the survey and as the factor with the greatest increase in occurrence among salmon (Appendix B1). Gill disease impairs oxygen uptake. Hvas et al. (2017) found that reduced maximum metabolic capacity decreased aerobic capacity by 50% in fish with amoebic gill disease (AGD) compared to fish with healthy gills. This makes fish more vulnerable to hypoxia, both during handling and in the period after delousing. Gill disease may also increase energy expenditure on respiration and osmoregulation, thereby reducing the capacity for tissue repair (Stien et al., 2025).

It has repeatedly been shown that non-medicinal delousing (IMM) is associated with increased mortality. Stien et al. (2025) reviewed the welfare indicators described in the LAKSVEL protocol in relation to delousing situations. Injuries to the eyes, gills, and snout were assessed as particularly burdensome for salmon in the period following delousing (Chapter 6.1 Welfare Indicators). To implement further targeted measures to reduce mortality, standardized categorisation of dead fish is essential (Chapter 2 Mortality in Aquaculture and Chapter 6.2 Fish Welfare and Health in Regulations and Public Management).

### Welfare Assessment of Treatments

Thermal delousing is controversial, as the water temperatures used have been shown to be painful for fish (Fish Health Report 2023, Table 5.7.1). Because delousing efficacy is highest at temperatures that have the most negative impact on fish welfare, this principle is challenging to apply in practice. Recent results from a laboratory study in which rainbow trout (~200 g and ~3 kg) were exposed to hot water at 26-34 °C and 28-34 °C for 30 seconds showed clear behavioural stress responses, with the strongest responses observed at 32-34 °C (Nilsson, 2025). Compared with salmon in comparable trials, trout exhibited a higher incidence of loss of equilibrium, particularly among larger fish. A smaller heart size relative to body mass may be a factor limiting stress tolerance. The duration of equilibrium loss was similar after exposure to 28, 30, and 32 °C, but significantly longer at 34 °C. The study demonstrates that thermal delousing is highly stressful for rainbow trout as well and

that documentation supporting welfare-acceptable use is still lacking. The Norwegian Food Safety Authority did not implement the previously announced ban on thermal delousing.

All delousing treatments must be prescribed by fish health personnel, i.e. veterinarians and fish health biologists. This applies to both medicinal and non-medicinal interventions. Fish health personnel first assess whether treatment is necessary and subsequently whether the fish's health and welfare status permits safe handling. Method selection is based on fish welfare considerations, expected efficacy (including resistance status), food safety, and environmental impact.

The role of fish health personnel can be demanding due to conflicting considerations between fish welfare and the interests of stock owners. Tekna conducted an occupational survey among fish health personnel in 2025, as in 2023. In 2025, 75% reported having considered leaving their job, with 43% citing high workload as the reason. In the same survey, one in three respondents expressed concern about losing assignments if they opposed farmers' assessments of delousing needs—an increase from one in four in 2023.

Prevention is preferable to treatment of diseases, including salmon lice. Aquaculture companies are responsible for ensuring the welfare of the fish in their care. The proposed new Regulation on Aquaculture Management (currently under public consultation) introduces requirements for obtaining relevant professional expertise in management and improvement efforts. Achieving the industry goal of 95% survival will require prioritisation of biological expertise in operational planning and risk assessments ([Chapter 6.2 Fish Welfare and Health in Regulations and Public Management](#)). Anchoring biological competence and steering towards a common welfare objective may also reduce the pressure experienced by fish health personnel.

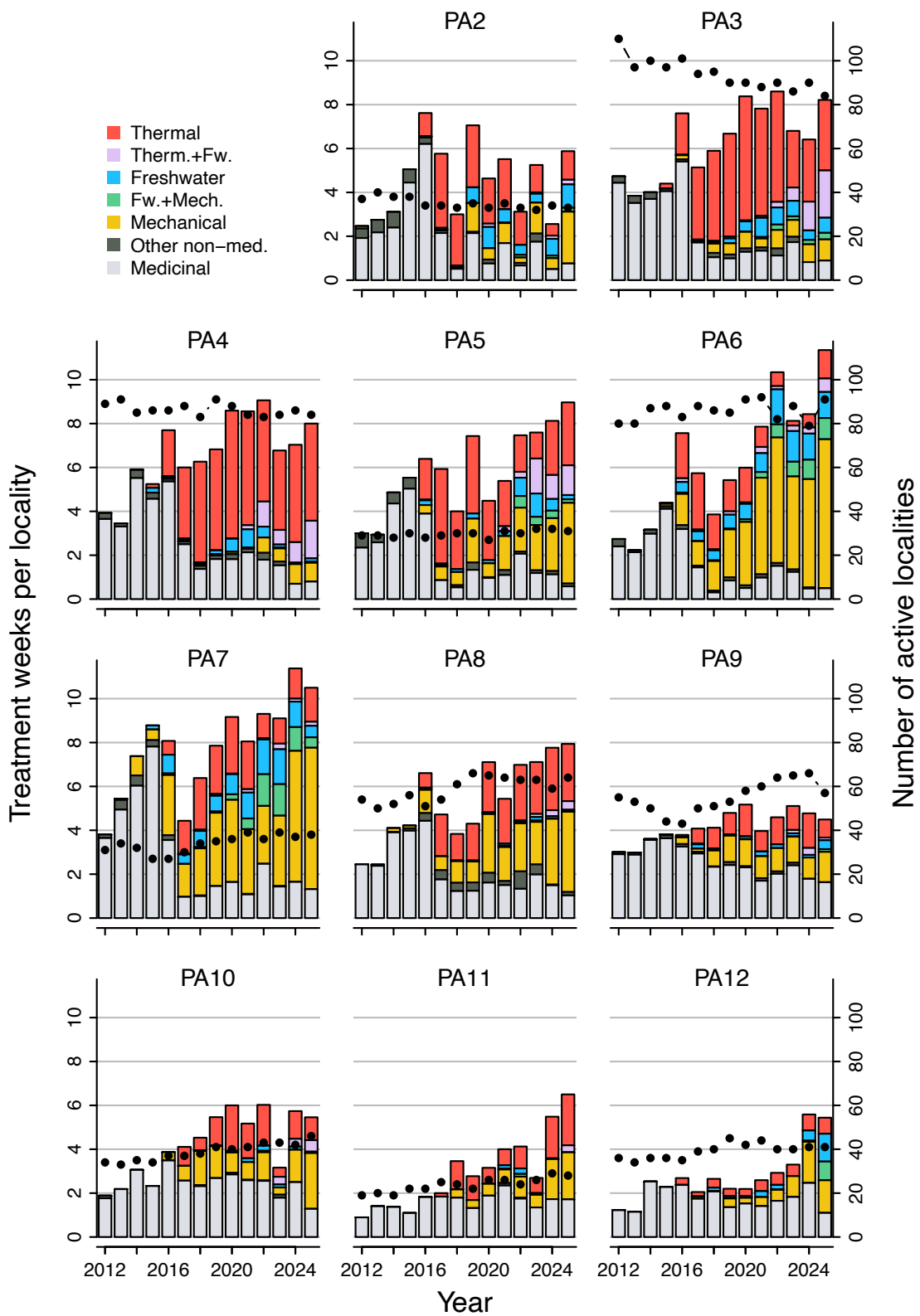
In May 2024, the Norwegian Food Safety Authority updated its guidelines for animal health personnel and the use of non-medicinal delousing (IMM) to clarify expectations regarding welfare-acceptable treatments. The guidelines specify threshold values for selected welfare parameters before, during, and after delousing. In the 2025 survey, respondents were again asked about the extent to which the guidelines were applied. Overall adherence was higher than in 2024: 78% (77 of 99 respondents) reported using guide-

line thresholds, compared to 52% in 2024. Fourteen percent reported not using the thresholds (30% in 2024), and 8% responded "do not know." Twelve respondents explained in free-text comments why the thresholds were not used. Several stated that the thresholds are unrealistic under current field conditions and/or not sufficiently anchored with fish health personnel. Temperature recommendations were highlighted as difficult to apply due to climatic conditions in Finnmark, and wound thresholds were described as difficult to meet in practice. Some respondents indicated that they use their own thresholds, which in certain cases were stricter than those outlined in the guidelines.

### Trends in Delousing Methods in 2025

In 2025, the highest number of non-medicinal delousing weeks ever recorded was reported. Use increased across all methods. Mechanical delousing as sole method showed the largest increase and was the most frequently used delousing method in 2025, as has been the case since 2023, when it surpassed thermal delousing in number of treatment weeks. [Table 10.1.2 in Chapter 10.1 Salmon Lice – \*Lepeophtheirus salmonis\*](#) presents reported combinations used at the same facility within the same week. From 2024 onwards, reporting practices were adjusted to better quantify confirmed combination treatments. When assessing trends over time, caution is required, as previous data do not distinguish between true combination treatments and cases where different cages at a site were treated with different methods in the same week. In 2025, the combination of freshwater and thermal treatment was the most used, as in 2024.

Delousing methods are used differently across geographical regions ([Figure 6.6.1](#)). In PA3, PA4, and PA11, thermal delousing is the most commonly used principle. These production areas have experienced increased use of freshwater combined with thermal treatment, as well as an overall increase in treatment weeks. In PA6-PA8 and PA10, a large proportion of delousing is mechanical. PA6 exhibited the strongest increase in delousing weeks in 2025, driven by increased use of both mechanical and thermal methods, with an average of approximately 12 treatment weeks per site. PA2 also recorded substantially more delousing weeks in 2025 compared to 2024, although the area appears to follow a two-year cycle of alternating high and low delousing activity. Nevertheless, delousing activity in 2025 was higher than in 2023, with more frequent use of mechanical delousing.



Fish Health Report 2025, Norwegian Veterinary Institute

Figure 6.6.1 Trends in the number of treatment weeks per site across the different production areas (PA). The bars represent the number of treatment weeks for the various delousing methods, including medicinal delousing treatments (scale on the left y-axis). The number of active sites per PA is indicated by black dots (right y-axis). PA1 and PA13 are omitted due to a low number of active sites.

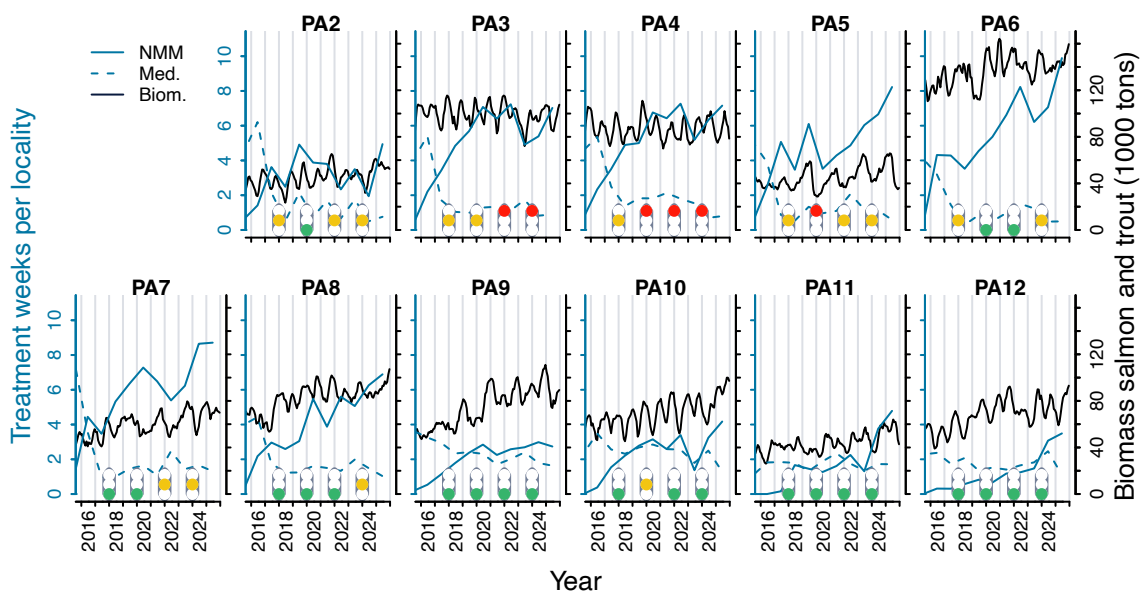
PA7 showed an overall decline in the number of delousing weeks, particularly for freshwater treatments, freshwater combined with mechanical treatment, and medicinal treatments. A general reduction in the use of medicinal delousing has been observed in Central and Northern Norway. The most pronounced reductions in 2025 compared with 2024 were observed in PA12 and PA10.

Overall, the use of medicinal treatments decreased (Table 10.1.1), although a slight increase in medicinal delousing weeks was observed in PA2-PA4 (Figure 6.6.1). Of the medicinal agents used, emamectin benzoate and azamethiphos were most widely applied (Chapter 10.1 Salmon Lice (*Lepeophtheirus salmonis*)). Northern Norway (PA8-PA12) experienced a substantial increase in delousing activity over the past two years compared with 2023, except in PA9, where activity declined. The past two years have been characterised by warm summers with elevated sea temperatures and consequently high salmon lice infection pressure

(Figure 10.1.4), which likely contributed to increased IMM use in northernmost areas. The reason for reduced delousing activity in PA9 is unknown, but lower biomass and fewer fish compared to 2024 likely reduced infection pressure. For further information on salmon lice larvae and infection pressure, see Figure 10.1.3.

### Welfare Consequences of the Traffic Light System

The Traffic Light System in Norwegian aquaculture was established to provide predictable and sustainable growth. The sustainability indicator currently used is mortality of migrating wild salmon smolts resulting from salmon lice infection. See the website of the Steering Group for Assessments of Salmon Lice Impact for further information (<https://trafikkllyssystemet.no/> in Norwegian). A summary of traffic light colours, temporal trends in delousing weeks (medicinal and non-medicinal), and biomass per production area is presented in Figure 6.6.2. As currently designed, the



Fish Health Report 2025, Norwegian Veterinary Institute

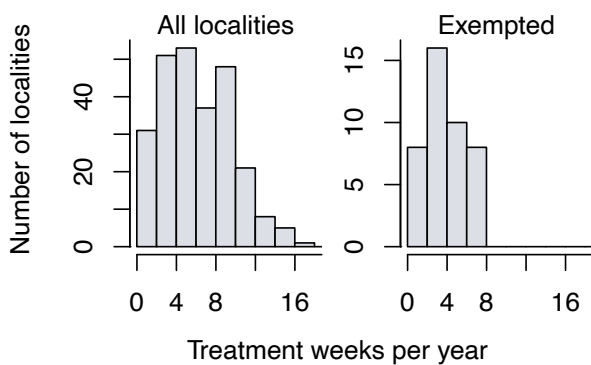
**Figure 6.6.2** Temporal trends in salmon lice treatments and farmed fish biomass in each production area (PA) from 2016 to 2025. Solid blue lines represent the number of weeks with non-medicinal lice treatments (IMM), while blue dashed lines represent weeks with medicinal treatment (Med.), as reported to the Norwegian Food Safety Authority. Black lines show the biomass (Biom.) of Atlantic salmon and rainbow trout in marine aquaculture sites, reported to the Directorate of Fisheries. The traffic lights indicate which production areas received green, yellow or red status from the Government under the Traffic Light System. Red status for PA3 and PA4 in the first period is shown as yellow, as red status did not result in a reduction in permitted production capacity during the first year. PA1 and PA13 are not shown due to the limited number of operating sites.

Light System challenges fish welfare. Industry growth is currently occurring from green into yellow zones across all areas, implying 10–30% lice-induced mortality among wild salmon smolts. Grazing damage caused by lice leads to prolonged suffering for wild fish and, in severe cases, slow and painful death. For farmed fish, continued high lice pressure combined with current IMM-based treatment regimes results in reduced welfare and increased mortality.

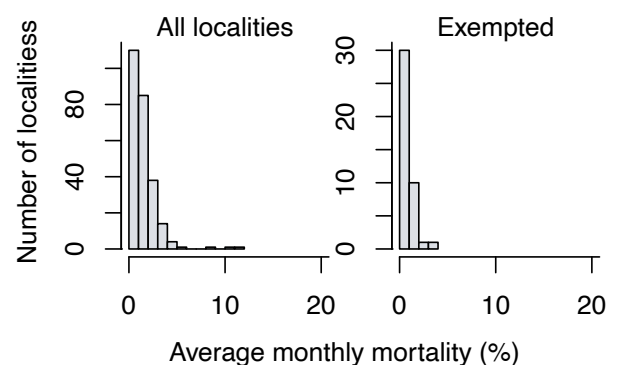
Section 12 of the Production Area Regulation currently allows for exemption growth, whereby aquaculture producers may apply for exemption from biomass reduction in red areas or permission to grow in yellow areas. Prior to regulatory amendments in September 2023, exemption growth conditions imposed no limits on the number of non-medicinal treatments allowed; currently, a maximum of six treatments per fish is permitted. There remains a lack of publicly available welfare documentation for six non-medicinal delousing treatments conducted on the same fish group. As such, the regulation may, in its current form, contribute to regulatory breaches, in reference to Section 20 of the Aquaculture Operations Regulation, which requires that methods,

installations, and equipment may only be used when their welfare consequences are documented. The exemption growth scheme has previously been proposed for removal by multiple stakeholders. The scheme was originally intended to encourage novel operational practices or technologies capable of documenting reduced parasite and disease transmission.

In 2025, 84 applications for exemption growth were submitted, of which 15 were rejected. Due to joint operations, the number of sites was somewhat lower than the number of applications. Most rejections were due to violations of lice reporting requirements or lice level thresholds, followed by breaches of the condition allowing a maximum of one medicinal treatment, violations related to qualification periods, and one case exceeding six non-medicinal treatments. A review of sites in PA3 and PA4 granted exemption growth in 2025 (N = 42) showed that these sites had fewer treatment weeks per production year (average 3.8) than other sites in the same areas (average 6.1) (Figure 6.6.3). The analysis does not account for the fact that, in most treatment weeks, only individual cages—not entire sites—were



**Figure 6.6.3** Total number of treatment weeks per year for all sites (left panel) compared with sites granted exemption growth in 2025 (right panel, N=42). The x-axis shows the number of weeks with non-medicinal delousing reported to the Norwegian Food Safety Authority per year, and the y-axis shows the number of sites. Only sites in PA3 and PA4 are included, as most sites granted exemption growth are located in these areas. The qualification period extended from week 40 of 2023 through week 39 of 2025; comparisons with other sites were therefore made using production cycles of equal duration.



**Figure 6.6.4** Mortality at all sites in PA3 and PA4 (left panel), compared with sites granted exemption growth in 2025 within the same areas (right panel, N=42). Mortality is defined as the average monthly mortality across all months during which the sites were active within the qualification period (from week 40 of 2023 through week 39 of 2025). The x-axis shows mortality, and the y-axis shows the number of sites.

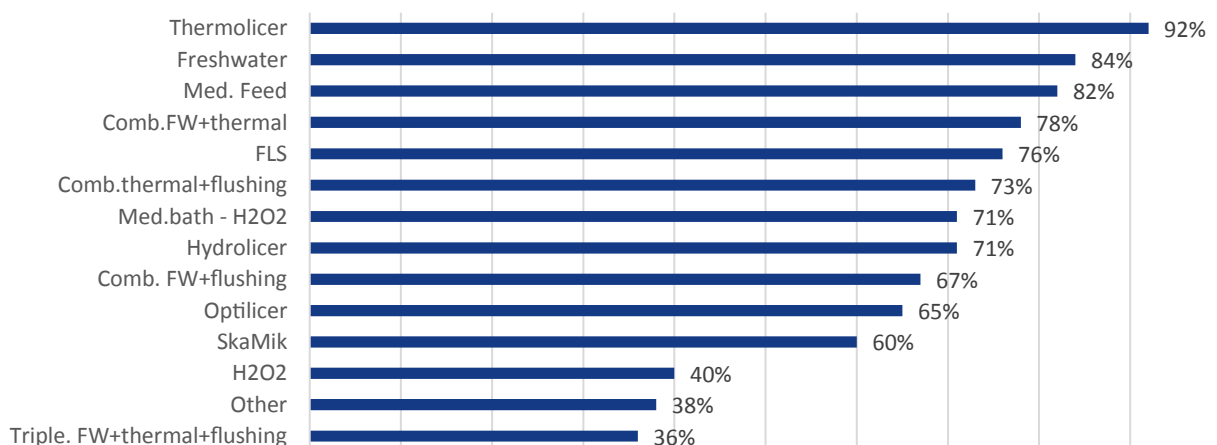
treated. Of the treatment weeks reported from sites granted exemption growth, 38% involved site-wide treatments, compared with 28% for PA3 and PA4 overall. Average monthly mortality rates at sites granted exemption growth compared with overall mortality in PA3 and PA4 are presented in Figure 6.6.4. The figure shows that some sites with up to 4% average monthly mortality nevertheless received exemption growth. Serious welfare incidents must be reported to the Norwegian Food Safety Authority, and in 2025 a total of 64 incidents were reported from the 42 sites granted exemption growth in PA3 and PA4 that year. To improve goal-oriented management towards good fish welfare, welfare clearance of sites could be introduced prior to growth approval. Such clearance could include requirements related to survival rates (including fish subjected to non-medicinal delousing), documentation of welfare impacts of treatments, evaluation of reportable welfare incidents, and slaughter quality (Chapter 6.7 Slaughter and Slaughter Data). This could strengthen the Traffic Light System and promote ethical value creation based on sustainability.

### The Annual Survey

A total of 101 respondents shared their experiences with various delousing methods in the annual survey among fish health personnel and inspectors from the Norwegian Food Safety Authority (Figure 6.6.5). Thermolicer remained the most widely experienced method in 2025, as in 2024, with 92% reporting experience compared to 87% in 2024. Experience with freshwater delousing and Flatsetsund Flusher (FLS) also increased, reported by 84% and 76% of respondents respectively, compared to 80% and 63% in 2024. Experience with Optilicer and SkaMik declined slightly, reported by 65% (down from 72%) and 60% (down from 64%).

The proportion of respondents with experience in combination treatments had increased in prior years but did not continue to rise in 2025. The freshwater-thermal combination was reported by 78% of respondents in 2025 (down from 84%). Other combinations, including thermal with washing and freshwater with washing, showed similar experience levels compared to 2024. Experience with triple-method treatments (freshwater, thermal, and washing) declined to 36% from 42%.

Experience with delousing methods 2025



Fish Health Report 2025, Norwegian Veterinary Institute

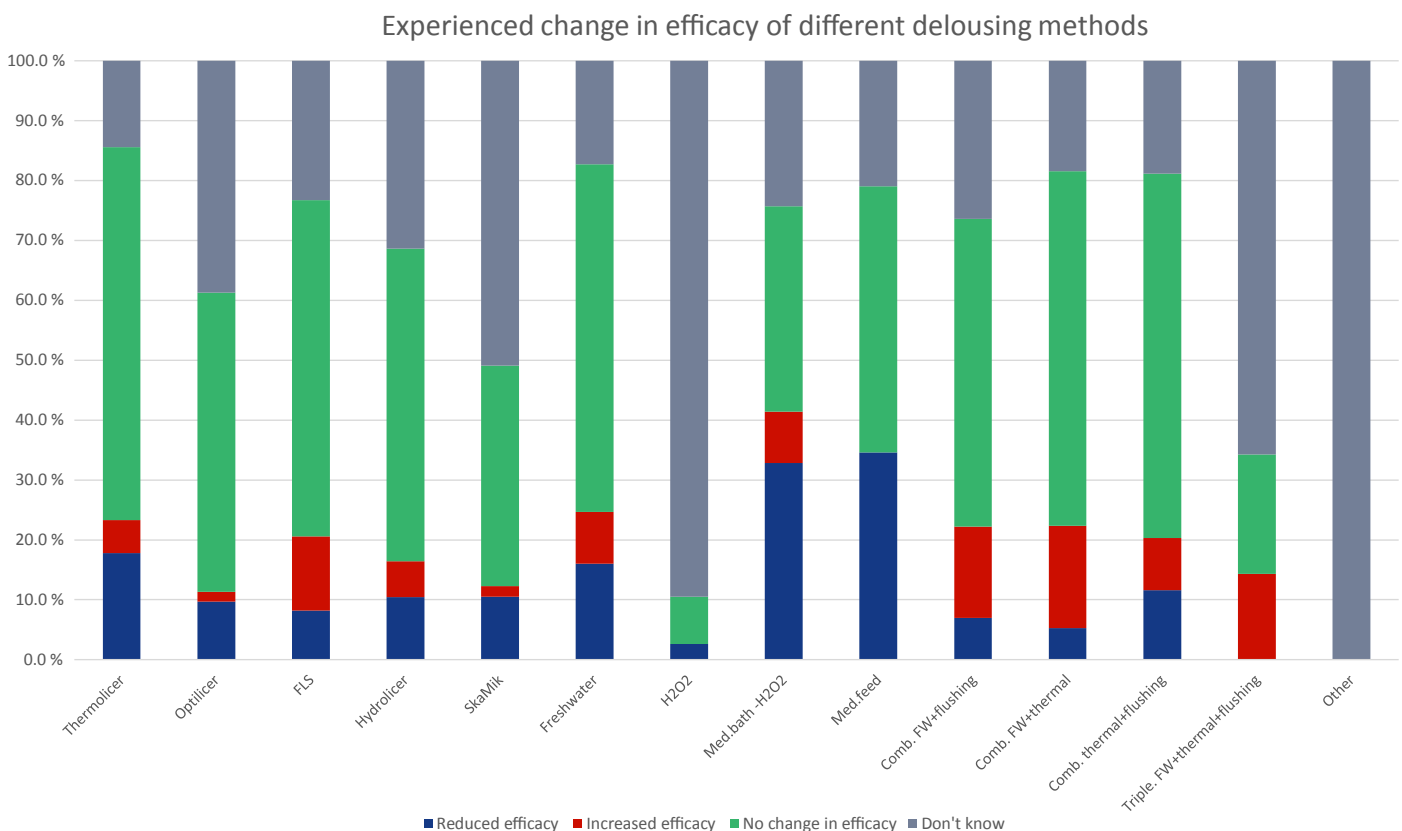
Figure 6.6.5 Overview of delousing methods with which fish health personnel participating in the survey had experience in 2025. N denotes the number of respondents who answered the question regarding experience with each method: Thermolicer (N=98), Optilicer (N=96), FLS delouser (N=96), Hydrolicer (N=94), SkaMik (N=95), Freshwater (N=96), H<sub>2</sub>O<sub>2</sub> (hydrogen peroxide) (N=96), Medicinal bath treatments excluding hydrogen peroxide (N=99), Medicinal treatment via feed (N=99), Combination of freshwater bath and flushing (e.g. Freshwell) (N=98), Combination of freshwater bath and thermal treatment (N=98), Combination of thermal treatment and flushing (including Optiflush) (N=97), Triple combination of freshwater bath, thermal treatment and flushing (N=96), and Other methods (N=66).

For medicinal treatments, 82% of respondents reported experience with medicated feed for delousing (84% in 2024), 71% with medicinal bath treatments (74% in 2024), and approximately 40% with hydrogen peroxide treatments, unchanged from 2024.

Delousing efficacy depends on many factors, including pressure, temperature, treatment duration, and crowding, as well as the potential development of reduced parasite sensitivity due to selection pressure in lice populations. To investigate possible trends, respondents were asked whether they had observed changes in efficacy. For most methods, the majority reported “no change” or “do not know” (Figure 6.6.6). Among respondents with experience, 35% reported reduced efficacy of medicated feed, and 33% reported reduced efficacy of medicinal bath treatments. For

combination methods involving freshwater and washing or freshwater and thermal treatment, as well as triple-method treatments, approximately 15% of respondents reported increased efficacy.

Twenty-three free-text responses addressed perceived changes in delousing efficacy. Several respondents noted that combination methods including freshwater are most effective when the freshwater is cooled (5–6 °C) in the well-boat. Adequate holding time in freshwater was also emphasised. When holding time was limited to four hours, higher temperatures in the thermal component were reported as necessary. Several respondents stated that pure thermal delousing becomes less effective later in autumn after repeated treatments, and that washing shows reduced effectiveness after multiple rounds using the same method-



Fish Health Report 2025, Norwegian Veterinary Institute

**Figure 6.6.6** Overview of respondents’ perceptions of changes in the efficacy of the different delousing methods. N denotes the number of respondents who answered the question regarding experience with each method: Thermolicer (N=98), Optilicer (N=96), FLS delouser (N=96), Hydrolicer (N=94), SkaMik (N=95), Freshwater (N=96), H<sub>2</sub>O<sub>2</sub> (hydrogen peroxide) (N=96), Medicinal bath treatments excluding hydrogen peroxide (N=99), Medicinal treatment via feed (N=99), Combination of freshwater bath and flushing (e.g. Freshwell) (N=98), Combination of freshwater bath and thermal treatment (N=98), Combination of thermal treatment and flushing (including Optiflush) (N=97), Triple combination of freshwater bath, thermal treatment and flushing (N=96), and Other methods (N=66).

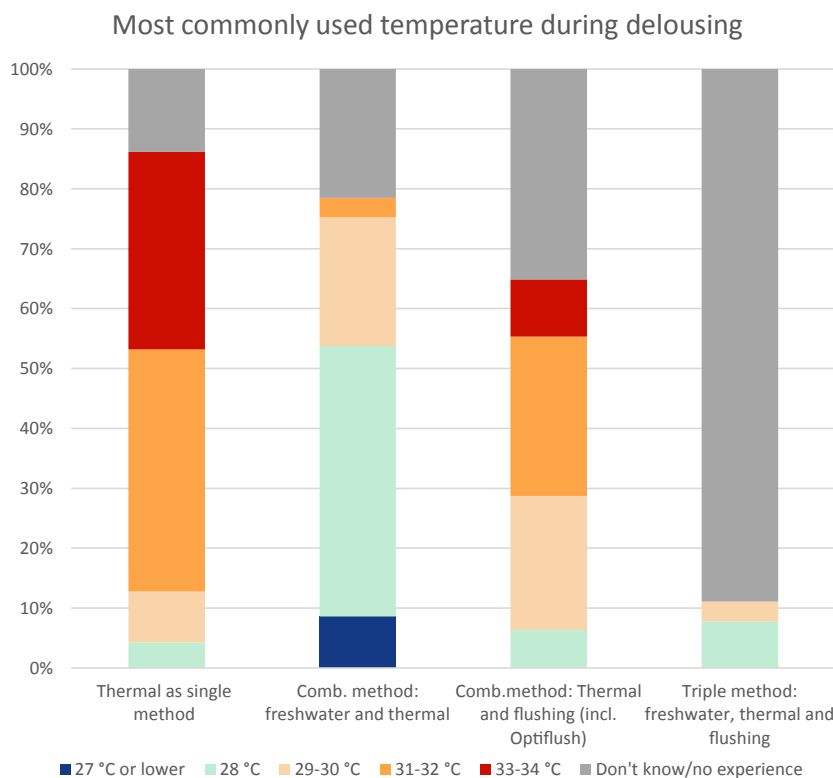
ology. Freshwater sensitivity of lice was reported to depend more on site salinity than on the number of freshwater treatments, with sites near large rivers showing reduced efficacy. Some respondents reported declining sensitivity to azamethiphos over time, while others achieved good efficacy using extended holding times (off-label). Temperature dependence of azamethiphos efficacy was also highlighted, with reduced effects observed at low temperatures.

Thermal delousing may be applied alone or in combination with other methods. Respondents were again asked to report common and maximum treatment temperatures (Figure 6.6.7 and Figure 6.6.8). In general, higher temperatures are used when thermal treatment is applied alone rather than in combination. The proportion routinely using the highest temperature range (33–34 °C) decreased from 41% in 2024 to 33% in 2025. As in 2024, combinations of flushing and thermal treatment generally involved higher temperatures than freshwater-thermal combinations. For

triple treatments, 28 °C was most frequently reported, although temperatures up to 33–34 °C were also used.

Respondents were asked whether the severity of external injuries associated with non-medicinal delousing had changed in 2025 compared to 2024. Fifty-two percent reported no change (47% in 2024), 24% reported improvement (29% in 2024), and few reported deterioration, consistent with 2024 levels. Twenty-two percent responded, “do not know”.

Thirty-eight free-text comments addressed injuries and mortality related to delousing. Many respondents identified crowding as particularly stressful for fish and a major source of injury. Respondents also noted reduced mortality associated with improved experience and technological development. Conversely, increased mortality was linked to handling fish at high water temperatures with low oxygen saturation. High lice pressure in 2025 led to rapid reinfesta-



Fish Health Report 2025, Norwegian Veterinary Institute

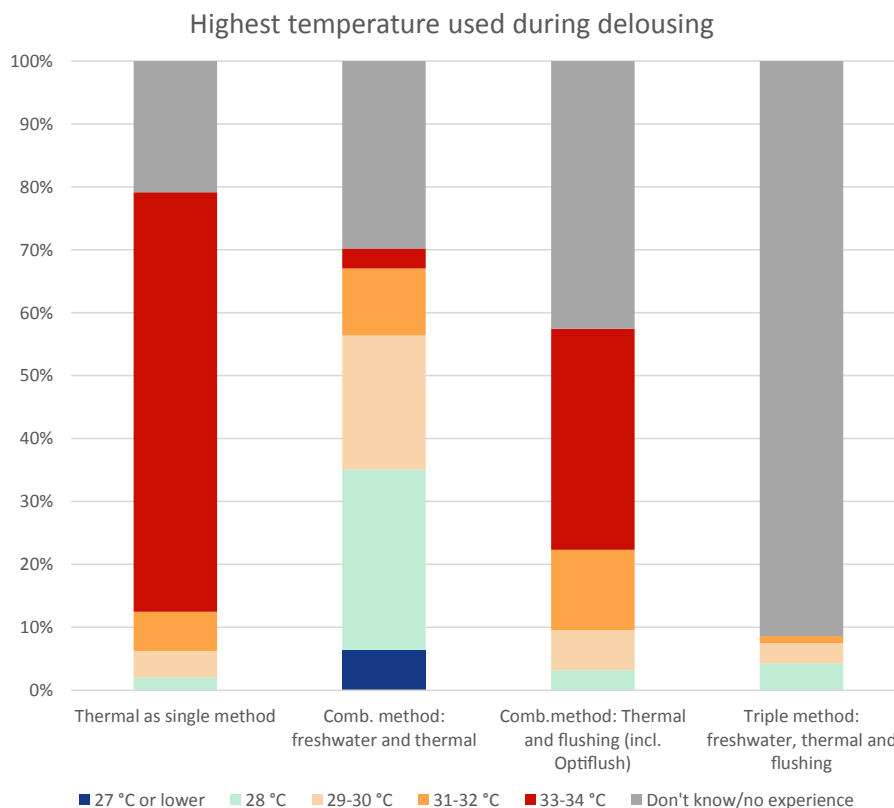
**Figure 6.6.7 Percentage of respondents reporting the most commonly used temperature during delousing where thermal treatment is applied either as a standalone method or in combination with other treatment principles. The number of respondents (N) for the columns from left to right is N=94, N=93, N=94 and N=90.**

tion after delousing, limiting recovery time and contributing to increased mortality. High lice levels also required more aggressive washing, resulting in more severe injuries. Frequent handling (every three weeks over extended periods) was associated with winter ulcers at low temperatures (December-May). Combination treatments were generally viewed as beneficial to welfare by enabling lower thermal temperatures. However, concern was expressed over reduced freshwater use in 2025 and increased reliance on single-principle mechanical and thermal treatments.

Several respondents described large variability in treatment tolerance between fish groups, with underlying diseases identified as a major risk factor. For mechanical delousing, fin splitting and skin haemorrhage were reported as challenges associated with new wellboats, particularly for Hydrolicer systems. Scale loss at high pressure (>0.8 bar) using FLS was also mentioned. Some respondents reported fewer injuries with FLS compared to Hydrolicer and SkaMik.

Since 2020, emergency slaughter of sick or weakened fish during delousing operations has been documented. Concerns have been raised that the use of slaughter vessels ("bløggebåt") may mask actual mortality and increase risk tolerance in delousing weakened fish. In the 2025 survey, respondents were asked about situations involving slaughter vessels. Fifty free-text responses were received. Many respondents reported their use in connection with delousing, both before treatment to remove weakened surface-dwelling fish and after treatment when fish proved unable to tolerate the procedure. Some respondents stated that emergency slaughter post-delousing is no longer practiced due to difficulty justifying the procedure. Others reported use of slaughter vessels to slaughter fish unfit for transport to slaughterhouses.

For knowledge-based management, it is essential that fish slaughtered in this manner are registered and reported, enabling continued assessment of welfare consequences of



Fish Health Report 2025, Norwegian Veterinary Institute

**Figure 6.6.8** Percentage of respondents reporting the highest temperature used during delousing where thermal treatment is applied either as a standalone method or in combination with other treatment principles. The number of respondents (N) for the columns from left to right is N=96, N=94, N=94 and N=93.

different delousing methods and providing a comprehensive overview of farmed fish health and welfare status (Chapter 6.2 Fish Welfare and Health in Regulations and Public Management).

In the open-text section on additional comments regarding fish health and welfare in Norwegian aquaculture, respondents called for increased focus on preventive lice measures, such as shielding technology (including closed systems), lower stocking densities, shorter production cycles, and earlier slaughter. Respondents emphasised that reducing mortality and improving welfare requires avoiding lice treatments involving handling and pumping fish out of cages. High sea temperatures, elevated lice pressure, and frequent treatments in recent years were described as unsustainable. Improved lice control prior to seawater transfer was requested, given that climate change and increasing host availability will likely continue to drive high lice pressure.

Several respondents stressed that quality should be prioritised over quantity, with fish health and welfare taking precedence over fish numbers. Concerns were expressed regarding biosecurity risks associated with moving vessels and equipment between areas, potentially introducing and establishing new diseases (Chapter 4 Biosecurity). Respondents also highlighted the need for sufficient delousing, slaughter, and emergency slaughter capacity within production areas. There was stated support for lower lice intervention thresholds where automated lice registration is used. At the Lice Conference 2026, it was noted that automated lice counters still have limitations, particularly in detecting attached and small mobile stages. Experiences from 2025 showed that manual counts provided better oversight of lice numbers and stages when quality-assuring data from laser systems. Combined with lower sea temperatures, this contributed to improved lice control compared to the 2024 season.

In the 2025 survey, 48 respondents shared experiences with laser technology. Lasers were reported to be effective under low infection pressure, during periods of low biomass and/or low temperatures. Effectiveness depends on factors such as the number of nodes, degree of manual positioning, and maintenance. During summer and autumn, laser use was reported to delay delousing seasons and extend treatment intervals. Lasers were described as effective primarily against mature female lice, not early stages. Infestation with

sea louse (*Caligus elongatus*) was identified as a factor reducing laser effectiveness due to interference with targeting. Freshwater runoff and algal blooms were also reported to affect image quality and reduce performance. Some respondents suggested better efficacy in rainbow trout than salmon due to higher fish activity. Others reported uncertainty regarding laser effectiveness.

Limited knowledge is currently available regarding the welfare impact of laser technology. Preliminary results from the ContrlLaser project (FHF 901985), presented at the Lice Conference 2026, showed a significantly higher prevalence of eye haemorrhage (primarily mild) following welfare scoring in commercial cages using lasers. Further investigations into efficacy and welfare effects are planned for 2026. Free-text comments in the survey also described avoidance behaviour in fish exposed to laser irradiation. Increased incidence of severe unilateral cataracts was reported at sites using lasers. Where delousing could be avoided, laser technology was described as a positive welfare measure.

## References:

- Hvas M et al. (2017). The gill parasite *Paramoeba perurans* compromises aerobic scope, swimming capacity and ion balance in Atlantic salmon. *Conservation Physiology*, 5(1). <https://doi.org/10.1093/conphys/cox066>
- Mechlaoui M et al. (2025). Observations of pathology in Atlantic salmon (*Salmo salar* L.) in association with three subsequent mechanical delousing treatments. *Aquaculture Reports*, 45. <https://www.sciencedirect.com/science/article/pii/S235251342500582>
- Nilsson J et al. (2025). [Effect of thermal and freshwater treatments on rainbow trout welfare, physiology, and infestation levels.](https://doi.org/10.1111/raq.70076)
- Virtanen MI et al. (2023). Chronic stress negatively impacts wound healing, welfare, and stress regulation in internally tagged Atlantic salmon (*Salmo salar*). *Frontiers in Physiology*, 14. <https://doi.org/10.3389/fphys.2023.1147235>
- Stien LH et al. (2025). Reviewing the severity of handling-induced injuries in the LAKSVEL protocol for salmon welfare. *Reviews in Aquaculture*. <https://doi.org/10.1111/raq.70076>

## 6.7 Slaughter data as a welfare indicator

By Kristoffer Vale Nielsen, Magnus Nygård Osnes and Kristine Gismervik

**All killing of animals carries a risk of suffering. Livestock and farmed fish must therefore be stunned before killing/bleeding. The likelihood of fish experiencing injury, pain, stress and other burdens is influenced not only by how well the stunning works, but also by previous handling. Crowding, pumping, possible live chilling, time out of water, and the design of pipes and channels all matter. The slaughter of farmed fish is largely automated.**

After slaughter, fish are often sorted into the quality categories superior, ordinary and production. When a group of fish is slaughtered, there is usually also a fraction that is not processed but instead sorted as “discard”. There may be several reasons why a fish is downgraded, such as sexual maturation, wounds, injuries and deformities. A common feature of a substantial share of the fish that are downgraded is that they have, before killing, gone through a period of reduced welfare.

The proportion of superior quality is a commonly used parameter in the industry to describe the quality of a group of fish after slaughter. It is usually given as a percentage of the total slaughtered quantity, calculated based on weight. The proportion superior quality represents the fish in the best quality class, i.e. the proportion of fish that has not been downgraded. From an animal-welfare perspective, the proportion of superior quality should ideally be calculated from the number of fish rather than from total weight, because the average individual weight of a superior fish is often higher than that of a downgraded fish from the same batch. As a result, a proportion superior quality based on weight is often higher than one based on fish count for the same batch. This affects the precision and usefulness of the welfare indicator “proportion superior quality”.

### Slaughter reports

Norwegian slaughterhouses and slaughter vessels submit weekly slaughter reports to the Norwegian Food Safety Authority (NFSA). The slaughter data contains information on locality, fish species and quantity slaughtered (gutted weight), and on the amounts of fish in the different quality categories. The reports also state the most important reason for downgrading to the “production” class and the most

important reason for assigning fish to the “discard” category. The NFSA launched new reporting forms for slaughter of farmed fish on 14 August 2025, without an option to report downgrading causes. The new form meant companies that transitioned to the new reporting forms during 2025, have incomplete reporting of downgrading causes, and that from 2026 there will likely be very little available information on reasons for downgrading.

The Norwegian Veterinary Institute was given access to the dataset containing slaughter data for 2025. The dataset describes fish slaughtered including salmon (*Salmo salar*), rainbow trout (*Oncorhynchus mykiss*) and cod (*Gadus morhua*). Cod is included because interest in this aquaculture species has increased in recent years despite a limited volume of production. There is also greater uncertainty associated with the cod data because the authors have limited knowledge of the standards and routines followed during slaughter and quality assessment of cod. The results for cod should therefore be interpreted with extra caution.

The raw dataset was cleaned in a somewhat different way for the 2025 Fish Health Report than in earlier years. In this report we clean the data for salmon and rainbow trout using the same criteria as NFSA for their new slaughter statistics dashboard. For cod, data from the NFSA were washed in the same way as the rainbow trout data, because the NFSA does not publish its own method for quality control for cod. This change in the quality control is likely to cause only minor changes in reports included and excluded and is unlikely to affect the national large-scale patterns described in this chapter.

After data cleaning, the material contained a total of 6,566 rows with slaughter reports (fish of the same species – salmon, rainbow trout or cod – from the same site and slaughtered on the same slaughter vessel or at the same slaughterhouse). The official slaughter statistics published by the Norwegian Directorate of Fisheries (DoF) report harvest

**For further information on fish welfare at slaughter, see the Norwegian Veterinary Institute’s fact page (in Norwegian):**

[Fiskevelferd ved slakting av oppdrettsfisk](#)

**Table 6.7.1** Overview of slaughter data for 2025 as reported from slaughterhouses and slaughter vessels to the Norwegian Food Safety Authority, divided into salmon, rainbow trout and cod. Number of slaughter reports, total slaughter volume (gutted weight), and quantity classified as superior, ordinary, production and discard, respectively.

	Salmon	Rainbow trout	Cod
Number of slaughter reports	5571	880	115
Total slaughter, tonnes	1,602,173	99,978	16,942
Total superior, tonnes	1,393,086	91,200	12,310
Total ordinary, tonnes	18,863	2,978	4,068
Total production, tonnes	183,006	5,450	68
Total discard, tonnes	7,218 (0.5%)	350 (0.4%)	497 (2.9%)
Proportion superior quality, %	86.9	91.2	72.7

volumes as whole (round) weight, recorded separately for tax purposes, making them a suitable independent dataset for validation. However, the comparison requires correction for gutting loss, which we did by adding 12.5% for salmon and 13.5% for rainbow trout corresponding to the official conversion factors. These data represent, by weight, 104% of all salmon and 104% of all rainbow trout slaughtered in Norway in 2025. There may still be duplicate entries or typing errors in the dataset that were not detected. For cod data, the DoF reports slaughter weight of 20,130 tonnes (whole weight), but do not state which conversion factor is to be used from slaughter. Using 1.18 as the conversion factor (condition 210, "head-on gutted") the slaughter data constitute 99% of the volume reported for cod by DoF. The slaughter data for salmon, rainbow trout and cod are summarized in [Table 6.7.1](#).

In addition to variation in fish quality and the species slaughtered, the use of the quality classes also varies between slaughterhouses and slaughter vessels. The proportion of slaughter reports that used all four quality classes was 15% for salmon, 33% for rainbow trout and 46% for cod. Nearly all slaughter reports used the superior class. The ordinary class was used in only 25% of the reports for salmon and 36% of the reports for rainbow trout, but in almost all reports (98%) for cod. The production class was used in almost all reports for salmon and rainbow trout (99% and 99%, respectively), but only in about half (46%) of the reports for cod. Compared to 2024, for cod this result rep-

resents an increase in the proportion of slaughter reports using the production class. Discard was recorded in 81% of the reports for salmon, 66% of the reports for rainbow trout and 97% of the reports for cod.

Before the change in the reporting form in mid-August 2025, each slaughter report stated the "most important reason for downgrading" of fish to the "production" class, and the submitter could choose among four predefined alternatives: "Defects", "Sexual maturation", "Clinical disease", and "Wounds/injuries". Only one reason could be given per slaughter report. From mid-August many reporters transitioned to the new form and stopped reporting reasons for downgrading ([Figure 6.7.1](#)). A summary of the reasons for downgrading is given in [Figure 6.7.2](#), which also included fish graded as production class without any reported downgrading reason. This means that for 2025, 15% of production fish among salmon and 37% of production fish among rainbow trout were reported without any stated reason for downgrading. In 2024 the most used category for the "most important reason for downgrading" of production fish was "wounds/injuries" for salmon, while "defects" was the most important category for rainbow trout. The figures for 2025 should be interpreted with caution because a substantial share were reported without downgrading causes, due to the new reporting forms. Cod is not included in the figure because the proportion of volume downgraded to production class is so low (0.4%).

### Weekly percent of production fish without a reported downgrading cause

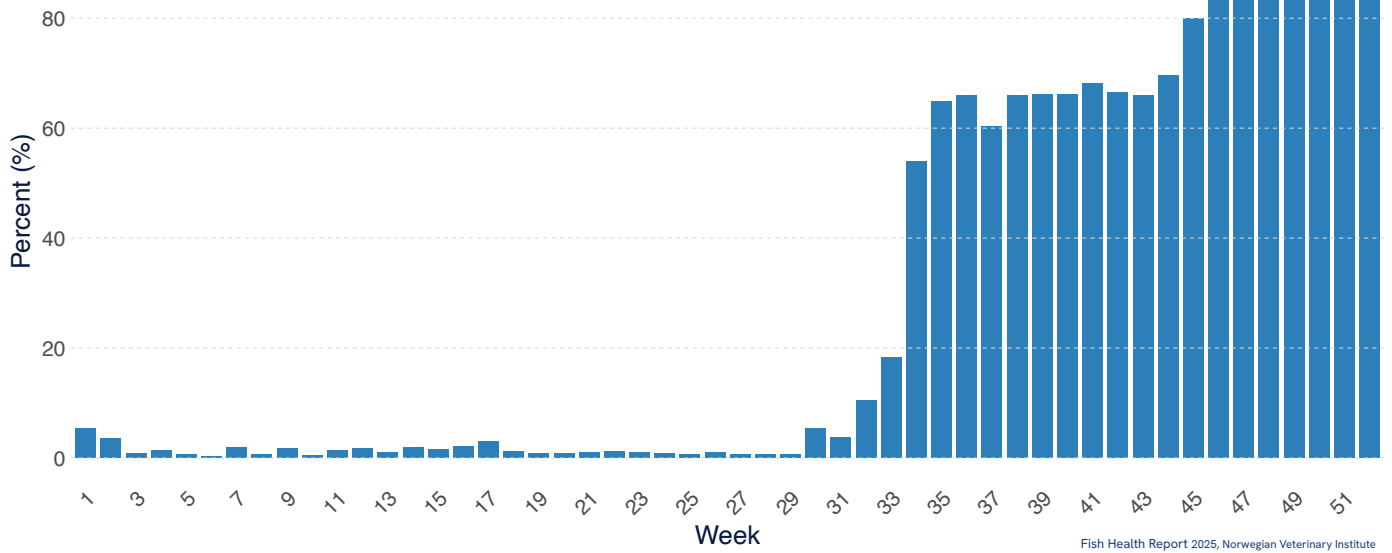


Figure 6.7.1. Weekly share of production fish (salmon and rainbow trout) without a reported reason for downgrading, as % of total weekly volume.

### Downgrading production fish

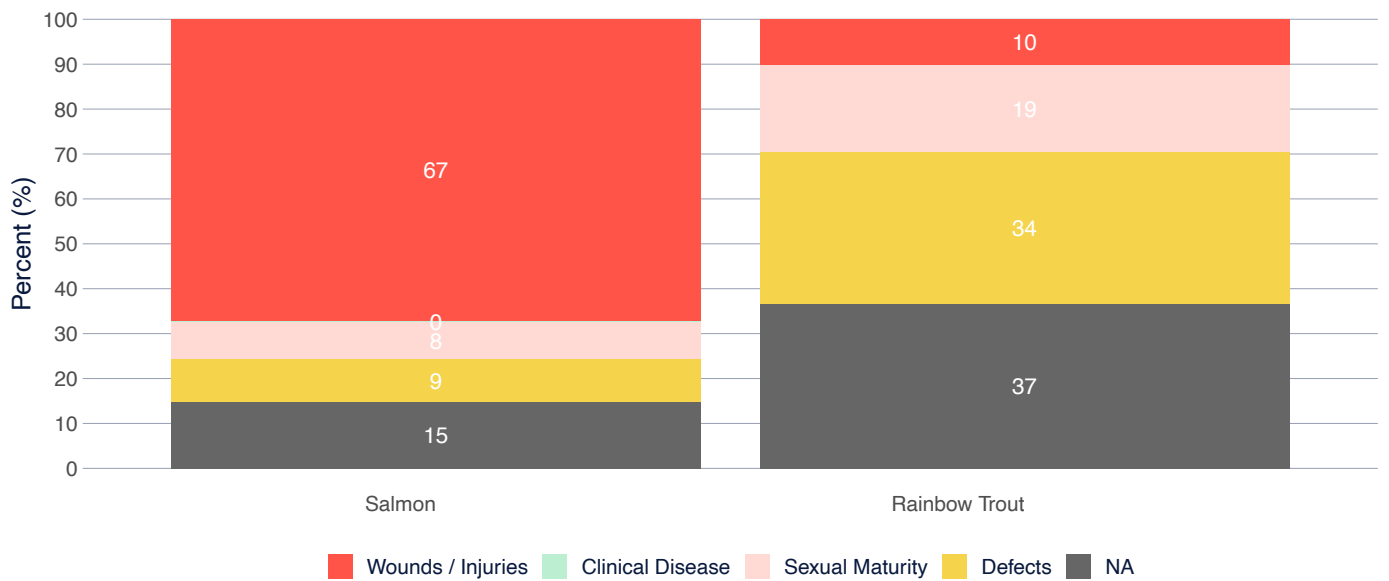
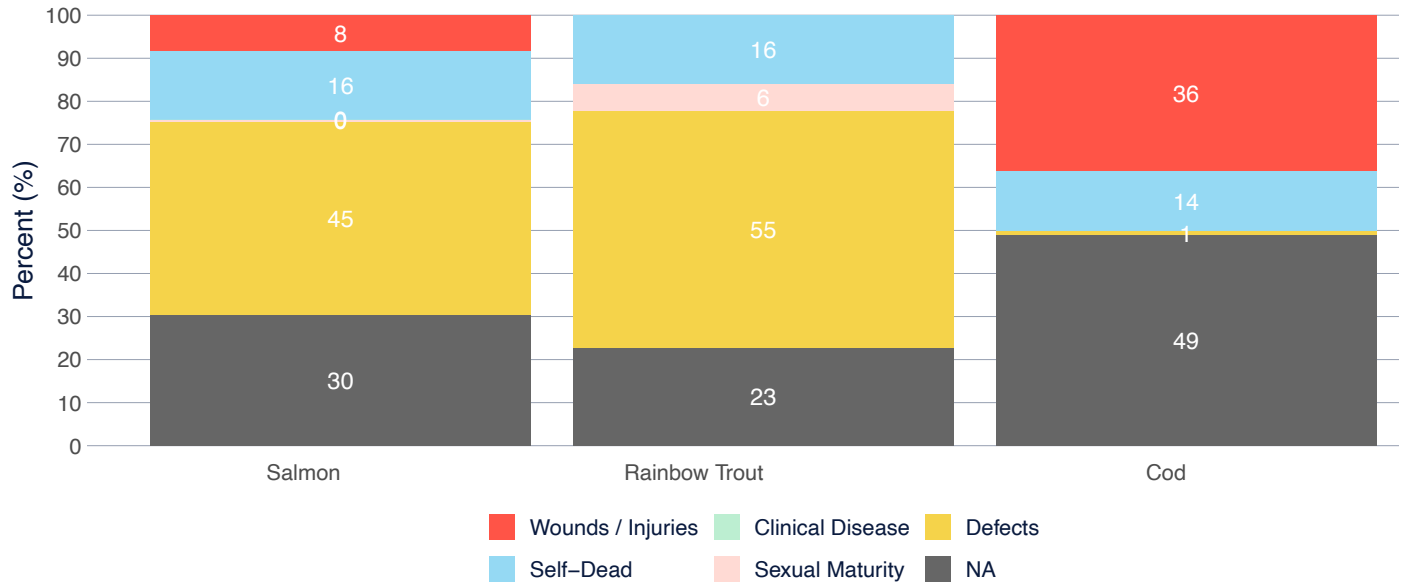


Figure 6.7.2. Share of production fish (by weight), salmon and rainbow trout, where the categories “defects”, “sexual maturation”, “clinical disease” and “wounds/injuries” were stated as the most important reason for downgrading. NA denotes production fish for which the most important reason for downgrading was not reported.

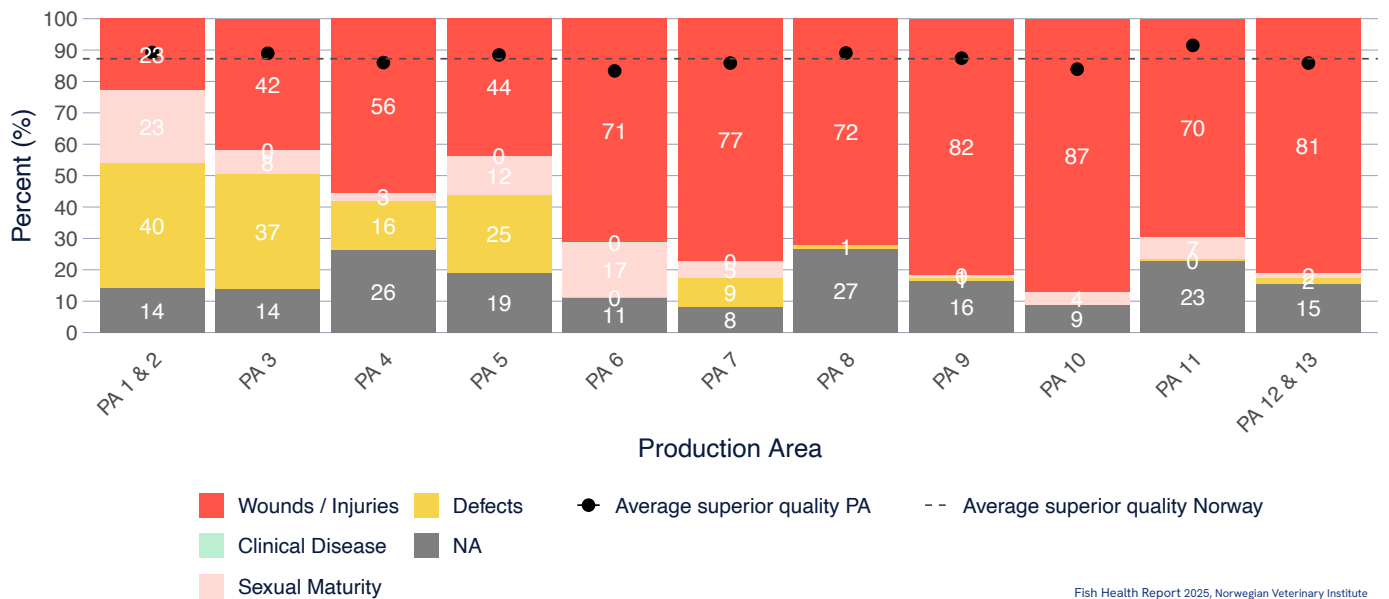
### Downgrading discarded fish



Fish Health Report 2025, Norwegian Veterinary Institute

**Figure 6.7.3.** Share of discard fish, salmon, rainbow trout and cod, where the categories “defects”, “sexual maturation”, “clinical disease”, “self-dead” and “wounds/injuries” were stated as the most important reason for downgrading. NA denotes discard fish for which the most important reason for downgrading was not reported.

### Fraction superior volume and downgrading causes for salmon 2025



Fish Health Report 2025, Norwegian Veterinary Institute

**Figure 6.7.4.** Fraction superior quality for salmon by production area (PA) in 2025 as % (black dots) of total slaughtered volume, and distribution (%) of the most important reason for downgrading to production fish. Data for PA1 and PA2, and data for PA12 and PA13, are combined. NA denotes production fish for which the most important reason for downgrading was not reported.

For fish that are not slaughtered but instead sorted into the “discard” category, the same issue applies regarding the reason for downgrading as for production fish (described above). In 2025 the categories available for discard were the same as for production fish, with the additional category “self-dead”. For both salmon and rainbow trout, “defects” was the category most frequently used, and for cod the category wounds/injuries were most frequently used (Figure 6.7.3). These results should also be interpreted with caution because a considerable proportion of the volume is reported without a downgrading cause. DoF reports that 2.67 million salmon and 132,000 rainbow trout were assigned to discard in 2025.

The average proportion of superior quality (%) for salmon slaughtered in the different production areas (PA) in 2025 is shown in Figure 6.7.4. Because there are few sites in PA1 and PA2, and in PA12 and PA13, data from PA1 and PA2 are combined, as are data from PA12 and PA13. The proportion superior quality varies between production areas, from 83% (PA6) to 91% (PA11) (shown as black dots in Figure 6.7.4). The figure also shows the percentage distribution of the most

important downgrading reasons, calculated from the volume. Because a new reporting system was introduced, the proportion of fish with missing reason data is larger than before and the figure must therefore be interpreted carefully. Results for rainbow trout and cod are not shown, because production of these species is far lower and the number of producers in the different production areas is small.

When the slaughter reports are organised chronologically, both slaughter volume and proportion superior quality varies by season (Figure 6.7.5). In the first half of 2025 the weekly slaughter volume was about 25,000 tonnes and the proportion superior quality averaged about 79%. In the second half of the year the weekly slaughter volume increased to about 35,000 tonnes and the proportion superior quality rose to an average of 92%.

The 2025 dataset contains slaughter data for salmon and rainbow trout from a total of 607 sites. By summing the slaughter reports for each site, a total proportion of superior quality was calculated. This represents the average of

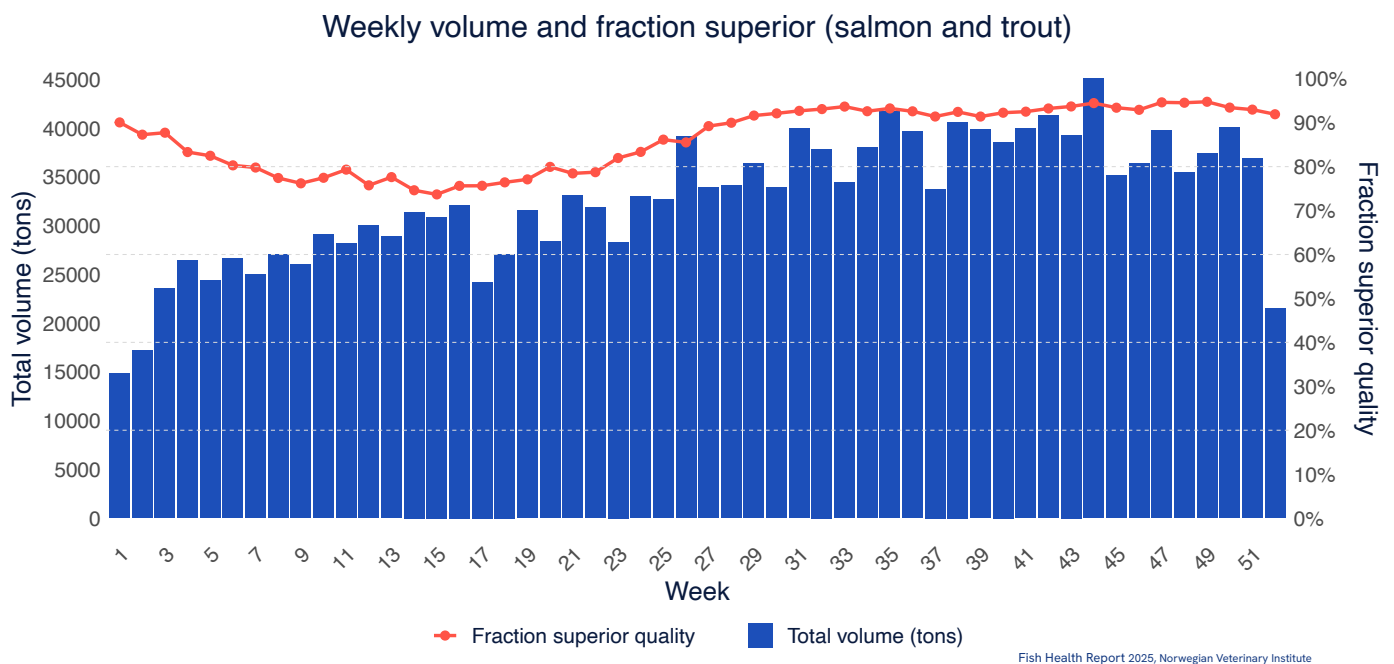


Figure 6.7.5. Weekly slaughter volume in tonnes and fraction superior quality (%), figures combined for salmon and rainbow trout in 2025.



**Figure 6.7.6.** Number of sites (locations) with proportion superior quality within different percentage intervals for salmon and/or rainbow trout in 2025 (total 607 sites).

all fish slaughtered in 2025 from each site. The mean proportion superior quality was 86.5% (25th percentile 82.0%, median 90.4% and 75th percentile 94.4%). Figure 6.7.6 shows the number of sites with proportion superior quality within different percentage intervals.

### Assessment of the situation

In 2025 the total slaughter volume of farmed salmon increased for the first time in several years. Compared with 2024, volume increased in 2025 by 14% for salmon and 16% for rainbow trout. At the same time, the average slaughter quality for salmon was better in 2025 than it has been since 2021. The average slaughtered batch of salmon had a proportion superior quality of 86.9%, while the corresponding figure for rainbow trout was 91.2%. It seems likely that less problems with string jellyfish (*Apolectia* sp.) in 2025, compared to 2023–2024, is a contributing factor to less wounds and downgrading in 2025. An additional contributing cause could be increased use of the effective new vaccine against *Moritella viscosa*. Slaughter reports for cod were included for the first time in the Fish Health Report 2024. Because cod farming is still relatively limited in production volume

and number of sites, the slaughter results are presented only at a general level. Even so, cod also had substantial downgrading at slaughter in 2025, and the average result was only 73% superior.

A lower share of downgraded salmon in 2025 (compared with 2021–2024) is seen both in the chronological overview at year, production-area, and at site level. Slaughter year 2025 also had a lower mean proportion superior quality in first half of the year (January–June, 79.8%) compared to the second half of the year (July–December, 92.5%). The difference between the two halves of the year was, however, more pronounced in 2024. This difference was more pronounced in 2024 especially because of a low proportion superior quality in the first half of the year. Between production areas (salmon only), however, there was less variation in proportion superior quality than in 2024, and there was a relatively high level throughout. At site level there were a higher proportion of location with high superior quality and a lower proportion with low proportion of superior quality, compared to 2024.

The new reporting solution introduced by the NFSA 2025 for slaughter of farmed fish led to less detailed data in some slaughter weeks, and more uncertain results regarding causes for downgrading. Despite uncertainty surrounding the interpretation of downgrading reasons in 2025 in connection with the transition, the results do not indicate major changes in the overall patterns reported in the Fish Health Reports 2023–2025 for the years 2021–2024. The same system is unlikely to work perfectly, but it nonetheless gives an impression of what currently constitute the biggest welfare problems for fish in the period up to slaughter. The Norwegian Veterinary Institute recommends keeping the cause of downgrading in the authority reports, so that slaughter data as a welfare indicator can be used in a

knowledge-based way. Without data on causal relationship, slaughter quality may lose some of its potential for use as a welfare indicator. Wider use of the indicator could nonetheless provide a useful basis for national overview and for, for example, detecting positive and negative changes that are results of new management and regulations. As noted in earlier Fish Health Reports, slaughter quality can be improved through increased standardisation, improved resolution of results and an improvement of reporting so that quality is reported at fish-level, not only by weight. A more systematic use of slaughter quality in the work to improve welfare may be an important tool for the industry.

# 7 Viral diseases in farmed salmonids

By Torfinn Moldal

Infectious salmon anaemia (ISA) was confirmed at 18 sites in 2025. In addition, suspicion of ISA arose at a further three sites during the year, while a landbased broodstock facility with suspected ISA dating back to January 2024 remained under suspicion at the end of 2025. A substantial proportion of last year’s confirmed outbreaks occurred in the Vest-erålen region, where transmission likely took place between several neighbouring sites. In addition, fish presumed to be infected were transferred from one site to another. The fish were vaccinated against ISA at seven of the 18 sites with confirmed ISA. Several ISA outbreaks may be linked to the presence of ILAV HPR0 during the juvenile production phase. Based on compiled data from the Norwegian Veterinary Institute and private laboratories, ILAV HPR0 was detected at 78 sites in 2025.

There were 44 new cases of pancreas disease (PD) in 2025. For comparison, there were 48 cases in 2024, 58 cases in 2023, and 98 cases in 2022. All cases detected last year occurred within the endemic zone, with 31 cases caused by SAV3 in PA3 and PA4 and 13 cases caused by SAV2 in PA5 and PA6. No new cases have been detected in PA8 since PD was detected at four sites in autumn 2023, and the restricted zone was lifted in November 2025. It is also worth noting that no new cases of PD were detected in PA2 in 2025 either.

Cardiomyopathy syndrome (CMS) and heart and skeletal muscle inflammation (HSMI) were detected at more sites in

2025 compared with 2024. The survey indicates that fish health personnel and inspectors from the Norwegian Food Safety Authority perceive CMS and HSMI as significant problems during the grow-out phase for Atlantic salmon, particularly regarding mortality.

Infectious pancreatic necrosis (IPN) was detected at a total of 40 sites with Atlantic salmon and rainbow trout in 2025, representing approximately a threefold increase compared with 2024. Despite the widespread use of QTL-selected eggs and vaccination in salmon farming, IPN is ranked among the ten most important health problems in juvenile production facilities for both salmon and rainbow trout. IPN was also ranked among the ten most significant health problems in grow-out facilities for Atlantic salmon.

Salmon Gill Pox Virus (SGPV), or salmon poxvirus, was detected at 191 sites last year, which is at the same level as in the previous year. However, the disease salmon pox was detected at only a few sites.

Surveillance of Atlantic salmon and rainbow trout at sea sites along the entire coast, as well as rainbow trout in inland aquaculture and brown trout from stocking facilities in Eastern Norway, revealed neither infectious hematopoietic necrosis virus (IHNV) nor viral haemorrhagic septicaemia virus (VHSV) last year.

**Table 7.1** Number of sites with salmonids with detected viral diseases during the period 2016–2025. For the period 2016–2019, the number of sites with CMS, HSMI, and IPN is based on samples submitted to the Norwegian Veterinary Institute, whereas data made available from aquaculture companies through private laboratories have been included in the counts since 2020 (Chapter 1 Statistical basis for the report).

	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
ISA	12	14	13	10	23	25	15	18	13	18
PD	138	176	163	152	158	100	98	58	48	44
CMS*	90	100	101	82	154	155	131	129	78	114
HSMI*	101	93	104	79	161	188	147	184	115	167
IPN*	27	23	19	23	22	20	12	12	13	40

# 7.1 Pancreas disease (PD)

By Hilde Sindre, Anne Berit Olsen and Hege Løkslett

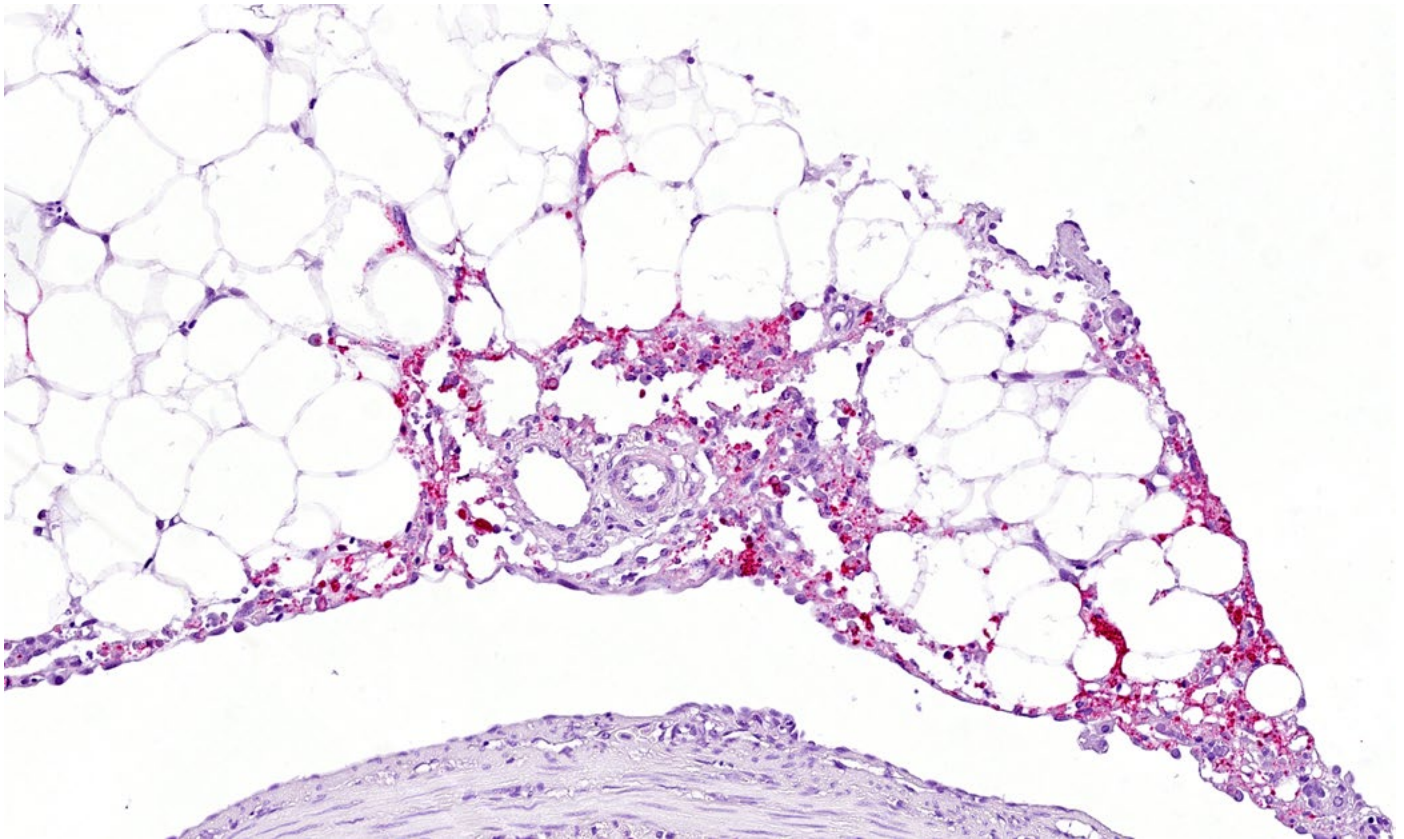
## The Disease

Pancreas disease (PD) is a serious infectious disease in farmed salmonids, caused by salmonid alphavirus (SAV). Infected fish suffer extensive damage to the pancreas as well as inflammation of the heart and skeletal muscles. There are two ongoing PD epidemics in Norway: the genotype SAV3 is widespread along the west coast, while marine SAV2 has been established in Central Norway since 2010. Mortality among fish affected by PD varies from low to moderate, but individual outbreaks with high mortality also occur. In addition, increased feed conversion ratio and the development of looser fish may lead to prolonged production times as a result of appetite loss and decreased quality at harvest.

Suspicion of PD may arise based on clinical signs, histopathological findings (Figure 7.1.1), PCR results, virus isolation, or detection of antibodies against PD virus in the blood. A PD diagnosis (confirmed PD) will in most cases be based on detection of the virus by PCR together with the presence of typical histopathological findings in the same individual. In addition, the genotype of the detected virus is determined for all detections. If fish with suspected or confirmed PD are moved to a new site, that site will also be assigned a diagnosis of confirmed or suspected PD, even if no new examinations have been carried out at the site.

**For further information on PD, see the Norwegian Veterinary Institute's fact page:**

[Pancreas disease \(PD\)](#)



**Figure 7.1.1** Acute PD. The pancreas producing digestive enzymes (exocrine pancreas) has been destroyed by the PD virus. Viral antigen in necrotic cells is stained red using immunohistochemistry. Photo: Anne Berit Olsen, Norwegian Veterinary Institute.

## Disease Control

PD is a notifiable disease in Norway (category F) and is also listed by the World Organisation for Animal Health (WOAH). To prevent the spread of infection, PD regulations have been in place since 2007. A continuous PD zone has been defined, extending from Jæren in the south to Skjemta in Flatanger (the former county border between Sør- and Nord-Trøndelag) in the north. The remainder of the coastline consists of two surveillance zones that extend on either side of the PD zone to the borders with Sweden and Russia, respectively. The infection reservoir is considered primarily to be infected farmed fish. Since 2017, intensive monitoring through the PD regulations has made it possible to detect PD at an early stage and thereby prevent or reduce the spread of infection and disease. Following and measures related to the transport of smolt and slaughter fish are important to limit spread of infection and disease. In addition, rapid slaughtering of infected populations in PD-free areas is beneficial to prevent the disease from establishing.

Several commercial vaccines against PD are available, and vaccination has been common along the west coast of Norway (PA2-PA5). In Trøndelag, PD vaccination has traditionally been less widespread, but vaccine coverage has increased in recent years. The effect of vaccination against PD has been debated; however, studies have shown that vaccination can be associated with reduced disease severity, lower mortality, decrease growth loss, and may also contribute to reduced viral shedding. The effectiveness of vaccines is closely linked to infection pressure. Other biosecurity measures are therefore essential to achieve maximal benefit from vaccination ([Chapter 4 Biosecurity](#)). The Norwegian Veterinary Institute (NVI) serves as both the international and national reference laboratory for SAV. In cases of suspected PD, samples must be submitted to the Norwegian Veterinary Institute for examination. The NVI collaborates with the Norwegian Food Safety Authority (NFSA) on PD data, which are regularly updated on the Institute's website and published in interactive maps ([BarentsWatch](#)).

## The Health Situation in 2025

### Official data

In 2025, a total of 44 new PD cases were registered (13 SAV2 and 31 SAV3; [Figure 7.1.2](#)), of which six occurred in rainbow trout (all SAV3). The number therefore represents a marginal reduction compared with 2024, when 48 cases were recorded, and a substantial reduction compared with 2020, when 158 cases were registered. Compared with 2024, there was a reduction of two SAV2 cases ([Figure 7.1.3](#)) and two SAV3 cases ([Figure 7.1.4](#)). No facilities were found to be infected with both SAV2 and SAV3 in 2025, and no cases were recorded in the PD-free zones.

Following the detection of PD caused by SAV2 at four sites along the Helgeland coast (PA8) in 2023, a restriction zone was established (FOR-2023-10-04-1564 og FOR-2024-11-22-2835). No new cases of PD have been detected in this area, and the restrictions zone was repealed from November 2025.

### Statistics and diagnosis

The PD cases included in the underlying data for the tables and figures in this report comprise sites that, according to the criteria set out in the regulations, are either suspected of PD or have confirmed PD. The data are based on information entered by inspectors from the NFSA, either in the NVI PD/ILA data portal (an access-restricted website for PD and ILA cases containing data up to the latter part of 2024) or, from the end of 2024 onwards, in the NFSA disease database, in addition to the NVI's own diagnostic data. These datasets form the basis for various interactive mapping services and are used, among other things, in [BarentsWatch](#) fish health application. Sites with suspected or confirmed PD from 2024 that were still in active seaphase production in 2025, are not included in the dataset for the number of PD cases in 2025. This means that the actual number of infected sites within the PD zone is somewhat higher, as infected fish from the previous year may still be present at sea.

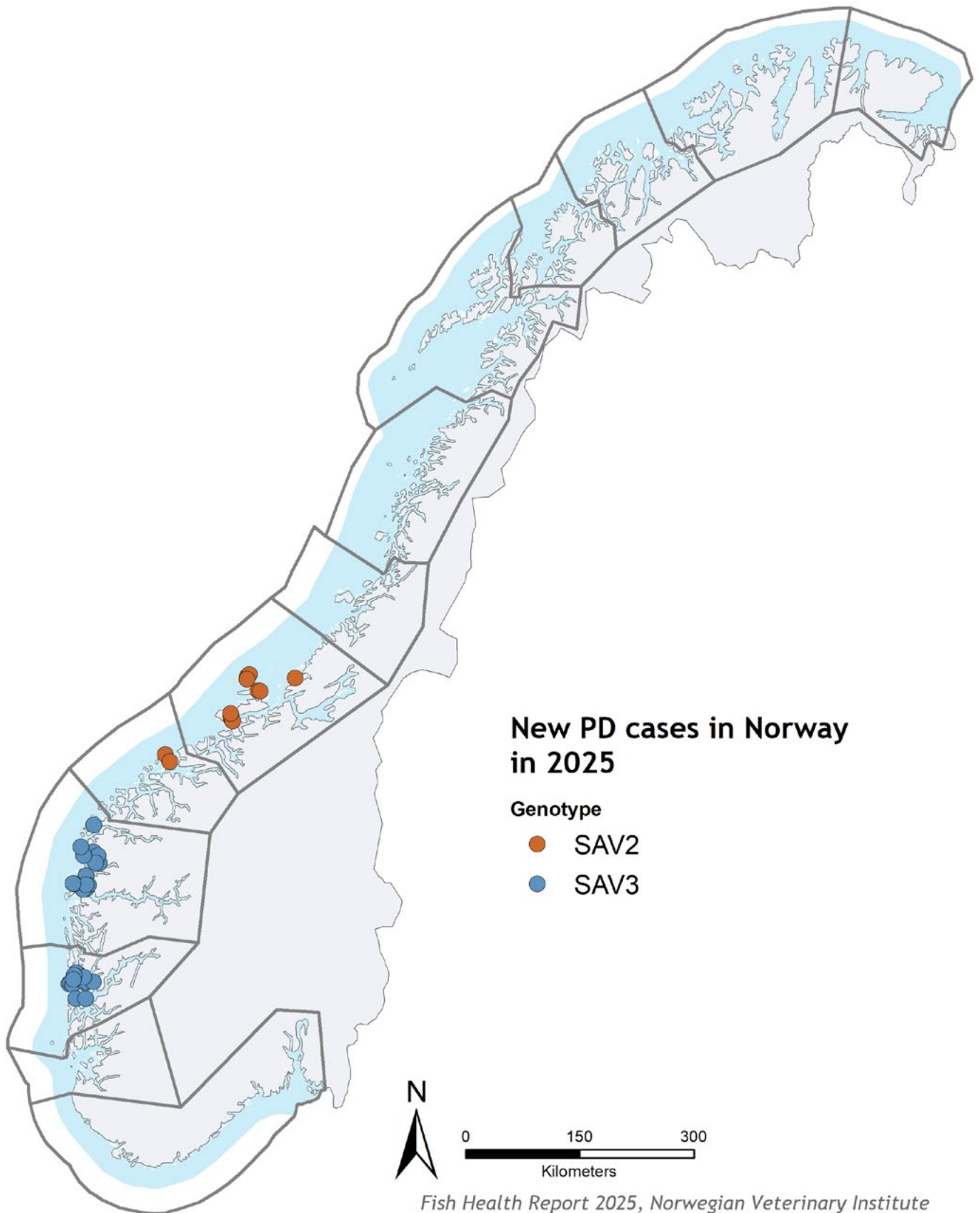


Figure 7.1.2 Map showing new cases of PD in Norway in 2025, by genotype SAV2 and SAV3. Illustration: Attila Tarpai, Norwegian Veterinary Institute.

### SAV2

The number of new registrations of SAV2 cases has stabilised and is approximately at the same level as in 2024, decreasing from 15 cases in 2024 to 13 cases in 2025 (Figure 7.1.3). The highest number of cases occurred in June (3), while no SAV2 cases were detected during the periods January–February, July–August, or October–November (Figure 7.1.5). The main area for SAV2 remains PA6 (Nordmøre and Sør-Trøndelag), accounting for 11 of the 13 cases, while, as in 2024, cases were again detected in PA5 (2). No SAV2 cases were detected in the PD-free zone spanning PA7–PA12.

### SAV3

PD caused by SAV3 has traditionally occurred mainly in PA2–PA4, which cover the area from Ryfylke to Stadt, i.e. the southern part of the PD zone. From 2024 to 2025, the total number of new detections in the SAV3 area stabilised at 31 new cases (33 in 2024), compared to 121 cases in the peak year 2017 (Figure 7.1.4). Detections were recorded throughout the year; however, in contrast to previous years, with a detection peak typically occurring during the summer months, the highest number of cases in 2025 was recorded

in March (7) (Figure 7.1.6). As in 2023 and 2024, no new SAV3 cases were detected in PA2 in 2025, in contrast to 17 cases in 2022. In PA3, the number of new cases decreased from 20 in 2024 to 14 in 2025, while an increase was observed in PA4, from 13 cases in 2024 to 17 cases in 2025. In PA5 (Stadt to Hustadvika), as in 2024, no new cases were detected in 2025, implying that the entire coastline from Stadt to East Finnmark (PA5–PA13) had no SAV3 detections in 2025.

### The Annual Survey

PD is no longer ranked among the ten most significant health challenges in on-growing facilities, for either Atlantic salmon or rainbow trout, which is consistent with the decline in the number of cases. Poor growth is still considered the main challenge associated with this disease (Appendix B1 and Appendix B3). Among respondents with experience of vaccination against PD, 28% report that the vaccine provides moderate protection, while 58% report good protection against clinical disease. No respondents report poor vaccine efficacy, but 14% are uncertain. As in previous years, several respondents comment that they observe milder disease courses following vaccination with a DNA vaccine.

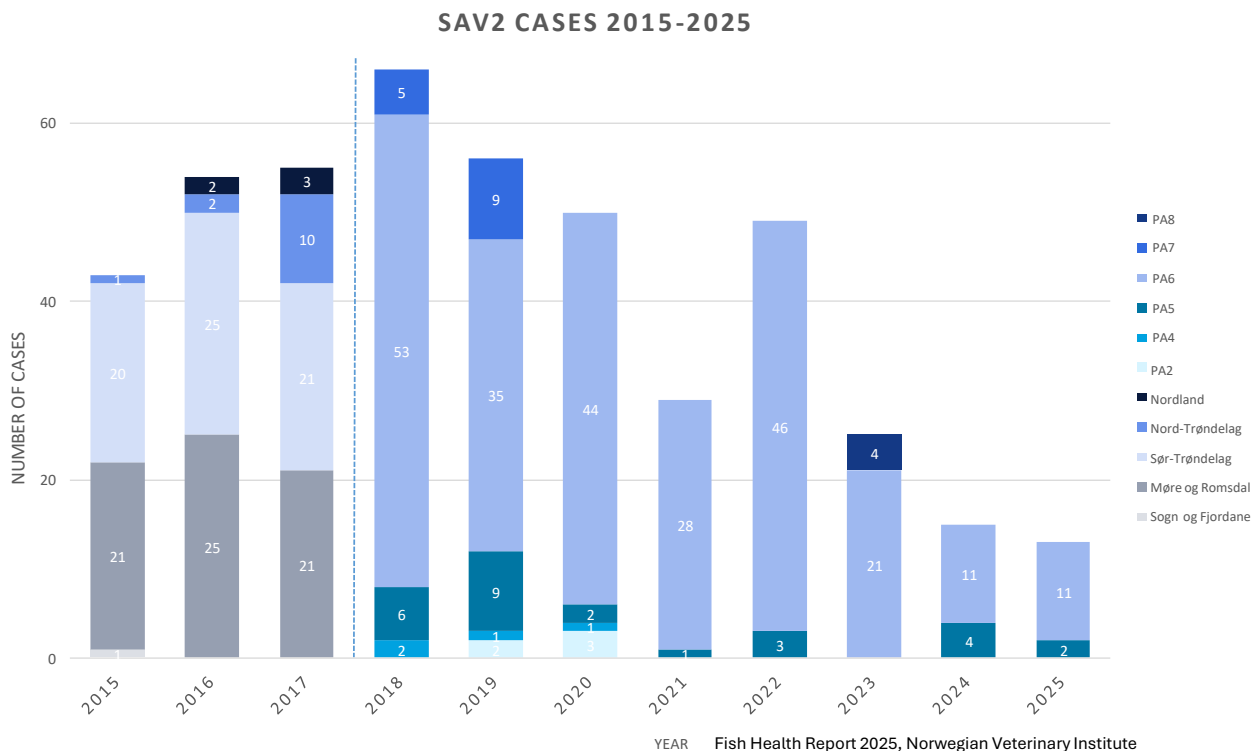
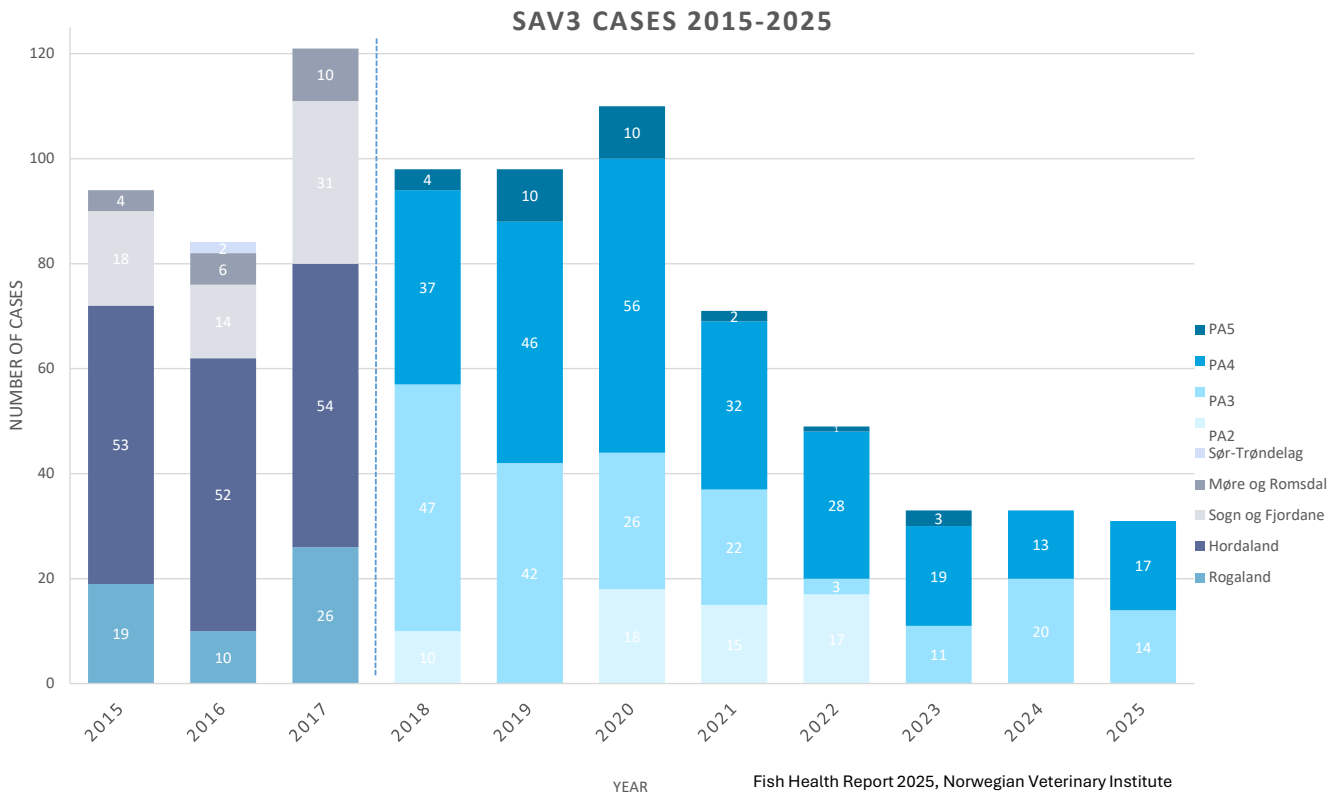
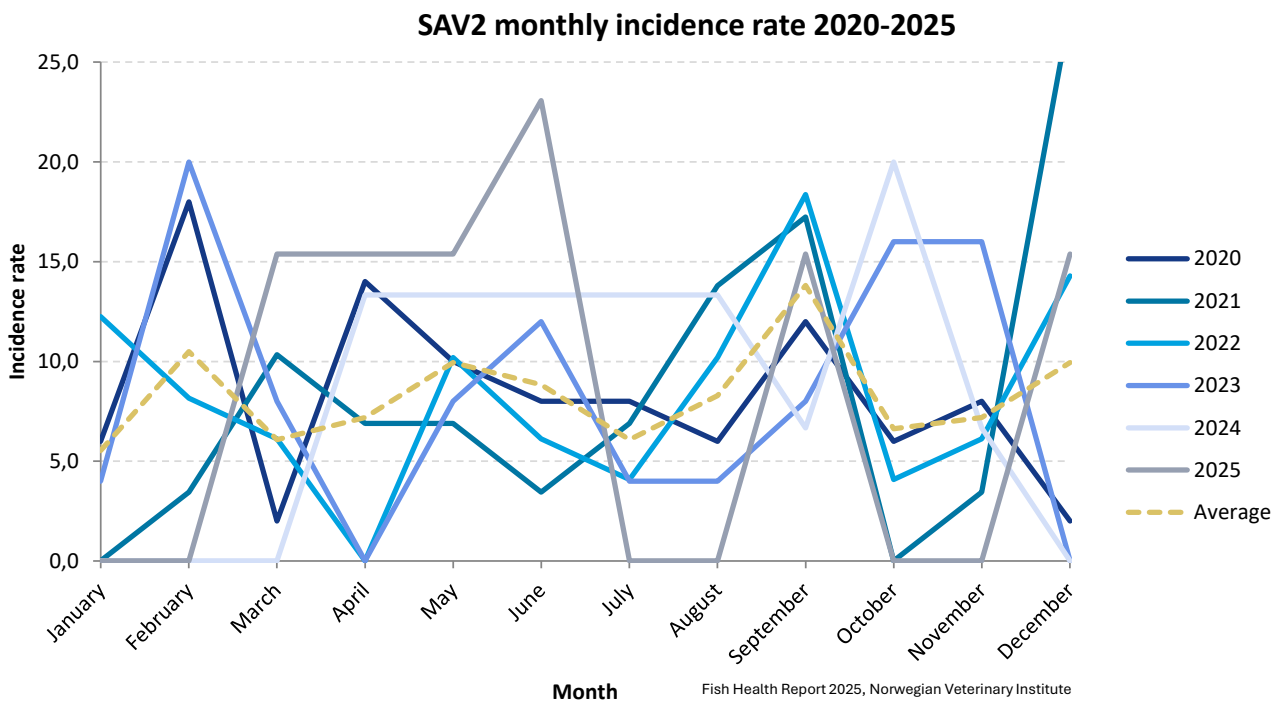


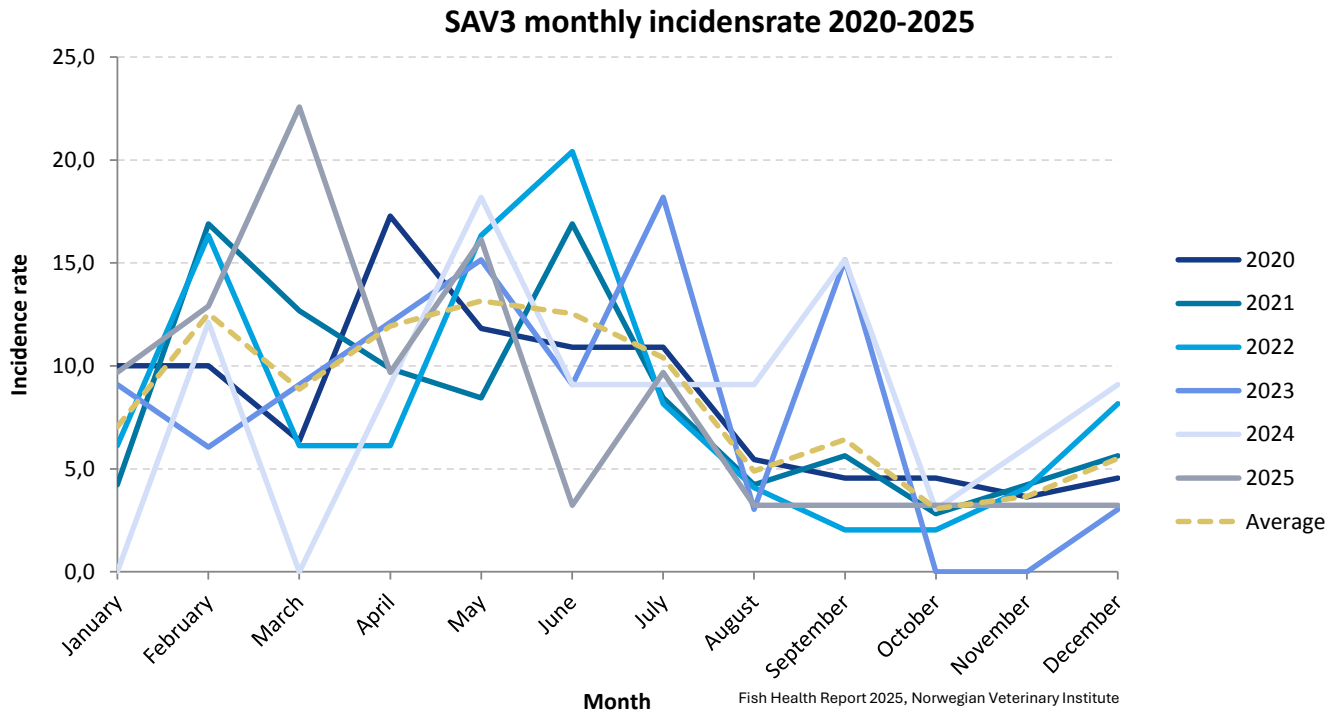
Figure 7.1.3 Distribution of the number of new SAV2 cases by county (2015–2017) and by production area (PA) (2018–2025). Areas without SAV2 cases are not included in the figure. Illustration: Hege Løkslett, Norwegian Veterinary Institute.



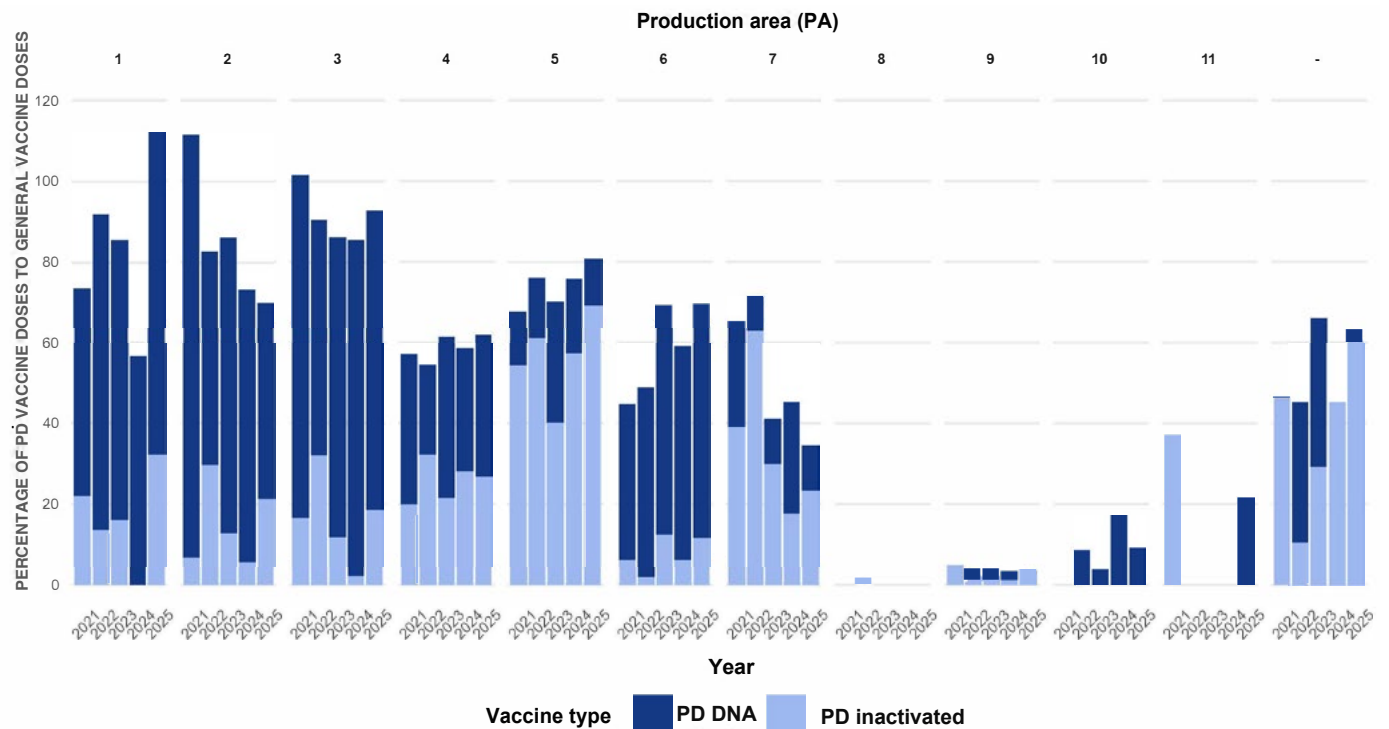
**Figure 7.1.4** Distribution of the number of new SAV3 cases by county (2015–2017) and by production area (PA) (2018–2025). Areas without SAV3 cases are not included in the figure. Illustration: Hege Løkslett, Norwegian Veterinary Institute.



**Figure 7.1.5** Monthly incidence rate of SAV2 from 2020 to 2025. The figure illustrates the number of cases each month relative to the total annual number of cases. During the period 2020–2025, the lowest number of SAV2 cases was recorded in 2025 (13), and the peak observed in June reflects that this was the month with the highest number of cases (3) that year. The incidence rate for each month was calculated by dividing the number of new cases in a given month by the total number of new cases for the entire year and multiplying by 100. Illustration: Hege Løkslett, Norwegian Veterinary Institute.



**Figure 7.1.6** Monthly incidence rate of SAV3 from 2020 to 2025. The figure illustrates the number of cases each month relative to the total annual number of cases. During the period 2020–2025, the lowest number of SAV3 cases was recorded in 2025 (31), and the peak observed in March reflects that this was the month with the highest number of cases (7) that year. The incidence rate for each month was calculated by dividing the number of new cases in a given month by the total number of new cases for the entire year and multiplying by 100. Illustration: Hege Løkslett, Norwegian Veterinary Institute.



**Figure 7.1.7** PD injection vaccine doses expressed as a percentage of “baseline vaccine doses” delivered from pharmacies to smolt hatcheries from 2021 to 2025, distributed by the production area (PA) in which the hatchery is located. The symbol “-” indicates that the PA could not be determined. PD vaccines are divided into two groups based on production method: PD DNA comprises DNA vaccines, whereas PD inactivated comprises traditional, inactivated vaccines. No use of PD vaccines has been recorded in brown trout or rainbow trout. Both vaccines are not included. Data were obtained from the Norwegian Food Safety Authority’s Veterinary Medicinal Products Register (VetReg), downloaded on 02 February 2026. Illustration: Leif Lukas Löfling, Norwegian Veterinary Institute.

## Assessment of the PD situation

The occurrence of PD cases stabilized in 2025, with a marginal decline in the number of cases linked to both SAV2 and SAV3 compared with 2024. Neither PA2 nor the northern surveillance zone has recorded any detections since 2023. The endemic areas for the different genotypes are now limited to PA3 and PA4 for SAV3 and PA5 and PA6 for SAV2, indicating that an increasing proportion of the coastline is PD free.

The disease nevertheless continues to pose a burden on the industry through increased production costs and welfare-related challenges for the fish. Fish may be infected with SAV long before showing clinical signs of disease (preclinical infection). Frequent screening of a sufficient number of samples is therefore important to enable early detection of infection. Low PD prevalence or individuals with very low viral loads at a site may result in failure to detect the virus even when it is present. PD is a typically stress-related disease, and a subclinical infection may therefore develop into a severe outbreak following, for example, handling associated with delousing treatments. SAV is transmitted within and between marine sites via water currents, as well as through transport and movement of infected populations between sea sites.

A review of the weights of Atlantic salmon registered with SAV infection/PD in 2025 shows that 59% weighed more than 2 kg, with a mean weight of 3.5 kg among these fish and a range of 2.2–6.8 kg. The mean weight of rainbow trout was 2.6 kg (range 0.8–5.4 kg). This suggests that a large proportion of the fish are able to balance infection pressure and their own resistance for a long period before developing disease, or that they are exposed relatively late in the sea phase. However, the proportion of large salmon was higher in 2024 (77%). In 2025, 22% of affected salmon weighed less than 1 kg (SAV3), and SAV infection was detected in salmon smolt weighing 60 g (runts approximately three months after sea transfer). Such cases indicate that some fish are exposed to infection pressure relatively early in the sea phase, likely in combination with stress.

As in 2024, data on prescribed vaccines for Atlantic salmon and rainbow trout have been extracted from the NFSA's Veterinary Medicinal Product Register (VetReg) (Chapter 4 Biosecurity and Figure 7.1.7). For PD vaccines, the numbers are distributed between the two main vaccine types: DNA vaccines and inactivated virus vaccines. The register contains only information on which hatchery site and fish species the vaccine has been prescribed for. In 2025, only Atlantic salmon were reported as vaccinated against PD, and the total number of vaccine doses sold is somewhat higher than in 2025. Calculation of PD vaccination coverage—that is, the proportion of basic-vaccinated fish that also receive a PD vaccine—indicates coverage of 70% or higher in PA1–PA3 and PA5–PA6. In PA4, coverage is somewhat lower, at around 60%, while PA7 shows a declining coverage of below 40% compared with previous years. These numbers are, however, somewhat uncertain, as coverage for PA2 and PA3 in some instances exceeds 100%. It should be noted that no PD vaccine is marketed for use in rainbow trout, even though this species is also susceptible to SAV infection and development of PD, and 20% of detections in the SAV3 area in 2025 are associated with this species.

Since the northern boundary of the PD zone was moved further north in 2017, sporadic PD cases have occurred in the northern surveillance zone. In 2023, PD caused by SAV2 was detected at sites in PA8, far outside the PD zone. No new cases have been detected in this area in 2024 and 2025, and the NFSA has therefore been able to lift the restriction zone. Targeted cooperation between the authorities and the industry has been important in combating the disease in the area and demonstrates once again that PD can be successfully combated through strict biosecurity measures.

## 7.2 Infectious salmon anaemia (ISA)

By Torfinn Moldal, Hege Løkslett and Johanna Hol Fosse

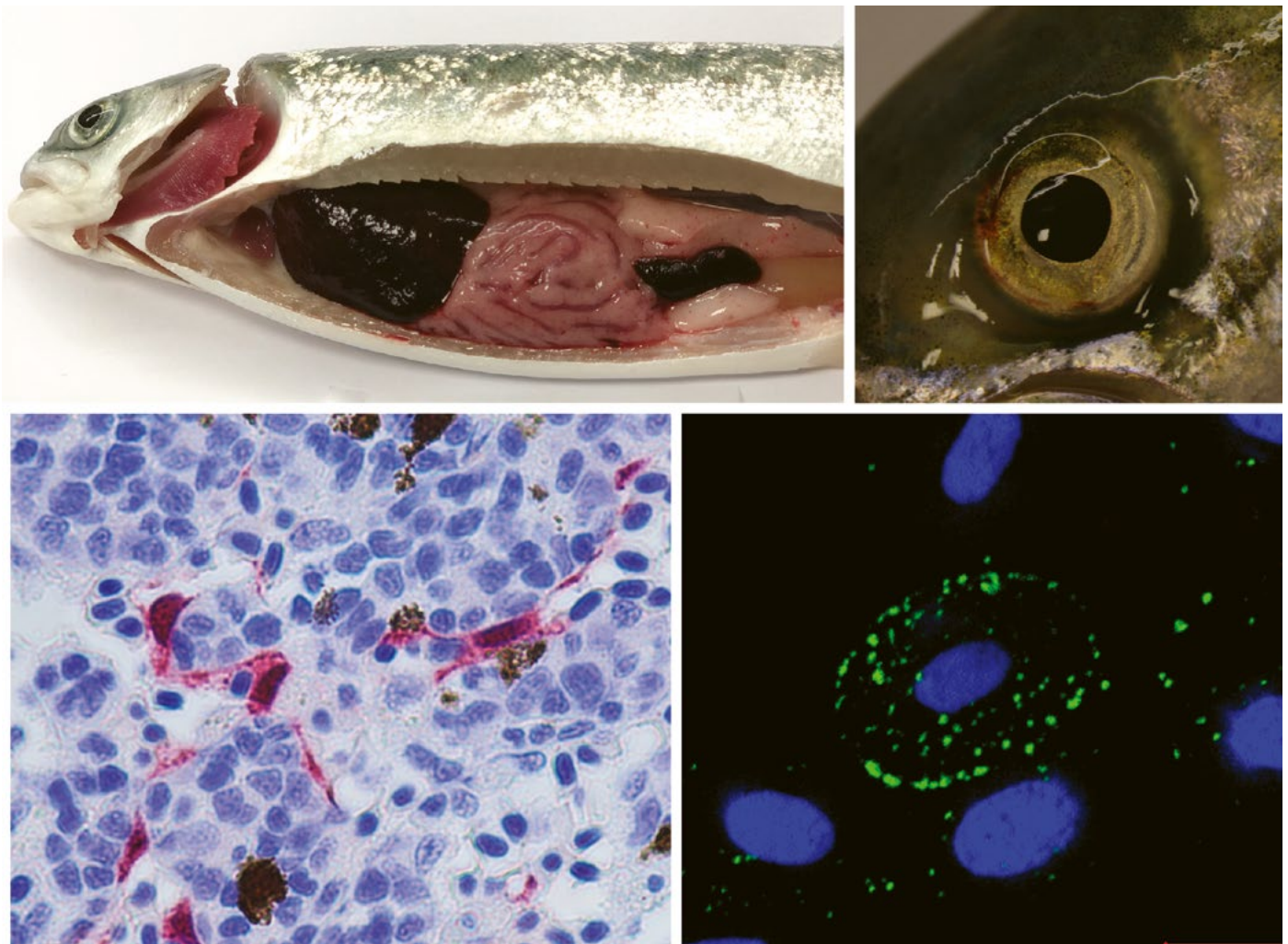
### The Disease

Infectious salmon anaemia (ISA) is a serious viral disease caused by virulent (disease-causing) variants of infectious salmon anaemia virus (ISAV HPRΔ). Natural outbreaks of ISA have only been detected in farmed Atlantic salmon, but both rainbow trout and brown trout are susceptible to infection.

The virus initially establishes itself on the fish's external surfaces (gills and skin) and subsequently attacks the vascular system. At necropsy, pale gills are often observed as a sign of severe anaemia, along with varying signs of circula-

tory disturbances and vascular damage, such as ascites, oedema, haemorrhages in the eye, skin, and internal organs, and necrosis (Figure 7.2.1).

The ISA virus may be present at a site for a long time before fish with typical clinical and pathological signs of disease and increased mortality are observed. A relatively small proportion of the fish at a site may be infected and diseased, and daily mortality in cages with affected fish is correspondingly low, typically 0.5-1 per mille. In such cases, detection of the virus can be challenging, and it may be



**Figure 7.2.1** Infectious salmon anaemia (ISA) may cause clinical signs such as pale gills, dark-coloured liver, and haemorrhages in internal organs and the eyes (upper images). The ISA virus replicates in cells lining the interior of the salmon's blood vessels (lower left; the virus is marked in red using immunohistochemical staining). When the virus is released into the bloodstream, it binds to the surface of the salmon's blood cells (lower right; the virus is marked in green using immunofluorescent staining). Photo: Frieda Betty Ploss, Adriana Magalhães Santos Andresen, and Johanna Hol Fosse.

necessary to examine many fish using PCR to demonstrate infection at the site.

The nonvirulent form of the virus, ISAV HPR0, is widespread, and transient infection with ISAV HPR0, without visible signs of disease, occurs in broodstock, juvenile fish, and growout fish. However, infection with ISAV HPR0 entails a risk of developing ISAV HPRΔ, although the magnitude of this risk is not known. Several studies suggest that true vertical transmission of ISAV HPR0 to offspring via eggs does not occur frequently. Furthermore, experience from several Norwegian juvenile production facilities shows that ISAV HPR0 can persist at a site for several years and contribute to ISA outbreaks in growout fish.

## The Health Situation in 2025

### Official Data

In 2025, ISA was confirmed at 18 sea sites, including one in PA4, two in PA6, four in PA7, six in PA9, one in PA10, two in PA11, and two in PA12 (Figure 7.2.2). A substantial proportion of the confirmed ISA outbreaks in 2025 occurred in the Vesterålen region (Figure 7.2.3). All outbreaks confirmed in 2025 followed suspicions that arose during the year. Three ISA suspicions that arose during the year were not confirmed. These suspicions were based on detection of ISAV HPRΔ at sites in PA5, PA8, and PA9. In addition, a land-based broodstock facility in PA8 with suspicion dating back to January 2024 remained under suspicion at the end of 2025. ISAV HPRΔ has been detected at this facility on several occasions, most recently in the summer of 2025.

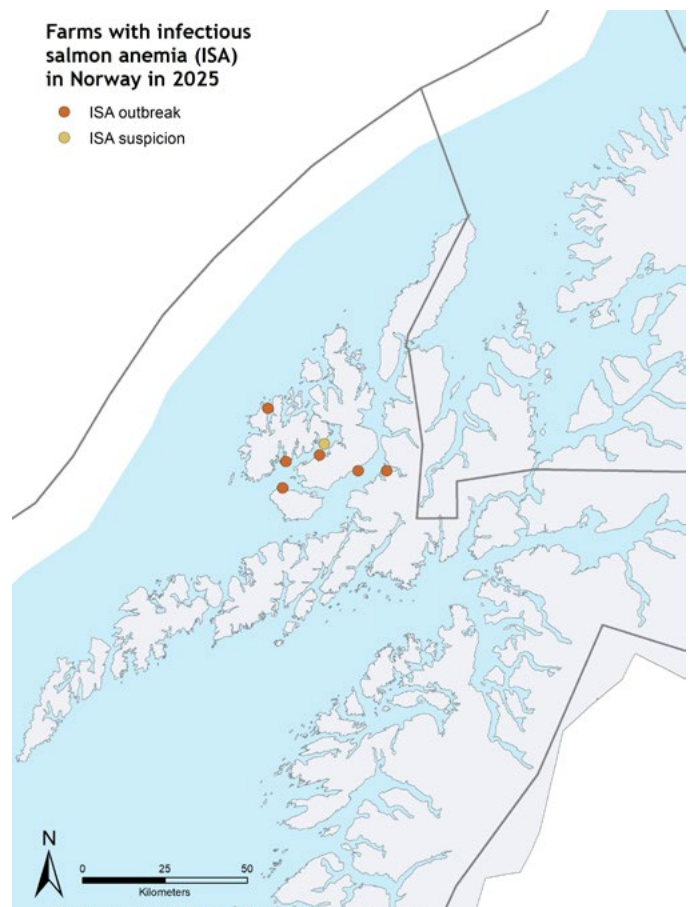
Three of the 21 sites with either confirmed outbreaks or suspicions of ISA that arose in 2025 were covered by existing ISA restricted zone regulations at the time the ISA suspicion arose. Of these, two sites were located within surveillance zones (FOR-2025-06-27-1350 and FOR-2024-06-07-927), and one site was located within a protection zone (FOR-2025-10-16-2053) at the time of suspicion. Among these, one of the surveillance zones and the protection zone had been established because of ISA outbreaks in 2025. On average, the fish had been in the sea for just over 12 months (from the first stocking date) when suspicion of ISA arose. The fish were vaccinated against ISA at seven of the sites where ISA was confirmed.

**For further information on ISA, see the Norwegian Veterinary Institute's fact page:**

[Infectious salmon anemia](#)

### Disease Control

ISAV HPRΔ is listed in Norway and the EU (categories C, D, and E), while infection with infectious salmon anaemia virus (both ISAV HPRΔ and ISAV HPR0) is listed by the World Organisation for Animal Health (WOAH). Outbreaks of ISA are regulated through strict control measures. A restricted zone is established around the affected site. This restricted zone includes a protection zone located closest to the outbreak site (typically with a radius of 5–10 kilometres) and a surveillance zone located outside the protection zone.



**Figure 7.2.3** Map of sites with confirmed and suspected infectious salmon anaemia (ISA) in PA9 in 2025. Illustration: Attila Tarpai, Norwegian Veterinary Institute.

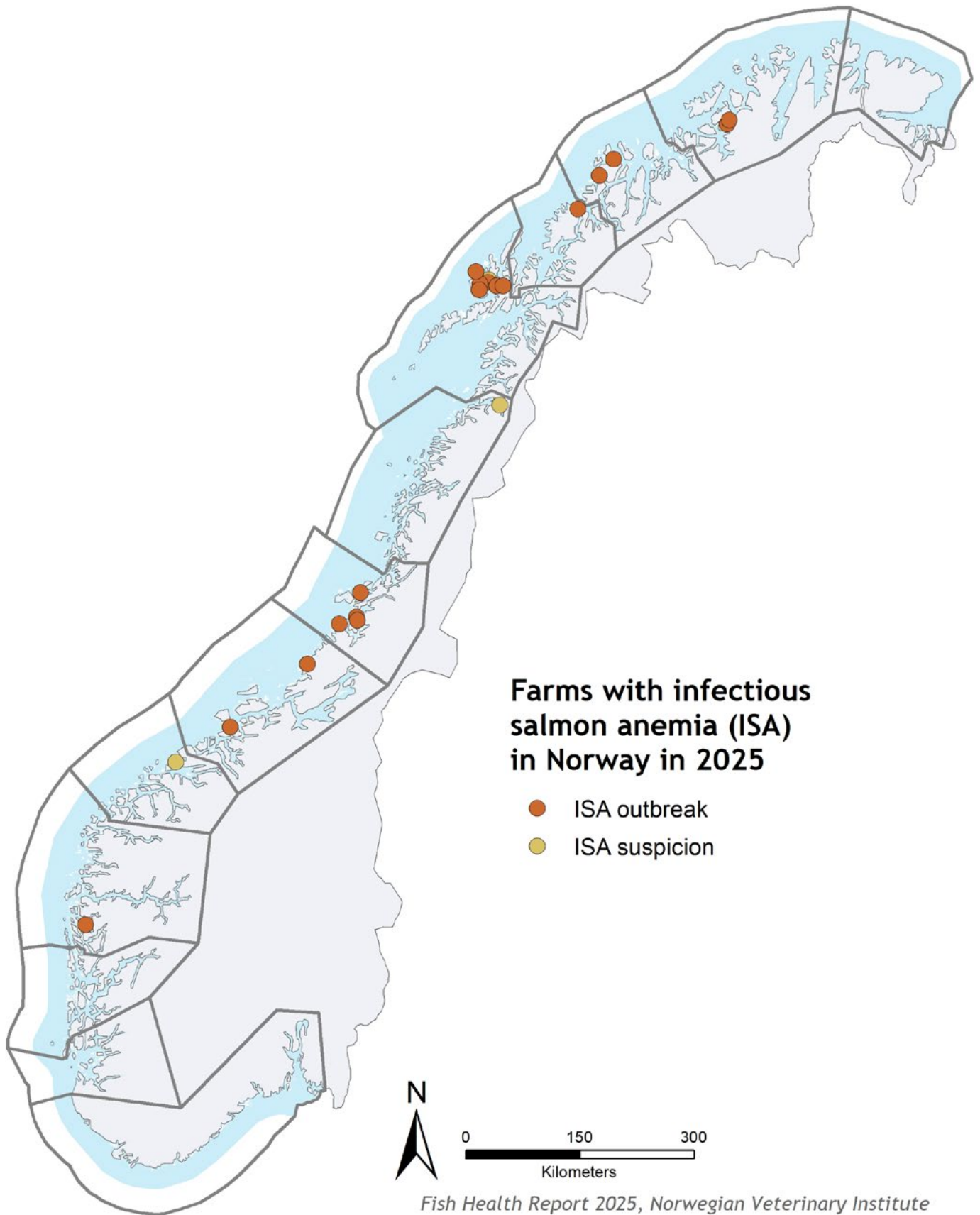


Figure 7.2.2 Map of sites in Norway with confirmed infectious salmon anaemia (ISA) and sites with suspected ISA in 2025. Illustration: Attila Tarpai, Norwegian Veterinary Institute.

### The Annual Survey

When ranking the five most important health problems across different production phases, the results of the survey show that 12 respondents perceive infectious salmon anaemia (ISA) to have an increasing occurrence in growout facilities for Atlantic salmon in 2025 (Appendix B1). An equal number of respondents consider ISA to be a cause of mortality, while two respondents believe that ISA leads to reduced welfare. Only one respondent considers ISAV HPR0 to have an increasing occurrence in juvenile production facilities for Atlantic salmon (Appendix A1), and one respondent believes that ISA causes mortality in broodstock facilities (Appendix C1). Several respondents note in freetext responses that fish vaccinated against ISA appear to have milder clinical signs, while one respondent points to an increasing trend of mortality and pronounced clinical signs in vaccinated fish.

### Assessment of the ISA situation

During the period 2015–2024, between 10 and 25 confirmed outbreaks of infectious salmon anaemia (ISA) were recorded each year (Figure 7.2.4), with an average of 15.8 outbreaks. The number of confirmed outbreaks in 2025 is therefore somewhat above the average for the previous ten-year period. Outbreaks occur throughout the year, but based on figures from the past six years, there appears to be a certain overrepresentation in late spring and summer

(Figure 7.2.5). Since 2020, confirmed outbreaks have been recorded in all production areas except PA1 and PA13 (Figure 7.2.6). Use of vaccines containing ISA virus has increased in recent years, and in 2025 approximately 190 million vaccine doses containing ISA virus were distributed from pharmacies (Chapter 4 Biosecurity).

Phylogenetic analyses based on sequences from genome segment 5 and segment 6 show that the ISA virus detected at the site where ISA was confirmed in PA4 is closely related to ISAV HPR0 detected at a juvenile production facility in the same area, although no known epidemiological link exists between the facilities. Multiple virus variants were detected at sites in PA5, PA6, PA7, and PA8. Viruses detected at two nearby sites in PA7 were closely related, and horizontal transmission between these sites is considered likely. The virus detected at the sea site in PA8 (ISA suspicion) is closely related to virus detected at a broodstock facility in PA8.

In PA9, two different virus variants were detected. There may be a link between ISAV HPR0 detected at a juvenile production facility and an ISA outbreak at a sea site that had received smolt from this facility. In addition, horizontal transmission between sea sites in the area likely occurred, and fish that were probably infected with ISA virus were transferred from one sea site to another.

Confirmed ISA outbreaks 1984-2025

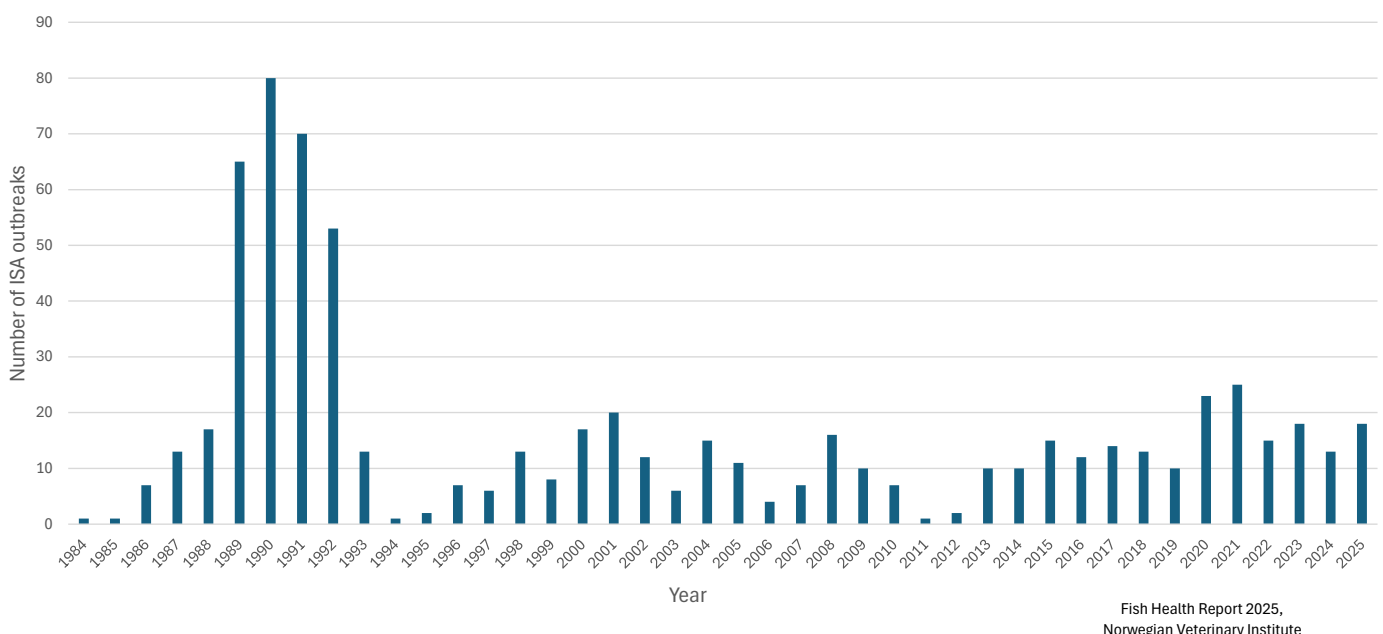


Figure 7.2.4 Number of confirmed outbreaks of infectious salmon anaemia (ISA) per year in Norway during the period 1984–2025.

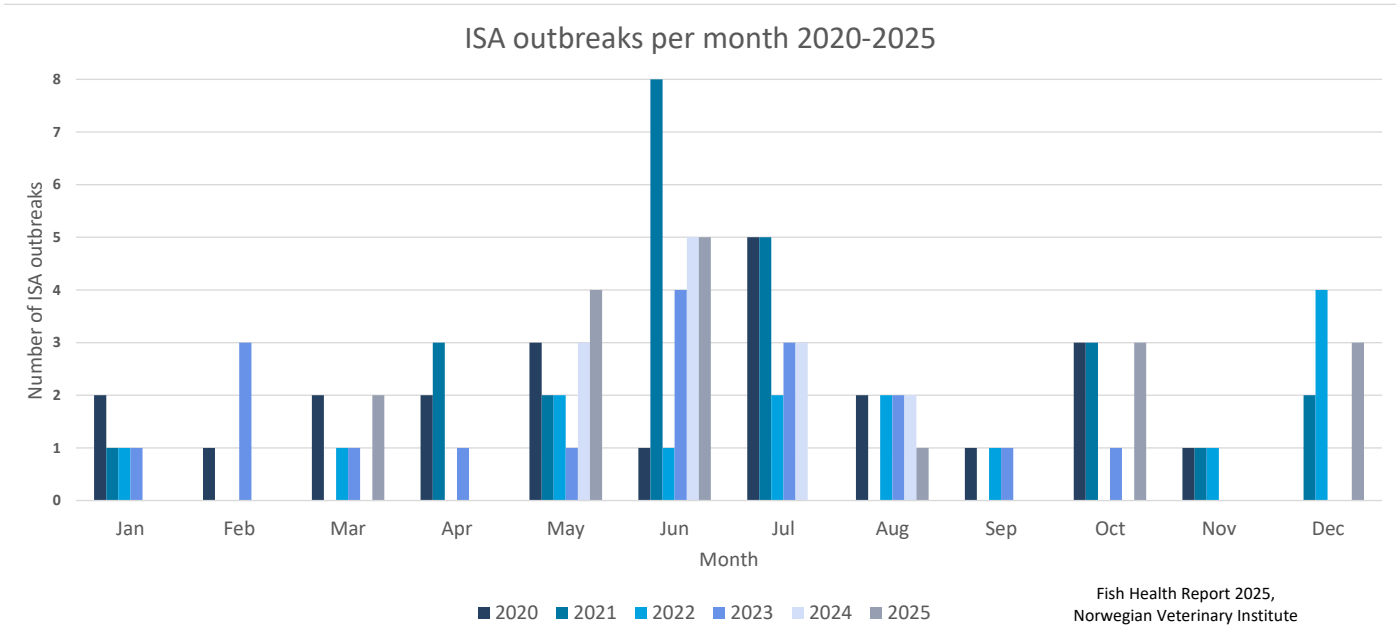


Figure 7.2.5 Number of confirmed outbreaks of infectious salmon anaemia (ISA) per month during the period 2020–2025.

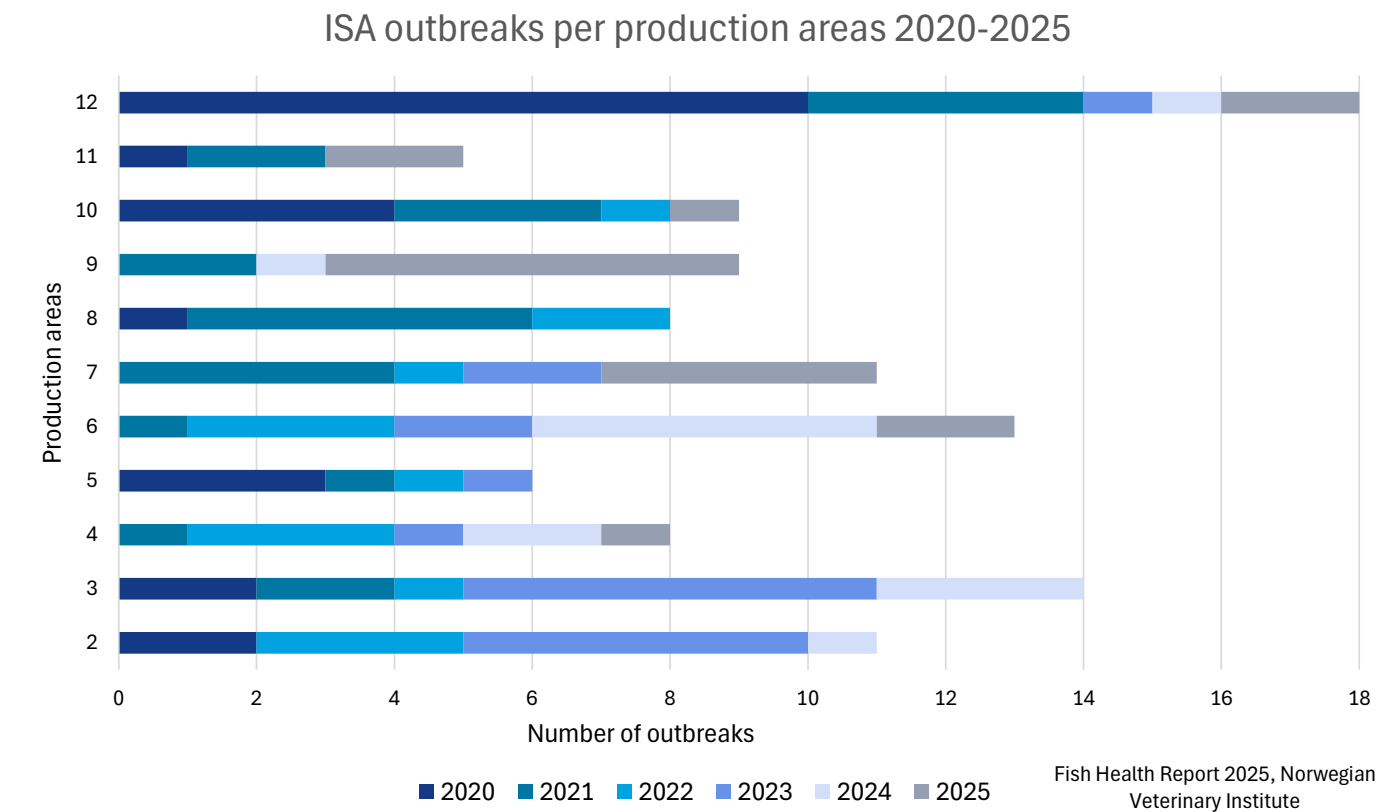


Figure 7.2.6 Number of confirmed outbreaks of infectious salmon anaemia (ISA) per production area during the period 2020–2025.

Different virus variants were detected at sites in PA10 and PA11. Viruses detected at two of these sites were closely related to ISAV HPR0 detected at the juvenile production facilities that supplied smolt to the respective sites where ISA was confirmed. Viruses detected at two neighbouring sites in PA12 were closely related, but exhibited different, non-compatible deletions in the highly polymorphic region (HPR). This suggests a common origin of the virus rather than horizontal transmission.

Since autumn 2015, systematic surveillance has been conducted in restricted zones (previously referred to as control areas) established following ISA outbreaks. This surveillance includes monthly inspections and sampling aimed at detecting ISA at the earliest possible stage. From 2019 to 2024, ISAV HPR0 in juvenile production facilities was mapped through a surveillance program in which approximately half of Norwegian juvenile facilities were examined for ISA virus by sampling 90 fish every second year. During this period, ISAV HPR0 was detected at thirty facilities. At eight facilities, ISAV HPR0 was detected on two occasions, while at two facilities it was detected on three occasions. ISAV HPR0 has been detected in fish weighing as little as 2-3 grams. In cases where sequencing of genome segments 5 and 6 was successful for viruses detected at multiple sampling occasions, it appears that the same virus variant persisted at the facility over time. ISAV HPR0 has been detected at a higher proportion of facilities using water recirculation systems compared with facilities using flow-through systems only.

ISAV HPR0 is not a notifiable infection, and the Norwegian Veterinary Institute does not have a complete overview of detections. Based on the institute's own investigations and data shared by aquaculture companies from analyses conducted at private laboratories, ISAV HPR0 was detected at a total of 78 sites in 2025 (Figure 7.2.7). This is twice as many as in 2024, when ISAV HPR0 was detected at 39 sites, and slightly more than in 2023, when ISAV HPR0 was detected at 61 sites.

Successful control of ISA requires early detection of the disease and rapid removal of infected fish to prevent further spread. However, prevention is preferable to con-

trol. The occurrence of ISAV HPR0 is likely a significant risk factor for ISA outbreaks. Increased knowledge about reservoirs of ISAV HPR0, factors affecting fish susceptibility to ISAV HPR0, and the drivers behind the transition from ISAV HPR0 to ISAV HPRΔ will be important for developing improved control strategies against ISA in the future.

In summary, it can be concluded that several confirmed ISA outbreaks in 2025 can be linked to ISAV HPR0 in juvenile production facilities and that horizontal transmission between sea sites likely occurred in both PA7 and PA9.

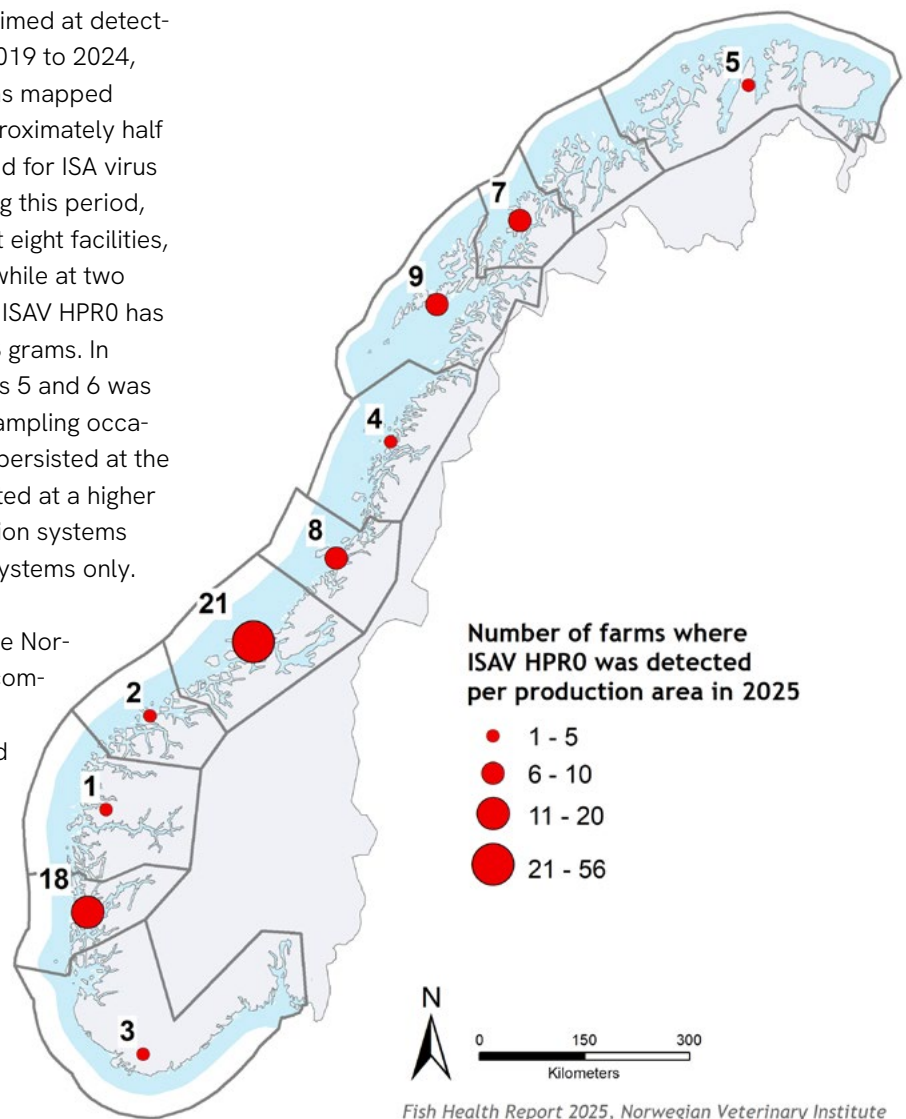


Figure 7.2.7 Map showing the number of detections of ISAV HPR0 per production area in 2025. Illustration: Attila Tarpai, Norwegian Veterinary Institute.

# 7.3 Infectious Pancreatic Necrosis (IPN)

By Irene Ørpetveit and Geir Bornø

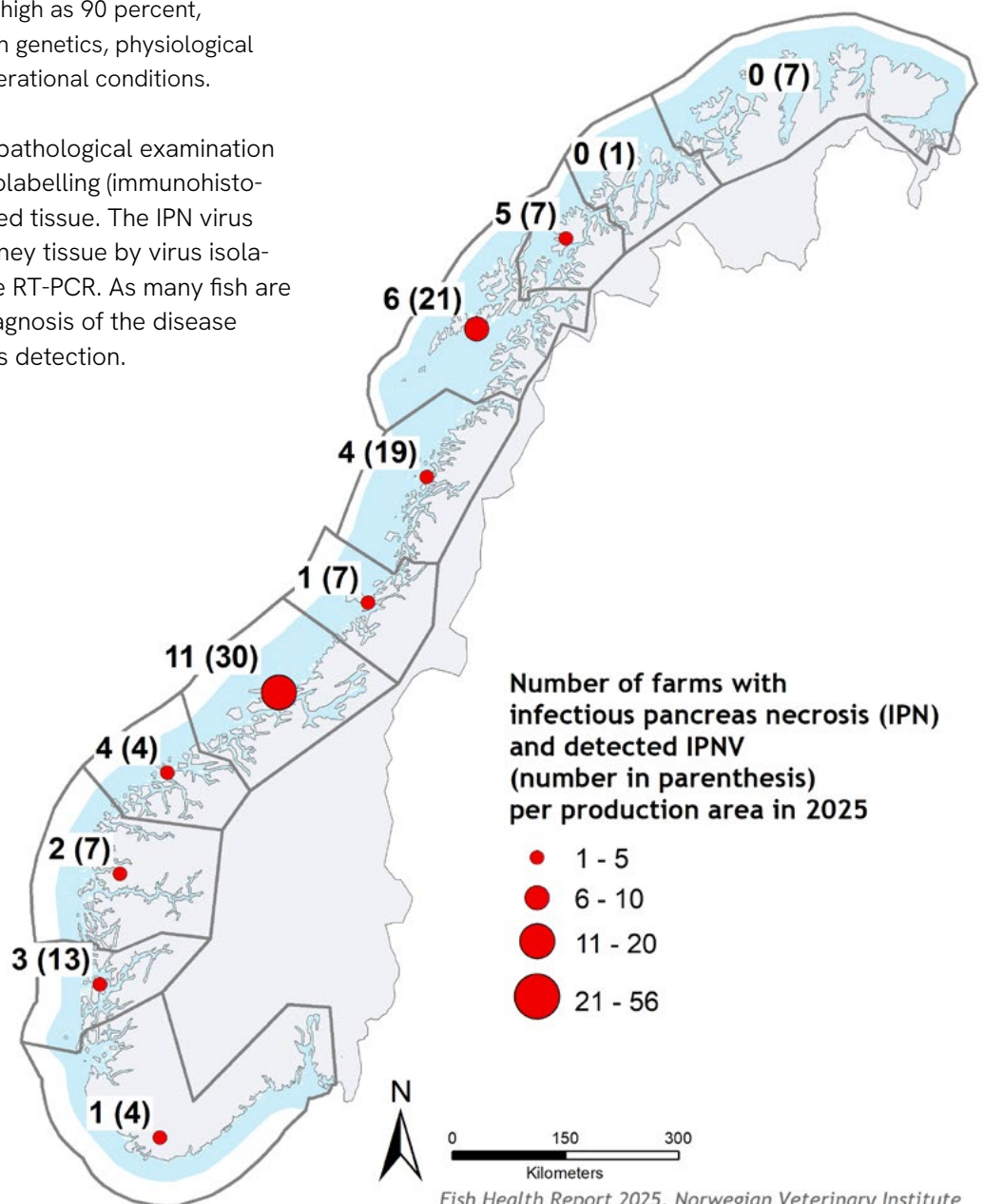
## The Disease

Infectious pancreatic necrosis (IPN) is a viral disease primarily associated with farmed salmonides. The IPN virus belongs to the genus *Aquabirnaviridae* in the family *Birnaviridae*. A high proportion of individuals infected with the IPN virus develop a lifelong, persistent infection. Fry and post-smolt appear to be the most susceptible. Mortality rates range from negligible to as high as 90 percent, depending on the virus strain, fish genetics, physiological stage and environmental and operational conditions.

IPN diagnosis is based on histopathological examination combined with positive immunolabelling (immunohistochemistry) of IPN virus in affected tissue. The IPN virus can also be detected in the kidney tissue by virus isolation in cell culture and real-time RT-PCR. As many fish are carriers of the IPN virus, the diagnosis of the disease cannot be based solely on virus detection.

For further information on infectious pancreatic necrosis (IPN), see the Norwegian Veterinary Institute's fact page:

[Infectious pancreatic necrosis \(IPN\).](#)



**Figure 7.3.1** Number of farms with an infectious pancreatic necrosis (IPN) diagnosis and detected IPN virus by production area, based on compiled data from the Norwegian Veterinary Institute and private laboratories. Production areas PA1 and PA2, and PA12 and PA13, respectively, have been combined due to a low number of farms. Illustration: Attila Tarpai, Veterinærinstituttet

## Disease control

There is no official control programme for IPN in Norway, and the disease is not notifiable. For the aquaculture industry, biosafety measures to prevent infection during the hatchery phase are important. A strong genetic marker has been identified, making it possible to produce IPN-resistant

salmon and rainbow trout (QTL eggs) through selective breeding. This type of roe is now widespread in Norway. Eradication of so-called 'house strains' of IPN virus has also contributed to the favourable IPN situation. Furthermore, a large proportion of fish are vaccinated against IPN-virus.

## The Health Situation in 2025

---

### Data from the Norwegian Veterinary Institute and private laboratories

Compiled data from the Norwegian Veterinary Institute and private laboratories ([Chapter 1](#) Statistical basis for the report) show that in 2025, IPN was detected at 37 salmon farms and three rainbow trout farms. This represents approximately a threefold increase compared with 2024. Of the 37 detections in salmon farms, eight were diagnosed at the Norwegian Veterinary Institute, comprising one hatchery site and seven sea sites. In addition, the Norwegian Veterinary Institute diagnosed IPN at one rainbow trout hatchery. IPN virus was detected, primarily by PCR, in 120 salmon farms and four rainbow trout farms along large parts of the Norwegian coast ([figure 7.3.1](#)). This is a substantial increase since 2023 and 2024, when IPN virus was detected in 38 and 72 farms, respectively. Of the farms where IPN virus was detected by PCR in 2025, 24 cases were reported as having clinical significance, compared with 17 in 2024 and three in 2023, indicating a marked increase in recent years.

### The Annual Survey

Despite extensive use of QTL stocks and vaccination in salmon farming, IPN ranks among the ten most important health problems in hatcheries for both salmon and rainbow trout ([Appendix A1](#) and [Appendix A2](#)). IPN was perceived as the fastestgrowing health problem (21 of 57 respondents).

IPN was also ranked among the ten most important health problems in salmon sea sites ([Appendix B1](#)), particularly in PA6-PA9 ([Appendix B2](#)). In contrast, for rainbow trout sea-water sites and salmon broodstock facilities, IPN was ranked relatively low ([Appendix B3](#) and [Appendix C1](#)).

### Assessment of the IPN situation

It is concerning that farmers are experiencing outbreaks of IPN in QTL fish, and also that the number of outbreaks has increased in recent years. In 2023 a virus variant distinct from recent years' detections was confirmed. Overall, the trend is clearly negative, both in terms of the frequency of IPN virus detections – which has increased markedly over the past three years – and the extent of clinical outbreaks.

## 7.4 Heart and Skeletal Muscle Inflammation (HSMI) in Atlantic Salmon and HSMI-like Disease in Rainbow Trout

By Maria K. Dahle and Julie C. Svendsen

### The disease

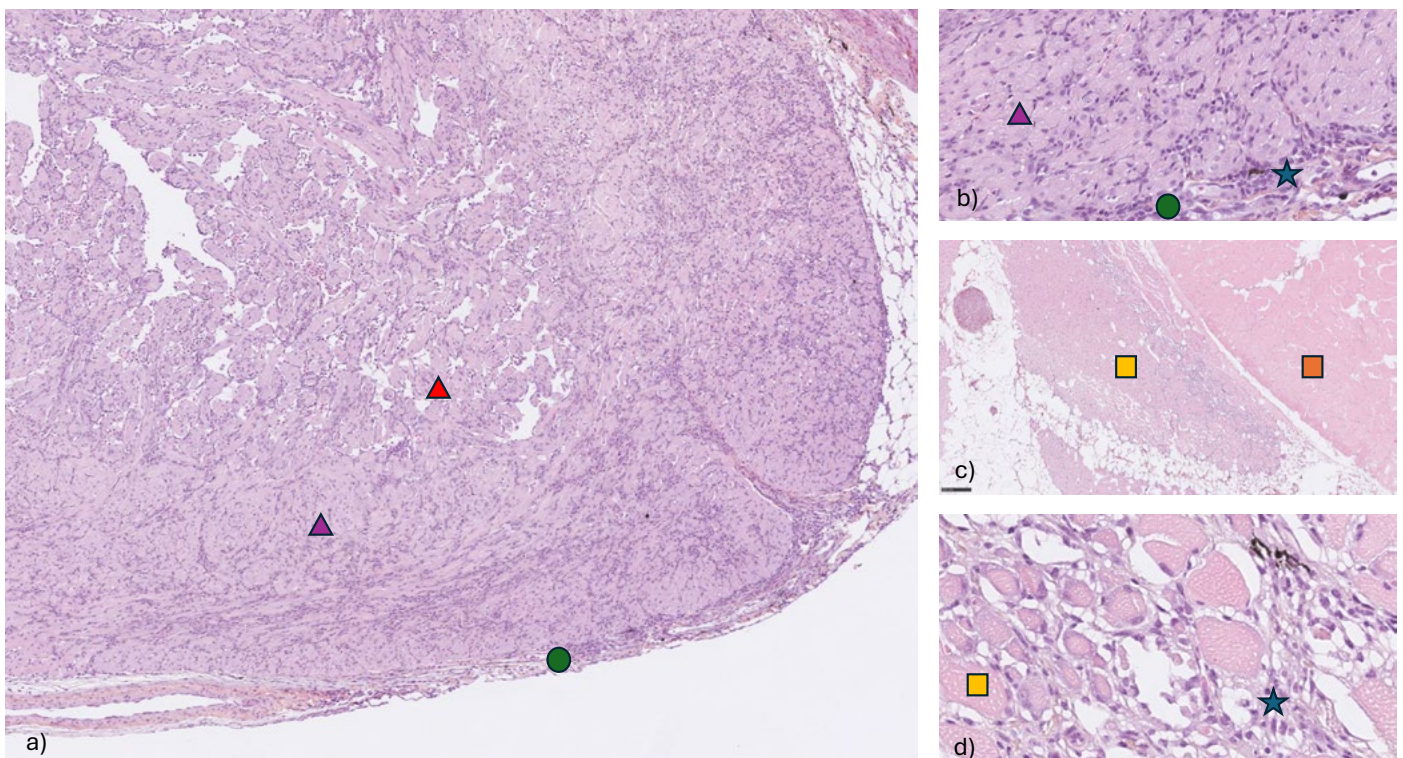
Heart and skeletal muscle inflammation (HSMI) is the most common viral disease in Norwegian farmed Atlantic salmon during the marine production phase, and rainbow trout may develop an HSMI-like disease that is somewhat less common. Both diseases can also occur during the freshwater (juvenile) phase.

HSMI in salmon and HSMI-like disease in rainbow trout are caused by two related genotypes of *Orthoreovirus piscis* (commonly referred to as *piscine orthoreovirus*, PRV). The virus was formally renamed by the International Committee on Taxonomy of Viruses (ICTV) in 2023.

HSMI was first clinically and histopathologically characterised in Norwegian Atlantic salmon in 1999. PRV-1 (genotype 1) was first identified in salmon affected by HSMI in 2010 (PRV-1) and was later experimentally confirmed as the aetiological agent of clinical HSMI. The HSMI-like disease in rainbow trout is associated with another PRV genotype, PRV-3 (genotype 3), which was identified in 2014.

**For further information on HSMI, see the Norwegian Veterinary Institute's fact page:**

[Heart and Skeletal Muscle Inflammation \(HSMI\)](#)



**Figure 7.4.1** HSMI pathological changes a) Heart chamber (ventricle). Red triangle = spongy inner layer (*stratum spongiosum*), Purple triangle = compact outer layer (*stratum compactum*), Green circle = epicardium (the outer lining of the heart). HSMI-typical changes with obvious infiltration of immune cells in the epicardium and both layers of the heart muscle, primarily *stratum compactum*. b) Detail from image a), showing inflammatory cells (blue star) in the epicardium and *stratum compactum*. c) Skeletal muscle from the same individual. Yellow square = red, aerobic portion, and orange square = white, anaerobic portion. Moderate inflammatory response in red skeletal muscle, also a typical finding in HSMI. d) Detail from image c), showing infiltration of inflammatory cells (blue star) in red skeletal muscle. Photo: Synne Grønbech and Julie C. Svendsen, Norwegian Veterinary Institute

PRV primarily causes pathology by infecting the heart, where progressively increasing inflammation develops, starting in the outer layer of the heart (epicardium) (Figure 7.4.1). The onset and severity of clinical disease are primarily determined by the extent of cardiac inflammation.

During outbreaks of clinical HSMI, inflammation is also commonly observed in the red (aerobic) portion of the skeletal musculature. The disease course may persist for several weeks and result in variable mortality outcomes. Low to moderate cumulative mortality is most frequently reported, although some outbreaks may present with a more acute course. Atlantic salmon that die during HSMI outbreaks often exhibit severe circulatory impairment.

PRV infects red blood cells (erythrocytes) during the early phase of infection, and systemic dissemination of the virus is considered to occur primarily via infected erythrocytes. This hypothesis is supported by the observation that the virus initially infects tissues with the highest oxygen demand supplied by red blood cells, including specific regions of the heart and musculature. Comparative investigations of erythrocyte antiviral responses to different PRV genotypes indicate that a delayed innate antiviral response in erythrocytes is associated with increased viral dissemination to cardiac tissue.

Rainbow trout affected by HSMI-like disease associated with PRV-3 may additionally present as markedly pale, consistent with anemia, which is not considered typical of HSMI in Atlantic salmon. A research study published in 2025 suggests that PRV-3 may induce erythrocyte lysis and anemia, whereas PRV-1 does not exert the same effect. The outcome is further influenced by host species susceptibility.

## Disease Control

There are no specific public regulations for the control of HSMI in Norway, and the disease has not been classified as notifiable in Norway since 2014. This reflects the high endemicity of PRV-1 infection in farmed Atlantic salmon, and the fact that detection of the virus is frequently not associated with clinical disease or increased mortality. Following recovery from clinical disease, Atlantic salmon typically remain persistently infected carriers of PRV-1, often until harvest, at which point cardiac lesions may have resolved. Similarly, HSMI-like disease associated with PRV-3 in rainbow trout is not notifiable. In contrast to PRV-1, PRV-3 appears to be more closely associated with the clinical disease phase and

does not appear to persist following recovery, indicating differences in host-pathogen dynamics.

Selective breeding programs aimed at increasing resistance to HSMI in Atlantic salmon are ongoing. The use of anti-inflammatory feed components has been reported to exert a moderating effect on disease expression, although these measures do not target the viral aetiology.

No commercial vaccines against PRV are currently available. However, multiple experimental vaccination studies—including DNA vaccines, inactivated vaccines, and virus-like particle-based vaccines—have demonstrated partial protective effects against clinical HSMI. The most effective protection reported to date appears to result from prior infection with less pathogenic PRV variants, resulting in elevated antibody levels and reduced disease severity.

The physiological condition of the host is a critical determinant of disease outcome. Clinical expression of HSMI and associated mortality may be triggered or exacerbated by environmental and management-related stressors, including hypoxia and handling. Consequently, HSMI-associated losses may be reduced by avoiding stress-inducing procedures such as crowding and pumping during transfer or mechanical delousing operations. Recent research further indicates that the stress hormone cortisol suppresses antiviral responses in erythrocytes, potentially facilitating increased replication of viruses such as PRV.

The principal reservoir for PRV-1 is considered to be horizontal transmission among farmed Atlantic salmon during the marine grow-out phase, although PRV is also frequently detected in freshwater production facilities. Infected fish may therefore introduce the virus into the marine environment, contributing to infection pressure and disease outbreaks.

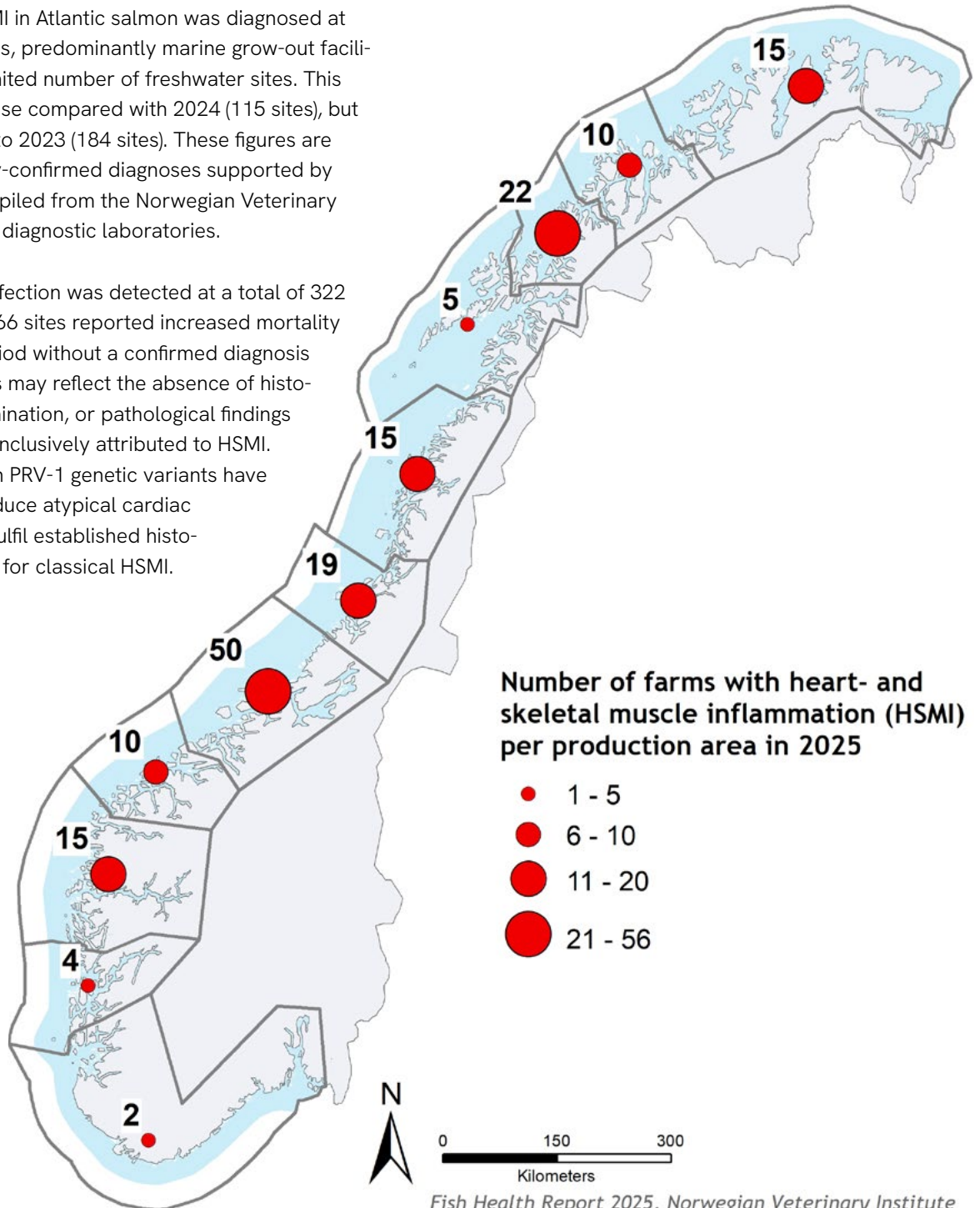
Similarly, rainbow trout infected with PRV-3 during the freshwater phase may contribute to transmission and disease development following transfer to sea. Effective control of infection status during the freshwater phase is therefore considered an important preventive strategy, in line with WOAHS biosecurity principles. Some freshwater facilities experience recurrent PRV infections, and targeted eradication efforts have been undertaken by certain industry actors. However, PRV is recognised as highly resilient, and successful eradication remains challenging.

## The Health Situation in 2025

### Data from the Norwegian Veterinary Institute and Private laboratories

In 2025, clinical HSMI in Atlantic salmon was diagnosed at 167 aquaculture sites, predominantly marine grow-out facilities, but also at a limited number of freshwater sites. This represents an increase compared with 2024 (115 sites), but a decrease relative to 2023 (184 sites). These figures are based on laboratory-confirmed diagnoses supported by histopathology, compiled from the Norwegian Veterinary Institute and private diagnostic laboratories.

In contrast, PRV-1 infection was detected at a total of 322 sites. Among these, 66 sites reported increased mortality during the same period without a confirmed diagnosis of clinical HSMI. This may reflect the absence of histological cardiac examination, or pathological findings that could not be conclusively attributed to HSMI. Furthermore, certain PRV-1 genetic variants have been reported to induce atypical cardiac lesions that do not fulfil established histopathological criteria for classical HSMI.



Fish Health Report 2025, Norwegian Veterinary Institute

**Figure 7.4.2** Number of localities diagnosed with HSMI in 2025, distributed by production areas, based on compiled data from the Norwegian Veterinary Institute and private laboratories. Due to low number of sites in production areas PA1 and PA2, these production areas have been combined. The same applies to PA12 and PA13. Illustration: Attila Tarpai, Norwegian Veterinary Institute

This combination of non-notifiable status and potential underdiagnosis complicates the precise estimation of HSMI-associated disease burden. Interpretation of diagnostic data should therefore be supplemented by epidemiological context and expert assessment by fish health professionals.

As in previous years, the majority of sites diagnosed with clinical HSMI in 2025 were located from production area (PA) 6 northwards (Figure 7.4.2). Previous genetic analyses have demonstrated the presence of multiple PRV-1 variants with differing pathogenic potential, and sequencing data suggest that more virulent variants may be overrepresented in northern regions.

PRV-3 infection in rainbow trout was detected at 18 sites in 2025, compared with 11 in 2024, with detections confined to PA3–PA5. One outbreak of clinical HSMI-like disease was reported (PA4), compared with none in 2024. While these figures may suggest increasing occurrence, survey data do not support a corresponding increase in perceived disease impact, potentially reflecting increased diagnostic awareness and testing intensity. As the condition is not notifiable, historical data may underestimate true prevalence.

### The Annual Survey

Fish health personnel assessed HSMI as the most important viral disease in Atlantic salmon marine grow-out sites. Overall, only gill diseases and consequences of delousing treatments were reported as more significant health problems (Appendix B1). HSMI was assigned greater importance than in previous years, and for the first time was experienced as the disease with the greatest impact on mortality.

The perceived impact of HSMI was greatest in northern Norway (PA10–PA13), where it was considered one of the most critical health challenges (Appendix B2). In Central Norway (PA6–PA9), HSMI was ranked among the three most significant challenges, while it was regarded of less importance in southern regions (PA1–PA5).

In the freshwater phase, HSMI was generally regarded as a minor problem, but a proportion of respondents nevertheless reported it as a mortality challenge (14 of 62) (Appendix A1). Although IPN was considered a greater viral challenge overall, its impact on mortality was reported to be comparable to that of HSMI. The significance of HSMI for broodstock facilities appears to have decreased (Appendix C1).

HSMI-like disease associated with PRV-3 in rainbow trout was ranked as the most significant viral challenge in rainbow trout marine grow-out sites, particularly with respect to mortality (Appendix B3), although this represented a slight decline compared with 2024. No disease issues were reported in freshwater rainbow trout facilities in 2025 (Appendix A2).

### Assessment of the HSMI Situation

More HSMI outbreaks were reported in 2025 than in 2024, but fewer than during 2021–2023. Fish health professionals reported a marked increase in the relative contribution of HSMI to mortality during the marine phase, and the disease was considered the most significant infectious condition in Norwegian salmon aquaculture. In northern Norway, HSMI was ranked as the most important disease challenge.

There is substantial reason to believe that HSMI-associated mortality remains underdiagnosed. Atlantic salmon may experience prolonged periods of low-mortality HSMI without formal diagnosis. Less severe cases may manifest only as handling-related mortality and be recorded accordingly. Given the high prevalence of PRV-1 infection during both freshwater and marine phases, and the existence of low-virulence PRV-1 variants, subclinical cardiac inflammation may compromise stress tolerance without causing direct mortality.

In this context, some mortality events attributed to mechanical delousing may in fact be influenced by undiagnosed HSMI. Combined with the consistently high perceived impact of HSMI on mortality, this strongly suggests that HSMI represents one of the principal health challenges facing Atlantic salmon in Norwegian aquaculture.

The number of rainbow trout sites with detected PRV-3 infection increased from 11 in 2024 to 18 in 2025, and one marine outbreak of HSMI-like disease was recorded. Concurrently, respondents reported a high impact of non-specific “cardiac disorders” on mortality and welfare in rainbow trout grow-out sites. Further investigation is warranted to determine potential diagnostic overlap between non-specific cardiac conditions and HSMI-like disease caused by PRV-3, and to improve disease attribution in line with diagnostic standards.

## 7.5 Cardiomyopathy syndrome (CMS)

By Hilde Sindre and Julie Christine Svendsen

### The Disease

Cardiomyopathy syndrome (CMS), commonly referred to as “heart rupture”, is a serious, infectious heart inflammation affecting farmed Atlantic salmon during the marine phase (Figure 7.5.1), and is widespread across all Norwegian production areas (PAs).

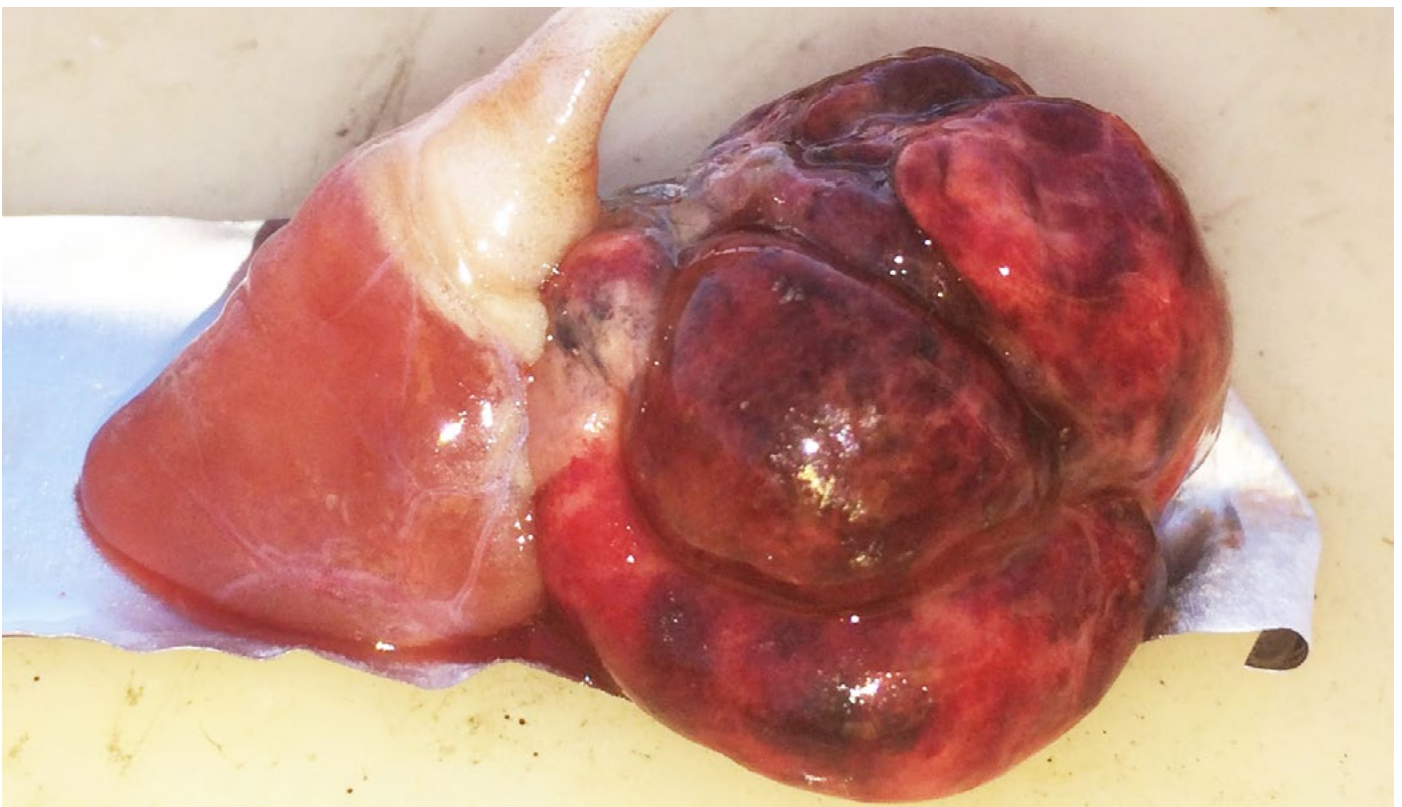
CMS is considered one of the most significant challenges for the Norwegian aquaculture industry, with a high number of annual diagnoses over many years and substantial economic losses. Mortality associated with CMS at a farming site may be low or moderately elevated over a prolonged period, or it may present as outbreaks with acutely high mortality, often triggered by a stressful event.

At present, CMS is diagnosed exclusively by histopathology, based on the detection of characteristic inflammatory

changes primarily affecting the inner, spongy layer of the atrium and ventricle. In severe cases, these lesions may become so extensive that the atrial wall ruptures, which is the origin of the commonly used name cardiac rupture. Newer in situ hybridization (ISH) techniques show promise in differentiating between various types of cardiac inflammation in histological examinations (Figure 7.5.2) but are not yet part of routine diagnostics. Clinically, the disease may resemble Pancreas Disease (PD), Infectious Salmon Anemia (ISA), and Heart and Skeletal Muscle Inflammation (HSMB), but without lesions in the exocrine pancreas or skeletal muscle.

**For further information on CMS, see the Norwegian Veterinary Institute’s fact page:**

[Cardiomyopathy syndrome \(CMS\)](#)



**Figure 7.5.1** Heart with a clearly dilated atrium. The heart originated from a fish at a site with an ongoing CMS outbreak, where several examined individuals showed similar changes. Photo: Julie C. Svendsen, Norwegian Veterinary Institute.

The disease is caused by piscine myocarditis virus (PMCV). The only known reservoir for the virus variant causing CMS is farmed salmon itself. Certain sites are more frequently affected by CMS than others, suggesting that as-yet unknown reservoirs in the fish's environment or unidentified factors influencing virus transmission may exist. There is still a significant lack of fundamental knowledge regarding the virus, its transmission routes, and disease development.

### Disease Control

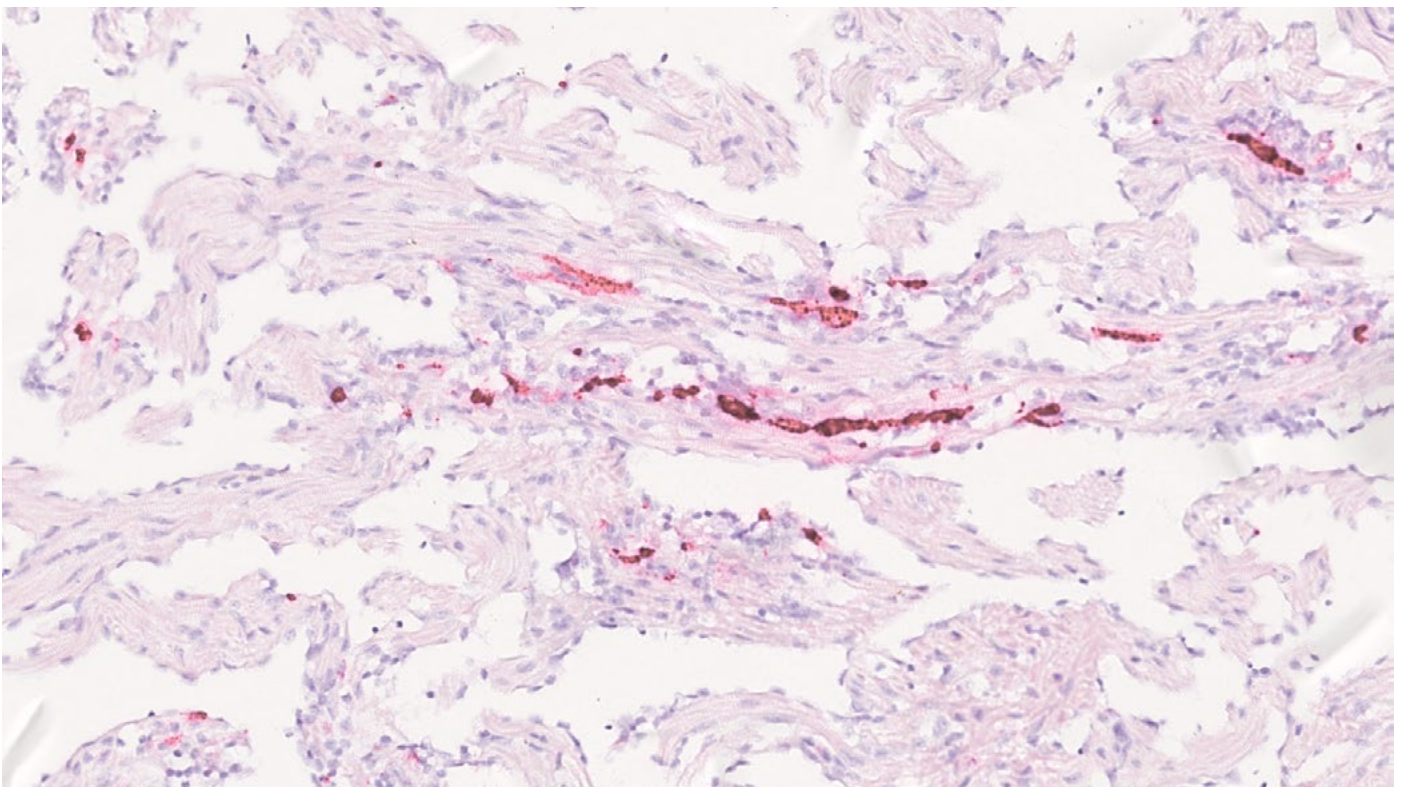
CMS is not a notifiable disease, either in Norway or to the World Organisation for Animal Health (WOAH), and there is no public control or eradication program for CMS in Norway. At present, there is no vaccine available against CMS, although vaccine development is ongoing. Breeding companies have developed and market eggs from QTL-selected strains with increased resistance to disease development. In addition, specialized feed, referred to as "functional feed", is available for use during CMS outbreaks, with the aim of reducing cardiac damage and mortality.

## The Health Situation in 2025

### Data from the Norwegian Veterinary Institute and Private laboratories

Based on compiled data from the Norwegian Veterinary Institute and private laboratories (Chapter 1, Data Basis), CMS was detected at 114 sites in 2025 (Figure 7.5.3), all of

which involved salmon. This represents a significant increase compared with 2024, when CMS was detected at 78 sites. However, the number of PMCV detections in 2025 (167) was only slightly higher than in 2024 (150). In 61% of



**Figure 7.5.2** Detection of PMCV (ORF-1) using RNAscope *in situ* hybridization in a histological tissue section of the atrium from salmon with CMS (infection trial). PMCV-specific RNA in areas of inflammation is marked with a dark reddish color. Standard light microscope, 200x magnification. Photo: Camilla Fritsvold, Norwegian Veterinary Institute

CMS diagnoses (70 of 114), PMCV was detected concurrently, representing an increase compared with 2024, when the corresponding proportion was 52%. CMS is a histopathological diagnosis that does not require detection of PMCV. Nevertheless, PMCV detection may serve as a useful supplementary analysis, particularly in cases with possible co-infection with PRV or SAV.

For PMCV detections that were not associated with a CMS diagnosis in 2025, i.e. sites where only PMCV was detected, 38% (37 sites) reported clinical disease, 19% reported no disease, and for 43% of sites information on clinical significance was lacking. The proportion of CMS cases was higher in 2024 (61%), but underreporting in 2024 may be a possible explanation for the apparent increase.

As CMS is not a notifiable disease, it is reasonable to assume that the disease has been and continues to be underreported. There is also a certain risk of misdiagnosis, as other diseases associated with circulatory failure and similar clinical findings, such as HSML and PD in various forms, may be overlooked and/or misinterpreted as CMS.

### Diagnoses by production areas (PAs)

The number of CMS diagnoses in the various production areas (PAs) is not directly comparable with figures from 2019 and earlier, as the data basis was expanded from 2020 onwards. However, changes may still serve as an indicator of trends over time.

The three northernmost production areas (PA11-PA13) had approximately the same number of cases as the previous year, with five diagnoses in 2025 compared with six in 2024. In PA8-PA10, there was a slight increase in diagnoses, from a total of nine in 2024 to 15 in 2025. In PA7, where only one diagnosis was recorded in 2024, there was a substantial increase, with ten cases in 2025.

PA6 remains a core area for CMS in 2025. CMS was diagnosed at 33 sites in this production area, an increase from 23 in 2024. This accounted for 29% of all detections.

For Western Norway south of Hustadvika, there were only minor changes in the number of CMS diagnoses. In PO5, there were ten diagnoses in 2025 compared with seven in 2024, while PA4 recorded ten cases in 2025 compared with nine in 2024. In PA3, the number of diagnoses in 2025 was

26 (23% of all diagnoses), compared with 20 in 2024. In PA1 and PA2 combined, five cases were recorded in 2025, compared with three in 2024.

### The Annual Survey

CMS was experienced by respondents as one of the ten most important health challenges affecting salmon in grow-out facilities ([Appendix B1](#)). The disease was ranked fifth, compared with ninth place in 2024. Respondents perceived CMS as a significant health problem, particularly with regard to mortality, but also reduced welfare and increasing prevalence. By contrast, the disease was assessed as a lesser problem when it came to reduced growth.

Perceptions vary along the coastline ([Appendix B2](#)). In PO1-PO5, CMS was ranked as the third most significant health challenge. In PA6-PA9, a core area for the disease, it was not ranked among the ten most important challenges. In PA10-PA13, CMS was again ranked among the ten most important challenges, with several respondents assessing the prevalence as increasing. It is emphasized that rankings by production area are based on fewer respondents, as individuals with responsibility for overlapping areas are not included in the data basis.

In broodstock, CMS is still considered one of the most important health challenges ([Appendix C1](#)). Mortality and reduced welfare are experienced as the most significant problems associated with the disease.

In the free-text responses, several respondents mention CMS as a reason for carrying out emergency slaughter using a bleeding vessel, possibly in combination with gill-related problems.

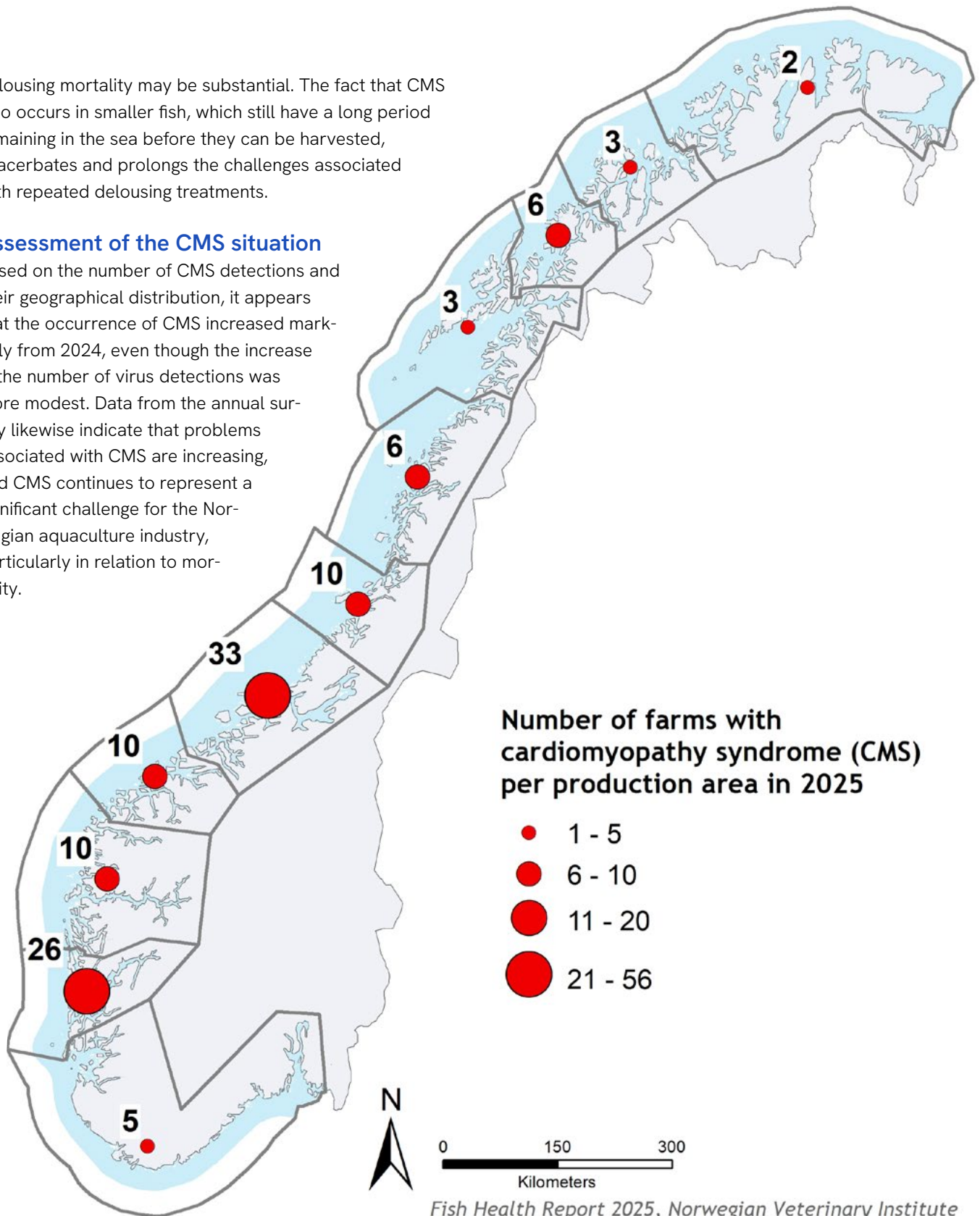
### Non-medicinal delousing and CMS

The non-medicinal delousing methods currently used in Norway involve crowding, pumping, and other stressors for the salmon. Stressful events have been identified as a risk factor for CMS outbreaks, and stress associated with delousing may likely contribute to PMCV infections without clinical signs progressing to clinical CMS and mortality. Fish with already advanced CMS, accompanied by tissue changes in the atrial chambers of the heart, will be particularly vulnerable to stress. Furthermore, a group of fish will often present with a complex disease picture, for example gill disease combined with HSML and/or CMS. In such cases, post-

delousing mortality may be substantial. The fact that CMS also occurs in smaller fish, which still have a long period remaining in the sea before they can be harvested, exacerbates and prolongs the challenges associated with repeated delousing treatments.

**Assessment of the CMS situation**

Based on the number of CMS detections and their geographical distribution, it appears that the occurrence of CMS increased markedly from 2024, even though the increase in the number of virus detections was more modest. Data from the annual survey likewise indicate that problems associated with CMS are increasing, and CMS continues to represent a significant challenge for the Norwegian aquaculture industry, particularly in relation to mortality.



*Fish Health Report 2025, Norwegian Veterinary Institute*

**Figure 7.5.3** Number of sites diagnosed with CMS in 2025, distributed across production areas, based on compiled data from the Norwegian Veterinary Institute and private laboratories. Due to the low number of sites in PO1 and PO2, these production areas have been combined. The same applies to PA12 and PA13. Illustration: Attila Tarpai, Norwegian Veterinary Institute.

# 8 Bacterial Diseases in Farmed Salmonids

By Snorre Gulla

The use of oil-based injection vaccines has for decades contributed to effective control of several serious bacterial diseases in farmed salmonids in Norway, resulting in a low level of antibiotic use. However, some bacterial diseases are still not controlled through vaccination, either because no vaccine is available or because existing vaccines do not provide full protection.

Summarised figures for confirmed detections of the most important disease-associated bacteria among salmonids in Norway in recent years are shown in Table 8.1. It is worth

noting that for all non-notifiable diseases, a varying degree of underreporting must be expected.

Short summaries on the bacterial diseases considered to have the greatest significance for farmed salmonids in Norway follow below.

For further information on fish diseases, see the Norwegian Veterinary Institute’s fact pages:

[vetinst.no/en/diseases](https://vetinst.no/en/diseases).

**Table 8.1** Number of sites with confirmed detection, per year, of selected bacteria associated with disease (in parentheses) in salmonids in Norway. Only detections in selected fish species (wild and farmed) are included. Empty cells indicate missing data. Numbers in italics represent aggregated data from the Norwegian Veterinary Institute and private laboratories (see Chapter 1 Statistical basis), and notifiable diseases are indicated with an asterisk.

	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
<b>All fish species</b>											
<i>Aeromonas salmonicida</i> subsp. <i>salmonicida</i> (furunculosis)*	3	5	2	3	2	5	5	2	0	0	0
<i>Renibacterium salmoninarum</i> (bacterial kidney disease/BKD)*	0	1	1	0	1	1	0	1	12	8	1
<b>Rainbow trout</b>											
<i>Flavobacterium psychrophilum</i> (systemic flavobacteriosis)*	3	4	1	4	4	2	1	4	1	1	2
<b>Atlantic salmon</b>											
<i>Yersinia ruckeri</i> (yersiniosis/ERM)	34	34	30	20	12	16	19	34	44	35	38
<i>Phocoenobacter</i> spp. (pasteurellosis)	0	0	0	7	14	57	45	52	27	29	34
<i>Piscirickettsia salmonis</i> (piscirickettsiosis)*	0	1	1	0	0	1	0	0	0	7	0
<i>Mycobacterium</i> spp. (mykobakteriosis)				3	7	5	5	8	10	10	12
<i>Moritella viscosa</i> ("classical" winter ulcer)							204	296	320	289	246
<i>Tenacibaculum</i> spp. (tenacibaculosis/"atypical" winter ulcer)							159	205	155	159	147

Winter ulcers associated with bacterial infection cause major health and welfare challenges every year in farmed Atlantic salmon along the entire Norwegian coastline. When an etiological agent is identified, different genetic variants of *Moritella viscosa* and/or *Tenacibaculum* spp. are detected in the vast majority of cases, either individually, together, or in mixed infections with other marine bacteria. Both were also detected at a high number of sites in 2025. Overall, however, it is difficult to obtain a precise picture of the situation regarding the prevalence of bacterial ulcer diseases in farmed Atlantic salmon, as these conditions are not notifiable and are often relatively straightforward to diagnose in the field. Despite the significant contribution of these bacteria to ulcer development, operational factors that can cause skin damage and stress the fish, such as e.g. mechanical delousing, are considered important risk factors. The majority of Atlantic salmon farmed in Norway are vaccinated against *M. viscosa* as part of multivalent vaccines, and a new vaccine that includes another variant of the bacterium has also seen increasing use. Although enhanced vaccine protection will likely have a positive effect, a comprehensive approach to fish health, which also involves continuous attention to operational practices, is considered particularly important for preventing ulcer disease in aquaculture.

*Yersinia ruckeri*, which causes yersiniosis (also known as enteric redmouth disease/ERM), was detected from approximately the same number of sites as in the previous year. Disease outbreaks are still most frequently observed among large salmon in seawater, and yersiniosis problems currently appear to be most extensive in PA1-PA4. A single genetic variant of *Y. ruckeri* is responsible for the majority of yersiniosis outbreaks in Norway, while other variants are also widespread without causing disease. Injection vaccination against the disease has increased markedly in recent years, and this has likely begun to show effects in PA5-PA7, where the previously relatively extensive problems now seem to have diminished. Sustained and broad vaccine coverage will likely be essential in the long term to bring the yersiniosis situation under control nationwide.

The pasteurellosis epizootic that has affected sea-farmed Atlantic salmon in Norway in recent years is caused by a bacterium previously known under the provisional name «*Pasteurella atlantica* genomovar *salmonicida*», but which in 2025 received the official name *Phocoenobacter atlanticus*

subsp. *atlanticus*. The number of sites where the bacterium was detected remained at a relatively high level, and although a northward spread was documented in 2024, the majority of cases are still concentrated in the southwestern production areas. Provided that the bacterium is present, a statistically significant association has been demonstrated between certain non-medicinal delousing methods and the risk of subsequent pasteurellosis outbreaks occurring. Autogenous vaccines against pasteurellosis have been developed and are used to some extent.

*Renibacterium salmoninarum* causes notifiable (category F) bacterial kidney disease (BKD) in salmonids. Following two years of markedly increasing detection numbers, the situation now appears to have stabilised. Although horizontal transmission from wild salmonids is currently considered the primary source of outbreaks in Norway, the bacterium can also transmit vertically. There are no effective vaccines or treatments against BKD, rendering general biosecurity measures and screening key tools for controlling the disease.

*Piscirickettsia salmonis* causes piscirickettsiosis, also known as salmonid rickettsial septicaemia (SRS), primarily in salmonids at elevated seawater temperatures. For the first time in several years, the disease was detected in 2024 in Norway from sea-farmed Atlantic salmon at multiple sites in PA8-PA10. Despite a few suspected cases, however, it was not recorded again in 2025. Piscirickettsiosis became notifiable (category G) in Norway in 2025.

Systemic flavobacteriosis (in rainbow trout) and furunculosis, respectively caused by *Flavobacterium psychrophilum* and *Aeromonas salmonicida* subsp. *salmonicida*, are both notifiable (category F), but remain only sporadically detected from very few, or no, sites annually in Norway. While furunculosis is effectively controlled through vaccination, biosecurity measures are important to prevent the spread of virulent *F. psychrophilum*.

Mycobacteriosis, primarily caused by *Mycobacterium salmoniphilum*, has shown a slight upward trend in recent years in terms of the annual number of sites with detections, and this trend continued in 2025. The disease can occur both in the seawater and freshwater phases. A chronic disease course with vague clinical signs and a long incubation period is common, which may contribute to underdiagnosis.

Gill epitheliocystis, often associated with *Candidatus* *Branchiomonas cysticola* or other non-culturable bacteria, are one among various common and often complex/multifactorial gill disorders of major importance in Norwegian salmon farming. This is discussed in more detail in Chapter 11.1 Gill diseases.

Among other known fish-pathogenic bacteria that occur or have occurred in Norway are *Vibrio anguillarum*, *Aliivibrio salmonicida*, atypical *Aeromonas salmonicida*, *Pseudomonas anguilliseptica*, and *Tenacibaculum maritimum*. These are currently only seen sporadically in Norwegian farmed salmon, and none are perceived to pose major problems. The first two are effectively controlled through vaccination. Nevertheless, an apparent increase in the number of cases involving infection with *V. anguillarum* (which causes classical vibriosis) is notable, first in rainbow trout in 2024, and subsequently in both rainbow trout and Atlantic salmon in 2025.

Various other bacteria are also regularly cultured from moribund or deceased farmed salmon in Norway but are often of unclear clinical significance and may instead be associated with operational or environmental challenges. Many of these are naturally occurring environmental bacteria that may act as secondary pathogens in already diseased, injured or stressed fish, or as saprophytes in dead tissues. Relevant genera/species include *Vibrio* spp., *Aliivibrio* spp., *Aeromonas* spp., *Serratia* spp., *Pseudomonas* spp., *Vagococcus salmoninarum* and *Carnobacterium maltoaromaticum*. Among these, *Vibrio splendidus* is perhaps the most noteworthy, as it is frequently isolated from fish in marine environments but is also suspected to play a role as a primary pathogen in Atlantic salmon.

# 8.1 Flavobacteriosis

By Hanne K. Nilsen

## The Disease

The bacterium *Flavobacterium psychrophilum* causes disease in many fish species in fresh and brackish water, affecting both fry and larger fish worldwide. Clinical signs include external lesions such as fin rot and skin lesions (Figure 8.1.1), as well as systemic infections, which vary among fish species and age of the affected fish.

Characterization of the bacterium's genetic material shows that there are many different variants (also called sequence types, ST) of *F. psychrophilum*. Some sequence types are associated with severe disease outbreaks and high mortality, for example, in rainbow trout, while other sequence types result in milder disease progression.

Previously, the disease has caused significant mortality in rainbow trout fry and small fish in several fish hatcheries in Norway, and is considered as a potential threat to the industry. It is not uncommon to find the bacterium in ulcers and in cases of fin rot in Atlantic salmon (*Salmo salar* L.) and brown trout (*Salmo trutta* L.) in freshwater.

The diagnosis of systemic infection with *Flavobacterium psychrophilum* in rainbow trout is made by culturing from internal organs and identification of the bacterium. Detection of the bacterium using immunohistochemistry and/or positive PCR tests are grounds for suspicion of infection.

**For more information on flavobacteriosis and *Flavobacterium psychrophilum*, see the Norwegian Veterinary Institute's fact page (in Norwegian):**

[\*Flavobacterium psychrophilum\*](#)

## Disease control

Systemic infection with *F. psychrophilum* in rainbow trout is notifiable and listed on the national list of diseases in aquatic animals (category F). The bacterium is transmitted horizontally from fish to fish, and fish showing clinical signs of infection can release large numbers of bacteria into the water. It is likely that the disease, in some cases, can spread vertically from broodstock to eggs, especially in rainbow



Figure 8.1.1 Infection with *Flavobacterium psychrophilum* in rainbow trout. Photo: Hanne Nilsen, Norwegian Veterinary Institute

trout. Good general biosecurity measures, along with disinfection of eggs to reduce potential vertical transmission, are general steps that can help prevent the spread and escalation of the disease. It is important to avoid moving infected fish to new areas in order to prevent further spread.

## The Health Situation in 2025

---

### Official Data

In 2025, systemic infection with *F. psychrophilum* was detected in rainbow trout in two rainbow trout hatcheries.

### Data from the Norwegian Veterinary Institute

Findings of *F. psychrophilum* have been reported in rainbow trout at two localities. At one facility, *F. psychrophilum* sequence type ST169 was detected. This sequence type belongs to a group of variants characterized by high genetic diversity and is presumed to represent possible environmental variants. At another facility, sequence type ST187 was detected; this sequence type has previously been identified in wounds in salmon in Norway.

In salmon from a broodstock facility with wound development, growth of *F. psychrophilum* was detected in samples from wounds and kidneys from several fish. Two isolates were sequence typed, and one of the isolates belonged to sequence type ST15, which has not previously been detected in Norway. The bacterium was also detected in salmon with wounds at a freshwater hatchery.

### The Annual Survey

Overall, respondents ranked this disease low on the list of conditions perceived as a health problem ([Appendix A1](#)).

An available injectable vaccine for large fish functions well, and a combination vaccine containing *F. psychrophilum* is actively used in areas exposed to flavobacteriosis.

### Assessment of the situation on flavobacteriosis

*F. psychrophilum* is still considered a threat to rainbow trout in Norwegian aquaculture. The bacterium may potentially pose a threat in large recirculating aquaculture systems that use freshwater. In the fjord system where *F. psychrophilum* has been detected in recent years, flavobacteriosis was not detected in large rainbow trout in 2025.

Compiled data ([Chapter 1](#), Data Basis) show that *F. psychrophilum* was detected in salmon at 14 localities in 2025. The findings are distributed along the coast (PA3-PA13). At four of the ten localities, the bacterium was detected in fish classified as healthy, while at three of the ten localities the findings were associated with disease. For salmon, the submitted material does not provide a comprehensive overview of the situation; however, results from diagnostic investigations and the survey indicate that the disease, as previously, may represent a challenge during the freshwater production phase.

The management of the disease in Norway has contributed to the favourable situation currently observed in Norwegian aquaculture with regard to its distribution, production losses, and fish welfare.

## 8.2 Furunculosis

By Duncan J. Colquhoun

### The Disease

Classical furunculosis (infection caused by *Aeromonas salmonicida* subsp. *salmonicida*) is a contagious bacterial disease that can cause high mortality in salmonids in both freshwater and seawater. Other fish species in Norwegian aquaculture, such as turbot and lumpfish, may also be affected. *A. salmonicida* subsp. *salmonicida* is often referred to as “typical” or “classical” *A. salmonicida*, while all other variants are grouped under the collective term “atypical” *A. salmonicida*. The diseases are therefore referred to as “classical furunculosis” and “atypical furunculosis”.

The most common findings in larger fish are skin ulcers and haemorrhagic boils (“furuncles”) in the musculature (Figure 8.2.1). The diagnosis is established through culture and identification of the bacterium. Clinical and histopathological findings support the disease diagnosis.

### Disease control

Classical furunculosis is a notifiable disease (category F, national diseases) in Norway. “Atypical furunculosis”, i.e. infections caused by other subspecies or strains of *A. salmonicida*, is not notifiable. The implementation of bio-security measures and vaccination programmes in the early 1990s contributed to the near disappearance of classical furunculosis. Today, the disease is well controlled due to vaccination, but occasional outbreaks in farmed salmon and lumpfish may still occur.

**For further information on furunculosis and *A. salmonicida* subsp. *salmonicida*, see the Norwegian Veterinary Institute’s fact page (in Norwegian):**

[Furunkulose](#)



**Figure 8.2.1** Furunculosis in salmon showing characteristic haemorrhagic furuncles in the musculature. Photo: Geir Bornø, Norwegian Veterinary Institute.

## The Health Situation in 2025

---

### Official data

Furunculosis (*A. salmonicida* subsp. *salmonicida*) was not detected in aquaculture in 2025.

### The Annual Survey

The results reflect that classical furunculosis is a rare disease in farmed salmon. None of the respondents assessed the disease as a cause of mortality, poor growth, reduced welfare, or as an increasing problem in any production phase for salmon and rainbow trout ([Appendices A1, A2, B1, B2 and C1](#)).

### Assessment of the furunculosis situation

The furunculosis situation in Norwegian salmon aquaculture is under control due to general biosecurity routines and the widespread use of effective vaccines. The fact that occasional outbreaks continue to occur at irregular intervals, and that furunculosis is expected to become more significant under a warmer climate, means that the disease should continue to be monitored. Vaccination against furunculosis remains a necessary measure.

## 8.3 Bacterial Kidney Disease (BKD)

By Duncan J. Colquhoun

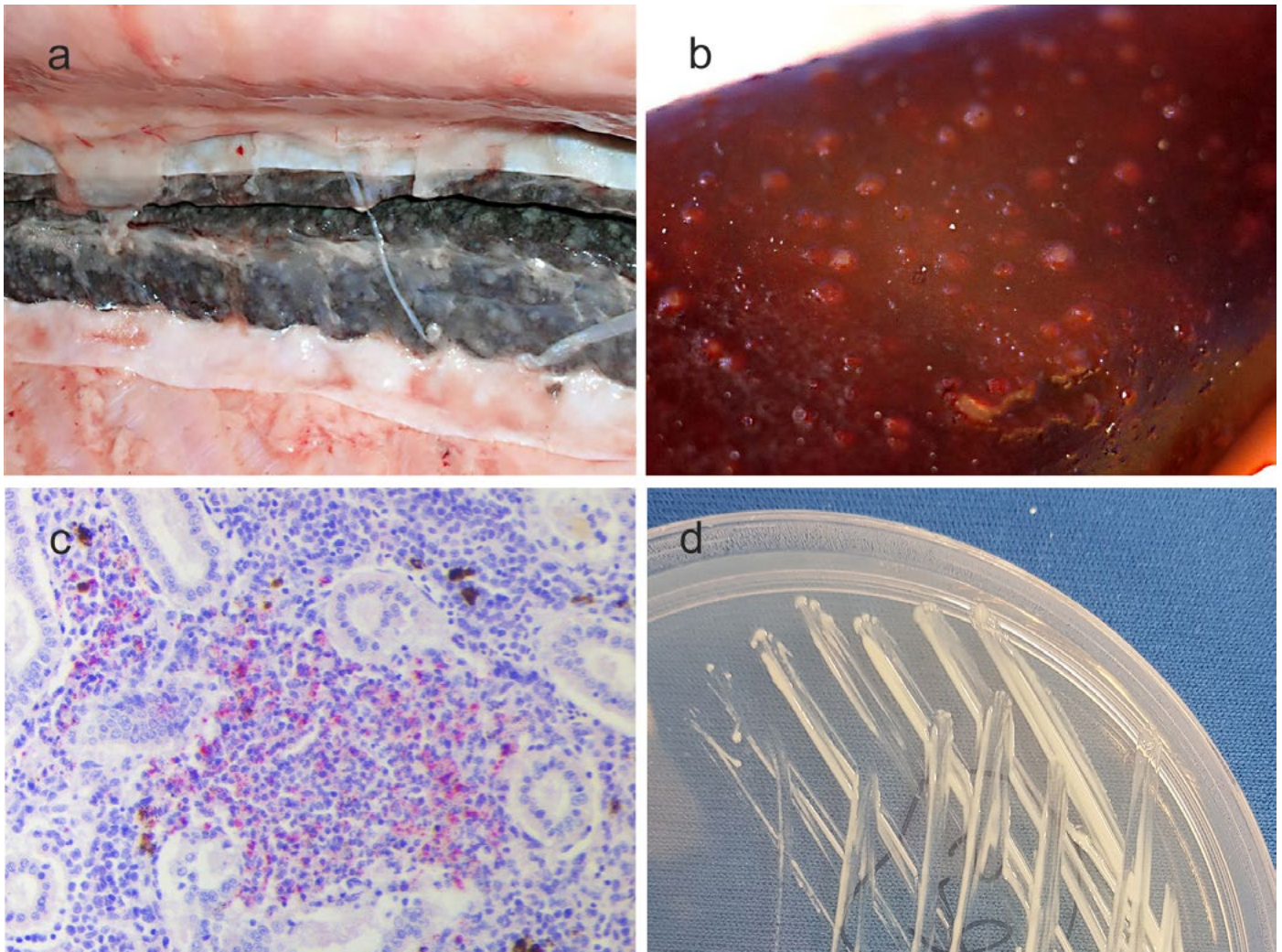
### The Disease

Bacterial kidney disease (BKD) in salmonids is a serious, notifiable disease caused by infection with the Grampositive bacterium *Renibacterium salmoninarum* (Figure 8.3.1). Known susceptible species include Atlantic salmon (*Salmo salar*), brown trout/sea trout (*Salmo trutta*), Pacific salmon including rainbow trout (*Oncorhynchus* spp.), Arctic char (*Salvelinus alpinus*), and grayling (*Thymallus thymallus*). BKD can result in acute mortality, particularly in younger fish, but most often occurs as a chronic disease. A lifelong carrier state may occur.

The bacterium can be transmitted from one generation to the next via infected roe (vertical transmission). The disease can also spread from fish to fish, and wild salmonids are assumed to be the main source of BKD cases in Norway in recent years.

**For further information on bacterial kidney disease and *Renibacterium salmoninarum*, see the Norwegian Veterinary Institute's fact sheet (in Norwegian):**

**[Bakteriell nyresyke \(BKD\)](#)**



**Figure 8.3.1** Bacterial kidney disease (BKD) in salmon. a) Pale nodules in the kidney. There may be few or many nodules, and their size may vary. b) BKD is also observed in organs other than the kidney; here, pale nodules in the spleen. c) Tissue section showing *Renibacterium salmoninarum* in the kidney. The bacteria are stained red using an immunohistochemical technique. d) *R. salmoninarum* cultured on Kidney Disease Medium (KDM). Photo: Anne Berit Olsen and Hanne Nilsen, Norwegian Veterinary Institute.

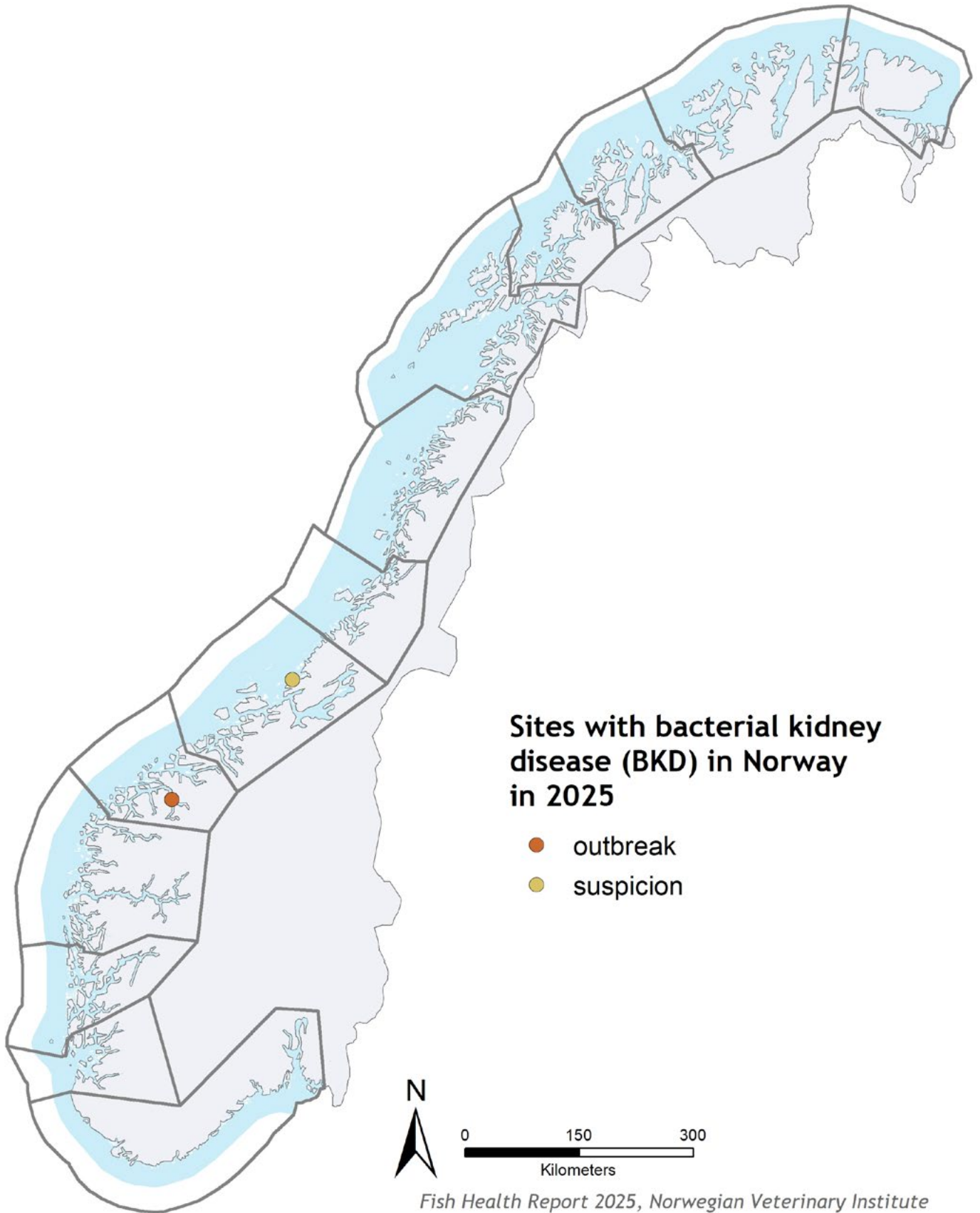


Figure 8.3.2 Sites with confirmed and suspected cases of bacterial kidney disease (BKD) in Norway in 2025. Illustration: Attila Tarpai, Norwegian Veterinary Institute.

### Disease control

The disease is nationally listed in category F. There are no effective medicinal treatments or vaccines against this

disease, and control relies on general biosecurity measures, screening of broodstock, and depopulation of infected stocks.

## The Health Situation in 2025

---

### Official Data

While bacterial kidney disease (BKD) was detected only sporadically in Norway from the late 1990s, the situation deteriorated significantly during the period 2022-2024. The situation appears to have stabilised somewhat in 2025, with only one confirmed diagnosis at a salmon growout site in PO5 and one suspected case (based on PCR alone) at a salmon broodstock facility in PO6 (Figure 8.3.2).

### The Annual Survey

For growout sites with salmon and rainbow trout, none of the respondents assessed BKD as an important cause of mortality, reduced welfare, poor growth, or as an increasing problem (Appendices B1 and B3). Nor was it considered a problem in juvenile fish or broodstock (Appendices A1, A2 and C1).

### Assessment of the BKD Situation

The current situation for BKD in the Norwegian aquaculture industry is assessed as good but highly dependent on strict biosecurity. BKD continues to represent a serious threat, as no effective vaccine or treatment is available. Although the risk of infection from wild fish is not high, it is always present. The infection situation during 2023-2024 highlights the need for increased biosecurity in general. Investigations suitable for detecting BKD should be carried out on all fish showing macroscopic signs characteristic of the disease, primarily enlarged kidneys and nodules in internal organs.

## 8.4 Winter Ulcer Disease

By Duncan J. Colquhoun and Anne Berit Olsen

### The Disease

The development of skin ulcers during the seawater phase is a serious welfare problem for farmed fish and leads to both increased mortality and reduced quality at slaughter. Ulcer development is typically an autumn and winter problem but may occur throughout the year. Outbreaks can often be linked to previous handling events, such as delousing or other procedures that impair the skin barrier and should largely be regarded as production-related.

The term “classical winter ulcer” is primarily associated with infection with the bacterium *Moritella viscosa* (Figure 8.4.1), whereas tenacibaculosis is used when ulcer development is mainly associated with infection by *Tenacibaculum* spp., and under Norwegian conditions particularly variants within the species *T. finnmarkense*. Tenacibaculosis manifests mainly as ulcers in the head region (Figure 8.4.2) and on the fins.

*Moritella* infections may be systemic, meaning that the bacterium can infect the fish’s internal organs (also without causing skin ulcers), whereas tenacibaculosis in Norwegian salmonids occurs almost exclusively as skin infections. Tenacibaculosis is less common than winter ulcer but may

be more severe. While *Moritella viscosa* and/or *Tenacibaculum* spp., alone or as mixed infections, can cause ulcers, other bacteria such as *Aliivibrio* (*Vibrio*) *wodanis*, *Aliivibrio* (*Vibrio*) *logei*, and *Vibrio splendidus* are also frequently present in the ulcers.

**For further information on disease caused by *M. viscosa* and/or *Tenacibaculum* spp., see the Norwegian Veterinary Institute’s fact page (in Norwegian): [Vintersår](#)**

### Disease Control

Winter ulcer is not a listed disease, and no official statistics on its occurrence are maintained. Vaccination of Norwegian farmed salmon against *M. viscosa* is common practice (Chapter 4, Biosecurity). There are no commercial vaccines against *Tenacibaculum* infections. In severe ulcer cases, some antibacterial treatment is used, but the effect is variable and uncertain. There is likely considerable potential for improvement through ensuring that fish are not exposed to conditions that compromise the skin barrier.



Figure 8.4.1 Winter ulcer in salmon. Photo: Per Anton Sæther, Åkerblå.

## The Health Situation in 2025

### Data from the Norwegian Veterinary Institute and Private laboratories

As in previous years, ulcers were detected in farmed salmon along the entire coast in 2025. Due to the need for specific typing methods to differentiate between various subtypes of both *Moritella viscosa* and *Tenacibaculum* spp., subtyping is often not carried out as part of routine diagnostic work.

Data compiled from the Norwegian Veterinary Institute and private laboratories indicate that winter ulcers, regardless of underlying cause, were detected at 299 salmon sites during 2025. *M. viscosa* was detected at 246 sites in 2025 (Figure 8.4.3), representing a moderate decline compared with 2024, when *M. viscosa* was detected at 289 sites. *Tenacibaculum* spp. were detected at 147 sites in 2025 (Figure 8.4.4); by comparison, *Tenacibaculum* spp. were detected at 165 sites in 2024.

Mixed infections with both *Moritella* and *Tenacibaculum* spp. were detected at 94 sites in 2025. Infection with *M. viscosa* was diagnosed at nine rainbow trout sites in PA3–PA5 during 2025. *Tenacibaculum* spp. were identified in rainbow trout at two sites in PA3 in 2025. In recent years, there has been a fairly even distribution of both *Tenacibaculum* and *Moritella* infections in salmon along the entire coast, but in the previous year it appeared that Southern and Central Norway were more affected.

### The Annual Survey

Overall, respondents assessed *Moritella viscosa* as one of the ten most important health problems in salmon at grow-out sites, particularly with respect to reduced welfare and mortality (40 and 36 of 119 respondents, respectively). The disease was perceived as a smaller problem than in 2024, and fewer respondents reported experiencing an increased occurrence (5 of 114). Several freetext responses reported improved vaccine protection following the introduction of the CC3 component. In salmon broodstock, *Moritella* infection was not ranked among the most significant health problems.

*Tenacibaculum* infections were generally considered to be of low prominence and, as in 2024, were included among the ten most important health problems only in PA10–PA13.

Unspecified ulcers, on the other hand, were of considerably greater importance and were assessed as one of the more central skin and ulcer-related problems in several areas, particularly in PA10–PA13.

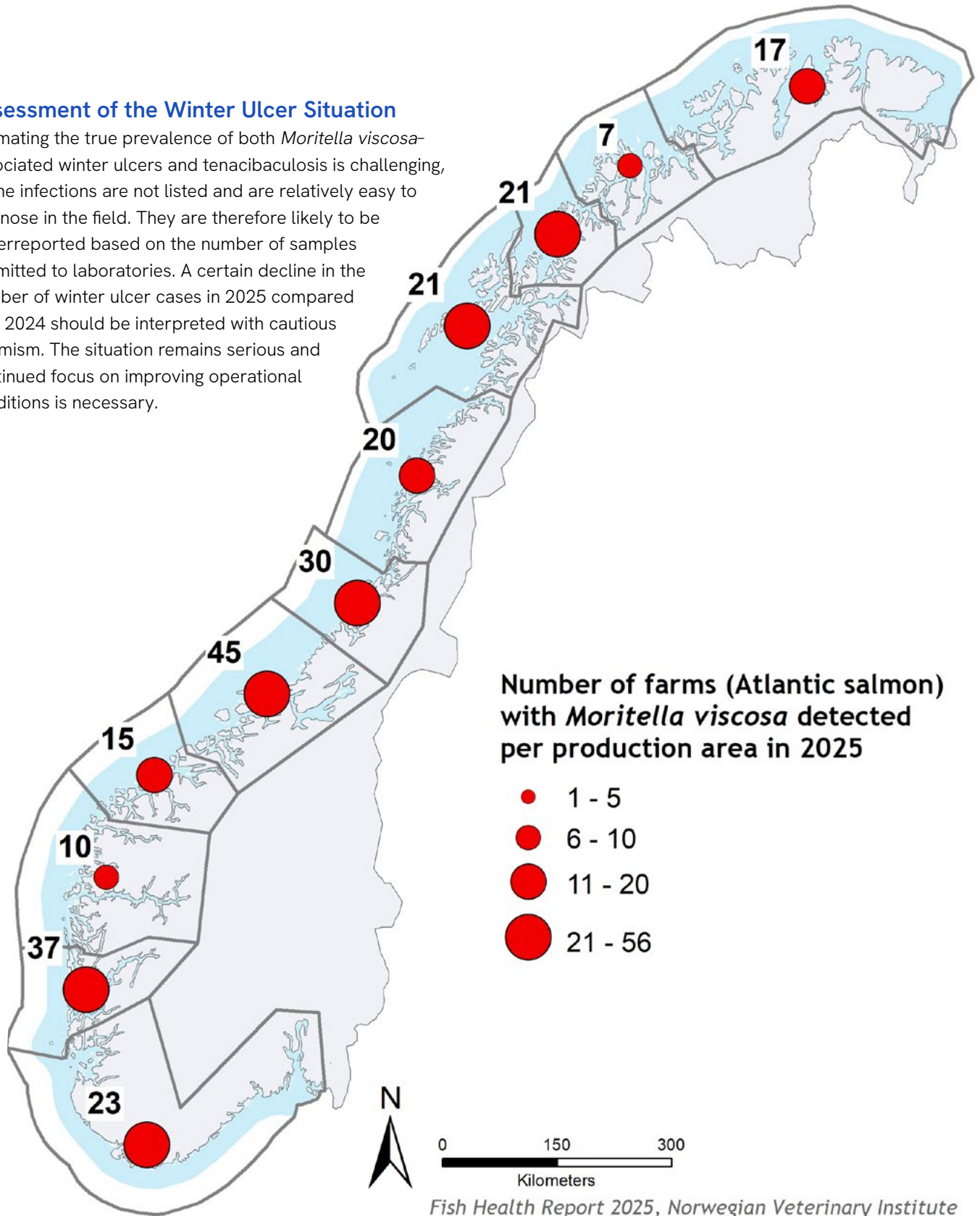
In rainbow trout during the seawater phase, both *Moritella* and *Tenacibaculum* infections were considered to be of minor importance compared with other disease challenges.



**Figure 8.4.2** Ulcers in the oral region of salmon are most often infected with *Tenacibaculum finnmarkense*. Photo: Geir Bornø, Norwegian Veterinary Institute.

### Assessment of the Winter Ulcer Situation

Estimating the true prevalence of both *Moritella viscosa*-associated winter ulcers and tenacibaculosis is challenging, as the infections are not listed and are relatively easy to diagnose in the field. They are therefore likely to be underreported based on the number of samples submitted to laboratories. A certain decline in the number of winter ulcer cases in 2025 compared with 2024 should be interpreted with cautious optimism. The situation remains serious and continued focus on improving operational conditions is necessary.



Fish Health Report 2025, Norwegian Veterinary Institute

**Figure 8.4.3** Number of sites at which *Moritella viscosa* has been detected, distributed by production area, based on compiled data from the Norwegian Veterinary Institute and private laboratories. The small number of sites in PA1 and PA2 means that these production areas have been merged. The same applies to PA12 and PA13. Illustration: Attila Tarpai, Norwegian Veterinary Institute.

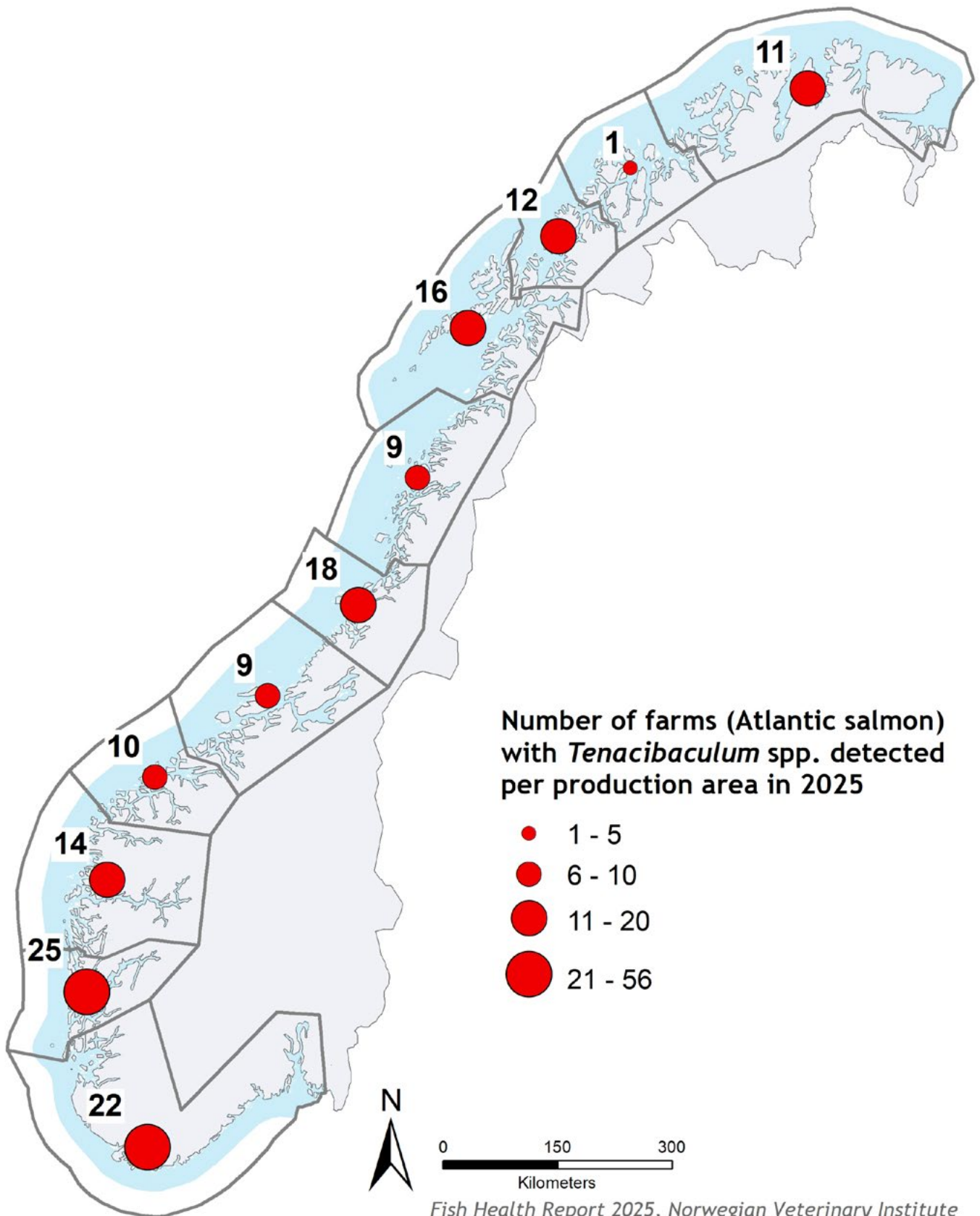


Figure 8.4.4 Number of sites at which *Tenacibaculum* spp. have been detected, distributed by production area, based on compiled data from the Norwegian Veterinary Institute and private laboratories. The small number of sites in PA1 and PA2 means that these production areas have been merged. The same applies to PA12 and PA13. Illustration: Attila Tarpai, Norwegian Veterinary Institute.

## 8.5 Pasteurellosis

By Hanne K. Nilsen, Snorre Gulla and Duncan Colquhoun

### The Disease

The disease pasteurellosis, caused by bacteria belonging to the Family *Pasteurellaceae*, has been established as endemic in Norwegian aquaculture since 2018. The term pasteurellosis encompasses infections in Atlantic salmon and lumpfish caused by bacteria previously known as *Pasteurella atlantica* genomovar *salmonicida*, *Pasteurella atlantica* genomovar *cyclopteri*, and *Pasteurella skyensis*.

Extensive characterization conducted by the Norwegian Veterinary Institute has shown that these bacteria belong to the genus *Phocoenobacter* within the Family *Pasteurellaceae*. In 2025, the names *Phocoenobacter atlanticus* subspecies *atlanticus* and *Phocoenobacter atlanticus* subspecies *cyclopteri* were formally approved. These bacteria are recognised as pathogenic to Atlantic salmon and lumpfish, respectively.

*Pasteurella skyensis*, which has been associated with disease in farmed Atlantic salmon in Scotland and was detected in Norway in 2020, also belongs to the genus *Phocoenobacter* and has consequently been renamed *Phocoenobacter skyensis*.

Infection with *Phocoenobacter atlanticus* subspecies *atlanticus* has been regarded as a serious bacterial disease in Norwegian aquaculture since 2018, with major consequences for salmon welfare, in addition to economic losses resulting from mortality, downgrading of fish, and the implementation of biosecurity measures. Since 2018, a steadily increasing incidence has been recorded along the west coast of Norway, within production areas two to five. The disease has also spread northwards.

The disease typically affects large fish toward the end of the production cycle. Historically, it has been characterized by inflammation with macroscopically visible haemorrhages in the adipose tissue around the eyes. This presentation was common during the initial outbreak in the 1990s and gave rise to the original name of the disease, "Varracalbmi," a Sami term meaning "bloody eye." In more recent outbreaks, inflammation of the pericardium, the abdominal wall, and the pseudobranch has been more common. Abscesses may also be observed in the skeletal musculature and at the bases of the pectoral fins.

Histopathological changes observed in inflamed areas are characteristic and include abundant inflammatory cells and exudate, in addition to short rod-shaped bacteria.

*Phocoenobacter atlanticus* subspecies *atlanticus* has been shown to exhibit low virulence in experimental infection trials. The bacterium can be difficult to culture, and preliminary results from investigations conducted at the Norwegian Veterinary Institute indicate that it has a limited ability to survive for extended periods when free-living in seawater and does not survive in freshwater.

*Phocoenobacter skyensis* was detected in Norway in 2020, but according to reports received by the Norwegian Veterinary Institute, it has not been detected since. *Phocoenobacter atlanticus* subspecies *cyclopteri* causes disease in lumpfish (see [Chapter 14](#), Health and Welfare of Cleaner Fish).

**For further information on pasteurellosis, see the Norwegian Veterinary Institute's fact sheet**

[Pasteurellosis in fish](#)

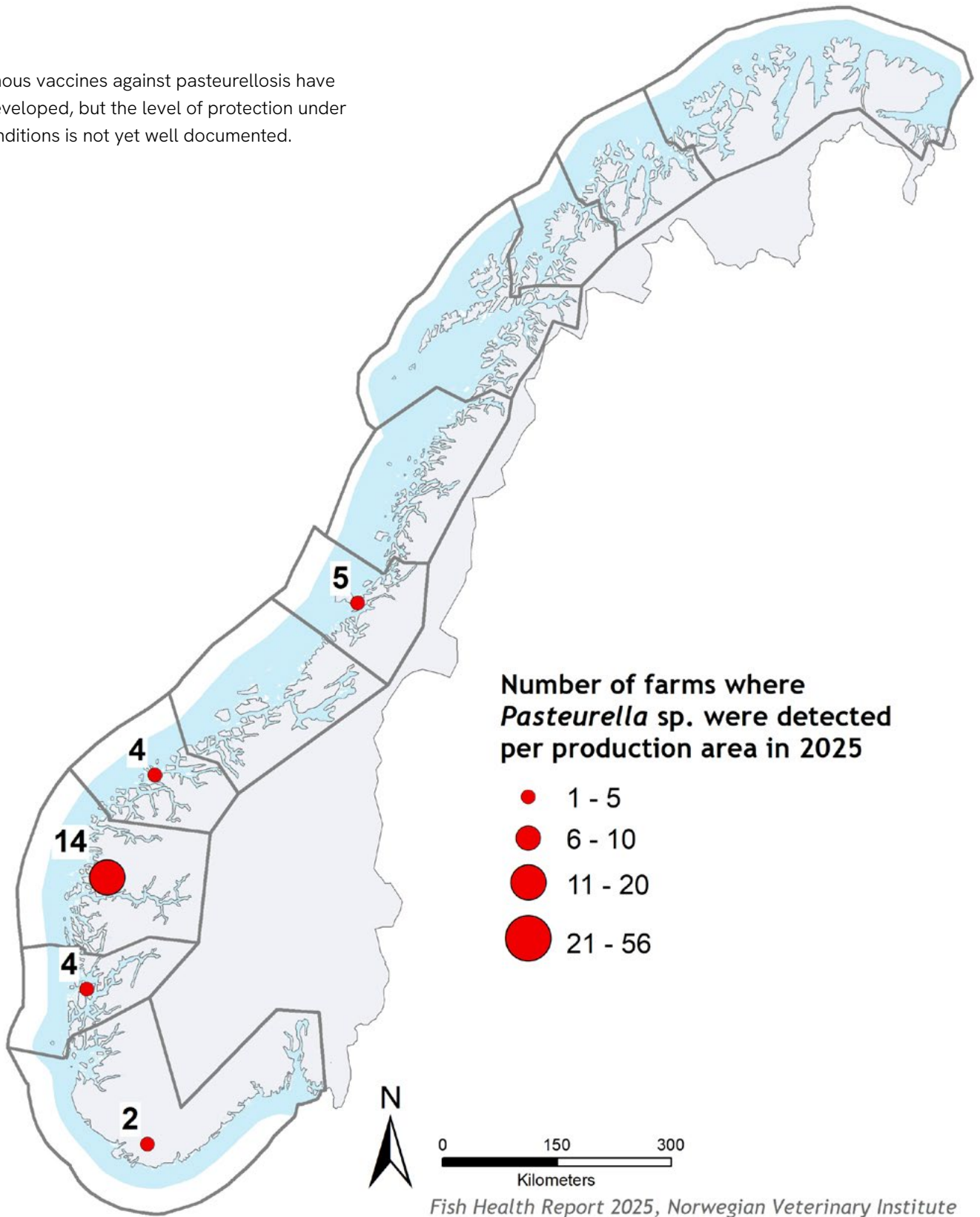
### Disease Control

As of February 2026, the disease is not notifiable.

The transmission routes and environmental survival of *Ph. atlanticus* subsp. *atlanticus* are unknown, but temporally coinciding outbreaks at nearby sites may indicate horizontal transmission. A high degree of genetic similarity among sequenced Norwegian salmon isolates from 2018 to 2024 suggests that these have been relatively recently spread from a common reservoir. Given the presence of the bacterium, nonmedicinal delousing using warm water and/or brushing/jetting has been shown to increase the likelihood that fish develop pasteurellosis. Standard biosecurity measures—such as frequent water exchange during nonmedicinal delousing to prevent potential accumulation of pathogens shed by diseased fish, as well as disinfection of equipment and personnel—may be useful preventive measures against the disease.

The reservoir for the bacteria is unknown, but genetic material from closely related bacteria has been detected in marine mammals (whales) worldwide.

Autogenous vaccines against pasteurellosis have been developed, but the level of protection under field conditions is not yet well documented.



**Figure 8.5.1** Number of «*P. atlantica* gv. *salmonicida*»-/pasteurellosis diagnoses in 2025 by production areas (PA) based on figures compiled from the Norwegian Veterinary Institute and private laboratories. PA1/PA2 and PA12/PA13 are merged due to few locations in these areas. Illustration: Attila Tarpai, Norwegian Veterinary Institute

## The Health Situation in 2025

---

### Data from the Norwegian Veterinary Institute and Private laboratories

In 2025, *Ph. atlanticus* subsp. *atlanticus* was isolated by culture and/or pasteurellosis was diagnosed by histopathological and immunohistochemical examination in salmon at 34 sites (Figure 8.5.1). The disease was detected in PA1–PA5 and PA7, with nearly half of the affected farms located in PA4.

As in previous years, feedback indicates that the clinical picture has been characterized by pericarditis and peritonitis, with reported findings of pus in the liver and gills, as well as lesions at the pectoral fins. The disease continues to occur in large fish, from approximately 2 kg up to 5 kg. As before, the disease has also been detected in fish groups that are simultaneously affected by viral diseases and/or other bacterial diseases.

### The Annual Survey

For pasteurellosis, 23 of 119 respondents (19%) considered the disease to be important for mortality in salmon growout facilities (Appendix B1). Furthermore, 17% reported that the disease led to reduced welfare, and 15% experienced it as an increasing problem. Few considered pasteurellosis to cause reduced growth.

When asked about the effect of vaccination against pasteurellosis, nearly half of the respondents (30 of 68) stated that no vaccination against the disease had been carried out. Among the 17 respondents who assessed vaccine efficacy, seven rated the effect as good and ten as moderate. No respondents rated the effect as poor. The remaining 21 respondents stated that they did not know whether the vaccine had any effect (Chapter 4, Biosecurity, Table 4.3.2).

### Assessment of the Pasteurellosis Situation

The number of detections showed a slight increase compared to 2024, when the bacterium and/or disease was detected at 29 sites, but the geographic distribution has not expanded further north.

Complex disease patterns involving multiple infectious agents, along with reports of extensive handling, may indicate a generally weakened resistance to disease. Vaccination appears to have some effect. Pasteurellosis in salmon poses a threat to fish welfare and the sustainability of the industry.

## 8.6 Yersiniosis

By Snorre Gulla

### The Disease

Yersiniosis, caused by the bacterium *Yersinia ruckeri*, can occur in several fish species, but it is mainly known as a problem in salmonids. In Norway, the disease is almost exclusively associated with Atlantic salmon. Internationally, yersiniosis is often referred to as “enteric redmouth disease”, but in Norway it usually manifests as a septicaemia with haemorrhaging and circulatory failure [Figure 8.6.1](#)), without reddening around the mouth being a prominent finding.

Infection with *Y. ruckeri* can occur both before and after sea transfer, but it is believed that the infection is primarily

introduced during the freshwater phase. Subclinical carrier states are possible, and stress (e.g., associated with delousing) may trigger these latent infections. In recent years, the disease has shifted in Norway from being most prevalent during the freshwater phase to also becoming a significant issue in larger salmon late in the marine phase.

For further information on yersiniosis, see the Norwegian Veterinary Institute’s fact page:

[Yersiniosis in Fish – \*Yersinia ruckeri\*](#)

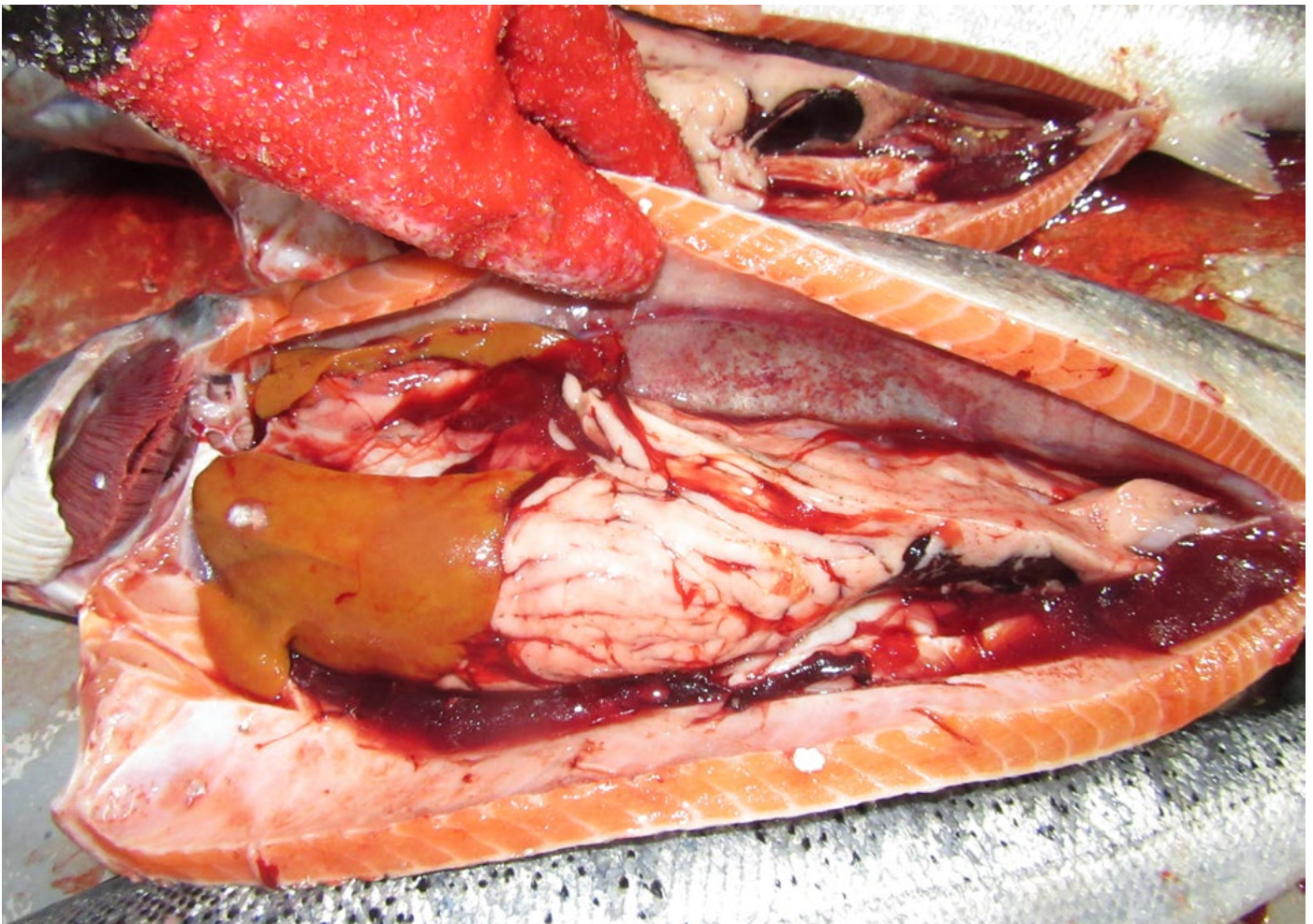


Figure 8.6.1 Yersiniosis in large Atlantic salmon. Photo: Øystein Markussen, Åkerblå

Almost exclusively one genetic variant of *Y. ruckeri* causes widespread disease outbreaks in Norway, and this variant has not been documented in other countries so far. It belongs to serotype O1, but this is also the most prevalent serotype amongst non-virulent variants of the bacterium, which are commonly found e.g. in freshwater facilities without clinical yersiniosis. Thus, similar serotype affiliation does not necessarily reflect genetic relatedness or other properties of *Y. ruckeri*. Occasionally, *Y. ruckeri* serotype O2 is also isolated from diseased salmon in Norway.

### Disease Control

Injection vaccination against *Y. ruckeri* has become fairly widespread in large parts of the country in recent years (Chapter 4 Biosecurity).

There are also examples of hatcheries that appear to have successfully eradicated virulent *Y. ruckeri*. However, it's important to note that the presence of *Y. ruckeri* in a facility does not inherently imply a disease problem, since in addition to the highly virulent variant, many seemingly non-virulent variants exist in freshwater environments. Genotyping of cultured isolates can determine which variant is present.

Medicinal treatment is used only to a limited extent and may lead to the development of resistant bacterial strains. Products based on bacteriophages, i.e. viruses that specifically target *Y. ruckeri*, are also available to control the bacterium in the environment.

## The Health Situation in 2025

### Data from the Norwegian Veterinary Institute and Private laboratories

Compiled data (Chapter 1 Statistical basis) shows that *Y. ruckeri* was detected, by culture and/or PCR, from farmed Atlantic salmon at 36 sites in 2025 (11 in freshwater/freshwater with seawater addition and 25 in seawater), distributed among 24 in PA1-PA4, three in PA6-PA7 and nine in PA8-PA10 (Figure 8.6.2). Additionally, two detections were registered from wild Atlantic salmon. Although reporting on clinical status was often lacking, available information suggests that most detections were associated with clinical disease. Cases diagnosed at the Norwegian Veterinary Institute through 2025 primarily originated from sea-farmed fish weighing over 1 kg.

The number of sites with detections in farmed Atlantic salmon is thus at the same level as in 2024 (35 sites), which was slightly down from 2023 (44 sites), and follows a decade characterised by considerable fluctuations in the number of detections of the bacterium. Since the launch of an injection vaccine against yersiniosis in 2020, its use has increased year by year, and according to VetReg, approximately 263 million doses of the vaccine were requisitioned in 2025 (Chapter 4 Biosecurity, Figure 4.4.1). Considering the overall use of general multivalent vaccines, this indicates that 61% of all salmon vaccinated in Norway in 2025 were also vaccinated against yersiniosis, and these figures do not

include any dip/bath vaccination against the disease. The corresponding proportion for 2024 was 60%.

### The Annual Survey

Nationwide, respondents rank yersiniosis as a relatively minor health problem in both the freshwater and seawater phases of Atlantic salmon production (Appendix A1 and Appendix B1). In PA1-PA5, the disease is ranked sixth (Appendix B2). An increasing incidence is considered of particular significance.

Among the 52 respondents who answered questions regarding the effectiveness of the yersiniosis vaccine, none indicate that it is poor, three consider it to be moderate, and as many as 49 rate it as good. A further seven report that they do not know. Ten respondents indicate that yersiniosis is not vaccinated against in their area (Chapter 4 Biosecurity, Table 4.3.2), of whom seven work in PA1-PA4.

Free-text responses reinforce the impression that the yersiniosis vaccine yields good protection, although a challenge is also highlighted in that stakeholders who previously vaccinated may elect to discontinue this when they perceive that the disease has disappeared.

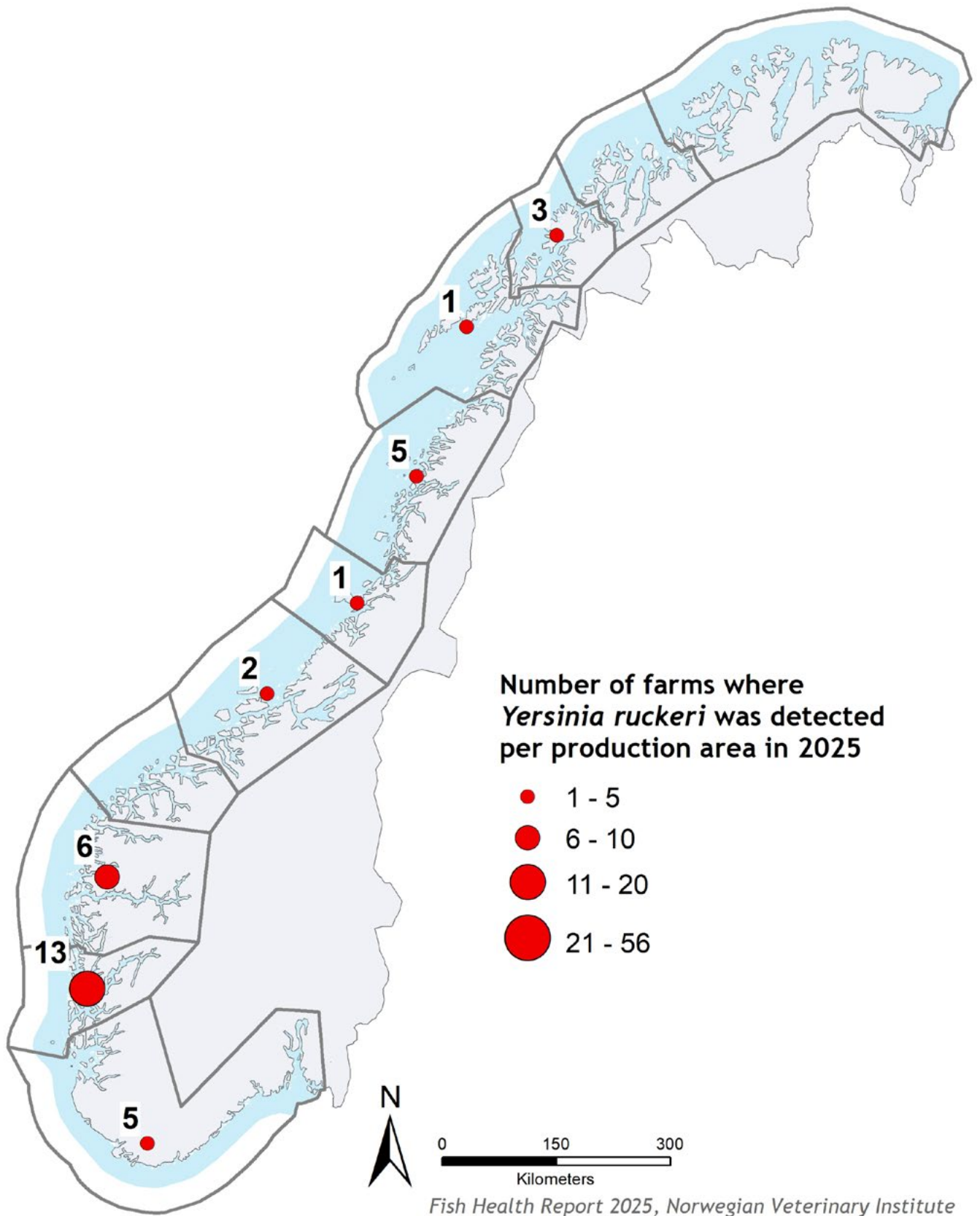


Figure 8.6.2 The number of sites at which *Yersinia ruckeri* was detected in farmed Atlantic salmon per production area in 2025, based on compiled data from the Norwegian Veterinary Institute and private laboratories. Due to a low number of farms located in PA1 and PA2, these production areas have been merged. Illustration: Attila Tarpai, Norwegian Veterinary Institute.

### Assessment of the Yersiniosis Situation

Most yersiniosis outbreaks among farmed Atlantic salmon in Norway still appear to occur during the seawater phase, and although *Y. ruckeri* was detected in most of Norway's production areas in 2025, southwestern regions (PA1–PA4) account for two-thirds of these (Figure 8.6.2). This is also reflected by the annual survey, where yersiniosis presents as an increasing problem particularly in farmed Atlantic salmon during the seawater phase in these areas (Appendix B2). Responses from the survey further suggest that vaccine coverage against yersiniosis is lowest in these regions.

Overall, the occurrence of yersiniosis has fluctuated considerably over the past decade, but many of the outbreaks still occur in large salmon late in the seawater phase, often following prior stressful handling. The Norwegian Veterinary Institute has previously shown that stressful handling, such as during thermal delousing, stimulates increased shedding

of *Y. ruckeri* from subclinically infected carrier fish. This could pose an infection risk for naïve fish treated alongside these and/or subsequently in the same water.

Since 2020, injection vaccines against yersiniosis have increased in use, but their effect have thus far not manifested in terms of a reduced number of sites with detection of *Y. ruckeri*. Nevertheless, the vaccine efficacy is reportedly good, and the disease appears to have declined markedly in PA5–PA7, where numerous outbreaks were recorded until a few years ago. It remains to be seen whether increased vaccine coverage will result in a similar decline in the rest of the country. Anyhow, for such a situation to persist over time, a consistently high vaccine coverage must likely be maintained, as it is unlikely that the bacterium will be eliminated altogether. In addition, effective disease control, with particular emphasis on detecting infections with the virulent and exclusively Norwegian strain of *Y. ruckeri* in hatcheries, will be essential.

## 8.7 Piscirickettsiosis

By Duncan J. Colquhoun

### The Disease

Piscirickettsiosis is caused by the bacterium *Piscirickettsia salmonis* and is also known as salmonid rickettsial septicaemia (SRS). Piscirickettsiosis has mainly been detected in salmonids in the marine phase, but detections have also been reported in brackish water and in other species such as lumpfish, turbot, and sea bass. In Norway, outbreaks have typically (but not always) been detected during the first autumn after transfer to sea, following warm summers with high seawater temperatures, and affected individuals may be observed over extended periods. Most often, weak groups of fish have been affected.

Fish with piscirickettsiosis do not necessarily show external signs of disease, but may exhibit reduced appetite, lethargy, and altered behaviour such as uncoordinated swimming. The gills may be pale and the skin may be darkly pigmented. Skin haemorrhages, ulcers (partly haemorrhagic and round), and/or firm, nodular swellings may be present. Internally, haemorrhages may be observed in the swim bladder, peri-

toneum, adipose tissue, and musculature, along with an enlarged kidney and spleen, and clear or bloody fluid (ascites) in the abdominal cavity (Figure 8.7.1).

Lesions and bacteria may be found in most organs, but under Norwegian conditions it has been typical to observe few to many pale, partly ringshaped and partially haemorrhagic areas in a yellowish or normally coloured liver. During diagnostic investigations, submitted carcasses or organs are assessed macroscopically, *P. salmonis* is cultured from infected tissues, and tissue samples are examined microscopically for characteristic pathological changes. The bacteria can be detected using immunohistochemistry (Figure 8.7.2).

**For further information on piscirickettsiosis, see the Norwegian Veterinary Institute's fact page (in Norwegian):**

[Piscirickettsiose](#)



**Figure 8.7.1** Salmon with piscirickettsiosis. The fish has a yellow liver with pale, petechial haemorrhages, a swollen and dark spleen, haemorrhages in the swim bladder, adipose tissue, and musculature, and an inflamed and haemorrhagic intestinal wall. Photo: Helene Kvam, Labora.

## Disease Control

Because *P. salmonis* survives partially within the host's own cells, antibiotic treatment often has limited effect. At present, no vaccines are approved for use in Norway. There are

significant gaps in knowledge regarding the bacterium's reservoirs and transmission mechanisms, particularly in a Norwegian/North Atlantic context. This has hindered the development of effective measures for disease control.

## The Health Situation in 2025

### Official Data

Piscirickettsiosis was listed in category G from June 2025. In 2025, suspicion of piscirickettsiosis in salmon was reported at three sites: two sites in PO8 and one site in PO9. None of these suspicions were confirmed.

### The Annual Survey

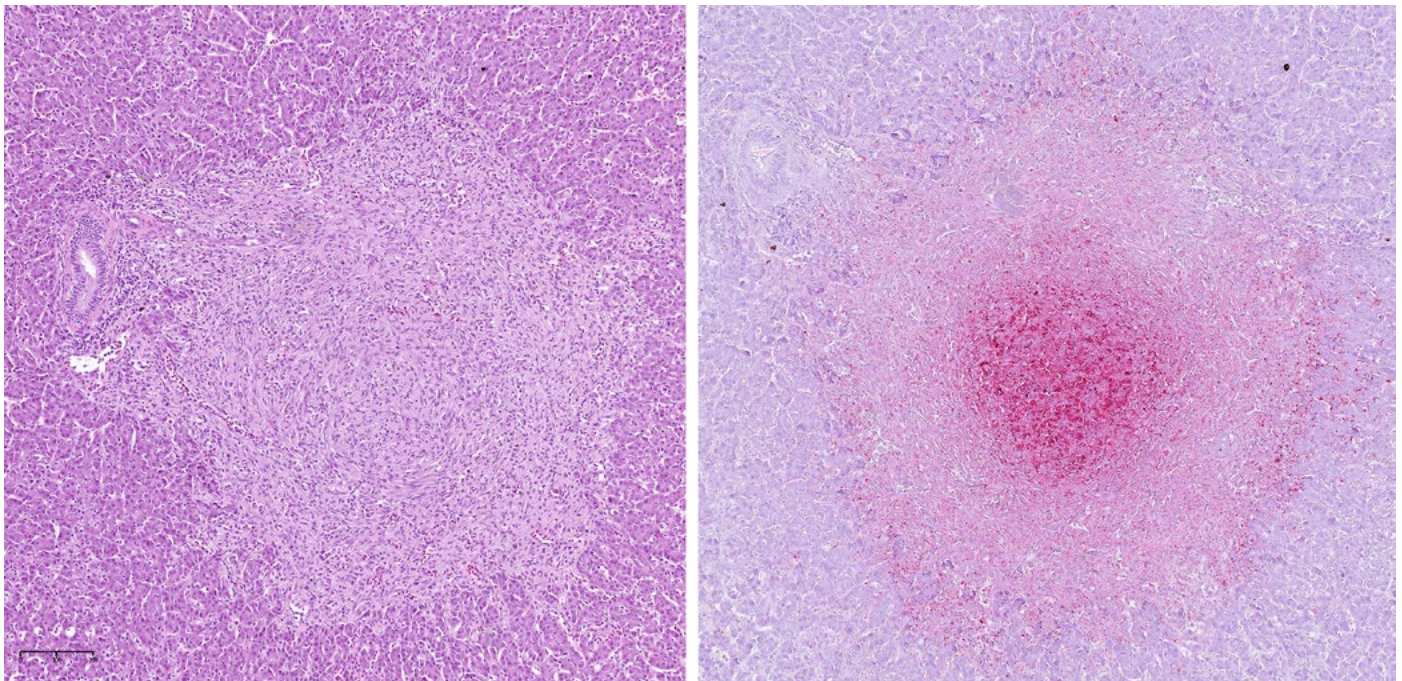
Respondents did not report piscirickettsiosis as a health problem in salmon growout facilities (Appendix B1).

### Assessment of the Piscirickettsiosis Situation

The absence of confirmed outbreaks in 2025 suggests that the disease is not continuing to develop following several

outbreaks in 2024. Piscirickettsiosis has previously been detected at relatively high seawater temperatures, and future temperature increases may therefore pose a risk that the disease could become established as a serious and persistent problem in Norwegian aquaculture.

The infection often occurs at low prevalence and results in limited mortality, making underdiagnosis likely. Norwegian isolates that have so far undergone wholegenome sequencing at the Norwegian Veterinary Institute belong to a cluster most similar to isolates from Canada but are markedly different from known Chilean strains. Sequencing and comparison with isolates from Scotland and Ireland are ongoing.



**Figure 8.7.2** Tissue section of liver from a fish with piscirickettsiosis. (Left) Pale area with tissue changes caused by inflammation (H&E staining). (Right) The bacterium *Piscirickettsia salmonis* detected in the same area using an immunohistochemical (IHC) method. Within the lesion, the highest numbers of bacteria (red) are observed centrally and along the border of healthy liver tissue. The bacteria infect new cells and promote the spread of inflammation. Photo: Anne Berit Olsen, Norwegian Veterinary Institute.

## 8.8 Mycobacteriosis

By Julie Christine Svendsen and Toni Erkinharju (Norwegian Veterinary Institute), William Reed and Helene Wisløff (Pharmaq Analytiq AS)

### The Disease

Mycobacteriosis is an infectious disease caused by mycobacteria. Several species have been described, but only some are associated with disease in fish. Among these, *Mycobacterium salmoniphilum* has been detected in Norway. Mycobacteriosis can occur in many fish species, and a field study conducted in the Varangerfjord during the summer of 2023 revealed a relatively high prevalence of *Mycobacterium* spp. in pink salmon.

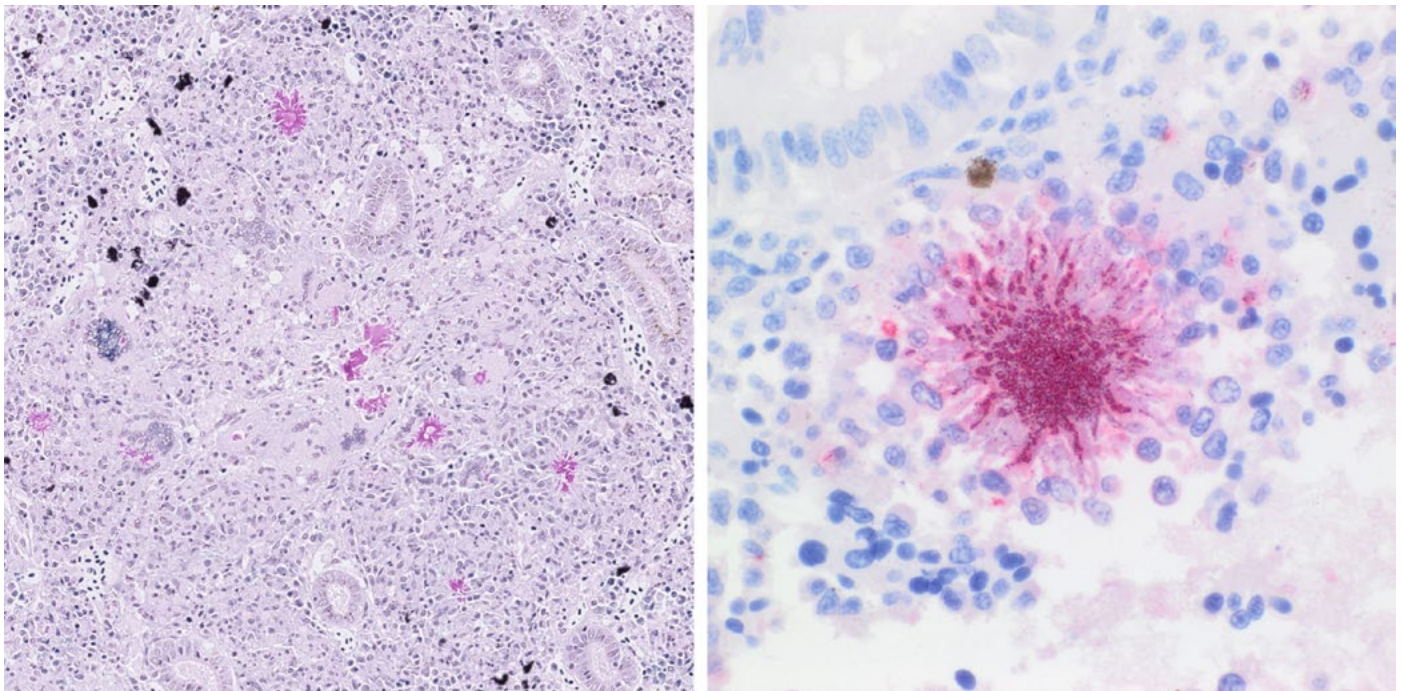
Mycobacteriosis typically appears as a chronic disease with variable mortality. Clinical signs are often vague and include lethargy and reduced growth. Some fish develop skin ulcers and haemorrhages. In fish that have been ill for a longer period, emaciation is a typical finding. In recent years, an acute form of the disease has been described in which histopathological examination has revealed fibrinous peritonitis with bacteria along the peritoneum, necrosis in internal organs, and large amounts of rod-shaped bacteria in blood vessels and the interstitium of the heart, gills, liver, kidney, skin, and musculature.

Infection most likely occurs through direct contact with infected fish, through feed, or via water. The disease has a long incubation period, up to several weeks, and infected fish may show no clinical signs for several years after becoming infected.

Typical necropsy findings are pale nodules (granulomas) in internal organs and enlarged spleen and kidney. In tissue sections, granuloma formation can be observed in internal organs, sometimes with the presence of Splendore-Hoeppli material in the centre of the granulomas. The bacteria can be stained in tissue sections using special stains and/or antibodies (immunohistochemistry) (Figure 8.8.1). The bacterium can be cultured and also detected using molecular biological methods.

**For further information on mycobacteriosis, see the Norwegian Veterinary Institute fact page:**

[Mycobacteriosis in fish](#)



**Figure 8.8.1** Kidney tissue from salmon. Granulomatous inflammation with giant cells and pink, star-shaped Splendore-Hoeppli bodies (Ziehl-Neelsen staining method) (left). Mycobacteria detected by immunohistochemical labeling (right). Photo: Julie Svendsen and Toni Erkinharju, Norwegian Veterinary Institute.

## Disease Control

There is currently no effective treatment for mycobacteriosis. The bacterial cell wall and formation of granulomas in

internal organs make treatment with antibacterial drugs difficult. At present, there are no approved vaccines against mycobacteriosis in fish.

## The Health Situation in 2025

---

### Data from the Norwegian Veterinary Institute and Private laboratories

When compiling data from the Norwegian Veterinary Institute and private laboratories (Chapter 1 Data basis), mycobacteriosis was detected at 15 sites in 2025. The cases originated from several production areas, with PA1–PA2 as the southernmost records and extending northwards to PA8. Twelve of the disease cases originated from the southern half of the coastline (PA1–PA5). Fewer (8) confirmations of *Mycobacterium* spp. were reported, and we do not have complete knowledge of the basis for diagnosis in the different confirmed cases. Histological and immunohistochemical examination (IHC), PCR, and bacteriological culture may all be part of a diagnostic investigation. At the Norwegian Veterinary Institute, a confirmed diagnosis is made when both histological tissue changes consistent with the disease are observed and the agent is detected using IHC, PCR, or bacteriological methods.

### The Annual Survey

Respondents in the survey do not consider mycobacteriosis to be a significant problem in terms of mortality, reduced welfare, or poor growth in farmed salmon or broodstock salmon (Appendix B1 and Appendix C1). The same applies to salmon in hatcheries; however, three out of 62 respondents have experienced mortality related to the disease, and two out of 57 respondents consider mycobacteriosis to be an increasing health problem (Appendix A1).

### Assessment of the Mycobacteriosis Situation

Mycobacteriosis is not a notifiable fish disease. The annual number of diagnosed cases of mycobacteriosis at the Norwegian Veterinary Institute from 2018 to 2025 has varied from zero to eight cases. In cases where the bacterium was identified at species level, only *M. salmoniphilum* was detected.

Data from Pharmaq Analytiq have shown an increasing number of cases of mycobacteriosis in salmon in recent years, although the number of detections varies somewhat from year to year (Reed et al., 2023). The number of detections was higher in 2025 than in 2024 and included a total of 15 confirmed cases from 12 unique sites (up from four cases in 2024). The majority of cases were the classic chronic form of the disease. Nine of the cases were from grow-out facilities, five from hatcheries, and one from broodstock.

Most fish-pathogenic mycobacteria, including *M. salmoniphilum*, do not grow at 37°C, and there is currently no solid basis for claiming that human consumption of fish infected with mycobacteria represents a health risk. Several mycobacteria, including *M. marinum* and *M. chelonae*, which are closely related to *M. salmoniphilum*, can cause skin lesions in humans in the form of superficial granulomas and ulcers, and may spread to deeper tissues in immunocompromised individuals. General precautions to prevent contact between bacterial-contaminated material and broken skin are recommended when handling infected fish.

### Reference:

Reed W, Østevik L, Lie K-I & Wisløff H (2023). Mycobacteriosis in Norwegian farmed Atlantic salmon (*Salmo salar* L.). *Journal of Fish Diseases*, 46:1151-1155.

## 8.9 Other Bacterial Infections

By Duncan J. Colquhoun, Anne Berit Olsen, and Hanne Nilsen

Most bacterial infections result from interactions between the bacterium, the fish, and the environment. In diseased fish, it is not uncommon to detect a broad range of different bacteria. These may include wellknown diseasecausing bacteria (pathogens) that are almost always associated with outbreaks, as well as more opportunistic bacteria that cause disease in stressed and compromised fish following mechanical damage, handling, or adverse environmental conditions such as poor water quality. In addition, bacteria from the surrounding environment rapidly invade weakened or dead fish.

In diagnostic work, it can therefore occasionally be challenging to directly associate findings of opportunistic bacteria with disease. Such findings are continuously evaluated to ensure that any new diseasecausing variants can be detected at an early stage. General culture-based investigations are therefore essential for identification of new, emerging bacterial pathogens and for ensuring access to strains suitable for genetic typing and vaccine development.

Many different types of bacteria, usually considered to be environmentally associated, are periodically isolated from diseased fish, including motile *Aeromonas* spp. and *Pseudomonas* spp. Both were detected during 2025, but not at levels considered higher than normal occurrence. *Pseudomonas anguilliseptica*, which is known as a serious pathogen in lumpfish in Norway and has also previously been sporadically detected in Norwegian salmon and rainbow trout, was not detected in salmonids in 2025.

According to compiled data from the Norwegian Veterinary Institute and private laboratories (Chapter 1, Data Basis), infections with *Vibrio anguillarum*, which causes the disease classical vibriosis, were detected in salmon at four sites located in PA1–PA2, PA4, PA6, and PA7, respectively. In rainbow trout, *V. anguillarum* was detected at 14 sites, 11 in PA4 and three in PA3. Fifteen percent of the antibacterial medicinal products dispensed for salmon in growout facilities were used to treat classical vibriosis (Chapter 8.10, Susceptibility to Antimicrobial Agents and Antibiotic Use). *Vibrio ordalii*, a pathogenic species closely related to *V. anguillarum*, was not detected by the Norwegian Veterinary Institute during diagnostic work in 2025.

*Tenacibaculum maritimum* has previously been detected in the gills of Norwegian farmed salmon as one of several *Tenacibaculum* species that may be present in cases of gill necrosis. *T. maritimum* was not detected by the Norwegian Veterinary Institute during 2025; however, data from private laboratories indicate that *T. maritimum* was detected in 17 salmon farms, with nine and seven of these located in PA3 and PA4, respectively.

Coldwater vibriosis, caused by *Aliivibrio* (*Vibrio*) *salmonicida*, was not detected in material submitted to the Norwegian Veterinary Institute from salmon or other fish species.

Compiled data show that atypical *Aeromonas salmonicida* was not detected in farmed salmonids. Atypical *A. salmonicida* infections have been uncommon in farmed salmon for many years, as vaccination against *A. salmonicida* subsp. *salmonicida* (the furunculosis bacterium) generally also provides good protection against atypical variants.

*Vibrio splendidus* was isolated during diagnostic work from 107 salmon farms distributed along the entire coast, but mainly in PA3 (21 sites) and PA6 (29 sites). In only 15 cases did fish health personnel consider the bacterium to be probably associated with clinical disease. In rainbow trout, *V. splendidus* was isolated from seven sites in PA3–PA5 and was associated with disease in two of these cases.

**For further information on mycobacteriosis, see the Norwegian Veterinary Institute's fact page (in Norwegian):**

[Kaldtvannsvibriose](#)

## 8.10 Susceptibility to Antibacterial Agents and Antibiotic Use

By Duncan J. Colquhoun, Hanne Nilsen, Leif Lukas Löfling, and Kari Olli Helgesen

### Susceptibility to Antimicrobial Agents

The Norwegian Veterinary Institute monitors antibiotic resistance in bacterial isolates cultured from diseased farmed fish as part of its annual diagnostic work. Antibiotic use in Norwegian aquaculture remains very low; however, antibiotic treatment may occasionally be necessary during outbreaks of bacterial disease in farmed fish to improve fish welfare and prevent major losses. In Norway, florfenicol is almost exclusively used. The use of oxolinic acid was very low in 2025 and accounted for less than half a percent of total consumption. Antibiotic use is known to be one of the most important drivers of the development of bacterial resistance to antimicrobial agents, and it is therefore essential that consumption remains as low as possible (Table 8.10.1).

In 2025, there are still few indications of widespread or increasing resistance among bacteria isolated from diseased farmed fish. As in previous years, reduced susceptibility to oxolinic acid was again identified in some isolates of *Yersinia ruckeri* from a salmon smolt facility in PO10.

### Antibiotic use

The consumption of antibacterial agents, measured in kilograms of active substance, has historically been used as an indicator of the occurrence of bacterial diseases. Vaccines against cold-water vibriosis and furunculosis in Atlantic salmon were introduced in the late 1980s and early 1990s, respectively. Since then, antibiotic use measured in kilograms has remained very low, despite a substantial increase in the production of farmed fish ([Surveillance of antimicrobial resistance \(NORM-VET\)](#)).

Table 8.10.1 shows the use of antibiotics in aquaculture, including cleaner fish, for the years 2016–2025, based on usage data from the Norwegian Veterinary Prescription Register (VetReg). Data for 2025 were downloaded from the Norwegian Food Safety Authority on 2 February 2026. The data were compared with sales data from wholesalers and feed companies reported to the Norwegian Institute of Public Health (NIPH) (in kilograms). For the period 2016–2025, there was good agreement between use data from VetReg and sales data from NIPH. Total antibiotic use in 2025 was 498 kg, representing a reduction of 211 kg compared with 2024.

**Table 8.10.1** Antibacterial agents (kg active substance) prescribed for use in aquaculture, including cleaner fish, for the years 2016–2025<sup>1</sup>. Data are based on the Norwegian Veterinary Prescription Register (VetReg) as of 2 February 2026. For the years 2019–2024, the figures include small quantities (0.05–1.14 kg) of antibacterial agents used in experimental fish.

Antibacterial agents	2016 <sup>1</sup>	2017	2018 <sup>1</sup>	2019	2020	2021	2022	2023	2024	2025 <sup>1</sup>
Florfenicol	134	264	857	152	113	531	397	516	703	496
Oxolinic acid	66	343	54	66	107	57	28	32	6.3	2.5
Oxytetracycline	0	0	20	0	0.16	0	0	0	0.04	0
Enrofloxacin	0.05	0.01	0	0.02	0.12	0.44	0.10	0.05	0.06	0.02
Amoxicillin	0	0	0	0	0.09	0	0	0	0	0
<b>Total antibiotics</b>	<b>199</b>	<b>607</b>	<b>930</b>	<b>218</b>	<b>220</b>	<b>588</b>	<b>425</b>	<b>548</b>	<b>709</b>	<b>498</b>

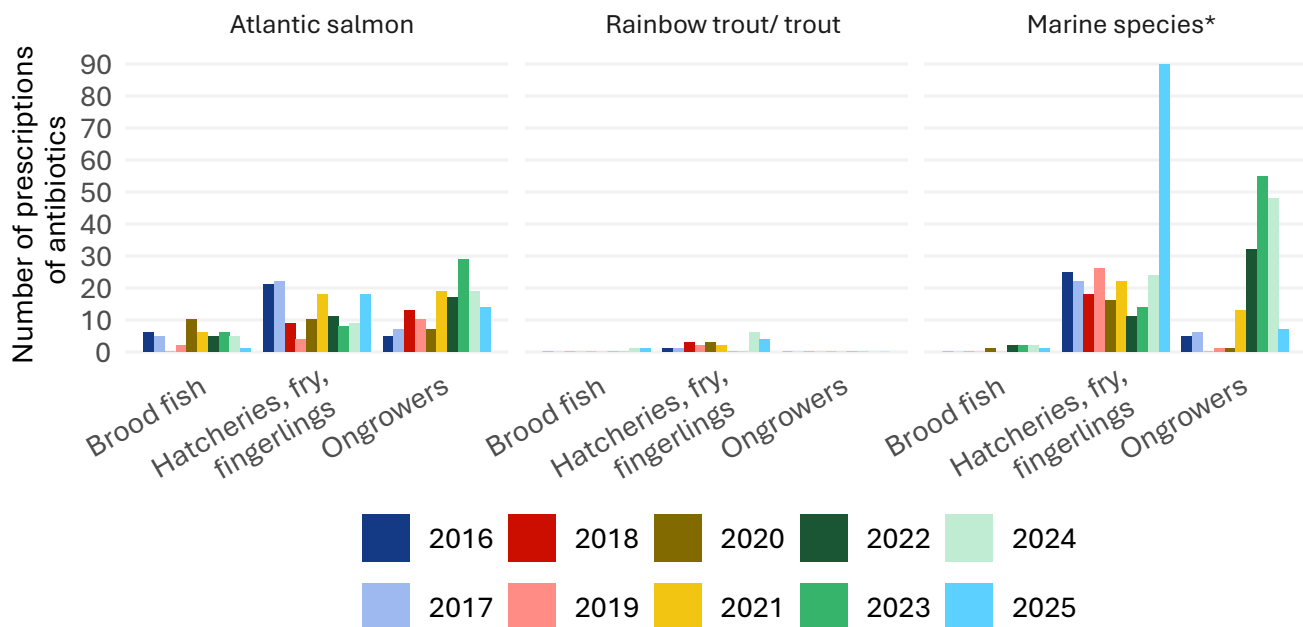
<sup>1</sup>Total amounts may vary slightly due to rounding of individual values.

VetReg includes variables such as fish species (including cleaner fish), production stage and diagnosis (Figure 8.10.2). During the period 2016–2020, the number of treatments administered to on-growing fish (salmonids and marine species) was relatively low (between 8 and 13 treatments). From 2021 (2022 for marine species) to 2024, on-growers constituted the most frequently treated production category. In 2025, this trend reversed, and on-growers no longer represented the main treatment category (a total of 21 treatments in on-growers out of 136 treatments overall).

Of the antibiotic prescriptions issued in 2025 (n = 136), 72% (98 prescriptions) were for marine species (94 for halibut and 4 for cod). These 98 prescriptions accounted for 34% (170 of 498 kg) of total antibiotic use in aquaculture. In marine species, atypical furunculosis and classical vibriosis were the most frequently reported diagnoses, accounting

for 74% (72) and 4% (4) of registered prescriptions, respectively. For Atlantic salmon, 33 antibiotic prescriptions were issued (24% of all prescriptions), corresponding to 66% of total antibiotic use (322 of 498 kg). The most frequently reported diagnoses in salmon were yersiniosis and classical vibriosis, accounting for 18% (6) and 15% (5) of prescriptions, respectively.

Historically, the number of antibiotic treatments administered to cleaner fish has been considerably higher than for fish for consumption. However, there has been a substantial decline in the use of antibiotics in cleaner fish in recent years. The highest number of reported treatments during the period 2016–2025 was in 2016, with 126 treatments, whereas in 2025 only four antibiotic prescriptions were issued for cleaner fish.



Fish Health Report 2025, Norwegian Veterinary Institute

**Figure 8.10.1** Number of treatments with antibacterial agents by fish species and production stage in the years 2016–2025 (cleaner fish and experimental fish excluded). The number of treatments refers to the number of prescriptions from the Norwegian Veterinary Prescription Register (based on VetReg data made available by the Norwegian Food Safety Authority on 02.02.2026).

\* Cod, halibut, turbot, Arctic char, spotted wolffish, saithe.

# 9 Fungal diseases of salmonids

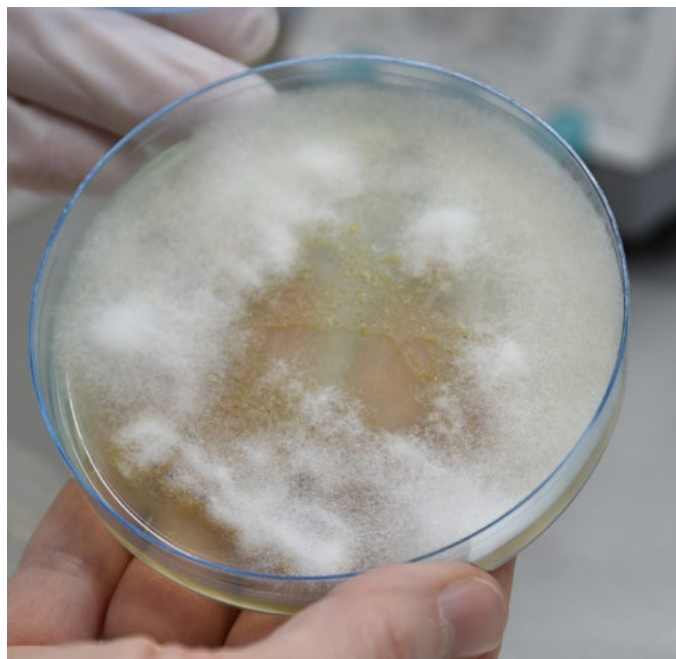
By Ida Skaar

## The diseases

Fungal diseases, or mycoses, are divided into superficial mycoses, which occur on the skin and gills, and systemic mycoses, which affect one or more internal organs.

Superficial mycoses in fish are primarily caused by *Saprolegnia* spp. and typically appear as a lightcoloured, cotton-like growth on the surface of the fish. *Saprolegnia* spp. are not true fungi but so-called water moulds (oomycetes). These organisms are found in virtually all freshwater environments worldwide and spread by means of motile spores (zoospores). In Norway, problems associated with *Saprolegnia* infections are most pronounced in hatcheries.

Systemic mycoses may be caused by a variety of fungal species, most commonly species belonging to the genera *Exophiala*, *Fusarium*, *Penicillium*, *Phialophora*, *Ochroconis*, *Paecilomyces*, *Ichthyophonus*, and *Lecanicillium*. These species are commonly present in the environment, and no specific reservoirs or typical routes of transmission are known. The species most frequently detected is *Exophiala psychrophila*, which causes granuloma formation in the kidney. Overall, fungal diseases in fish are generally considered to be a minor problem in Norway.



## Disease Control

Formalin is the most cost-effective agent against *Saprolegnia* spp. and is, in most cases, the first choice of treatment during an outbreak. The use of formalin in aquaculture is controversial and remains under evaluation within the EU regulatory system.

Important preventive measures include avoiding unnecessary stress and handling fish as gently as possible during situations where handling is required, such as grading, transfer, and vaccination. Maintaining good general hygiene and water quality is also essential to prevent the proliferation of spores within the facility. For eggs during incubation and the hatching period, the most important preventive measure is the frequent removal of dead eggs and residual organic material.

**For further information on saprolegniosis, see the Norwegian Veterinary Institute's fact page (in Norwegian):**

[Saprolegniöse](#)

**Figure 9.1** *Saprolegnia* spp. isolated from salmon and cultured on Sabouraud medium. Photo: Mari M. Press, Norwegian Veterinary Institute

## The Health Situation in 2025

---

### Data from the Norwegian Veterinary Institute

Saprolegniosis is usually diagnosed and treated in the field without laboratory confirmation. Consequently, the Norwegian Veterinary Institute records only a limited number of cases of saprolegniosis each year, and these do not reflect the true extent of the problem. The Institute regularly receives enquiries regarding problems associated with *Saprolegnia* spp. and fungal infections. In 2025, however, no cases of saprolegniosis or systemic mycoses were detected in submissions from farmed fish.

### The Annual Survey

As in 2024, respondents perceive saprolegniosis to be a relatively minor problem in both salmonids and cleaner fish. For salmon in the freshwater production phase, seven of 62 respondents reported that the disease had caused mortal-

ity, five of 60 reported negative effects on fish welfare, four of 57 reported an increasing occurrence, and two of 59 reported reduced growth. For rainbow trout in the freshwater production phase, the number of respondents was lower, and only a small proportion reported saprolegniosis as a problem.

### Assessment of the Saprolegniosis and Fungal Infection Situation

Based on the number of submissions and responses from the annual survey, fungal infections and oomycetes appear to continue to be effectively controlled through preventive measures and are therefore not regarded as a major problem in aquaculture.

# 10 Parasitic Diseases in Farmed Salmonids

By Geir Bornø and Haakon Hansen

**Sea lice (*Lepeophtheirus salmonis*) continue to represent the most significant disease and parasite challenge in farmed salmonids. The release of sealice larvae from aquaculture facilities during the spring period with a lower lice threshold increased from 2024 to 2025 in ten of the 13 production areas. In six production areas, larval release during the smolt migration period in 2025 was also higher than in any of the years in the fiveyear period preceding 2024.**

In most production areas, larval release during autumn was relatively high from a longterm perspective, although levels were even higher in 2024 in the northernmost areas (PA8–PA12).

The lowest lice levels are recorded in spring, when wild salmon smolts migrate from the rivers to the sea, whereas the highest levels of sea lice in 2025 were recorded in August, September, and October. Longterm trends in the total abundance of adult female lice in each production area are largely driven by trends in the volume of farmed fish.

In 2025, as in 2024, most delousing operations were nonmedicinal. The number of such treatments increased by 24% compared with 2024 and represents the highest number recorded since data collection began. Medicinal lice treatments have declined in recent years, and this trend continued in 2025. In the questionnaire survey, increased mortality following delousing is still considered very important, and delousing is likely to contribute indirectly to a substantial proportion of total mortality at sea. The responses further indicate that injuries resulting from delousing are regarded as an important cause of reduced fish welfare.

The louse species *Caligus elongatus* does not appear to have caused major challenges in 2025. In previous years, cases have been reported in which *C. elongatus* occurred at levels severe enough to warrant treatments specifically targeting this parasite. In some instances, treatments are carried out simultaneously against both *C. elongatus* and *L. salmonis*. Feedback from fish health professionals and inspectors from the Norwegian Food Safety Authority indi-

cates that *C. elongatus* was ranked as a lowpriority issue in 2025 and caused few challenges.

The parasite *Parvicapsula pseudobranchicola* remains a persistent problem in aquaculture in Troms and Finnmark. In 2025, as in previous years, this region experienced challenges related to mortality, growth performance, and fish welfare associated with the parasite. It is noteworthy that parvicapsulosis has in recent years also been detected in production areas south of Troms and Finnmark. Whether this indicates that the disease will become more significant further south in the future is unknown, but this development will be important to monitor. Until very recently, the definitive host of *P. pseudobranchicola* was unknown; it has now been identified as the polychaete worm *Chaetozone setosa* (Cirratulidae). Increased knowledge of the biology of this definitive host will be important for the future prevention and control of the disease.

The amoeba *Paramoeba perurans*, which causes amoebic gill disease (AGD), was detected throughout the year from Vestland county northward to and including Trøndelag. In 2025, it was also detected in Troms county, which represents a new finding. Both disease cases and parasite detections were recorded at a substantial number of sites, and an increasing trend has been observed over the past three years. In cases of complex gill disease in seareared salmon, this parasite may occur together with other parasites, such as the microsporidian *Desmozoon lepeophtherii*. Disease caused by *D. lepeophtherii* was detected at five sites with salmon and one site with rainbow trout.

In production areas PA1–PA11, the parasite was detected by PCR at 147 sites with salmon and 12 sites with rainbow trout. Of these detections, 41 were associated with clinical disease in salmon and 12 with clinical disease in rainbow trout.

Several other parasites commonly occur in farmed salmon and may become problematic. The tapeworm *Eubothrium crassum* is found in the intestines of salmon in seawater, and problems associated with this parasite are most pronounced at aquaculture facilities in Western and Central Norway. Among unicellular parasites, *Ichthyobodo necator* (in salmon in freshwater), *I. salmonis* (in salmon in freshwater)

and seawater), and *Trichodina* spp. are commonly found in Norwegian aquaculture. Most detections of both tapeworms and these unicellular parasites are made by fish health services. In the questionnaire survey, problems related to these parasites are given relatively low priority nationwide overall; however, some respondents report increased problems with *Trichodina* spp. and *I. salmonis* as a consequence of higher water temperatures.

The Xcell parasite *Salmoxcellia vastator*, which has been sporadically detected for many years, was also detected in 2025. The disease was confirmed at five sites with rainbow trout.

The parasite *Spironucleus salmonicida* causes systemic spironucleosis, a serious disease with major consequences for fish health, fish welfare, and economic performance. Since its first detection in 1989, outbreaks of spironucleosis have occurred at approximately ten-year intervals, primarily in Finnmark. The most recent outbreaks occurred in 2022–2023, during which very substantial losses were recorded at the affected facilities. In 2025, the parasite was not detected, either as a cause of disease or through PCR testing.

# 10.1 Salmon lice – *Lepeophtheirus salmonis*

By Lars Qviller, Leif Christian Stige and Kari Olli Helgesen

## The disease

Salmon lice (*Lepeophtheirus salmonis*) are naturally occurring parasitic crustaceans on salmonids in the marine environment of the Northern Hemisphere (Figure 10.1.1). The life cycle consists of eight developmental stages separated by moults. The parasite reproduces sexually. Adult females can produce up to eleven pairs of egg strings, each containing several hundred eggs. At high temperatures, each pair of egg strings hatches at intervals of a few days, while at low temperatures this process may take several weeks. The eggs hatch into larvae that are dispersed planktonically by ocean currents. During the planktonic larval stages, which may last several weeks at low temperatures, lice larvae can be dispersed over many kilometres. When the larvae reach the third stage (the copepodid stage), they can infect salmonids. The final five life stages are parasitic on fish.

The lice feed on skin, mucus and blood from the fish. High numbers of lice in the three largest stages on a fish may result in wounds and anaemia. These wounds may subsequently act as entry points for secondary infections and can cause problems with osmoregulation and salt balance. Heavy lice infestations can be fatal.

Lice larvae can be transmitted between farmed and to wild fish. Due to the lice's transmission potential, the availability of hosts, and the potentially severe impacts on both wild and farmed fish, salmon lice are considered one of the most serious challenges facing Norwegian aquaculture today.

For further information on salmon lice (*Lepeophtheirus salmonis*), see the Norwegian Veterinary Institute's fact page: [Salmon lice](https://www.vetinst.no/salmon-lice) (vetinst.no).

## Disease control

Regulations specify limits on the number of lice permitted per farmed fish, with one limit applied in spring and a higher limit during the rest of the year. The spring limit is set lower to protect wild salmon smolts migrating to sea during this period. Lice levels are reported weekly from all marine sites farming salmon, trout or rainbow trout.

The impact of salmon lice on wild salmonids is the environmental indicator in the Norwegian Traffic Light System, which regulates production capacity for salmon, trout and rainbow



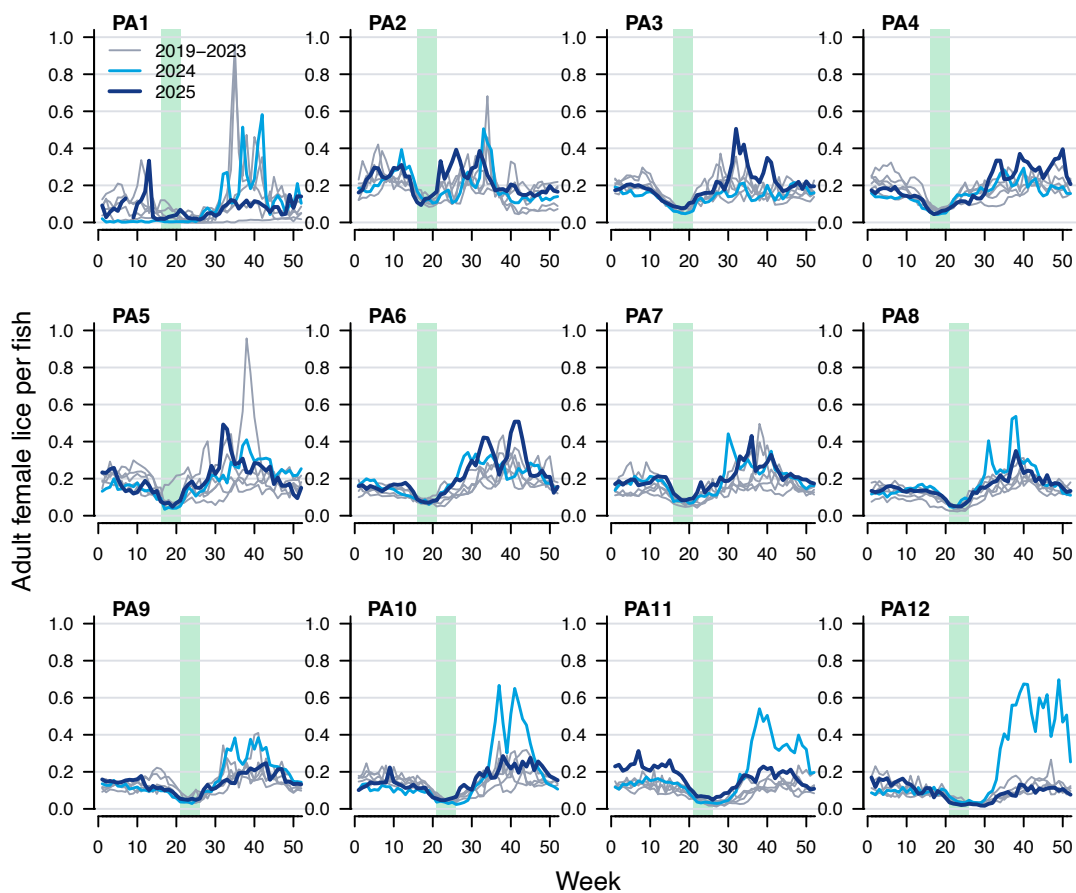
Figure 10.1.1 Salmon lice at different developmental stages. Photo: Hans Henrik Grøn, Åkerblå.

trout farming at sea per production area (abbreviated PA and numbered 1 to 13 from south to north). If the Ministry of Trade, Industry and Fisheries assess the environmental impact in a production area as unacceptable, it may reduce the permitted production capacity. If the impact is considered moderate, capacity may remain unchanged, while acceptable environmental impact may allow an increase in production capacity.

Traditionally, the main control measure against salmon lice has been medicinal treatments. However, widespread resistance to available medicinal products has led to the devel-

opment and extensive use of alternative control methods. Farmers commonly apply a combination of preventive measures, continuous delousing using cleaner fish, and delousing using both non-medicinal and medicinal methods.

Increased treatment frequency and the expanded use of non-medicinal control measures have contributed to higher production costs in open net-pen farming of salmonids. Increased treatment frequency also represents a cost to fish welfare, as all treatments involve some risk of injury and mortality, particularly non-medicinal methods compared with medicinal treatments.



Fish Health Report 2025, Norwegian Veterinary Institute

**Figure 10.1.2** Average weekly reported numbers of adult female salmon lice per fish in each production area (PA). Salmon lice counts are reported from all sea farms with salmon or rainbow trout (downloaded from BarentsWatch on 29.01.2026). The lines show the seasonal variation for each of the most recent years. PA13 is omitted due to the small number of active aquaculture facilities. The green shaded areas indicate the weeks with a lower lice limit in each production area.

## The Health Situation in 2025

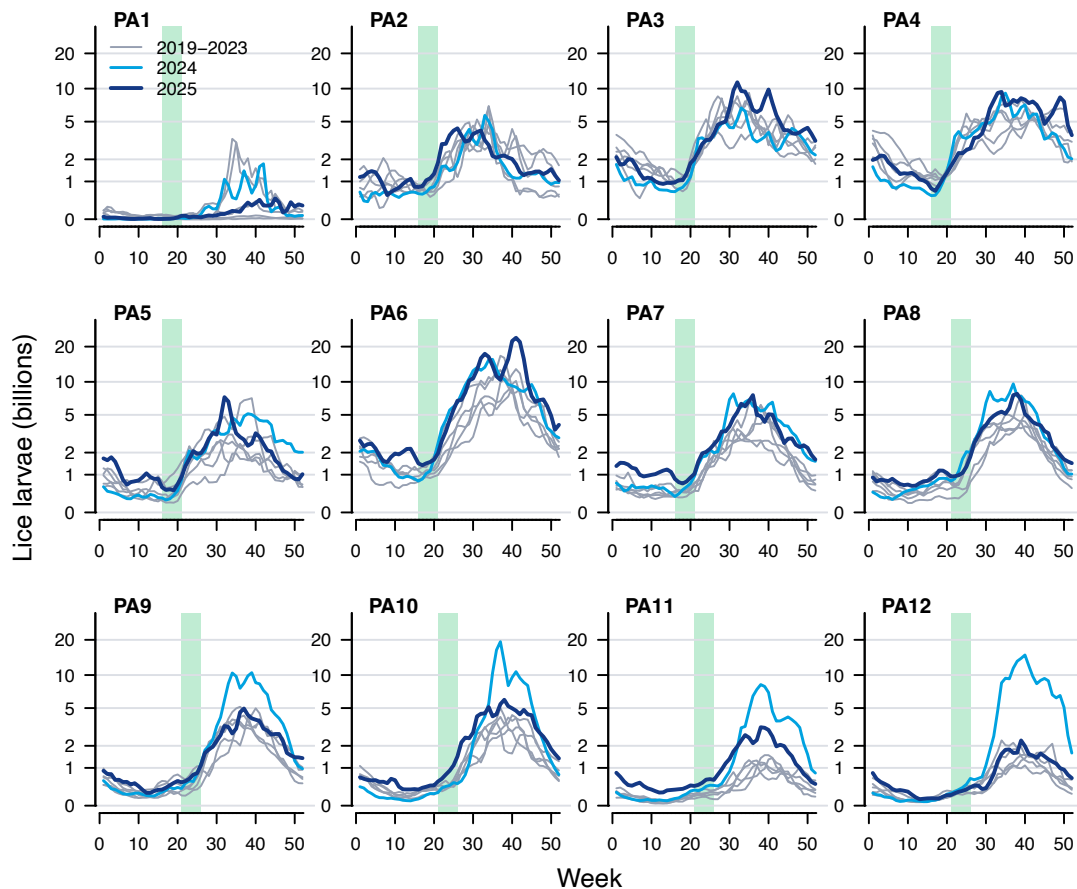
### Official data

All farmers are required to count and report salmon lice weekly. National weekly averages show a cyclical pattern, with the lowest lice levels in spring and the highest in autumn (Figure 10.1.2). The highest lice levels in 2025 were reported in August, September and October, when the average number of adult female lice per fish exceeded 0.4 during one or more weeks in PA3 and PA5–PA7.

To better assess the infection pressure, the total release of salmon lice larvae from aquaculture facilities was estimated for each production area (Figure 10.1.3). Calculations of larval release are based on reported lice counts, seawater temperatures and fish numbers from all farms, combined

with knowledge of salmon lice reproduction (i.e. egg production per week and hatching rates at different temperatures, quantified as described in Stige et al. 2021). To reduce the impact on migrating wild salmon smolts, the lice limit is reduced from 0.5 to 0.2 for a six-week period in spring (weeks 16–21 in PA1–PA7 and weeks 21–26 in PA8–PA13).

Larval production during the spring period increased from 2024 to 2025 in all production areas except PA8, PA12 and PA13. In PA2, PA7, PA8, PA10, PA11 and PA13, larval production during this period was higher than in any year from 2019 to 2023, while in other production areas larval production fell within the historical variation.



Fish Health Report 2025, Norwegian Veterinary Institute

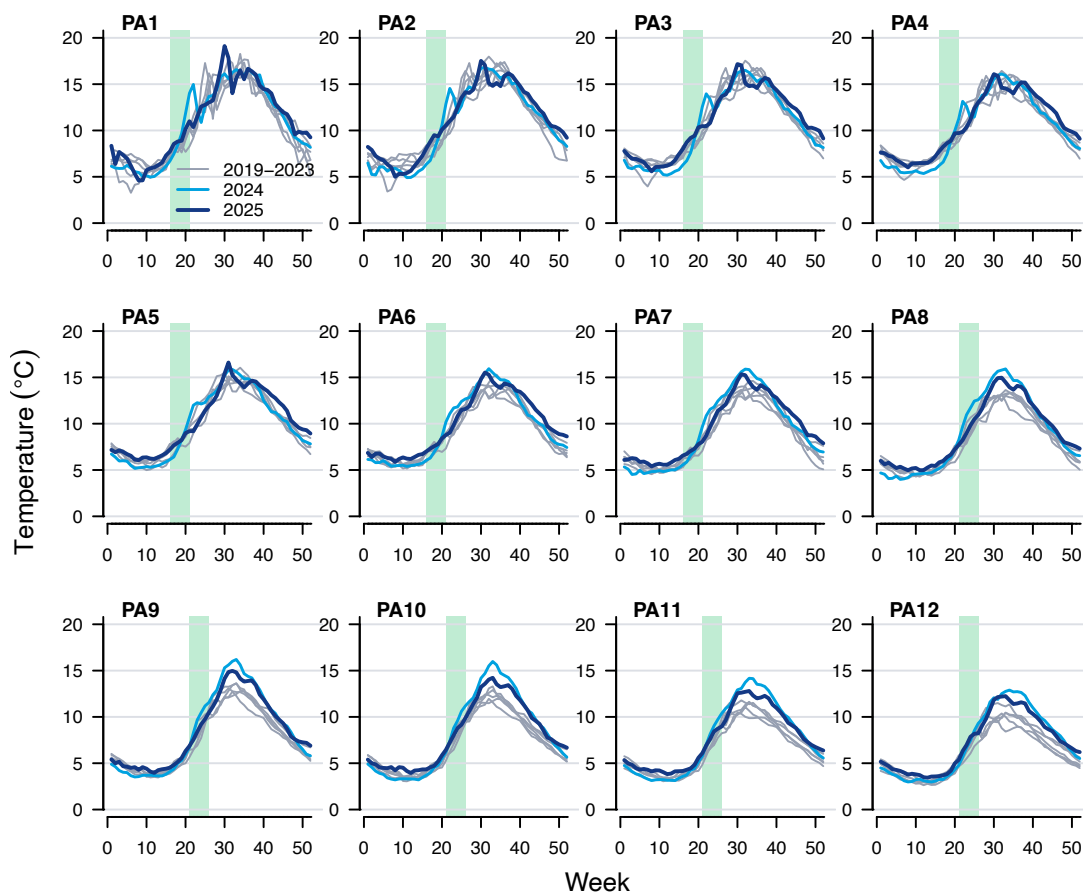
**Figure 10.1.3** Estimated total weekly release of salmon lice larvae (in billions) from all sites within each production area (PA). The lines show the seasonal variation for each of the most recent years. Note that the y-axis is on a logarithmic scale. PA13 is omitted due to the small number of active farms; this area had an estimated larval release of less than 110 million larvae per week throughout 2025. The green shaded areas indicate the weeks with a lower lice limit in each production area.

During autumn 2025, total larval production exceeded five billion lice larvae per week in PA3–PA7 and PA10. The highest output occurred in PA6, peaking at over 20 billion larvae per week, followed by PA3 with over 10 billion. In most production areas, autumn larval production was high in a long-term perspective, although levels were even higher in the northernmost areas (PA8–PA12) in 2024.

The marked increase in larval production during summer reflects both increasing numbers of adult female lice (Figure 10.1.2) and higher larval production per female at higher temperatures. Temperature development per production area is shown in Figure 10.1.4. In both 2024 and 2025, summer temperatures increased more than normal in

the northernmost production areas. Larval output in PA13 (not shown in Figure 10.1.3) remained below 110 million larvae per week throughout the year and was lower than in all other areas.

Long-term trends in total numbers of adult female lice within each production area largely reflect trends in farmed fish biomass (Figure 10.1.5). Production capacity is regulated through the Traffic Light System. Broadly, biomass and lice numbers have increased in green areas, stabilised in yellow areas, and declined in red areas. An exception is PA4, where the biomass of salmon and trout has remained relatively stable despite several red traffic lights.



Fish Health Report 2025, Norwegian Veterinary Institute

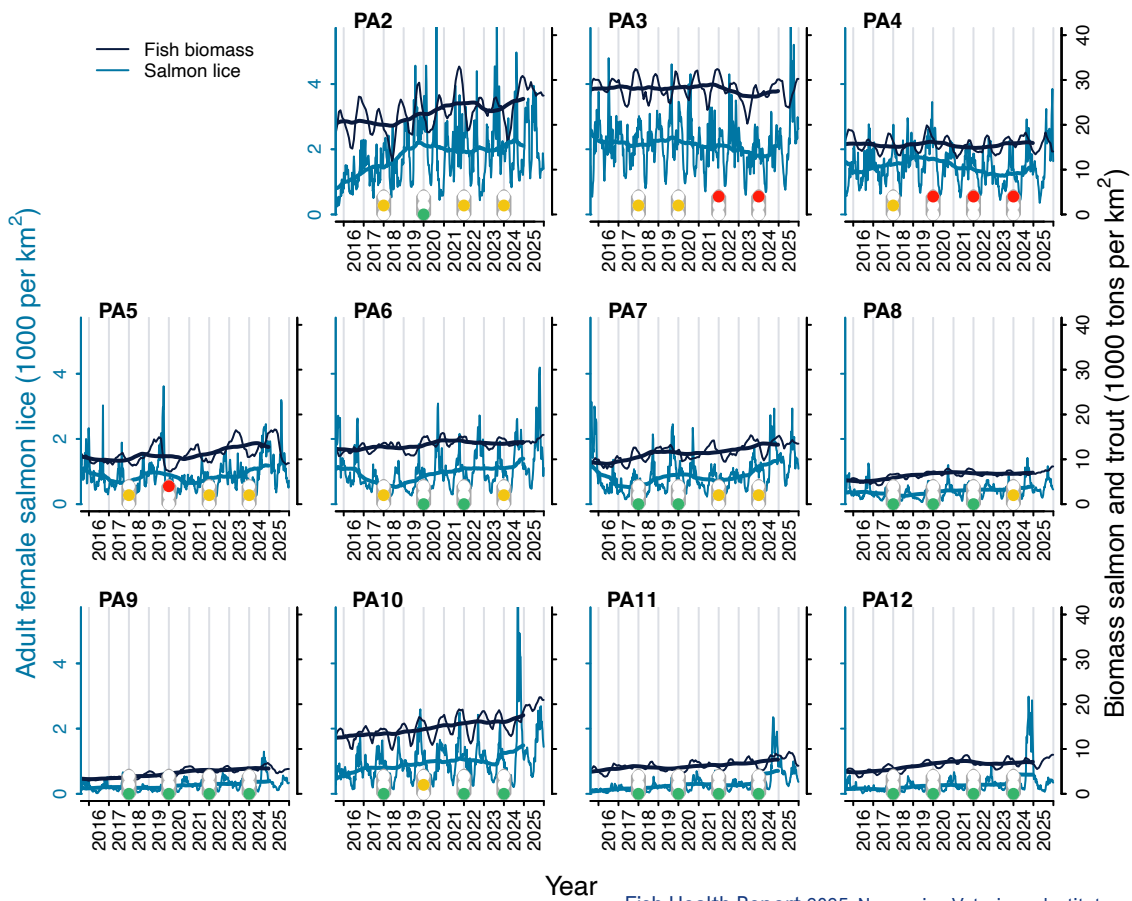
**Figure 10.1.4** Variation in sea temperature for each production area (PA). Sea temperature represents weekly averages measured at a depth of 3 metres, reported from all sea farms with salmon or rainbow trout. The lines show the seasonal variation for each of the most recent years. PA13 is omitted due to the small number of active sea farms. The green shaded areas indicate the weeks with a lower lice limit in each production area.

Biomass refers to the total weight of fish present in marine production areas at any given time and is distinct from total production, which is expressed per time unit. Annual production can increase without increasing biomass by deploying larger smolts, thus reducing time at sea.

Several factors explain why actual biomass may differ from maximum permitted biomass, including flexible schemes allowing capacity to be shared across production areas and variable utilisation of permitted capacity. Despite stable biomass, total adult female lice declined over several years in PA4, and an even greater reduction relative to biomass

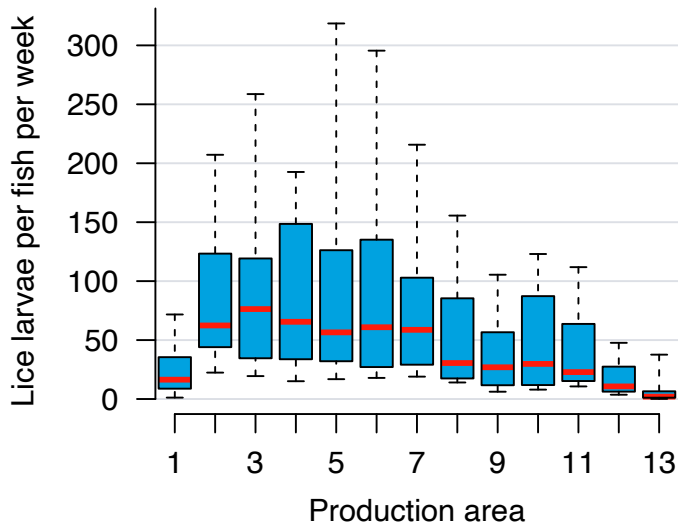
occurred in PA3, indicating fewer lice per kilogram of farmed fish. However, high lice levels in the latter half of 2025 broke this trend.

When larval production is normalised per fish present, large spatial differences in larval production per fish are observed (Figure 10.1.6). Median weekly larval production per fish was highest in PA3 and decreased towards both southern and northern areas. This demonstrates that changes in salmon and rainbow trout production will have varying effects on larval output depending on geographic location.

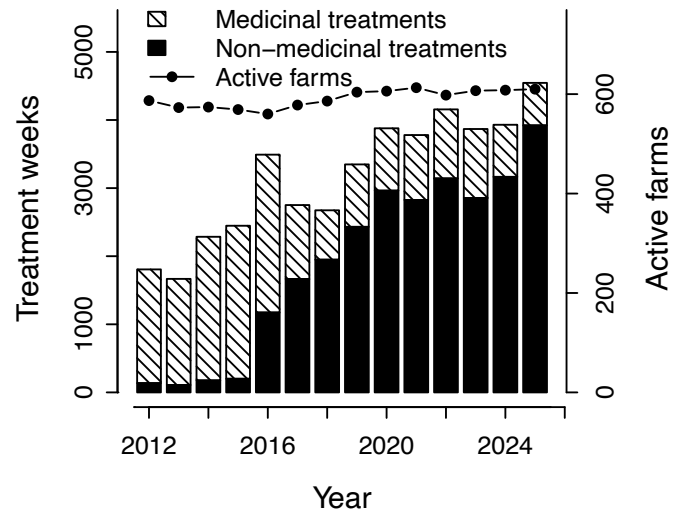


Fish Health Report 2025, Norwegian Veterinary Institute

**Figure 10.1.5** Time trends in salmon lice and farmed fish in each production area (PA) from 2016 to 2025. The blue lines show the estimated total number of adult female salmon lice on farmed fish, based on weekly reporting to the Norwegian Food Safety Authority. The black lines show the biomass of salmon and rainbow trout in marine aquaculture facilities, based on monthly reporting to the Norwegian Directorate of Fisheries. Values are shown as numbers or biomass per square kilometre of sea area within the baseline. The thick lines represent moving two-year averages, where each point is the average for the period from one year before to one year after the given time, while the thin lines also show short-term variation. The traffic lights indicate whether each production area was assigned green, yellow or red status by the Government under the Traffic Light System. Red status for PA3 and PA4 in the initial period is shown as yellow, as the red status did not result in a reduction in permitted production capacity. PA1 and PA13 are not shown due to the small number of active aquaculture facilities.



**Figure 10.1.6** Estimated average weekly release of salmon lice larvae per fish within each production area (PA1-PA13) in 2025. The red lines indicate median values, while 50% of the values fall within the blue boxes. The dashed lines show the range from the lowest to the highest weekly value for each PA.



**Figure 10.1.7** Number of reported medicinal and non-medicinal treatments against salmon lice and the number of active sea farms from 2012 to 2025. Treatments represent weeks in which sites reported to the Norwegian Food Safety Authority that lice treatments were carried out (data downloaded from BarentsWatch on 30.01.2026). The number of active farms is the average number of aquaculture facilities farming salmon or trout in the sea in the given year (based on monthly reports to the Directorate of Fisheries).

### Salmon lice treatments

The number of lice treatments in 2025 is summarised in [Figure 10.1.7](#) and [Table 10.1.1](#) and [10.1.2](#). Medicinal treatments represent the total number of weeks in which such treatments were reported to the Norwegian Food Safety Authority. Treatments may have been applied to individual cages or entire sites.

After annual increases in weeks with medicinal treatments from 2018 to 2022, a continuous annual decrease continued into 2025. From 2024 to 2025, the reduction was 19% (146 treatment weeks). For the first time since 2018, there was a decline in weeks with azamethiphos treatment (32%, corresponding to 95 weeks). Fewer treatments in 2025

compared to 2024 were seen for all other active substances except hydrogen peroxide, which increased slightly. Imidacloprid was not reported used in 2025.

In-feed treatments (with emamectin benzoate and flubenzuron) extend over several days and may therefore be recorded across multiple weeks, unlike bath treatments, which are often completed within a single week. The strong decline in medicinal treatments and transition to non-medicinal methods is largely attributed to resistance development in salmon lice, as documented in annual resistance monitoring reports from 2013 to 2023: [Resistance in salmon lice - Norwegian Veterinary Institute](#).

Table 10.1.1 Number of weeks with reported medicinal treatment using a given active substance, 2012–2025<sup>1</sup>. Pyrethroids include treatments with the active substances deltamethrin and cypermethrin, while flubenzuronones include treatments with the active substances teflubenzuron and diflubenzuron.

	Azamethiphos	Pyrethroids	Emamectin benzoate	Flubenzuronones	Hydrogen peroxide	Imidacloprid	Other	Sum of weeks
2012	494	821	196	168	59	0	245	1983
2013	375	840	171	196	113	0	148	1843
2014	560	779	438	208	425	0	185	2595
2015	485	526	601	242	562	0	338	2754
2016	208	230	637	279	327	0	824	2505
2017	57	72	521	142	144	0	197	1133
2018	33	51	454	77	84	0	40	739
2019	76	67	581	104	77	0	24	929
2020	122	48	605	90	62	0	13	940
2021	151	34	607	57	45	0	74	968
2022	239	31	586	35	40	0	100	1031
2023	273	14	540	58	19	11	59	974
2024	294	12	393	51	5	14	5	774
2025	199	10	379	34	6	0	0	628

<sup>1</sup> Data for 2012–2023 are sourced from BarentsWatch (06.02.2024), while data for 2024–2025 are from the Norwegian Food Safety Authority (02.02.2026). Minor differences compared with the 2024 Fish Health Report for the 2024 figures are due to late registrations and updated coding to identify active substances reported as “other” based on information in free-text fields. The use of multiple active substances for the same site and week is included in the table for each of the relevant substances. A new reporting form was introduced in autumn 2023, allowing for the registration of combination treatments, i.e. simultaneous treatment of the same fish with two active substances. There were eight registrations of multiple active substances for the same site and week in 2024 and three in 2025. None of these were registered as combination treatments.

Reported non-medicinal delousing treatments increased by 24% from 2024 to 2025, reaching the highest number recorded since data collection began in 2012 (Figure 10.1.6), table 10.1.2). These treatments represent weeks in which non-medicinal methods were reported in weekly submissions. Since 2017, 73–80% of treatments were conducted in individual cages only. From 2024 onwards, reporting includes the number of cages treated per week (average 3.6 cages in both 2024 and 2025). The increase in the number of treatments is consistent with the fact that lice levels were also higher throughout large parts of 2025 than in previous years (Figure 10.1.2).

Non-medicinal treatments are categorised as thermal (delousing using heated water), mechanical (delousing using water pressure and/or brushes), freshwater and other. Since

revised reporting procedures in 2024, combination treatments (simultaneous use of multiple methods) can be distinguished. Thermal treatment combined with freshwater was the most common combination. Preventive and continuous control measures, including lice skirts, lasers and cleaner fish, were also widely used.

Geographical distribution of freshwater treatments is shown in Table 10.1.3. Freshwater treatments increased every year with comparable data, from 591 weeks in 2024 to 841 weeks in 2025, with most treatments in PA3–PA7 and PA12. In 2025, 305 sites used freshwater delousing. Of these, 125 sites used freshwater for more than two weeks during 2025. Frequent use may increase tolerance to freshwater in salmon lice.

**Table 10.1.2** Number of reported non-medicinal treatments, 2012–2025. Treatments represent weeks in which sites reported having carried out non-medicinal delousing against salmon lice<sup>1</sup>. Treatment methods were divided into four categories: thermal (THERM), mechanical (MECH), freshwater (FW) and other. Thermal refers to delousing using heated water, while mechanical refers to delousing using water pressure and/or brushes. The combination categories indicate whether multiple delousing methods were reported for the same site during the same week. The number of these reports that were specified as combination treatments (simultaneous treatment using multiple methods) is given in parentheses (information not available prior to 2024).

	THERM	MECH	FW	THERM + MECH	THERM + FW	MECH + FW	THERM + MECH + FW	Other	Sum of weeks
2012	0	4	0	0	0	0	0	132	136
2013	0	2	1	0	0	0	0	107	110
2014	3	37	1	0	0	0	0	136	177
2015	36	34	28	0	0	0	0	103	201
2016	685	311	73	12	16	7	0	75	1179
2017	1245	236	75	42	21	1	0	52	1672
2018	1327	423	84	35	17	7	1	69	1963
2019	1447	674	148	56	27	7	0	87	2446
2020	1723	823	220	59	20	24	1	92	2962
2021	1456	862	286	30	63	56	5	72	2830
2022	1357	1074	225	47	141	153	9	139	3145
2023	888	980	186	59	227	151	12	106	2609
2024	1111	1311	116	139 (55)	318 (252)	148 (99)	9 (1)	11 (4)	3163
2025	1139	1746	136	177 (70)	502 (416)	189 (163)	14 (3)	15 (2)	3918

<sup>1</sup> Until autumn 2023, treatments were categorised based on information in free-text fields in lice reports submitted to the Norwegian Food Safety Authority. Following the introduction of a new reporting form in autumn 2023, categorisation has been based on a drop-down menu for treatment method. Treatments reported as “other” in the drop-down menu were, when possible, categorised based on information provided in free-text fields. Data reported to the Norwegian Food Safety Authority as of 02.02.2026. Minor differences compared with the 2024 Fish Health Report for the 2024 figures are due to late registrations and updated coding to identify methods reported as “other” based on information in free-text fields.

## The Annual Survey

In the survey among fish health personnel working for various enterprises and inspectors from the Norwegian Food Safety Authority, questions were asked about health problems related to grazing damage caused by salmon lice in general, and injuries associated with delousing in particular.

For salmon on-growing farms, respondents ranked injuries following delousing as the most important cause of mortality (80 of 119), reduced welfare (83 of 119), and poor growth performance (57 of 116). Some respondents also perceived such injuries as an increasing problem (18 of 114). Grazing damage caused by salmon lice was considered a

lesser problem, but by several respondents it was regarded as a relatively important cause of reduced welfare and as an increasing issue (Appendix B1).

For rainbow trout on-growing farms, injuries following delousing were, as in salmon, considered the most important cause of reduced welfare (12 of 23), and only gill diseases were ranked as a more significant health issue with respect to mortality (12 of 23). Some respondents experienced that these injuries contributed to reduced growth and perceived them as an increasing problem (Appendix B3). Grazing damage caused by salmon lice was experienced as a minor problem.

**Table 10.1.3** Number of reported freshwater treatments per production area (PA). Freshwater treatments represent weeks in which sites reported freshwater as the sole treatment method or as one of several methods. Minor differences compared with the 2024 Fish Health Report for the 2024 figures are due to late registrations and updated coding to identify methods reported as "other" based on information in free-text fields.

	PA1	PA2	PA3	PA4	PA5	PA6	PA7	PA8	PA9	PA10	PA11	PA12	Sum of weeks
2012	0	0	0	0	0	0	0	0	0	0	0	0	0
2013	0	0	0	0	0	0	0	1	0	0	0	0	1
2014	0	0	0	1	0	0	0	0	0	0	0	0	1
2015	0	0	0	19	0	4	5	0	0	0	0	0	28
2016	0	0	2	4	7	54	23	5	1	0	0	0	96
2017	0	3	6	12	4	46	14	0	12	0	0	0	97
2018	0	3	11	7	4	44	27	1	5	1	0	6	109
2019	0	25	28	17	7	67	28	2	3	1	0	4	182
2020	2	37	46	54	4	70	35	4	7	3	0	3	265
2021	2	21	85	85	14	106	56	6	12	7	4	12	410
2022	0	15	98	136	36	143	60	5	11	10	6	8	528
2023	7	15	115	67	85	147	76	21	20	21	1	1	576
2024	1	31	158	86	53	118	49	24	30	21	1	19	591
2025	2	42	243	158	48	167	27	30	32	29	9	54	841

The respondents' experiences indicate that salmon lice treatments pose similar challenges in broodstock facilities for salmon. Injuries following delousing were ranked as the most important cause of mortality (12 of 21), reduced welfare (10 of 21), and reduced growth (7 of 18). Some respondents considered the problem to be increasing ([Appendix C1](#)). Grazing damage caused by salmon lice was not perceived as a major health problem. The number of respondents from rainbow trout broodstock facilities was too low for the results to be presented.

Free-text responses regarding efficacy and welfare in connection with non-medicinal delousing provide a comprehensive picture of stakeholders' experiences with lice control. Many treatment types involve crowding in cages and pumping fish to treatment units, and several respondents describe such handling as a risk factor for both mortality and reduced welfare.

Reduced efficacy in late autumn following repeated thermal treatments was reported, along with welfare challenges related to handling lice at high sea temperatures. According to one respondent, pure thermal delousing may require temperatures of up to 34 °C, while another reported acute

mortality observed in isolated cases at 33 °C. Freshwater treatments were described as effective; however, four respondents reported that extended exposure time are now required to achieve the desired effect, both when used alone and in combination with thermal delousing. Some respondents reported that effectiveness appears to be influenced by local salinity, for example that lice near large rivers tolerate freshwater somewhat better. Several respondents reported good efficacy and welfare outcomes when using combinations of non-medicinal methods, particularly the combination of thermal delousing and freshwater, which allows treatment temperatures to be reduced to below 30 °C.

Mechanical methods such as brushing and flushing were reported to provide good efficacy against adult lice, but weaker efficacy against other motile stages. One respondent suggested that higher lice levels may require more intensive flushing, thereby causing more damage. The respondent did not specify why, but a possible explanation is the need for more effective treatment to reach the same target levels (for example, to remain below the lice threshold). Modern flushing systems were described as being more gentle than older systems, while high pressure (above 0.8 bar) was associated with increased injury.

Laser technology was described as effective at low lice infestation pressure, and several respondents reported that it reduces the need for other treatments. The effect was reported to be greatest against adult lice, but lower at high lice infestation pressure. Increased occurrence of unilateral severe cataracts in harvest-size fish has also been reported at sites using laser systems in cages.

With regard to medicinal methods, several respondents reported a slight reduction in sensitivity to azamethiphos, and reduced efficacy at low sea temperatures. Emamectin benzoate was reported to have poorer efficacy at high sea temperatures.

### Assessment of the salmon lice situation

The highest numbers of salmon lice per farmed fish were reported from August to October in PA3 and PA5-PA7. The highest total release of salmon lice larvae from aquaculture facilities occurred in PA6, with a peak exceeding 20 billion lice larvae per week, followed by PA3 with over 10 billion. In most production areas, autumn larval output was relatively high from a long-term perspective, although levels in the northernmost areas (PA8-PA12) were even higher in 2024. The strong increase in larval production during summer is due both to increasing numbers of adult female lice and to higher larval production per female at higher temperatures. In both 2024 and 2025, summer temperatures increased more than normal in the northernmost production areas. Increased biomass of farmed fish across large parts of central and northern Norway has also contributed to higher total numbers of salmon lice and increased larval production in these regions.

In PA3 and PA4 in western Norway, there have been indications of a declining trend in the total number of salmon lice, mainly driven by fewer lice reported per fish; however, high lice levels in the second half of 2025 broke with this trend. The release of salmon lice larvae from aquaculture facilities during the spring period with a lower lice limit increased from 2024 to 2025 in ten of the thirteen production areas. In six production areas, larval release during the smolt migration period in 2025 was higher than in any year in the five-year period prior to 2024, while larval production in the remaining areas was within the range of variation observed for this period.

The use of non-medicinal lice treatments increased in 2025 compared with 2024 (overall increase of 24%), while the use of medicinal treatments declined (overall reduction of 19%). In total, the number of treatment weeks increased by 15%. Use of all medicinal products against salmon lice decreased in 2025 compared with 2024, except for hydrogen peroxide, which showed a minimal increase (six weeks in 2025 compared with five weeks in 2024). When weeks in which methods were used either alone or in combination with other methods are included, mechanical delousing was the most frequently applied method, with 2 126 treatment weeks. Thermal delousing was applied in 1 832 treatment weeks, and freshwater treatment in 841 weeks.

Since 2017, salmon lice control measures have predominantly been non-medicinal. In 2025, non-medicinal measures were reported to be used more than six times as often as medicinal measures. A total of 3 918 non-medicinal treatments were reported in 2025.

The survey demonstrates a clear association between salmon lice treatments and reduced fish welfare for both salmon and rainbow trout in the on-growing phase, as well as for salmon broodstock. Free-text responses reveal a consistent pattern in which several non-medicinal methods (thermal, mechanical, laser and freshwater treatments) are still perceived as challenging for fish welfare, particularly at high sea temperatures. Combination treatments are reported to be more welfare-friendly than thermal treatment alone, and some modern flushing systems are perceived as more gentle than older systems. For medicinal treatments, reduced sensitivity to several active substances over multiple years and diminished efficacy at low or high temperatures were reported.

Some respondents indicated that extended exposure times are now required to achieve the desired effect of freshwater treatments, and that efficacy may be lower at low ambient salinity. If these observations reflect broader patterns, they may indicate that salmon lice are developing increased tolerance through physiological adaptation to the environment or through evolutionary processes.

### Reference

Stige, L.C., Helgesen, K.O., Viljugrein, H., Qviller, L. (2021). A statistical mechanistic approach including temperature and salinity effects to improve salmon lice modelling of infestation pressure. *Aquaculture Environment Interactions*, 13: 339-361.

## 10.2 Sea louse – *Caligus elongatus*

By Geir Bornø and Haakon Hansen

### The parasite

Sea louse (*Caligus elongatus*) is a parasitic crustacean belonging to the same family (Caligidae) as the salmon louse (*Lepeophtheirus salmonis*). Like the salmon louse, *C. elongatus* lives mainly on the skin of fish in seawater. Sea louse has a much lower host specificity than salmon lice, which occur only on salmonids. *C. elongatus* has been detected on approximately 80 fish species, including salmonids, gadoids, herring, flatfish, gobies, and lumpfish. Lumpfish are one of the main host species for *C. elongatus*.

The developmental stages of *C. elongatus* differ from those of salmon lice. The adult stages are more mobile and highly capable swimmers. This allows them to actively switch hosts, meaning that lice from lumpfish can easily leave their host and infect salmon—and vice versa—under farming conditions. Salmon and any cleaner fish present in the cages may also become infected with *C. elongatus* from fish out-

side the cages. Both infective copepodites and adult lice originating from these fish can contribute to infection pressure and rapidly establish on fish in the cages. *C. elongatus* can cause skin damage to the host fish, which in turn may lead to secondary infections, but it generally causes less damage to the host than salmon lice.

During lice counts, *C. elongatus* can be distinguished from salmon lice, among other characteristics, by being more translucent, having less pigmentation, being smaller, and often more mobile than salmon lice (Figure 10.2.1).

### Disease Control

Treatment against *C. elongatus* is most often carried out simultaneously with treatment against salmon lice. It is reported that all medicinal treatments have good efficacy against *C. elongatus*.



Figure 10.2.1 Salmon lice (*Lepeophtheirus salmonis*) and *Caligus elongatus* (smaller) on sea trout. Photo: Rune Nilsen, Institute of Marine Research

## The Health Situation in 2025

---

### The Annual Survey

Respondents ranked *C. elongatus* as a minor problem in salmon growout production on a national basis ([Appendix B1](#)). In production areas PA10–PA13, however, the parasite was ranked as the fifth most important problem, particularly regarding reduced welfare (9 of 26 respondents) and increasing occurrence (8 of 26 respondents) ([Appendix B2](#)). No respondents reported *C. elongatus* as a health problem in rainbow trout in growout facilities ([Appendix B3](#)), nor in salmon and rainbow trout in broodstock facilities ([Appendix C1](#)).

### Assessment of the situation for *Caligus elongatus*

Infections with *C. elongatus* appear to be of limited extent in 2025 and seem to be at a level similar to that observed in recent years. For 2025, respondents to the questionnaire survey reported only minor problems associated with *C. elongatus*. Challenges related to *C. elongatus* have traditionally been greatest in Northern Norway (PA10–PA13).

## 10.3 Parvicapsulosis – *Parvicapsula pseudobranchicola*

By Geir Bornø and Haakon Hansen

### The Disease

Parvicapsulosis has been known in Norwegian farmed Atlantic salmon since 2002 and has been reported to be particularly problematic in aquaculture in Troms and Finnmark. Parvicapsulosis is caused by the parasite *Parvicapsula pseudobranchicola* (Myxozoa), and the disease may cause high mortality in salmon growout facilities. Myxozoans use fish as an intermediate host, and *P. pseudobranchicola* has been detected in Atlantic salmon, rainbow trout, brown trout and Arctic char. The definitive host was until very recently unknown but has now been identified as the polychaete worm *Chaetozone setosa* (Cirratulidae).

For further information on parvicapsulosis, see the Norwegian Veterinary Institute's fact page (in Norwegian):

[Parvicapsulose](#)

### Disease Control

No specific measures to prevent parvicapsulosis are known, but good environmental conditions and robust fish health, with fish free from other diseases, may reduce losses.

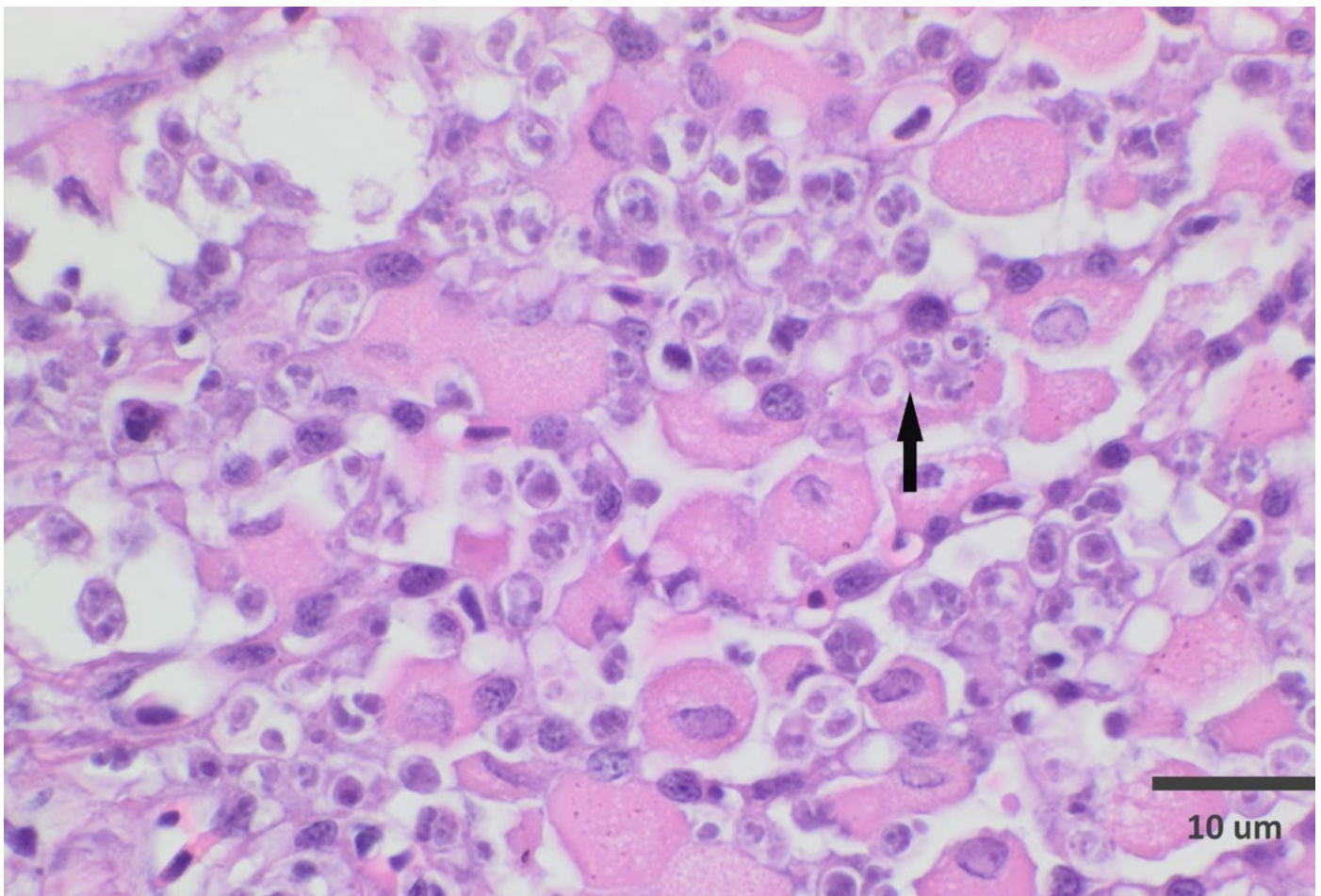


Figure 10.3.1 Pseudobranchia in salmon affected by the multicellular parasite *Parvicapsula pseudobranchicola* (arrow). Photo: Toni Erkinharju, Norwegian Veterinary Institute

## The Health Situation in 2025

---

### Data from the Norwegian Veterinary Institute and Private laboratories

Compiled data from the Norwegian Veterinary Institute and private laboratories show that parvicapsulosis was detected at 18 salmon farming sites, which is at the same level as in 2024. Of the 18 sites, six were located in PA12 and PA13. The remaining detections were distributed among PA8 (four sites), PA9 (three sites), PA10 (two sites), and PA11 (three sites). Detections of *P. pseudobranchicola* by PCR were reported at 14 sites.

### The Annual Survey

In 2025, problems related to mortality, reduced welfare, and poor growth in salmon during the growout phase were also reported; however, no respondents considered parvicapsulosis to be an increasing problem ([Appendix B1](#)). The challenges were greatest in the northernmost production areas ([Appendix B2](#)).

### Assessment of the Parvicapsulosis Situation

Parvicapsulosis has for many years been a recurring problem in salmon growout facilities in the northernmost areas, and these problems appear to be continuing at approximately the same level in 2025. As the parasite is widespread in wild fish along the entire coast, detections in farmed fish in areas other than the northernmost ones are not unlikely. Based on what is known about the distribution of the parasite in aquaculture, it is likely that the number of detections underestimates the true extent of its occurrence.

## 10.4 Amoebic Gill Disease (AGD) – *Paramoeba perurans*

By Geir Bornø and Haakon Hansen

### The disease

Amoebic gill disease (AGD) is caused by the amoeba *Paramoeba perurans* (synonym *Neoparamoeba perurans*). AGD is not a notifiable disease. Since the mid 1980s, the disease has caused major losses each year in the production of farmed salmon in Australia (Tasmania). In the mid 1990s, *P. perurans* was discovered in the Atlantic Ocean, and the amoeba has since been detected progressively further north.

AGD was first detected in Norwegian farmed salmon in 2006, followed by several years in which the amoeba was not detected. Since 2012, however, the amoeba has caused significant losses in the Norwegian aquaculture industry.

For further information on AGD and *Paramoeba perurans*, see the Norwegian Veterinary Institute's fact sheet: [Amoebic gill disease \(AGD\)](#)



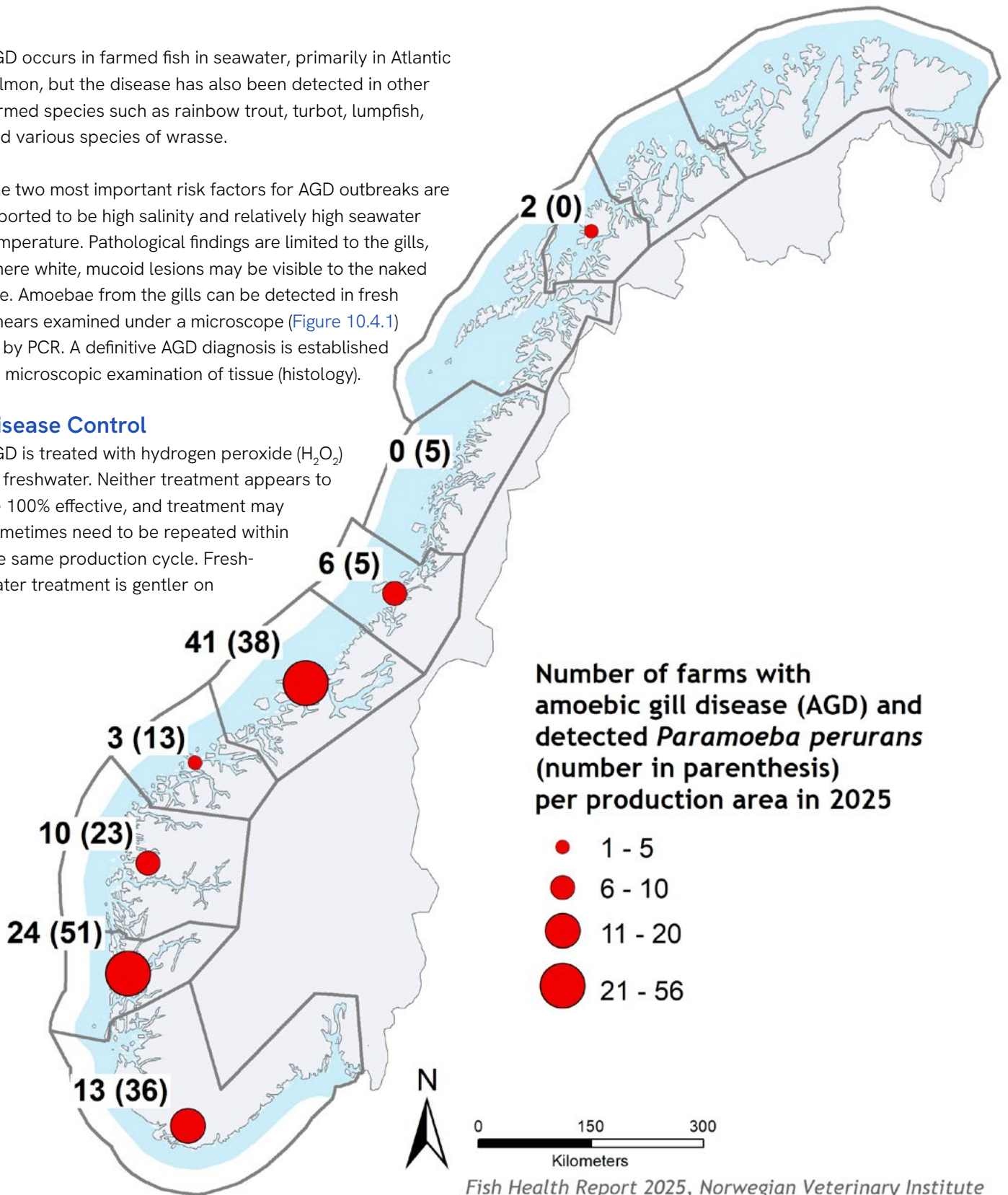
**Figure 10.4.1** Amoebic gill disease (AGD) in salmon. The white spots on the gills are caused by the amoeba *Paramoeba perurans*. Monoculture of *Paramoeba perurans* (phase-contrast microscopy) (left). Gill filament displaying lesions associated with *Paramoeba perurans* infection (right) (scanning electron microscope, coloured, magnified 130 times). Photo: Jannicke Wiik-Nielsen, Norwegian Veterinary Institute

AGD occurs in farmed fish in seawater, primarily in Atlantic salmon, but the disease has also been detected in other farmed species such as rainbow trout, turbot, lumpfish, and various species of wrasse.

The two most important risk factors for AGD outbreaks are reported to be high salinity and relatively high seawater temperature. Pathological findings are limited to the gills, where white, mucoid lesions may be visible to the naked eye. Amoebae from the gills can be detected in fresh smears examined under a microscope (Figure 10.4.1) or by PCR. A definitive AGD diagnosis is established by microscopic examination of tissue (histology).

**Disease Control**

AGD is treated with hydrogen peroxide (H<sub>2</sub>O<sub>2</sub>) or freshwater. Neither treatment appears to be 100% effective, and treatment may sometimes need to be repeated within the same production cycle. Fresh-water treatment is gentler on



**Figure 10.4.2** Number of AGD diagnoses in 2025 and detected *Paramoeba perurans* per production area (PA), based on compiled data from the Norwegian Veterinary Institute and private laboratories. Due to a low number of sites located in PA1 and PA2, these production areas have been merged. The same applies to PA12 and PA13. Illustration: Attila Tarpai, Norwegian Veterinary Institute

salmonids and appears to have better efficacy against the amoeba than treatment with H<sub>2</sub>O<sub>2</sub>. Treatment of AGD is most effective when administered early in the course of disease development. This reduces the likelihood of relapse and the time required for AGD to redevelop. Therefore, it is important to monitor the presence of amoebae on farmed fish to detect the disease at an early stage. This is usually carried out through PCR screening and visual inspection of the gills.

A specific scoring system has been developed for the classification of macroscopic gill changes caused by AGD. This scoring system is an important tool for fish health services. After repeated treatments, however, assessment of gill scores may be challenging, and the method requires considerable experience. Several factors and agents can induce AGD-like gill changes, and it is therefore important to confirm an AGD diagnosis through histological examinations and PCR analyses.

## The Health Situation in 2025

---

### Data from the Norwegian Veterinary Institute and Private laboratories

AGD is not a notifiable disease, and diagnoses are often made by fish health services at the cage side. Consequently, it is not possible to provide a complete annual overview of the number of sites diagnosed with AGD. AGD is usually detected macroscopically (visually), and PCR and histology are subsequently used to confirm findings.

Compiled data from private laboratories and the Norwegian Veterinary Institute show detections of AGD at 99 salmon farming sites. This represents an increase compared with 2023 and 2024, when 73 and 40 detections were reported, respectively. The highest number of detections was reported from PA6, with 41 sites. Disease detections were reported from PA1-PA10, with the exception of PA8 and PA9.

In addition to the 99 detections of AGD in salmon, there were 171 detections of the agent (*P. perurans*) in salmon and nine detections in rainbow trout. In cases where the agent was detected at a site where an AGD diagnosis had not been established, 31 detections were reported to have clinical relevance (associated with disease), while the remaining detections were either not assessed with respect to clinical signs in the field or were reported as having no clinical significance. There were nine detections of *P. perurans* in rainbow trout, of which two were reported to be of clinical significance.

### The Annual Survey

Feedback from respondents indicates that AGD is perceived as an increasing health problem (19 of 114 respondents), but to a lesser extent as a contributor to mortality, reduced

growth, and poor welfare in salmon growout facilities ([Appendix B1](#)). AGD is considered a very minor problem in salmon broodstock facilities ([Appendix C1](#)).

In rainbow trout growout facilities, no respondents reported AGD as an important problem, either as a cause of mortality, reduced welfare, poor growth, or as an increasing issue ([Appendix B3](#)).

### Assessment of the AGD Situation

AGD continues to be a serious disease in Norway. In 2025, a relatively high number of sites reported disease, exceeding the numbers reported in both 2023 and 2024. The number of outbreaks and the severity of individual outbreaks vary from year to year, which may be related to climatic conditions.

In 2025, disease was also reported from PA10, which is new and may be of concern regarding fish health in the northern parts of the country.

Fish farmers and fish health services have developed substantial experience in managing AGD, both in determining whether treatment is necessary and in deciding at what stage of disease development treatment should be initiated. This experience, combined with frequent screening, contributes to improved disease control. In some areas, increased experience and knowledge have resulted in fewer treatments, as stakeholders have observed that the disease may resolve naturally, particularly following changes in environmental conditions in late autumn.

# 11 Other Health Problems in Farmed Salmonids

By Julie Christine Svendsen

**Health challenges in farmed salmonids that cannot be attributed to infectious agents are commonly classified as production-related disorders and are typically associated with environmental and operational conditions. Such conditions may arise as a result of influences from the external environment and production conditions at the facility. Key issues in this category include gill disease, reduced smolt quality and “loser syndrome”, nephrocalcinosis, haemorrhagic smolt syndrome (HSS), water quality-related challenges, and algal impacts.**

Farmed salmonids are susceptible to gill damage and disease throughout their life cycle, with the seawater phase representing the period of greatest vulnerability. The aetiology of gill disease is often complex and multifactorial. Significant infectious agents include the amoeba *Paramoeba perurans*, the bacterium *Candidatus Branchiomonas cysticola*, the microsporidian *Desmozoon lepeophtherii*, Salmon Gill Poxvirus (SGPV), and the protozoan parasite *Ichthyobodo* spp. Additionally, infections caused by bacteria of the genus *Tenacibaculum* spp. may lead to extensive pathology.

In 2025, gill disease was identified as the primary health challenge affecting Atlantic salmon in both grow-out and broodstock facilities. Furthermore, respondents indicated an emerging concern regarding gill disease in rainbow trout. An increasing occurrence of epitheliocysts was recorded, and *Ca. B. cysticola* was detected at a large proportion of sites along the coast. Epitheliocysts were found in fish from all production areas, in contrast to 2024 when no cases were recorded in the far north. Gill disease leads to significant mortality, reduced welfare, and poor growth. There are still many knowledge gaps regarding gill health and specific gill diseases, but gradual progress is being made in diagnostics and monitoring. A focus on biosecurity, systematic screening, and open information sharing among all stakeholders is crucial for improved control.

Hemorrhagic smolt syndrome (HSS), wound development, salmon pox, and other gill diseases are examples of conditions that can negatively affect smolt quality. Commercial aquaculture employs diverse smoltification strategies, including intensive production of large smolts in recirculating aquaculture systems (RAS). Poor smolt quality predisposes fish to osmoregulatory disturbances, which in turn can lead to stress, reduced welfare, and an increased risk of health problems and mortality in the early period after sea transfer, and may result in unsatisfactory development in terms of growth and health during the seawater phase.

The causes of “runt syndrome” may be complex; stress and poor smolt quality can increase the risk. Loser fish represent both a significant welfare issue and a potential infection risk. For salmon in the freshwater phase, survey respondents reported that production-related conditions/syndromes were the most problematic in 2025. Among health problems with increasing occurrence, smoltification issues ranked highly. Loser-related problems appear to have somewhat greater importance in rainbow trout production. There is strong motivation for a knowledge-based approach to operational routines, and the field is continuously subject to research and development.

Nephrocalcinosis is an environmentally induced condition in farmed fish, characterized by the deposition of mineralized material within the renal excretory system. It serves as an important welfare indicator, as it may reflect suboptimal water quality or deficiencies in husbandry practices. Nephrocalcinosis is frequently observed as a secondary condition in association with HSS. The disorder is multifactorial in origin, with contributing factors including temperature, water chemistry, smoltification protocols, operational practices, and seawater exposure. Preventive measures include ensuring high-quality intake water, maintaining stable in-tank conditions (including CO<sub>2</sub>, O<sub>2</sub>, and pH), and providing adequate water exchange. In 2025, respondents identified nephrocalcinosis as the most significant health challenge affecting salmon during the freshwater phase.

HSS, also referred to as haemorrhagic diathesis (HD), is a haemorrhagic disorder affecting Atlantic salmon, typically occurring shortly before or after transfer to seawater. Between 2021 and 2025, HSS was ranked as the leading cause of mortality in salmon during the freshwater phase. Although the overall prevalence remains uncertain, it appears to have been relatively stable over this period.

In 2025, NIVA Aquaculture managed nearly 200 individual cases related to water quality, approximately 18% of which were associated with acute or elevated mortality events. Approximately half of these mortality events were linked to freshwater treatments conducted in well boats, while around 35% were associated with land-based aquaculture systems, predominantly RAS facilities.

Survey data indicate that poor water quality is a major determinant of reduced growth and has substantial impacts on welfare and mortality in salmon during the freshwater phase. In contrast, water quality was considered a less critical issue in rainbow trout production, where mortality was prioritized. In flow-through systems, temperature was among the most frequently reported factors negatively affecting fish welfare in 2025, continuing an upward trend observed since 2021. Carbon dioxide (CO<sub>2</sub>) and oxygen (O<sub>2</sub>) levels were also identified as significant risk factors, with insufficient CO<sub>2</sub> degassing capacity cited as a recurring issue. In RAS facilities, approximately half of the respondents reported negative effects of turbidity and temperature on fish welfare. Additionally, CO<sub>2</sub> and O<sub>2</sub> were ranked as more critical welfare challenges than nitrogenous compounds and gas supersaturation.

The year 2025 was characterized by multiple extreme weather events, including a significant spring flood in March, followed by a warm and dry summer, and a late summer/autumn marked by storms and heavy precipitation. Such events can exacerbate water quality challenges across all production systems. Survey responses suggest an increas-

ing emphasis on documenting water quality during well-boat operations, representing a positive trend that supports improved management and knowledge acquisition.

Algae constitute a fundamental component of marine primary production; however, certain microalgae can form harmful blooms under favourable environmental conditions, producing toxins detrimental to fish and other organisms. In spring 2025, blooms of *Chrysochromulina leadbeateri* and *Phaeocystis* occurred in Northern Norway, resulting in substantial mortality among farmed salmon. The previous bloom of *C. leadbeateri* was recorded in 2019. The Tox-ANoWa project, led by the Norwegian Veterinary Institute, was initiated to enhance understanding of harmful algal species. This research identified the toxin leadbeaterin-1, produced by *C. leadbeateri*, which has demonstrated high toxicity to gill cells in both salmon and trout. Monitoring of leadbeaterin-1 concentrations in seawater surrounding aquaculture facilities is feasible during bloom events.

Other harmful algal species, including *Prymnesium parvum* and *Pseudochattonella*, have also caused significant losses in Scandinavian aquaculture. In October–November, several facilities in the Flekkefjord region experienced fish mortality likely associated with algal blooms. Survey respondents reported a marked increase in the significance of algae as a health challenge in salmon grow-out operations in 2025, with 23% reporting mortality events linked to algal exposure. A comparable proportion indicated an increasing frequency of such occurrences. Climate change and environmental variability are expected to elevate the risk of these events, particularly in conjunction with compromised gill health and fluctuations in oxygen availability.

# 11.1 Gill Diseases

By Mona Gjessing and Anne Berit Olsen

**The surface area of the gills is almost as large as the total skin surface area, and the gills have a central role as a barrier towards the surrounding environment, just like the skin and the intestinal mucosa. Bacteria, viruses, and parasites spread much more easily in water than in air, and the gills are therefore more exposed to potential pathogenic organisms than organs in animals that breathe with lungs.**

In addition to their essential roles in gas exchange, excretion of nitrogenous waste products, acid-base regulation, and hormone metabolism, the gills must also prevent infectious agents from entering the body. The gill surface must furthermore withstand other stressful influences from the aquatic environment. Naturally, the gills have a large reserve capacity and an ability to repair damage, provided that the damage is not too extensive. Healthy gills are a prerequisite for good overall health.

## Gill Disease

Farmed salmonids are exposed to gill damage and gill disease (Figure 11.1.1) throughout their entire life cycle. Salmon in the seawater phase are the most vulnerable, and because the gills have a large reserve capacity, substantial pathologi-

cal changes may occur before the fish shows clinical signs of disease. Operational routines, unfavourable water conditions, infectious agents, algae, and jellyfish—individually or in combination—can all damage the gills. In many cases, the predisposing factors are not well understood. The term complex gill disease or complex gill disorder often indicates multifactorial causes.

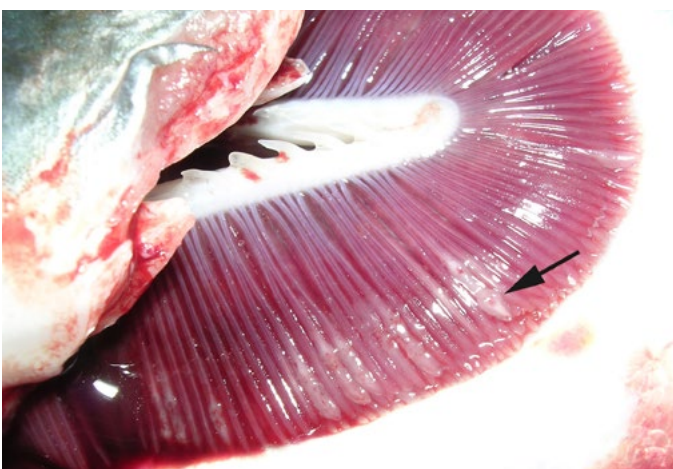
Several agents may cause gill pathology. The most well-known are the amoeba *Paramoeba perurans*, which causes amoebic gill disease (Chapter 10.4 Amoebic Gill Disease (AGD)); the bacterium *Ca. Branchiomonas cysticola*; and the fungus-like organism (microsporidian) *Desmozoon lepeophtherii* in salmon in the marine phase, as well as salmonid poxvirus, which may cause severe acute disease, particularly in juvenile fish (smolt and parr). The unicellular parasite *Costia (Ichthyobodo)* may also cause gill irritation, both alone and as part of a complex disease picture in freshwater facilities and in the marine environment.

Salmon gill poxvirus disease (SGPVD) may cause high mortality in freshwater hatcheries and is associated with relatively characteristic gill lesions in the acute and subacute phases. Fish populations may also be infected without showing clinical signs of disease. Experimental studies have shown that outbreaks may be triggered when the immune response of the fish is impaired, for example due to stress. The virus infects epithelial (surface) cells, and experimental studies have demonstrated infection in epithelial cells of the gills, mouth, and skin.

A previously unknown poxvirus has recently also been described on the gills of Atlantic cod (Chapter 12 Health and welfare in farmed Atlantic cod).

**For further information on complex gill disease and salmon gill poxvirus, see the Norwegian Veterinary Institute's fact page (in Norwegian):**

[Kompleks gjellesykdom hos laks](#)



**Figure 11.1.1** White, thickened and firm areas on gill filaments in Atlantic salmon, indicating pronounced proliferation of surface cells. This represents a chronic reaction that does not heal. Photo: Brit Tørud, Norwegian Veterinary Institute

Infection with *Ca. Branchiomonas cysticola*, the most important epitheliocyst-forming bacterium, may present with different manifestations. The bacterium is often detected

without pathological changes in the gills, but it may also be associated with severe gill disease involving vascular damage, inflammation, and tissue necrosis, and is most commonly found in salmon in the marine phase. The microsporidian *Desmozoon lepeophtherii* (*Paranucleospora theridion*) is not commonly detected in northern Norwegian waters, but is frequently present on gills further south, both at sites without disease problems and in association with complex gill disease.

In addition, bacteria of the genus *Tenacibaculum* may cause necrotising gill inflammation. The gills may also be involved in systemic infections, such as infection with *Phocoenobacter atlanticus* subsp. *atlanticus* (previously pasteurellosis).

With the exception of the gill amoeba *P. perurans* and *Tenacibaculum* spp., it has not yet been possible to culture most gill pathogens, making controlled experimental studies difficult to conduct. Efforts to culture these agents are necessary to gain greater insight into their biology, which in turn will aid in controlling the problems caused by these gill pathogens.

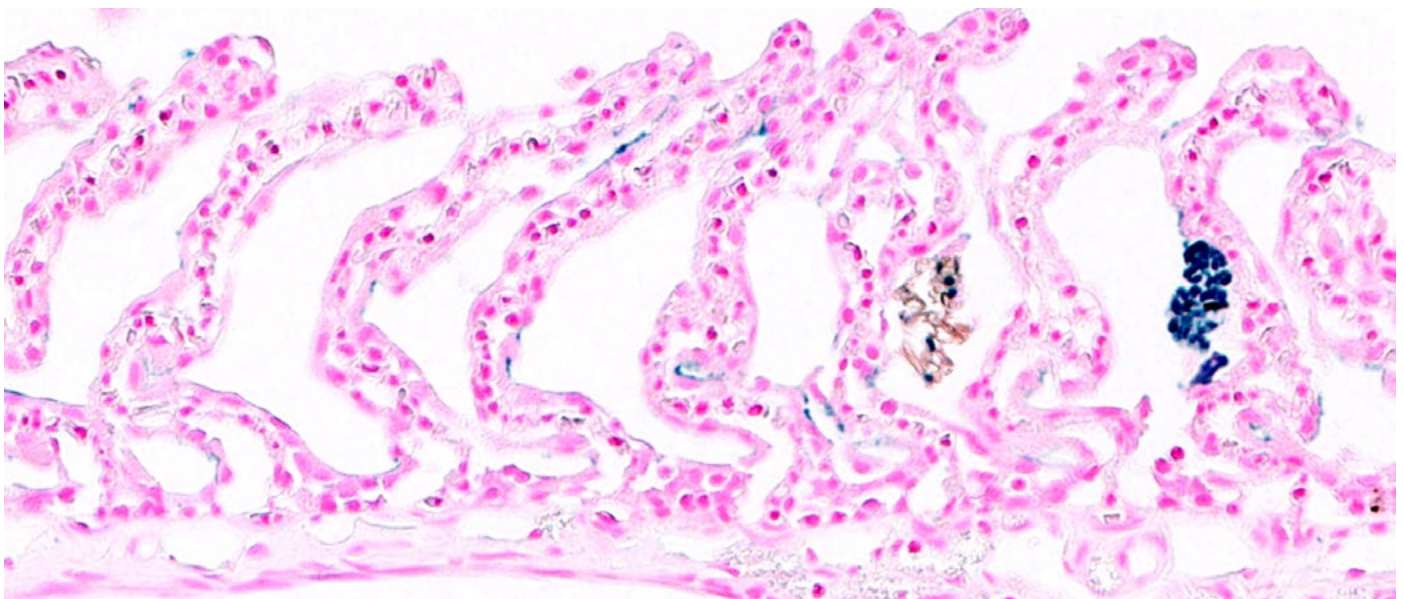
In recent years, several large hatcheries and post-smolt facilities have become operational, many of which are based on recirculating aquaculture systems (RAS). Unfavour-

able water chemistry may place stress on the gills (Chapter 11.5 Water quality), and imbalances in the microbial environment, with proliferation of potentially pathogenic organisms, may also increase the risk of compromised gill health. During the freshwater phase, infections with the oomycete *Saprolegnia* spp. may occur, often due to poor water quality (Chapter 8 Fungal diseases in farmed salmonids).

In marine farms, non-medicinal delousing methods may damage the gills. For example, increased prevalence of *Ca. Branchiomonas cysticola* has been observed following thermal delousing. When freshwater treatments are applied, with reuse of water for multiple delousing cycles, changes in water chemistry and an increased risk of metal deposition on the gills have been observed (Figure 11.1.2).

It is reasonable to assume that changes in the marine environment as a result of climate change—such as increased water temperature and reduced oxygen solubility—may increase the burden on gill health and impair the fish's ability to cope with such challenges.

Gill disease has been a major problem for many years, not only in Norwegian salmon aquaculture but also in other salmon-producing countries worldwide. To facilitate knowledge sharing, the global collaborative platform the **Gill**



**Figure 11.1.2** Histological section of gills stained with Prussian blue (potassium ferrocyanide in acidic solution for detection of trivalent iron). Iron is stained blue. The lamellae are covered by a thin layer of iron in several areas. Some lamellae are stuck together, likely due to altered surface tension as a result of iron deposition. Photo: Mona Gjessing, Norwegian Veterinary Institute.

**Health Initiative** was established in 2013. The aim is to provide a forum where researchers, the industry, and other stakeholders can collaborate to identify solutions to these often complex problems.

### Tools and monitoring

Standardisation of scoring protocols is necessary to further improve knowledge sharing and to serve as tools for gill health surveillance within individual companies. This applies to both macroscopic and histopathological assessment. Histopathology is the most important tool for gaining an overview of pathological changes and possible causes. Automated in situ hybridisation (ISH) in tissue samples, used for visualisation and identification, has been established for several gill-associated microbes. Efforts are under way to improve the efficiency of routine gill examinations using artificial intelligence. Regular sampling of gills for histopathological and PCR analyses is important for monitoring gill health.

### Prevention and treatment

There is strong focus on water quality in hatcheries, among other reasons to ensure good gill health. Strict biosecurity routines must be implemented to prevent pathogens from

entering facilities via biological material or intake water. Recirculating systems often contain higher levels of particles in the water than flow-through systems. There is limited documentation on whether and how such particles may damage the gills. In cases of recurrent gill disease in RAS facilities, it should be considered whether the biofilter needs to be sanitised.

During outbreaks of salmon gill poxvirus, experience shows that mortality may be significantly reduced by ceasing feeding, supplying additional oxygen, and avoiding all forms of handling or other stressors. Among specific gill diseases in the marine phase, only AGD can be treated. Some operators use lice skirts at various depths to protect fish from algae and jellyfish, but a challenge is that these organisms are not restricted to specific depths. Smolt transferred to sea should not be carriers of gill pathogens. It is important to keep nets clean and to pay particular attention to cleaning routines that do not burden the gills with detached fouling organisms. Examination of gill samples throughout the entire production cycle is recommended, as this may constitute an important part of a risk assessment prior to handling of fish.

## The Health Situation in 2025

---

Gill disorders are not notifiable and are therefore not reported to the Norwegian Food Safety Authority. The prevalence of gill problems at farming sites is thus uncertain; however, compiled data are available from examinations conducted by the Norwegian Veterinary Institute and private laboratories for some specific conditions ([Chapter 1](#) Statistical basis for the report).

In samples from salmon in freshwater hatcheries in 2025, the Norwegian Veterinary Institute detected gill changes without identification of a specific cause, although water quality was suspected. Gill irritation caused by the unicellular parasite *Costia* (*Ichthyobodo necator*) and gill necrosis associated with the oomycete *Saprolegnia* sp. occurred sporadically. Some hatcheries reported gill problems persisting over several months. As in previous years, very few submissions were received from rainbow trout hatcheries with gill problems.

In the Norwegian Veterinary Institute's material from 2025, submissions from salmon in marine farms with primary or secondary gill-related diagnoses were distributed throughout the year, with a clear predominance in the first half of the year (72%). This represents a marked change from 2024, when submissions were mainly received during the period June–November. Gill diagnoses were most often additional findings alongside other diagnoses. At some sites, gill problems appeared to be persistent. In many cases, complex lesions indicated multifactorial causes.

Compiled data from diagnostics at the Norwegian Veterinary Institute and private laboratories for gill disease in salmon in the marine phase, where epitheliocysts were detected by histopathology, showed an increase from 65 localities in 2024 to 83 in 2025, corresponding to the level observed in 2023. In 2025, findings were recorded in all production areas, whereas in 2024 no registrations were made in the northernmost areas (PA11–PA13). As in 2024,

most detections were recorded in PA4 (19) and PA6 (17), with additional detections in PA9 and PA10.

Based on submissions to the Norwegian Veterinary Institute, sparse to extensive occurrence of epitheliocysts detected by histopathology was identified at 65% of farms with gill diagnoses (50% in 2024). Epitheliocysts were detected throughout the year, with no distinct autumn predominance as seen in previous years. Most cases involved fish weighing between 1.5 and just over 3 kg, with a range from approximately 200 g to nearly 6 kg. Only one case of gill disease with epitheliocysts was recorded in rainbow trout in 2025.

The bacterium *Ca. Branchiomonas cysticola* may be present on gills both with and without pathological changes and may also be involved in lesions without epitheliocyst formation. Detection of the bacterium by PCR in salmon was recorded at 240 localities (245 in 2024 and 189 in 2023) along the entire coast. The highest number of detections was recorded in PA3 (56) and PA1–PA2 (34), similar to 2024. Numerous detections were also recorded in PA6 and PA8 (30 each) and in PA4 (27). In rainbow trout, an increase was observed from six to 16 localities with detected *Ca. Branchiomonas cysticola* in PA3.

There were also some detections of *Costia* on gills of salmon in marine farms, often as part of complex gill disease. In isolated cases, *Costia* and *Costia*-associated pathology dominated, referred to as seawater *Costia*. This was detected in fish weighing up to 5 kg. Submissions where salmon were diagnosed with gill haemorrhage were particularly frequent at the Norwegian Veterinary Institute during the previous summer (June–August). Gill haemorrhage is a long-recognised condition of unknown cause and has traditionally been most common in autumn. Few submissions of rainbow trout from marine farms with gill diagnoses were received.

Compiled data show that Salmon Gill Pox Virus (SGPV) was detected at 191 localities (both freshwater and marine), approximately the same as in 2024. The disease salmon gill poxvirus disease was described at only a limited number of sites.

## The Annual Survey

Gill disease in salmon and rainbow trout during the freshwater phase was not identified as a major health problem in 2025 (Appendices A1 and A2). Nevertheless, some respond-

ents experienced that gill disease affected welfare, growth performance, and mortality. Opercular shortening, which is a risk factor for gill damage, was perceived as a slightly more significant problem, particularly with respect to reduced welfare.

As in 2024, respondents ranked gill disease as the single most important health challenge in salmon production in marine growout facilities, followed by delousing-related injuries and HSMI (Appendix B2). More than half of the respondents (62 of 114) reported an increasing occurrence of gill problems. The disease was also perceived as a significant cause of mortality, poor growth, and reduced welfare. However, clear regional differences were observed (Appendix B2). Gill disease was perceived as the most significant problem in PA1–PA5, followed by mechanical injuries from delousing and CMS. In PA6–PA9, gill problems were also rated as the most significant challenge—ranked higher than in 2024. In PA10–PA13, injuries caused by delousing, HSMI, and nonspecific wounds were ranked higher than gill disease, although gill disease was still perceived as a greater challenge than in 2024.

In broodstock facilities, gill disease was also experienced as an increasing challenge and was reported as the most significant health problem, followed by mechanical lice treatment and sexual maturation (Appendix C1).

In contrast to 2024, when few respondents considered gill disease a problem for rainbow trout in marine growout facilities, gill health challenges were ranked as the third most significant issue in 2025 (Appendix B3).

In freetext responses, reduced gill health was mentioned as an increasing challenge. Respondents reported that gill haemorrhage of unknown cause may result in prolonged mortality. Autumn infections with either *Ca. Branchiomonas cysticola* or *P. perurans* (AGD) were described, and particularly in cases where there was a high pathogen load combined with HSMI, increased mortality was reported. Respondents also reported regular screening of gill swabs every second week throughout the season, in addition to monthly histopathological examination.

## Assessment of the Gill Health Situation in Farmed Salmonids

As in 2024, the survey indicates that gill disease remained the most significant health challenge for salmon in the

marine phase in 2025. The problem continues to increase and has major implications for growth performance, welfare, and production losses. The survey also indicates that rainbow trout are increasingly affected by gill health challenges. In previous years, gill problems in the marine phase were most frequently recorded in late summer and autumn, but it now appears that salmon in marine farms are increasingly affected throughout the entire year.

There are still many knowledge gaps regarding gill health and specific gill diseases, and the situation is particularly complex when multiple infections and stressors occur simultaneously. New knowledge has emerged, more tools are available, and improved monitoring has been implemented, but substantial efforts are still required. There are significant opportunities associated with extensive screening and systematic registration to identify risk factors and establish targeted measures. Open sharing of information among all stakeholders is necessary to achieve better control of gill health problems.

## 11.2 Poor smolt quality and runt syndrome

By Synne Grønbech and Benedikte Hansen Bendiktsen

**Good protocols for smoltification, sea transfer at the correct time, close follow-up during the initial period after sea-transfer, and optimization of feeding strategy are important for normal development, growth, and good health in farmed salmonids.**

Salmonids farmed in Norway consist mainly of Atlantic salmon (*Salmo salar*) and some rainbow trout (*Oncorhynchus mykiss*), both of which are anadromous fish species. The term anadromous refers to both the life cycle and the migratory pattern of the fish. In the wild this means that fish eggs are fertilized and hatch in freshwater, the juvenile fish undergo smoltification and migrate out to the marine environment for feeding, where they spend most of their adult life, before eventually returning to freshwater again to

spawn. The smoltification process, which prepares the fish for the transition from freshwater to seawater, begins once parr have reached a certain size (typically >10 cm). The process is initiated by environmental cues, with seasonal changes in photoperiod and water temperature being important factors. During smoltification, the fish undergo extensive physiological, metabolic, and hormonal changes, and both physical appearance and behavior are also altered. Several physiological adjustments occur, including a shift in enzyme activity in the gills. The activity of the enzyme  $\text{Na}^+/\text{K}^+$ -ATPase in specialized gill cells (chloride cells) changes from a freshwater-adapted to a seawater-adapted form, which is essential for the fish's ability to regulate osmotic balance. The smoltification process is energy-demanding, and during this period the immune system is often reduced.



Salmon juveniles before smoltification.

Photo: Johan Wildhagen

In commercial smolt production, various different regimes are used to initiate and synchronize smoltification, among which photoperiod manipulation is a key method for mimicking natural environmental cues. Traditionally, protocols involving a “winter signal” have been applied, consisting of a period with a defined number of hours of darkness per day to simulate the reduced light availability characteristic of the winter season, followed by a “spring signal,” defined as a period of light or increasing day length. These protocols have typically been applied in flow-through production systems. With increasing production intensity and the implementation of recirculating aquaculture systems (RAS), protocols using continuous light have also been adopted, often in combination with relatively high water temperatures, as well as increased salinity in the freshwater phase through the addition of seawater and/or the use of specialized feed. The production of large smolts has for several years been a strategy aimed at reducing the duration of exposure to sea lice and infectious microorganisms in the marine environment. Within the industry, several methods are used to assess whether groups of fish are smoltified and ready for sea transfer. In addition to the so-called smolt index, which is based on assessment of the fish’s external appearance and the development of the characteristic smolt coloration, methods also include seawater tolerance tests and analyses used to provide indications of enzyme activity in the gills.

In juvenile salmonid production facilities, several challenges may be encountered in connection with the smoltification process. These include uneven smoltification, desmoltification, early sexual maturation, poor rearing environment, and suboptimal water quality. Both infectious and environmentally induced diseases can disrupt the smoltification process. Hemorrhagic smolt syndrome (HSS), wound development, salmon poxvirus disease, and other gill diseases are examples of diseases and disorders that may negatively affect smolt quality. Osmoregulatory problems associated with suboptimal smoltification lead to increased stress, reduced welfare and an increased risk of health problems

and mortality in the first period after sea transfer and may result in unsatisfactory development with regard to growth and health in the seawater phase.

Runt syndrome is a term used to describe a condition in which fish become emaciated or fail to grow normally, resulting in individuals that appear thin and elongated, often referred to as “losers/runts” or “sticks.” The term is mainly used for fish after sea transfer; however, runts are also observed in juvenile production facilities. Typical findings during histological examination of runts include a reduced amount of adipose tissue surrounding the internal organs and an increased amount of melanin-containing pigment (melanization) in internal organs, such as in the kidney. The causes of runt syndrome are likely multifactorial, and stress may play a significant role. Problems associated with smoltification and poor smolt quality may increase the risk of developing this condition. Emaciation can be observed in several disease conditions, for example in fish that have survived infectious pancreatic necrosis (IPN) or pancreas disease (PD). The development of runts as a result of disease typically acquired during the seawater phase (for example PD) can be distinguished from “smolt-related runts” by the fact that these fish exhibit normal growth up until disease onset. In contrast, the growth curve of “smolt runts” differs, as these fish have not shown significant growth in length post sea transfer.

Runts are likely more susceptible to parasite infestations and disease than normally growing fish, for example tapeworm infection is a common finding in runts. A higher number of runts at a production site may therefore increase the risk of pathogen transmission and disease outbreaks. Fish that develop runt syndrome can survive for a long time and thus also represent a significant welfare concern. In many cases it can be challenging to remove such fish from sea cages but culling them is nevertheless an important measure with regard to fish welfare and the reduction of infection risk to other fish.

## The Health Situation in 2025

### Data from the Norwegian Veterinary Institute

The prevalence of poor smolt quality and runt syndrome among samples examined by the Norwegian Veterinary Institute is difficult to determine with certainty, as these are multifactorial conditions with clinical and pathological similarities to other disease conditions. This, in combination with a lack of systematic registration, complicates the assessment of national prevalence.

The background for most submissions of Atlantic salmon smolts, both from juvenile production facilities and following sea transfer, was increased mortality and/or wound-related problems. The most common diagnoses established in these submissions were bacterial infections, followed by infectious pancreatic necrosis (IPN), nephrocalcinosis, heart and skeletal muscle inflammation (HSMI), and hemorrhagic smolt syndrome (HSS).

In cases involving wounded fish where bacteria could be identified using immunohistochemistry and/or bacteriological analyses, the most common findings were *Tenacibaculum* spp., *Moritella viscosa*, and *Aliivibrio wodanis*. In most cases, nephrocalcinosis was considered an incidental finding, and was occasionally observed together with calcified deposits in additional organs, such as the pseudobranch and/or adipose tissue. In a few cases, nephrocalcinosis was observed with such extensive tissue alterations in the kidney that it was assessed to have a direct association with mortality. In the majority of diagnosed cases of hemorrhagic smolt syndrome (HSS), nephrocalcinosis was also observed concurrently.

### The Annual Survey

For Atlantic salmon in the juvenile production phase, respondents in the survey (n = 62) reported that production-related conditions and syndromes were the most problematic, out of a total of 28 possible health issues (Appendix A1). The largest proportion of respondents considered conditions such as hemorrhagic smolt syndrome and nephrocalcinosis to be among the most important causes of mortality, and development of runts and smoltification problems were also ranked highly within this category. Among health problems with increasing incidence, smoltification problems received the highest number of responses after infectious

pancreatic necrosis (IPN). Other aspects of juvenile production that were collectively ranked as major challenges were issues related to poor water quality and internal transfer and handling of fish within the facility. Among infectious diseases, IPN and heart and skeletal muscle inflammation (HSMI) were considered the most important.

For Atlantic salmon in the seawater phase, inadequate smoltification and runt syndrome problems received the highest number of responses in respect to reduced growth. HSMI was ranked as the third most important health problem, after gill disease and injuries related to delousing operations (Appendix B1).

There were fewer respondents with experience in rainbow trout production. A total of 14 and 23 respondents, respectively, completed the survey for the juvenile production phase and the sea water production phase (Appendix A2 and Appendix B3). Emaciation/runt syndrome was the health issue ranked highest in both production phases. Smoltification problems in the juvenile production phase were reported, similarly to Atlantic salmon, to be among the most important health problems with increasing incidence.

A number of respondents made use of the opportunity to provide additional comments related to questions on factors and health problems perceived as most important for mortality, reduced growth, reduced welfare, and those with increasing incidence. The comments were predominantly related to Atlantic salmon production. Several detailed remarks were also provided concerning water quality. Challenges related to smoltification and the assessment of when fish should be transferred to sea were highlighted among the comments. Some respondents reported that a number of producers experience difficulties with determining the correct timing for sea transfer of large Atlantic salmon smolts and described several cases in which fish were already undergoing desmoltification at the time of sea transfer. Increasing challenges associated with undesired pseudosmoltification were mentioned, leading to subsequent problems such as hemorrhagic smolt syndrome (HSS) and desmoltification, as well as nephrocalcinosis, softtissue calcifications, fin erosion, and other conditions. Several

respondents also emphasized high stocking density in tanks as a problematic factor, and some suspected that this contributes to variation in smoltification within fish groups. It was further described that insufficient size grading of fish groups causes significant challenges related to feeding management, deterioration of the rearing environment, and increased stress. Under conditions of high production intensity, this was reported to result in a reduced likelihood of detecting runt development, abnormal fish, or moribund individuals. In this context, it was additionally pointed out that high stocking densities may cause “shading” within tanks, resulting in uneven light distribution under the lighting regimes used to induce smoltification. This, together with stress induction, was highlighted as an important potential contributing factor to smoltification problems.

As contributing factors to reduced growth and welfare, respondents also pointed to suboptimal technical solutions related to tank dimensions and feeding systems, as well as other operational conditions, including water temperature. Low water temperatures, particularly in flowthrough systems during winter and spring, were associated with reduced appetite and delayed healing of fin and wound injuries. Elevated temperatures in intake water in recirculating aquaculture systems (RAS), or more generally at facilities using intake water from deepwater sources, were described by some respondents as an increasing challenge that can make it difficult to feed fish to satiation during the ongrowing phase. At high ammonium loads in RAS, feeding may have to be reduced, and similar limitations apply when production water has high turbidity or particle loads, conditions under which biofilter capacity may be reduced. High particle concentrations were further noted as a contributing factor to gill damage and impaired smoltification.

The survey also included questions specifically addressing the production of large smolts. The majority of respondents (out of a total of 24 respondents answering these questions) reported that smoltification problems occur occasionally or not at all, while some respondents experienced such problems frequently. Early sexual maturation appears as a less significant problem. The production of large smolts in pure freshwater was commented on as resulting in suboptimal welfare and potentially making it challenging to maintain homogeneous fish groups with respect to smoltification status prior to sea transfer. Experiences varied, with some

respondents considering large smolts to be generally less robust, while others held the opposite view. Several respondents highlighted the positive effect of a shorter production period in the marine environment, which entails fewer handling events and delousing operations.

From the general comments on fish health and welfare in the Norwegian aquaculture industry, there is a call for increased focus on the juvenile production phase, with robust smolts where health status and physiological condition are considered more important than time pressure associated with intensive production practices and targeted growth rates. Some respondents, however, point out that robust smolt production has already been a priority area, that some improvement compared to previous years can be observed, and that significant progress has been described by certain respondents with regard to methods for defining smoltification and for better adapting land-based production to the requirements associated with production in the marine environment.

For further information on conditions related to production in juvenile production phase, see [Chapter 6.5, Welfare challenges in juvenile salmonid production](#).

### Assessment of the situation regarding smolt quality and runt syndrome

As in previous years, production-related disorders dominate among the health problems perceived as most important during the juvenile production phase. Overall, the ranking of smoltification problems has decreased slightly compared with the previous year; however, in 2025 there remains a relatively large proportion of respondents who considered it to be a health problem with increasing incidence. Problems related to runt syndrome appear to be of somewhat greater significance in the production of rainbow trout. Causes of suboptimal smoltification and runt development are often multifactorial, and it can be difficult to provide clear, definitive explanations. Furthermore, a wide range of different smoltification protocols are applied across juvenile production facilities, and together with the continuous introduction of new production technologies, this contributes to making the field relatively complex and difficult to oversee.

In recent years, the production of large smolts has been a strategy aimed at shortening the production phase in the

marine environment. This production is often carried out under intensive conditions to meet market demands, with variable experience regarding posttransfer performance. Some producers instead focus on so-called “old smolts,” characterized by a slower production cycle under more natural conditions. There is little doubt that the “quality” of the smolt at the time of transfer from the juvenile production facility will influence how robust the smolt is in meeting a new environment and exposure to infectious pressure, and this forms an essential foundation for life following sea transfer. In general, the design of the juvenile production facility, operational conditions, and sound routines for safeguarding fish health and welfare are all factors of importance for optimizing smolt production. Planning and adaptation of production based on the physiological needs and health status of the fish are crucial. There is strong motivation for a knowledgebased approach to operational practices, and the field remains the subject of ongoing research and development.

## 11.3 Nephrocalcinosis

By Julie Christine Svendsen and Arve Nilsen

### The Disease

Historically, nephrocalcinosis (renal calcification, nephrolithiasis) was described as a problem in the farming of rainbow trout in water with elevated CO<sub>2</sub> levels. The condition has since become widespread in Norwegian freshwater hatcheries and has also been reported in the intensive culture of other fish species.

Nephrocalcinosis is considered an important welfare indicator in farmed fish, as it may reflect suboptimal water quality or deficiencies in husbandry practices. Consequently, the detection of nephrocalcinosis may indicate the presence of additional welfare challenges within the facility.

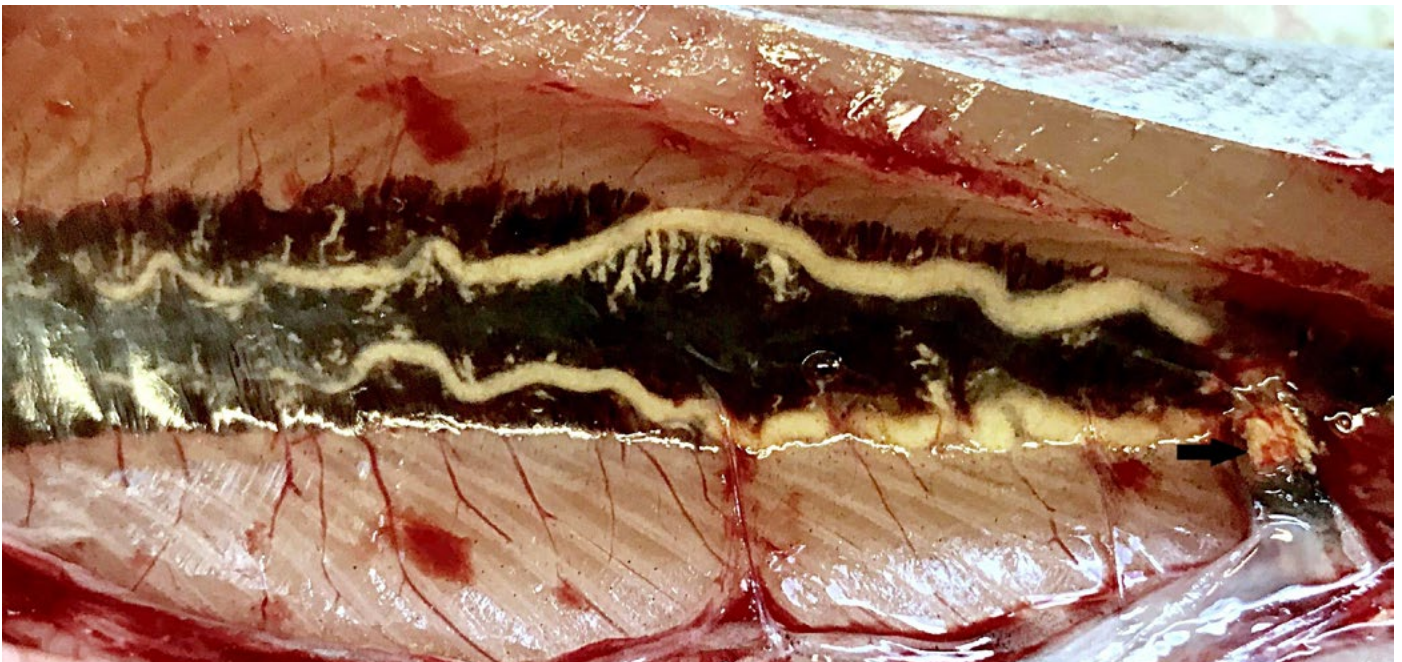
Macroscopically, nephrocalcinosis is often visible as white longitudinal streaks in the renal tissue. In severe cases, the posterior portion of the kidney becomes swollen, nodular, and greyish. Histopathological examination reveals precipitation of mineralized material within the renal excretory system, where urine is formed. Even mild precipitations can damage the epithelium of the renal tubules. Over time, the tubules become dilated and obstructed, leading to secondary damage of the surrounding hematopoietic tissue. Min-

eral deposits may also be observed in the pseudobranch (the reduced first gill arch) and the gastric wall.

Urine production is essential for the excretion of metabolic waste, and damage to the excretory system disrupts this process. Severe nephrocalcinosis, involving extensive destruction of hematopoietic tissue, may result in immunosuppression and reduced erythropoiesis. Fish affected by nephrocalcinosis often exhibit elevated plasma levels of magnesium, calcium, glucose, and aspartate aminotransferase (ASAT), which may be associated with impaired osmoregulation and increased physiological stress.

Chemical analyses of renal calculi from multiple studies indicate that the precipitates primarily consist of phosphate-based stones containing calcium, magnesium, carbon, and nitrogen. Formation of such phosphate stones requires alkaline urine. The normal pH in Atlantic salmon is estimated to be approximately 7.5, suggesting that physiological conditions may favour such precipitation.

Nephrocalcinosis is frequently observed as a secondary finding in haemorrhagic smolt syndrome (HSS)



**Figure 11.3.1** Severe nephrocalcinosis. The collecting ducts and urinary bladder (arrow) are heavily filled with yellowish-white calcified material. Photo: Stim

(Chapter 11.4). However, recent studies suggest that HSS does not predispose fish to nephrocalcinosis; rather, the conditions may co-occur under similar farming conditions.

Renal lesions associated with nephrocalcinosis may resemble those observed in bacterial kidney disease (BKD), a notifiable disease, and therefore require laboratory confirmation for accurate diagnosis.

### Possible causes

Multiple environmental and operational factors are likely involved in the development of nephrocalcinosis. Smoltification protocols may represent a key factor, while environmental variables such as temperature, water chemistry, and early exposure to seawater are also considered important.

It has been hypothesized that intensive production systems characterized by elevated temperatures and rapid growth, combined with environmental cues that do not adequately support the physiological transition from freshwater to seawater (smoltification), may negatively affect renal function, acid-base balance, and mineral metabolism. This may impair the kidney's filtration capacity, alter mineral composition and pH of the urine, and thereby increase the risk of stone formation. In addition to persistently poor water quality, large fluctuations in environmental conditions may also have detrimental effects.

Elevated CO<sub>2</sub> levels in water typically lead to increased CO<sub>2</sub> concentrations in the blood. Fish compensate for this by absorbing bicarbonate (HCO<sub>3</sub><sup>-</sup>) from the surrounding water via ion exchange mechanisms in the gills, where bicarbonate is exchanged for chloride ions (Cl<sup>-</sup>). This process restores blood pH but reduces plasma chloride levels.

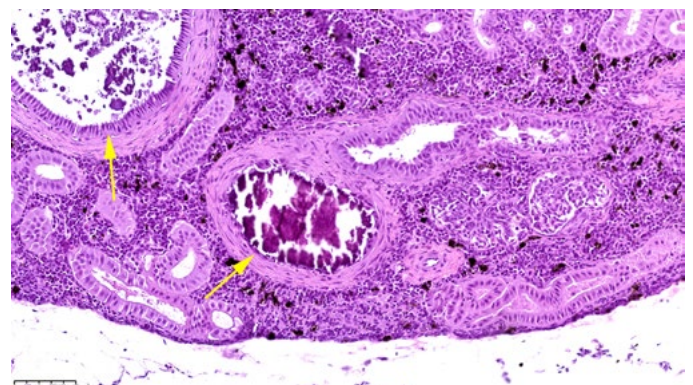
Numerous studies have demonstrated that CO<sub>2</sub> concentrations exceeding 15–16 mg/L increase the risk of nephrocalcinosis in freshwater, brackish water, and seawater. In rainbow trout during the freshwater phase, such levels have been associated with increased prevalence and severity of renal lesions. However, nephrocalcinosis is clearly a multifactorial condition. Some studies in Atlantic salmon have not found a direct correlation between CO<sub>2</sub> levels and lesion severity. Other experimental studies have shown increased physiological stress and reduced growth at CO<sub>2</sub> levels ranging from 5 to 40 mg/L, even prior to the onset of nephrocalcinosis.

Severe renal damage is generally irreversible and associated with increased mortality. In hatcheries, the highest prevalence is often observed shortly before sea transfer. Increased occurrence has also been reported with higher seawater content during the post-smolt phase. Laboratory studies indicate that nephrocalcinosis in salmon smolts exposed to elevated CO<sub>2</sub> during the freshwater phase may regress following transfer to seawater with lower CO<sub>2</sub> levels. In rainbow trout, however, nephrocalcinosis may persist throughout much of the seawater phase.

### Prevention and Control

Nephrocalcinosis is considered an environmentally induced disease. Preventive measures include ensuring high-quality intake water, maintaining stable water conditions (including CO<sub>2</sub>, O<sub>2</sub>, and pH), and providing adequate water exchange rates. Systematic monitoring of water parameters and metabolic waste products, particularly CO<sub>2</sub>, using reliable equipment tailored to production conditions, is essential.

A well-managed water environment, combined with established and documented smoltification protocols, is likely critical for prevention. Careful management of seawater use during production—both in the early freshwater phase and during smoltification and post-smolt transition—is also recommended.



**Figure 11.3.2** Renal calcification in salmon. Histopathological examination shows calcified material in the collecting ducts for urine (arrow). Photo: Anne Berit Olsen, Norwegian Veterinary Institute

Nephrocalcinosis serves as a sensitive indicator of suboptimal rearing conditions, making early detection essential. Diagnosis is often based on gross pathological findings in the field; however, cases may go undetected due to the absence of visible deposits, leading to underestimation. The condition is also frequently identified incidentally in samples submitted for other diagnostic purposes.

Routine sampling of renal tissue for histopathological examination is recommended. Additionally, regular screening of moribund and dead fish for macroscopic signs of nephrocalcinosis is important. Radiographic imaging represents a potential method for detecting the condition in live fish and is currently under development for broader application.

## The Health Situation in 2025

---

Data from the Norwegian Veterinary Institute identified nephrocalcinosis in 45 submissions from 29 commercial salmonid facilities, predominantly involving Atlantic salmon and to a lesser extent rainbow trout. The condition was also detected in carp and in some wild salmonid samples. Nephrocalcinosis was observed in parr and smolt both before and after sea transfer, as well as in adult fish in grow-out and broodstock facilities. In hatcheries, affected fish weighed between 40 and 110 g. During the seawater phase, affected fish ranged from 115 g to approximately 7 kg, with more than half of cases occurring in fish around or exceeding 1 kg.

### The Annual Survey

Survey respondents identified nephrocalcinosis as the most significant health challenge in Atlantic salmon during the freshwater phase in 2025. This assessment was based on its impact on mortality, reduced growth, and impaired welfare, as well as its increasing prevalence. Among these factors, reduced welfare was given the greatest weight, and the condition ranked third in terms of increasing occurrence. This represents a shift compared to 2024, when poor water quality, smoltification issues, and HSS were considered more significant challenges.

Free-text survey responses highlighted challenges related to elevated CO<sub>2</sub> levels and nephrocalcinosis in RAS facilities. Similar issues were reported in flow-through systems, particularly in association with high CO<sub>2</sub> levels prior to fish transfer. Elevated intake water temperatures were also identified as a potential contributing factor.

During the seawater phase, nephrocalcinosis was generally considered to have limited impact on mortality and welfare

in Atlantic salmon. However, 15 of 116 respondents identified it as a significant contributor to reduced growth.

Although fewer responses were available for rainbow trout hatcheries, nephrocalcinosis was ranked as the second most significant health challenge across mortality, growth, welfare, and increasing prevalence. Only emaciation/taper syndrome was considered more severe. This represents a reversal compared to 2024. In the seawater phase, nephrocalcinosis, together with cardiac disorders, was ranked as the joint fourth most significant health issue in rainbow trout.

### Assessment of the Nephrocalcinosis situation

The survey findings are consistent with previous assessments, confirming that nephrocalcinosis remains a common and significant condition affecting the health and welfare of both Atlantic salmon and rainbow trout in hatchery systems, with implications for survival and performance in the seawater phase.

In grow-out facilities, nephrocalcinosis is likely a condition that fish carry over from the freshwater phase. Mild tissue damage may resolve following sea transfer, whereas severe lesions are associated with increased mortality and prolonged recovery periods. In 2025, nephrocalcinosis was also detected in adult salmon in some cases. It remains unclear whether these cases are linked to earlier life stages or to other contributing factors, warranting further investigation.

The disease is closely associated with operational conditions, particularly water quality and likely smoltification protocols. Improvements in these factors should provide effective opportunities for prevention and mitigation of nephrocalcinosis.

# 11.4 Hemorrhagic Smolt Syndrome (HSS) / Hemorrhagic Diathesis (HD)

By Geir Bornø, Anne Berit Olsen and Toni Erkinharju

## The disease

Hemorrhagic smolt syndrome (HSS), also known as hemorrhagic diathesis (HD), is a bleeding disorder in salmon that typically occurs during the late freshwater smolt production phase and shortly after transfer of salmon smolts to seawater. Affected fish often develop hemorrhages in the musculature, peritoneum, and internal organs, and exhibit pale gills as a sign of anaemia. A characteristic early feature is bleeding into the renal excretory system (tubuli), where urine is formed (Figure 11.4.1 and Figure 11.4.2). The condition most often affects relatively large, wellgrown fish.

The disease has also been described in salmon in Scotland. The cause of this condition is unknown, and there is currently no documentation indicating that the disease is caused by an infectious agent. It is assumed that the condition is related to osmoregulatory disturbances associated with the smoltification process, although this requires fur-

ther research. HSS usually does not result in particularly high mortality; however, in some cases several thousand individuals have been affected, and relatively acute mortality has been reported. In most cases, the condition improves in affected fish groups a few weeks after transfer to seawater.

## Disease Control

The progression of the disease can be slowed or halted by transferring affected fish groups to seawater. It is very important that serious contagious diseases such as viral haemorrhagic septicaemia (VHS) and infectious haematopoietic necrosis (IHN) are considered as possible differential diagnoses, as these diseases may also produce a similar hemorrhagic picture. In cases of suspected HSS, samples should be secured for histopathological examination and PCR testing for VHS and IHN viruses.

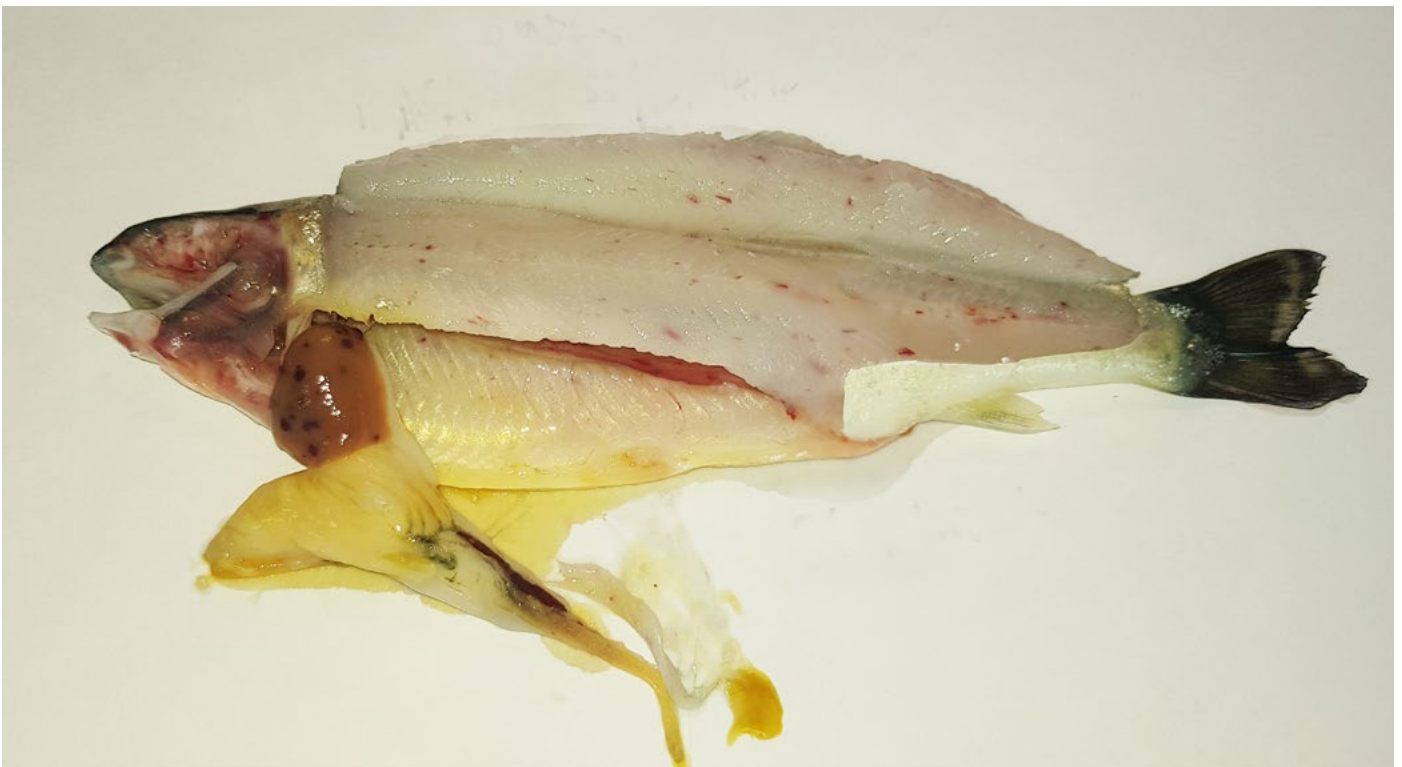
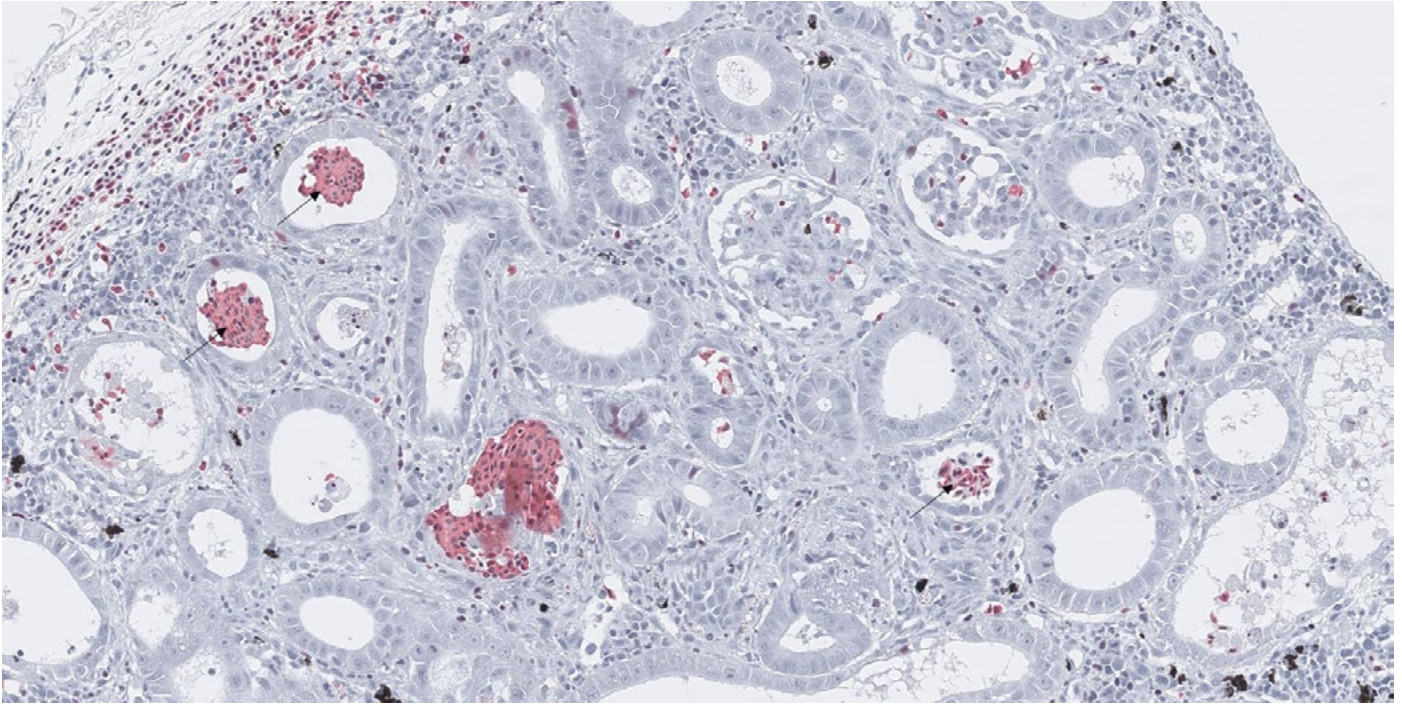


Figure 11.4.1 Hemorrhagic smolt syndrome (HSS) in salmon smolt. Photo: Anne Berit Olsen, Norwegian Veterinary Institute



**Figure 11.4.2** Tissue section showing hemorrhagic smolt syndrome (HSS) in salmon smolt. The arrows indicate hemorrhages in the renal excretory system (tubules). Luna stain. Photo: Toni Erkinharju, Norwegian Veterinary Institute

## The Health Situation in 2025

### Data from the Norwegian Veterinary Institute

The true occurrence of HSS is uncertain. The disease is not notifiable, and in some cases, samples are not submitted for laboratory examination. No compiled data are available from investigations carried out by the Norwegian Veterinary Institute and private laboratories, but there were few recorded cases of HSS in the Norwegian Veterinary Institute's own material.

### The Annual Survey

In 2025, respondents reported HSS as the most important problem related to mortality in salmon during the freshwater smolt production phase (29 of 62 respondents) (Appendix A1). Furthermore, HSS was considered an important cause of reduced welfare (22 of 60 respondents). Fewer respondents regarded the condition as a cause of reduced growth or as an increasing problem.

### Assessment of the HSS Situation

During the period 2021–2025, HSS has been ranked in the questionnaire survey as the most important cause of mortality in salmon during the freshwater smolt production phase. The overall occurrence of the disease is uncertain but appears to have been relatively stable, although some respondents have assessed HSS as an increasing problem in their regions. As HSS can resemble serious viral diseases, it is important that samples are submitted for laboratory examination.

# 11.5 Water Quality

By Kamilla Furseth, Endre Steigum, Ole-Kristian Hess-Erga and Åse Åtland  
Norwegian Institute for Water Research (NIVA), Section for Aquaculture

**During 2025, the Section for Aquaculture carried out a wide range of advisory assignments for the aquaculture industry. In total, NIVA Aquaculture handled just under 200 individual water quality cases. Of these, approximately 18% were related to incidents involving acute or elevated mortality. The remaining cases were associated with general monitoring of raw water sources and risk assessments of the water quality, with a particular focus on the presence of toxic metals.**

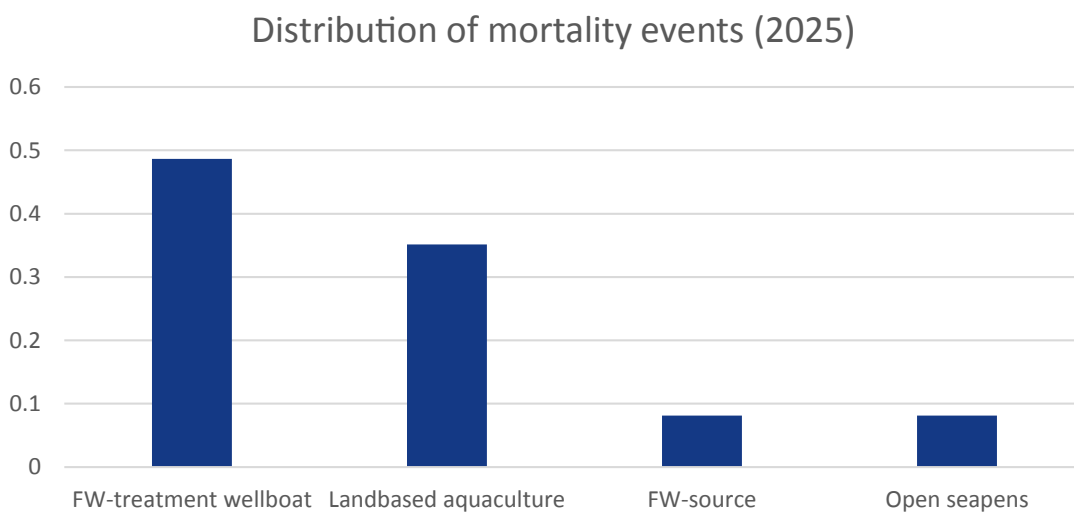
NIVA conducted several analyses and assessments related to particle-related water quality issues, monitoring and advice on the prevention of H<sub>2</sub>S risk, evaluation of water chemistry in recirculating aquaculture systems (RAS), as well as some smaller assignments related to water treatment and chemical dosing in salmon smolt production. Some monitoring assignments (approximately 15% of the cases) extended over longer periods and were linked to water chemistry risk factors in the intake water.

As in previous years (2021–2024), many of the acute mortality events were related to freshwater treatment of salmonids in wellboats (Figure 11.5.1). These cases accounted for approximately half of the mortality events handled by NIVA in 2025. Several advisory assignments also concerned testing of freshwater and reverse osmosis (RO) water for use in wellboats, as well as assessment and prevention of mortality during various wellboat operations.

Approximately 35% of the mortality events handled by NIVA in 2025 were related to land-based aquaculture. The majority of these occurred in recirculating aquaculture systems (RAS), although some events also took place in flow-through systems (FTS). In addition, work was carried out on several mortality events involving wild fish in freshwater and marine environments.

## The Annual Survey

In the survey, respondents perceive nephrocalcinosis as the only challenge greater than poor water quality during the freshwater stage of salmon production (Appendix A1).



**Figure 11.5.1** Number of mortality events associated with freshwater (FW) treatment in well boats, in land-based aquaculture systems (RAS and flow-through systems), related to the freshwater source, and in open sea-based aquaculture facilities, handled by NIVA Aquaculture in 2025.

Among 28 health-related issues, poor water quality is assessed as the most important cause of reduced growth (31 of 59 respondents) and is also experienced as a significant cause of mortality (22 of 62 respondents) and reduced welfare (21 of 60 respondents). Only a minority (6 of 57 respondents) perceived the occurrence of poor water quality as increasing.

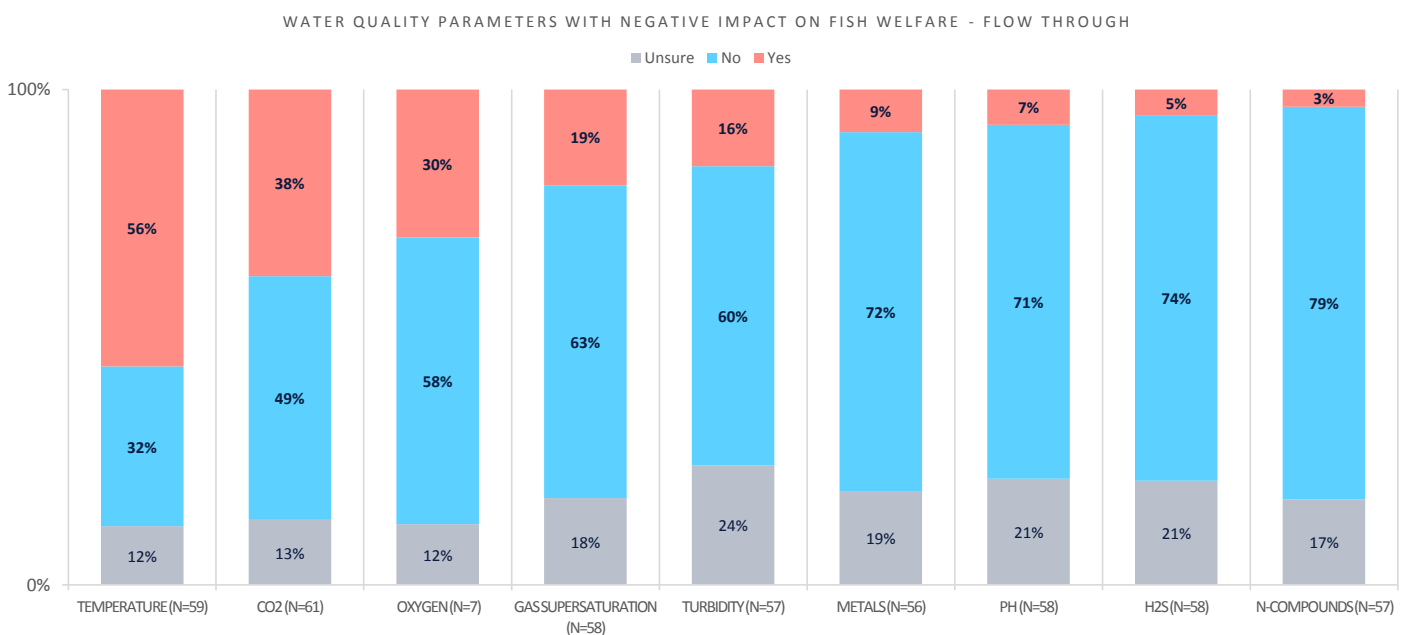
Respondents considered poor water quality to be a lesser problem for rainbow trout than for salmon in the freshwater stage (Appendix A2). Among 25 health-related issues, it ranks fifth, based on a lower number of respondents. Mortality is perceived as the most prominent consequence of poor water quality (7 of 14 respondents). None of the respondents believe that the occurrence is increasing.

The results indicate that continued focus on water quality monitoring and increased knowledge of water chemistry remains important. This is essential for reducing welfare challenges and mortality in land-based aquaculture in Norway. In the survey, a distinction was made between water quality in flow-through systems and RAS (Figure 11.5.2 and 11.5.3). For each of these, we examined which main types of water chemistry challenges respondents identified as the most important causes of reduced fish welfare.

### Flow-through systems

In flow-through systems, temperature was one of the most common challenges in 2025 (Figure 11.5.2). This trend has been increasing since 2021. More than half of the respondents report temperature as a cause of reduced fish welfare. The survey does not specify whether this refers to excessively high or low temperatures, but it is likely that the issue is related to both. This is well aligned with respondent comments indicating that high water temperatures during summer and low temperatures during winter have created challenging conditions for the fish. Furthermore, 43% and 30% of respondents reported that CO<sub>2</sub> and O<sub>2</sub>-related issues, respectively, had negatively affected fish welfare. Another recurring issue is insufficient efficiency of CO<sub>2</sub> stripping systems.

Problems related to turbidity/particle concentration and gas supersaturation are ranked somewhat lower. The remaining categories (metals, pH, hydrogen sulfide (H<sub>2</sub>S), and nitrogen compounds) ranked further down the list. This is also reflected in the respondents' comments, where high summer temperatures, water shortages during summer, and low winter temperatures are repeatedly mentioned, along with several CO<sub>2</sub> and O<sub>2</sub>-related incidents that may be linked to variable temperatures.



**Figure 11.5.2** Responses from fish health personnel to the question of which water quality parameters in flow-through systems have negatively affected fish welfare in 2025. The number of respondents is indicated after each water quality parameter (N). N-compounds = nitrogen compounds.

The year 2025 was characterized by several severe weather events, including a major spring flood in March, a warm and dry summer, and a late summer/autumn marked by storms and extreme precipitation (Florin in August and Amy in October). For flow-through systems, this may lead to increased vulnerability and fish welfare challenges related to, among other factors, elevated levels of metals and particles in intake water. During flood events, it is particularly important that water treatment systems are properly dimensioned to handle such water quality challenges.

### Recirculating aquaculture systems (RAS)

For RAS facilities, approximately half of the respondents reported that turbidity and temperature negatively affected fish welfare (Figure 11.5.3). The comments also reflect this, as challenges related to raw water temperature and high particle loads in the system have created demanding operational conditions. Several respondents link these challenges to limitations in cooling systems during high summer water temperatures. The gases carbon dioxide and oxygen are ranked higher as welfare challenges than both nitrogen compounds and gas supersaturation. Other factors such as

temperature, oxygen, nitrogen compounds, H<sub>2</sub>S, pH, and metals are ranked lower. In the comments, challenges associated with elevated CO<sub>2</sub> concentrations towards the end of the production cycle are frequently mentioned, in addition to suspected gas supersaturation.

### Water quality-related incidents associated with wellboats

Questions regarding whether reduced water quality causes reduced fish welfare in connection with wellboat operations have been included in the survey since 2022. The responses from 2025 clearly show that fewer respondents answered “do not know” when asked whether water quality had caused issues during freshwater treatments (Figure 11.5.4). This represents a decrease from 30% of respondents in 2024 and 2023 to 10% in 2025. A similar trend is observed for smolt transport and harvest transport. At the same time, there is an increase in responses such as “very rarely,” “rarely,” and “occasionally,” which may indicate that more operators are focusing on documenting water quality during various wellboat operations. This is a positive development that provides valuable opportunities for learning.

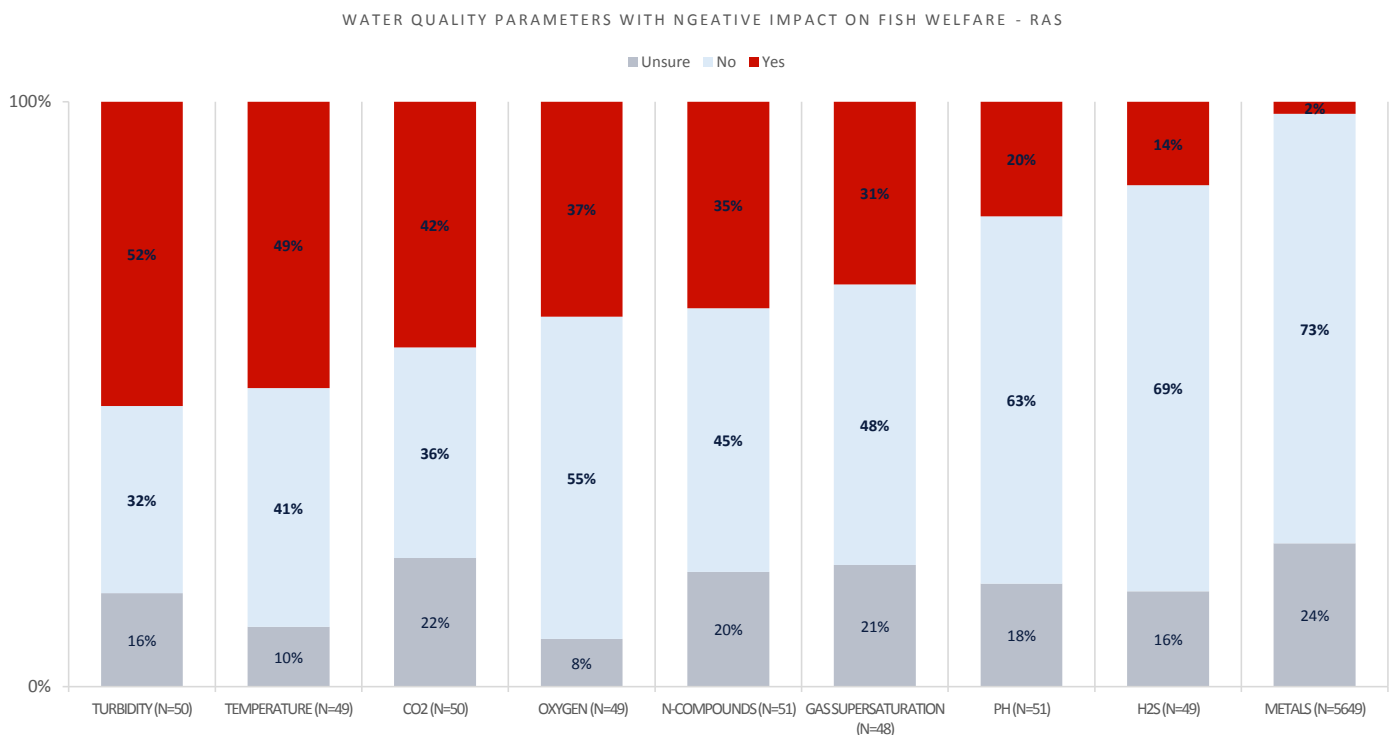
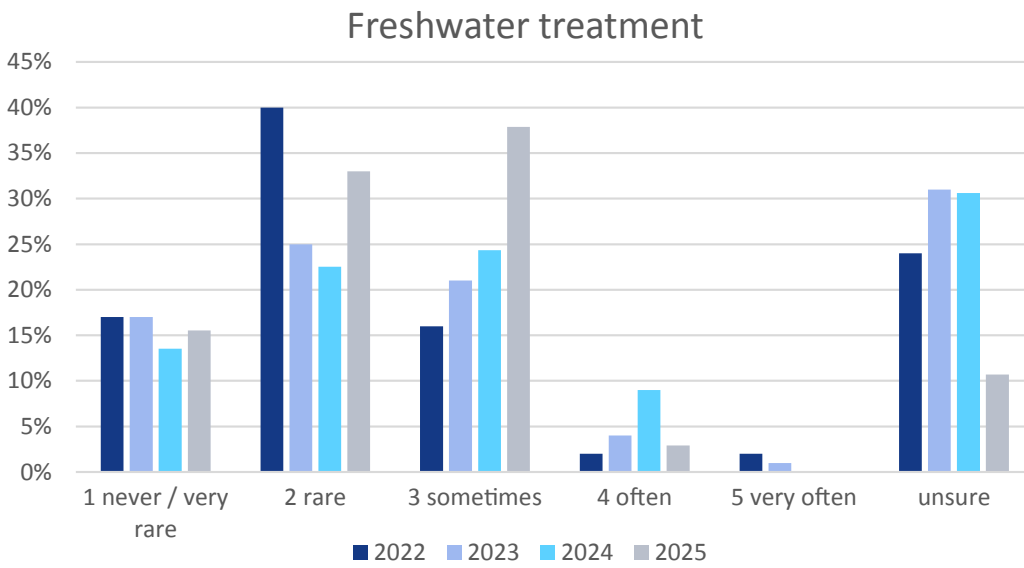


Figure 11.5.3 Responses from fish health personnel to the question of which water quality parameters in RAS have negatively affected fish welfare in 2025. The number of respondents is indicated after each water quality parameter (N). N-compounds = nitrogen compounds.



**Figure 11.5.4** The proportion of fish health personnel who reported having experienced that water quality has negatively affected fish welfare since 2022.

NIVA Aquaculture also observes an increasing focus within the industry on water analyses and the establishment of water sample banks, particularly in connection with freshwater treatments. There is clearly a lower threshold for conducting water quality mapping, even during operations that are completed without apparent problems.

Among the wellboat-related incidents handled by NIVA Aquaculture last year, there was increased emphasis on mapping raw water sources and ensuring proper treatment prior to the initiation of wellboat operations. In addition, gas-related issues and zinc toxicity remained highly relevant. The advisory work is based on the Wellboat Guidelines and on work from several projects within this field, including the ongoing FHF project NYBRØK II, which follows the earlier NYBRØK and BRØK projects. This is important for the industry to gain access to more evidence-based advice derived from up-to-date research.

### Assessment of the water quality situation

The main challenges identified through the survey, related to both excessively high and low temperatures and CO<sub>2</sub>-related issues, clearly indicate a need for robust technological solutions and correct dimensioning of both cooling and aeration systems.

Mortality and reduced welfare following freshwater treatment in wellboats continue to account for the majority of incidents monitored by NIVA. Regardless of whether the root cause can be attributed to water quality or not, this emphasizes that these operations, despite increased knowledge and improved monitoring, remain high-risk activities.

A multidisciplinary review of mortality events is important in order to achieve the best possible understanding of causal relationships. It is also essential for understanding the broader context of how water quality challenges and disease-related issues influence each other.

## 11.6 Algae and Fish Health

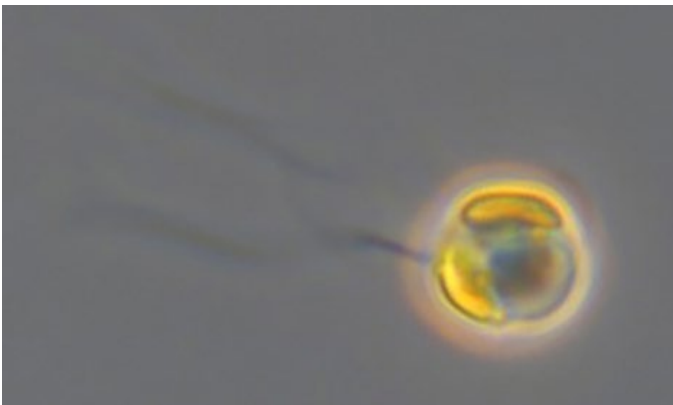
By Ingunn Anita Samdal

**Algae are a group of photosynthetic organisms ranging from unicellular forms to large macroalgae such as kelp and seaweed. Algae play an important role in aquatic food webs by producing oxygen and organic matter. Under favourable conditions, microalgae may form large blooms, some of which can produce substances harmful to fish or mammals.**

In spring 2025, blooms of *Chrysochromulina leadbeateri* and *Phaeocystis* occurred in northern Norway from late April and to end of May. The highest mortality was reported during the period 10–12 May. These algae, which at high concentrations can be harmful to fish, caused extensive mortality among farmed Atlantic salmon. According to the Norwegian Directorate of Fisheries, the bloom resulted in approximately two million dead fish.

The first reports of fish mortality from Øksfjorden were received in late April. In the following days, the algae spread to Raftsundet and Kanstadfjorden. In early May, they were detected in Astafjorden and the surrounding areas. The highest mortality was reported during 10–12 May. After 15 May, mortality gradually declined over the course of the following week (<https://www.fiskeridir.no/nyheter/alger-medforer-fiskedod>).

*Chrysochromulina leadbeateri* is a very small microalga, approximately 5–8 µm in size, with two flagella (11–20 µm)



**Figure 11.6.1** *Chrysochromulina leadbeateri* observed using differential interference contrast (DIC) light microscopy. The cells are small microflagellates, 5–8 µm in diameter, with two flagella, a haptorium, and two chloroplasts. Photo: Bente Edvardsen, University of Oslo.

and a longer spiral haptorium (approximately 20 µm) (Figure 11.6.1). The surface scales of the algal cell are only visible by electron microscopy, which is required for reliable identification. The cell also contains two chloroplasts. Approximately 60 different species of *Chrysochromulina* have been described to date, and these species are found worldwide. *C. leadbeateri* is a flagellated haptophyte that is common along the Norwegian coast but is not harmful unless it blooms in large quantities. The previous such event occurred in 2019, when 7.5 million farmed fish died in connection with a bloom. At that time, the exact cause of fish mortality was not known, beyond its association with the algal bloom. A bloom of *C. leadbeateri* also occurred in 1991, causing fish mortality in the same area.

The ToxANoWa project was initiated to generate more knowledge about algae that are harmful to fish. The ToxANoWa project was a collaboration led by the Norwegian Veterinary Institute together with the University of Oslo, the Technical University of Denmark, and the National Research Council of Canada. The most important result of this project was the identification of the toxin leadbeaterin1 produced by *C. leadbeateri*. Leadbeaterin1 has been shown to be toxic to gill cells from both rainbow trout and Atlantic salmon. In addition, the project also studied *Prymnesium parvum* and its toxins, prymnesins, which were already known to be harmful to fish. A bloom of *P. parvum* in Sandsfjorden in Ryfylke in 1989 caused the death of 750 tonnes of salmon and rainbow trout. In subsequent years, *P. parvum* bloomed regularly, and mortality in farmed salmon was recorded in 1990, 1991, and 1995. Aquaculture operations were largely discontinued in this area in the years that followed, but production was resumed in 2005. In 2007, *P. parvum* bloomed again, resulting in the death of 135 tonnes of fish.

Leadbeaterin1 was identified through the cultivation of algal cultures of *Chrysochromulina leadbeateri* originating from the blooms in 2019 and 1991. The algal cultures were extracted, chemically fractionated, and tested for toxicity in multiple rounds using gill cells from rainbow trout (RTgillW1) and Atlantic salmon (ASG10). A previously unknown polyketide present in a fraction that caused gill cell toxicity was identified, and this compound was subsequently purified to allow structural elucidation using nuclear magnetic resonance (NMR) analysis and mass spectrometry. The polyket-

ide resembles previously known fishkilling toxins such as karlotoxins, and it has therefore been proposed that these new toxins be designated “leadbeaterins”. These leadbeaterins constitute a new family of algal toxins. The compounds have also been detected in cultures of *C. leadbeateri* originating from the harmful algal bloom that caused fish mortality in 1991.

Leadbeaterin1 has been purified, quantified, and characterised so that its concentration is known, allowing it to be used as a quantitative standard. This standard has been tested on gill cells from both salmon and trout, and the results show that the compound is highly toxic to gill cells. Leadbeaterin1 has also been detected in water samples collected during the 2019 bloom, as well as in fresh seawater samples from 2025. With this standard, it is now possible to measure concentrations of leadbeaterin1 in seawater surrounding fish farms during algal blooms.

It remains to be determined how much leadbeaterin is required to cause lethal damage to fish. Both the concentrations involved and the duration of exposure remain open questions. Leadbeaterins comprise an entire family of compounds, and so far, only leadbeaterin1 has been tested in gill cell assays. It is likely that additional leadbeaterins within this family are also toxic.

Knowledge of these leadbeaterins makes it possible to develop tools for monitoring their presence in seawater. Current methodologies are based on algal cell counts; however, because *C. leadbeateri* is relatively small and several *Chrysochromulina* species exist, it is difficult to distinguish them reliably using light microscopy. This has contributed to poor correspondence between algal counts and fish mortality in areas affected by algal blooms.

In late March and early April, high mortality was reported along the west coast of Denmark as a result of a bloom of *Pseudochattonella* on the Danish side of the Skagerrak (Figure 11.6.2). Concentrations of up to 10 million cells per litre were reported, which can cause mortality in fish. In early April, the bloom moved towards southern Norway but did not reach concentrations there that were toxic to fish.

In late October and early November, several aquaculture sites in the area around Flekkefjord were affected by what was assumed to be an algal bloom followed by fish mortal-

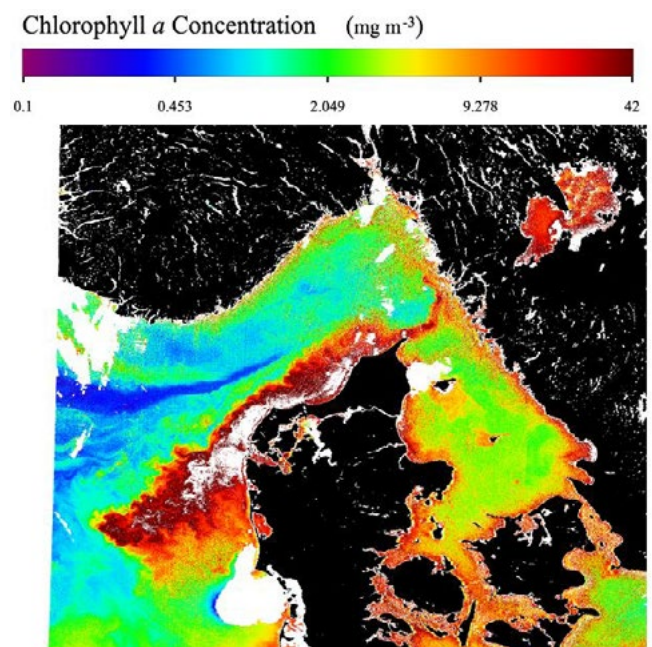
ity. The suspected cause of death in salmon was a combination of impaired gill health, algae in the water, and fluctuations in oxygen levels.

## The Annual Survey

Respondents rank algae as the seventh most significant health problem in salmon produced in aquaculture facilities, among 38 reported health challenges. This represents a clear increase compared with 2024. In total, 23% (27 of 119) of respondents report that algae are a cause of mortality, and 24% perceive the occurrence as increasing. Respondents less frequently report that algae lead to reduced growth (11%) or impaired welfare (13%).

In broodstock facilities and aquaculture farms producing rainbow trout, algae are perceived as a minor problem.

In freetext responses to questions regarding climate change and environmental impacts, several respondents mention algae as a challenge to fish health and welfare.



**Figure 11.6.2** Satellite image of the Skagerrak, 1 April 2025. The red colour along the Danish west coast indicates the algal bloom (land areas are shown in black). The bloom appears to extend northeastwards near Skagen. This part of the bloom may be transported further into Norwegian waters. White areas represent clouds or chlorophyll a values outside the measurement range. Source: ESA Sentinel 3B, OLCI, L2 NRT, WFR, OCI chlorophyll algorithm. Data processed by SMHI / Swedish Meteorological and Hydrological Institute. Photo: Bengt Karlson, SMHI.

# 12 Health and Welfare in Farmed Cod

By Kristin Bjørklund, Mona Gjessing, Hanne Nilsen, Sonal Patel and Kristine Gismervik

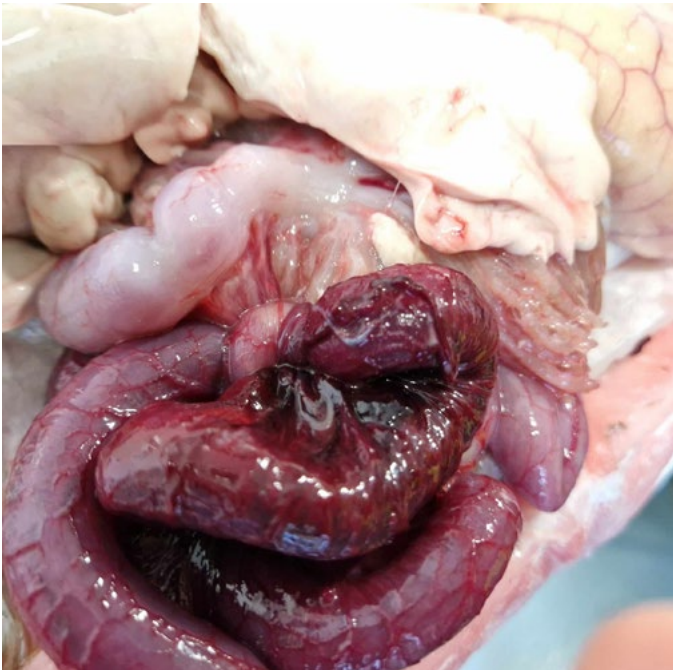
**Since the 1980s, several attempts have been made to establish cod aquaculture. However, a combination of disease challenges, early sexual maturation, low market prices, strong fisheries for wild cod, and limited access to capital following the financial crisis of 2008 resulted in the near collapse of the industry. Around 2012, commercial investment largely ceased. Nevertheless, both public and private actors continued to develop breeding programmes and genetic lines for farmed cod, laying the foundation for the subsequent revitalisation of the industry.**

In recent years, interest in cod aquaculture has increased, and since 2019 there has been a steady rise in cod stocking. In 2025, 8.7 million fish were stocked, compared to 6.3 million in 2024. Approximately 19,700 tonnes were harvested in 2025, representing an increase from 14,400 tonnes in 2024 ([Chapter 2.1](#) Production statistics and trends, [Table 2.1.5](#)). In 2025, the estimated mortality risk for cod in the

ongrowing phase was 20.4%, a slight reduction from 22.2% in 2024. As in 2024, monthly mortality risk in 2025 remained relatively stable through winter and spring but increased from July and peaked in September. Information from fish health personnel indicates that high sea temperatures during handling contributed to mortality, in addition to infections with *Vibrio* bacteria. In the juvenile phase, an increasing proportion of losses is observed in cod, particularly for fish weighing approximately 60–100 grams. Field information suggests that this is largely due to an increasing proportion of fish being culled and destroyed, partly because of deformities ([Chapter 2](#) Mortality in fish production).

With regard to slaughter quality, the proportion of cod classified as “superior” declined to 73% in 2025, compared to 78% in 2024. This means that 27% of the fish delivered to slaughter had quality deficiencies in 2025 ([Chapter 6.7](#) Slaughter data as a welfare indicator).





**Figure 12.1** Cod with intestinal strangulation and severe circulatory disorders. Photo: Mona Gjessing, Norwegian Veterinary Institute.

**For further information on francisellosis, nodavirus, and IPN, see the Norwegian Veterinary Institute's fact page:**

[Francisellosis \(in Norwegian\)](#)

[Nodavirus in marine fish disease](#)

[Infectious pancreatic necrosis \(IPN\)](#)

## Health and Welfare Challenges

Cod is a marine species with anatomy and physiological requirements that differ from those of salmonids. During the on-growing phase, cod are reared in open sea cages that often allow close contact with wild conspecifics. This represents a risk for transmission of infectious agents between farmed and wild cod. There is also concern regarding potential genetic impacts on wild cod populations if farmed cod reach sexual maturity and spawn within sea cages. Increased knowledge of the underlying causes is required to develop effective preventive measures against sexual maturation in cages. During maturation, farmed cod may also experience spawning rupture (egg release into the body cavity), which is likely a painful condition and constitutes a welfare concern.

Intestinal disorders, including intestinal volvulus/strangulation and enteritis, represent another well-known health and welfare challenge (Figure 12.1). Although more knowledge is required regarding the underlying causes, these issues are speculated to be linked to feed quality, feeding regimes, anatomy, and/or production conditions in farmed cod.

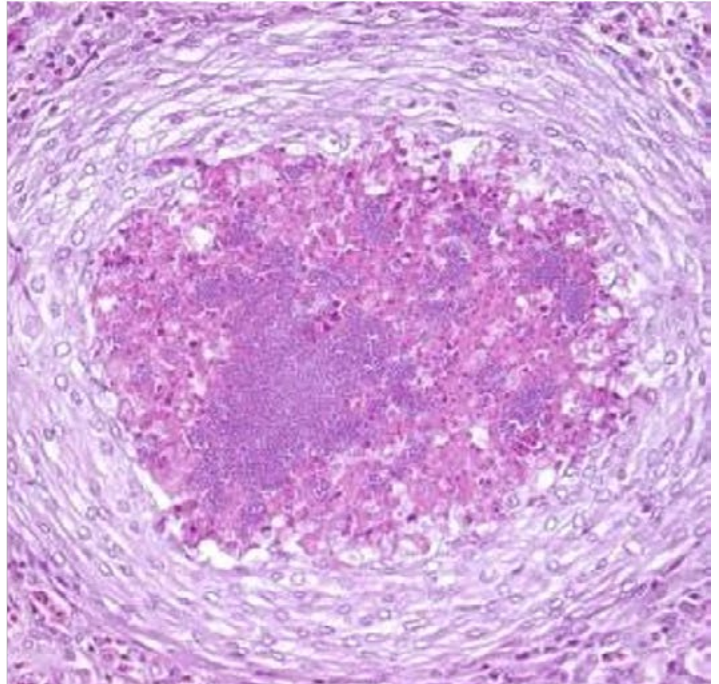
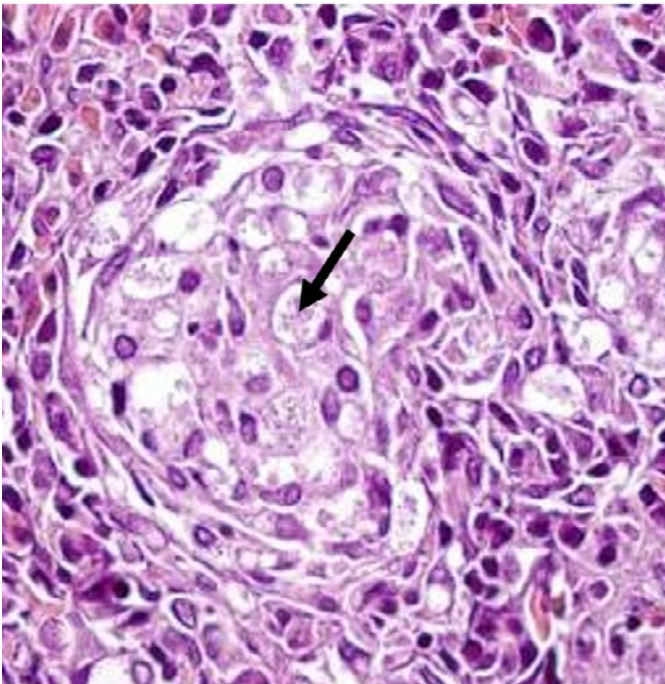
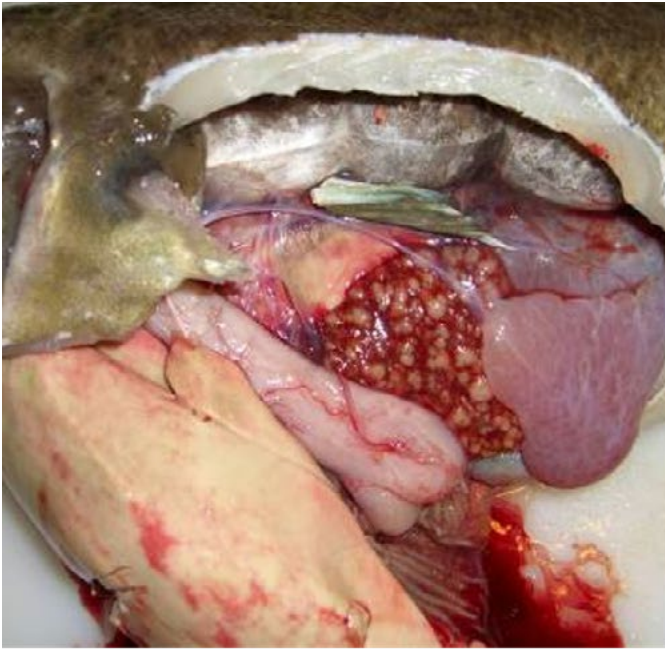
Skeletal deformities, including those affecting the vertebral column and jaws, are not uncommon in farmed cod. Pedro et al. (2025) investigated feeding strategies using specialised live feed (barnacle nauplii and planktonic eggs) combined with two experimental dry feeds for cod larvae. One group that, following live feeding, received a dry feed with the highest content of vegetable fatty acids (as opposed to marine lipids) exhibited the greatest reduction in skeletal deformities—from 91% in the control group to 52% in the experimental group. The diet also promoted faster maturation and development of internal organs, such as the digestive system and liver, compared to controls. The study demonstrates that early nutritional intervention is essential to reduce developmental disorders, although further knowledge is still required to reduce deformity prevalence further.

Biosecurity in cod aquaculture is challenging. There are few broodstock and hatchery facilities, close contact with wild fish at sea sites, lack of requirements for water quality and disinfection of intake water for marine species, absence of species-specific regulations relating to transport and transfer, following groups, and no mandatory screening programmes for infectious diseases. Further development and enforcement of regulatory frameworks are required to prevent major welfare consequences and to address emerging challenges. Operational practices and infection prevention measures must be adapted accordingly. Collaboration among industry actors and fish health personnel with experience across multiple species will be essential for sharing knowledge on effective biosecurity measures (Chapter 4 Biosecurity).

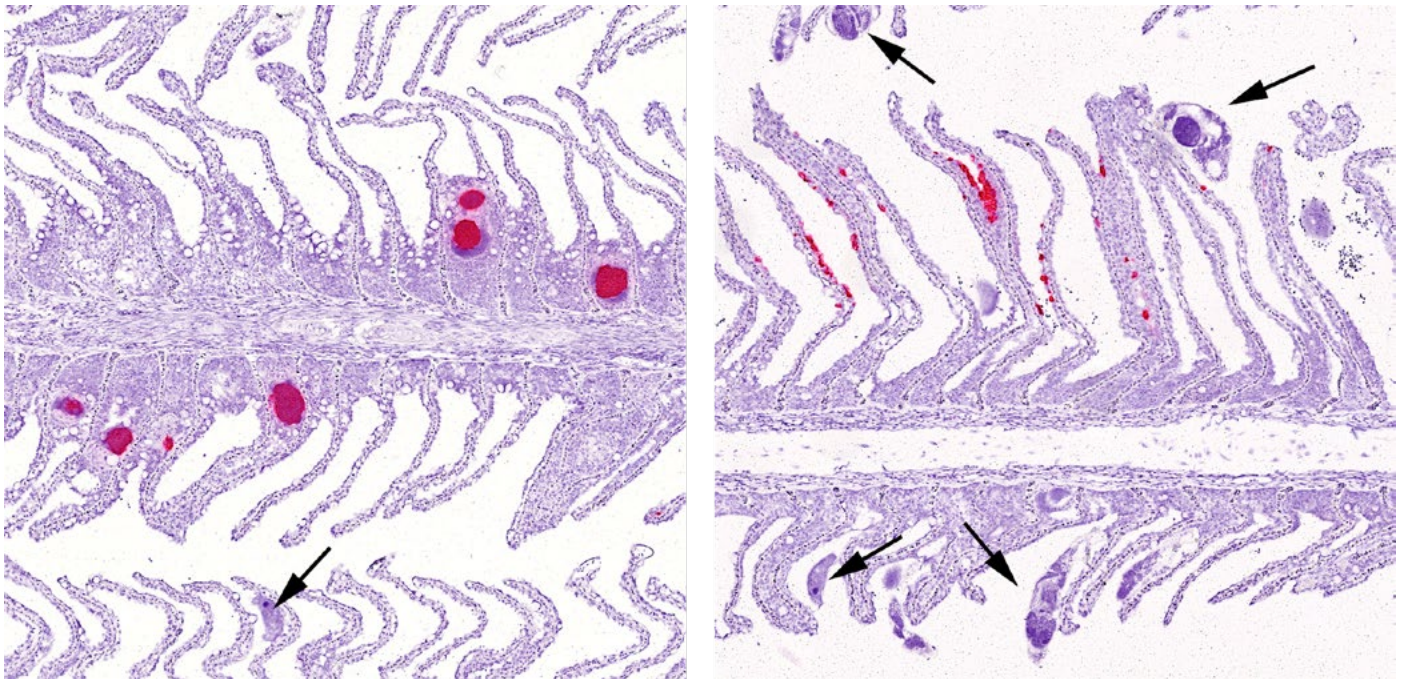
A risk map developed by the Norwegian Veterinary Institute and the Institute of Marine Research has identified and systematised risk factors, events, and consequences related to disease transmission between farmed fish and between farmed and wild fish (Codrisk, FHF 901832). Significant knowledge gaps were identified regarding the susceptibility of different wild fish species to various pathogens, as well as regarding vaccination status and other preventive measures. There is also limited overview of non-listed diseases, which

account for the majority of disease outbreaks in aquaculture. Increased knowledge of these factors is necessary to improve risk analyses of disease transmission and thereby strengthen biosecurity in cod aquaculture.

Among infectious diseases, bacterial infections dominate in cod farming. Infection with *Francisella noatunensis* subsp. *noatunensis* causes francisellosis, characterised by granulomatous inflammation in several organs, particularly the



**Figure 12.2** Internal organs of cod with francisellosis, and tissue sections of spleen showing francisellosis and atypical furunculosis. Final stage with numerous large white nodules in the spleen (upper left). Earlier stage, with several small white nodules in the spleen (upper right). Granuloma in francisellosis with numerous bacteria (arrow) located inside the cells (lower left). Atypical furunculosis and francisellosis appear similar during necropsy but differ in histopathological examination. In atypical furunculosis, bacteria are found in 'colonies' at the center of the granuloma, not inside the cells as in francisellosis (lower right). Photo: Mona Gjessing, Norwegian Veterinary Institute.



**Figure 12.3** Multifactorial gill disease in cod with pathological changes causing reduced respiratory surface. Both images are from the same fish. In situ hybridization (red) shows detection of the epitheliocyst-forming bacterium *Ca. Branchiomonas cysticola* (left) and cod poxvirus (right). The ectoparasite *Trichodina* spp. (arrows). Photo: Mona Gjessing, Norwegian Veterinary Institute

spleen and kidney. An important differential diagnosis is atypical furunculosis (infection with “atypical *Aeromonas salmonicida*”), as both diseases can present with similar macroscopic findings, including white nodules in internal organs, particularly the spleen and kidney (Figure 12.2). However, histopathological examination reveals distinct lesion types for the two conditions.

Infection with *Vibrio anguillarum* may result in severe septicaemia and mortality in cod. Wound infections involving *Moritella viscosa* and *Tenacibaculum* spp. have also been reported in farmed cod. Cod has a preferred temperature range between 8 and 13 °C. Elevated temperatures have previously been shown to impair the skin barrier in cod, potentially increasing susceptibility to infection. Climate-driven increases in sea temperature may therefore elevate the risk of both known and emerging diseases.

Complex gill disease in cod can be caused by multiple agents, including codpoxvirus (Figure 12.3). In recent years, several severe episodes with high mortality have been reported at cod farming sites, where gill disease involving codpoxvirus has been implicated as part of the causal com-

plex. The contribution of cardiac disease combined with stress cannot be excluded as an additional factor.

Infection with nodavirus can cause viral nervous necrosis (VNN) / viral encephalopathy and retinopathy (VER), a disease affecting the central nervous system that can result in mortality in several marine species, including farmed cod.

Infection with infectious pancreatic necrosis virus (IPNV) can cause pathological changes in several organs, most notably necrosis of the enzyme-producing part of the pancreas. The first case of IPN in farmed cod in Norway was reported in 2024. New research from the Norwegian Veterinary Institute has demonstrated that IPNV-infected cod can transmit the virus to other farmed species, including Atlantic salmon, Atlantic halibut, and lumpfish, in cohabitation trials (Weli et al., 2025). The IPNV isolate used in the trial, originally obtained from cod larvae, was genetically similar to isolates previously obtained from salmon, indicating that IPNV is capable of infecting multiple species. Cross-species transmission must therefore be considered in planning multi-species facilities, biosafety measures, and coastal area management.

Infestation with the parasites *Ichthyobodo* spp. and *Trichodina* on skin and gills can cause health problems, and cod may also be infested with lice, including sea louse (*Caligus elongatus*) and cod louse (*Caligus curtus*). These parasites can pose welfare problems for both farmed and wild cod, particularly with increased cod aquaculture production.

### Welfare Incidents and Disease Control

Serious welfare incidents are subject to mandatory reporting to the Norwegian Food Safety Authority. In 2025, a total of 33 incidents involving increased mortality or gill problems were reported in cod farming. Five incidents occurred in land-based facilities and were related to unexplained mortality, human or technical failure, disease, or other causes. Incidents at sea were related to miscellaneous causes, dis-

ease, transport, pumping (grading/crowding/counting), stocking mortality, unexplained mortality, algal and jellyfish blooms, and natural forces such as storms or strong currents. Where disease was specified, gill disease, non-specific myocarditis, *Vibrio anguillarum*, and infectious wounds were reported.

Both francisellosis and VNN/VER are nationally listed diseases, classified as Category F and Category G, respectively. Vaccines against several serotypes of *Vibrio anguillarum* are authorised for use, and autogenous vaccines are also employed against various bacterial diseases. Field reports indicate challenges related to limited vaccine efficacy, and autogenous vaccines can only be used within the same “epidemiological unit.”

## Health and Welfare Situation in 2025

### Official data

Francisellosis was detected at one cod farming site in 2025. VNN was not reported in cod during 2025.

### Data from the Norwegian Veterinary Institute

The Norwegian Veterinary Institute received 25 submissions from eight different cod farming sites in 2025.

Complex gill disease with detection of codpoxvirus, combined with inflammation and circulatory disturbances in the heart, was identified in association with increased mortality in grow-out cod at several sites. Multiple agents associated with gill damage were detected, including *Trichodina* spp. and epitheliocystis-like structures. Cod gill disease involving a novel poxvirus was first described at one site in 2024, and in 2025 the virus was detected at four additional sites across Western Norway, North-western Norway, and Northern Norway. The virus can be detected using PCR.

Structures consistent with *Gadixcellia*-like parasites (X-cell parasites) were detected in skeletal muscle at one site.

Cod tend to respond to infectious agents (bacteria, parasites, fungi) as well as vaccination by forming granulomas. Granulomas are therefore a non-specific finding and may be detected in the abdominal cavity—particularly following vaccination—or in internal organs during infection.

*Moritella viscosa* was detected in association with skin wounds, together with *Aliivibrio wodanis* and *Aliivibrio logei*. At one site with increased prevalence of corneal damage, vibriosis caused by *V. anguillarum* O2 was detected, along with *Tenacibaculum* spp. Unicellular parasites of uncertain significance were observed in the kidneys of cod at several sites.

### The Annual Survey

According to the survey among fish health personnel, production-related disorders were the primary causes of mortality and reduced welfare in cod across production stages in 2025. Development of looser fish (“runt syndrome”) was identified as the most important cause of mortality and reduced welfare in juvenile facilities (larvae and fish up to approximately 100–200 g) (Appendix A3). Vertebral deformities, intestinal disorders, and jaw deformities were also highlighted as major contributors.

Seventeen respondents completed the grow-out phase survey (Appendix B4). Intestinal disorders (including volvulus/ invagination and inflammation) and runt syndrome were considered the most important causes of mortality and reduced welfare. Gill disease and vibriosis were regarded as increasing challenges compared to 2024, followed by vertebral deformities. Reduced growth was primarily associated

with emaciation/runt syndrome, followed by intestinal disorders. Increased incidence was most frequently linked to intestinal disorders, vibriosis, gill disease, emaciation, and X-cell parasite infection.

Fourteen respondents provided free-text assessments of cod welfare in 2025. In juvenile facilities, welfare was generally considered moderate to good, with welfare reductions associated with spinal and jaw deformities and aggression affecting weaker individuals. One respondent observed a higher prevalence of deformities in fish originating from summer-spawned eggs compared to winter-spawned eggs. High stocking density and inadequate nutrition were identified as underlying contributing factors.

In on-growing facilities, several respondents reported improving or periodically good welfare due to lower disease occurrence and mortality, although welfare was poor among fish affected by runt syndrome or intestinal disorders. Gill disease involving poxvirus was highlighted as a welfare concern due to mortality and reduced feed intake. Vibriosis and emerging challenges with francisellosis were also noted, alongside X-cell parasite-associated mortality. Algal blooms were reported to affect farmed cod, and one respondent suggested that cod may be more susceptible to secondary infections following algal exposure or handling stress. Elevated sea temperatures during summer 2025 were also identified as contributors to sustained high mortality and challenges related to harvesting operations.

### Overall Assessment of Health and Welfare

The most significant health and welfare challenges in cod aquaculture are non-infectious in origin, including intestinal disorders, runt syndrome, skeletal and jaw deformities, and spawning rupture. In 2025, gill disease and vibriosis appear to have increased in importance. These conditions are associated with pain and stress, and fish affected by one or more of these issues experience poor welfare.

Mortality risk in 2025 remains relatively high compared to 2022 and 2023, when mortality was approximately 13.5%. Together with reduced slaughter quality, this may indicate that a larger proportion of individuals experience health and welfare challenges, warranting further investigation.

Significant knowledge gaps remain regarding biosecurity in cod aquaculture. Until these gaps are addressed, precau-

tionary measures are necessary to reduce the risk of disease transmission to both farmed and wild fish. Increased production volumes and climate-driven warming of seawater may further elevate the importance of francisellosis, gill disease, vibriosis, and other known or emerging diseases.

### References

- Pedro, J. et al. (2025). Early nutrition impacts on growth, skeletal anomalies and organ ontogeny in larval Atlantic cod (*Gadus morhua*). *Animals*, 15(20), 2985. <https://doi.org/10.3390/ani15202985>
- Weli, S. et al. (2025). Infectious Pancreatic Necrosis Virus can be transmitted through cohabitation from Atlantic cod (*Gadus morhua*) to Atlantic cod, Atlantic salmon (*Salmo salar*), Atlantic halibut (*Hippoglossus hippoglossus*) and lumpfish (*Cyclopterus lumpus*). *Journal of Fish Diseases*, e70042. <https://doi.org/10.1111/jfd.70042>

# 13 Health Status of other Marine Species in Aquaculture

By Hanne K. Nilsen, Sonal Patel, Toni Erkinharju and Mona Gjessing

**Marine species include fish species that complete their entire life cycle in seawater. In Norwegian aquaculture, several species have been tested for farming, such as Atlantic halibut, turbot, spotted wolffish and cod, but production remains limited compared with salmonid farming. The production cycle for these species is still long—often several years—compared with other commonly farmed fish species in Norwegian aquaculture.**

Atlantic halibut and turbot are both flatfish—species characterized by a flattened body with both eyes on the same side of the head in adulthood. Good knowledge and expertise regarding the species' specific biological needs are crucial for good fish health and increased production.

In Norway, the first attempts at farming Atlantic halibut (*Hippoglossus hippoglossus*) began at the research station in Flødevigen in the late 1970s. Production has remained

stable in recent years, ranging between 2,000 and 7,000 tonnes from 2020 to 2024, and there is an ambition to increase production in the future. Atlantic halibut thrives best at low temperatures and spends much of its time on the seabed under natural conditions. In newly constructed facilities, "raceways" or water channels are therefore used to provide increased area and sufficient space for natural behaviour. Norway is a world leader in farming this species, despite the relatively small production volume on a national scale. Other countries engaged in farming Atlantic halibut include Iceland, Scotland and Canada.

Farming of turbot (*Scophthalmus maximus*) in Norway is very limited, but the species is becoming an important aquaculture species globally, with a significant share produced in recirculating aquaculture systems (RAS). Turbot farming is carried out in China and Spain, and there is also some production in the United Kingdom, Portugal, France and



**Figure 13.1** Gills from halibut showing abundant presence of "Costia" (*Ichthyobodo* sp., likely *I. hippoglossi*) parasites on the surface of the lamellae (indicated by arrow). Photo: Toni Erkinharju, Norwegian Veterinary Institute

Germany. Turbot thrives best in warmer water than Atlantic halibut and is produced in land-based facilities where temperature can be controlled.

Farming of spotted wolffish (*Anarhichas minor*) began experimentally in Norway in the 1990s and is currently conducted by only a few producers. There are no known attempts at farming this species in other countries. Juvenile production is considered somewhat easier than for Atlantic halibut; for example, wolffish larvae can be fed dry feed immediately after hatching. The production time is reported to be up to three years, with a slaughter weight of up to 4,500 g. Spotted wolffish thrive best at low temperatures.

### Diseases in Farmed Marine Species

Bacterial diseases reported in farmed marine species worldwide include infections with various species of *Tenacibaculum* and *Vibrio*, often associated with ulcers and septicæmia. *Aeromonas salmonicida* (several subspecies/genotypes) is a common cause of granuloma formation and systemic bacterial spread. In 2025, the intracellular bacterium *Piscirickettsia salmonis* was reported in turbot for the first time. Among more exotic bacteria, species within the genera *Streptococcus*, *Edwardsiella* and *Mycobacterium* (rapid-growing species) have been reported to cause disease in the warm-water species turbot.

The most important viral disease in farmed marine species is viral nervous necrosis (VNN), also known as viral encephalopathy and retinopathy (VER), caused by nodavirus. Typical

clinical signs include spiral swimming and convulsions. Histopathological changes are characterised by necrosis and vacuolisation of nervous tissue. Mortality during the juvenile stage may reach 100% in some cases. In Atlantic halibut, infection with Atlantic halibut aquareovirus (AHRV) may also cause necrosis in the liver and pancreas, as well as increased mortality. Infection with infectious pancreatic necrosis virus (IPNV) can lead to lesions in several organs, particularly necrosis in the enzyme-producing part of the pancreas.

Infestation with the parasites *Ichthyobodo* spp., causing the disease “costiasis,” and *Trichodina* spp. on skin and gills may cause problems in marine species.

**For further information on nodavirus, piscirickettsiosis and IPN, see the Norwegian Veterinary Institute’s fact pages (Nodavirus and Piscirickettsiosis in Norwegian):**

Nodavirus hos marin fisk

[Piscirickettsiose](#)

[Infectious pancreatic necrosis](#)

### Disease control

Piscirickettsiosis and VNN/VER are nationally listed in category G. Reporting is mandatory only for diseases listed in this category.

## The Health Situation in 2025

### Official Data

*Piscirickettsia salmonis* was detected in turbot at one facility in 2025. Infection with nodavirus was not detected.

### Data from the Norwegian Veterinary Institute

In 2025, a total of 19 submissions (six from turbot and 13 from Atlantic halibut) were received from three different localities farming turbot and Atlantic halibut. No submissions were received from spotted wolffish.

The intracellular bacterium *Piscirickettsia salmonis* was detected in turbot. This is the first time this bacterium has

been reported in this fish species—not only in Norway, but also internationally. Increased mortality was observed in the affected group following a period of suboptimal water quality. Post-mortem examination of diseased fish revealed lesions in the stomach, which histopathological examination showed to be consistent with infection with *Piscirickettsia salmonis*. The bacterium could not be cultured but was detected using immunohistochemistry and in situ hybridisation. Measures to improve environmental conditions were sufficient to control the outbreak.

*Carnobacterium maltaromaticum* was detected in broodstock Atlantic halibut. This bacterium can be found in the intestinal tract of fish and is a common finding in submissions from several fish species, especially broodstock. It is associated with inflammation of serous membranes. Atypical *Aeromonas salmonicida* and *Vibrio anguillarum* serotype O2beta were detected in halibut juveniles with reduced appetite and increased mortality, together with *Vibrio tapetis*. *Vibrio tapetis* is commonly detected in submissions from Atlantic halibut and turbot, and its significance is somewhat uncertain. *Tenacibaculum dicentrarchi* was detected in ulcers in turbot. The significance of this finding is somewhat unclear. Nephrocalcinosis and gill disease of unknown aetiology have also been detected in turbot.

## The Annual Survey

Respondents were asked which health problems are observed in facilities farming marine species other than cod. From Atlantic halibut facilities, it was reported that eye injuries are not an uncommon finding in grow-out facilities. This is consistent with reports from previous years. In wolffish, challenges related to spawning, wound problems and findings of *Trichodina* spp. were reported. In both species, atypical furunculosis was reported as a problem.

# 14 Health and Welfare of Cleaner Fish

By Ewa Harasimczuk, Toni Erkinharju, Snorre Gulla and Kristine Gismervik

Cleaner fish is a collective term for lumpfish and various wrasse species (Figure 14.1) used as part of the strategy to control salmon lice. The most used wrasse species are corkwing wrasse (*Symphodus melops*), ballan wrasse (*Labrus bergylta*), and goldsinny wrasse (*Ctenolabrus ruperris*), while rock cook (*Centrolabrus exoletus*) is used to a lesser extent. In 2025, according to the Norwegian Directorate of Fisheries (data as of 20 January 2026), more than 19 million cleaner fish were deployed, representing a reduction of approximately five million individuals compared to the previous year.

## Use of cleaner fish in aquaculture

This marks the sixth consecutive year in which a reduction in cleaner fish deployment has been recorded. Compared with the peak year of 2019, a decrease of 69% has been documented (Figure 14.2). The number of salmon and rainbow trout farming sites reporting the presence of cleaner fish declined from 444 locations in 2019 to 148 locations in 2025. No cleaner fish were deployed in production areas (PA) 9–13.

One of the primary reasons for the phaseout of cleaner fish is high mortality, together with challenges associated with ensuring acceptable health and welfare. Some producers have replaced cleaner fish with alternative technological

solutions. In addition, part of the observed reduction may be explained by earlier misreporting of cleaner fish deployment and mortality figures. These reporting errors were subsequently corrected, and some of the apparent decline reflects adjustments in reporting to the Directorate of Fisheries.

In the summer of 2025, §28 of the Aquaculture Operations Regulations, which concerns handling and care, was amended. The exemption that allowed cleaner fish to remain in production units during various operations was removed. This regulatory change has contributed to an increased number of operators discontinuing the use of cleaner fish.

Due to high mortality rates and poor welfare outcomes, the Norwegian Food Safety Authority published a Guide for Cleaner fish in autumn 2025. The guide addresses the applicable regulatory framework for the capture of wild-caught wrasse, the farming of ballan wrasse and lumpfish, and the use of cleaner fish in aquaculture.

Among the wrasse species, goldsinny wrasse, ballan wrasse, corkwing wrasse, and cuckoo wrasse are used for salmon lice control. It is notable that large numbers of goldsinny wrasse continue to be deployed, despite this



Figure 14.1 Lumpfish (*Cyclopterus lumpus*) (left) and ballan wrasse (*Labrus bergylta*) (right). Photo: Toni Erkinharju, Norwegian Veterinary Institute

species being considered particularly vulnerable. Corkwing wrasse have a shorter life cycle than other wrasse species, and it has been suggested that their high postdeployment mortality may be partly explained by the fact that many individuals are in the final stage of their life cycle at the time of capture and transfer to sea cages.

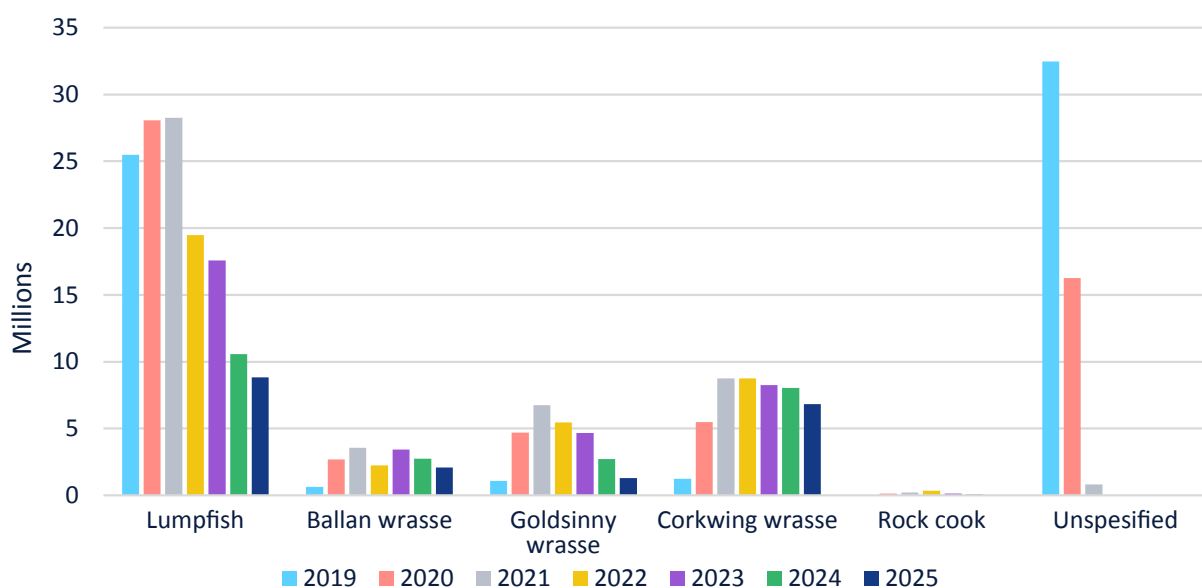
Of the wrasse species, only ballan wrasse is farmed. Production is demanding due to long production times and very small larvae that require live feed. The live feed currently in use is likely suboptimal and may negatively affect larval development, leading to deformities and early mortality. Skeletal deformities are common in farmed ballan wrasse and negatively affect both animal welfare and licegrazing efficiency. The remaining wrasse species, as well as some ballan wrasse, are wild-caught.

Wrasse fisheries are regulated by quotas and divided into three geographical regions: southern Norway, western Norway, and north of 62°N. Capture takes place during the summer, using traps or pots. Following capture, fish are transported to farming facilities by boats, smaller vessels,

or tank trucks. In addition to domestic capture along the Norwegian coast, wild-caught wrasse has also been imported from Sweden. According to the Norwegian Seafood Council, 13 tonnes of wrasse were imported from Sweden in 2025, compared with 21 tonnes in 2024.

Wild-caught wrasse has unknown infection status and represent a significant biosecurity risk due to the potential spread of pathogenic agents carried by the fish. These include *Aeromonas salmonicida*, which causes atypical furunculosis. Following deployment in sea cages, infection can develop rapidly and lead to high mortality. Long transport distances pose an additional stressor. Furthermore, the introduction of wrasse into new areas may lead to genetic impacts on local populations. For example, a high proportion of goldsinny wrasse in PA6-PA7 have been shown to originate genetically from the Skagerrak region due to escape events (Risk Report Norwegian Fish Farming 2023). The ecological impact of wrasse fisheries on wild populations and source ecosystems has previously been described as largely unknown.

## The use of Cleaner-fish 2019-2025



Fish Health Report 2025, Norwegian Veterinary Institute

Figure 14.2 Deployment of lumpfish and wrasse species in sea cages with salmonids from 2019 to 2025. Data as of 20 January 2026, based on Biomass Statistics from the Directorate of Fisheries.

Farmed lumpfish account for approximately 46% of the total cleaner fish deployed. Compared with wrasse, lumpfish are considered easier to farm and have a shorter production time. Lumpfish are also more active and tolerate lower water temperatures better, which has resulted in more extensive use in northern parts of Norway. Advantages of using farmed cleaner fish include a reduced risk of pathogen transfer, more stable quality, and decreased pressure on wild stocks. However, few vaccines are currently available for farmed cleaner fish, and there is a clear need for vaccines with improved efficacy.

The natural habitats of wrasse and lumpfish differ considerably from the environment in sea cages, which is designed for farmed salmon. Salmon are athletic fish and strong swimmers. Wrasse, by contrast, are adapted to life in shallow waters among kelp and seaweed. Their lifespan ranges from 8 to 29 years, depending on the species. Lumpfish begin life in the intertidal zone before moving out into the open sea, and return to the coast to spawn. The lifespan of lumpfish is 7–8 years. Both lumpfish and ballan wrasse have lower swimming capacity than salmon and do not thrive at sites with moderate to strong currents. Exposed locations with strong currents therefore pose a major challenge. Lumpfish have a low tolerance for high sea temperatures, and summer temperatures in Southern Norway represent an additional strain. Although lumpfish are usually stocked at lower temperatures, releases of lumpfish during the summer months in Southern Norway have also been recorded in 2025. This practice entails a high risk of cataracts, abnormal behaviour, and infectious diseases, which in turn lead to reduced welfare and increased mortality in lumpfish. Wrasse, on the other hand, are warm-water species and exhibit low activity at temperatures of 5–10 °C. It is therefore positive that stocking does not take place in the northern production areas (PA7–PA13).

## Diseases and agents in cleaner fish

### Bacteria

Atypical *A. salmonicida*, *Vibrio anguillarum*, *Vibrio ordalii*-like bacteria, *Phocoenobacter atlanticus* subsp. *cyclopteri* (formerly *Pasteurella* sp.), *Pseudomonas anguilliseptica*, *Moritella viscosa*, and *Tenacibaculum* spp. are among the most common bacterial species identified in connection with disease outbreaks in wrasse and/or lumpfish in Norway. Other bacteria are also isolated from sick and dying

fish, but their significance as pathogens in cleaner fish is uncertain.

Two genetic variants of atypical *A. salmonicida* dominate in Norway (A-layer type 5 and 6). The typical disease presentation is a chronic infection with the formation of abscesses, ulcers, and granulomatous inflammation in internal organs with microcolonies of bacteria (Figure 14.3). *A. salmonicida* subsp. *salmonicida*, which causes classical furunculosis in salmonids, is notifiable (category F). In recent years, this bacterium has been sporadically detected in lumpfish in an area of Trøndelag with known endemic infection in wild salmonids (Chapter 8.2 Furunculosis).

Classical vibriosis, caused by *Vibrio anguillarum*, is an important disease in marine fish and also occurs sporadically in cleaner fish. Clinical signs include ulcers, fin erosion, skin hemorrhages, and hemorrhages in internal organs. High water temperatures are often associated with disease development, but outbreaks have also been described in lumpfish at temperatures down to 6 °C. Serotype O1 and several subtypes of O2 are most commonly detected in cleaner fish. Infections with *Vibrio ordalii*-like bacteria have occurred sporadically in farmed lumpfish in Norway, leading to severe hemorrhagic septicemia and high mortality, with reports of recurrent outbreaks.

Other *Vibrio* and *Aliivibrio* species, such as *V. splendidus*, *A. logei*, *A. wodanis*, and *V. tapetis*, are frequently isolated from cleaner fish. However, their role in disease remains unclear, as many are common environmental bacteria in seawater. Stressful conditions and external stressors likely increase susceptibility to infection by bacteria that would not normally cause disease in healthy individuals.

*Phocoenobacter atlanticus* subsp. *cyclopteri* causes pasteurellosis in farmed lumpfish in Norway and Scotland. Although the bacterium has changed nomenclature, the term pasteurellosis remains appropriate, as the genus *Phocoenobacter* belongs to the family Pasteurellaceae. Clinically, the disease manifests as bacterial sepsis with skin lesions in the form of white spots, caudal fin erosion, ascites, and hemorrhages in gills and at the fin base. Outbreaks may occur both in hatcheries and at sea, with mortality sometimes approaching total losses. Another subspecies of *Ph. atlanticus* causes disease in salmon in Norway (Chapter 8.5 Pasteurellosis).

*Pseudomonas anguilliseptica* was first detected in lumpfish in Norway in 2011. The disease typically presents as hemorrhagic septicemia and has been detected at several locations in recent years.

*Moritella viscosa* occurs intermittently in cleaner fish, often in association with ulcerative conditions and mainly at lower sea temperatures. *Tenacibaculum* spp. are frequently isolated from ulcerated fish (Figure 14.3) and from fish with tail fin erosion, both as pure cultures and mixed flora. *Tenacibaculum* spp. have also been isolated from lumpfish with so-called "crater disease." These bacteria are naturally widespread in the marine environment, and several species, including *T. maritimum*, *T. finnmarkense*, *T. dicentrarchi*, and *T. soleae*, have been described in cleaner fish. Several of these species are also isolated from salmonids with ulcers (Chapter 8.4 Winter ulcers).

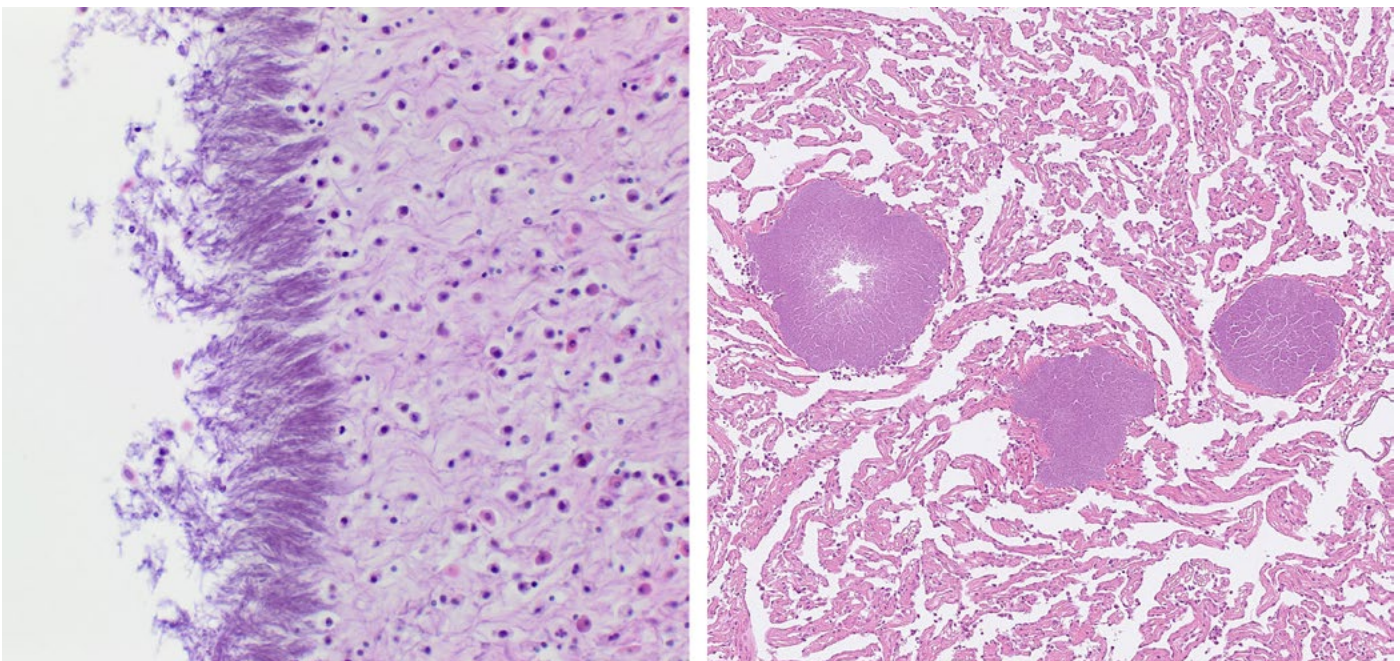
Among bacterial infections reported in cleaner fish outside Norway is *Piscirickettsia salmonis*, which causes the listed disease piscirickettsiosis (category G) (Chapter 8.7 Piscirickettsiosis), detected in lumpfish in Ireland in 2017, and *Photobacterium damsela* subsp. *damsela*, detected in wild-caught ballan wrasse in England in 2019.

Experimental studies from Canada have shown that lumpfish can be susceptible to infection with *Renibacterium salmoninarum*, the causative agent of bacterial kidney disease (BKD), a listed disease in salmonids (Chapter 8.3 BKD). In these studies, lumpfish infected via injection developed chronic infections, and bacteria could be reisolated from organs for nearly 100 days. A more recent study also demonstrated that injection with this bacterium may lead to early-stage immunosuppression in lumpfish. To date, no natural disease outbreaks caused by *R. salmoninarum* have been detected in cleaner fish, and the bacterium is regarded in literature as a serious pathogen primarily for salmonid species.

In 2021, one case of mycobacterial infection (previously known as fish tuberculosis) was reported at a site with wrasse in Norway. Such infections may result in chronic disease with granuloma formation in multiple organs. The disease also occurs in several other fish species, including salmon (Chapter 8.8 Mycobacteriosis). Mycobacteriosis has not been described in lumpfish.

## Fungi

Fungal diseases occur sporadically in cleaner fish. In lumpfish, episodes of increased mortality and systemic infection



**Figure 14.3** Bacterial infections in cleaner fish. Bacterial wound infection in lumpfish, dominated by several filamentous bacteria on the skin surface (likely *Tenacibaculum* spp.), (left) and microcolonies of short rod-shaped bacteria in the heart of lumpfish with atypical furunculosis (right). Photo: Toni Erkinharju, Norwegian Veterinary Institute

caused by yeast-like fungi (*Exophiala* spp.) have been described, with three species identified: *E. angulospora*, *E. psychrophila*, and *E. salmonis*. Infections with *E. psychrophila* were previously reported in lumpfish in Norway and were last detected at one location in 2022.

## Parasites

Several unicellular and multicellular parasites have been described in both wild and farmed cleaner fish. In particular, *Paramoeba perurans*, *Nucleospora cyclopteri*, *Trichodina* sp., *Ichthyobodo* sp., *Kudoa islandica*, *Gyrodactylus* sp., *Caligus elongatus*, *Eimeria* sp., *Spironucleus salmonicida*, and *Ichthyophonus* sp. are considered potentially serious threats to cleaner fish in Norwegian aquaculture and may cause mortality. For *P. perurans*, *C. elongatus*, *Ichthyophonus* sp., and *Anisakis simplex* (roundworm), cross-infection between cleaner fish and salmon is also of concern.

The amoeba *Paramoeba perurans*, which causes amoebic gill disease (AGD), was first detected in Norwegian farmed salmon in 2006 and has since been detected in both lumpfish and wrasse. As in salmon and other fish species (Chapter 9.4 AGD and *Paramoeba perurans*), the parasite causes pathological changes in the gills and may become problematic in heavy infections. The amoeba has been detected both in cleaner fish cohabiting with salmon in sea cages and in lumpfish in land-based tank facilities.

Microsporidians are unicellular intracellular parasites. In Norway, *Nucleospora cyclopteri* has been detected in lumpfish. This parasite infects the nuclei of white blood cells, thereby destroying leukocytes. Infected fish often develop pale and enlarged kidneys, with or without white nodules. The parasite is difficult to detect through routine histological examination and is therefore likely underdiagnosed when only histology is used.

Infestations with the ectoparasite *Caligus elongatus* (scaly louse) have been reported as a problem in lumpfish in several areas of Troms and Finnmark. In some cases, several hundred lice have been observed on a single fish. The parasite causes skin lesions that may predispose fish to secondary infections. Lumpfish have previously been shown to be the primary host for one genotype of *C. elongatus*. Due to its low host specificity, the parasite may potentially be transmitted to salmonids.

In 2022, systemic spironucleosis was reported in salmon at several grow-out sites in northern Norway. At one of these sites, infection with *Spironucleus salmonicida* was also detected in lumpfish through histopathological examination combined with PCR and sequencing. A recently completed FHF project (901831 SpiroFri) demonstrated that lumpfish are highly susceptible to infection with this parasite and rapidly develop severe disease with high mortality. Lumpfish can become infected through contact with salmon infected with *S. salmonicida* and are therefore unsuitable as cleaner fish at sites with outbreaks of this parasitic disease.

## Viruses

Cyclopterus lumpus virus (CLuV), also known as lumpfish flavivirus, has been frequently reported in farmed lumpfish since 2016, with a gradual decline in detections in recent years. Nationally, the virus has been among the major challenges for lumpfish, particularly in the hatchery phase. Disease outbreaks are associated with high mortality, and massive hepatic necrosis may occur at high viral loads. In chronic cases, liver changes resembling cirrhosis are observed. The virus is believed to occur along the entire Norwegian coast and was recently reported in connection with a mortality event at an aquaculture producer in England, involving imported lumpfish from Norway. This is likely to represent the first known outbreak in that country.

Other virus types have also been reported in cleaner fish, including a novel ranavirus detected in lumpfish in Ireland, Scotland, the Faroe Islands, and Iceland, termed European North Atlantic Ranavirus (ENARV). This virus is closely related to epizootic hematopoietic necrosis virus (EHNV), which is notifiable. Recent experiments showed that injection of lumpfish with Irish, Icelandic, and Faroese virus isolates resulted in reduced survival and development of clinical signs, including distended fluid-filled abdomen, skin hemorrhages, and hemorrhages around the brain and spinal cord. Histological examination revealed necrotic changes in internal organs such as the kidney and gastrointestinal tract. The study did not confirm differences in virulence among the isolates. Cohabitation experiments demonstrated horizontal transmission between infected and naïve fish, with viral replication for up to 3–4 weeks, lower mortality, and none or only mild pathological changes in randomly examined fish. The virus has not yet been detected in cleaner fish in Norway.

In 2018, two novel viruses were described in diseased lumpfish fry with fluid-filled intestines (diarrhea), named Cyclopterus lumpus Totivirus (CLuTV) and Cyclopterus lumpus Coronavirus (CLuCV). By the end of 2020, a new virus associated with high fry mortality in ballan wrasse was detected and named Ballan wrasse birnavirus (BWBV). The prevalence of these viruses in Norwegian cleaner fish populations is unknown.

Experimental studies have demonstrated that lumpfish can be infected with nodavirus and that both wrasse and lumpfish may be infected with infectious pancreatic necrosis virus (IPNV). One recent cohabitation study showed that lumpfish can be infected with IPN virus from infected cod, although the lumpfish did not develop clinical disease. Nodavirus has previously been detected in wild-caught wrasse along the Norwegian and Swedish coasts. Viral hemorrhagic septicemia virus (VHSV) has been detected in wild-caught wrasse and lumpfish in Scotland and Iceland, respectively. None of these viruses have been reported in cleaner fish in Norwegian aquaculture.

Salmonid pathogenic viruses such as salmonid alphavirus (SAV), infectious salmon anemia virus (ILAV), piscine myocarditis virus (PMCV), and piscine orthoreovirus (PRV) have been detected sporadically in wrasse cohabiting with diseased salmon in sea cages in or outside Norway. These detections had little or unknown clinical significance for the wrasse, and sample contamination could not be ruled out in

several cases. In 2020, a unique variant of SAV was described in ballan wrasse in Ireland and proposed as SAV genotype 7 (SAV7). None of these viruses have previously been detected in lumpfish.

In a recent experimental study from Canada, attempts were made to infect lumpfish with ILAV via cohabitation and injection. During cohabitation, ILAV was detected in a single gill sample but not in other organs, and the detection was therefore considered likely due to contamination. After injection, ILAV was detected in some gill and blood samples at three and five weeks post-injection, respectively, but not in other organs. Viral loads in blood were low, and the fish did not develop clinical signs of infectious salmon anemia such as anemia. The study concluded that ILAV lacks the ability to replicate in lumpfish, and lumpfish are therefore not a susceptible host for the virus.

### Other diseases and health related issues

Cataracts (opacity of the eye lens) have previously been a common finding in lumpfish in hatchery and broodstock facilities. Renal calcifications (nephrocalcinosis) are sporadically detected at varying prevalence in cleaner fish. Since 2016, black spot syndrome has been increasingly recorded in cuckoo wrasse from the Austevoll area, and similar findings have also been sporadically observed in other wrasse species. The underlying cause of these changes remains unclear.

## The Health Situation in 2025

---

### Data from the Norwegian Veterinary Institute and Private laboratories

#### Bacteria

In 2025, the Norwegian Veterinary Institute and private laboratories detected atypical *Aeromonas salmonicida* using culture and/or molecular methods in lumpfish and wrasse at seven and 13 locations, respectively. Information on clinical significance was limited; however, in cases where such information was available, findings were consistent with atypical furunculosis. The majority of detections were reported from production areas PA1-PA3. By comparison, atypical *A. salmonicida* was detected at 21 locations for each fish group in

2024. Infection with *A. salmonicida* subsp. *salmonicida* was not detected in cleaner fish in 2025.

*Phocoenobacter atlanticus* subsp. *cyclopteri* was detected by the Norwegian Veterinary Institute and private laboratories in lumpfish at two locations in 2025, compared to one location in 2024. The bacterium was not detected in wrasse in 2025.

In 2025, *Pseudomonas anguilliseptica* was detected by the Norwegian Veterinary Institute in lumpfish at one location, as was also the case in 2024. Data from recent years indicate a steady decline in the number of detections, from 18 affected locations in 2020. Despite this decline, the Norwegian Veterinary Institute has received reports of locations where *P. anguilliseptica* has been the primary cause of mortality in lumpfish following sea transfer in recent years. The bacterium is not listed, and it is considered likely that infections are underdiagnosed. *P. anguilliseptica* was not detected in wrasse in 2025.

In 2025, *Vibrio anguillarum* was detected in wrasse at four locations and in lumpfish at two locations. No detections of *V. anguillarum* in cleaner fish were reported in 2024. *Vibrio ordalii*-like bacteria were not detected in lumpfish in 2025.

A wide range of *Vibrio* and *Aliivibrio* species (*V. splendidus*, *A. logei*, *V. tapetis*, *A. wodanis*, and unspecified *Vibrio* spp.) were also isolated from cleaner fish in 2025, often as part of mixed bacterial flora.

In 2025, the Norwegian Veterinary Institute and private laboratories detected *Moritella viscosa* infections in lumpfish at 16 locations and in wrasse at one location. *Tenacibaculum* spp. were detected in both lumpfish and wrasse at seven locations each. When species identification was performed, *T. maritimum* was detected in lumpfish at one location, *T. dicentrarchi* in both wrasse and lumpfish at one location, and *T. finnmarkense* in wrasse at two locations and lumpfish at four locations.

## Fungi

No cases of fungal disease or infection with specific fungal agents were identified in diagnostic material from cleaner fish submitted to the Norwegian Veterinary Institute in 2025.

## Viruses

No viruses were detected in diagnostic material from cleaner fish submitted to the Norwegian Veterinary Institute in 2025. No cases of *Cyclopterus lumpus* virus (CLuV) or lumpfish flavivirus were reported by private laboratories in 2025. By comparison, CLuV was detected at three, one, and twelve locations in 2024, 2023, and 2022, respectively.

## Parasites

In 2025, the Norwegian Veterinary Institute and private laboratories detected amoebic gill disease (AGD) in both lumpfish and salmon at two locations per group. In addition, *Paramoeba perurans*, the causative agent of AGD, was detected in cleaner fish at several locations where clinical signs consistent with disease outbreaks were present.

The flagellate *Spironucleus salmonicida* was not detected in cleaner fish in 2025. The parasite was last detected in lumpfish at one location in 2023.

*Nucleospora cyclopteri* was not detected in lumpfish by the Norwegian Veterinary Institute in 2025 and has not been detected in recent years. As previously mentioned, it is considered likely that *N. cyclopteri* is underdiagnosed due to difficulties in detection using routine histological examination.

## Other diseases and health issues

No cases of nephrocalcinosis were detected in diagnostic material from cleaner fish submitted to the Norwegian Veterinary Institute in 2025.

## Mortality

Mortality can be used as a rough indicator of animal welfare, and accurate mortality data are therefore essential. As noted above, more than 19 million cleaner fish were deployed in 2025, and 12.8 million were registered as dead (Norwegian Directorate of Fisheries, data as of February 2026). These figures include both fish that died naturally and fish that were euthanized and destroyed for various reasons. In addition, undocumented losses occur. Consequently, the available data have been insufficient to calculate reliable survival rates.

The Norwegian Food Safety Authority has assumed responsibility for reporting and introduced a new reporting form effective from 1 January 2026. This system aims to ensure more reliable and detailed data on cleaner fish health, welfare, and mortality. Operators are required to maintain accurate records and document the number of cleaner fish deployed, the number removed alive for reuse or euthanasia, and the number of dead cleaner fish removed.

## The Annual Survey

Regarding health problems in ballan wrasse and lumpfish during the hatchery phase, respondents were asked to rank the three most significant health issues that, in their assessment, resulted in mortality, poor growth, and reduced welfare (5 respondents), or that were increasing in prevalence (4 respondents). As in previous years, fin erosion was ranked as the most significant problem for ballan wrasse, followed by wounds and suboptimal husbandry, which shared second place (Appendix D2). These conditions negatively affect growth.

The rankings correspond well with freetext responses, which emphasize the need for better tank design tailored to the natural habitat of the fish. The importance of size grading to reduce aggression—thereby reducing fin damage and wounds—was also highlighted, as was the need for stricter grading criteria based on fin condition. For lumpfish, the number of respondents was too low to provide a representative assessment (Appendix D1).

For wrasse kept in sea cages together with salmonids, emaciation, fin erosion, and handling were identified as the most important causes of mortality, reduced welfare, and increasing prevalence (Appendix E2). For lumpfish cohabiting with salmonids, emaciation, handling, and atypical furunculosis were identified as the most important contributing factors (Appendix E1).

Emaciation may indicate insufficient feed availability, inability to access feed, inappropriate feed quality, or disease-related anorexia. In freetext responses, several respondents emphasized the importance of appropriate feed tailored to the species and regular, frequent feeding. The Norwegian Food Safety Authority has assessed feeding requirements in several appeals decisions, emphasizing that fish must be fed at a fixed time and place, and that feed must be suitable. Cooked crab, frozen mackerel, or ground salmon feed are not considered appropriate feed. Wrasse are more timid than lumpfish, and respondents emphasized the importance of feeding the fish in areas where they naturally congregate.

Handling continued to be ranked as a significant welfare challenge. Cleaner fish tolerate crowding, netting, and pumping less well than salmonids, and such practices should therefore be avoided. As noted previously, wrasses may act as healthy carriers of bacteria causing atypical

furunculosis, and when fish of different origins are mixed in stressful environments, disease outbreaks may occur. No effective vaccine is available, and treatment of sick cleaner fish in sea cages is not practically feasible. Diseased cleaner fish may therefore contribute to an increased infection pressure within the salmon farming environment.

## Additional Survey Findings

As in previous years, respondents were asked which experiences had improved or impaired welfare in cleaner fish. The question was answered by 22 respondents. Fish health professionals remain critical of current practices, and discontinuation of cleaner fish use was also mentioned in 2025. For the hatchery phase, operational factors such as husbandry routines, grading, and similar practices were highlighted. Several respondents emphasized the importance of thorough grading prior to sea transfer.

For cleaner fish in sea cages with salmonids, the same challenges were repeatedly identified. Respondents emphasized the importance of systematic planning and followup, adequate shelter, sufficient feeding, and gentle handling during delousing and net cleaning.

Fourteen respondents reported experiences related to discontinuation of cleaner fish use. Several reported increased lice pressure and a higher frequency of delousing, while, as in previous years, others reported positive outcomes following discontinuation.

In the Fish Health Report survey, respondents were asked whether postdeployment mortality of cleaner fish was approximately the same, higher, lower, or unknown compared to previous years. For lumpfish, 19 respondents replied: five reported lower mortality, five reported approximately the same mortality, and six responded “do not know.” For wrasse, 25 respondents replied: seven reported lower mortality, 12 reported approximately the same mortality, and six responded “do not know.” These responses indicate that fish health professionals still have limited overview of cleaner fish mortality in sea cages. Improved data quality is expected following the introduction of the new reporting system.

Freetext responses again identified weather and current conditions as factors negatively affecting cleaner fish welfare. Lumpfish were also described as being subjected to

unnecessary disease burden due to difficulties in sourcing cleaner fish and implementing timely euthanasia.

### Observed Effect on Salmon Lice

The effectiveness of cleaner fish remains uncertain. It is unclear to what extent salmon and cleaner fish interact within sea cages, due to large cage volumes and differing habitat preferences. Uncertainty also remains regarding the cleaner fish’s ability to consume lice. Nevertheless, some producers report beneficial effects. Freetext responses emphasize that sites with dedicated personnel who systematically follow up on lumpfish health and grazing activity tend to achieve better outcomes.

Experimental studies conducted at small scale have shown variable effect, with the highest efficiency observed in land-based tank trials. Largescale industry data analyzed by the Institute of Marine Research indicate only limited overall benefits. Cleaner fish size is correlated with grazing efficiency. Smaller lumpfish (<50 g) are most effective lice grazers, whereas fish approaching 150 g frequently shift to consuming salmon feed. Rapid growth therefore limits the period during which lumpfish function effectively as cleaner fish.

Fish health professionals were also asked in 2025 to assess the perceived effectiveness of lumpfish, farmed ballan

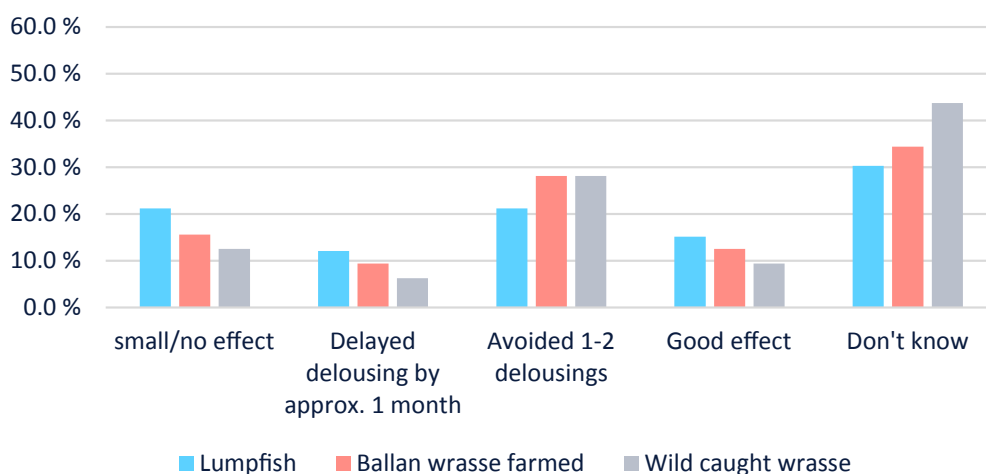
wrasse, and wildcaught wrasse against salmon lice (Figure 14.4). For lumpfish, five of 33 respondents reported good effect, representing a slight increase from 2024, while seven reported little or no effect. For farmed ballan wrasse and wildcaught wrasse, four and three of 32 respondents, respectively, reported good effect, while five and four reported little or no effect. Approximately onethird of respondents answered “do not know” in all groups.

For farmed ballan wrasse and wildcaught wrasse, approximately onethird of respondents reported avoiding one to two delousing events per salmon production cycle, with a slightly lower proportion for lumpfish. Fewer respondents reported postponing delousing by approximately one month. The high proportion of “do not know” responses and the relatively low proportion reporting good effect illustrate the substantial uncertainty regarding cleaner fish efficacy.

### Assessment of Health and Welfare in Cleaner Fish

Cleaner fish have been used in Norwegian aquaculture since the late 1980s. Despite ongoing development efforts and systematic improvements—including vaccination attempts, provision of shelter, specialized feed, and feeding strategies—many of the same factors continue to contribute to poor welfare and high mortality. In Mowi’s annual report of 1993, the following was stated:

Experienced effect of cleaner-fish against lice



Fish Health Report 2025, Norwegian Veterinary Institute

Figure 14.4 Fish health professionals’ assessment of the lice grazing effectiveness of lumpfish (N = 33), farmed ballan wrasse (N = 32), and wild caught wrasse (N = 32).

“In trials with biological delousing, survival of wrasse has varied, but most producers have experienced that the majority of wrasse disappear from the cages during late autumn or winter. Possible causes: disease, escape, injuries during salmon handling, deadfish collection, predation by salmon, starvation, temperature, lack of shelter, stress from water currents.”

The underlying reason is that cleaner fish, under current conditions, lack the capacity to adapt to or cope with salmon farming environments.

In 2025, producers reported 75 serious welfare incidents involving cleaner fish in sea cages to the Norwegian Food Safety Authority. Approximately one-third were reported as “other,” with freetext descriptions including net cleaning (pressurewashing injuries and mortality), harvesting/sorting/removal of weak or diseased fish, wrasse seeking shelter among dead salmon and being removed during deadfish pumping, sudden temperature drops, strong currents, and disease investigations. Nearly as many incidents were reported as “unexplained mortality.”

Fewer incidents were attributed to “disease,” primarily categorized as other disease, with references to winter ulcers caused by *Moritella viscosa*, pressurewashing injuries, emaciation, various ulcer conditions and ulcer-associated bacteria, and gill inflammation/disease. Fin erosion and atypical furunculosis were also mentioned. A smaller number of incidents were related to deployment mortality, pumping (sorting/training/counting), natural forces/storms, and algae or jellyfish blooms.

Corearing multiple fish species within the same sea cage presents biosecurity challenges, particularly when wild-caught cleaner fish or fish originating from different geographic regions are introduced. Transmission of *Paramoeba perurans* between cleaner fish and farmed salmon has previously been demonstrated experimentally, and cleaner fish may potentially act as vectors for other pathogens. Detection of *Spironucleus salmonicida* in both salmon and lumpfish at a single site in 2022 suggests potential interspecies transmission.

In 2024, outbreaks of *Piscirickettsia salmonis* were detected in salmon at several sites in northern Norway. Although no corresponding infections have been reported in cleaner fish

under Norwegian conditions, outbreaks have previously been reported in lumpfish in Ireland, and the Norwegian Scientific Committee for Food and Environment has identified the bacterium as highly relevant in the context of lumpfish import. Monitoring of pathogen dynamics in multispecies farming systems is therefore essential, particularly for pathogens with marine reservoirs.

Assessing the effectiveness of measures aimed at improving survival and welfare remains challenging. Cleaner fish production continues to be associated with high mortality and compromised welfare. Limited knowledge regarding the actual number of cleaner fish that die in sea cages—and at which stage of production—makes it difficult to estimate mortality rates and to evaluate the impact of welfare improvements.

The mortality target outlined in the Animal Welfare White Paper (approximately 5%) applies to all farmed fish species and reflects the intrinsic value of animals as stipulated in the Animal Welfare Act. It is unknown whether any producers currently achieve this target for cleaner fish. By comparison, mortality rates below 5% are achievable for Atlantic salmon in the marine phase.

The Norwegian Council for Animal Ethics has stated that continued use of cleaner fish is not ethically defensible. External input to the Animal Welfare White Paper also indicates broad consensus that cleaner fish use must be phased out or discontinued unless living conditions and welfare are significantly improved. The Norwegian Veterinary Institute has previously recommended either substantial improvement in the welfare situation of cleaner fish or, more realistically, complete cessation of use as soon as possible and by no later than 2029.

A substantial reduction in cleaner fish deployment over the past five years has resulted in reduced resource allocation, which in turn affects further development efforts. However, experimental animal statistics for 2024 show an increase in cleaner fish use. For lumpfish, this increase was primarily attributable to a single welfare-focused research study involving 30,000 fish. The pronounced increase in ballan wrasse use in 2024 was due to a single developmental biology study involving 220,000 fish.

# Appendix A1:

## Health problems in juvenile salmon production

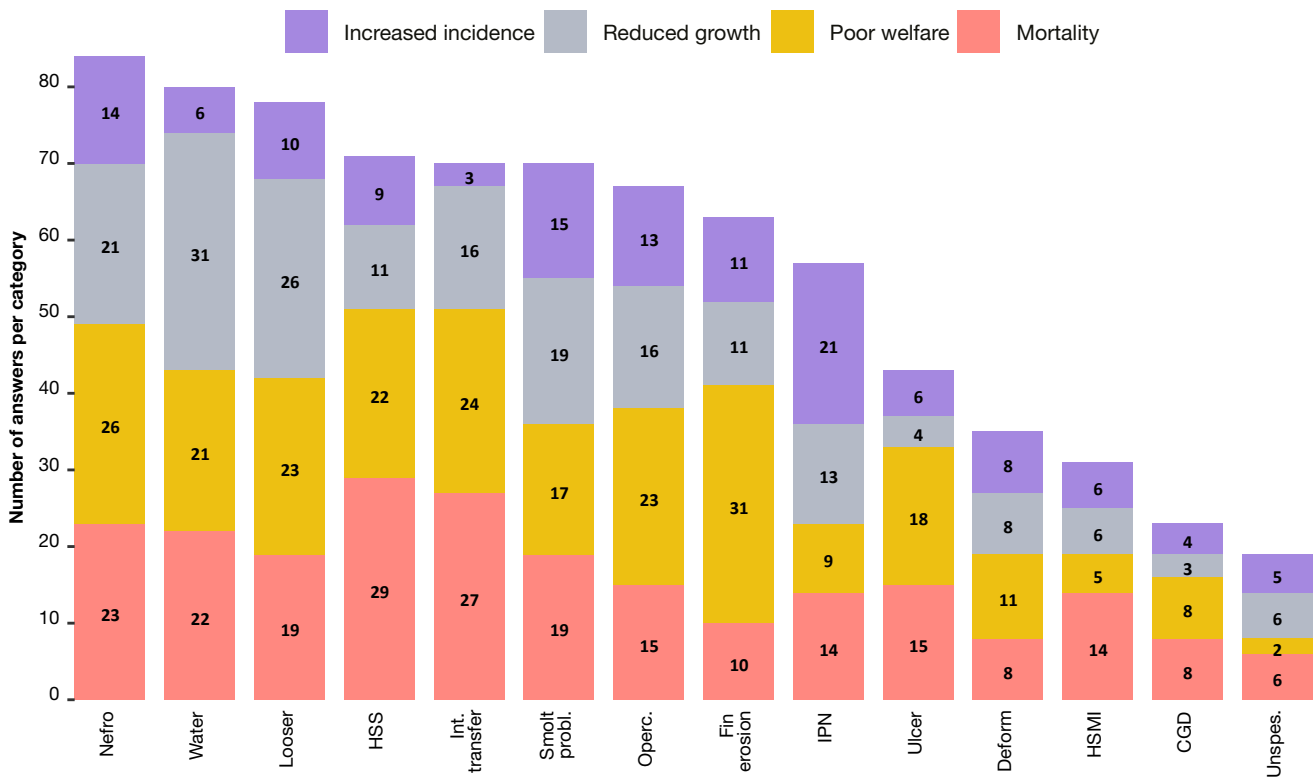
Results from the Annual Survey conducted among fish health personnel and inspectors at the Norwegian Food Safety Authority as part of the Norwegian Fish Health Report 2025. Respondents with experience in salmon hatcheries were asked to identify the five most significant fish health problems out of 28 listed, based on their contribution to mortality, reduced growth, reduced welfare, or were considered to be an increasing problem (increased prevalence).

A total of N=62 respondents provided input on mortality, N=59 on reduced growth, N=60 on reduced welfare, and N=57 on increasing prevalence.

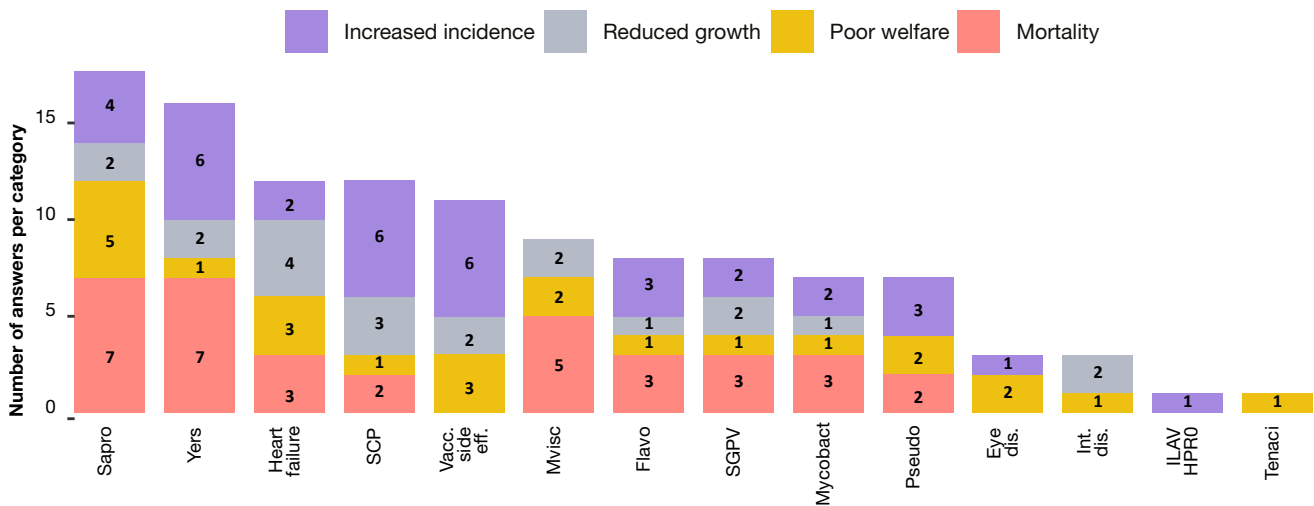
The following abbreviations refer to the health problems the respondents were asked to evaluate (only the problems selected by the respondents are shown in the figure, and are explained in the list of abbreviations below)

Cardiac disorder = cardiac disorder without detection of infectious agent  
 CGD = gill disease complex/multifactoral  
 Deform = deformities  
 Fin eros = fin erosion  
 Flavo = *Flavobacterium psychrophilum* infections  
 Furunc = Furunculosis  
 HSMI = heart and skeletal muscle inflammation  
 HSS = haemorrhagic smolt syndrome  
 Int transfer = moving fish between operational  
 IPN = infectious pancreas necrosis  
 ISAV HPRO = infection with non-virulent ISAV (ISAV HPRO)  
 Looser = runt fish, runt syndrome, emaciation  
 Mvisc = infection with *Moritella viscosa* (classic winter ulcer)  
 Nefro = nephrocalcinosis

Operc = shortened gill covers  
 Pseudo = infection with *Pseudomonas* spp.  
 Sapro = infection with *Saprolegnia* spp.  
 SGPV = salmon gill pox virus  
 Smoltprob = smoltification problems  
 SPC = single-celled parasites on gills/skin (e.g. *Ichthyobodo* spp., *Trichodina* spp.)  
 Tenaci = infection with *Tenacibaculum* spp. (non-classic winter ulcer)  
 Ulcer = skin ulcers and underlying tissues, unspecified cause  
 Unspes = unspecified diseases  
 Vacc = vaccine side effects  
 Water = poor water quality departments with different water qualities (e.g. RAS to flow-through)  
 Yers = infection with *Yersinia ruckeri* (yersinosis)



Fish Health Report 2025, Norwegian Veterinary Institute



Fish Health Report 2025, Norwegian Veterinary Institute

# Appendix A2:

## Health problems in juvenile rainbow trout production

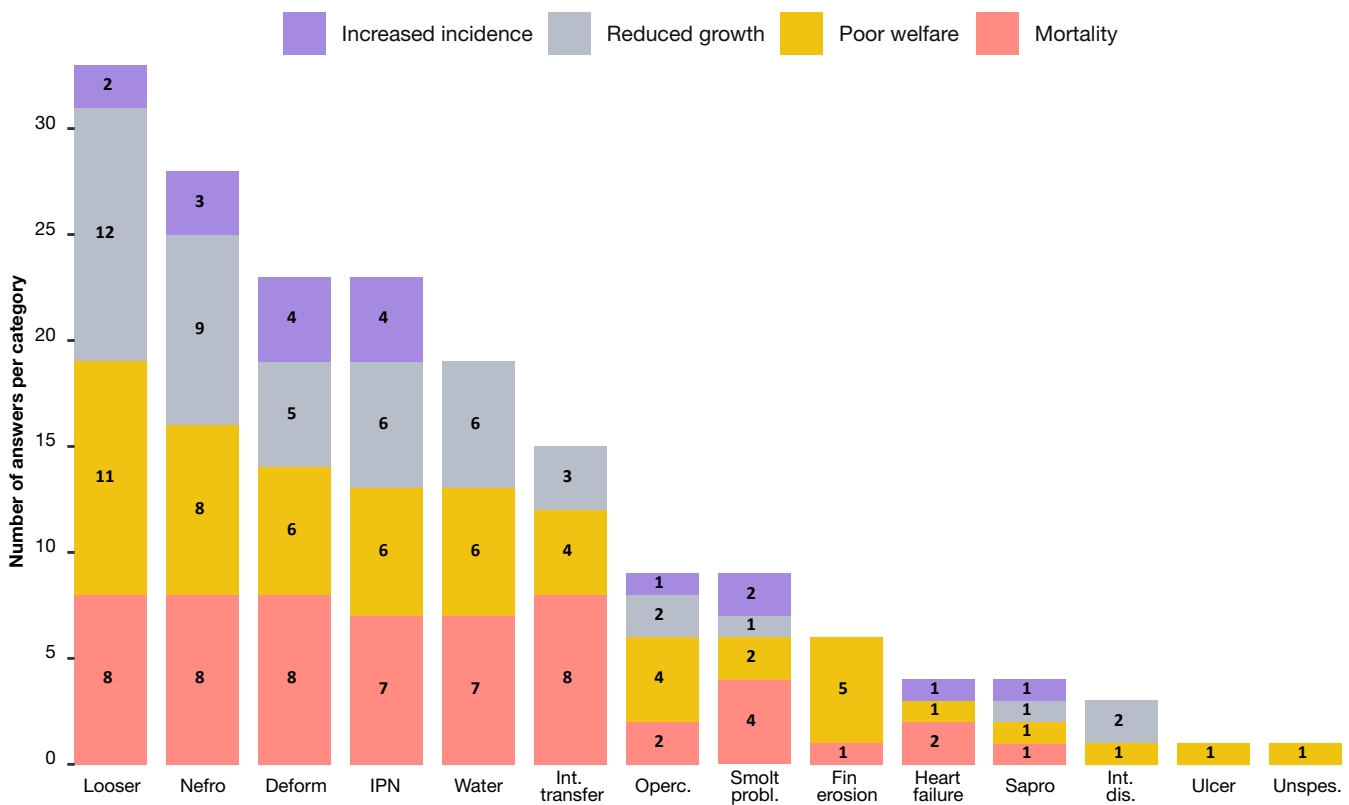
Results from the Annual Survey conducted among fish health personnel and inspectors at the Norwegian Food Safety Authority as part of the Norwegian Fish Health Report 2025. Respondents with experience in rainbow trout hatcheries were asked to identify the five most significant fish health problems out of 25 listed, based on their contribution to mortality, reduced growth, reduced welfare, or were considered to be an increasing problem (increased

prevalence). A total of N=14 respondents provided input on mortality, N=14 on reduced growth, N=13 on reduced welfare, and N=9 on increasing prevalence.

The following abbreviations refer to the health problems the respondents were asked to evaluate (only the problems selected by the respondents are shown in the figure, and are explained in the list of abbreviations below):

- Deform = deformities
- Fin eros = fin erosion
- Flavo = *Flavobacterium psychrophilum* infections
- HSMI like = heart and skeletal like muscle inflammation
- Int transfer = moving fish between operational
- IPN = infectious pancreas necrosis
- Looser = runt fish, runt syndrome, emaciation
- Nefro = nephrocalcinosis
- Operc = shortened gill covers
- Pseudo = infection with *Pseudomonas* spp.

- Sapro = infection with *Saprolegnia* spp.
- Smoltprob = smoltification problems
- Unspes = Unspecified disease
- Ulcer = skin ulcers and underlying tissues, unspecified cause
- Vacc = vaccine side effects
- Water = poor water quality departments with different water qualities (e.g. RAS to flow-through)



Fish Health Report 2025, Norwegian Veterinary Institute

# Appendix A3:

## Health problems in juvenile cod production

Results from the Annual Survey conducted among fish health personnel and inspectors at the Norwegian Food Safety Authority as part of the Norwegian Fish Health Report 2025. Respondents with experience in cod hatcheries were asked to identify the five most significant fish health problems out of 26 listed, based on their contribution to mortality, reduced growth, reduced welfare, or were considered to be an increasing problem (increased prevalence). A

total of N=7 respondents provided input on mortality, N=7 on reduced growth, N=7 on reduced welfare, and N=3 on increasing prevalence.

The following abbreviations refer to the health problems the respondents were asked to evaluate (only the problems selected by the respondents are shown in the figure, and are explained in the list of abbreviations below):

- Atyp. asal = Atypical furunculosis
- Spinal deform. = Spinal deformities
- Fin eros = fin erosion
- Gran infl = granulomatous inflammation, unspecified cause
- Heart failure = heart failure
- Int dis = intestinal disorders (eg. intestine twist or invagination)

- Int inf = intestinal inflammation without invagination
- Jaw deform = jaw deformities
- Looser = runt fish, runt syndrome, emaciation
- Mvisc = infection with *Moritella viscosa*
- Trichod = *Trichodina* spp.
- Vibrio = vibriosis



Fish Health Report 2025, Norwegian Veterinary Institute

# Appendix B1:

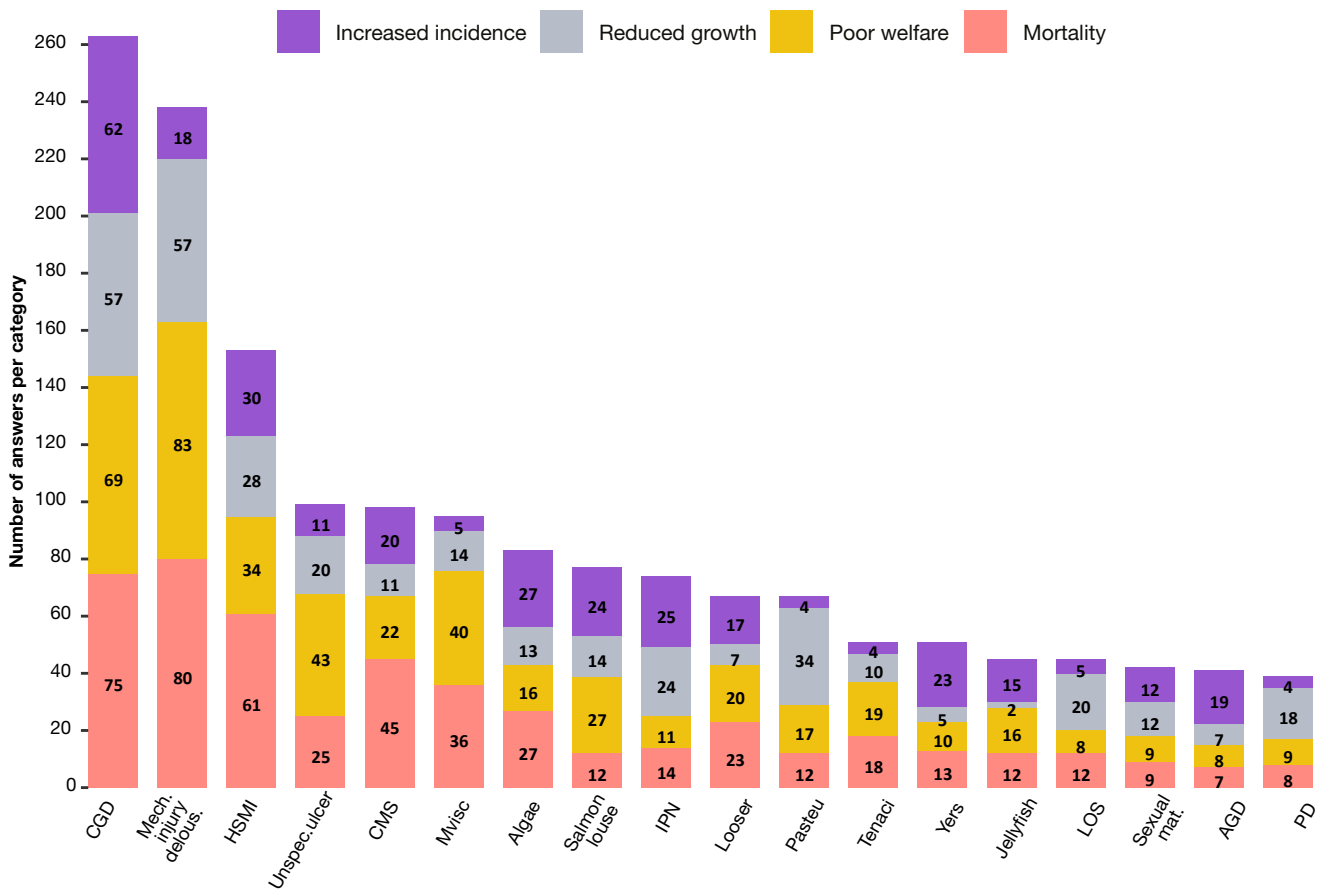
## Health problems during ongrowing salmon

Results from the Annual Survey conducted among fish health personnel and inspectors at the Norwegian Food Safety Authority as part of the Norwegian Fish Health Report 2025. Respondents with experience in ongrowing salmon facilities were asked to identify the five most significant fish health problems out of 38 listed, based on their contribution to mortality, reduced growth, reduced welfare, or were considered to be an increasing problem (increased

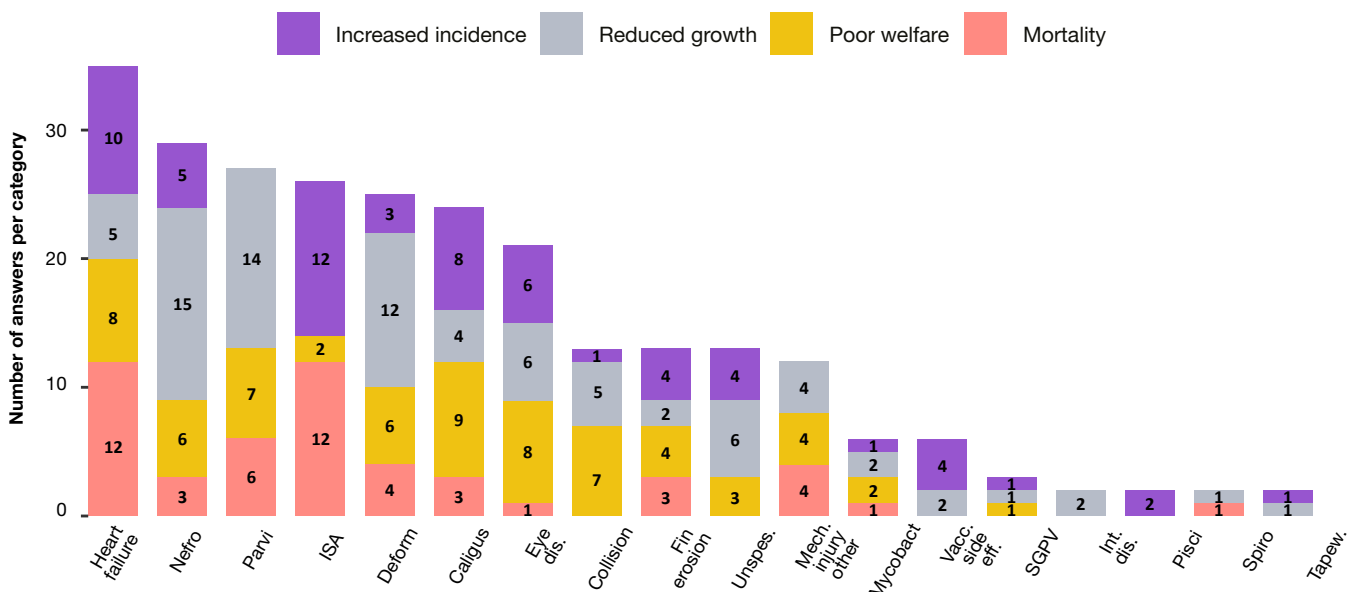
prevalence). A total of N=119 respondents provided input on mortality, N=116 on reduced growth, N=119 on reduced welfare, and N=114 on increasing prevalence.

The following abbreviations refer to the health problems the respondents were asked to evaluate (only the problems selected by the respondents are shown in the figure, and are explained in the list of abbreviations below):

AGD	= amoebic gill disease	Mvisc	= infection with <i>Moritella viscosa</i> (classic winter ulcer)
Algae	= algae	Mycobact	= infection with Mycobacteria
BKD	= Bacterial kidney disease	Nefro	= nephrocalcinosis
Caligus	= <i>Caligus elongatus</i> (grazing injuries following infestation with <i>C. elongatus</i> )	Parvi	= infection with <i>Parvicapsula pseudobranchicola</i> (parvicapsulosis)
CGD	= gill disease complex/multifactoral	Pasteu	= infection with Pasteurella sp. (pasteurellosis)
CMS	= cardiomyopathy syndrome	PD	= Pancreas disease
Collision	= jumping injuries, collision with equipment in cage	Salmon louse	= salmon lice (grazing injuries following infection with <i>Lepeoptheirus salmonis</i> )
Deform	= deformities	Sexual mat	= sexual maturation
Fin eros	= fin erosion	SGPV	= salmon gill pox virus (gill disease due to SGPV)
HSMI	= heart and skeletal muscle inflammation	Smolt probl	= smoltification problems
IPN	= infectious pancreas necrosis	Tapew	= Tapeworm
ISA	= Infectious salmon anaemia (infection with ISAV HPR-deleted)	Tenaci	= infection with <i>Tenacibaculum</i> spp. (non-classic winter ulcer)
Jellyfish	= jellyfish	unspes	= unspecified disease
Looser	= runt fish, runt syndrome, emaciation	ulcer	= skin ulcers and underlying tissues, unspecified cause
Mech injury delouse	= mechanical harm related to delousing	Vacc	= vaccine side effects
Mech injury other	= mechanical harm not related to delousing, e.g. after manual handling, transport	Unspes	= unspecified disease
		yers	= infection with <i>Yersinia ruckeri</i> (yersinosis)



Fish Health Report 2025, Norwegian Veterinary Institute



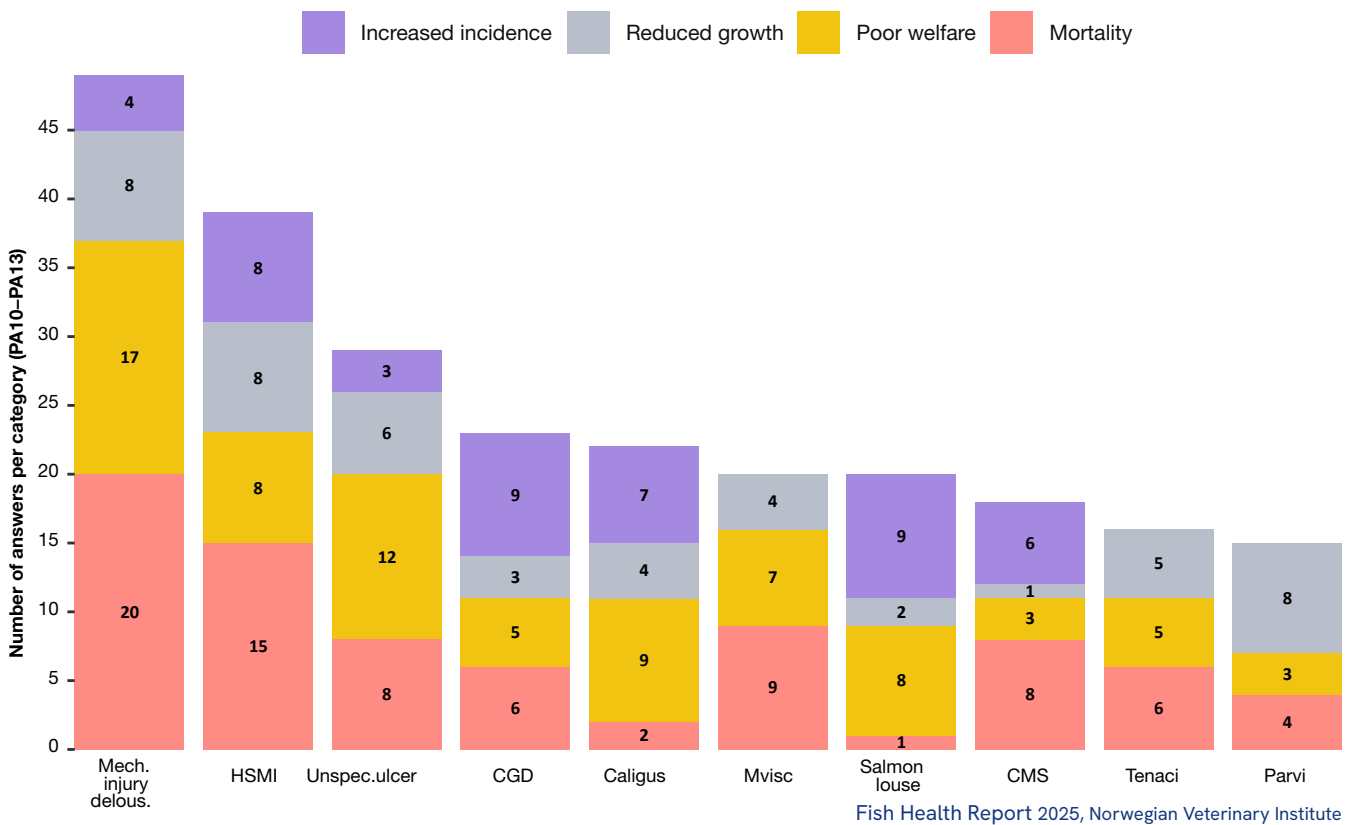
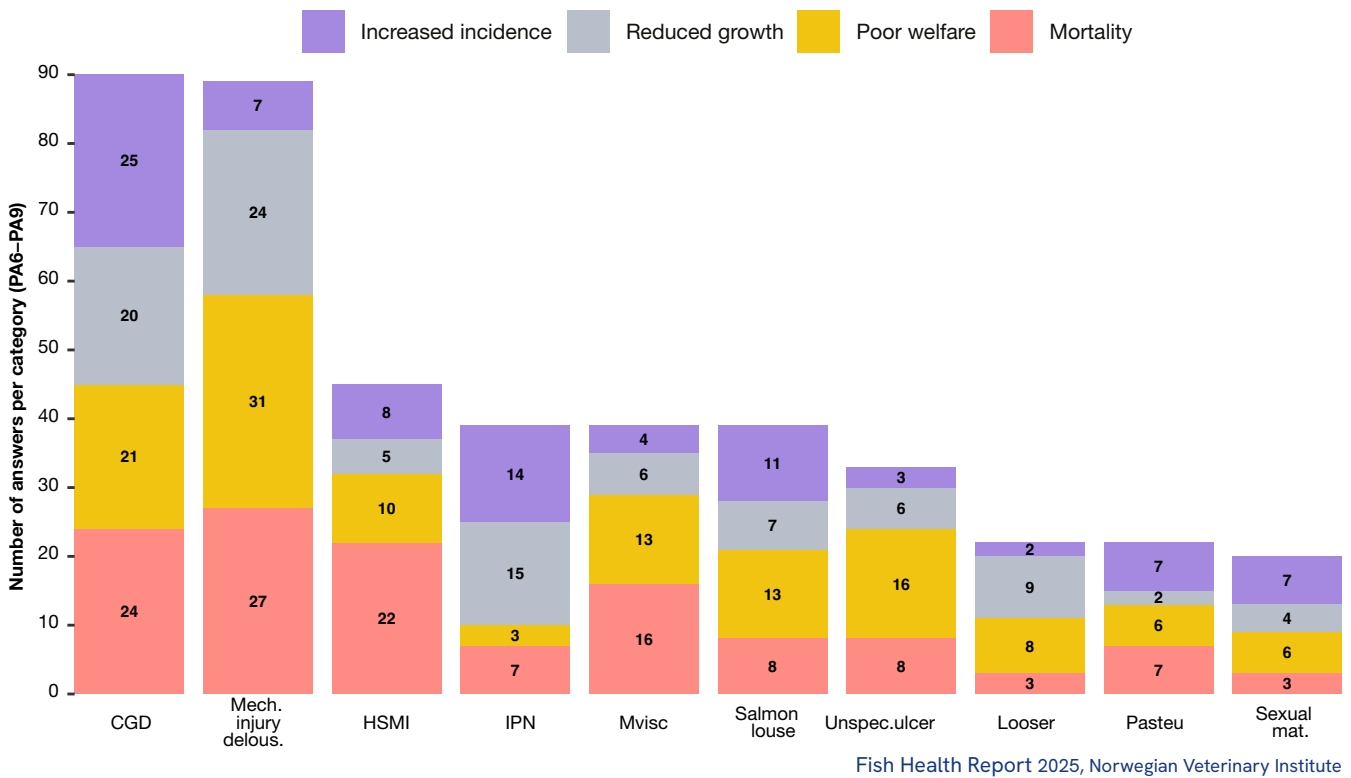
Fish Health Report 2025, Norwegian Veterinary Institute

# Appendix B2:

## Health Problems in salmon facilities distributed by production areas (PA)

The ten most frequently reported health problems in salmon farming facilities, based on the number of check-marks per combined production area: PA1-PA5 (N=41), PA6-PA9 (N=39), and PA10-PA13 (N=26). Respondents with experience in overlapping areas were excluded from the data set. See Appendix B1 for explanations of abbreviations and the complete overview for the entire country.





# Appendix B3:

## Health problems during ongrowing rainbow trout

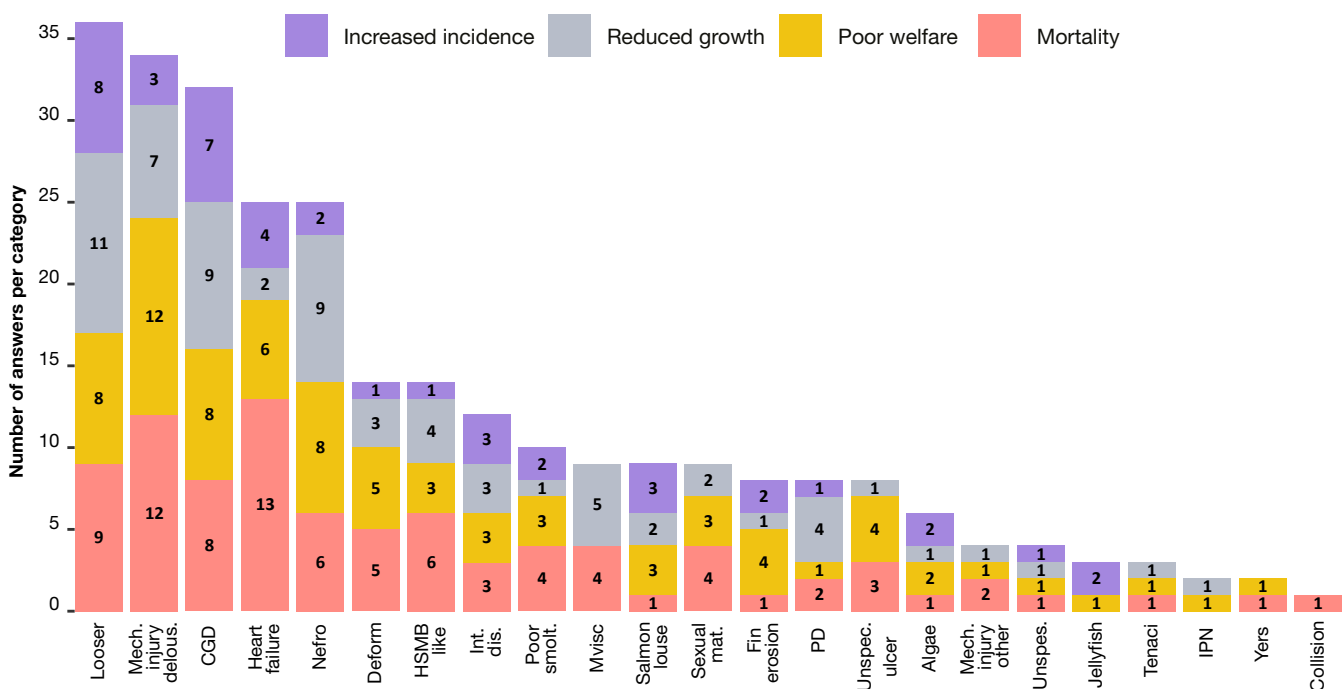
Results from the Annual Survey conducted among fish health personnel and inspectors at the Norwegian Food Safety Authority as part of the Norwegian Fish Health Report 2025. Respondents with experience in ongrowing rainbow trout facilities were asked to identify the five most significant fish health problems out of 32 listed, based on their contribution to mortality, reduced growth, reduced welfare, or were considered to be an increasing problem

(increased prevalence). A total of N=23 respondents provided input on mortality, N=22 on reduced growth, N=23 on reduced welfare, and N=19 on increasing prevalence.

The following abbreviations refer to the health problems the respondents were asked to evaluate (only the problems selected by the respondents are shown in the figure, and are explained in the list of abbreviations below):

- Algae = algal bloom
- BKD = Bacterial kidney disease
- CGD = gill disease complex/multifactoral
- Deform = deformities
- Fin eros = fin erosion
- Heart failure = heart failure, not related to known infectious disease
- HSMB-like = heart and skeletal muscle like inflammation
- IPN = infectious pancreas necrosis
- Jellyfish = jellyfish
- Looser = runt fish, runt syndrome, emaciation

- Mech injury delouse = mechanical harm related to delousing
- Mech injury other = mechanical harm not related to delousing, e.g. after manual handling, transport
- Mvisc = infection with *Moritella viscosa* (classic winter ulcer)
- Nefro = nephrocalcinosis
- PD = Pancreas disease
- Sexual mat = sexual maturation
- unspes = unspecified disease
- ulcer = skin ulcers and underlying tissues, unspecified cause



Fish Health Report 2025, Norwegian Veterinary Institute

# Appendix B4:

## Health problems during ongoing cod

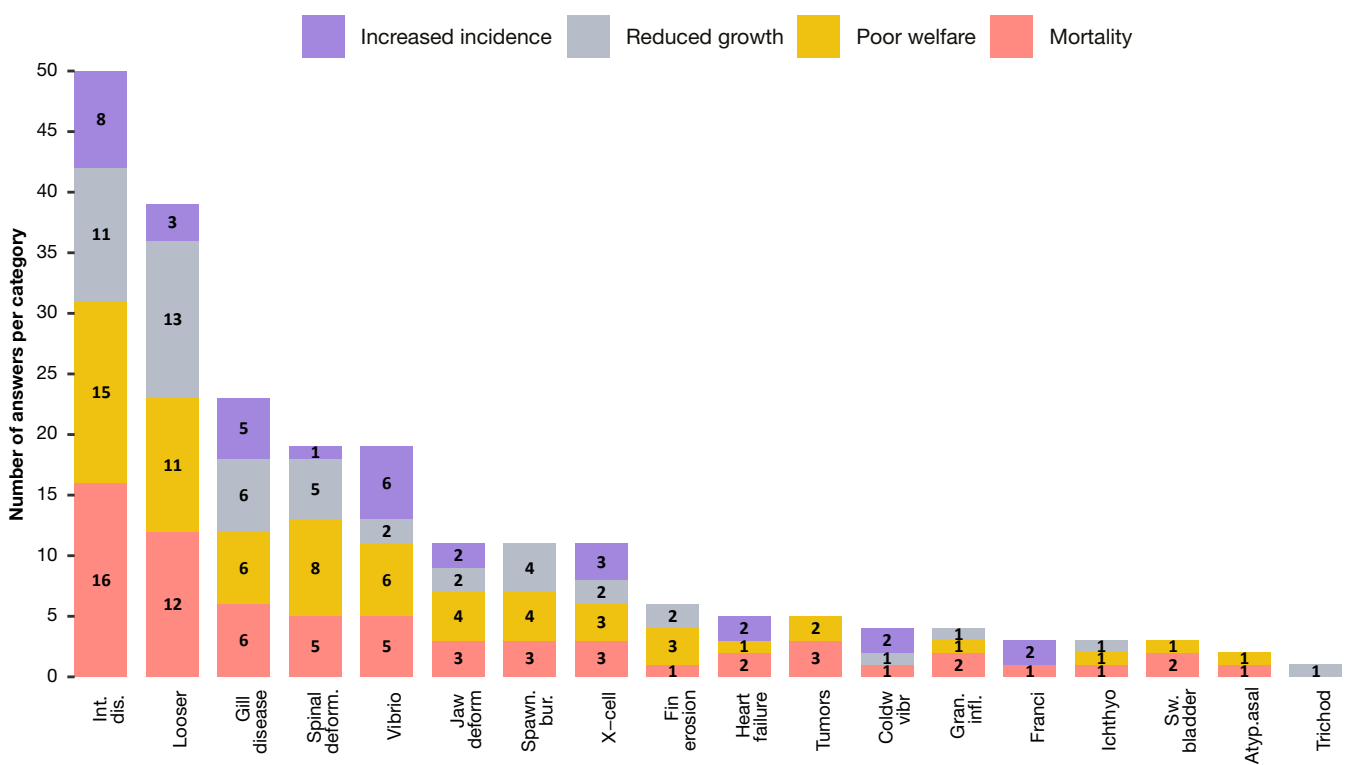
Results from the Annual Survey conducted among fish health personnel and inspectors at the Norwegian Food Safety Authority as part of the Norwegian Fish Health Report 2025. Respondents with experience in on-growing cod facilities were asked to identify the five most significant fish health problems out of 28 listed, based on their contribution to mortality, reduced growth, reduced welfare, or were considered to be an increasing problem (increased

prevalence). A total of N=17 respondents provided input on mortality, N=16 on reduced growth, N=17 on reduced welfare, and N=13 on increasing prevalence.

The following abbreviations refer to the health problems the respondents were asked to evaluate (only the problems selected by the respondents are shown in the figure, and are explained in the list of abbreviations below):

- Atyp. asal = Atypical furunculosis
- CGD = gill disease complex/multifactorial
- Spinal deform = spinal deformities
- Fin eros = fin erosion
- Gran infl = granulomatous inflammation, unspecified cause
- Heart failure = heart failure
- Int disord = Intestinal disorders (eg. intestine twist or invagination)
- Int infl = intestinal inflammation without invagination

- Jaw deform = jaw deformities
- Looser = runt fish, runt syndrome, emaciation
- Mvisc = infection with *Moritella viscosa*
- Sw bladder = swim bladder puncture/other pressure-related problems
- Spawn. rupt. = spawning rupture
- Trichod = *Trichodina* spp.
- Vacc = vaccine side effects
- Vibrio = vibriosis



Fish Health Report 2025, Norwegian Veterinary Institute

# Appendix C1:

## Health problems in broodstock salmon production\*

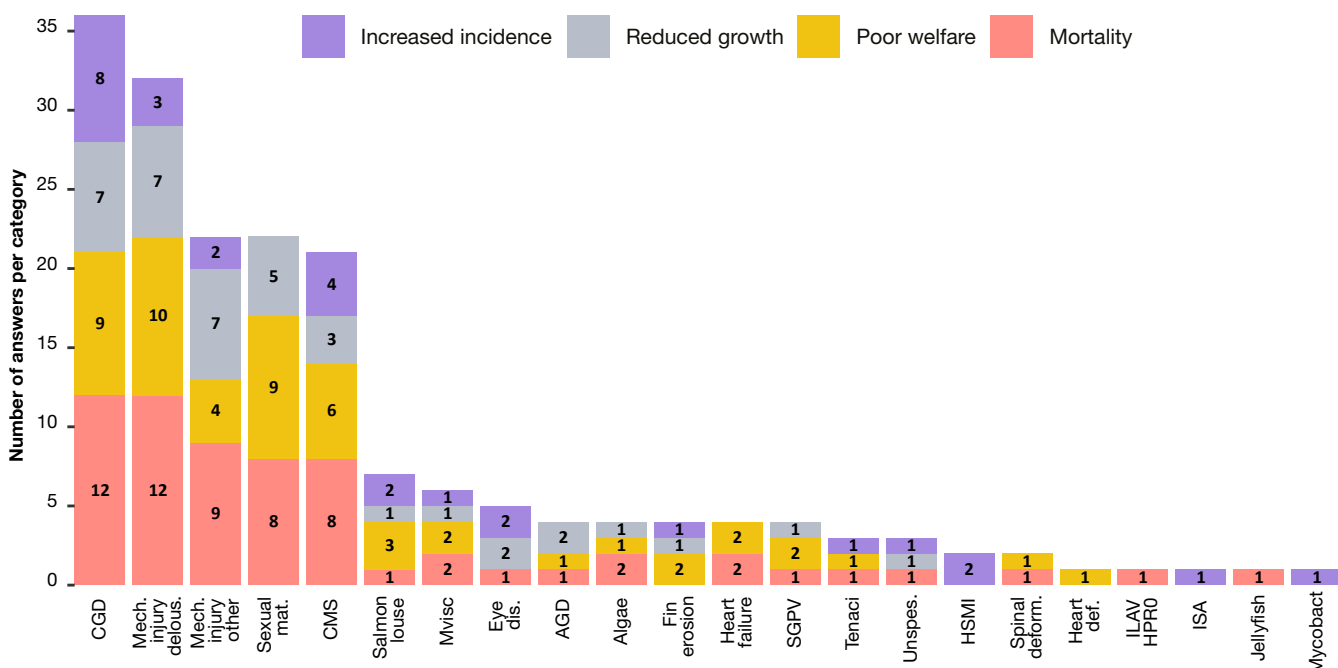
Results from the Annual Survey conducted among fish health personnel and inspectors at the Norwegian Food Safety Authority as part of the Norwegian Fish Health Report 2025. Respondents with experience in broodstock salmon facilities were asked to identify the five most significant fish health problems out of 32 listed, based on their contribution to mortality, reduced growth, reduced welfare, or were considered to be an increasing problem (increased

prevalence). A total of N=21 respondents provided input on mortality, N=18 on reduced growth, N=21 on reduced welfare, and N=14 on increasing prevalence.

The following abbreviations refer to the health problems the respondents were asked to evaluate (only the problems selected by the respondents are shown in the figure, and are explained in the list of abbreviations below):

- AGD = amoebic gill disease
- CGD = gill disease complex/multifactoral
- CMS = cardiomyopathy syndrome
- Fin eros = fin erosion
- HSMI = heart and skeletal muscle inflammation
- IPN = infectious pancreas necrosis
- ISA HPR 0 = Infection with non-virulent infectious salmon anemia (ISAV HPR0)
- Jellyfish = jellyfish
- Mech injury delouse = mechanical harm related to delousing
- Mech injury other = mechanical harm not related to delousing, e.g. after manual handling, transport

- Mvisc = infection with *Moritella viscosa* (classic winter ulcer)
- Mycobact = infection with Mycobacteria
- Parvi = infection with *Parvicapsula pseudobranchicola* (parvicapsulosis)
- Pasteu = infection with *Pasteurella* sp. (pasteurellosis)
- Salmon louse = salmon lice (grazing injuries following infection with *Lepeoptheirus salmons*)
- Sexual mat = sexual maturation
- SGPV = salmon gill pox virus (gill disease due to SGPV)
- unspes = unspecified disease



Fish Health Report 2025, Norwegian Veterinary Institute

# Appendix D1:

## Health problems in juvenile lumpfish production

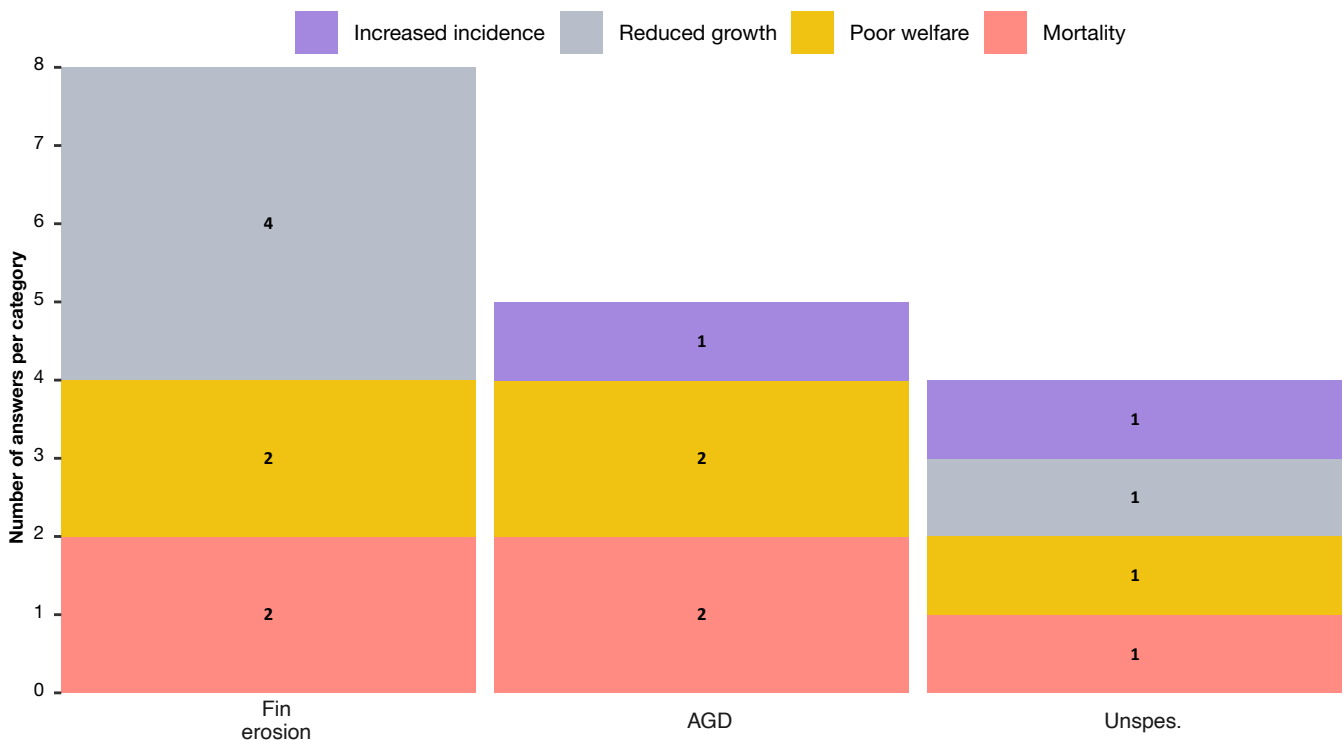
Results from the Annual Survey conducted among fish health personnel and inspectors at the Norwegian Food Safety Authority as part of the Norwegian Fish Health Report 2025. Respondents with experience in juvenile lumpfish production were asked to identify the three most significant fish health problems out of 12 listed, based on their contribution to mortality, reduced growth, reduced welfare, or were considered to be an increasing problem (increased

prevalence). A total of N=4 respondents provided input on mortality, N=3 on reduced growth, N=4 on reduced welfare, and N=2 on increasing prevalence.

The following abbreviations refer to the health problems the respondents were asked to evaluate (only the problems selected by the respondents are shown in the figure, and are explained in the list of abbreviations below):

- Atyp asal = atypical furunculosis (infection with atypical *Aeromonas salmonicida*)
- Fin eros = fin erosion
- Fungus = Fungal infection

- Sub rearing = suboptimal care
- Ulcer = skin ulcers and underlying tissues, unspecified cause
- Unspes = unspecified disease



Fish Health Report 2025, Norwegian Veterinary Institute

# Appendix D2:

## Health problems in juvenile wrasse production

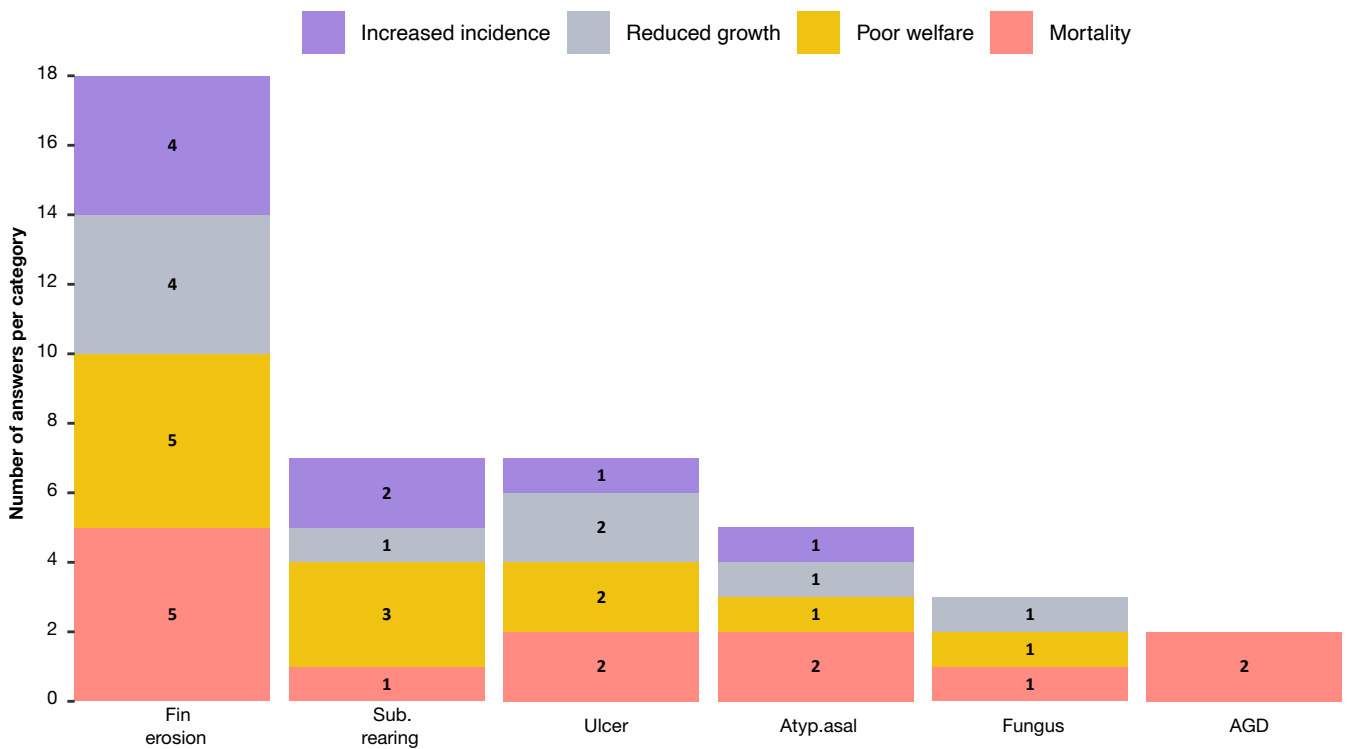
Results from the Annual Survey conducted among fish health personnel and inspectors at the Norwegian Food Safety Authority as part of the Norwegian Fish Health Report 2025. Respondents with experience in juvenile wrasse production were asked to identify the three most significant fish health problems out of 10 listed, based on their contribution to mortality, reduced growth, reduced welfare, or were considered to be an increasing problem

(increased prevalence). A total of N=5 respondents provided input on mortality, N=5 on reduced growth, N=5 on reduced welfare, and N=4 on increasing prevalence.

The following abbreviations refer to the health problems the respondents were asked to evaluate (only the problems selected by the respondents are shown in the figure, and are explained in the list of abbreviations below):

- AGD = amoebic gill disease
- Atyp asal = atypical furunculosis (infection with atypical *Aeromonas salmonicida*)
- Fin eros = fin erosion

- Fungus = fungal infection
- Sub rearing = suboptimal care
- Ulcer = skin ulcers and underlying tissues
- Unspes = unspecified disease



Fish Health Report 2025, Norwegian Veterinary Institute

# Appendix E1:

## Health problems in lumpfish held with ongrowing salmon

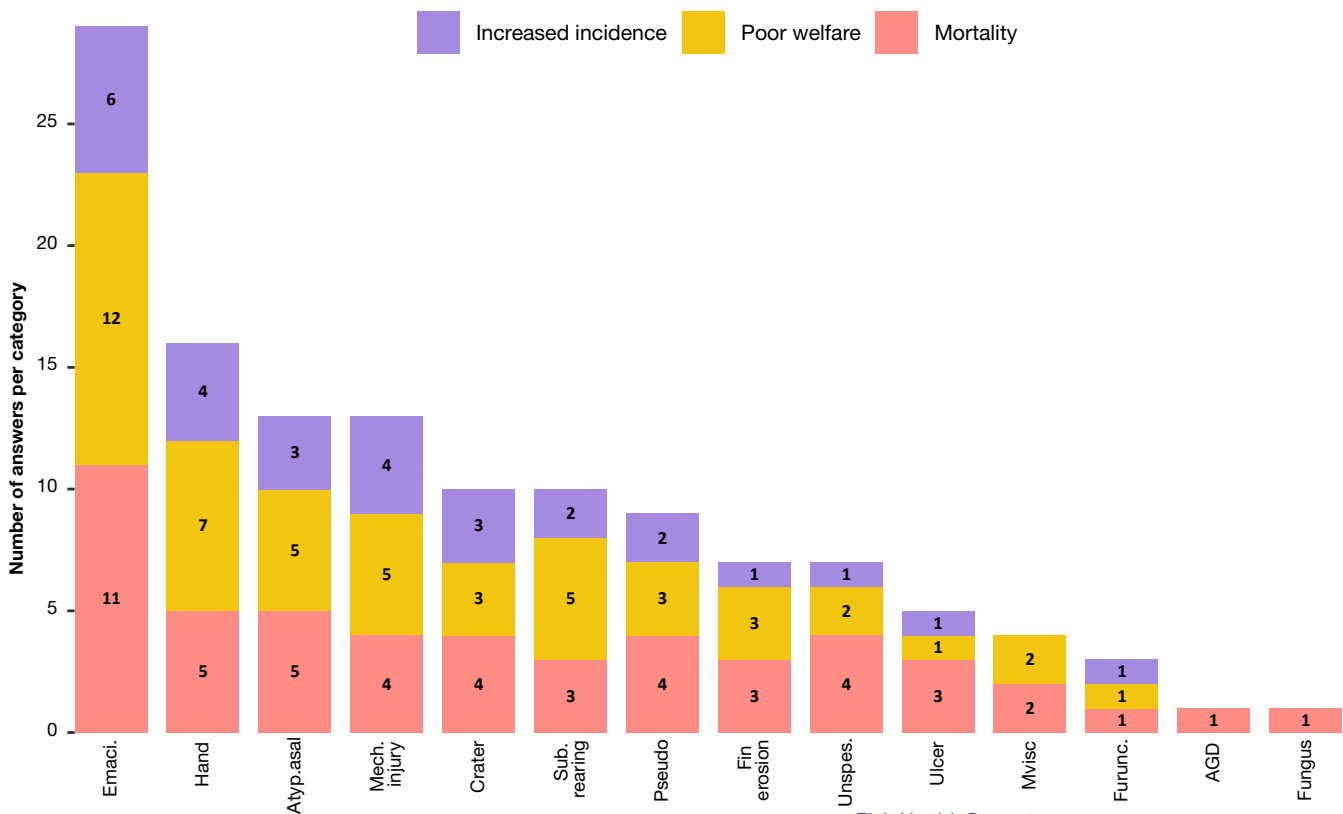
Results from the Annual Survey conducted among fish health personnel and inspectors at the Norwegian Food Safety Authority as part of the Norwegian Fish Health Report 2025. Respondents with experience in juvenile wrasse production were asked to identify the three most significant fish health problems out of 20 listed, based on their contribution to mortality, reduced welfare, or were considered to be an increasing problem (increased prevalence).

A total of N=20 respondents provided input on mortality, N=20 on reduced welfare, and N=14 on increasing prevalence.

The following abbreviations refer to the health problems the respondents were asked to evaluate (only the problems selected by the respondents are shown in the figure, and are explained in the list of abbreviations below):

- AGD = amoebic gill disease
- Atyp asal = atypical furunculosis (infection with atypical *Aeromonas salmonicida*)
- Caligus = *Caligus elongatus* (grazing injuries following infestation with *C. elongatus*)
- Crater = crater disease (infection with *Tenacibaculosis* spp.)
- Emaci = emaciation
- Fin eros = fin erosion
- Flavi = lumpfish flavivirus
- Furunk = furunculosis

- Hand = mortality due to handling
- Med injury = mortality related to medical delousing
- Mech injury = mortality not related to medical delousing
- Mvisc = infection with *Moritella viscosa*
- Pasteu = infection with *Pasteurella* sp. (pasteurellosis)
- Pseudo = infection with *Pseudomonas anguilliseptica*
- Sub rearing = suboptimal care
- Ulcer = skin ulcers and underlying tissues, unspecified cause
- Unspes = unspecified disease
- Vibrio = vibriosis (infection with *Vibrio* spp.)



Fish Health Report 2025, Norwegian Veterinary Institute

# Appendix E2:

## Health problems in wrasse held with ongrowing salmon

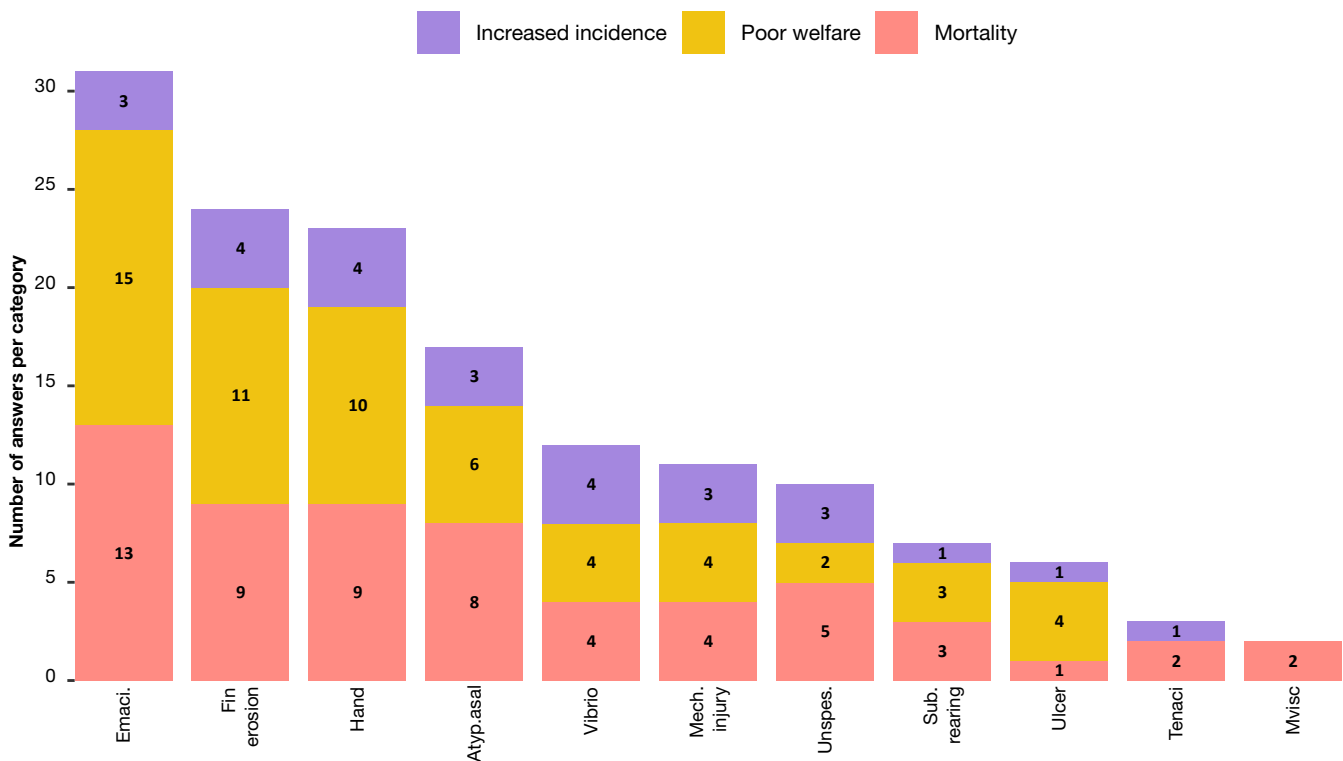
Results from the Annual Survey conducted among fish health personnel and inspectors at the Norwegian Food Safety Authority as part of the Norwegian Fish Health Report 2025. Respondents with experience in wrasse held with ongrowing salmon were asked to identify the three most significant fish health problems out of 15 listed, based on their contribution to mortality, reduced welfare, or were considered to be an increasing problem (increased prevalence).

A total of N=25 respondents provided input on mortality, N=25 on reduced welfare, and N=13 on increasing prevalence.

The following abbreviations refer to the health problems the respondents were asked to evaluate (only the problems selected by the respondents are shown in the figure, and are explained in the list of abbreviations below):

- AGD = amoebic gill disease
- Atyp asal = atypical furunculosis (infection with atypical *Aeromonas salmonicida*)
- Caligus = *Caligus elongatus* (grazing injuries following infestation with *C. elongatus*)
- Emaci = emaciation
- Fin eros = fin erosion
- Hand = mortality due to handling

- Med injury = mortality related to medical delousing
- Mech injury = mortality not related to medical delousing
- Mvisc = infection with *Moritella viscosa*
- Sub rearing = suboptimal care
- Ulcer = skin ulcers and underlying tissues, unspecified cause
- Unspes = unspecified disease
- Vibrio = vibriosis (infection with *Vibrio* spp.)



Fish Health Report 2025, Norwegian Veterinary Institute

# Acknowledgements

**The editorial committee would like to thank everyone that has contributed to the Fish Health Report 2025 and the statistical basis upon which it is based.**

Many thanks to the 143 respondents to the annual survey, and with this have contributed with important information from the field. The survey is sent to employees of various fish health services, fish health personnel employed by the various farming companies and inspectors employed by the Norwegian Food Safety Authority, amongst others:

Adele Knutson Dahl  
Amund Strand  
Anna Osland Kjærgård  
Anne Alina Sandvik  
Anne Kristin Fosshaug  
Anne Tjessem  
Anton Michael King Øyerhamn  
Aoife Westgård  
Are Strøm  
Arild Kollevåg  
Aslak Reikvam  
Astrid Lofnes  
Aud Skrudland  
Bernt k Melgård  
Birgit Stautland  
Camilla Jacobsen  
Camilla Valan Moen  
Cecilie Flatnes Nystøyl  
Cecilie Skjegen  
Charlotte Asserson  
Eirin Ottesen  
Eirin Vassbotn Ulvin  
Eline Røislien  
Elisabeth Ann Myklebust  
Elise Fure  
Emma-Lovise Fauskanger  
Endre Nordstrand  
Erika Kunickiene  
Glenn Krossøy  
Glenn Sundnes  
Hanna Bjerke-Ertenstein  
Hanna Ommedal Aa  
Hanna Torvik Knutsen  
Hedda Kjølleberg Tengesdal  
Hedda Skjold  
Hedda Wahl-Ovesen  
Hege Skjåvik

Heidi Dyregrov  
Helene Katrine Kvam  
Helle Hagenlund  
Henrik Botnevik  
Herman H. Kvinnsland  
Håkon Rydland Sæbø  
Ida Winsnes Undlien  
Ida Øien  
Ida-Charlene Dalan  
Ine Rysjedal  
Ioan Simion  
Iris Jenssen  
Jenny Lian Fjereide  
Jens Herman Anthun Meland  
Julia Eidsmo  
Julie Seem  
Kari Kaasen McDougall  
Kari Lillesund  
Katarina Sævareid  
Kjetil Steihaug Olsen  
Knut Børsheim  
Koen Van Nieuwenhove  
Kristoffer Berglund Andreassen  
Liss Lunde  
Magnus Høyen Mangersnes  
Magnus Ruland

Malene Waage Skår  
Maria Breivik Skarshaug  
Marta Baxarias Canals  
Marte Todal Nilsen  
Martin Rønbeck Lundberg  
Martine Aardal  
Mathias Abrahamsen  
Mathias Cheetham Overrein  
Mattias Bendiksen Lind  
Mikael Fjeld Wold  
Mirjam N. Petterson  
Oda Klingenberg Øfsti  
Oda Marie Nilsson  
Pernille Lovise Lyng  
Rebekka Bruin Ødegaard  
Sigmund Larsson  
Silje Fløtnes Hansen  
Stian Nylund  
Susanne Holmås  
Sverri Biskopstø Strøm  
Thomas Hille  
Tom Christian Tonheim  
Vebjørn Woll  
Vemund Holstad  
Viktoria Fure Lukes  
Vilde Lundin

The Norwegian Veterinary Institute thanks Pharmaq Analytiq AS, PatoGen AS and Blue Analytics AS for their important contributions to this year's Fish Health Report in making available data lists for the detection of selected diseases and/or infectious agents (see [Chapter 1](#) Statistical Basis). Further, we would like to thank the various farming companies who have shared their health-related data and contributed to quality assurance of its use prior to publication in the Norwegian Fish Health Report. Thanks also to AquaCloud for enabling the sharing and use of standardized data that provides an overview of causes of loss and mortality.

Finally, we would like to express our thanks to the aquaculture companies that have quality-assured the data and granted permission for its use in the Fish Health Report 2025.



Ås | Sandnes | Bergen | Trondheim | Harstad | Tromsø

postmottak@vetinst.no  
vetinst.no

**Promoting  
good health  
in animals  
and humans**