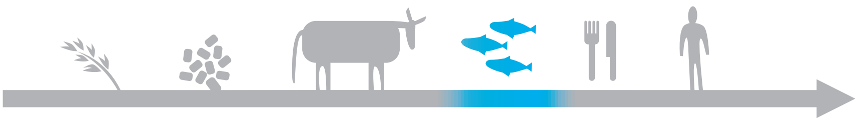
Report 1b - 2018

The Health Situation in Norwegian Aquaculture 2017



Veterinærinstituttet
Norwegian Veterinary Institute

The Health Situation in Norwegian Aquaculture 2017

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Norwegian Veterinary Institute, annual summary of fish health in Norway

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The Health Situation in Norwegian Aquaculture 2017

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Poor Health – No growth

Fish are Norway's most important domestic animals and knowledge of the health status of farmed fish is critical. Improvement of the health and welfare situation will be crucial for future expansion of the aquaculture industry. Sustainable expansion will be impossible without good fish health.

This is the main reason that the Norwegian Veterinary Institute each year compiles available information and risk analyses related to the disease situation in 'The Health Situation in Norwegian Aquaculture' report. The aim of the report is to inform and aid the public authorities and industry in development of specific and effective counter measures against disease.

Total losses of fish during the seawater phase of culture is an important indicator of fish health, but one that should be interpreted with care. Most losses are a result of injury or disease. For salmon, diseases and injury accounted for 88% of post sea-transfer losses in 2017.

Seawater losses may be calculated in several ways, and these are discussed later in this report. According to the Directorate for Fisheries, 53 million salmon were lost during the sea phase of culture in both 2016 and 2017. Our industry survey indicates that while a proportion of this loss is related to salmon-louse treatment, the actual number of fish involved is difficult to estimate precisely. No matter how the data is statistically analysed we believe that seawater losses in the Norwegian aquaculture industry are excessive. Large losses of fish are not consistent with good fish health. There are significant differences in the level of seawater losses between regions and individual farming companies, indicating that reduction of losses should be possible in many cases. Several farming companies have worked towards lowering losses during the seawater phase of culture and many can boast good results.

Live with or eradicate fish diseases? In Norway, living with certain diseases has become an accepted strategy. Examples include HSMI, CMS and for large parts of the country, PD. As fish production becomes more and more industrialised this strategy becomes ever more fragile. This is increasingly clear in light of large losses now experienced during and following handling e.g. lice treatments. We need a robust, disease-free fish. In 1965, the term 'The Five Freedoms' was introduced. This was in many ways an 'Animal rights charter' under which one of the freedoms is 'Freedom from pain, injury and disease'. Denmark has recently eradicated the viral disease VHS. The EU has established eradication plans for VHS and IHN.

New technologies are adopted rapidly by the aquaculture industry. While such technologies may reduce the impact of diseases caused by e.g. the salmon louse, they may also result in 'new' fish health problems. It is important therefore that new technologies are developed in consultation with fish health specialists. Recirculation based aquaculture (RAS) has become a standard technology for production of juvenile salmon and 'large' smolts. Experiences with this type of technology indicate that biosecurity and maintenance of disease-free status is extremely important.

The Norwegian Veterinary Institute has a responsibility for fish health in farmed and wild fish, marine and freshwater. This broad area of responsibility allows a holistic approach to the health status of different types of fish sharing common environments. Infectious diseases are an important area of study for the Norwegian Veterinary Institute, but not all diseases are infectious. We maintain and continue to build alliances with other institutions in order to investigate how environmental pollution may affect the health of fish. As part of this work, the Norwegian Veterinary Institute has become engaged in several initiatives related to the massive plastic pollution along our coast and on the possible health threats represented by micro- and nano-plastic particles.

Fish health or profit?
The Norwegian Food Safety Authority and political decision makers must find the balance between the various societal interests involved. The Norwegian Veterinary Institute has a responsibility to be a strong and clear 'spokesperson' for fish health.

Brit Hjeltnes,
Editor for 'The Health Situation in Norwegian Aquaculture 2017'.

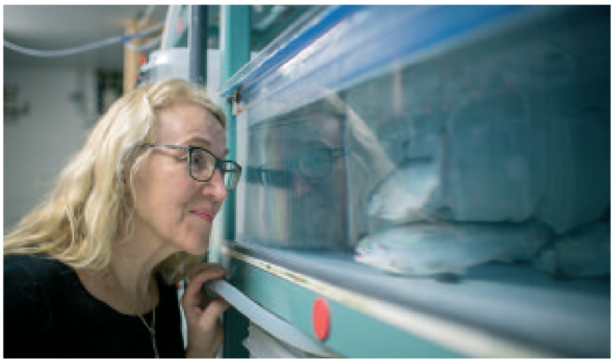


Photo Eivind Senneset

Summary

The injurious effect of salmon lice remains the major fish health related problem in Norwegian aquaculture. The health- and welfare consequences of salmon louse treatment relates mainly to the acute and often fatal injuries associated with the treatments themselves.

With the exception of the salmon louse problem, marked changes in the pancreas disease (PD) and infectious salmon anaemia (ISA) situations constitute the most significant fish-health developments observed during 2017. The Health Situation in Norwegian Aquaculture report, which has since 2003 provided an annual status and risk-evaluation of the fish health situation in Norway, also shows that the bacterial disease yersiniosis has increased in impact in mid-Norway in 2017.

Changes in the salmon louse situation

The salmon louse situation has changed somewhat between 2016 and 2017. The numbers of lice were lower than in the previous year, particularly in the autumn. Peak numbers of lice have not been lower since 2012, but other indicators suggest less significant change and some individual farms lay periodically above permitted infestation levels in 2017. A further positive development was that no regional loss of control of infestations, with consequential lice-induced injury, as experienced in Sør-Trøndelag in 2016, were registered in 2017.

Norwegian salmon louse control in 2017 was based mainly on non-medicinal treatments. Both medicinal and non-medicinal salmon louse treatments may result in increased mortality. Such mortality events were more commonly registered in association with non-medicinal than medicinal treatments in 2017. The trend towards increasing use of non-medicinal treatments, as reported in the 2016 report, continued in 2017. As medicinal treatment has largely been replaced by non-medicinal treatment, it is therefore reasonable to assume that overall mortality related to salmon louse treatment has increased in 2017. Despite the marked reduction in number of medicinal treatments performed in 2017 compared to 2016, the resistance situation remains serious along the whole coast.

Challenging viral diseases

Pancreas disease (PD) remains the most serious viral disease of salmonid fish in marine aquaculture in Norway. There are two epidemics in Norway, SAV3 in Western Norway and marine SAV2 North of Hustadvika in Møre og Romsdal and Trøndelag. In 2017, 176 new cases of PD were diagnosed. This is a significant increase from the previous year and may be due to early identification of virus following introduction of mandatory screening. The number of cases of PD appears to be increasing in the more northerly areas of its range.

Infectious salmon anaemia (ISA) was diagnosed in 14 farming sites in 2017 compared to 12 in 2016. In contrast to earlier years, in which positive sites most commonly lay in physical close proximity to each other within endemic areas, the pattern has changed to a larger proportion of single outbreaks in geographically disparate locations.

Heart and skeletal muscle inflammation (HSMI) is today one of the most common viral diseases of Norwegian farmed salmon. In 2017, the Norwegian Veterinary Institute and private laboratories diagnosed HSMI in 93 and 90 farms respectively. Although considerable uncertainty surrounding the real number of cases exists, the figures may indicate that HSMI remains at a level similar to previous years.

Cardiomyopathy syndrome (CMS)

The Norwegian Veterinary Institute and private laboratories diagnosed CMS in 96 and 100 farms respectively, which is a slight rise from the previous year. Taken together with the results of our annual survey carried out in association with the current report, this indicates an increase in the number of CMS cases.

Infectious pancreatic necrosis (IPN)

IPN was diagnosed by the Norwegian Veterinary Institute and private laboratories in 23 and 4 salmonid farms respectively. This indicates a prevalence similar to the previous year, but clearly lower than the peak year of 2009 when IPN was diagnosed in 223 farms. Use of QTL-roe is probably the most important factor in the reduction in number of cases. Increased focus on eradication of ‘house’ strains has also contributed to the situation.

Other health challenges

Amoebic gill disease (AGD) is caused by the parasitic amoeba *Paramoeba perurans*. The amoeba was identified throughout the year from Agder in the south to Nordland in the north, and the clinical situation followed the same pattern as 2015 and 2016. Despite occasional serious cases, AGD has not developed into the dramatic disease initially feared.

Poor gill-health in marine farmed salmon is a significant and increasing problem particularly in Western, North-Western and Mid-Norway. Gill infections are complicated and often multifactorial, involving a number of infectious agents.

Skin problems associated with bacterial infection remain on a level observed in previous years and are particularly prominent in northern Norway.

Yersiniosis is on the increase in mid-Norway. While in previous years marine outbreaks have mainly been associated with newly transferred smolts, approximately 90% of marine outbreaks in sea-farmed salmon in 2017 occurred in larger fish (>1kg), several months, and often > 1 year post sea-transfer.

According to Kontali analyse, approximately 30 million cleaner fish were produced in 2017. In addition, many wild-caught cleaner fish were utilised. In 2016, 37 359 000 cleaner fish were transferred to marine cages (Directorate for Fisheries). Figures for 2017 were not available at time of publishing. Disease problems in cleaner fish species include the bacterial diseases atypical furunculosis, vibriosis and pasteurellosis and vaccination against bacterial infections is now common. Parasitic and viral diseases (flavivirus) are also observed. Mortality in cleaner fish is high and considerable welfare issues exist related to the use of cleaner fish.
Preliminary figures from the Veterinary Medicine Register (VetReg), suggest that slightly over 600 kg (active substance) antibiotics were prescribed for Norwegian farmed fish in 2017. This is an increase from the all-time low of 212 kg registered in 2016, but remains an insignificant amount in relation to the quantity of salmon produced in Norway. Almost one third of the total antibiotic consumption in 2017 was related to a single treatment of relatively large salmon with yersiniosis.

Losses between sea-transfer and harvest remain high, and according to the Directorate for Fisheries, 53 million salmon and 3.2 million rainbow trout were lost in 2017. This indicates a situation similar to 2016.

In this year's report, in addition to calculation of losses per generation (figures from Kontali) we have calculated annual losses as a sum of monthly losses. This method provides an estimate of losses on an annual basis. The method in its present form is based upon a number of assumptions that may not always represent the true situation, due to variation in sea-transfer, movement and splitting of populations. The method is therefore subject to considerable uncertainty.

According to the analysis described above, sea-losses in 2017 were calculated as 13.3% for salmon and 16% for rainbow trout. Considerable differences are found when losses are calculated on a regional basis, with Hordaland and Nordland, the two regions with most aquaculture activity, at each end of the scale. Losses in Hordaland (22.5%) lie over three times the level identified in Nordland (6%).

The salmon parasite *Gyrodactylus salaris* remains a serious threat to wild salmon in a number of Norwegian rivers. Comprehensive eradication actions have been carried out over many years, and 2017 represented a milestone in this respect, as nine rivers in the Vefsna region and the river Lærdal were declared free of infection.

During 2017 (Kontali analyse), 1 207 800 tons of salmon, 60 000 tons of rainbow trout, 5500-6000 tons (estimate) of wild-caught, cage-held cod, 1600 tons (estimate) halibut, 2-300 tons (estimate) turbot and 4-500 tons (estimate) arctic char were produced in Norway. In addition, 27-30 million individual lumpsucker and 1.0-1.2 million Ballan wrasse were produced.

1 Statistical basis for the report

By Britt Bang Jensen

The statistics presented in the current report are obtained from three different sources; official data, data from the Norwegian Veterinary Institute, and data based on responses to a survey sent out to Fish Health Services and the Norwegian Food Safety Authority.

In each section of the report the information source/s upon which the statistics and the author's evaluation of the situation are based, is/are clearly indicated.

Official data

According to current legislation, all notifiable diseases must be reported to the Norwegian Food Safety Authority. In addition, legislation states that 'on increased mortality, with the exception of when the mortality is clearly unrelated to disease, health inspection must be carried out without delay to identify the cause'. A veterinarian or fish health biologist must perform the health inspection. The Norwegian Food Safety Authority must be immediately notified of unexplained 'increased mortality in an aquaculture facility or aquaculture area for mollusc farming, or on any reason for suspicion of disease on list 1, 2 or 3 in aquaculture organisms'. On the basis of surveillance programmes and routine diagnostic work, we know that List 1 diseases do not exist in Norway today. A summary of the numbers of farming localities affected by diseases on Lists 2 and 3 is presented in Table 1.1.

The table is based on data from the Norwegian Veterinary Institute, which continually supports the Norwegian Food Safety Authority in maintaining an overview of the prevalence of notifiable diseases. These statistics include both diagnoses made by the Norwegian Veterinary Institute and diagnoses made by private laboratories (see under) which have been reported to the Norwegian Food Safety Authority.

The 'official statistics' in this report relate to the number of new diagnoses/positive sites following fallowing. As some farms may contain fish diagnosed the previous year, the actual number of affected sites may be higher.

Table 1.1 Summary of list 2- and 3-diseases with number of diagnoses. The statistics are based on data from the Norwegian Veterinary Institute.

Disease	List	2011	2012	2013	2014	2015	2016	2017
Farmed fish (salmonids)								
ILA	2	1	2	10	10	15	12	14
VHS	2	0	0	0	0	0	0	0
PD	3	89	137	100	142	137	138	176
Furunculosis	3	0	0	0	1	0	0	0
BKD	3	3	2	1	0	0	1	1
Farmed fish (marine species)								
Francisellosis (cod)	3	3	2	1	1	0	0	0
VNN/VER	3	0	1	1	0	0	0	0
Furunculosis (lumpsucker)	3	0	0	0	0	1	4	0
Wild salmonids (fresh water)								
Gyrodactylus salaris	3	2	0	1	1	0	0	0
Furunculosis	3	1	0	0	0	2	1	2

Data from the Norwegian Veterinary Institute

The Norwegian Veterinary Institute receives samples for diagnostic investigation from a number of Fish Health Services. These samples are analysed in our laboratories in Harstad, Trondheim, Bergen and Oslo. All information generated from submitted samples is stored in the Institute's electronic journal system (PJS).

Data from PJS was used to generate tables, graphs, maps and text for the current report. Only results of diagnostic investigations are included. Samples submitted for research, quality assurance testing or surveillance programs were excluded. The number of individual sites affected by each disease/agent was registered. We commonly identify the same organism/disease from individual sites several times in the course of a year. For reporting purposes each site is registered only once in any year for any particular disease/agent. In some cases, the same disease/agent may have been diagnosed in the same batch of fish in 2016, so the statistics do not necessarily describe the number of new cases in 2017. The exception is for notifiable diseases, as described above.

For non-notifiable diseases, Norwegian Veterinary Institute data alone does not provide a complete picture of the national situation. We have therefore asked several private diagnostic laboratories to provide data related to their own diagnostic investigations. Since the information collected is probably not complete, the statistics may represent an underestimate. On the other hand, some diagnoses made by private laboratories are also likely to 'overlap' cases diagnosed by the Norwegian Veterinary Institute.

The Norwegian Veterinary Institute has in the course of 2017, received diagnostic submissions from 484 salmon farms compared to 556 in 2016 and 593 in 2015.

Data from the annual survey

As in recent years, the Norwegian Veterinary Institute sent out an electronic survey to obtain the views of Fish Health Services along the whole coast as well as officers of the Norwegian Food Safety Authority. Respondents were asked to rank the importance of different diseases in salmon and rainbow trout, in both hatcheries and ongrowing farms, as well as diseases affecting cleaner fish species. Respondents were also asked to comment on the effect of lice treatments and on various parameters relating to fish welfare.

The survey was sent to 29 Fish Health Services or farming companies with in-house fish health personnel and a response was received from 17. In some cases, several workers from the same Fish Health Service responded and 34 questionnaires were completed. Eighteen Norwegian Food Safety Authority inspectors completed and submitted the survey. All contributors were offered a public acknowledgement for their contribution, and those who accepted are listed by name at the end of this report.

The data received was used in relevant sections throughout the report.

2 Changes in risk of infection

By Atle Lillehaug, Edgar Brun, Arve Nilsen and Brit Hjeltnes

An important part of the annual 'Health Situation in Norwegian Aquaculture 'report is a review of the changes observed in the disease situation for important infectious diseases. Individual diseases in farmed fish and the health status for wild salmonids are discussed in specific chapters. In the present chapter devoted to risk, we will discuss production related factors within the aquaculture industry in 2017, which may have been important for fish health and transmission of infectious diseases in farmed fish in Norway, primarily salmon.

Consumption volumes and information given from the prescription register (VetReg) for different pharmaceutical products e.g. antibiotics and chemotherapeutants for control of salmon lice and intestinal worms, provide a good basis for evaluation of the status of different types of infections. Production statistics, fish biomass, post sea-transfer losses, number of active farming sites together with regional production of salmon smolts also constitute important parameters upon which a picture of the risks for transmission of disease and infection may be drawn. Changes in production conditions and implementation of new technologies, as well as regulative changes, may all contribute to change in the risk situation.

Infection pressure and biomass

Until 2012, production of salmon in Norway had increased annually by 10-20% over several decades. In recent years, production has stabilized, and preliminary sales figures for 2017 indicate a continuation of this trend (table 2.1). Biomass reported in the sea phase at the end of 2017, together with preliminary figures for sea-transfer of smolts and juveniles produced, indicate a similar or slightly increased total production in 2018. The number of sites actively farming salmon in the sea has increased slightly compared to 2016.

Marine production of rainbow trout and other species e.g. halibut, turbot, and char remains comparatively stable. For 2017, approximately 23 000 tons (preliminary statistics from Kontali analyse) were produced, which is around the same as the previous year. There is a significant annual increase in the number of wild caught and farmed cleaner fish stocked in Norwegian salmon farms. An increasing proportion of these fish are of farmed origin, which allows greater control with infection than is the case for wild-caught cleaner fish. Stocking of aquaculture facilities with wild-caught cleaner fish represents a considerable risk of introduction of infection. Use of farmed cleaner fish therefore represents an important improvement in biosecurity.

Almost 37 million cleaner fish were stocked in salmon cages during 2016, 11 million more than in 2015. Production and husbandry of this type of fish does however, result in new health and specific welfare challenges. This is reflected in the fact that the majority of prescriptions for antibiotic treatment in farmed fish in Norway are prescribed for treatment of cleaner fish (Table 2.4).

Fish losses during the seawater phase

Fish losses occurring between sea transfer and harvest must be reported to the Directorate for Fisheries. Losses are categorised as either mortality, rejected, escapees or 'other'. Mortality covers losses associated with disease or injury etc. Infectious disease is one of the most important causes of biological and economical loss in aquaculture. 'Rejected' relates to fish removed during harvest on quality grounds. 'Other' can relate to mortality episodes occurring in association with e.g. lice treatment or other management procedure, but also fish destroyed as part of a disease control procedure. Post sea transfer losses are an indicator of fish welfare and an indirect measure of fish health. Mortalities resulting from treatment procedures or other management routines represent a serious welfare problem.

Post sea transfer losses are high for the fish farming industry as a whole. Following a drop to 38 million salmon and 2.9 million rainbow trout in 2013, the number of fish lost has risen to 53 million salmon in both 2016 and 2017 (Table 2.1). For rainbow trout, 3.8 million fish were reported lost from production in 2015, and the number fell to 3.5 million in 2016 and further to 3.2

million in 2017. Of the 53 million salmon lost in 2017, 88% were mortality related, 6.5% rejected at harvest, 0.01% as escaped and 5.2% as 'other'. For rainbow trout, the distribution was 77% mortality, 6.7% reject, 0.2% escaped and 16% 'other'. The figures for 2017 from the Directorate for Fisheries are preliminary as of February 2018.

Pre- sea transfer losses for salmonid fish are also reported. This data has not been made available to the Norwegian Veterinary Institute, but will be included in next year's report. Losses during the freshwater phase can also be utilised as an indicator of fish welfare.

In the fish health reports of previous years, post sea transfer losses have been presented as the number of fish reported lost as a proportion of the number of fish transferred to sea the same year. This figure does not represent a true picture of the total losses from the farmed population as a whole, but it is often interpreted as such during public debate. Another approach is to calculate losses as a percentage of the total number of fish farmed in the sea on a monthly basis. The sum of monthly losses equates to the total annual loss. This additive system is dependent, however, on the total

Tabell 2.1 Production of farmed fish, figures from the Directorate for Fisheries.

	2013	2014	2015	2016	2017*
Number of farms					
Salmonid,licenses, juvenile production	230	222	214	220	220
Salmonid, active sites, sea	810	806	790	799	826
Marine fish, number of sites, sea	110	105	79	69	58
Biomass at end of year, tons					
Salmon	726 000	761 000	722 000	740 000	788 000
Rainbow trout	42 000	43 000	47 000	31 000	35 000
Harvested, tons					
Salmon	1 168 000	1 258 000	1 303 000	1 234 000	1 234 000
Rainbow trout	71 000	69 000	73 000	87 800	80 700
Marine species (halibut, char, cod, other)	5 626	3 140	1 713	2 473	2 300**
Juvenile fish transferred to sea, millions					
Salmon	280	289	299	292	297
Rainbow trout	18,0	19,6	16,1	14,9	16,8
Cleaner fish	16,2	24,5	26,4	37,4	~30**
Post sea-transfer losses, millions					
Salmon	38	47	46	53	53
Rainbow trout		2,9	3,7	3,8	3,5 3,2
Post sea-transfer losses. In percent***					
Salmon	10,2	12,1	11,9	13,7	13,2
Rainbow trout	11,9	14,9	15,3	17,2	16,0

* Preliminary figures for 2017, Directorate for Fisheries, February 2018
** Preliminary estimate, Kontali analyse, February 2018
*** Proportion of fish lost per month, in percentage of stocks held, total for the year

population remaining relatively stable throughout the year. The coefficient of variation (standard deviation divided by the mean) provides an expression for this variation, and is in our material 7-8% for the years 2013-2017. This indicates that the calculated values may be moderately under- or over-estimated. Our estimates for post-sea transfer losses are shown in table 2.1, based on figures published by the Directorate for Fisheries for 2017 (as of February 2018). From the lowest losses in 2013 (10.2% for salmon and 11.9% for rainbow trout), there was an increase to 13.7% and 17.2% in 2016 for these two species. In 2017, these losses fell to 13.2% and 16%.

Another way to express percentage losses post-sea is to calculate the losses per generation, from sea transfer to harvest. This method results in higher percentage losses, as the period examined is longer than one year. Kontali analyse has calculated 'generation' based losses to be fairly stable at around 20-21% for the four last generations harvested, which were transferred to sea between 2012 and 2015 (12G – 15G), and preliminary figures for 16G are also 21%.

It is hypothesised that mortalities associated with new mechanical and physical methods of louse control have contributed to an increase in post sea-transfer losses in recent years. Pharmaceutical- louse and amoeba treatments may also cause mortality. A significant reduction in post sea-transfer mortality must be a clear goal for the industry.

Significant regional differences exist in post sea-transfer losses (table 2.2). Hordaland and Nordland, the two largest farming counties, lie at each end of the scale, with over three times post sea-transfer losses experienced in Hordaland (22.5%) than in Nordland (6.0%). The other three counties in Western Norway also experience high levels of post sea-transfer losses of between 18.5-19.5%. Troms lies at the same level as Nordland, and Finnmark at 14%. In Finnmark, a single event, categorised under 'other' was responsible for a loss of 4%. Hordaland also lies at the top of the scale for rainbow trout losses at 21.7%.

There is a clear tendency towards geographical differences in post sea-transfer losses. Northern Norway has considerably lower losses than western Norway, with Mid-Norway (Trøndelag) in between at 12.2%. It is not known whether these differences are a result of regional differences in disease status, but it is clear that 'Western Norway' is geographically equivalent to the endemic zone for SAV3 pancreas disease. SAV2 is present in the southern part of Trøndelag, while Nord-Trøndelag is mainly PD-free. Northern Norway remains PD-free. The

Table 2.2 Percentage post-seawater transfer losses of salmon and rainbow trout by county in 2017. Percentage losses are calculated as the number of fish reported lost per month in relation to the number of fish held in farms the same month. The figures for 2017 are preliminary, supplied by the Directorate for Fisheries as of February 2018.

Regional	% post-seawater transfer losses salmon	% post-seawater transfer losses rainbow trout
Finnmark	14,0	-
Troms	6,5	-
Nordland	6,0	15,6
Trøndelag	12,2	2,1
Møre og Romsdal	19,5	9,7
Sogn og Fjordane	18,9	10,3
Hordaland	22,5	21,7
Rogaland	18,5	-

reasons behind ‘mortality’ and ‘rejected’ are not reported in more detail, but the large regional differences in post sea-transfer losses may indicate different regional disease/infection status as discussed elsewhere in this report.

Spread of infection via transport of live fish

Transport of live fish, both smolt and fish for harvest, is considered to represent one of the most significant risk factors for spread of disease. Latent infections may be difficult to identify, and there is always a risk that presumptively healthy smolt populations may in fact be infected. Infection may be introduced to smolt production units in several ways, including exposure to ‘marine’ pathogens through use of seawater supplement in the farm.

Long distance transport is necessary when smolts are produced in one region and stocked to sea in another region, or when harvest ready fish are transported to a harvest facility in another region. The ratio between the number of smolts produced within a county and the number of smolts transferred to sea within the same county will provide an indirect indication of the number of fish crossing borders (table 2.3). Figures for 2017 are not yet available, but for 2016, the total number of smolts transferred to sea in Northern-Norway were 17 million greater than the number of smolts produced within the region. Figures for 2015 and 2014 were 11 and 13 million greater, respectively. There is, therefore, a lack of coverage of smolt within the region. The situation in the remainder of the country appears quite stable, with the exception of Møre og Romsdal and Sør-Trøndelag, where sea-transfer of smolt appears to vary on a two-year cycle, with alternately high and low numbers of smolt transferred to sea each year. The two regions appear to operate on opposite cycles.

Live fish are now almost exclusively transported in well-boats. New technologies including disinfection of influent and affluent water and logging of valve position open or closed has significantly reduced the risk of spread of infectious disease via well-boat traffic. Extensive use of closed valves during the whole or a large part of the transport also means that water is not taken in or released to the environment. New well-boats are constructed to allow efficient cleaning and disinfection of wells, pipes and pumping systems between jobs, and their transport routes are electronically logged. Together with legal constraints, these measures result in safer well-boat transport with a reduced risk of spread of infection. There appears to be increasing specialisation of individual well-boats for transport of either smolts or larger fish, and towards operation within geographically restricted areas.

Table 2.3 Regional production and sea-transferred smolts (million), with a calculated index relating production and number of smolts transferred to sea on a regional level. Figures from the Directorate for Fisheries.

Region	2013			2014			2015			2016			2017*
	Smolt prod	Smolt to sea	Index	Smolt prod	Smolt to sea	Index	Smolt prod	Smolt to sea	Index	Smolt prod	Smolt to sea	Index	Smolt to sea
Finnmark and Troms	23,9	56,1	0,43	26,5	60,4	0,44	29,7	66,0	0,45	31,9	66,2	0,48	69,3
Nordland	72,8	54,9	1,33	78,7	57,8	1,36	83,3	57,6	1,45	83,4	66,0	1,26	55,2
Nord-Trøndelag	38,1	20,9	1,82	36,2	25,9	1,40	39,1	25,6	1,53	38,5	21,3	1,81	73,5
Sør-Trøndelag	27,1	53,9	0,50	32,4	16,1	2,01	33,4	53,2	0,63	32,6	19,6	1,66	
Møre og Romsdal	44,7	14,1	3,20	44,6	47,2	0,94	53,8	15,0	3,59	44,5	48,1	0,93	9,8
Sogn og Fjordane	14,5	22,9	0,63	15,1	23,8	0,63	15,8	24,2	0,65	15,6	25,2	0,62	23,0
Hordaland	54,3	46,6	1,17	57,4	41,0	1,40	54,9	45,9	1,20	56,3	44,9	1,25	42,8
Rogaland	15,6	19,1	0,82	13,2	19,1	0,69	15,1	19,4	0,78	13,5	20,7	0,65	23,2
Sum	291,1	288,5		304,3	291,3		325,1	307,0		316,4	312,2		296,7

* Preliminary statistics, Directorate for Fisheries, February 2018

Bacterial infections – antibacterial treatments

Consumption of antibiotics is a good indicator of the prevalence of bacterial diseases. Ever since vaccines against coldwater vibriosis and furunculosis became available at the end of the eighties and early nineties, consumption of antibiotics has been low. From 1996 onwards, consumption has lain between ½ and 1½ tonnes active antibacterial substance, despite continually increasing volumes of fish farmed during this period. In 2015 and 2016, antibiotic consumption lay between 200-300kg. In 2017, preliminary figures from VetReg (Veterinary Medicines Register) indicate an increase to just over 600kg antibiotics prescribed to farmed fish. This still remains a small amount, and the fact that approximately one third of the total consumption was related to treatment of a single outbreak of yersiniosis in large salmon, illustrates the infrequency of antibiotic treatment of farmed fish in Norway.

The total amount of antibiotic substance utilised in farmed fish in 2017 was 641kg (active substance) and compares to 212kg prescribed in 2016 (Table 2.5). Only six treatments involving salmon farmed in the sea were reported to VetReg (table 2.4). The treated biomass in such cases is large compared to other categories of fish, and treatments in large fish at sea contribute heavily towards the total consumption figures. The situation in 2017 clearly illustrates how the low antibiotic consumption Norwegian aquaculture has experienced for nearly thirty years, can quickly change on emergence of new or re-emergence of established diseases for which we do not have effective vaccines. It is extremely important that management procedures be developed, which as far as possible do not allow establishment of bacterial infections within the industry.

According to data from VetReg, the vast majority of antibiotic prescriptions were prescribed for cleaner fish (table 2.4). The causes for prescription were primarily reported as ‘bacterial infection’, with vibriosis specifically reported in 12 cases and furunculosis in one.

The health situation associated with new production technologies

In Norway, salmonids have traditionally been farmed using through-flow technology in freshwater and in open cages at sea. Introduction of new technologies such as land-based recirculation based systems (RAS) and enclosed or semi-enclosed systems in the sea, has led to new health challenges for the fish farmed in these systems.

Land-based recirculation systems

RAS is a well-established technology, which saves both water and energy. Under optimal operation, it can provide a more stable aquatic environment than is possible in traditional farming systems. There is an increasing number of RAS farms in Norway, with a varying degree of re-use of water. RAS has been the sole method of smolt production on the Faroe Islands for many years, and RAS technology is frequently used for production of juvenile marine fish and warm water species. Recent production data from RAS-based smolt farms indicate good survival and growth after sea transfer. Surveillance and documentation of various water parameters, including temperature, current speed, specific water use (/kg/min), total gas pressures, oxygen, pH, carbon dioxide (CO2), H2S, ammonia (NH3), nitrite (NO2), total suspended solids (TTS), turbidity (NTU) and heavy metals (e.g. copper) is, however, paramount. Periodical over-feeding and insufficient particle removal should be taken into account when planning the capacity of any particular system. Biofilters may be unstable during start up, prior to establishment of a stable microflora.

Good biosecurity is paramount for successful RAS operation. Infections may be introduced via biological material (roe and fish), or via the water source. Pathogens, once introduced, may recirculate within the system. Eradication of infectious agents within a RAS system can be difficult without negatively affecting the function of the biofilter. Examples of diseases which may be particularly challenging in RAS farms include the bacterial diseases furunculosis (reported from Denmark) and yersiniosis. Yersiniosis (*Yersinia ruckeri*) has been a serious problem in RAS farms in Northern and Mid-Norway, with repeated outbreaks and high mortality.

To reduce the production period in traditional open cages, land-based seawater RAS farms have been established for production of 'large smolts' of up to 1 kg. Seawater RAS systems are more prone to high levels of carbon dioxide than freshwater RAS farms. Seawater use also increases the risk of infection by bacteria that can cause skin infection and ulcers, a problem reported by many fish health services during 2017. Knowledge relating to the aetiology of such infections and their management is currently lacking. Production of larger smolts leads to welfare challenges related to handling, transport and sea transfer. It is now possible, by light and temperature manipulation, to transfer smolts or large smolts to sea throughout the whole year. Sea transfer to cold seawater may lead to stress, ulcer development and mortality in the period following sea-transfer.

Avirulent ISA-virus is widespread and has been identified in several juvenile production facilities. The Health Situation in Norwegian Farmed Fish report of 2015 described a case in which virulent ISA spread from a RAS juvenile production facility. There was a further case in 2016, in which spread from a RAS juvenile production facility could not be excluded. The extent to which RAS environments influence the virulence of potential pathogens circulating within the system should be further investigated.

New seawater based production technologies

A number of different concepts including enclosed or semi-enclosed marine farms are under planning or testing. The aim of these concepts is to create a physical barrier between the enclosed fish and the external environment. Two main strategies are under testing; open cage constructions sited offshore and various forms of enclosed or semi-enclosed cages sited in sheltered localities. The first priority has been to identify technologies that prevent settlement of salmon lice. Completely enclosed cages effectively prevent lice infestation, while other systems with partial enclosing and/or having the ability to be lowered in the water column provide varying degrees of protection.

Enclosed or semi-enclosed farms provide a greater degree of security against fish escape and greater opportunities for collection of waste products than open cages. Common to all such systems are the environmental and water quality challenges presented by internal currents, temperature, biomass and feeding. There is a considerable need for research and increased experience of the interplay between production intensity, environment and fish welfare, before these systems can be operated in a predictably secure way. Open, offshore cages, similar in shape and operation to inshore farms, achieve lower lice settlement by moving the fish away from the heavy infection pressures associated with coastal currents. The hygienic status and fish welfare aspects of such farms have not yet been fully documented.

Table 2.4 Number of prescriptions per year for antibiotic treatments for different categories of farmed fish. Preliminary figures January 2018 from the Veterinary Medicines Register (VetReg).

Category farmed fish	2013	2014	2015	2016	2017
Salmon, ongrowing and brood stock	15	11	8	11	6
Salmon, juvenile fish	35	39	24	21	28
Rainbow trout and trout	1	5	0	1	1
Marine fish (cod, halibut etc.)	18	18	29	30	28
«Other species» (cleaner fish)	38	59	108	126	115
Sum	107	132	169	189	178

Zero salmon lice: In February 2018, the national television service (NRK) will air the series ‘The fantastic wild salmon’. Several employees of the Norwegian Veterinary Institute will contribute with information on the gene bank, Gyrodactylus eradication and re-establishment of wild salmon populations. In this photograph, we see researcher Arve Nilsen perform a lice count on a farmed salmon, watched by program presenter Kenneth Bruvik. The photograph was taken on an Akvafuture farm in Velfjorden outside Brønnøysund, which was at that time the only farm in Norway testing enclosed farming of salmon on a commercial scale. The Norwegian Veterinary Institute is a research partner in the project. Photo: Asle Haukaas, Norwegian Veterinary Institute.

What developments can we expect?

Pancreas disease is notifiable within the OIE system and is a list 3 disease in Norway. Farmed fish represent the main reservoir of infection, and pancreas disease has been allowed to become endemic along the whole west coast, as far as the northern parts of Trøndelag. This infection could have been controlled and possibly eradicated following the early outbreaks. Recently introduced legislation against pancreas disease requires extensive PCR screening for PD-virus. This may provide an overview of the geographical range of PD-virus within the farmed fish population.

The aim of the new legislation is 'to reduce the consequences of pancreas disease (PD) in a PD zone, to prevent establishment of PD in a surveillance zone, and to limit the geographical range of the individual subtypes of Salmonid alphavirus (SAV)'. The authorities have in reality accepted that PD will remain endemic in current PD-zones, but hope to prevent its establishment within surveillance zones. The legislation also states that 'The Norwegian Food Safety Authority can, after evaluation of the situation, demand that fish in a site diagnosed with PD be harvested or destroyed'. 'Diagnosed PD' is defined as 'identification of SAV by PCR or culture, in addition to clinical symptoms or pathological changes consistent with PD'.

Virus shedding begins long before development of clinical signs of disease. Current legislation allows infected fish to remain in the farms, shedding virus until clinical signs of disease develop. The competent authority then decides upon control measures. The farmer may appeal against control measures, thus delaying their introduction. These procedures may, therefore, result in significant 'leakage' of infectious virus particles prior to introduction of eventual counter measures. This situation increases the risk of northerly spread of pancreas disease.

The new legislation requires monthly virus screening. The results of this screening should form a direct basis for initiation of control-measures in the most northerly areas of the virus range. Control measures should be introduced in advance of clinical disease.

There is broad support in the scientific community for the hypothesis that virulent ISA-virus develops from the so-called avirulent variant HPRO ISAV. This hypothesis forms the basis for the notifiable status of HPRO-variant in the OIE reporting system. HPRO is most probably widespread in ongrowing and juvenile production facilities along the entire coastline. Publics surveillance programmes for ISA focus exclusively on the virulent

Table 2.5 Pharmaceutical products prescribed for farmed fish (kg active substance). Figures from the Norwegian Institute for Public Health.

Antibacterial substance	2012	2013	2014	2015	2016	2017
Florfenicol	191	300	403	194	138	285
Oxolinic acid	1399	672	108	82	74	346
Oxytetracycline	1			(25)		10
Total antibiotics	1591	972	511	276	212	641
Anti-salmon lice medication						
Azamethiphos	4059	3037	4630	3904	1269	204
Cypermethrin	232	211	162	85	48	8
Deltamethrin	121	136	158	115	43	14
Diflubenzuron	1611	3264	5016	5896	4824	1803
Emamectin	36	51	172	259	232	128
Teflubenzuron	751	1704	2674	2509	4209	293
Hydrogen peroxide (tons)*	2538	8262	31577	43246	26597	9277
Anti-tapeworm						
Praziquantel	423	460	625	942	518	380

*Total consumption of hydrogen peroxide, includes both treatment against salmon lice and amoebic gill disease (AGD) virus. There is no systematic epidemiological documentation of the distribution of HPR0, but a considerable body of screening is performed annually by the industry.

Results from a recently completed FHF research project (FHF 901051) provide further indications that HPR0 ISAV may mutate and become virulent ISAV. Such mutation is probably influenced by various factors, such as management routines, handling stress and other infectious diseases.

In the Faroe Islands it is hypothesised that extreme weather conditions and consequent stress to the fish may have been a critical factor leading to mutation of avirulent ISAV to virulent ISAV. It is possible, therefore, that more frequent and stressing de-lousing treatment may result in increased virus production and an increased probability of mutation. It is well established that stress can lead to activation of latent infections.

The international situation - threats - legislation

Most fish farming countries are threatened through importation of infected animals, animal products and by sharing of aquatic areas with neighbouring countries. Norway has fairly limited import of live animals, and has a thorough, strictly policed import control. This means that the threats posed by imported animals are minor. Import of various products and possible vectors of infection are less well controlled. It is recognised that waste products from imported seafood may pose a risk of infection should they reach freshwater or seawater. White spot disease of shrimp is one such example. Bait organisms may pose a similar risk of infection spread. Introduction of disease by this mechanism will depend on the presence of susceptible species and the ability of the infectious agent in question to survive in a new environment.

Uncontrolled transport of animals may occur via illegal import and/or illegal release.
Gyrodactylus salaris is a parasite that can travel easily with fish transported for stock enhancement purposes. In the border areas between Norway, Russia and Finland, shared watersheds represent a particular risk of cross border spread of *G. salaris* as well as other infections.

For many years, pink salmon have been observed and caught regularly in rivers in Finnmark and Troms, with sporadic observations further south. In 2017, this fish species was more widely observed and in much larger numbers. This may indicate a natural spread in its range. Pink salmon is a blacklisted species in Norway. As its numbers increase, this species will constitute a greater risk of introduction of fish diseases in general, and infectious hematopoietic necrosis (IHN) in particular. Few investigations relating to the disease status of pink salmon have been undertaken. With increasing levels of fish-farming on the Kola Peninsula, there is an obvious risk that these fish may carry various infectious diseases. Salmon farming on the Kola Peninsula will also increase the probability that escaped Russian Atlantic salmon will migrate westwards to Norwegian coastal/farming areas.

During 2017, IHN was identified in rainbow trout (brood stock) farmed in inland Finland. IHN may be transmitted both horizontally and vertically. The source of the Finnish outbreak is unknown. Russian fish farms situated in the eastern Baltic Sea, receive fish from a number of Russian sources of largely unknown infectious status. Establishment of IHN in this area would represent an increased risk of infection for Norwegian farmed salmon.

Coastal states commonly share a coastal border with neighbouring countries. In many cases, fish farming is performed on both sides of the border. Such borders do not normally represent a barrier to horizontal transmission of infection, and different legislation, levels of expertise, capacity and attitude on either side of a border may lead to widely differing disease control practices. In June 2017, a meeting held in Ottawa discussed the need for legislation and cooperation aimed at limiting and control of state-to-state infections. The resulting report was submitted to the OIE as background for the possible introduction of a minimum requirement for coordinated fish health work between neighbouring states.

China has identified import of Norwegian farmed salmon diagnosed with PD or ISA as a possible risk to domestic fish stocks. Identification of virulent ISA-virus in salmon fillets exported to China has highlighted this threat. An increase in the geographical range of PD and/or ISA in Norway will make export to China more difficult.

3 Fish welfare

By Kristine Gismervik, Siri Kristine Gåsnes, Kristoffer Vale Nielsen and Cecilie M. Mejdell

Most researchers consider that fish have the ability to sense and thereby experience fear, pain and discomfort. Farmed fish are included in current animal welfare legislation, are subject to the same levels of protection as other domestic animals, and should have an environment and husbandry that ensures good welfare throughout the whole life cycle.

Animal welfare relates to the animals quality of life and may be defined in several ways. Three normal interpretations of the term are 1) The animals biological function, with good health and normal development, 2) The animals own experience, with regard to feelings such as fear and pain, or 3) a most natural life.
When evaluating fish welfare it is sensible to focus primarily on approaches 1) and 2).

Good health is a precondition for good welfare. Disease has a negative impact on welfare, but the degree of impact will vary between different diseases, dependent on the organs and functions affected. Both intensity and duration of pain and discomfort are important animal welfare parameters. A disease with a chronic course may affect welfare to a greater degree than a disease with an acute course with similar or even higher levels of mortality.

Fish health personnel and research institutions have a particular responsibility to work towards better fish welfare, inform on and promote good fish welfare to both the industry and the public at large. The Norwegian Veterinary Institute's work in this field is based on a holistic approach as fish health, infection hygiene, biosecurity and welfare are all closely intertwined.

Welfare indicators

Evaluation of fish welfare is normally based on the physiological, behavioural and health related needs of the fish. These needs will vary between species and life stage. Different production systems and handling situations present different challenges and require use of different welfare indicators. As practical and financial factors normally limit the number of welfare parameters examined, there is a need to identify the most suitable indicators to identify whether environmental conditions and health status are within acceptable welfare limits. Welfare indicators should also be reproducible and simple to record and interpret. Identification of acceptable limits for each environmental parameter e.g. water temperature, oxygen saturation and fish density are important. Biology is complex and demarcation between poor and acceptable welfare is not always easy on analysis of several welfare indicators. In many cases, welfare analyses are used for documentation of the absence of poor welfare. Identification of indicators that document that the fish experience their own welfare as good, and not merely document the absence of poor welfare, may be challenging. This requires more knowledge of fish preferences and how fish behaviour can best be interpreted for estimation of how well the fish thrives, and not merely identification of the environmental conditions it is able to tolerate.

Survival is no guarantee that welfare is good. Mortality is an important and much used welfare indicator, but one which must be supplemented with other indicators. Welfare indicators are commonly either categorised as environmentally based (available resources such as water quality and husbandry) or animal-based, which may be measured at the individual or group level. Of the animal-based indicators, behaviour and appearance/injury are commonly used, as are condition factor and prevalence of deformity or disease. Animal-based indicators may be subjective and several scoring systems have been developed to help reproducible grading and registration. The 'welfare poster' is such a scoring system developed by the Norwegian Veterinary Institute together with various Fish Health Services, for registration of acute external injuries in fish. The survey indicates that the welfare poster was frequently used in 2017.

Operational welfare indicators may be used for practical on-farm monitoring and quantification of fish welfare. During 2017, the FISHWELL project produced a review/manual describing indicators suitable for different production and handling situations in salmon farming (see Figure 3.1). An equivalent manual will be available for rainbow trout in the course of 2018 (latest status can be found here; http://www.fhf.no/prosjektdetaljer/?projectNumber=901157). Development of good methodology and technology for monitoring fish behaviour and welfare will contribute to early identification of poor welfare, which may in turn allow initiation of counter measures prior to the occurrence of injury.

It is important to remember that animal welfare is directly related to the quality of life experienced by each individual animal, and that average values for the whole population must be interpreted with care. It is important to consider the breadth of data for each group and pay particular attention to weaker fish, as it is probable that they have the poorest welfare.

Welfare challenges in production

Fish welfare is a challenge during all stages of production. The collective loss of recently sea-transferred smolts remains too high, but it appears that runt syndrome (emaciated individuals which do not grow after sea-transfer), was less prominent in 2017 (see chapter 8.2 on poor smolt quality and runt syndrome). The great variation between farms shows that it is possible to reduce many such losses. In larger fish, high mortality related to repeated handling and de-licing was again a frequent problem in 2017. During all stages of the farmed fish's life, compromises must be made between production, financial, technological, and biology/welfare aspects. Development of good, scientifically based welfare protocols covering the whole production cycle is therefore important. It is also important to identify countermeasures against the most important welfare challenges and generally highlight fish welfare in today's fish farming industry. In this way, we can ensure that financial gains are not prioritised over fish welfare, just because fish welfare is too poorly defined or measurable.

Welfare challenges and new technology

Technology aimed at optimization of production and handling of fish is under rapid and constant development. All new technologies must be demonstrated as providing acceptable animal welfare before being taken into use. Although the general aquaculture legislation has for many years required that new technology be documented in terms of acceptable animal welfare, this requirement has been followed up to a varying degree and proposed

Figure 3.1. A new review of welfare indicators for farmed salmon is available in the form of a manual. FISHWELL is a FHF-financed cooperative project involving Nofima, the Institute for Marine Research, North University, University of Stirling and the Norwegian Veterinary Institute.

changes remain in the consultation process. In the survey performed in association with this report, most respondents (69%) agreed strongly or less strongly to a proposal that fish welfare documentation relating to new technologies should be stricter, while only 8% disagreed somewhat or more strongly, 21% neither agreed nor disagreed, while 2% did not know (see Figure 3.11).

It is important that engineers and personnel with fish health expertise work together during development and testing of new technologies, such that equipment can be rapidly refined before use on a larger scale. More reliable and comparable results may be achieved through standardisation of welfare indicators and their documentation.
Handling should be reduced as far as possible as it poses a risk of injury and stress, and diseased fish have a poor tolerance for handling. Introduction of new technologies increases the risk of poor fish welfare due to a lack of operating experience and as the equipment used may not be optimally adjusted for its purpose. It is therefore important that the '3 R's' (replace, reduce and refine), known from laboratory animal science, are followed during developmental work in order to reduce the impact on fish welfare as much as possible (see fig. 3.2). To ensure good fish welfare there is most commonly a requirement for developers of new technologies to apply for a licence or dispensation from current legislation.

Due to widespread resistance to medicinal de-lousing treatments, many new technologies have been directed at novel methods of louse removal from salmon. New technologies preventing louse infestation have also been introduced e.g. enclosed cages. Such technologies may also reduce the number of fish escaping. Terrestrial farms based on water recirculation and other enclosed farms require high fish densities to be economically feasible, resulting in changes in water quality and social environment for the fish. Although fish health and fish welfare in closed and semi-closed systems has become an important research area, knowledge in these fields remains limited.

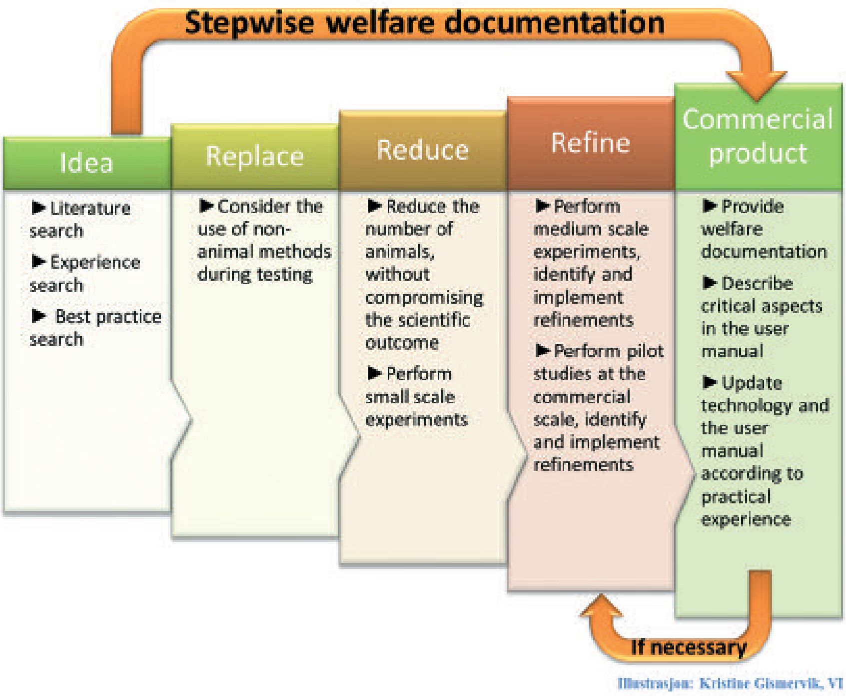


Figure 3.2. Step-wise documentation, from idea to commercial product, of implementation of the «3R's » (Replace, Reduce, Refine) during development of new technologies. Prior to commercial sale, it is important that new technologies are tested and found satisfactory in terms of fish welfare. Illustration by Kristine Gismervik, Norwegian Veterinary Institute.

Welfare challenges related to salmon lice, particularly thermal and mechanical de-lousing

Prevention of high levels of lice production is an important environmental target for the industry. In some cases, the number of lice in individual farms is so high that it represents a direct welfare challenge to the farmed fish. Such cases were observed in 2016. If the louse burden is held below the maximum treatment threshold of 0.5 adult female lice per fish (a limit set to hold infection pressure towards wild salmon low), there will be a low degree of direct impact on the welfare of farmed fish.De-licing has on the contrary, been identified to represent a considerable challenge to fish welfare, particularly if the fish are weakened by other infections. Special consideration must also be given to the welfare of cleaner fish species during lice treatment. If ignored, these fish commonly die during lice-treatment.

Salmon lice display, to an increasing degree, significantly reduced susceptibility to most available chemical treatments. This has led to rapid expansion of novel non-medicinal treatments. In 2017, we have seen further increases in use of thermal and mechanical de-lousing in particular (see also chapter 7.1 on salmon lice). Thermal de-lousing requires transfer of the fish to a water bath (usually 29-34°C, dependent on seawater temperature) for approximately 30 seconds. There are two main systems used for thermal de-lousing, one of which uses a paddle wheel to transport the fish through the water bath. While research has shown that such temperatures are generally painful to fish, specific research on salmon is lacking. Fish health services have, during 2017 observed salmon displaying significant brain haemorrhages following thermal de-lousing (see Figure 3.3) in both (otherwise) apparently healthy large fish that died and fish appearing moribund after treatment. Gas supersaturation and poor water quality (particles and slime) are commonly identified in such treatment chambers. Panic reactions are frequently observed both during and after treatment, and there is some discussion on whether haemorrhaging in the brain, palate and eyes may be associated with this panic state.

Mechanical de-lousing represents various forms of physically flushing the lice from the skin of the salmon. Currently there are three different methodologies in use; one based on water flushing alone, one based on a turbulent water current, and another which combines water flushing and physical brushing. Information from the Norwegian Food Safety Authority indicates that the latter system has been improved during 2017 to ensure better fish welfare, and that the brushes now direct the salmon towards the water jets rather than physically

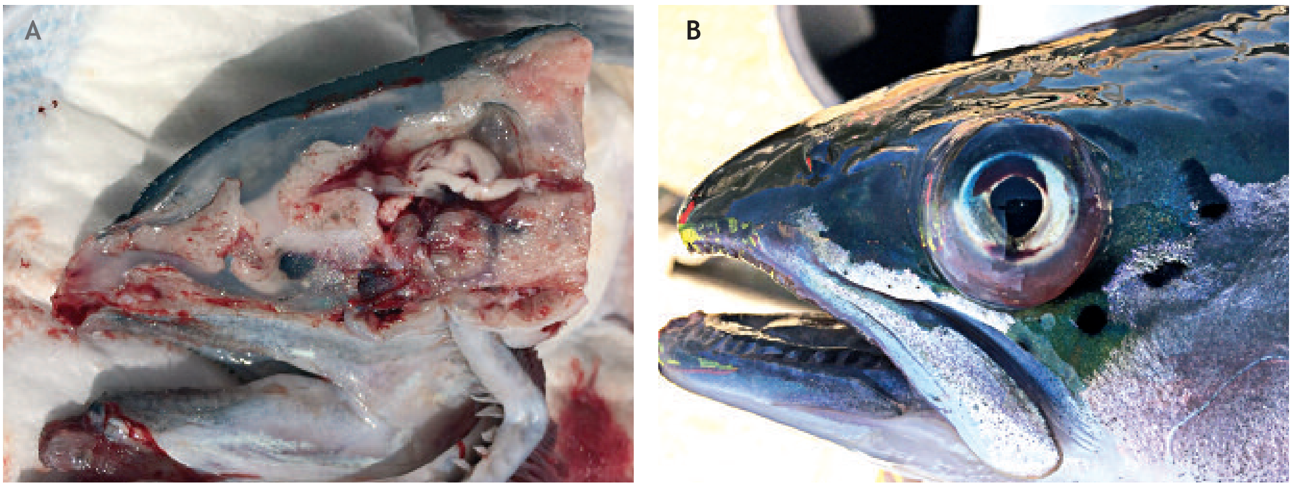


Figure 3.3. The Fish Health Service HaVet observed serious haemorrhage in the brain, palate (A) and eyes (B) following thermal de-lousing of salmon. (Photo: Kristin K.S. Ottesen, HaVet ©).

brush the lice from the salmon. The manufacturer's homepage continues to state, however, that the technology 'brushes clean' the salmon. Injuries including scale loss and skin bleeding are particularly associated with the different forms of mechanical de-lousing. The possible relationship between these methods of de-lousing and occurrence of brain haemorrhage has not been investigated as far as the Norwegian Veterinary Institute is aware.

A common factor involved in all non-medicinal lice treatments is the need for crowding of the fish prior to pumping into the de-lousing system. Crowding is in itself known to represent a considerable welfare risk. Thermal, mechanical and freshwater treatments involve considerable handling and a series of stressful situations will occur as well as direct physical injury to gills, fins, eyes, skin etc. Additional stressors include changes in water quality e.g. fall in oxygen levels or gas supersaturation.

Water temperature may also be decisive in relation to ulcer development. Underlying or active infections e.g. AGD, HSMI are reported to result in significant mortality. De-lousing systems are relatively new and under continual development. Available documentation regarding fish welfare in these systems is minimal and was produced during early developmental phases. A comprehensive overview of welfare problems and risk factors associated with non-medicinal de-lousing remains lacking.

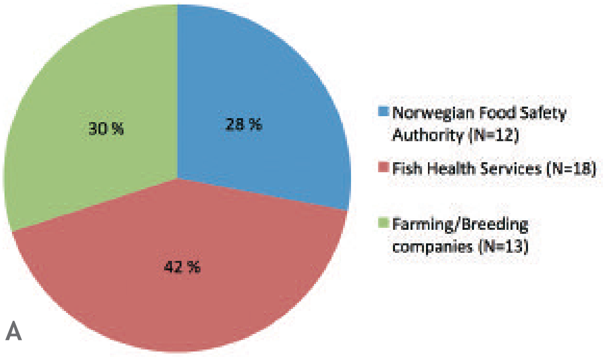
During 2017, the Norwegian Food Safety Authority received 963 reports of welfare related incidents in ongrowing sites for salmon. Of these, 625 reports were related to de-lousing and the majority to non-medicinal treatments and handling. The severity and extent of the reported incidents varied, and different companies may have different thresholds for reporting of such incidents. In comparison, the Norwegian Food Safety Authority received 400 reports of de-lousing associated mortality (> 0.2%) during 2016. An increase in number of reports received was observed from the middle of 2016, following a general reminder to the industry of the compulsory nature of reporting by the Norwegian Food Safety Authority. This can partly explain the increased number of reports in 2017 compared to 2016. Another explanation could be that welfare problems are increasing concordantly with the increased use of non-medicinal methods.

The steady reduction in use of medicinal anti-louse treatments continued in 2017, despite limited continued attempts utilising increased doses and exposure times. Such experimentation, which can lead to both acute poisoning and serious welfare consequences, has occurred less often following an increase in field checks by the Norwegian Food Safety Authority. As far as combination treatments are concerned, the authorities require that documentation of the efficacy of mixtures of various active ingredients must be improved before use.

Documentation of the effect of multiple treatments and treatment intervals on the fish is lacking. The additive effects of other management routines such as net changing, movement of fish from cage to cage or between sites, and well-boat transport, give grounds to believe that the tolerance limits of the fish are exceeded in many farms. This is a particular problem in relation to the significant increase in use of non-medicinal lice treatments in 2017.

In order to collate field fish welfare experiences with respect to novel de-lousing technologies, the annual survey performed in association with this report, sent out to Fish Health Services, farming companies, and the Norwegian Food Safety Authority, included questions related to fish welfare. Forty-three Fish Health personnel shared their experiences of de-lousing on 956 farming localities in 2017 (Figure 3.4A). As the Directorate for Fisheries report only 794 active farming sites in 2016, it is likely that several workers reported the same farms. Figure 3.4B shows therefore the number of farming localities reported per occupation category. The number of respondents from the different geographical regions varies; Northern Norway N=14, Mid-Norway N=13, North Western-Norway N=7 and South Western-Norway N=8.

Respondents were asked to supply the average number of louse treatments (medicinal and non-medicinal) per fish group between (and including) spring de-lousing to the end of November 2017.



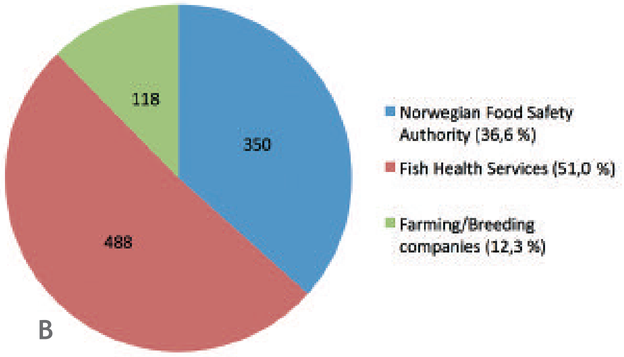


Figure 3.4 A shows the categories of respondents (N=43) and B the number of localities (total 956) reported by each category upon which experiences of de-lousing in 2017 are based.

Figure 3.5 summarises the results for fish transferred to sea in 2016, while Figure 3.6 shows equivalent data for 2017. It would appear that the number of treatments performed in Mid-Norway fell between 2016 and 2017, while the number of treatments rose in Northern West-Norway. For the whole country, 27.9% answered that the total number of treatments has increased between 2016 and 2017, 30.2% considered that the number of treatments had not risen and 7% did not know.

A summary of the de-lousing methodologies respondents

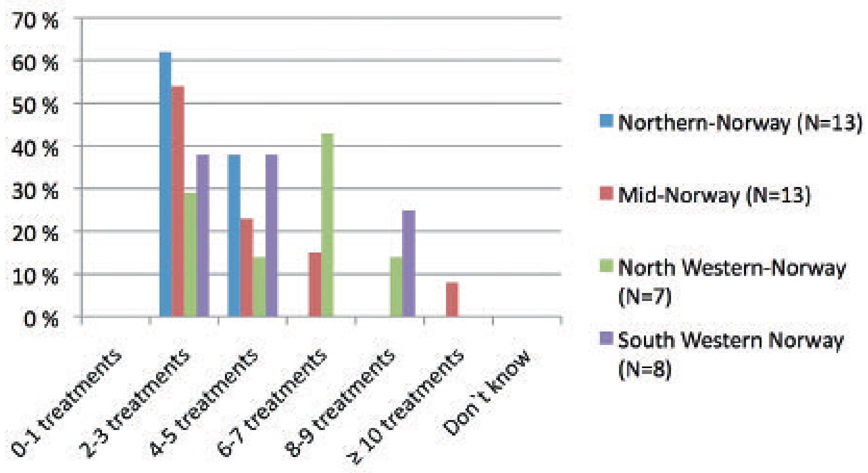


Figure 3.5. Approximate number of louse treatments (medicinal and non-medicinal) per fish group from and including Spring de-lousing 2017 until the end of November 2017, for fish transferred to sea in 2016. The Y-axis displays the response rate (%) (N=41) based on geography, and it is not adjusted for the number of sites in respondents.

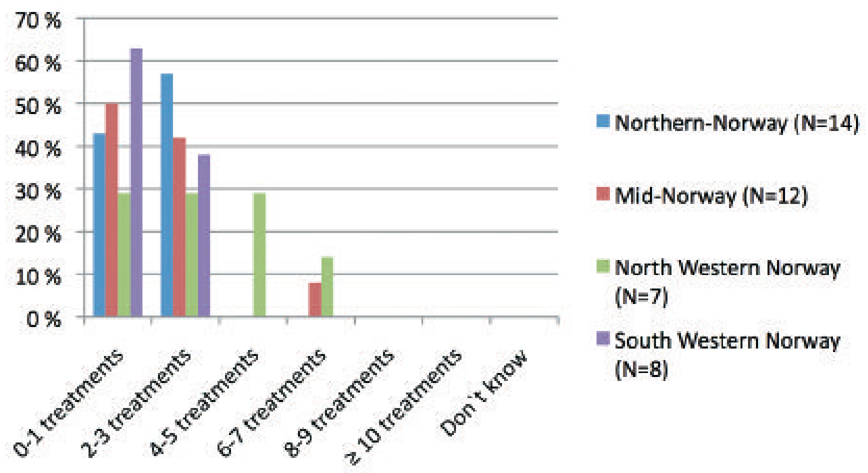


Figure 3.6. Approximate number of louse treatments (medicinal and non-medicinal) per fish group from and including Spring de-lousing 2017 until the end of November 2017, for fish transferred to sea in 2017. The Y-axis displays the response rate (%) (N=41) based on geography, and it is not adjusted for the number of sites in respondents.

had experience with during 2017 is shown in Figure 3.7. It can be clearly seen that the Optilicer method was considerably more in use in 2017, while fewer experiences of the SkaMik method were registered compared to 2016. Another trend is that use of medicinal treatment reduced further.

The efficiency of non-medicinal methods for removal of lice can depend on many factors including the basic principle behind each treatment method, how the machine is adjusted on the treatment day (e.g. water pressure in mechanical systems and temperature in thermal systems), exposure time (freshwater and thermal), model and eventual modifications to the original specification. Other factors such as crowding and the number of fish treated per hour also have an impact. To find out whether field experiences indicated differing success rates between the various non-medicinal treatments, respondents were asked to estimate the average success rate for removal of motile and sexually mature lice following thermal de-lousing, the various flushing systems and freshwater treatment (see Figure 3.8). Heated water appears to score a higher treatment effect than the other treatment types. Common observations included rapid re-infestation following treatment and that de-lousing performance at current threshold infection levels the effect of treatment is difficult to estimate. Respondents were also asked to supply the temperatures normally used during thermal de-lousing. The results must be interpreted with care as treatment temperature, as mentioned previously, varies with sea temperature. Of 38 replies received, 47.4% indicated temperatures between 33-34°C, 31.6% answered 31-32°C, 7.9% answered 29-30°C. One respondent (2.6%) answered that temperatures of 35°C or higher were utilised. When asked to estimate the highest temperatures utilised, several respondents answered 36°C or higher, at sea temperatures of approximately 13°C.

The upper temperature limit for thermal de-lousing is not scientifically documented. There is, therefore, a significant welfare risk associated with de-lousing at the higher temperatures reported here. Given the relatively common occurrence of acute mortality episodes in association with thermal de-lousing, there must be a considerable question mark over whether this method, as it is currently used, represents an acceptable means of treating fish in terms of fish welfare.

The frequency of injury or mortality associated with the various means of de-lousing was also surveyed (see Figure 3.9) on a scale where 1 = never/seldom observed to 5 = nearly always observed in all fish (for the two questions related to mortality, 5 = nearly all de-lousing treatments). Respondents could also answer ‘don’t

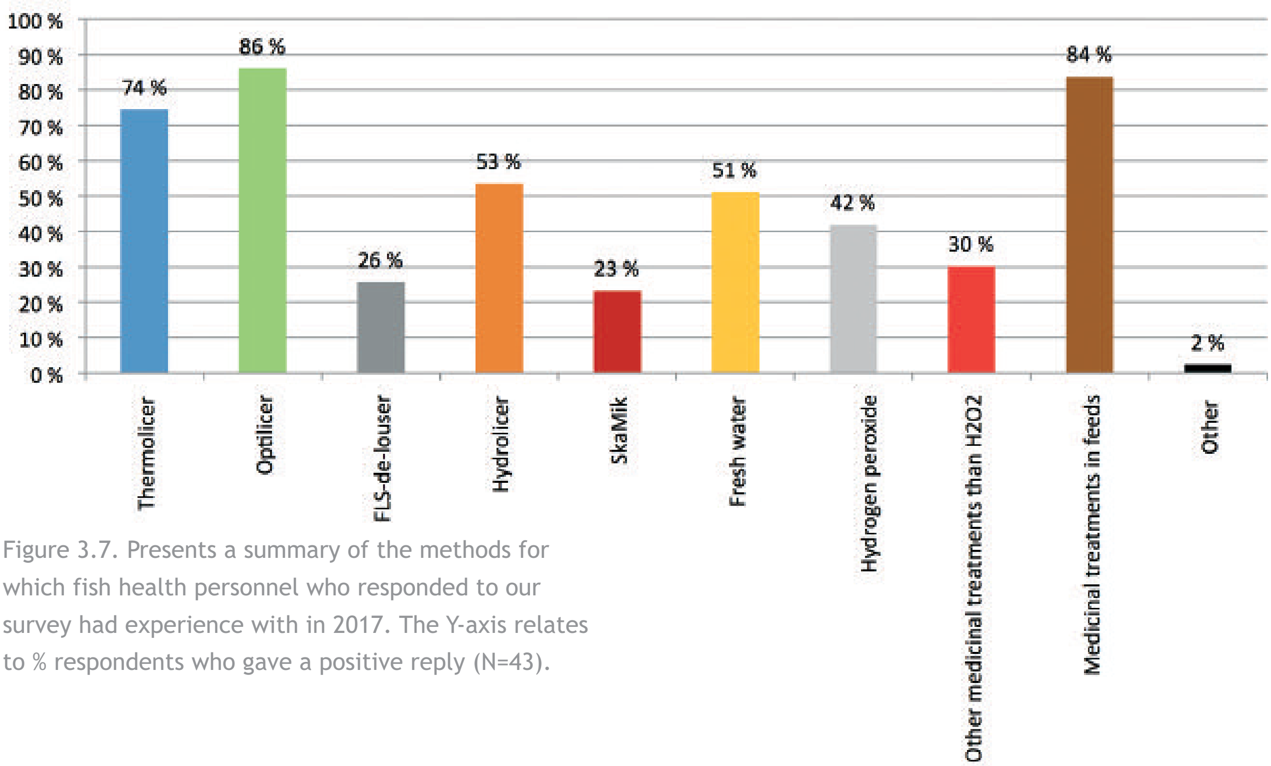


Figure 3.7. Presents a summary of the methods for which fish health personnel who responded to our survey had experience with in 2017. The Y-axis relates to % respondents who gave a positive reply (N=43).

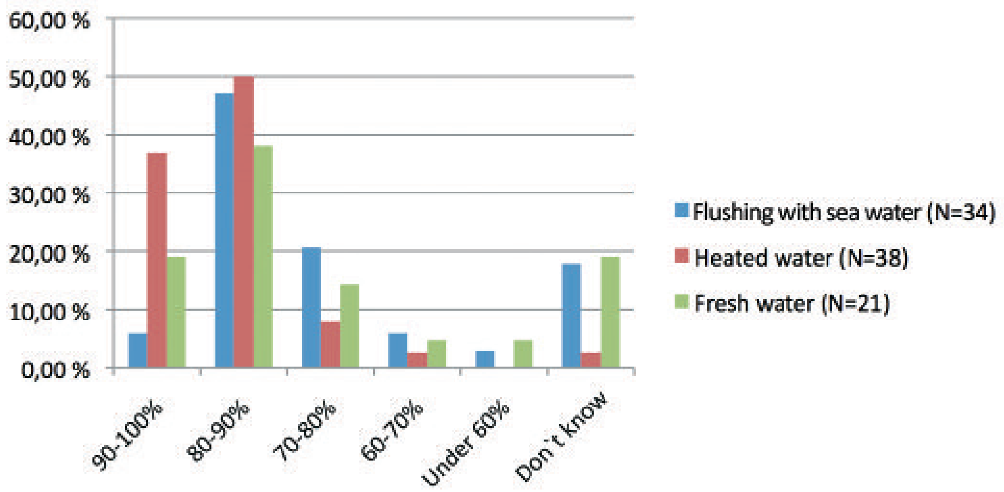


Figure 3.8. Presents a summary of the considered average reduction in number of motile and sexually mature salmon lice after treatment with the various flushing methods (three different types), thermal treatment and freshwater treatment. The Y-axis displays % replies. The number of respondents who reported for each type of treatment (N) is provided in the legend.

know'. These are experiences from 2017, and since these technologies are under continual improvement, experiences will change with time. As in the previous year, thermal de-lousing scored worst in terms of acute mortality, while the flushing methods resulted in greatest scale losses. Both thermal and mechanical de-lousing were considered to result in a greater degree of physical damage than freshwater or medicinal treatments. For freshwater, a larger proportion of respondents replied 'don't know' in terms of the different consequences, which may indicate that fish treated by this method are not followed up to the same extent as other methods. A similar situation was identified in relation to treatment with hydrogen peroxide. Medicinal treatments performed in well-boats and in sea cages were not investigated separately. The method most frequently utilised could influence the resulting handling related injuries. Injuries/side effects registered in association with

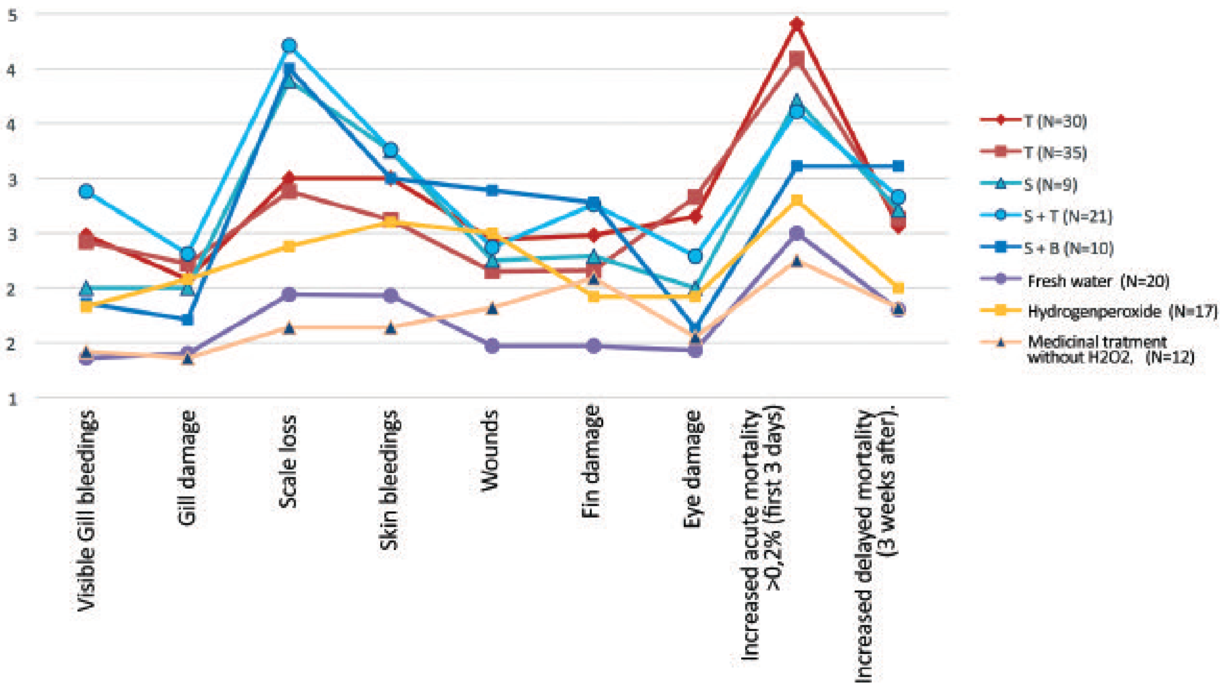


Figure 3.9. Displays the average frequency of injury or mortality each respondent experienced in relation to various methods of de-lousing in 2017, on a scale where 1 = never/extremely rare, to 5 = observed in nearly all fish. For the two questions related to mortality, 5 = nearly all de-lousing operations. The red line relates to two different thermal methods, the blue line three different flushing methods. The number (N) of respondents who replied for each type of treatment is provided in the legend.

thermal de-lousing include panic reactions in which many individuals collide with the walls of the treatment unit during and after treatment. Moribund fish with protruding eyes, bleeding eyes and brain and palate haemorrhage are a common observation. Acute mortality has been associated with CMS or gill bleeding and other underlying diseases such as yersiniosis, gill inflammation, and HSMI. Good fish health prior to de-lousing is therefore extremely important.

Other factors of importance include duration of pre-treatment fasting, crowding and pumping technologies, the latter particularly in relation to fish of differing size. Crowding has been directly related to scale loss and skin bleeding and it may be difficult to distinguish such injuries from those caused by the de-licer. Relatively long and frequent periods of crowding have been the norm in relation to mechanical and thermal de-lousing, and unless less damaging methods of crowding are developed, crowding-associated injury will continue to accompany these de-lousing methods. Mechanical de-lousing is also reported to result in a degree of injury. Gill and operculum injuries have been related to non-medicinal treatments. Hydrogen peroxide treatment performed in well-boats was described to result in more scale loss than cage-based treatments.

When asked whether scoring was performed on individual fish prior to/during/following non-medicinal de-lousing, 19% of respondents replied that such scoring is not common, while the remainder replied that fish health personnel or farm staff perform this type of scoring. The 'welfare poster' scoring system was used actively by fish health personnel in particular, but also by other operators. Different scoring systems developed by fish health personnel and individual farming companies were also used. Respondents were also asked the degree to which non-medicinal de-lousing was performed on fish with grade 3 (= serious, according to the fish welfare poster) external injuries prior to treatment (see Figure 3.10 A). While no one replied that this occurred often (compared to 9.8% in last year's survey), 14.3% replied that this happened occasionally (also a reduction). Respondents were then asked the degree to which external injuries of grade 2 and 3 were observed following non-medicinal de-lousing (see Figure 3.10 B), and 24.4% chose the alternative 'often', which is a slight increase from the previous year.

In 2017, 90 % of respondents stopped a non-medicinal treatment due to serious fish welfare concerns, and most considered this necessary on a maximum of five

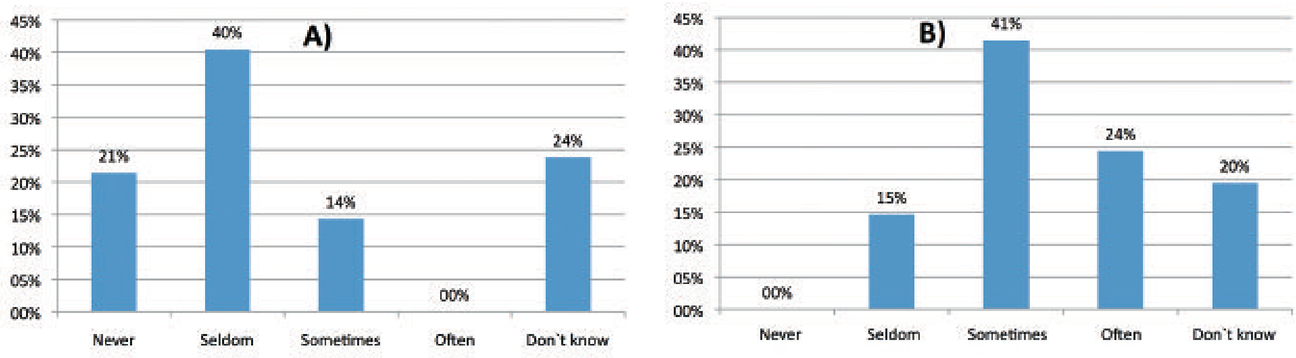


Figure 3.10. A) The degree to which non-medicinal treatments are performed on fish displaying grade 3 (= serious) external lesions prior to treatment, and B) The degree to which new external lesions of grade 2 and 3 are registered following non-medicinal de-lousing. The Y-axis displays the number of replies (N=42 in A and N=41 in B), while the X-axis describes the reply alternatives. For lesion grading, see 'The welfare poster'.

occasions. Most (65%) found that farmers were willing to follow advice from fish health personnel on whether or not to perform a planned non-medicinal de-lousing, while 35% had experienced that a farmer had continued the treatment despite advice to the contrary from the fish health personnel (a slight increase from 2016). 41% of fish health personnel had experience of farms performing non-medicinal de-lousing without involving fish health personnel. In 2017, 90% of fish health personnel reported early harvest of fish with increasing lice numbers, on the supposition that the fish population concerned would not have tolerated further de-lousing. This is an increase from previous years and may indicate that early harvest on fish welfare grounds may be more usual than previously. Around 40% had observed poor biosecurity through unsatisfactory cleaning/disinfection of de-lousing barges. Such practices may indirectly lead to increased treatment associated mortality, via spread of infectious diseases. While cage-side harvesting continues to be an exceptional event, 15% of respondents had experienced this type of event a few times in the course of 2017.

Thermal de-lousing and welfare- what does the Norwegian Veterinary Institute's Diagnostic Service say?

In 2017, 69 cases related to thermal de-lousing were submitted to the Norwegian Veterinary Institute for diagnostic investigation. Of these cases, 63 involved salmon, 5 involved rainbow trout and 1 involved lumpsucker. Increased mortality was described in nearly all cases (64 of 69), either acute or following thermal treatment. In comparison, 13 cases were submitted involving either flushing (eight cases) or freshwater (five cases). Cases not including a description of the de-lousing methodology utilised are not included here.

In many of the submitted cases, the submitter enquired as to whether the mortality observed could be explained by underlying disease or was directly related to the de-lousing treatment itself. In 25 cases involving salmon, diagnoses including CMS, HSMI and PD were made or suspected (see table 3.1). These conditions are known to weaken the fish, resulting in a poorer capacity to tolerate the stresses of de-lousing. Gill disease was common. This affects the ability of the fish to tolerate handling, but may also result directly from handling and thermal treatment. Other findings reported included ulceration, mechanical injuries, bleeding in eyes and brain following handling and thermal de-lousing. In 11 cases, a probable causal relationship was identified between death and/or pathological changes and thermal de-lousing. In several cases it was difficult to confirm whether the fish died with- or of- the disease. The Norwegian Veterinary Institute recommends that submissions to the diagnostic service include a comprehensive case history including a description of the de-lousing method used and observations prior to and following de-lousing.

This is important information that will allow use of diagnostics as an active constituent of knowledge building.

Table 3.1. Diagnoses awarded in cases related to thermal de-lousing of salmon submitted to the Norwegian Veterinary Institute in 2017
* Co-infection CMS and HSMI in two cases.
** Co-infection PD and CMS in one case.
*** Identified most commonly concurrently with other diseases

Diagnosis	Number cases	Comments
CMS	10*	
HSMI	13*	
PD	5**	Suspected and confirmed
Yersiniosis	1	Suspected
Gill disease	29***	Includes both detection of infectious agents and other pathological conditions

Welfare challenges associated with transport

Farmed fish are transported as smolts or as harvest ready fish. Fish are also graded and moved during the sea-phase of culture. These are operations involving a number of workers, large boats and advanced technologies. There exists little knowledge of how these operations impact fish welfare.

The Norwegian Food Safety Authority received nine reports of 'welfare concern' in association with transport of fish in 2017. Most occurred in the summer and autumn months and may have been related to relatively high water temperatures or reduced water quality. The Norwegian Food Safety Authority classified these events as either transport injury, water quality or 'other', with equal numbers in each category. Generally, it is important to produce a robust, disease-free smolt and subject it as far as possible to gentle production and handling methodologies. Stress during transport to the harvesting facility results in reduced product quality; particularly if the fish are not allowed time to recover prior to harvest. Downgrading or customer complaints are indicators of poor welfare.

Wrasse are a particular challenge. These fish are captured on a large scale by local fishermen along the coast from Østfold to Agder and are transported to salmon farms in the west and north of the country. Handling and transport can be rough with extremely high associated mortalities (up to 40% has been recorded). Some wrasse species are also particularly sensitive to the poor water quality that may develop during transport.

Welfare challenges associated with harvesting

All harvesting processes involve a risk of suffering associated with handling (crowding, pumping, chilling, time out of water, blows against harvesting furniture), sedation and bleeding. Some sedation methods such as 'swim in' tanks with a following blow to the head are dependent on the fish's own motivation to swim towards the sedation mechanism. This requires fish that are not exhausted or injured.

Sedation methods permitted for salmonids i.e. electricity or a physical blow to the head (or combination), are satisfactory on fish welfare grounds as long as the system is used and maintained properly. For sedation systems resulting in reversible loss of consciousness, it is essential that the fish be bled properly and quickly following sedation. Cutting a single gill-arch results in a slower bleed than cutting of both gill arches.

Slaughter of fish is now highly automated. Small improvements and close surveillance are of real importance for both total fish welfare and product quality. All automated systems require human supervision and back-up systems. The training requirement for personnel involved increases focus on animal welfare.

Fish stressed prior to harvest rapidly enter a severe rigor mortis that makes them less suitable for filleting. Stressed fish also develop a higher fillet pH, which reduces shelf life.

Increased use of 'cage-side' harvest would reduce the effect on acutely sick/stressed fish. Pumping into a well-boat, transport to harvesting facility, possible pumping to and from a waiting cage are considered significant risk factors for reduced welfare of such fish.

Welfare challenges related to feed and feeding

Correct nutrition is essential for normal development and growth of all animals. Nutritional requirements change throughout the life cycle, and the needs of individual fish may differ. Commercial feeds are designed to meet the needs of the majority of fish within a particular age group and rarely contain excess quantities of the most expensive ingredients. The nutritional requirements of species new to farming are generally poorly understood. Changes in feed composition (due to change in ingredient price or environmental concerns e.g. vegetable ingredients for salmon), may result in health related side-effects and must therefore be monitored closely, both in the short and long term.

Feeding practices and quantity may affect fish welfare directly e.g. due to competition for feed leading to aggression. Fasting is common prior to transport and handling, with the aim being reduction of metabolism. The effects of fasting on fish welfare are poorly understood.

Welfare challenges for species new to aquaculture

New aquaculture species present new challenges in terms of fish welfare and lack of knowledge relating to their needs is common. In Norway, use of cleaner fish species has increased enormously in recent years. This has visualised the challenges faced regarding both health and welfare in these species.

Cleaner fish (wrasse spp. and lumpsucker) represent an important part of salmon-lice control in modern marine salmon farming. All lumpsucker used today are farmed, while wrasse spp. are mostly wild-caught. For wild-caught wrasse there are significant welfare challenges related to capture, storage, transport and risk of infection in addition to those related to keeping a wild fish in captivity.

Concerns have been raised on how the capture of large numbers of wild fish affect the population as a whole and the ecosystem from which they are removed.
The same concerns have been expressed regarding the ecosystem into which they are introduced and from which they may escape. The lumpsucker is now one of the main farmed fish species in Norway. Replacement of wild-caught cleaner fish with farmed cleaner fish ensures a more stable quality and makes improved fish welfare possible, with a lower probability of transmission of disease between species and regions. Vaccination of farmed cleaner fish against the most important bacterial diseases results in lower mortality and improved fish welfare. The increased focus and knowledge base related to the special needs and welfare of cleaner fish species has increased dramatically in recent years.
Monitoring of capture and transport, use of suitable 'cover' in the cages and feeding have contributed to improved welfare, increased survival and better de-lousing effect. Several farmers have increased focus on recapture of cleaner fish prior to harvest, which is also positive for the welfare of the fish concerned.
Mortality levels remain, however, very high. Many fish die during handling procedures and during anti-louse treatments. Freshwater treatment against AGD or lice will most commonly kill any cleaner fish not removed from the system prior to treatment. In the North of the country particularly, lumpsucker may themselves develop such serious Caligus infections that they represent a serious source of infection to the farmed salmon. Legislation surrounding fallowing and movement of fish make reuse of cleaner fish difficult. This effectively makes cleaner fish a 'single use' product, which in itself constitutes a welfare challenge for which both the industry and the authorities must find a better solution. All fish species held in Norwegian aquaculture are in principle given equal protection under the law. It is therefore a paradox that cleaner fish, which are used to improve the welfare of farmed salmonids, are themselves subject to extremely high levels of mortality and a series of other health and welfare challenges.

Although the principles behind welfare evaluation are the same for different species of fish, a deep understanding of the biology and biological requirements of each individual species is necessary in order to develop welfare indicators more specific than total mortality levels. We do not currently have good standardised welfare indicators for cleaner fish.

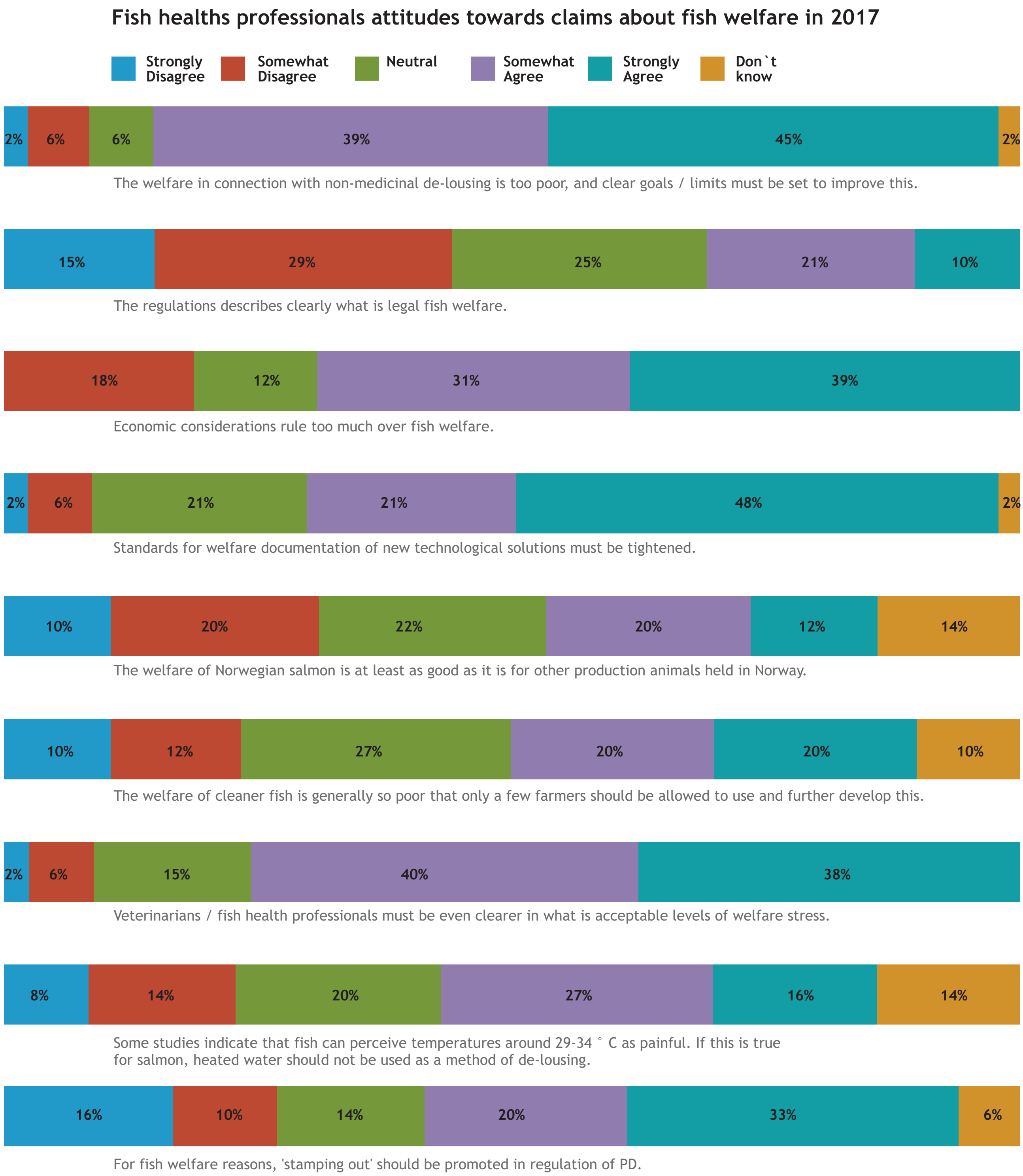


Figure 3.11. Fish health personnel working in independent fish health services, farming companies and the Norwegian Food Safety Authority were asked the degree to which they agree/disagree with nine different assertions relating to welfare, based on their own experiences in 2017. The alternative answers are presented in the figure (N= 48 for three assertions and N=49 for the remainder).

Attitudes surrounding fish welfare in 2017

The limits of what is considered acceptable or not in terms of fish welfare reflect current attitudes to fish welfare. Attitudes are influenced by current knowledge and technological capability/limits. Societal views of animal welfare and current legislation considerably influence individual attitudes to fish welfare. Veterinarians and fish health personnel have a particular responsibility to contribute to good fish welfare, and it was particularly interesting to identify the degree to which they agreed with several assertions, based on their own experiences in 2017. The results are summarised in Figure 3.11.

Evaluation of fish welfare in 2017

Farmers must find a balance between financial, technological and biological factors throughout the whole production cycle. To find the best solutions it is necessary to identify current routines and problems. As the aquaculture industry is so large, even small-scale improvements resulting in fewer injuries or disease will affect very many fish.

The community at large is showing an increasingly critical interest in the environmental consequences of the aquaculture industry and in fish welfare in particular. Post-sea transfer losses are considered by many to be unacceptably high. The underlying causes of these losses and welfare situations must be identified before they can be improved upon e.g. measures to reduce non-medicinal de-lousing losses. Fish welfare concerns that do not necessarily lead directly to mortalities must also be addressed. Scientifically based welfare protocols should be utilised through the whole production chain.

Fish welfare challenges posed by new technologies were also observed in 2017. Large-scale mortality and injury were associated with non-medicinal de-lousing treatments. Documentation of acceptable treatment frequencies and inter-treatment recovery periods are unavailable. This makes maintenance of fish welfare particularly challenging. Cleaner fish are often ‘forgotten’ in terms of fish welfare.

New for 2017 were reports from the field noting panic reactions with consequent brain haemorrhage and bleeding in eyes and palate identified in moribund fish, following thermal de-lousing. Acute mortality related to de-lousing remains high. Examples of higher than recommended temperatures during de-lousing were reported, despite a lack of knowledge of the consequences in terms of pain and absolute tolerance of the treated fish. Gas supersaturation was also identified. Mechanical de-lousing continues to cause scale loss and skin bleeding, while crowding continues to pose a significant welfare risk associated with both thermal and mechanical de-lousing. Both clinically sick fish and fish with underlying disease tolerate handling poorly and it is important to point out that such fish should not be subjected to de-lousing using methods that lead to significant handling stress.
While many farmers already work systematically towards improved fish welfare, more should be encouraged to do so more actively.

Salmon farming now has its own ‘welfare encyclopaedia’, produced in 2017 by the FISHWELL project and financed by FHF. This document has gathered current knowledge of the salmon’s needs and how welfare can be practically measured and documented. This is a necessary part in creation of a common understanding of good fish welfare. The next step is to encourage industry to adopt standardised welfare operating procedures and establish a general requirement for documentation of new technologies in terms of fish welfare, prior to general use. The dynamics of various legislations are currently under review to examine their positive or negative effects on fish welfare and health. The industry needs concrete drivers towards production systems that increasingly focus on fish welfare and health. This applies equally to cleaner fish.

4 Viral diseases of farmed salmonids

A brief summary of the 2017 situation is provided in Table 4.1. Individual diseases are more closely described in subsequent disease specific sections. The statistics stated for notifiable diseases are the official statistics. For the remaining diseases, the provided statistics relate to the number of cases registered in the Norwegian Veterinary Institute system. Diagnoses made by private laboratories are not included in this table.

General evaluation of the viral disease situation

With the exception of the salmon louse, it is the viral diseases which have the greatest effect on fish health in Norwegian aquaculture. Pancreas disease (PD) remains the most important viral disease and the number of localities awarded a PD diagnosis rose considerably from the previous year. This is a result of the increased screening for PD virus performed after introduction of new legislation. The number of PD diagnoses has increased in the northernmost part of its geographical range. In Nord-Trøndelag, the number of cases rose from two to ten and in Nordland, from two to three.

The number of farms affected by infectious salmon anaemia (ISA) was also similar to 2016 with 14 diagnoses. In contrast to previous years with a situation dominated by geographic clustering of outbreaks, the outbreaks identified in 2017 were spread over a broader geographical area. For heart and skeletal muscle inflammation (HSMI) it is difficult to conclude on whether there has been any significant change in the situation over the last two years, but the prevalence of this disease is considered to remain high, and may be an underlying cause for many cases of handling associated mortality. For cardiomyopathy syndrome (CMS), Norwegian Veterinary Institute statistics and figures from other laboratories indicate a continuing increase in the number of affected localities. This view is supported by replies to our annual survey. An evaluation of the situation for each individual disease is provided in the following chapters.

Table 4.1 Prevalence of various viral diseases in farmed salmonids during the period 2001-2017. For non-notifiable diseases, the data is based solely on diagnoses made by the Norwegian Veterinary Institute.

	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
ISA	12	8	16	11	4	7	17	10	7	1	2	10	10	15	12	14
PD	14	22	43	45	58	98	108	75	88	89	137	99	142	137	138	176
HSMI			54	83	94	162	144	139	131	162	142	134	181	135	101	93
IPN	174	178	172	208	207	165	158	223	198	154	119	56	48	30	27	23
CMS			88	71	80	68	66	62	49	74	89	100	107	105	90	100

4.1 Pancreas Disease (PD)

By Britt Bang Jensen, Jinni Gu and Torunn Taksdal

The disease

Pancreas disease (PD) is an important and serious viral disease of salmonid fish farmed in the sea, caused by Salmonid alphavirus (SAV). Diseased fish display extensive pathology in the pancreas and inflammation in the heart and skeletal musculature.

There are currently two PD epidemics underway in Norway. Subtype SAV3 has been widespread in Western Norway since its introduction from the Bergen area in 2003-4. Following introduction of a new sub-type, marine SAV2 in 2010, PD caused by this sub-type has spread rapidly in Mid-Norway. Most cases of SAV3 PD occur south of Stadt, while nearly all SAV2 cases are registered north of Hustadvika in Møre og Romsdal.

For more information on pancreas disease, see: https://www.vetinst.no/sykdom-og-agens/pankreassykdom-pd

Control of PD

PD is a notifiable disease in Norway (national list 3). Since 2014, infections with Salmonid alphavirus (SAV) have been listed on the World Organisation for Animal Health (OIE) list of infectious fish diseases. This means that countries that can document freedom of this disease can refuse to import salmonid fish from SAV-affected areas in Norway.

To hinder spread of infection, legislation relating to PD has been in place since 2007. New legislation introduced in 2017 (2017-08-29 nr 1318) replaces previous legislation (2007-11-20 nr 1315 and 2012-11-06 nr 1056). In the new legislation, a PD zone has been defined between Jæren in the south and Skjemta in Flatanger (the previous border between Sør- and Nord-Trøndelag) in the north. The remainder of the coastline is split into two surveillance zones stretching from the southern and northern borders of the PD zone to the borders of Sweden and Russia respectively.

In response to outbreaks of PD in the surveillance zone north of Skjemta in Flatanger in Nord-Trøndelag, the Norwegian Food Safety Authority established a new control zone with the intention of prevention, hindering and eradication of pancreas disease (PD) in the council areas of Nærøy, Vikna, Leka, Bindal, Brønnøy and Sømna within the regions of Nord-Trøndelag and Nordland. This zone was extended in December 2017 to include Flatanger, Fosnes and Namsos in Nord-Trøndelag (2017-12-15 nr 2096)

The largest reservoir of infection is infected farmed fish. Intensive health surveillance to identify early stage disease forms the basis for prevention of spread. Focus on diverse parameters associated with transport of smolts and harvest-ready fish, combined with re-stocking of large fallowed areas are important disease reducing factors. Rapid harvesting/removal of infected stocks within surveillance zones is favourable both in economic terms and for prevention of spread of PD.

Commercial vaccines against PD are available, and vaccination is standard practice in Western-Norway. Vaccination is less widely used in Trøndelag. The effect of vaccination is debatable and protection is undoubtedly lower than for equivalent vaccines against bacterial agents such as furunculosis. It has been shown however, that vaccination against PD does reduce the number of outbreaks and can lower overall mortality. The vaccine will also result in reduced viral shedding from infected fish.

According to current legislation, all salmonid fish farmed in untreated seawater must be investigated monthly for possible SAV. The Norwegian Veterinary Institute is both national and international reference laboratory for SAV. The Norwegian Veterinary Institute cooperates with the Norwegian Food Safety Authority to produce a daily update (map) and monthly reports of PD-diagnoses, which are published on www.vetinst.no.

Situasjonen i 2017

Offisielle data

I 2017 ble det registrert totalt 176 nye tilfeller av pankreassykdom. Fordelingen viser at det var en økning for SAV3-tilfeller fra 84 til 121 på Vestlandet, mens antallet SAV2-påvisninger på Nord-Vestlandet og i Midt-Norge var nesten det samme som året før, 55 i 2017 mot 54 i 2016. Etter en liten nedgang i 2013, har det totale omfanget og den geografiske spredningen av registrerte nye PD-tilfeller vært forholdsvis uendret med omkring 135-145 tilfeller årlig fra 2012 til 2016. I 2017 var det ingen registreringer av SAV3 nord for Hustadvika, men det ble registrert ett tilfelle av SAV2 sør for Hustadvika (i Romsdalsfjorden). Antall påvisninger i Nord-Trøndelag økte fra to i 2016 til ti i 2017 og i Nordland fra to til tre. PD forekommer hele året, men i 2017 var det en kraftig øking i antall påvisninger av SAV3 på Vestlandet. Dette skyldes trolig innføring av obligatorisk screening fra september som beskrevet over. Antallet av SAV2-påvisninger toppet også i oktober og november av samme årsak. Bortsett fra dette var den månedlige forekomsten av PD lik det den har vært tidligere.

Dødeligheten når det gjelder PD med SAV3 varierer fra lav til moderat, men kan fortsatt være høy i enkelttilfeller. For SAV2-infeksjonene ser det ut til at dødeligheten gjennomgående er lav, men også for denne virusvarianten kan det være høy dødelighet i enkeltmerder. SAV2-infeksjoner medfører ofte økt fôrfaktor og utvikling av taperfisk. For begge infeksjonene er det ofte forlenget produksjonstid forårsaket av langvarig appetittsvikt, og det kan oppstå en del tap på grunn av redusert kvalitet ved slakting.

Spørreundersøkelsen

I forbindelse med denne rapporten har Veterinærinstituttet utført en spørreundersøkelse blant fiskehelsetjenester og inspektører i Mattilsynet. I nord oppfattes ikke PD som noe stort problem av hverken fiskehelsetjenesten eller Mattilsynet. I Midt-Norge vurderes PD som et stort problem av Mattilsynet (4,5),

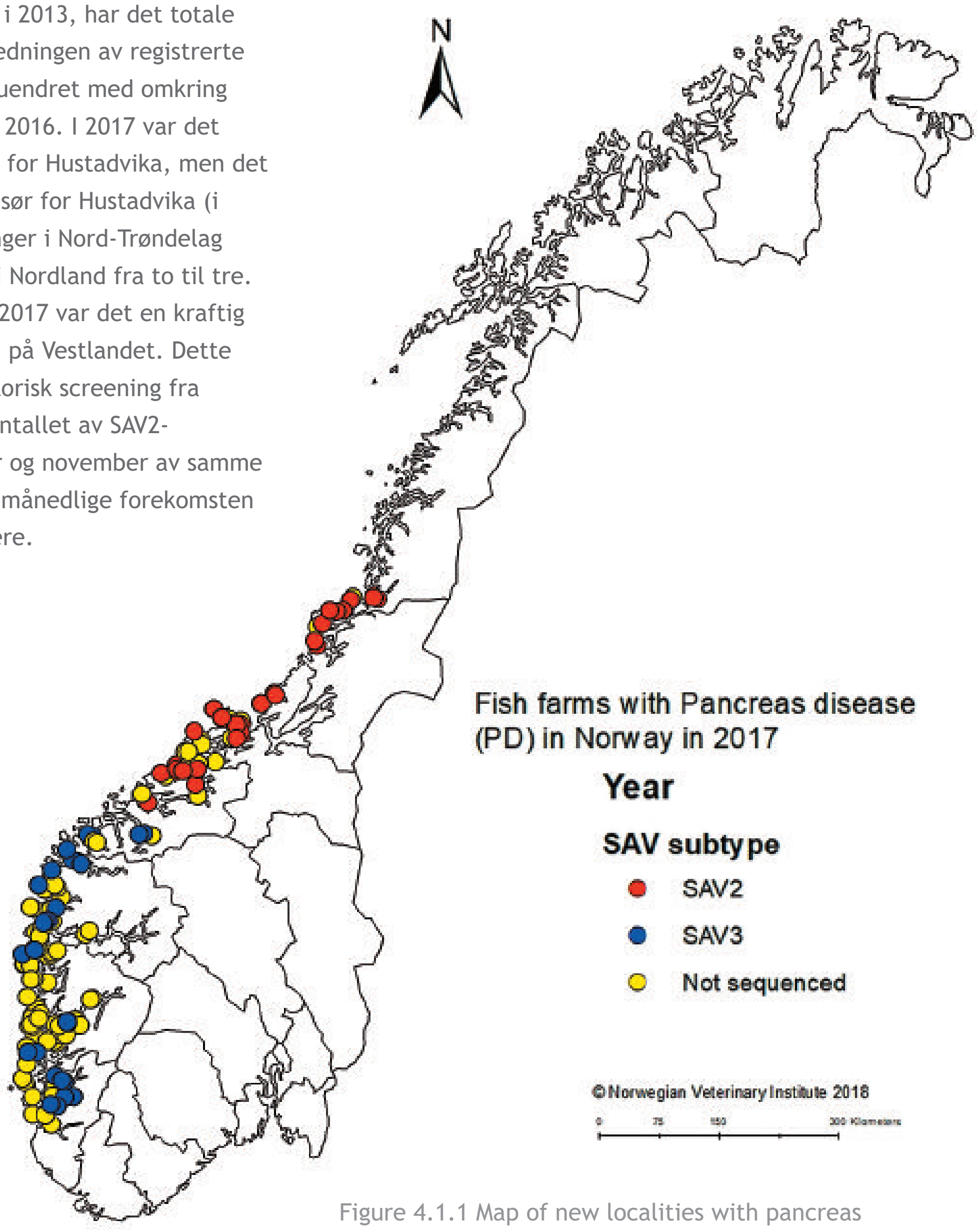


Figure 4.1.1 Map of new localities with pancreas disease (PD) in Norway in 2017 caused by sub-types SAV2 and SAV3

men ikke like alvorlig av fiskehelsetjenesten (3,1). Fra Møre og Romsdal og sørover vurderes PD som et av de viktigste problemene, sammen med lakselus og gjellesykdom, av både Mattilsynet (4,8/4,7) og fiskehelsetjenestene (4,3/3,8).

SAV3

PD med SAV3 forekommer i hovedsak i Hordaland og Rogaland, dvs. i den sørlige delen av PD-sonen. Mens antallet nye tilfeller i Hordaland i 2017 var uendret sammenlignet med tidligere år (vel 50 tilfeller), var antallet nye påvisninger i Rogaland og i Sogn og Fjordane over dobbelt så høyt som i 2016 (26 og 31 i 2017 mot 10 og 14 i 2016). Dette er det høyeste antallet som noen gang har vært registrert i disse to fylkene som ellers opplevde en nedgang i fjor i forhold til tidligere år (se tabell for detaljer).

Antallet av tilfeller av SAV3 i Møre og Romsdal tok seg også opp i 2017. Siden den raske spredningen i 2007-08 med over 20 tilfeller på ett år, har det bare vært et fåtall nye registreringer per år, avgrenset til en lokal epidemi i Storfjorden. Men i 2016 var det seks nye tilfeller, og i 2017 var det ti.

SAV2

Antallet nye registreringer av SAV2-infeksjoner var uendret fra 2016 (55 mot 54). Mens antallet i Møre og Romsdal og Sør-Trøndelag gikk litt ned, økte antallet av tilfeller i Nord-Trøndelag fra to i 2016 til ti i 2017.

I slutten av mai ble PD-virus påvist i overvåkingsprøver på stor stamfisk (12 kg) i et landbasert anlegg ca. to uker etter landsetting. Deretter ble PD med SAV2 bekreftet i juli på Veterinærinstituttet. Samtidig ILA ble også påvist i anlegget. Fisken ble avlivet etter påvisningen.

I juli var det også ett tilfelle med mistanke om PD på stor stamfisk (12 kg) i sjøanlegg, der det også ble påvist ILA samtidig. Denne diagnosen ble ikke verifisert før fisken var utslaktet.

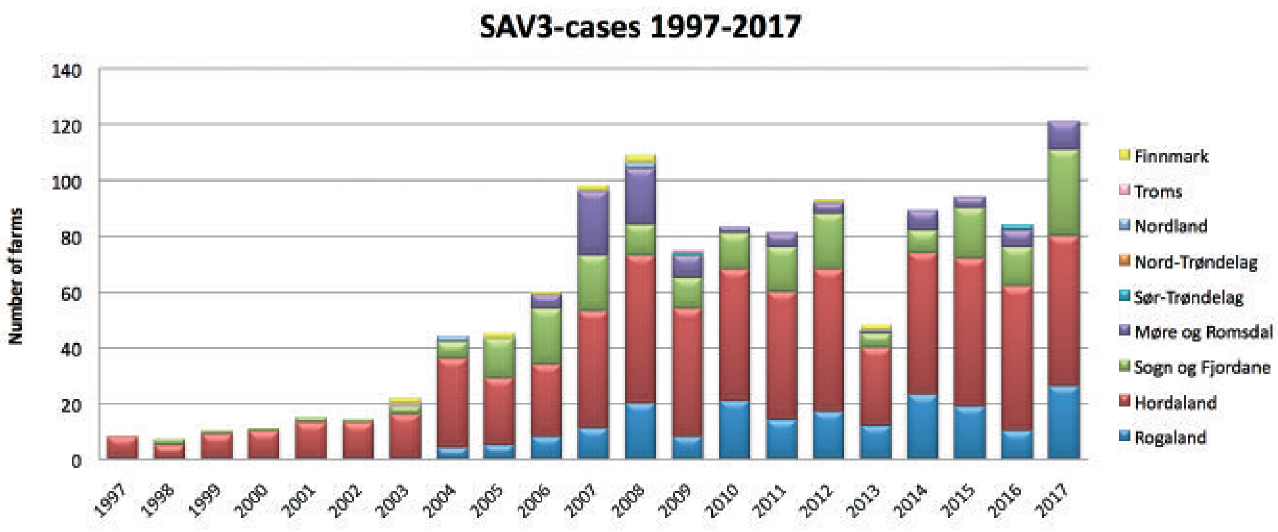


Figure 4.1.2 Regional distribution of new PD-cases per year 1997 – 2017, sub-type SAV3

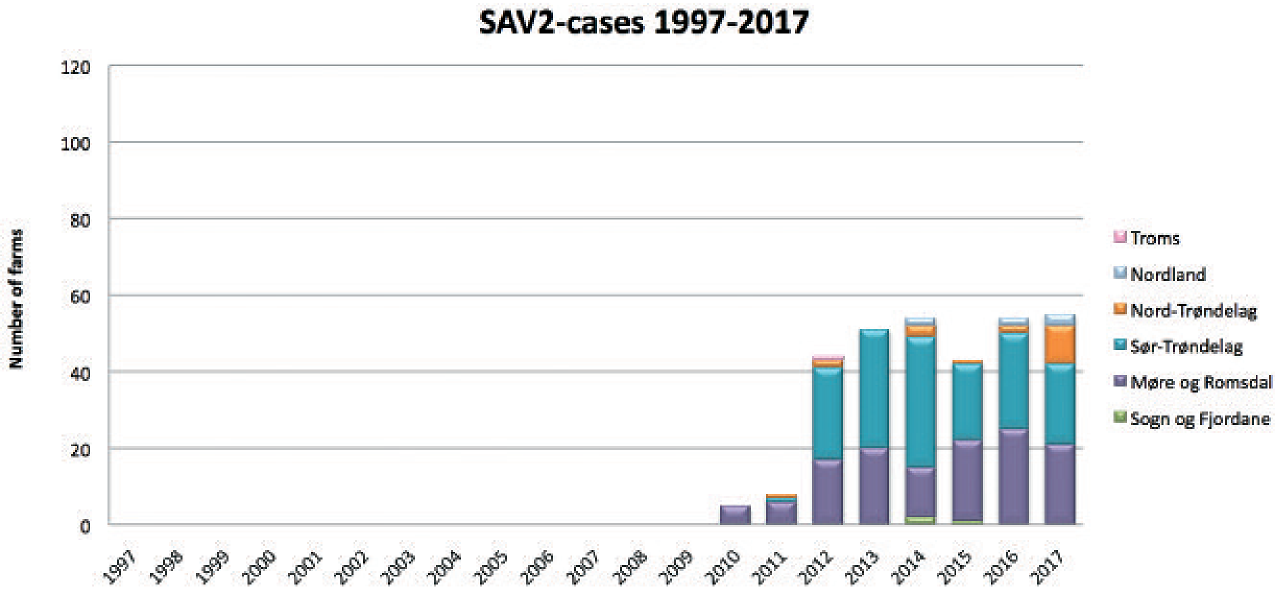


Figure 4.1.3 Regional distribution of new PD-cases per year 1997 – 2017, sub-type SAV2

Statistikk og diagnose

Statistikken disse dataene er hentet fra teller antall nye positive lokaliteter eller nye påvisninger etter en brakkleggingsperiode. Det betyr at det reelle antall infiserte lokaliteter hvert år er mye høyere, ettersom det også står smittet fisk i sjøen fra året før.

Pankreassykdom er her definert som 1) histopatologiske funn karakteristiske for PD, og PD-virus påvist i organ fra samme fisk (påvist PD) eller 2) histopatologiske funn typisk for PD, men der det ikke foreligger prøver for virusundersøkelse (mistanke om PD). I statistikken er tallene for påvist og mistanke (få) slått sammen. I noen SAV2-tilfeller er det kun påvisning av virus ved PCR som er grunnlag for mistanken om PD.

Vurdering av PD-situasjonen

Den høye forekomsten av PD-tilfeller er en utfordring for næringen og medfører store kostnader (Veterinærinstituttets rapportserie 2015 nr. 5, Pankreassykdom hos laksefisk – en review med fokus på forebygging, kontroll og bekjempelse, ISSN 1890-3290).

PD er en svært smittsom sykdom som kan opptre snikende. Fisk kan være infisert med virus lenge før den blir synlig syk. Hyppig screening er derfor viktig og vil kunne avdekke smitte tidlig, men en lokalitet kan være smittet selv om screeningresultatet er negativt. Smitten spres i sjø, med transport og med flytting av infiserte populasjoner mellom sjølokaliteter. PD er en typisk stressrelatert sykdom. En stille infeksjon kan derfor utvikle seg til et alvorlig utbrudd f eks ved håndtering som følge av lusebehandling.

Antallet nye påvisninger steg dramatisk etter implementering av ny forskrift med krav om månedlig screening for SAV. Uten slike undersøkelser ville en del av disse virusfunnene trolig ha gått uobservert som stille infeksjoner. Det er like fullt godt mulig at disse infeksjonene hadde utviklet seg til aktive kliniske utbrudd som da ville blitt påvist seinere. Om dette er tilfellet, vil antallet påvisninger i 2018 trolig bli færre, spesielt i Rogaland og Sogn og Fjordane som er de områdene der det er sett størst oppgang i påvisninger etter innførselen av den nye forskriften.

Med denne forskriften er det åpnet opp for at anlegg, som får påvist SAV2 utenfor PD-sonen, kan få lov å ha fisk stående i sjø frem til slakt, hvilket trolig vil medføre at sykdommen sprer seg lengere nordover.

Det er i 2017 lansert en ny vaksine som forventes å være mer effektiv mot PD enn de som hittil har vært tilgjengelig på markedet. I 2018 lanseres en DNA-basert vaksine som det også er store forventninger til. Det gjenstår å se om disse nye vaksinene vil ha noen reell effekt på sykdomsproblemet i felt.

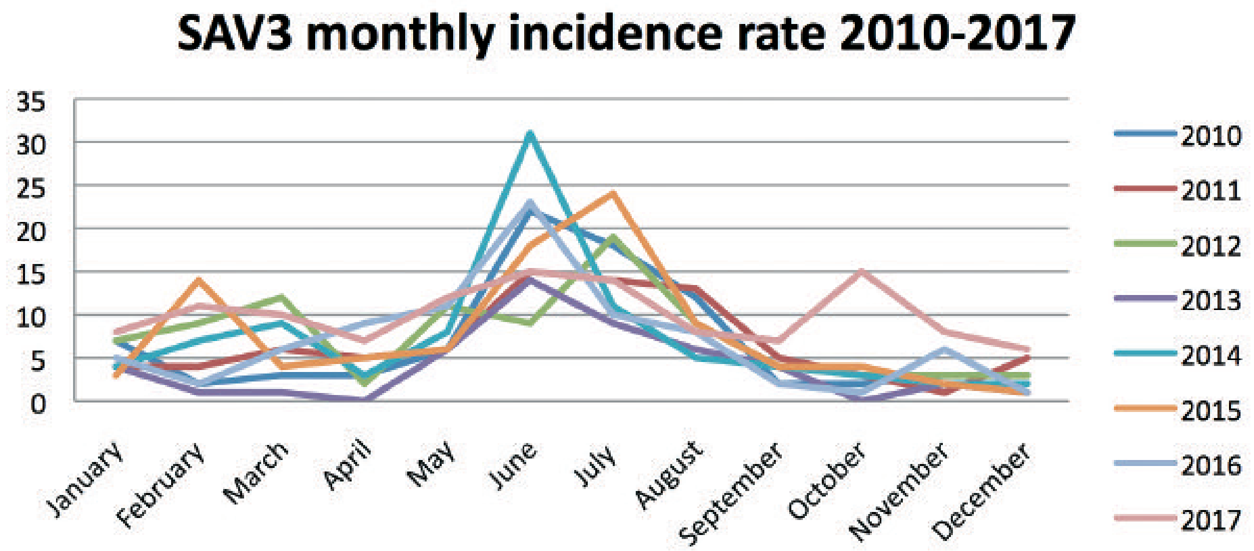


Figure 4.1.4 Monthly incidence rate of localities with PD SAV3 2010 – 2017

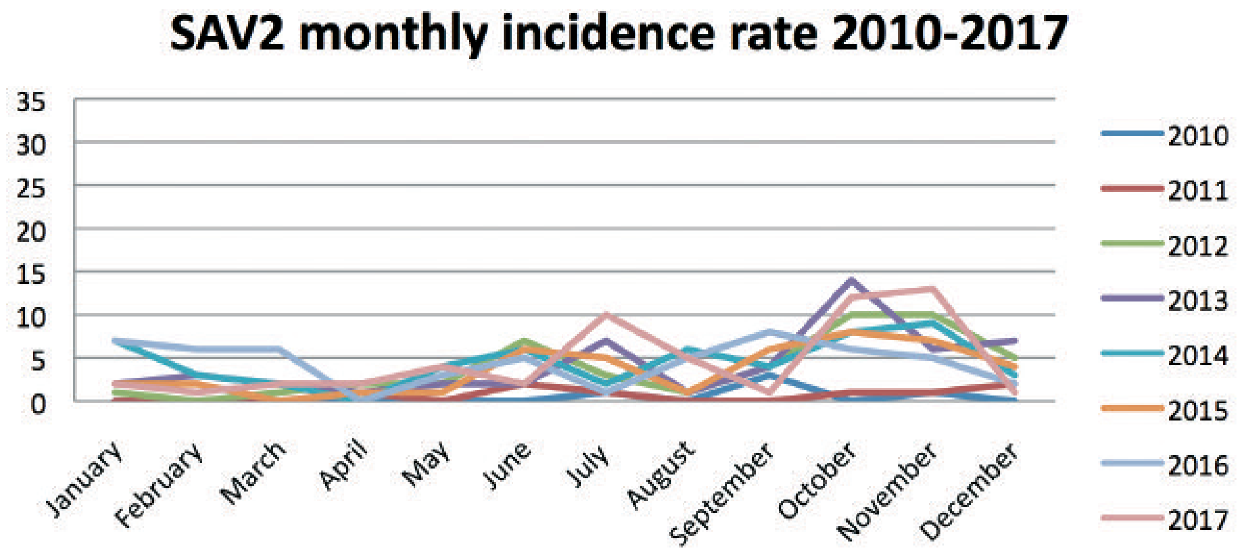


Figure 4.1.5 Monthly incidence rate of localities with PD SAV2 2010 - 2017

4.2 Infectious salmon anaemia (ISA)

By Trude Marie Lyngstad, Maria Aamelfot, Monika Hjortaas, Torfinn Moldal, Geir Bornø and Knut Falk

The disease

Infectious salmon anaemia (ISA) is a serious and infectious viral disease of fish caused by the infectious salmon anaemia virus (ISAV). Natural outbreaks of ISA have only been identified in farmed Atlantic salmon. The virus primarily attacks blood vessels. On post-mortem examination, the main findings include serious anaemia (lack of red blood cells) and various signs of circulatory disturbance and blood vessel damage including a fluid-filled abdomen (ascites), oedema, bleeding in the eye, skin, inner organs and necrosis.

ISA may be compared to a 'smouldering fire', as the fish may be infected for extended periods and display few or no signs of infection prior to outbreak of clinical disease. During the early stages of an outbreak PCR testing may require analysis of many fish to identify the infection, as in many cases only a small proportion of the fish in an affected population may be infected. Daily mortality in cages with sick fish is often low, typically 0.05-0.1%.

ISA virus can be differentiated into either non-virulent ISAV (HPR0 ISAV) or highly virulent ISAV (HPR-del ISAV). These variants are separated on the basis of amino acid sequence differences within the hyper-variable region (HPR) of the gene encoding the hemagglutinin esterase protein. HPRO ISAV is widespread in farmed salmon. It is now generally accepted that virulent HPR-del ISAV originates from HPR0 ISAV. Knowledge of the risk of development of HPR-del from HPR0 is, however, lacking, particularly in terms of how often it happens and what drives this change.

Control

ISA is a notifiable disease in Norway (list 2) and in the World Organisation for Animal Health (OIE) system. Outbreaks of ISA are combatted through implementation of strict counter measures. As a rule, control and observation zones are established around the affected site.

Situation in 2017

Official data

In 2017, ISA was diagnosed in 14 localities; 1 in Rogaland, 2 in Hordaland, 3 in Møre og Romsdal, 1 in Nord-Trøndelag, 2 in Nordland, 1 in Troms and 4 in Finnmark.

Evaluation of the ISA situation

The 14 outbreaks were distributed amongst 7 regions from Rogaland in the south to Finnmark in the north. Since 1993, Norway has experienced between 1 - 20 outbreaks annually (see Figures 4.2.1 and 4.2.2). Over the last few years, the majority of outbreaks have occurred in Northern-Norway, but as far back as 2003-2006, outbreaks were distributed along the whole coastline.

The 2017 outbreaks occurred in the council areas of Tysvær (1) in Rogaland, Kvinnherad (1) and Bømlo (1) in Hordaland, Tingvoll (1), Nesset (1) and Rauma (1) in Møre og Romsdal, Nærøy (1) in Nord-Trøndelag, Vestvågøy (1) and Sørfold (1) in Nordland, Tranøy (1) in Troms, and Hammerfest (1) and Alta (3) in Finnmark (Figure 4.2.3).

The three outbreaks in Møre og Romsdal and the

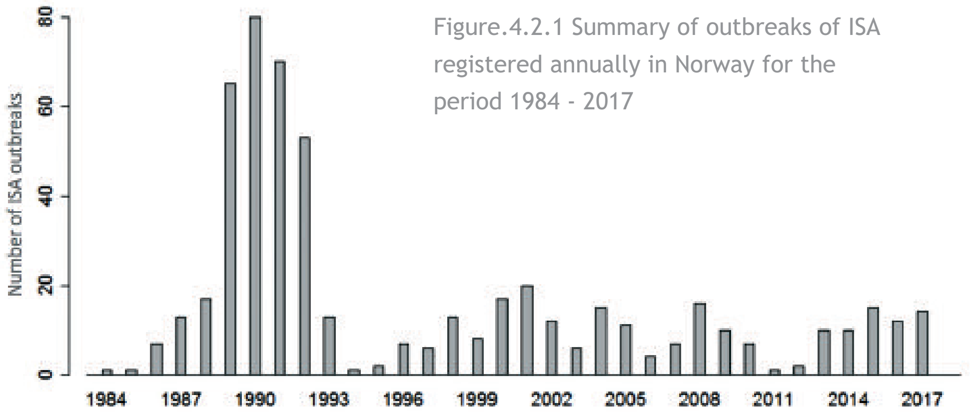


Figure.4.2.1 Summary of outbreaks of ISA registered annually in Norway for the period 1984 - 2017

suspected case in Sør-Trøndelag involved broodstock populations, while the remaining outbreaks involved marine ongrowing sites. There were no ISA diagnoses made in freshwater hatcheries in 2017.

Phylogenetic analyses performed by the Norwegian Veterinary Institute revealed that the majority of ISA virus from outbreaks in 2017 were not closely related and thereby represent isolated occurrences of unknown infection source. Such outbreaks may be explained by mutation of HPR0 ISAV to HPR-del ISAV. One such occurrence was described in a new publication from the Faroe Isles (Christiansen et al., 2017). Recent research has generated results supporting the hypothesis that spontaneous ISA-outbreaks may be related to poor biosecurity and stress (FHF project nr. 901051). Little is known of possible reservoirs and infection routes for HPR0-ISAV. Arguments have been made for the existence of a marine reservoir of HPR0-ISAV and/or that HPR0-ISAV circulates mainly in populations of farmed salmon.

The ISAV isolates responsible for the three outbreaks in Hordaland and Rogaland appear to have different origins based on an

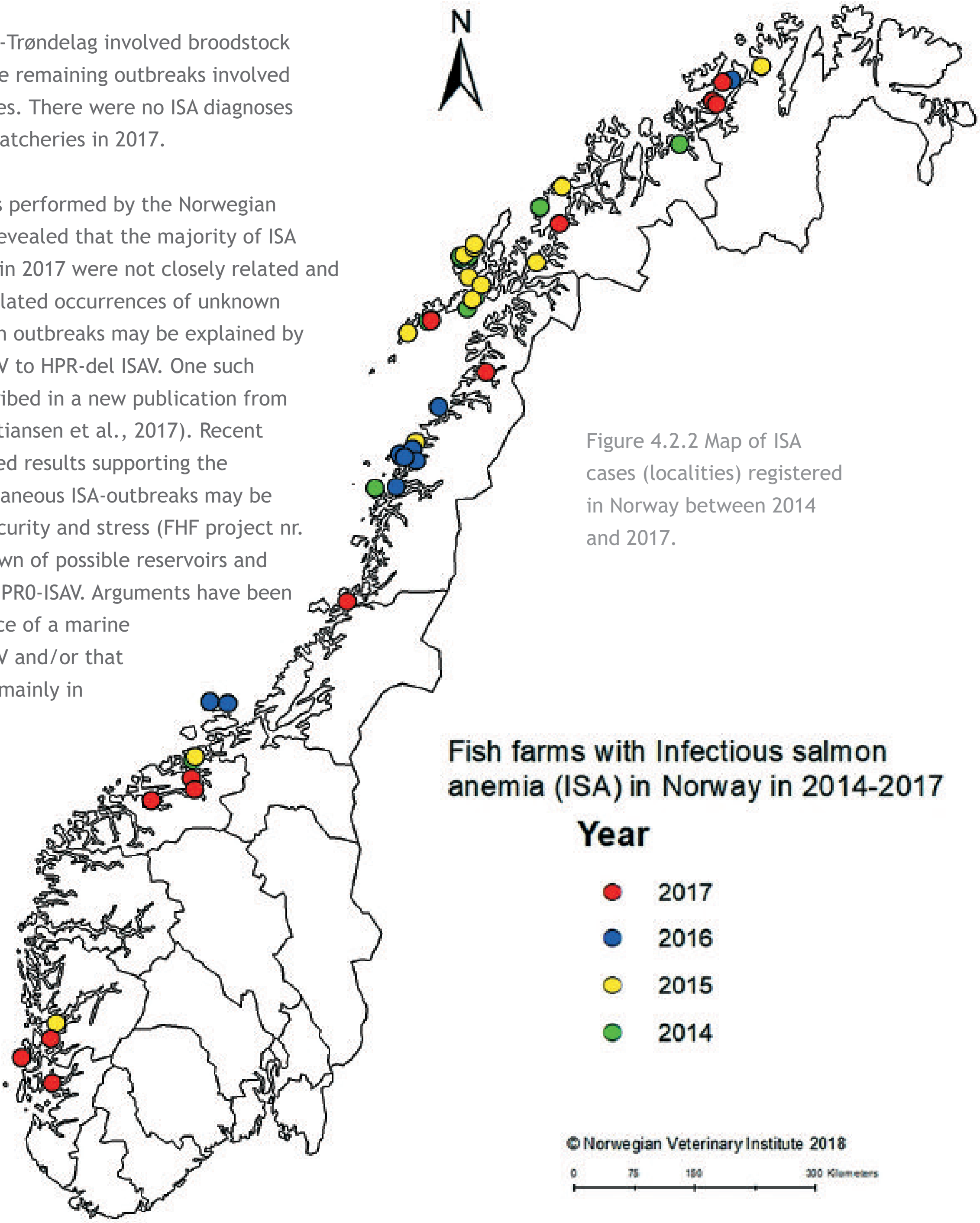


Figure 4.2.2 Map of ISA cases (localities) registered in Norway between 2014 and 2017.

analysis of segment 6 of the HE gene.
The viruses isolated from Tysvær and Bomlø are however, more closely related than the Kvinnherad isolate. At the end of the year, ISA was suspected on a new locality within the control zone surrounding the Tysvær outbreak. Sequencing of the segment 6 gene in this isolate revealed a close relationship with ISAV from the neighbouring outbreak. This means that horizontal infection is most likely in this case.

Of the three outbreaks involving broodstock fish in Møre og Romsdal, ISAV isolates from two (Tingvoll and Nesset) were closely related. It was subsequently established that fish had been moved between these two farms. The source of infection remains unknown, as is the case for the third outbreak in Rauma and the single outbreak in Nord-Trøndelag. An association between the Trøndelag outbreak and a delivery of HPR0-ISAV positive smolts has been suggested, but there is considerable uncertainty surrounding this situation.

Sources of infection for the Sørfold and Vestvågøy outbreaks in Nordland remain unknown. The same is true for the outbreak in Tranøy in Troms. Phylogenetic analysis of segment 6 of the Tranøy isolate indicates a close relationship with the virus from infected broodstock in Rauma at the end of the year (i.e. several months previously). Evaluation of possible sources of infection are difficult due to the time aspect, and any epidemiological link between these two cases cannot readily be arrived at.

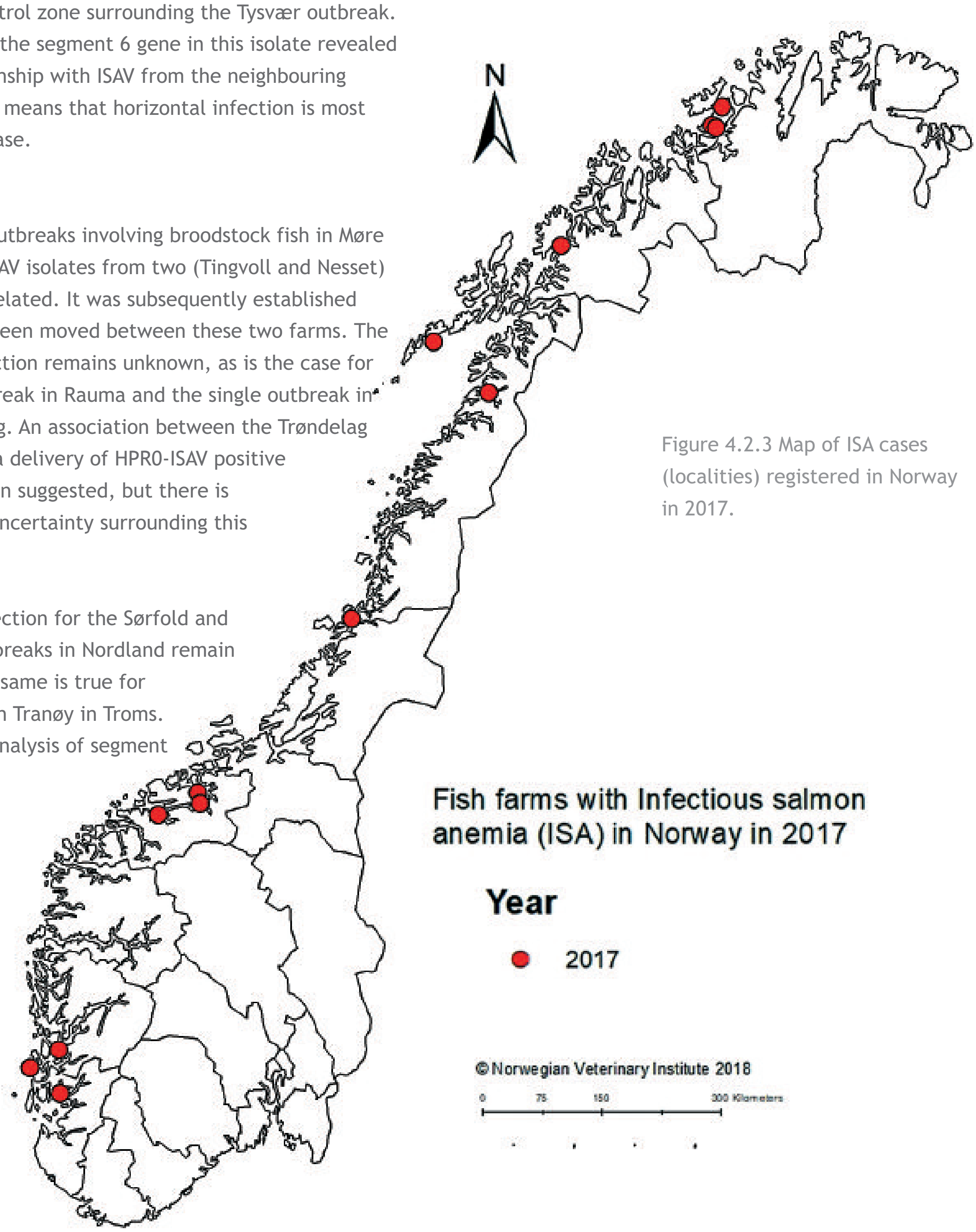


Figure 4.2.3 Map of ISA cases (localities) registered in Norway in 2017.

For the three outbreaks in the Hammerfest region, we found clear indications of horizontal spread of infection. Two of the affected farms had received smolts from the same juvenile production facility situated in the proximity of an ISAV infected farm. It was not, however, possible to confirm direct transmission of ISAV via the smolt delivery.

Successful control of ISA is based on prevention of spread through early diagnosis and rapid removal of diseased fish from the affected farm. The industry, Fish Health Services and the Norwegian Food Safety Authority have, since 2015, worked together on systematic surveillance within ISA control zones. Surveillance includes monthly inspection and sampling for ISA in order to identify new infections at an early stage. Identification of ISAV in samples taken from fresh fish exported from Norway to China underline the importance of effective counter measures against ISA in Norway (Xiao et al., 2018).

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Salmon displaying macroscopic changes consistent with infectious salmon anaemia (ISA). Dark liver, haemorrhage in inner organs, pale gills and ascites. Photo: Per Anton Sæther, MarinHelse AS

Norwegian Veterinary Institute, fieldwork during an outbreak of infectious salmon anaemia (ISA) in Northern-Norway. Photo: Einar Karlsen, Norwegian Food safety Authority.

4.3 Infectious pancreatic necrosis (IPN)

By Torfinn Moldal and Geir Bornø

The disease

Infectious pancreatic necrosis (IPN) is a viral disease primarily associated with farmed salmonids. The IPN virus belongs to the genus Aquabirnaviridae in the Family Birnaviridae. A significant proportion of IPN infected fish develop a lifelong, persistent infection. Juvenile fish and post-smolts appear to be most susceptible. Mortality varies between negligible and 90% dependent on virus strain, strain of fish and other environmental or production related parameters.

Control

There is no publically organised control program for IPN in Norway and the disease is not notifiable. Within the industry, avoidance of infection during the hatchery phase is important. A genetic marker for resistance to IPN makes selective breeding of (QTL) salmon and rainbow trout with a high degree of IPN resistance possible. This type of stock is now widespread in Norway. Eradication of 'house strains' of IPN virus has also contributed to the favourable IPN situation. Although a large proportion of Norwegian salmon are vaccinated against IPN-virus, the protective effect is uncertain.

Situation in 2017

Data from the Norwegian Veterinary Institute

In 2017, IPN or IPN-virus was identified in 23 salmonid farming localities, which represents a slight reduction from 2016 when IPN was diagnosed in 27 farms.

The reduction in number of cases involves ongrowing salmon as there were 14 cases registered in this type of fish in 2017 compared with 19 cases in 2016. IPN or IPN-virus was diagnosed in six salmon hatcheries last year, a similar number to the previous year.

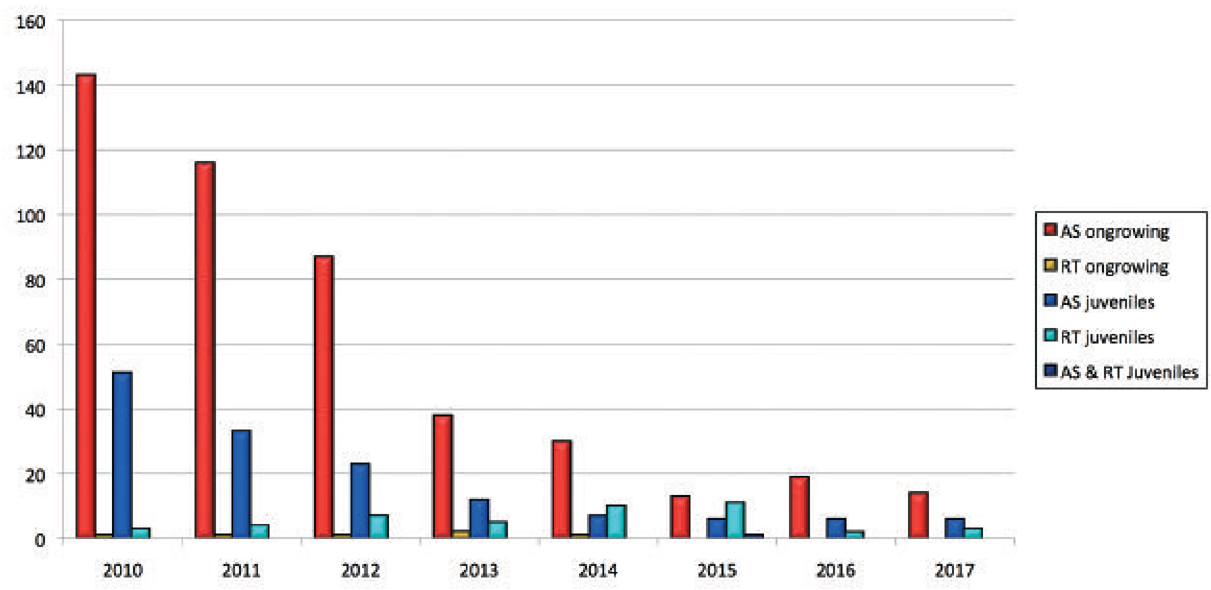


Figure 4.3.1: Number of registered IPN-outbreaks 2010-2017

IPN or IPN-virus was identified in three rainbow trout hatcheries in 2017 compared to 2 in 2016. As in 2016, IPN was not diagnosed in ongrowing rainbow trout. Around half of the outbreaks identified in 2017 were in the three most northerly regions.

Survey

While respondents to our survey generally considered IPN to be relatively unimportant, several experienced significant problems in hatcheries and broodstock farms in 2017. QTL roe is much utilised, both salmon and rainbow trout and nearly all fish are vaccinated against IPN.

Evaluation of the IPN situation

Private laboratories have diagnosed at least four cases involving three freshwater- and one marinefacilities. As IPN is non-notifiable and diagnoses do not require confirmation by the Norwegian Veterinary Institute, the actual number of cases is likely to be higher. Whether cases diagnosed by the Norwegian Veterinary Institute and private laboratories wholly or partly overlap is unknown. There may also be overlap between cases identified by different private laboratories. It would appear however, that the number of cases appears to remain stably low.

Read more: www.vetinst.no/sykdom-og-agens/infeksiøs-pankreasnekrose-ipn

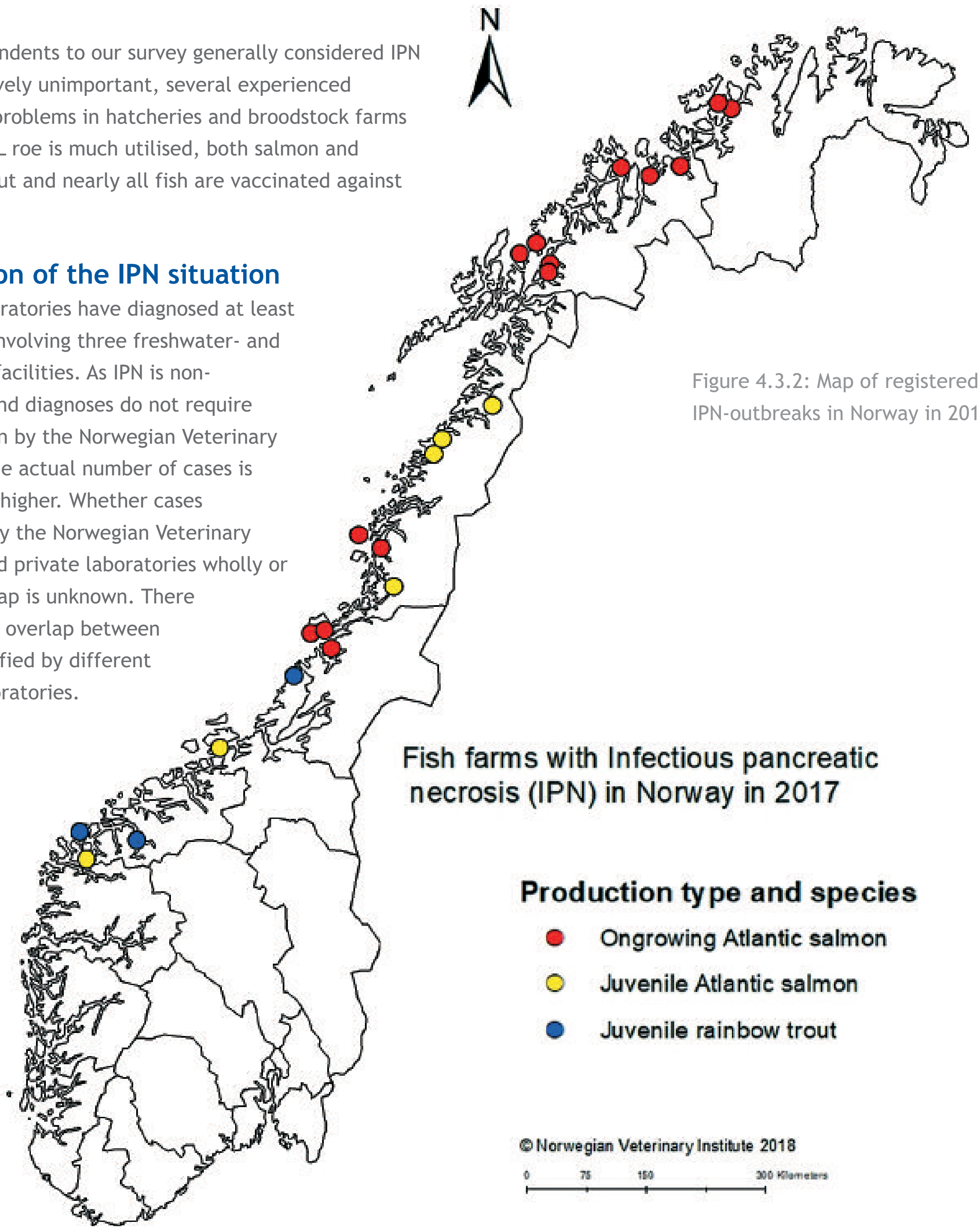


Figure 4.3.2: Map of registered IPN-outbreaks in Norway in 2017

4.4 Heart and skeletal muscle inflammation (HSMI) in Atlantic salmon and HSMI-like disease in rainbow trout

By Maria K. Dahle, Anne Berit Olsen and Torunn Taksdal

The disease

HSMI is a very common infection in Norwegian farmed salmon. HSMI was first diagnosed in salmon in 1999, and in 2014 an HSMI-like disease was identified in rainbow trout. In salmon, the disease is primarily identified during the first year in seawater, but outbreaks may also occur in freshwater. Outbreaks of HSMI-like disease in rainbow trout have so far only been identified in freshwater and in fish transferred to sea from infected freshwater farms. The disease primarily affects the heart. On histological investigation, sparse to gradually more advanced levels of inflammation may be observed in the heart. Outbreaks may last several weeks. Inflammation of the skeletal musculature is a relatively common finding in salmon with HSMI.

HSMI may result in a variable degree of mortality, and losses are often associated with stressful management routines. Affected rainbow trout commonly display anaemia, which is not common in salmon. Salmon dying with HSMI often display signs of circulatory disturbances.

Piscine orthoreovirus (PRV) was identified in HSMI-affected salmon in 2010 (PRV1). Another type of this virus was identified in rainbow trout suffering a clinically similar disease in 2015 (PRV3, also called virus Y or PRVOm). The evidence indicates that the PRV-subtypes are relatively fish-species specific, but may spread to a degree between species. PRV1 from salmon and PRV3 from rainbow trout have a genetic similarity of around 83%. In 2017, the aetiological relationship between PRV1 and HSMI was finally confirmed after salmon experimentally challenged with purified PRV1 developed HSMI. While PRV1 is widespread and has been identified in wild and farmed salmon, infected salmon do not necessarily develop HSMI. HSMI has not been identified in infected wild salmon. PRV3 is less widespread in Norwegian rainbow trout aquaculture. All known subtypes of PRV infect red blood cells and may be found in most blood-filled organs. Fish developing HSMI can have a high viral load in heart and muscle cells.

For more information on HSMI, see: www.vetinst.no/faktabank/HSMB

Control

There is no official control programme for HSMI in Norway and the disease has not been notifiable since 2014. This situation is due to the widespread presence of the virus in Atlantic salmon, which in most cases cannot be associated with disease. PRV3 in rainbow trout is less widespread in Norway, and is also associated with non-clinical infections. There are no vaccines available on the market, but vaccine development work is in progress. Treatment of HSMI with anti-inflammatory components is reported to have some effect.

Losses to HSMI may be reduced through avoidance of management routines resulting in stress in fish with a high viral load. Recent experiments have shown that salmon with HSMI are sensitive to stress in combination with reduced levels of oxygen saturation in the water. This may be related to infection of red blood cells leading to reduced levels of haemoglobin.

Intake of untreated seawater to freshwater facilities represents a risk of infection. Most outbreaks are identified in seawater and it would appear that the most important reservoir of infection is probably to be found in the marine environment. A number of farmers have initiated a disinfection campaign against PRV in infected juvenile production facilities, but little is known of effective ways to be rid of PRV.

The situation in 2017

Data from the Norwegian Veterinary Institute

In 2017, HSMI was diagnosed by the Norwegian Veterinary Institute in 93 salmon farms, 85 ongrowing sites, 2 broodstock farms and 6 hatcheries. This is a significant reduction in the number of diagnoses made in ongrowing sites in previous years. This situation is not, however, reflected in responses from Fish Health Services and the Norwegian Food Safety Authority to our annual survey. The reason behind the low number of diagnoses may be that many outbreaks are diagnosed by private laboratories and are no longer registered by the Norwegian Veterinary Institute. HSMI-like disease was not diagnosed by the Norwegian Veterinary Institute in 2017.

Data from other laboratories

HSMI was diagnosed by private laboratories in 90 farms. Whether these cases are in addition to those identified by the Norwegian Veterinary Institute or are wholly or partly overlapping is unknown. There may also be overlap between cases identified by different private laboratories.

Annual survey

Both Fish Health Services and field officers of the Norwegian Food Safety Authority consider HSMI in salmon to represent a significant problem. On a scale of 1-5

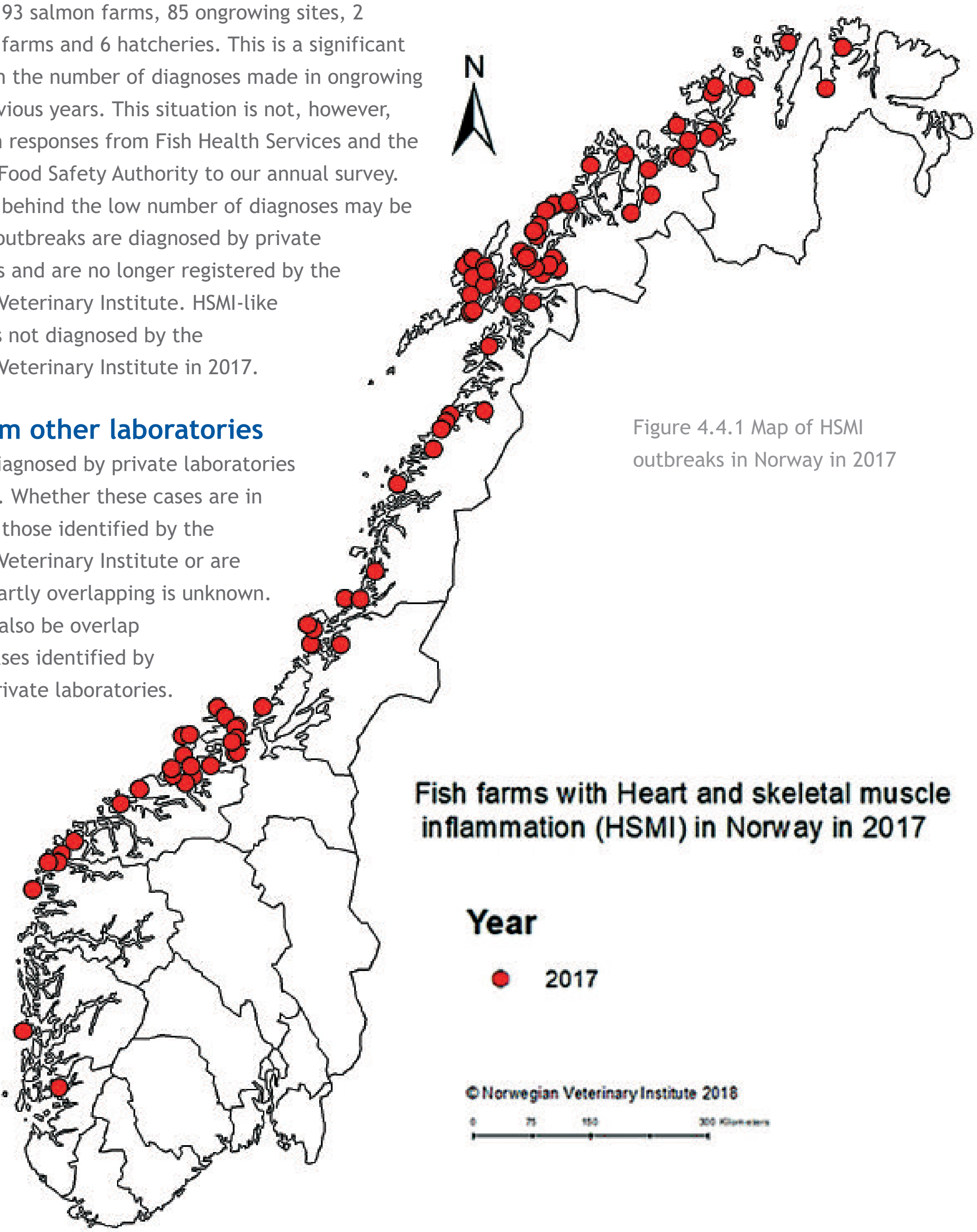


Figure 4.4.1 Map of HSMI outbreaks in Norway in 2017

where 5 = maximal significance, HSMI was graded to 3.6 and is thereby considered the third most important disease of farmed salmon. Fish Health Services in Northern- and Mid-Norway consider HSMI to be a greater problem than the remainder of the country and graded the disease as 4.6 and 4.3, respectively. It is considered less of a problem in juvenile production facilities, scoring an average of 2.3 for through-flow facilities and 2.4 for recycling facilities. Some individual farms seem to have much greater problems than others. In hatcheries, the disease does not seem to be geographically limited or related to any specific type of production system.

PRV3 in rainbow trout (termed virus Y in the survey) scored high for brood stock farms in general (score 3.8) and for juvenile production units in south-western Norway (score 4.0), but not further north. The Norwegian Food Safety Authority (but not Fish Health Services) report problems in ongrowing sites (score 2.7). This is despite an absence of reported diagnoses in 2017, but illustrates the general increased focus on this virus.

Evaluation of the HSMI situation

HSMI appears to continue to be a significant problem in salmon farming. Fish Health Services covering the whole country report problems with HSMI. In Northern and Mid-Norway, it is considered one of the most important health challenges during the seawater phase of culture and is of increasing importance in south-western Norway. The fall

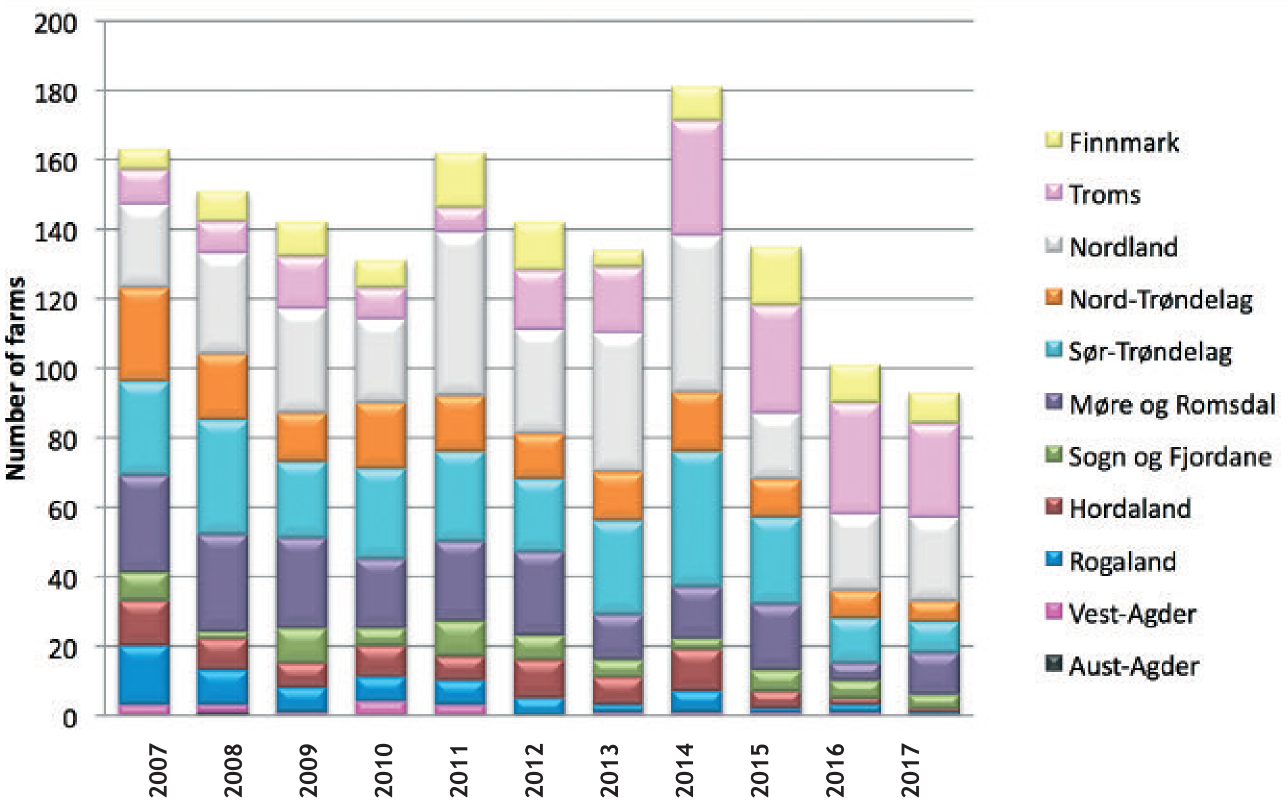


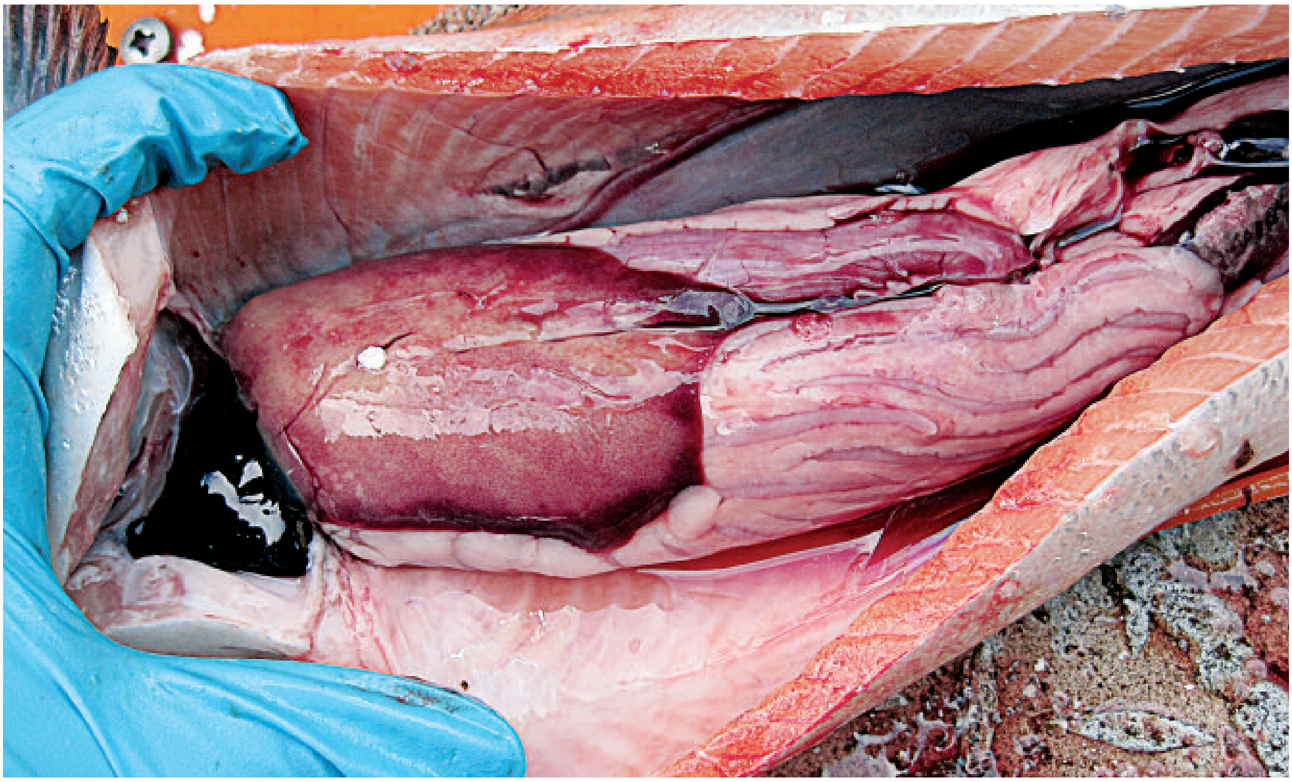
Figure 4.4.2 Regional distribution of HSMI outbreaks 2007 - 2017

in number of reported cases in ongrowing sites does not, in all probability, reflect an actual fall in number of outbreaks, but is more probably related to the now non-notifiable status of the disease. HSMI outbreaks diagnosed by private laboratories are not included in official statistics, but the incomplete reports we have received indicate a minimum of 90 HSMI diagnoses during 2017. The HSMI situation remains, therefore, at least at the level of the previous year.

HSMI appears to be an important factor related to mortality episodes following de-lousing or other handling routines. HSMI affected fish have a low tolerance for treatment and handling, and high levels of mortality may result. The significance of HSMI in juvenile production units seems to vary, but severity does not seem particularly related to geography or production system.

HSMI-like disease was not identified in rainbow trout during 2017, but PRV3 (virus Y/ PRV-Om) is reported as problematic at all levels of production. This is particularly the case in south-western Norway, where focus on this virus has been greatest.

HSMI and associated diseases mediated by PRV are of increasing international importance. HSMI was reported in Chilean Atlantic salmon farming in 2016 and in Canada in 2017. PRV3 has been associated with disease in rainbow trout in several European countries.



Heart and skeletal muscle inflammation (HSMI) in salmon. Photo provided by Labora.

4.5 Cardiomyopathy syndrome (CMS)

By Julie Christine Svendsen and Camilla Fritsvold

The disease

Cardiomyopathy syndrome (CMS) is a serious cardiac disease affecting sea-farmed salmon. Typically, fish are affected during their second year at sea, but the number of cases affecting younger fish is increasing. The disease is caused by the totivirus Piscine myocarditis virus (PMCV), a naked double stranded RNA-virus with a relatively small genome. Clinical findings normally include inflammatory changes in the inner, spongious parts of the atrium and Ventricle, while the compact muscle layer of the heart is/remains relatively unaffected. In extreme cases the wall of the heart may effectively burst. The disease results in pathological changes similar to PD and HSMI, but CMS does not normally result in changes to exocrine pancreas or skeletal muscle tissues. Waterborne fish-to-fish transmission is known to occur, and the most important reservoir of infection is farmed salmon.

Results from a current epidemiological research project suggest that the virus may be more widespread than originally thought. PMCV was detected in corkwing and Ballan wrasse utilised in salmon farming in Ireland during 2017.

For more information on CMS, see: http://www.vetinst.no/sykdom-og-agens/kardiomyopatisyndrom-cms

Control

CMS is not a notifiable disease, neither in Norway nor for the World Organisation for Animal Health (OIE). There is no official control program for CMS in Norway.

It is known that stress during e.g. de-lousing, transport etc. may trigger outbreaks and associated mortality. Following a CMS diagnosis, all stressful management routines should be reduced to a minimum.

The virus's biophysical characteristics are poorly understood. Choice of a biosecurity strategy is therefore challenging. General control of the health status of incoming fish and water as well as possible vector organisms are important risk reducing elements. There are no available vaccines against CMS, but CMS-QTL smolts are available on the market.

The CMS situation in 2017

Data from the Norwegian Veterinary Institute

The Norwegian Veterinary Institute diagnosed CMS on 96 locations / sites during 2017. All were ongrowing sites or broodstock farms. This represents a slight increase in prevalence compared to the previous year when the disease was identified in 90 farms.

Data from other laboratories

CMS was identified by other laboratories in 100 locations / sites during 2017. Whether these diagnoses are in addition to those made by the Norwegian Veterinary Institute or are partly or wholly overlapping is unknown.

Annual survey

In our nationwide survey, Fish Health Services and field officers of the Norwegian Food Safety Authority considered CMS to represent the most important disease in Norwegian salmon farming in 2017. These evaluations

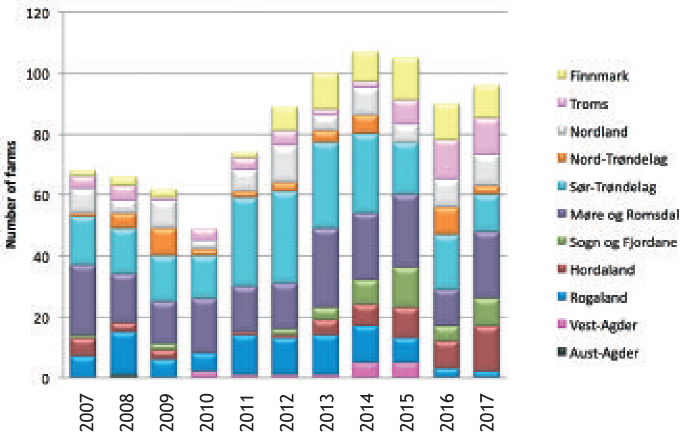


Figure 4.5.1: Summary of CMS affected localities 2007– 2017, distributed by year and region. The data is based on material submitted to the Norwegian Veterinary Institute.

were based on a scoring scale in which 1 = unimportant to 5= extremely important. CMS scored a nationwide average of 3.9, with only salmon louse and challenges related to the parasite scoring higher. On a regional basis, CMS is considered most important in mid-Norway and scored 4.3 in this area (in common with HSMI). Fish health personnel in south-western Norway also gave CMS a high score at 4.2. and 4.7 by Fish Health services and the Norwegian Food Safety Authority, respectively.

However, in this region, salmon louse is considered a greater problem by Fish Health Services and both salmon louse and gill-disease are considered greater problems than CMS by the Norwegian Food Safety Authority.

Evaluation of the CMS situation

In 2017, approximately one third of CMS diagnoses made by the Norwegian Veterinary Institute were in Nordland, Troms and Finnmark. A slightly larger proportion (36%) originated from Trøndelag and Møre og Romsdal, while around a quarter were identified in west and south-western Norway. The number of cases identified by other laboratories has increased since 2015, and some of these cases may overlap with Norwegian Veterinary Institute cases. This makes exact estimaion of the total number of cases for 2017 and recent years difficult.

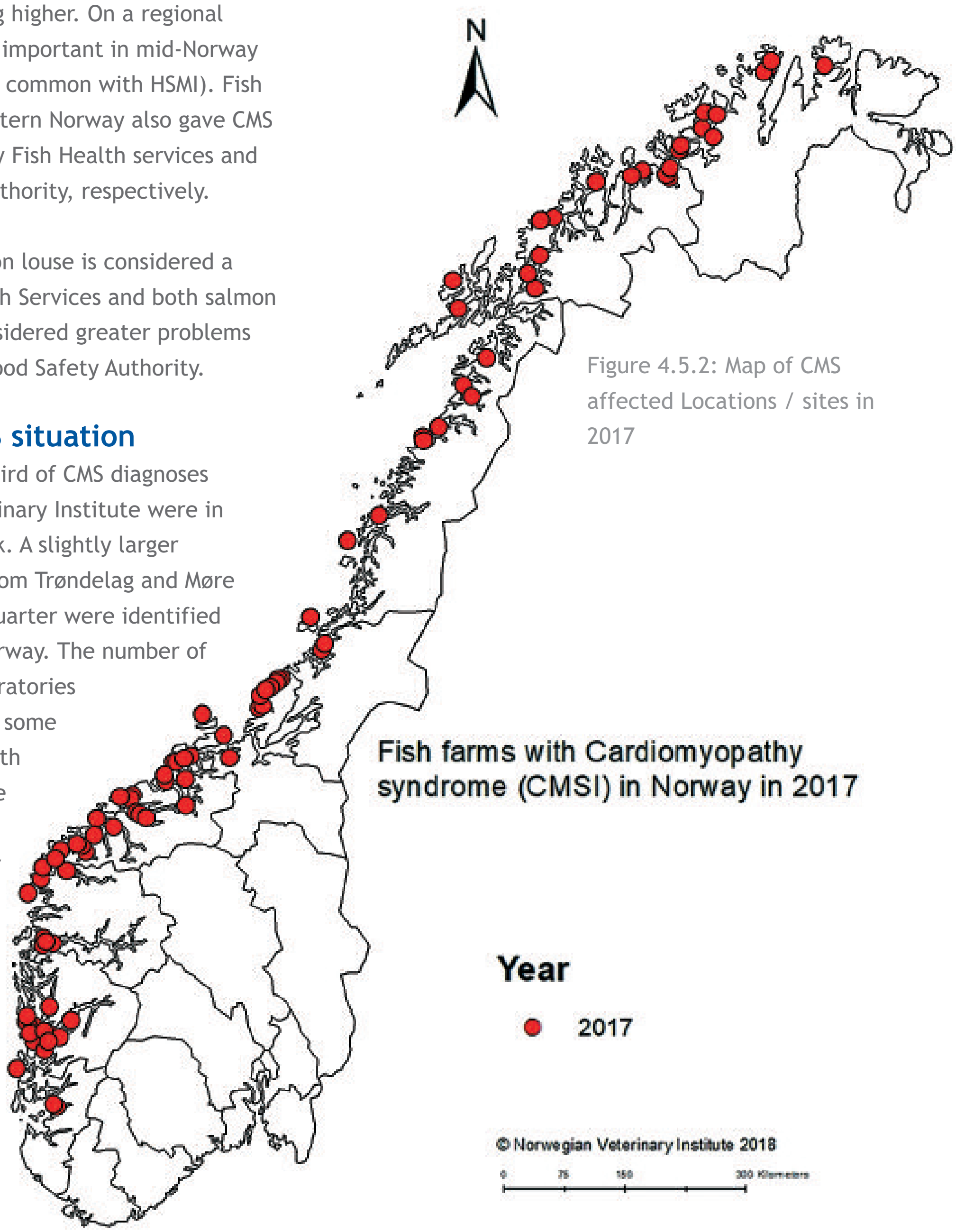


Figure 4.5.2: Map of CMS affected Locations / sites in 2017

4.6 Viral haemorrhagic septicaemia (VHS)

By Torfinn Moldal

The disease

Viral haemorrhagic septicaemia (VHS) is a viral disease that has been identified in around 80 different fish species both farmed and wild. The VHS virus belongs to the genus Novirhabdovirus within the Family Rhabdoviridae. Outbreaks with high mortality in farmed fish populations are primarily associated with rainbow trout. Acute disease is characterized by high mortalities, bulging eyes, haemorrhage, anaemia and abnormal behaviour involving spiral swimming. 'Flashing' may also be observed. On post-mortem, a swollen kidney and pale liver with patchy haemorrhaging can commonly be observed and histological investigation normally reveals haematopoietic tissue damage.

Control

VHS is a notifiable disease (list 2 non-exotic diseases) which is controlled through destruction (stamping out) of all fish on an infected farm. A risk-based surveillance program is in place in Norway, based on examination of samples sent in for routine diagnostic investigation. Following diagnosis of VHS, control and observation zones are established. Vaccination is not relevant for the Norwegian situation.

The situation in 2017

Official data

VHS was not identified in 2017 in Norway. The last Norwegian outbreak occurred in rainbow trout farmed in Storfjorden in 2007-2008.

Evaluation of the VHS situation

No outbreaks of VHS were reported in neighbouring countries during 2017, but previous identification of VHSV in various wrasse species in Shetland in 2012 and lumpsucker in Iceland in 2015 highlights the need for vigilance, as these fish species are used as cleaner fish in Norwegian salmon farming.

The Norwegian Scientific Committee for Food and the Environment (VKM) has recently concluded that the risk (probability x consequence) for transmission of infection from wild-caught cleaner fish to farmed fish is high. Given the serious consequences of outbreak of VHS, constant surveillance of Norwegian farmed fish is important to allow rapid destruction of infected fish.

VHS was for many years endemic in Denmark, but the virus has not been identified in this country since 2009 following a successful eradication programme. France published plans for an eradication programme in 2017. This work is supported by the EU.

Read more: www.vetinst.no/sykdom-og-agens/viral-hemoragisk-septikemi-vhs

4.7 Infectious Hematopoietic Necrosis (IHN)

By Torfinn Moldal

The disease

Infectious hematopoietic necrosis (IHN) is a viral disease that affects primarily salmonid fish. IHN-virus belongs to the genus Novirhabdovirus in the Family Rhabdoviridae. Juvenile fish are most susceptible. Outbreaks occur most commonly during the spring and autumn at temperatures between 8 and 15ºC. Externally, exophthalmos is common. Internally, haemorrhage in internal organs, swollen kidney, ascites and hematopoietic tissue damage are commonly observed.

*IHN was first isolated from Sockeye salmon (*Oncorhynchus nerka*) in a juvenile production unit in Washington State, USA during the 1950's. The virus has since been identified in a number of salmonid species including Atlantic salmon and rainbow trout. The virus can be divided into five main types (U, M, L, J og E) based on phylogenetic differences, and there seems to be a strong association between virus type and host fish species. The majority of virus strains isolated from rainbow trout in North America belong to genogroup M, while isolates from sockeye salmon belong to genogroup U. Isolates belonging to genogroup E have been identified in rainbow trout in a number of European countries since the late 80's.*

Control

IHN is a notifiable disease (list 2 non-exotic diseases), controlled by destruction (stamping out) of all fish on an infected farm.

A risk-based surveillance program is in place in Norway, based on examination of samples sent in for routine diagnostic investigation. Following confirmed diagnosis, control and observation zones are established. Several effective vaccines have been developed, but vaccination is not relevant for the Norwegian situation.

The situation in 2017

Official data

IHN has never been diagnosed in Norway.

Evaluation of the IHN situation

IHN is endemic in western USA and Canada, from Alaska in the north to California in the south. The virus has spread to Japan, China, Korea and Iran as well as several European countries including Russia, Italy, France, Germany, Austria, Switzerland, Poland and the Netherlands. IHN was diagnosed for the first time in Finland in 2017. It is not known how the virus was introduced to Finland, but spread of infection is most commonly associated with trade of infected eggs detected or juvenile salmonids. The virus has also been identified in marine fish species following experimental infection and in wild marine fish. Such fish may therefore act as a reservoir of infection. Given the serious consequences of an outbreak in Norway, constant vigilance is important such that infected fish may be rapidly destroyed.

Read more: www.vetinst.no/sykdom-og-agens/infeksiøs-

4.8 Salmon pox

By Ole Bendik Dale and Mona Gjessing

The disease

Salmon pox, caused by the Salmon Gill Pox Virus (SGPV), is primarily a gill disease and was first identified in 1995. The virus is 'the oldest known relative' of the feared human pathogen, the smallpox virus. SGPV was full-genome sequenced and characterised in 2015. The disease is normally found in juvenile fish displaying high level, per acute mortality. Histopathological investigation reveals characteristic pathological changes in the absence of other pathogenic agents.

New diagnostic methodologies have allowed identification of the virus in complex cases of gill disease during all phases of the farming cycle. Losses vary from insignificant to extremely high. The virus was found to be widely prevalent among wild salmon broodstock monitored during last year's surveillance programme and the virus could be detected directly in gill lesions.

Control

There is no public control programme for salmon pox in Norway. Affected hatcheries reduce the risk of mass mortality by stopping feeding, increasing oxygen levels and avoidance of stress on detection of SGPV. Fundamental knowledge relating to prevention of infection is lacking. This important disease is currently being researched in a project funded by the Norwegian Seafood Research Fund (FHF) and the Research Council of Norway (RCN).

Situation in 2017

Data from the Norwegian Veterinary Institute

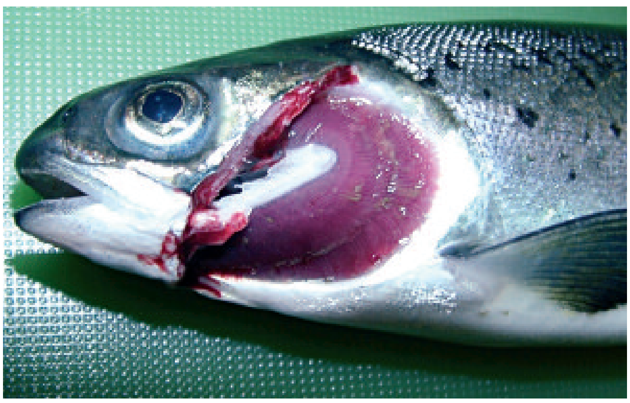
In 2017, salmon poxvirus was identified in the gill tissues of sick salmon in 8 ongrowing sites and 8 hatcheries, from Troms in the north to Vest-Agder in the south.

Annual survey

Variable responses were received from respondents with salmon pox being considered of between very low and extremely high importance. This may indicate that outbreaks of salmon pox may be relatively infrequent, but severe.

Evaluation of the salmon pox situation

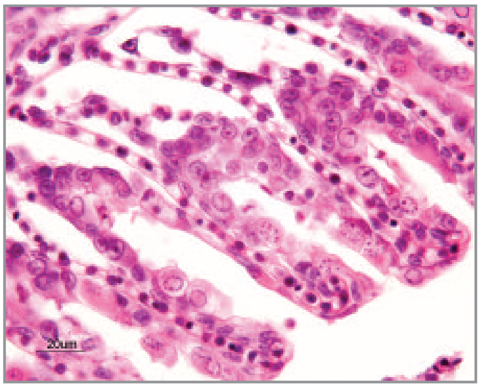
New data indicates that salmon pox may be an important component of complex gill disease in both hatcheries and ongrowing sites, and that seawater outbreaks are commonly related to freshwater outbreaks. Whether this situation is new or been previously overlooked, is



Pox infection in juvenile salmon
Smolt with poxvirus infection
Photo: Per Anton Sæther, Marin Helse AS.

difficult to conclude. Much of the screening work now carried out for SGPV is performed by private laboratories.

Salmon pox and other agents involved in complex gill diseases may be overlooked unless molecular biological analyses are utilised. These analyses must be combined with clinical findings and histopathological characterisation of the pathological changes involved. Salmon pox is also found on the Faroe Isles and in Scotland, where a similar clinical picture has been identified.



Gill tissues with poxvirus infected cells HE-stained section of gills with poxvirus infected cells. Photo: Cecilie Sviland Walde. Norwegian Veterinary Institute

Read more- https://www.vetinst.no/sykdom-og-agens/laksepox#sthash.LDI1QT0c.dpuf

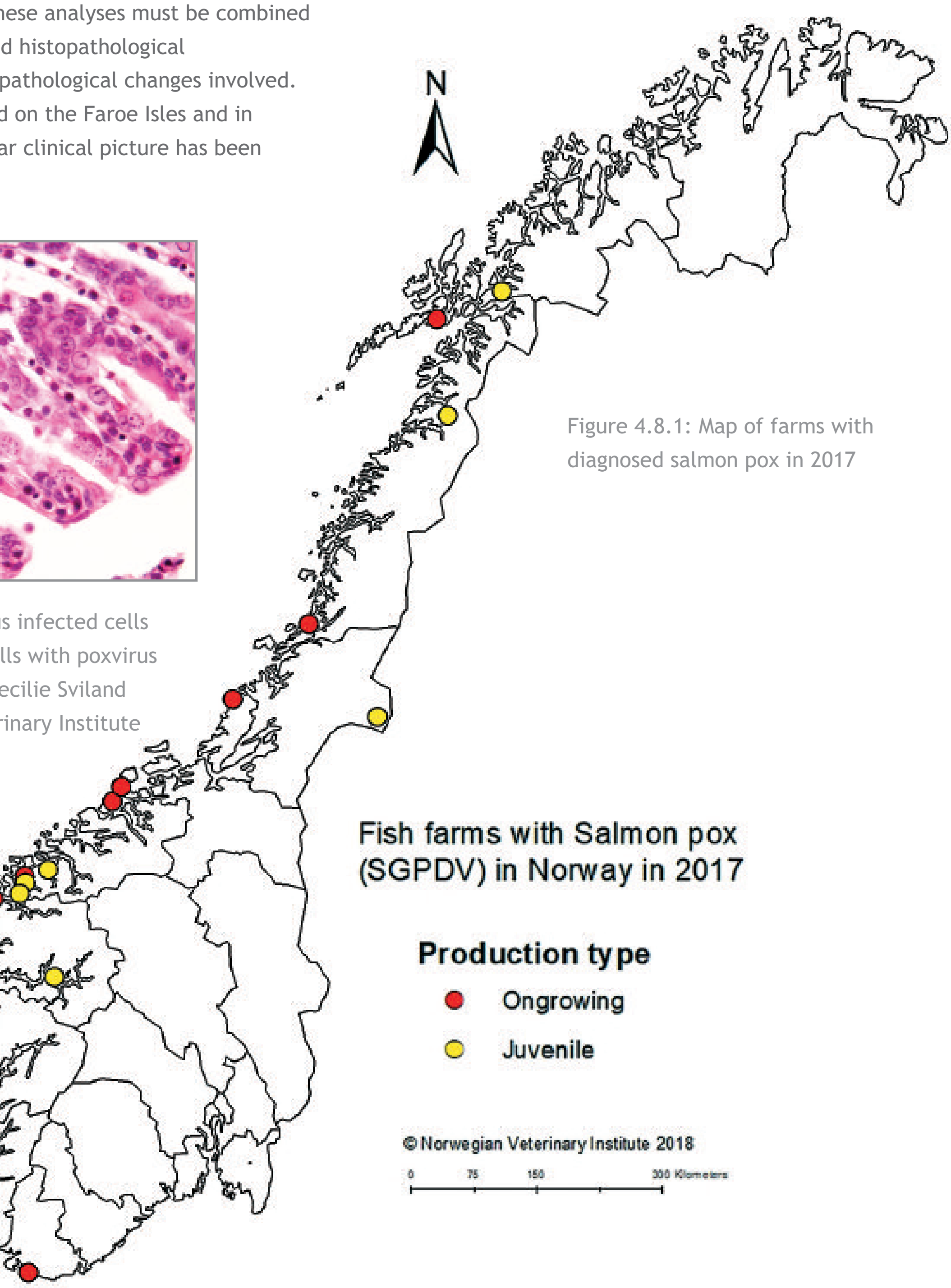


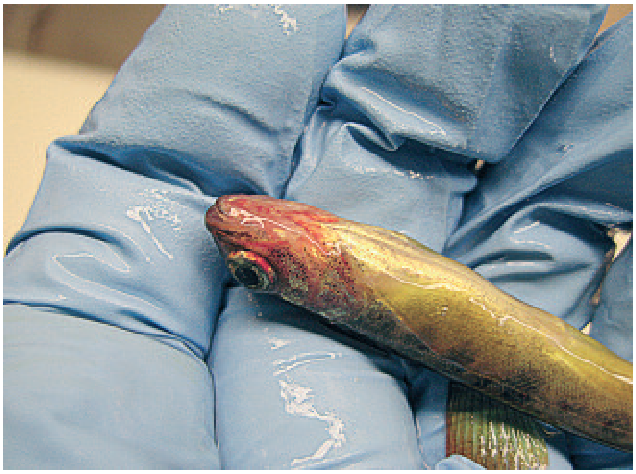
Figure 4.8.1: Map of farms with diagnosed salmon pox in 2017

5 Bacterial diseases of farmed salmonids

Overall, the situation regarding bacterial diseases of farmed salmonids is relatively favourable and stable. In 2017, bacterial kidney disease (BKD) was diagnosed in large salmon in a single farm and a single case of systemic infection with Flavobacterium psychrophilum *was diagnosed in rainbow trout. Both infections (*F. psychrophilum *only in rainbow trout) are notifiable diseases in Norway.*

Previously important diseases including furunculosis and vibriosis, which in earlier years caused huge losses, are now under control, thanks to extensive vaccination. While the general situation is good, winter ulcer continues to cause concerns and is a serious welfare problem. Yersiniosis also appears to be an increasing problem in mid-Norway, particularly in ongrowing fish in the sea. Consumption of antibiotics remains at an extremely modest level both in terms of previous quantities used and in relation to current levels of salmon production. Preliminary figures indicate, however, an increase in antibiotic use in 2017. This increase is probably related to treatment of yersiniosis in mid-Norway.

Individual disease situations are described in specific chapters below. Figures for notifiable diseases are the official statistics. For the remaining diseases, the figures presented represent findings registered by the Norwegian Veterinary Institute. Diagnoses made by private laboratories are not included.



Yersiniosis in juvenile and ongrowing salmon
Photo: Per Anton Sæther, Marin helse and Berit Seljestokken, Grieg Seafood.

5.1 Flavobacteriosis

By Hanne K. Nilsen

The disease

The bacterium Flavobacterium psychrophilum *causes the disease flavobacteriosis in salmonid and other fish species in fresh- and brackish water. The disease causes 'boils' and skin injuries with spread to inner organs and results in high mortality. Rainbow trout (*Oncorhynchus mykiss*) are particularly susceptible to the disease and in Norway* F. psychrophilum *has previously caused large losses during the hatchery phase of culture of this fish species. In recent years, the disease has primarily occurred in larger rainbow trout farmed in brackish water. The bacterium is a relatively normal finding associated with skin conditions in salmon* Salmo salar *L. farmed in freshwater. Particular genotypes of the bacterium are associated with serious outbreaks of flavobacteriosis in rainbow trout. Other genotypes are found in salmon.*

For more information on the disease, see: http://www.vetinst.no/sykdom-og-agens/flavobacterium-psycrophilum

Control

Flavobacterium psychrophilum *transmits horizontally from fish to fish. It is also thought to transmit vertically from broodstock to eggs. Basic hygiene such as disinfection of equipment, personnel and eggs is important for prevention of outbreaks. There is no available effective vaccine for small fish. For larger fish over 30g an autogen vaccine has been developed.*
Systemic infection with F. psychrophilum *in rainbow trout is a notifiable disease in Norway (List 3).*

The situation in 2017

Official data

Systemic infection with *F. psychrophilum* was identified in rainbow trout of approximately 2kg, farmed in seawater in the autumn of 2017. Genotyping revealed that the causal strain belonged to ST2, a variant of the bacterium internationally associated with systemic infection and high mortality in rainbow trout. As is typical of this strain, it displayed reduced sensitivity to quinolone antibiotics. The affected fish group originated from a fjord system in western Norway in which ST2 associated outbreaks are not unusual, see http://www.vetinst.no/rapporter-og-publikasjoner/rapporter.

Late in 2017, a suspicion of systemic infection of *F. psychrophilum* in rainbow trout was raised following indirect detection (immunohistochemistry) of the bacterium in hatchery-reared rainbow trout. The bacterium could not be cultured in a follow up investigation.

During the autumn of 2017, an ulcerous condition with associated isolation of *F. psychrophilum* was identified in salmon farmed in freshwater. Sequence typing of the bacterium revealed that the outbreak was caused by sequence type (ST) 187, which has been previously associated with similar infections in salmon farmed in western Norway.

Suspicions of infections involving *F. psychrophilum* were raised in two other farms in association with ulcerous conditions, following indirect detection by immunohistochemistry. Common findings in both cases included nephrocalcinosis and fungal infection. Stress, resulting from handling and vaccination performed at low temperatures may have contributed to development of the disease. Flavobacteriosis in salmon is non-notifiable.

Evaluation of the flavobacteriosis situation

In the fjord system in which F. *psychrophilum* ST2 has been found in recent years, no outbreaks were reported in 2017. This infection was, however, identified in rainbow trout farmed at high salinity that had originated from the fjord system in question. The situation should be monitored closely in case the bacterium may be developing a tolerance for higher salinities.

Successful control of F. psychrophilum is dependent on close cooperation between industry, fish health services, the Norwegian Food Safety Authority and R+D institutions.

5.2 Furunculosis

By Duncan J. Colquhoun

The bacterium and the disease

Classical furunculosis (infection caused by Aeromonas salmonicida *subsp.* salmonicida*) is a notifiable disease (list 3 national disease) in Norway. Classical furunculosis is an infectious disease which can result in high mortality in salmonid fish both in freshwater and in seawater. In recent years, cage-held lumpsucker have also been affected.*

A. salmonicida *belongs to the Family Aeromonadaceae. Five subspecies have been described,* salmonicida, achromogenes, masoucida, pectinolytica *and* smithia. *Recent work performed at the Norwegian Veterinary Institute has shown that the diversity within the species may be described more exactly based on sequence variation in the gene (vapA) coding for the A-layer protein, a protein found on the surface of the bacterium. Twenty-two different A-layer types have now been identified.*

Despite identification of many equally different types of A. salmonicida, *the various strains and subspecies continue to be generally referred to as either 'typical/classical' (subsp.* salmonicida*), or 'atypical' (all remaining types).*

All variants of A. salmonicida *are non-motile short rods.* A. salmonicida *subsp.* salmonicida *produces rich quantities of water-soluble brown pigment when grown on media containing tyrosine and/or phenylalanine. Atypical variants produce variable quantities of pigment from much to none.*

The main mode of transmission is assumed horizontal, from fish to fish. Outbreaks of furunculosis in Norway have, in the main been associated with the marine phase of culture and in hatcheries utilising seawater.

Control

Generally, good hygiene combined with vaccination introduced in the early 1990's have contributed to the effective disappearance of the disease from Norwegian aquaculture. The disease is currently under extremely good control, and very few outbreaks are registered.

For more information see: https://www.vetinst.no/sykdom-og-agens/furunkulose

The situation in 2017

Official data

Furunculosis was not identified in farmed salmon or lumpsucker in 2017, but *A. salmonicida* subsp. *salmonicida* was again isolated from wild salmon sampled during stripping in the river Bognaelva and in wild salmon from the Ferjaelva, both in Nord-Trøndelag.

Evaluation of the furunculosis situation

The furunculosis situation in Norwegian salmon farming must be considered extremely satisfactory due to extensive use of effective vaccines. That the disease remains identified almost annually in wild salmon and in recent years in farmed lumpsucker, illustrates that the bacterium is still present in the environment and that vaccination against furunculosis remains necessary.

5.3 Bacterial kidney disease (BKD)

By Duncan J. Colquhoun

The disease

Bacterial kidney disease is a serious chronic disease of salmonid fish caused by the bacterium Renibacterium salmoninarum. *BKD is a notifiable disease (list 3, national disease) and only affects salmonid fish.*

R. salmoninarum *is a gram positive, non-motile and slow growing bacterium. It does not grow on standard agar types and requires special media containing the amino acid cysteine e.g. KDM agar.*
The bacterium can transmit vertically from parent to offspring. BKD was first identified in Norway in 1980 in juvenile fish produced from wild broodstock. BKD outbreaks are most frequently identified in western Norway where several rivers are most probably endemically infected. In later years, outbreaks in northern Norway have been related to smolts imported from Iceland.
*Susceptible species include salmon and brown/seatrout (Salmo spp.), Pacific salmon and rainbow trout (*Oncorhynchus *spp.), char (*Salvelinus *spp.) and grayling (*Thymallus thymallus*). BKD may result in acute mortality, particularly in younger fish, but is usually associated with chronic disease. Life-long latent infections can occur.*

Control

As BKD is a notifiable disease and counter measures may have significant economic consequences, the diagnosis must be verified. This is done by relating pathological changes consistent with BKD to detection of the bacterium by at least two biologically independent laboratory analyses.
As no effective treatment or vaccine exists, avoidance of infection is the primary element of control of BKD. The alternative is destruction of affected stocks.

For more information see:
https://www.vetinst.no/sykdom-og-agens/bakteriell-nyresjuke-bkd

The situation in 2017

Official data

Bacterial kidney disease (BKD) is now only sporadically identified in Norway with between none and three cases occurring annually. In 2017, as in 2016, BKD was diagnosed in large salmon in a single farm in Sogn og Fjordane. Samples were taken in response to acutely increased mortality levels. CMS was concurrently diagnosed.

Evaluation of the BKD situation

The current BKD situation is favourable. It is, however, important that we remain vigilant, particularly during broodstock health surveillance.

5.4 Other bacterial infections of fish

By Duncan J. Colquhoun

On introduction of new species to farming, new pathogenic agents and diseases always appear. Most new, emerging and re-emerging diseases are identified during routine diagnostic investigations. The Norwegian Veterinary Institute continually evaluates the broad spectre of different bacteria isolated from sick fish, such that new patterns and trends are rapidly identified. While salmon are protected by vaccination against the most important bacterial infections, the frequency of outbreaks of 'less' important infections such as those caused by Rhodococcus *spp. varies from year to year (see below). Examples of 'novel' diseases identified following routine diagnostic investigation by the Norwegian Veterinary Institute include classical furunculosis and infection by* Pseudomonas anguilliseptica *and* Pasteurella *sp. in lumpsucker.*

The *Pasteurella* bacterium identified in lumpsucker is closely related to, but not identical with that which causes disease in salmon in Norway from time to time. *Pasteurellosis* has not been identified in Norwegian farmed salmon since 2012.

Rhodococcus spp. have previously been associated with post-vaccination infections in salmon. The bacterium was identified in two different salmon farms in 2017, with one case involving vaccinated fish of approximately 100g and the other ongrowing fish of approximately 2kg.

Coldwater vibriosis, caused by *Vibrio salmonicida*, was not identified in salmon in 2017.

Vibrio anguillarum serotype O1 infection was diagnosed in one salmon hatchery utilising seawater and *V. anguillarum* serotype O2b was found in 500g salmon held in the sea. V. anguillarum O2b infection is extremely unusual in salmon and must be considered together with the concurrent atypical *Aeromonas salmonicida* and *Piscirickettsia salmonis* infections identified in the same population (see below).

Pseudomonas fluorescens was not identified in association with disease in 2017. It is now several years since this bacterium was last associated with serious losses in juvenile salmon production.

Atypical *Aeromonas salmonicida* (atypical furunculosis) was identified in farmed salmon in a single farm in 2017. The case was complicated and infections with *Piscirickettsia salmonis* (see under), *Vibrio anguillarum* and cardiomyopathy syndrome (CMS) were concurrently diagnosed.

Piscirickettsiosis caused by *Piscirickettsia salmonis*, was, as in 2016, identified in a single case in Norway in 2017. This bacterium continues to cause significant losses in salmon farming in Chile, but has not led to significant losses in Norway for many years.

Photo: Colourbox.

5.5 Winter ulcer

By Duncan J. Colquhoun and Anne Berit Olsen

The disease

Ulcer development during the sea-phase of culture is a serious fish welfare problem and results in both increased mortality and reduced quality at harvest. Ulcer development is a typical autumn and winter problem, but may occur at any time of the year.

Ulcer 'syndromes' associated with salmonid farming in cold seawater (mainly salmon but also rainbow trout) can be separated into two main types.

Most common is 'typical' winter-ulcer, which is primarily associated with Moritella viscosa *infection. The bacteriological picture may be complex and while experimental* M. viscosa *infection results in ulcer development consistent with the disease, other bacteria including* Tenacibaculum *spp. and* Aliivibrio *(Vibrio) wodanis are also commonly found during diagnostic investigations. The skin lesions associated with this type of disease are found primarily on the flanks of affected fish and at all stages of the seawater phase of culture.*

'Atypical' winter-ulcer or 'tenacibaculosis' *is less common but can be very severe. The condition is commonly associated with high mortality and is characterised by deep lesions of the jaw (mouth rot) and head, tail and fins. Such cases are associated in the main with infections involving diverse strains of* Tenacibaculum *spp. which may be identified in pure culture.*

Moritella viscosa *infections are commonly systemic i.e. found in all inner organs, while the various* Tenacibaculum *bacteria isolated from salmon in Norway are almost exclusively identified as 'local' ulcer infections. Both types of bacterium may result in injuries to the eye.*

Several genotypes of M. viscosa *have been described, which can be roughly separated into phenotypically 'typical' or 'atypical' groups. Commercial salmon vaccines contain components of the 'typical' variety.*

There is a high degree of genetic variation amongst the Tenacibaculum *bacteria identified from skin disease in Norwegian farmed salmon. Many isolates are, or are closely related to,* T. dicentrarchi. *The name* 'T. finnmarkense' *has been recently proposed for an isolate from Northern Norway.*

Control

Winter-ulcer is non-notifiable. No official statistics relating to the prevalence of such infections are maintained. Nearly all Norwegian farmed salmon are vaccinated against M. viscosa *infection. Antibiotic treatments are performed on occasion, but the effect is variable.*

The situation in 2017

Official data

Information from Fish Health Services and Norwegian Veterinary Institute regional laboratories indicates that ulcers were prevalent in Norwegian farmed fish along the whole coast during 2017. The prevalence varies from area to area, but most identifications of both *Moritella viscosa* and *Tenacibaculum* spp. related to ulcer development in salmon were made in northern Norway. This is presumably related to water temperature.

Survey

In response to the annual survey sent to Fish Health Services and the Norwegian Food Safety Authority, winter ulcer scored 2.8 on a national basis (scale 1-5). Northern Norway scored highest (3.2), Mid-Norway (3.0), North-western (southern) Norway (2.3) and south western Norway (2.0)

Evaluation of the winter ulcer situation

Estimation of the actual prevalence of both typical and atypical winter ulcer is difficult as neither type of infection is notifiable. *M. viscosa* is relatively easily identified on agar culture due to its colony viscosity, and *Tenacibaculum* spp. are relatively easily identified due to their typical cell morphology i.e. long, thin, hair-like cells, when studied in the light microscope either from marine agar cultured colonies or in direct scrapes from damaged tissues.

Diagnostic experience suggests that both *M. viscosa* and *Tenacibaculum* spp. may, in some cases, be difficult to culture and that the total prevalence of infections involving these bacteria may be under estimated.

It has recently been shown that *M. viscosa* may be more effectively isolated on blood agar containing 2% NaCl with an additional antibiotic (vibriostat) which inhibits growth of fast-growing Vibrio species. *Tenacibaculum* spp. require sea-salts for growth and marine agar is a therefore a suitable medium.

Information received from the field indicates that winter ulcer is often associated with de-lousing treatments and other management routines requiring handling or stress. Avoidance of production factors that may predispose to ulcer development is therefore important. The winter ulcer situation in the industry as a whole is considered relatively stable.

Winter ulcers are injuries following bacterial infection in cold seawater, generally found in the autumn or winter Photo: Per Anton Sæther, Marin Helse AS.

Winter ulcer syndromes on salmon are injuries after bacterial infections in cold sea water normally occurring during the autumn or the winter. Photo: Per Anton Sæter, Marin Helse AS.

5.6 Yersiniosis

By Snorre Gulla, Jinni Gu and Anne Berit Olsen

The disease

Yersiniosis, caused by the bacterium Yersinia ruckeri *has been identified in several types of fish, but is most common in salmonids. In Norway, the disease, also known as enteric redmouth disease, is almost exclusively associated with farmed Atlantic salmon, manifesting with classical signs of systemic bacterial disease (Figure 5.6.1).*

The disease may occur before and after sea-transfer, but infection is presumed to occur primarily during the freshwater phase. The disease is becoming more common in seawater and large seawater farmed fish are now affected to a greater degree. Serotype O1 dominates the Norwegian disease situation with fewer outbreaks associated with serotype O2.

Control

Several commercial actors consider vaccination necessary to maintain production in certain juvenile production units. No commercial oil-based vaccines are currently licensed for use in Norway. Intraperitoneal vaccination with water-based vaccines is practiced to a degree. Y. ruckeri can survive in biofilms and it is probable that such biofilms help the bacterium survive disinfection and other hygienic measures. It appears that some hatcheries are colonised by 'house strains'.

The situation in 2017

Official data

The diagnostic service of the Norwegian Veterinary Institute diagnosed 54 cases involving 30 farming localities in 2017. This represents a slight reduction in number of cases from 2016 from the 34 localities affected that year (Figure 5.6.2). The 2017 diagnoses involved 4 juvenile production facilities and 26 marine cage sites (23 ongrowing and 3 broodstock). Yersiniosis was identified in 3 marine sites shortly after sea-transfer of smolts, and two of these cases involved smolts delivered from the same juvenile production unit. In 10 cases involving larger sea-farmed fish, outbreaks occurred following de-lousing/handling.

In most cases, the serotype of the strain involved was characterised directly from bacterial cultures or by serotype specific immunohistochemistry. With the exception of a single case involving serotype O2, all cases involved *Y. ruckeri* serotype O1.

Most cases in 2016 occurred in mid-Norway. This trend continued with an even higher proportion (25 of 30 affected farms) of cases identified in the three mid-Norwegian regions in 2017 (Figure 5.6.3).

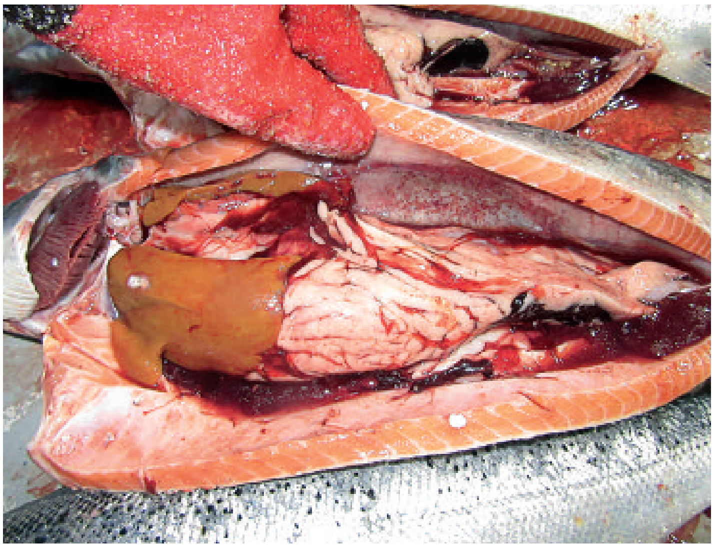


Figure 5.6.1: Large salmon with yersiniosis. Photo: Øystein Markussen, Marin Helse AS.

Survey

Responses to the annual survey sent to Fish Health Services and the Norwegian Food Safety Authority concerning the yersiniosis situation indicate general agreement between field experiences and data gathered by the Norwegian Veterinary Institute diagnostic service. The most significant change from previous years is the increasing number of outbreaks of yersiniosis in ongrowing fish in mid-Norway in 2017. There was a variable response regarding the impact of the disease on a national level, probably reflecting a situation in which large areas of the country are free of this disease. Generally, the disease is considered to have a greater impact in recirculation-based hatcheries than through-flow. The extent to which vaccination is practised against yersiniosis in Norwegian aquaculture is uncertain, but it appears that a larger proportion of fish are vaccinated in mid-Norway than in the remainder of the country.

Evaluation of the situation

Although the diagnostic-based statistics appear to indicate a slight reduction in number of cases between 2016 and 2017 (Figure 5.6.2), we have reason to believe that this is not in fact the case. A significant proportion of national diagnostic work is now performed by private laboratories and such cases are not included in Norwegian Veterinary Institute statistics. We are aware of private laboratory diagnoses in at least 17 farms in 2017.

Both survey responses and other correspondence with various industry actors throughout the year indicate that yersiniosis is a growing problem in mid-Norway, which is very consistent with our data (Figure 5.6.3). Most outbreaks occur in marine farmed fish, but the trend now is towards outbreaks in fish considerable periods after sea-transfer (also observed to a degree in 2016).

Approximately 90% of outbreaks occurring in 2017 involved salmon ≥1 kg, several months and often > 1 year, after sea-transfer.

The reasons behind this change in the clinical picture are uncertain, but it is noteworthy that nearly half of recorded outbreaks are registered shortly following de-lousing or similar stressful production routine. Such treatments represent considerable stressors to the fish and could possibly activate sub-clinical infections. Recent histopathological findings indicate that fish suffering yersiniosis late in the sea-phase, may have been chronically infected for an unknown period. We now also know that a particular genetic variant of *Y. ruckeri* serotype O1, found only in Norway, to be the cause of all serotype O1 outbreaks in Norway over the last 20+ years (Gulla, unpublished data). A number of other genetic

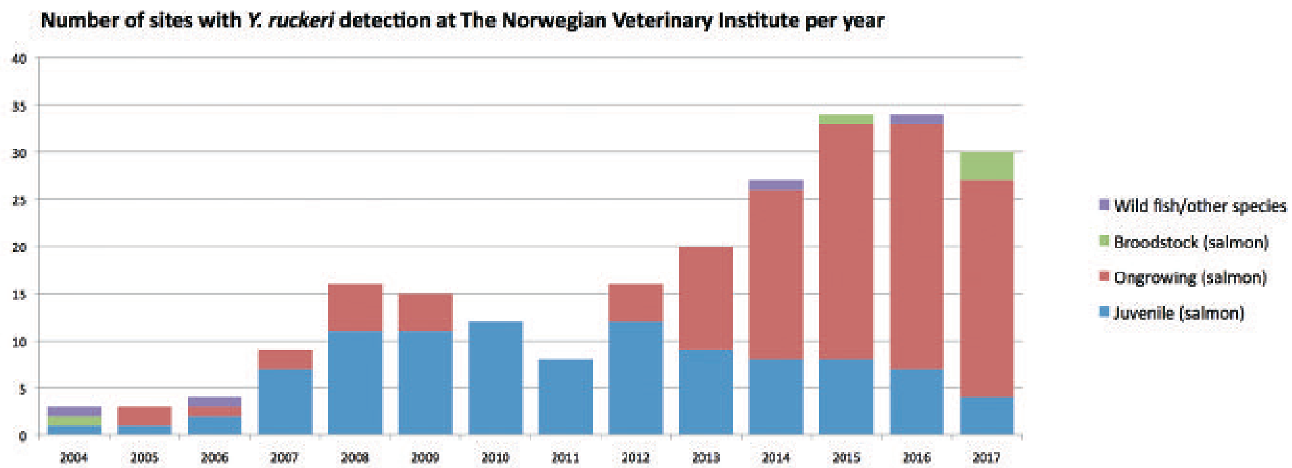


Figure 5.6.2: Distribution of Y. ruckeri-positive localities diagnosed by the Norwegian Veterinary Institute in recent years. Repeated diagnoses from the same locality are not included.

variants of *Y. ruckeri* serotype O1 are also found in Norway, but cannot be directly associated with disease in salmon.

Another genetic variant of *Y. ruckeri*, also belonging to serotype O1, has for decades, caused serious disease in rainbow trout around the world and appears to be specific for this species of fish. This variant has never been found in Norway, but was cultured from sick rainbow trout in Sweden in 2017. The consequences of introduction of this variant of the bacterium to Norwegian aquaculture could be severe. We recommend that the Norwegian Veterinary Institute be contacted should *Yersinia ruckeri* be cultured from Norwegian rainbow trout, such that the isolate may be genetically typed.

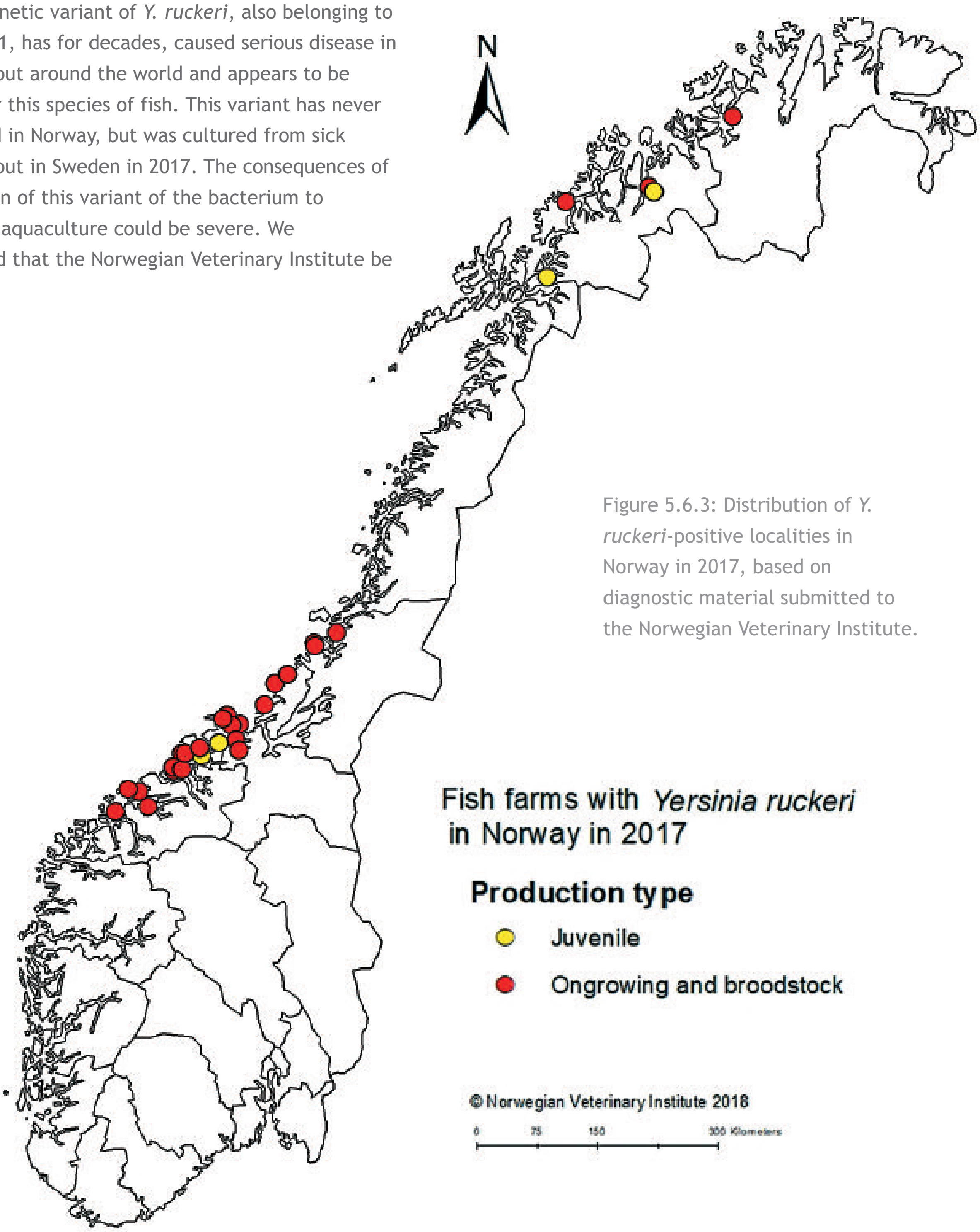


Figure 5.6.3: Distribution of *Y. ruckeri*-positive localities in Norway in 2017, based on diagnostic material submitted to the Norwegian Veterinary Institute.

5.7 Antibiotic sensitivity in bacterial pathogens of salmonids

By Duncan J. Colquhoun and Hanne K. Nilsen

Preliminary figures for consumption of antibiotics in Norwegian aquaculture indicate an increase from 201kg in 2016 to ~600kg in 2017, following several years of decreasing consumption. This increase can most probably be related to treatment of yersiniosis in sea-farmed salmon in mid-Norway (see chapter 5.6, Yersiniosis). The total consumption of antibiotics in Norwegian aquaculture remains modest- 600kg utilised in production of 1.3 million tons salmonids plus considerable marine fish production. Reduced antibiotic sensitivity as a result of antibiotic treatment continues to be an extremely rare occurrence in fish pathogenic bacteria in Norway.

Antibiotic resistance is a naturally occurring phenomenon in environmental bacteria and resistance may be readily transferred from environmental bacteria to fish pathogenic bacteria in the aquatic environment. There is good reason therefore to limit as far as is possible, antibiotic use in aquaculture.

Antibiotic sensitivity is routinely investigated in our laboratories using the so-called 'disc-diffusion' assay. For this assay, bacteria are cultured on an agar plate upon which a paper disc impregnated with antibiotic is placed. As the bacteria start to grow, the antibiotic diffuses from the paper disc in a decreasing concentration gradient. When the bacterial cells meet a concentration of antibiotic high enough to stop bacterial growth, a growth-free zone is formed around the paper disc. The diameter of the zone is then measured and the size of the zone indicates whether the bacterium is sensitive or resistant to the antibiotic tested. Zone diameters which indicate sensitivity vary between bacteria. How effective an eventual treatment would be will depend on, amongst other factors, how effectively the fish absorb the antibiotic and how the antibiotic is distributed in various tissue types. The relationship between the laboratory zone diameter and effect of treatment for different bacterial pathogens of humans and warm-blooded animals is well characterised, but is less well known for fish pathogenic bacteria.

At the Norwegian Veterinary Institute, we therefore continually compare new and previously recorded zone sizes identified for the same type of bacteria. On identification of zone sizes smaller than those previously experienced, the isolates are characterised more thoroughly (normally genetically).

As in previous years, we have in 2017, identified reduced sensitivity for oxolinic acid in *Flavobacterium psychrophilum* isolated from sick rainbow trout. We have also in the course of the year identified reduced sensitivity to oxolinic acid in *Yersinia ruckeri* from two salmon farms, in three isolates of *Vibrio anguillarum* (two from salmon and one from lumpsucker) and a single isolate of *Aeromonas salmonicida* subsp. *salmonicida* isolated from wild salmon.

The mechanism behind the reduced sensitivity to oxolinic acid in these bacteria has been related to chromosomal mutations. The danger of transfer of such resistance to other bacteria is therefore, considered low.

6. Fungal diseases

By Even Thoen

The diseases

Fungal diseases account for a modest proportion of the diagnoses made by the Norwegian Veterinary Institute each year. The most common mycological agents identified are Saprolegnia *spp.- oomycetes belonging to the Kingdom* Straminipila. *Infections caused by* Saprolegnia *spp. occur in all fresh water stages of the culture cycle from egg to smolt and in freshwater held broodstock. Saprolegniosis is diagnosed each year in various species of wild fish, normally during the breeding season or in weakened fish under particularly unfavourable environmental conditions.*

The disease manifests as a topical infection of the skin, normally first affecting areas with few scales e.g. head, dorsal surfaces and fins. Lesions appear as a white, almost cotton wool-like layer spreading across the skin. Field diagnosis, based on macroscopic investigation is, therefore, comparatively easy. Fish die of osmoregulatory failure if the area affected is large enough. Cases are also observed in which the gills appear to be the main organ affected. It is probable that fish affected in this way suffocate as a result of the mycelia covering the respiratory epithelia. The disease occurs mainly in fish with damaged skin and mucus layer or following exposure to some other form of stress.

Other fungal diseases identified include systemic mycoses caused by species belonging to the genera Exophiala, Phialophora *and* Phoma. *Such infections are normally identified in single fish and are considered more or less as incidental findings. In recent years, outbreaks of systemic mycosis have been identified in farmed lumpsucker. No causal relationship has yet been established in such cases.*

The situation in 2017

Official statistics

Fungal diseases of salmonid fish are non-notifiable. There are therefore no official statistics relating to fungal diseases.

Data from the Norwegian Veterinary Institute

As previously, few cases of disease caused by mycotic agents (mycoses) were identified in 2017, although the number of cases registered was slightly higher than in recent years. Mycoses may be categorised as either surface infections affecting the skin or gills, or systemic infections that affect the inner organs and may spread via the circulatory system. Surface infections are dominated by the oomycete *Saprolegnia* (saprolegniosis), while systemic infections may be caused by a number of different fungal species e.g. *Fusarium, Exophiala, Ochroconis, Paecilomyces, Ichthyophonus* and *Lecanicillium*.

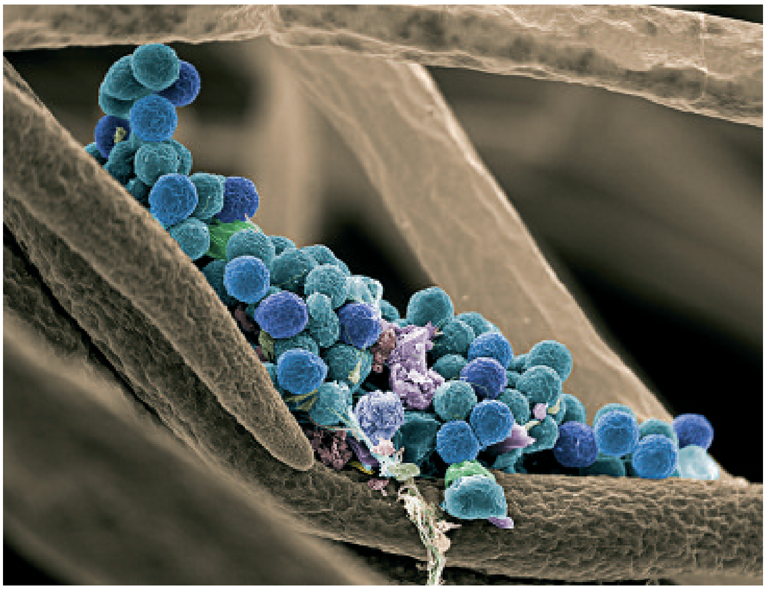
The Saprolegnia statistics for 2017 are lower than in recent years. As this disease is easily diagnosed in the field, it is commonly unreported, so the real figures are certainly much higher.
For systemic mycoses, a marked increase in number of cases was observed in 2017 compared to 2016 (from three to ten cases). While most of these diagnoses were made

in individual fish and most probably do not represent outbreaks of disease, in three cases systemic infections were identified in several fish examined.
Diagnoses made include classic 'kidney fungus' (usually caused by *Exophiala* sp.) and general systemic infections affecting several organs. The diagnoses were made in fish from differing production stages in farmed salmon, rainbow trout and lumpsucker.

Due to the small number of diagnoses, it is difficult to estimate the importance of changes in the number of cases identified from year to year. It is probably more useful to consider long-term trends over several years.

For more information see:
https://www.vetinst.no/sykdom-og-agens/saprolegniose

Fish eggs with and without the oomycete *Saprolegnia*,. The species *Saprolegnia parasitica* and *Saprolegnia diclina* are most commonly associated with fish disease in freshwater, while other Saprolegnia species are only sporadically identified in association with disease. For an infection to develop, the oomycete is normally dependent on depressed immune function or external injury in the infected fish. Photo: Jannicke Wiik-Nielsen, Norwegian Veterinary Institute.



Saprolegnia spores in colour. Saprolegnia is a common species of fungus in freshwater and spreads via motile spores as shown here. Hatcheries and juvenile production units may be exposed to infection via their intake water. *Saprolegnia* spp. can produce spores within the farm without causing disease in fish or eggs. It is assumed that the fungus can survive within biofilms and survive by feeding on organic debris. Photo: Jannicke Wiik-Nielsen, Norwegian Veterinary Institute.

7. Parasite diseases in farmed salmonids

The salmon louse represented by far the most significant parasitic threat to salmonid production in 2017. Increasing levels of resistance and high mortalities associated with de-lousing are an increasing challenge to the industry. The situation for AGD appears to be improved somewhat compared to the previous year. A detailed evaluation of each agent is provided in specific sections below.

Photo: Colourbox

7.1 The salmon louse – *Lepeophtheirus salmonis*

By Kari Olli Helgesen and Peder A. Jansen

The parasite

*The salmon louse (*Lepeophtheirus salmonis*) is a naturally occurring crustacean parasite on salmonid fish in marine environments in the northern hemisphere. The lifecycle comprises eight developmental stages separated by moulting. The parasite reproduces sexually. Adult females can produce up to 11 pairs of egg-strings, each with several hundred eggs. During the first three planktonic stages, which may last several weeks at low temperatures, the larvae may travel many kilometres. The last five stages are all parasitic on anadromous salmonid fish in the sea.*
Salmonlice feed on the skin, mucus and blood of the fish. If the burden of lice in the three last developmental stages is high, this may result in wounds and anaemia in the fish.
Lesions may provide a point of entry for secondary infections and may result in osmoregulatory problems for the fish. High lice burdens may be fatal.

Lice larvae may transmit from farmed fish to wild fish. Due to the louse's infection potential and the number of available hosts, together with the potential for serious injury in both farmed and wild fish, the salmon lice represents one of the most serious problems in Norwegian aquaculture today.

Control

The maximum permitted lice burden is defined in legislation, with different maximum thresholds of infection defined for spring and the remainder of the year. The maximum permitted spring lice burden was changed in 2017. Lice numbers are monitored and reported weekly. The main control measures have traditionally been pharmaceutically based, but increasing levels of resistance have led to a situation in which non-pharmaceutical methods now dominate. Farmers commonly now use a combination of preventative measures including continual delousing (mainly cleaner fish) and both pharmaceutical and non-pharmaceutical methods.

The increased frequency of treatment methods and increased use of non-pharmaceutical control methodology has led to a considerable increase in production costs in farming of salmonids in open cages, both in terms of increased direct costs and in relation to the increased risk of injury and mortality related to every treatment event.

For more information, see the Norwegian Veterinary Institute factsheet on the salmon louse

The situation in 2017

Official data

All farmers are required by law to count and report lice burdens weekly. The average number of lice reported weekly for the country as a whole reveals a cyclical variation with the lowest lice counts in spring and the highest during the autumn (Figure 7.1.1). The highest numbers of adult female lice were recorded in September 2017 and the highest numbers of other mobile stages (pre-adults and adult males) were observed in November.

Overall, louse numbers for 2017 were somewhat lower than those observed for the period 2012-2016, the period for which comparable data is available. While the total spring numbers of lice were higher in 2017 than in 2012 and 2013, the numbers of adult females was lower than observed in 2015 and 2016. Numbers of motile lice in the spring of 2017 were similar to spring 2016. The peak number of lice recorded in 2017 was the lowest recorded peak in the period 2012-2017.

To analyse the louse situation at a level deeper than average numbers of lice, we have modelled production of louse larvae. Calculation of larval production is based on the reported number of lice, sea temperature and numbers of fish in each farm, together with knowledge of louse reproduction, developmental time and survival rates for each developmental stage (Kristoffersen et al. 2014, Epidemics 9: 31-39).

Production of louse larvae was calculated for each of the 13 new salmon production zones (https://lovdata.no/dokument/SF/forskrift/2017-01-16-61?q=produksjonsområde) (Figure 7.1.2) around the coast. These zones were established as part of the decision-making process regarding possible expansion of the aquaculture industry.

Highest larval production occurred in production areas 3, 4 and 6 (Figure 7.1.3). These areas experienced, however, a fall in larval production from 2016-2017. Production areas 2, 9 and 10 were the only areas to increase larval production in 2017 compared to 2016.

On dividing the number of larvae produced by the number of fish held in each farm, large variations in the number of larvae produced per fish are identified (figure 7.1.4)
The median value for average louse production per fish per week was highest in production zone 2 and decreased with increasing latitude.
This shows that the effect on numbers of lice produced by eventual expansion of the aquaculture industry will depend on where in the country the expansion occurs.

The number of anti-louse treatments in 2017 are summarised in Table 7.1.1.
The number of medicinal treatments relates to the number of prescriptions submitted to the Veterinary Prescription Register (VetReg), while the number of non-

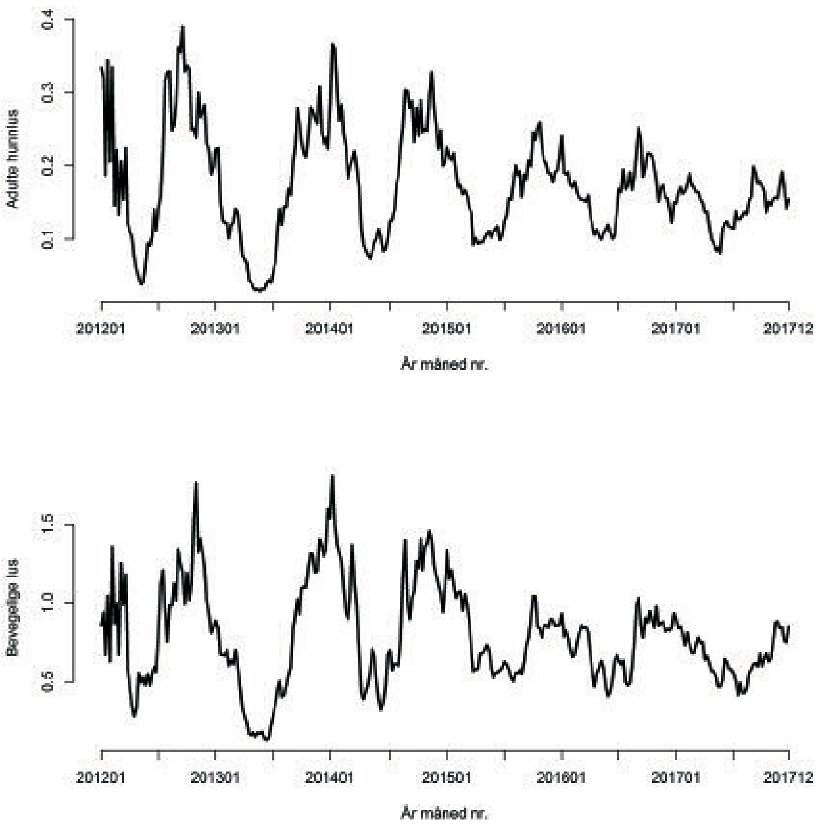


Figure 7.1.1. Average numbers of lice per fish reported by all marine sites in Norway farming salmon or rainbow trout for the period January 2012 until December 2017. The upper panel describes the number of adult female lice and the lower panel other motile stages (pre-adults and adult males)).

Active ingredient category	2011	2012	2013	2014	2015	2016	2017
Azamethiphos	409	691	480	749	616	257	58
Pyrethroids	456	1155	1123	1043	662	276	80
Emamectin benzoate	288	164	162	481	523	608	319
Flubenzurons	23	129	170	195	201	173	79
Hydrogen peroxide	172	110	250	1009	1279	629	214
Sum	**1348**	**2249**	**2185**	**3477**	**3284**	**1943**	**750**
Non-medicinal treatments		136	110	177	202	1178	1669

Table 7.1.1. Number of prescriptions categorised by active ingredient, prescribed for treatment of salmon lice 2011-2017, together with number of registered non-medicinal treatments. The number of prescriptions was obtained from VetReg 16.01.18.The number of non-medicinal treatments are the number of mechanical treatments reported to the Norwegian Food Safety Authority as of 18.01.18.

medicinal treatments is based on the number of such treatments reported as part of the weekly 'louse data' reported to the Norwegian Food Safety Authority.

Non-medicinal treatments include both thermal and mechanical de-lousing as well as freshwater treatments. Both medicinal treatments and non-medicinal treatments may have been performed at the cage- or farm-level.

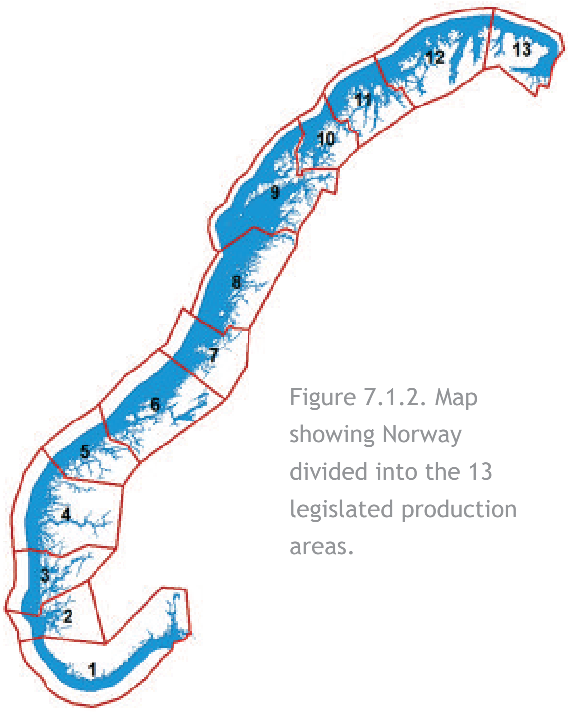


Figure 7.1.2. Map showing Norway divided into the 13 legislated production areas.

The table reveals that the drastic reduction in the number of prescriptions for medicinal treatment of salmon lice infestations, which started in 2016, continued in 2017.

The number of pharmaceutical prescriptions issued for treatment of salmon lice fell by 61% between 2016 and 2017. At the active constituent level, the figures for 2017 show a significant reduction in prescription of all categories of anti-louse pharmaceuticals. The quantity of hydrogen peroxide presented in the table represents treatment of both salmon lice and AGD. Emamectin benzoate was the most frequently prescribed anti-louse pharmaceutical in 2017.The relatively frequent use of emamectin benzoate continues, as it is considered to limit settlement of louse larvae on treated fish, in also of lice strains where later life stages are resistant to emamectin benzoate treatment.

The reduction in prescription of medicinal anti-louse treatments has probably several explanations. One contributing factor is undoubtedly the widespread resistance towards these pharmaceuticals. Increased control of salmon lice through use of non-medicinal methodologies is another contributing factor. In addition to non-medicinal treatments, various prophylactic measures with cleaner fish as the dominating form have been widely used. No new anti-lice pharmaceuticals were registered in 2017, although several appear to be under licensing.

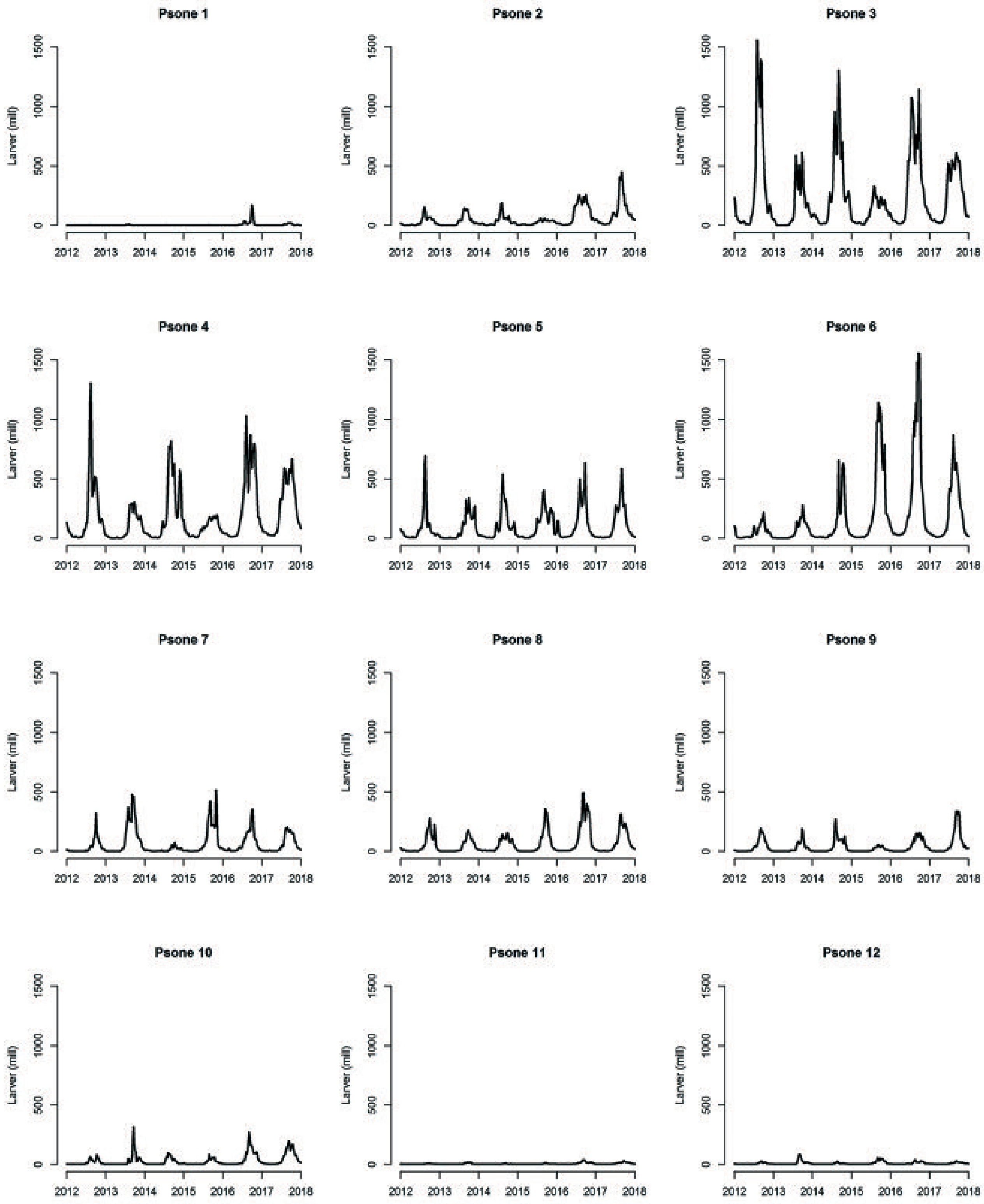


Figure 7.1.3. Calculated total production of louse larvae (in millions) per week per locality in each production area (Psone) for the period 2012-2017. Production area 13 is not included. This area had insignificant larval production throughout the whole period.

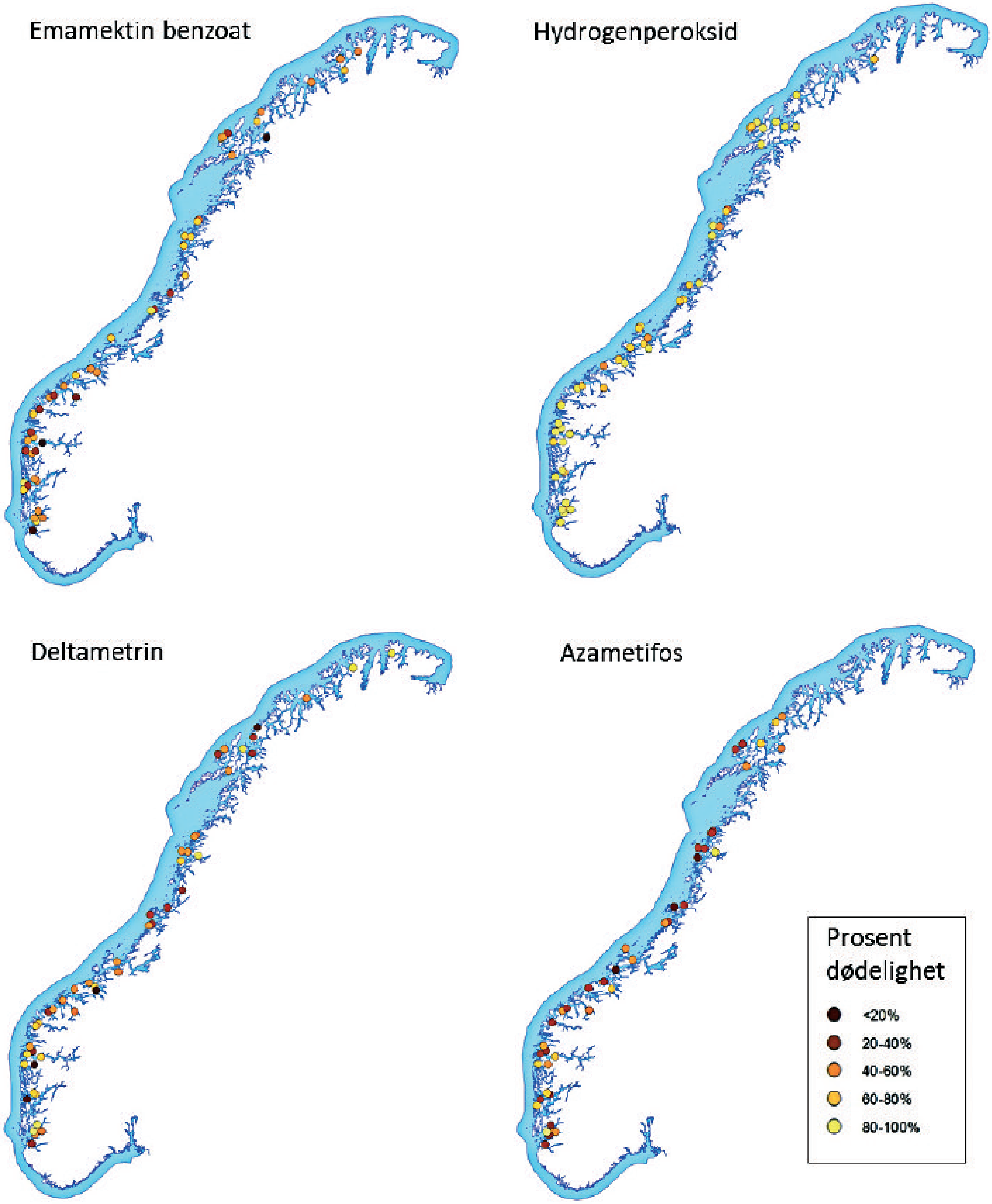


Figure 7.1.5: Mortality of lice in the simplified bioassay for emamectin benzoate, hydrogen peroxide, the pyrethroid deltamethrin and azamethiphos, where darker colours represent lower mortality on exposure to a known concentration of active ingredient and therefore more resistant lice.

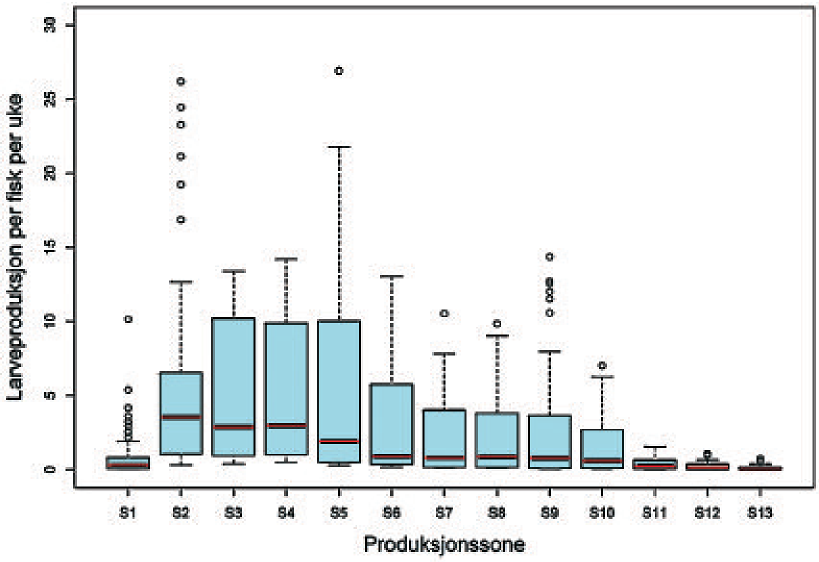


Figure 7.1.4. Calculated average louse larva production per fish per week in each production area (S1-S13) in 2017. The red lines represent the weekly median values, while 50% of the values are within the blue boxes.

Survey

In our annual survey of fish health personnel, fish health services, the Norwegian Food Safety Authority and farming companies, the salmon louse was considered to represent the most significant health threat to sea phase of salmon and rainbow trout farming. The salmon louse scored 4.5 (of maximum 5.0) in relation to salmon (n=45) and 4.1 in relation to rainbow trout (n=12). Mechanical injury following de-lousing was considered the second and third most important health problem for rainbow trout and salmon respectively (scores of 3.2 and 3.9; n=12 and N=44). For broodstock of both salmon and rainbow trout, the salmon louse was also considered the most important health challenge (scores of 4.1 and 3.8 respectively; n=11 and n=8).

When questioned on mortality in relation to de-lousing (score 1=seldom/never, score 5=nearly always), the category 'increased mortality exceeding 0.2% over the first three days post treatment' was awarded a score of between 3.25 and 4.4 for the various non-medicinal methods. Medicinal and freshwater treatment for the same category scored 2.3 and 2.8 (n= between 7 and 34). Scores for 'delayed mortality' were 2.6-3.3 for mechanical de-lousing and 1.8-2 for non-medicinal and freshwater (n= between 7 and 32). Thus, increased acute and delayed mortality was observed more commonly following the various methods of mechanical and thermal de-lousing compared to medicinal or freshwater treatment.

Specific welfare concerns surrounding non-medicinal louse treatments are discussed in the Fish welfare chapter of this report.

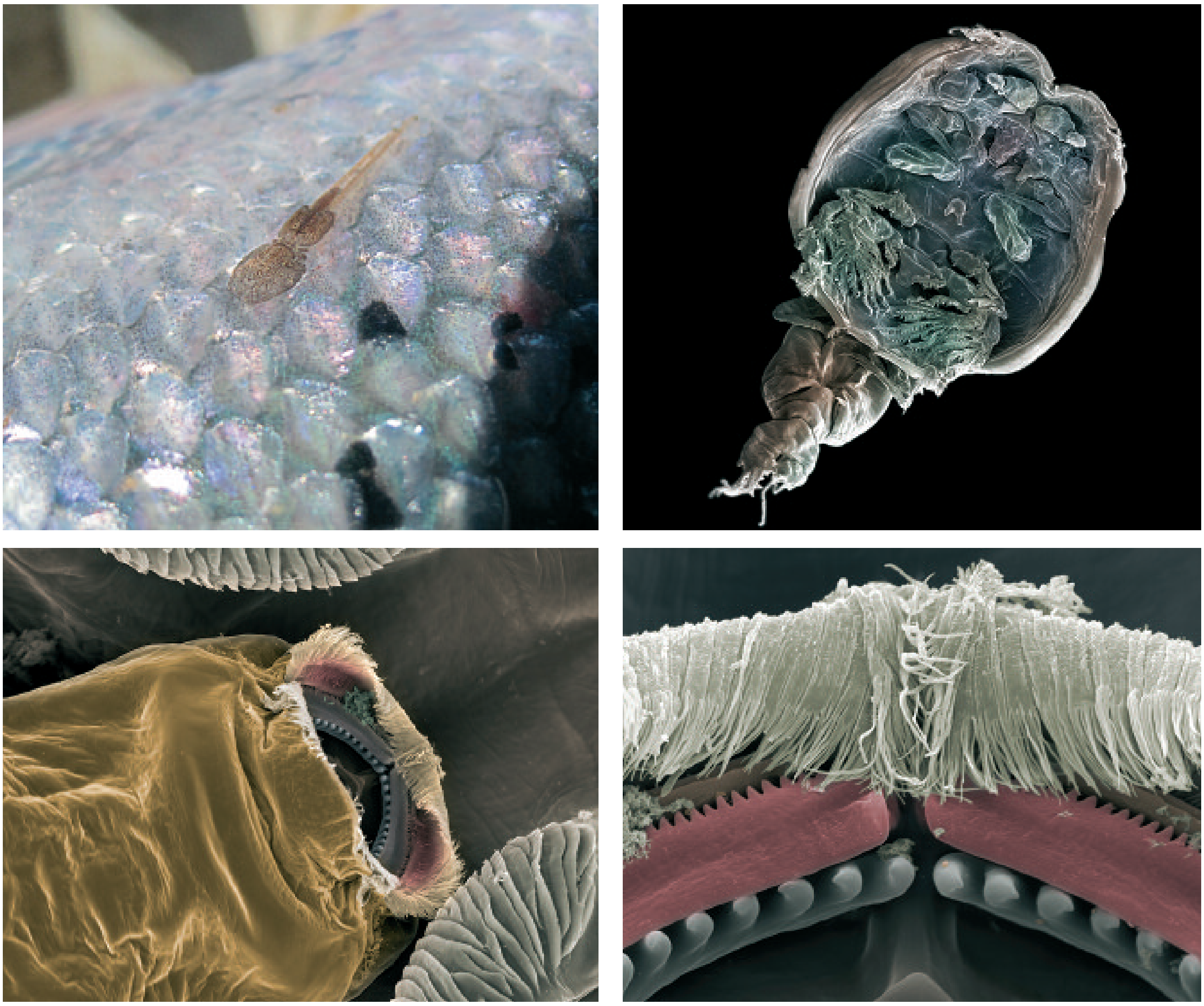
Evaluation of the salmon louse situation

The salmon louse situation has changed somewhat between 2016 and 2017. There were generally lower numbers of lice than the year before, particularly in the autumn. Production of louse larvae fell in all production areas with the exception of 2, 9 and 10 (Ryfylke, Vestfjorden and Vesterålen and Andøya to Senja). Although a few farms exceeded the maximum number of permitted lice in 2017, no regional loss of control and consequent louse-related injury, as was observed in Sør-Trøndelag in 2016 was experienced in 2017.

The total number of louse-related prescriptions for medicinal treatment fell by 61% from 2016 to 2017 (750 prescriptions). The number of non-medicinal treatments increased during the same period by 42%, to 1669 reported treatments. Salmon louse control in Norway in 2017 was, therefore, mainly dependent on non-medicinal and prophylactic measures.

Despite the reduction in medicinal treatment, high resistance levels were recorded along the whole coastline during 2017.

Both medicinal and non-medicinal salmon louse treatments may result in increased mortality in the treated fish. This was observed more commonly following non-medicinal treatment in 2017 than following medicinal treatment. It is therefore reasonable to suppose that mortality in relation to louse treatment has increased as medicinal treatments have now been largely replaced by non-medicinal methods.



Salmon louse. Photo: Labora (nr 1) and Jannicke Wiik Nielsen, Norwegian Veterinary Institute (Photo nr 2-4)

7.2 Amoebic Gill Disease (AGD) and *Paramoeba perurans*

By Sigurd Hytterød and Haakon Hansen

The disease

Amoebic gill disease- AGD, is caused by the amoeba Paramoeba perurans *(synonym* Neoparamoeba perurans*).*

Since the mid 1980's the disease has caused large losses in production of farmed salmon in Tasmania. In the mid 1990's P. perurans *was discovered in the Atlantic Ocean and the amoeba has since been steadily identified further north. In 2011 and 2012, AGD was one of the most significant causes of loss to the Irish and Scottish salmon farming industries. In 2013,* P. perurans *was identified in several farms in the Faroe Isles and the disease has since become a serious problem in Norwegian salmon farming.*

Paramoeba perurans *and AGD was first identified in Norwegian farmed salmon in 2006, but was not found again until 2012. It has since caused considerable losses.* P. perurans *infects fish farmed in seawater, primarily Atlantic salmon but also other farmed species such as rainbow trout, turbot, lumpsucker and various wrasse spp.* P. perurans *has also caused AGD in a number of these species.*

The two most important risk factors for outbreak of AGD are considered to be high salinity and relatively high seawater temperatures. Pathological changes are limited to the gills where white mucoid patches may be macroscopically observed. Amoeba may be observed in fresh microscopy preparations of gill tissues or by PCR. Reliable diagnosis is based on histology of affected gill tissues.

Control

AGD is a non-notifiable disease. AGD is treated either with hydrogen peroxide (H2O2) or freshwater. Neither method appears to be 100% effective and treatment must commonly be repeated several times within the same production cycle. Treatment with freshwater is the milder form of treatment for salmonid fish and appears to be more effective than H2O2.

Treatment of AGD has best effect when performed in the early stages of disease development. This reduces the probability of treatment relapse. It is therefore important to monitor the prevalence of amoeba in farmed fish in order to identify the disease at an early stage. This is done by PCR-screening and macroscopic examination of the gills.

A scoring system has been developed for classification of macroscopically visible changes associated with AGD. This scoring system is an important tool for Fish Health Services. Scoring of gills can be difficult following repeated treatment and may require considerable experience.
Since a number of other factors/agents may cause similar changes to the gills, it is important to confirm the diagnosis by histological investigation.

For more information on AGD see: https://www.vetinst.no/sykdom-og-agens/amobegjellesykdom

The situation in 2017

Official statistics

Since AGD is not notifiable and diagnoses are often made locally by Fish Health Services, it is not possible to identify precisely the number of farms affected. AGD is suspected mainly following visual macroscopic examination. PCR and histology are then used to confirm the suspicion. To supplement our own data, the Norwegian Veterinary Institute obtained situation reports from several Fish Health Services (Åkerblå AS, FoMas – Fiskehelse og Miljø AS, PatoGen AS, Labora AS and Pharmaq Analytiq).

In 2017, *P. perurans* was identified by RT-PCR from Vest-Agder to Nordland. No outbreaks have so far been described north of Nordland. There is limited sampling performed in this part of the country, but farms exposed to high levels of salinity are tested to some degree.

In some areas including Romsdal, initial treatments were performed later in the year than in 2016. Farms in Nordmøre and Sør-Trøndelag started treatment earlier, and in these areas, early treatment is a clear strategy. In Rogaland and Hordaland there have been very few treatments, while in Northwest-southern Norway and in Sør-Trøndelag there have been many more treatments of individual cages and farms. Both freshwater and hydrogen peroxide treatments have been utilised.

Survey

AGD in southern-Norway is considered an extremely important disease of farmed salmon (score 4.3). It is considered less important in the North (score 3.5 in North-west southern Norway). It is also considered more important in rainbow trout farming in the south of the country. A few respondents considered the disease extremely important.

Evaluation of the AGD situation

AGD has, in the course of a relatively short period, established itself as a serious fish disease in Norway. The number of outbreaks and the degree of severity varies from year to year and this appears to be related to climatic conditions. Reports from the field suggest that treatment frequencies were higher in north-west southern Norway than in Rogaland and Hordaland. Farmers and Fish Health services have now gained more experience in management of AGD, both in terms of the necessity for treatment and when in the course of disease the treatment should be performed. This, together with frequent screening, has contributed to better control of the disease. Poor gill-health remains a significant problem particularly in western Norway, north-west southern Norway and in mid-Norway. The amoeba *P. perurans* is often one component of a complex and multifactorial disease situation involving several infectious agents.

P. perurans causes amoebic gill disease
Photo: Jannicke Wiik Nielsen,
Norwegian Veterinary Institute

7.3 Other parasite infections

By Haakon Hansen and Geir Bornø

Desmozoon lepeophtherii (syn.Paranucleospora theridion)

Desmozoon lepeophtherii is a microsporidian first identified as a parasite of the salmon louse, and has later associated with ‘autumn disease’ in farmed salmon. These parasites are very small and may have been previously overlooked during histological investigations. The parasite is highly prevalent in farmed salmon but is only considered of clinical importance by a few respondents to the annual survey. The significance of the infection remains uncertain, but recent research indicates that this parasite may cause pathological changes in the gills and intestine of infected fish.

*Parvicapsula pseudobranchicola (*parvicapsulosis*)*

Parvicapsulosis, caused by *Parvicapsula pseudobranchicola* may result in high mortality in ongrowing salmon. The parasite has a broad geographical range and is found at high prevalence in wild salmonids. Parvicapsulosis is, however, only reported as a problem in farms in Troms and Finnmark. In 2017, the Norwegian Veterinary Institute identified the parasite (mainly via histological investigation) in 38 salmon farms, which is a similar number to 2016. Diagnoses were restricted to the three most northerly regions, with 17 in Finnmark, 19 in Troms and 2 in Nordland. *Parvicapsula pseudobranchicola* has a complicated life cycle with a polychaete worm as its main host and fish as the intermediate host. The main host for *P. pseudobranchicola* remains unknown.

Ichthyobodo spp. («Costia»*)*

At least two species of this parasite can be found in salmon in Norwegian aquaculture; *Ichthyobodo* necator in salmon in freshwater and *I. salmonis* in salmon farmed both in freshwater and the sea.

These parasites have a wide geographical range, are common and can damage both skin and gills.
Most diagnoses are made locally by Fish Health Services. The Norwegian Veterinary Institute diagnosed *Ichthyobodo* spp. in 74 submissions from 57 different farms in Norway in 2017. Most diagnoses are associated with salmon, both in juvenile production sites and in ongrowing phases. *Ichthyobodo* spp. were also identified in halibut and lumpsucker.

Tapeworm - *Eubothrium spp.*

An increasing prevalence of intestinal tapeworms in sea-farmed salmon has been reported in recent years, and again in 2017 several Fish Health Services reported problems associated with this parasite. Tapeworm infestations may lead to increased feed consumption and decreased growth in affected fish. *Eubothrium* spp. are treated with praziquantel and there has been a significant increase in the quantity of this drug sold since 2010. Several Fish Health Services report treatment failure and there are concerns regarding development of resistance. Most diagnoses are made locally and the organisms concerned are not identified to species level. The Norwegian Veterinary Institute identified tapeworm in 36 farming sites in 2017. No diagnoses were made north of Nord-Trøndelag.

Tapeworms were identified in both salmon and lumpsucker held in the same locality, but the organisms were not identified to species level. Tapeworms were also found in a single diagnostic submission involving wild brown trout. The Norwegian Veterinary Institute has recently initiated a project in which one of the aims will be to study the prevalence of *Eubothrium* spp. in Norwegian fish farming and how these tapeworms affect the salmon.

Runt fish with *parvicapsulosis*. Photo: Per Anton Sæther, Marin Helse AS.

8. Miscellaneous health problems in farmed salmonids

This chapter presents diverse health problems in farmed fish, including AGD, salmon pox and other diseases affecting the gills. Further, poor smolt quality, runt syndrome and vaccine side effects are discussed. Finally, heart diseases other than those previously presented (PD, CMS and HSMI) are discussed.

Photo Siri Ag, Midt Norsk Havbruk

8.1 Gill disease in farmed salmonids

By Anne-Gerd Gjevre, Mona Gjessing, Jinni Gu and Anne Berit Olsen

The disease

Gill disease affects salmon farmed in both freshwater and seawater. While various environmental factors and microorganisms may be involved, the roles of the various factors and agents are poorly understood. Pathological changes in the gills may lead to respiratory problems and problems with ion regulation, which may make affected fish more susceptible to other infections. Organic and inorganic substances in the water may also have a negative effect on gill health. Precipitation of toxic iron and aluminium compounds can occur in freshwater but may also occur during freshwater treatment of AGD or salmon lice in seawater. 'Epitheliocystis' is caused by bacteria living within cells on the surface of the gills. A number of different bacterial species can cause epitheliocystis and some appear more pathogenic than others. Ca. Branchiomonas cysticola *is one such bacterium.*

Other microorganisms that may result in gill health issues include Paramoeba perurans, *which causes AGD, the microsporidian* Desmozoon lepeophtherii, *salmon poxvirus and 'Costia'* (Ichthyobodo spp.). *It has been shown that* B. cysticola *and Salmon Gill Poxvirus transmit from fish to fish in freshwater. Bacterial gill disease in salmon farmed in freshwater is commonly a secondary infection to another gill injury caused by e.g. metal precipitation or salmon poxvirus infection. The same is the case for* Saprolegnia spp. *Bacteria belonging to the genus* Tenacibaculum *may cause gill problems in seawater. Often several agents are involved and the pathological changes to the gills can vary significantly. While both* B. cysticola *and salmon poxvirus may cause problems in both freshwater and seawater,* P. perurans *only causes problems in seawater. Salmon gill pox and AGD are discussed in specific chapters in this report. Blooms of algae and jellyfish may also cause gill damage. The same is true of fouling organisms e.g. hydroids freed during net washing. Gill disease is commonly chronic, particularly in seawater.*

For more information on gill disease see: Chronic gill inflammation in salmon and salmon pox under diseases and agents at http://www.vetinst.no/dyr/oppdrettsfisk

Control

Formalin can be used to control parasites such as 'Costia'. No vaccines or treatment regimens are available against the bacteria and viruses associated with gill disease. Control of AGD is discussed in section 7.2.

Focus on biosecurity is important. There are strong indications that smolts transferred to sea may already be infected with gill pathogenic agents in some cases. Effective disinfection of intake water is important for prevention of microbial gill disease. Freshwater hatcheries utilizing water from a source containing wild fish must ensure efficient disinfection of intake water. Disinfection of biofilters in RAS farms should be considered in cases of recurring gill disease. On outbreak of disease caused by Salmon Gill Poxvirus, supplemental oxygen should be provided, feeding should be stopped and stress should be avoided. Increased water supply in tanks holding fish with initial signs of gill disease may reduce the problem, but one should be aware of the possibility of metal precipitation as a contributory factor. It is therefore important that the water quality in hatcheries is well characterized and that the various water quality parameters are continually monitored. This is critical if relevant counter measures to e.g. precipitation of metal compounds are to be initiated.

The situation in 2017

Data from the Norwegian Veterinary Institute

Gill disease is non-notifiable. It is therefore difficult to estimate how many farms are affected each year. Data sourced from the electronic journal system of the Norwegian Veterinary Institute revealed that our laboratories in Oslo, Bergen and Trondheim investigated samples from 130 ongrowing sites and 20 juvenile production units in which gill disease was the primary diagnosis. These submissions were mainly related to salmon. Submissions made to our laboratory in Harstad were not included.

The annual survey

Results of our survey indicate that, as in previous years, gill disease is considered a more serious problem in ongrowing salmon farming in south-west- and north-west southern Norway (score 4-5), than in mid- and northern Norway (score 2-3) (Table 8.1.1). There appears to be a tendency towards greater problems in freshwater sites based on recirculation of water compared to through flow systems. The results are summarised in Table 8.1.2.

Asessment of the gill disease situation

Gill disease remains a significant problem for salmon in Norwegian ongrowing farms, particularly in western Norway. Gill disease is also a problem in rainbow trout farming.

There are few regional differences in the poxvirus situation in ongrowing and broodstock salmon. In 2017, the virus scored 1.8 on a countrywide basis, which is a similar level to jellyfish, while AGD and algae were scored at 2.4 and 2.0 respectively on a national level.

Specific and non-specific gill diseases occur both in through-flow and recirculation farms (Table 8.1.2), but are scored slightly higher in recirculation sites. Gill disease is nevertheless considered less important in freshwater than in seawater.

Disease caused by salmon poxvirus appears to represent a significant problem in some hatcheries. All regions seem to be affected.

Tale 8.1.1. Weighting/scoring of gill disease in ongrowing salmon (1 = unimportant, 5 = very important)

Region	Weighting/ scoring of gill disease. Average per region	
	Number of replies (N)	ongrowing sites
Fish Health Services North	9	2.6
Norwegian Food Safety Authority North	4	1.8
Fish Health Services Mid	13	3
Norwegian Food Safety Authority Mid	2	2
Fish Health Services North-west	4	5
Norwegian Food Safety Authority North-west	4	4.8
Fish Health Services South-west	5	4
Norwegian Food Safety Authority South-west	3	4
Average total, salmon	44	3.4
Average total, rainbow trout	12	3

Moderate problems (score 3.0) associated with the microsporidian *D. lepeophtherii* are reported in both salmon and rainbow trout hatcheries in south-western Norway. Detection of the microsporidian was also reported in hatcheries in 2015 and 2016. Infection with *B. cysticola* causes problems in some juvenile production sites in western Norway.

Table 8.1.2. Weighting of gill-related disease in juvenile salmon production (1 = unimportant, 5 = very important)

Weighting of gill-related disease juvenile, average per region										
Through flow sites										
	Salmon					Rainbow trout				
	BC	DL	Pox	Non-specific Gill inflam.	N	BC	DL	Pox	Non-specific Gill inflam.	N
Fish Health Services North	1.6	1	2	2.6	7	-	-	-	-	0
Norwegian Food Safety Authority North	1	1	3	4	2	-	-	-	-	0
Fish Health Services Mid	1.9	1	2.4	2.8	8	1	1	3	1.5	2
Norwegian Food Safety Authority Mid	1.5	1	1.5	2	2	2	2	2	2	2
Fish Health Services North-west	1.5	1.5	2	3	2	1.5	1	1.5	2	2
Norwegian Food Safety Authority North-west	2.8	1	3	3.5	4	1.3	1	1	1.3	3
Fish Health Services South-west	1	1	1.5	2	2	1	1	1	1	1
Norwegian Food Safety Authority South-west	2.7	2.7	2.7	3.3	3	3.3	3.3	3.3	3.3	3
Total	**1.7**	**1.2**	**2.2**	**2.6**	**36**	**1.8**	**1.7**	**2.1**	**2**	**13**

Recirculation sites										
	Salmon					Rainbow trout				
	BC	DL	Pox	Non-specific Gill inflam.	N	BC	DL	Pox	Non-specific Gill inflam.	N
Fish Health Services North	2	1	1.8	2.5	4	-	-	-	-	0
Norwegian Food Safety Authority North	2	2	2	4	1	-	-	-	-	0
Fish Health Services Mid	2.3	1	2.3	2.5	4	-	-	-	-	0
Norwegian Food Safety Authority Mid	-	-	-	-	0	-	-	-	-	0
Fish Health Services North-west	2	1	3	4	1	-	-	-	-	0
Norwegian Food Safety Authority North-west	4	1	5	5	2	1.5	1	1	2	2
Fish Health Services South-west	1	1	1	2	1	-	-	-	-	0
Norwegian Food Safety Authority South-west	3	3	3	3	3	4	4	5	4	2
Total	**2.2**	**1.6**	**2.4**	**2.9**	**16**	**2.5**	**2.3**	**2.3**	**3**	**4**

BC= Branchiomonas cysticola; DL= Desmozoon lepeophtherii; Pox=Salmon Gill Poxvirus; N= number of respondents

8.2 Poor smolt quality and runt syndrome

By Jinni Gu

Poor or varying smolt quality is probably a major contributing factor to unsatisfactory development, growth and health following sea-transfer. Many factors may play a role in poor or varying smolt quality, including variation in fish size, precocious sexual maturation, dense stocking densities, irregular light regimes, poor water quality etc.

Diseases, both infectious and environmental will influence the smoltification process. Biased selection of fish for analysis may also lead to a misleading conclusion regarding smolt status. Good control of smoltification and careful evaluation of available information will help ensure good smolt quality.

Runt syndrome is a condition where the fish become emaciated or do not grow normally after sea-transfer. A typical histological picture in runts includes a lack of perivisceral fat and increased melanisation in the kidney, but with an intact pancreas. Bacteriological and virological investigations are often negative. Runts may also be observed in freshwater, but the term is normally associated with sea-farmed fish. The cause/s of runt syndrome remain/s unclear and may be complex. Smoltification problems may be involved. Observations made during the sea phase indicate that fish surviving IPN, PD or parvicapsulosis outbreaks may become severely emaciated. It is considered likely that runt syndrome may be related to stress and stress-related situations.

Runted fish may survive for considerable periods and undoubtedly represent a significant welfare challenge. These fish are considered to carry a higher burden of infectious agents than fish in normal condition. Tapeworms are a normal finding in runted fish. Runts should, therefore, be removed from the population to reduce transmission of infection.

The situation in 2017

Data from the Norwegian Veterinary Institute

In 2017, runts were registered in approximately 40 ongrowing farms. This is a significant reduction from the previous year when such fish were registered in 71 farms. Diagnosis of 'emaciated' fish fell from 45 registered sites in 2016 to 26 sites in 2017. Large regional differences have been identified in recent years. The majority of affected farms were situated in northern-Norway.

The annual survey

In the survey, inspectors of the Norwegian Food Safety Authority reported runting as a significant problem in ongrowing salmon (4.9) and rainbow trout (3.7) in south-west Norway. In the remainder of the country, runting is considered less of a problem with average scores of 2.7 for salmon and 2.3 for rainbow trout.

Fish Health Services report that spontaneous smoltification can be a problem associated with production of large smolts, and that handling of such fish may result in considerable mortality. Several workers report that smoltification in spring fish is often more challenging than in autumn fish, which may be related to variation in water quality. Changes in water quality often occur at the same time as smoltification in 1+ smolts and that the fish may have entered and left the 'smoltification window' several times. Some fish health workers report that HSS continues to represent a problem during smoltification and that nephrocalcinosis is probably an increasing problem related to increasing stocking densities. There are reports that spring sea-transferred fish are more challenging than fish transferred to sea during the autumn.

Field observations differ. Some farms experienced an improved situation, while others experienced a greater degree of runt syndrome. While runt development may vary between cages and fish groups, in some cases whole farms are affected independent of smolt source. A large proportion of runts has been identified in individual groups of fish that have suffered yersiniosis during the freshwater stage.

Evaluation of the smolt quality and the runt syndrome situation

Several farms and fish groups continue to experience poor or varying smolt quality. This increases the risk of poor growth, health and general development in affected fish and may be a contributing factor in runt development.

Runt development is both a production and welfare problem, and that the cause/s remain unknown is unsatisfactory for both farmers and fish health services. The syndrome is reported along the entire coast, but appears most serious in northern Norway where it is considered one of the most important health related challenges following sea-transfer. Despite an improvement in the general situation, some localities have continued to experience significant problems during 2017.

Optimal smoltification, transfer to sea at the correct time, close monitoring during the sea phase and optimal feeding strategies are important for normal development and growth in salmonid fish.

Photo: Colourbox.

8.3 Vaccine side effects

By Kristoffer Vale Nielsen and Siri Kristine Gåsnes

Fish may be vaccinated by dip, bath, orally via feed and by injection. Both the effect of vaccination and the possible side effects vary according to method of administration. In Norway, intraperitoneal injection of multivalent oil-based vaccines is the most common form of vaccination in salmonid fish, but the method also generates the most significant side-effects.
Current aquaculture legislation (§63) requires that Atlantic salmon must be vaccinated against furunculosis, vibriosis and cold-water vibriosis. In addition to these diseases, it is normal to vaccinate against winter-ulcer (M. viscosa), IPN and in some areas PD (western Norway and northern west-Norway). Vaccination against yersiniosis, ISA and other diseases occurs more sporadically. A limited number of vaccines are available for marine fish species, but autogen vaccines are used to an increasing degree.

Vaccine side-effects following injection vaccination in salmonid fish normally consist of growth of connective tissues between the inner organs and between the inner organs and the peritoneal walls, melanin deposition, reduced appetite and growth, increased frequency of deformity, iridocyclitis and autoimmune symptoms. Some of these side effects must be painful to the fish. The degree of side effects varies with vaccine type and conditions related to the vaccination process e.g. fish size, water temperature and hygiene. Vaccine side effects are commonly graded according to the Speilberg scale, which is based on the degree of adherence and melanin deposition within the peritoneal cavity. The scale starts at 0, which is equivalent to no visible changes, and ends at 6, which represents huge change. Grade 3 and above in the Speilberg scale represent injuries that are considered unacceptable in terms of fish welfare. Since introduction of the first oil-based vaccines to the market in the early 90's, there has been a general reduction in the degree of vaccine side effects registered. This is a result of increased knowledge of the risk factors, improved administration procedures and changes in vaccine formulation and dosage volume.

Vaccination of salmonid fish has reduced the number of outbreaks of historically important bacterial diseases to a minimum. Vaccination has therefore contributed to lower losses, dramatically reduced antibiotic use and improved fish welfare. While vaccines and vaccine administration undoubtedly lead to a degree of negative side effects, the consensus is that on balance, fish vaccines are positive for both the health and welfare of farmed fish.

Given the extensive use of vaccination in Norwegian aquaculture and negative welfare aspects of vaccination, it is important that a focus be maintained on reduction of vaccine related side effects. Vaccine formulations must be continually improved upon, vaccine administration must be performed under optimal conditions and vaccine side effects should be monitored in all fish groups.

Annual survey 2017

The current feeling amongst Fish Health Service personnel and inspectors of the Norwegian Food Safety Authority is that vaccination does not constitute a significant health or welfare problem compared to other diseases. This applies to farming of salmonids in both fresh and seawater. When asked on their views regarding whether vaccination represents a welfare problem for ongrowing salmon, 40 % of respondents answered 'No, not at all', 31% replied 'Yes, to a minor degree', 2% answered 'yes, to a significant degree' and 6% answered 'don't know'. Vaccine side-effects of over 3 on the Speilberg scale are registered 'not at all' by 20 % of respondents, 'to a minor degree' by 47%, 'to a degree' by 14%. 'to a significant degree' by 0%, while 18% answered 'don't know'.

8.4 Other cardiac complaints (other than PD, HSMI and CMS)

By Muhammad N. Yousaf

Normal heart function is an important basis for good fish health, particularly in stressful situations e.g. during grading, transport or de-lousing. The salmon heart comprises the atrium, ventricle and bulbus arteriosis.

In addition to the viral diseases PD, HSMI and CMS, which all affect the heart, there a number of different cardiac conditions that are regularly identified. Abnormalities relating to both the shape and size of the ventricle i.e. deviation from the normal pyramidal shape, are relatively common. The most commonly identified abnormalities are small and more or less rounded, bean shaped hearts. Sub-epicardial hypercellularity (epicarditis) is a normal finding in relation to PD, HSMI and CMS, but also appears to manifest as an independent condition that cannot readily be related to other diseases. The significance of this condition is unknown, but such changes are considered as negative for optimal heart function. These conditions may therefore contribute to 'unexplained mortality' episodes and mortality associated with de-lousing. Cartilaginous tissues are often observed in the bulbus arteriosus of both healthy and diseased salmon. The aetiology of this condition is uncertain, but is probably related to cardiac overload. The salmon heart does not require cartilage for normal function and the presence of cartilage may have a negative effect on normal function. Further research is required to understand this condition better.

The situation in 2017

There are no official statistics compiled for such heart complaints in fish.

Several Fish Health Services report the death of many 'fine fish', often fish transferred to sea in the autumn dying during the first winter at sea.
With the exception of congestion, ascites and cardiac tamponade, there are few or no specific post mortem findings in these fish. Laboratory investigations seldom identify specific findings other than inflammatory changes in the heart.

Fish farming in northern Norway. Photo: Geir Bornø, Norwegian Veterinary Institute.

9 The health situation in wild salmonid fish

By Sigurd Hytterød, Asle Moen, Siri K. Gåsnes and Åse Helen Garseth

9.1 Introduction

Wild fish activity at the Norwegian Veterinary Institute includes, in addition to health related surveillance, diagnostics and research, an extensive engagement in conservation biology. Conservation biology is a cross-disciplinary science aimed at meeting and countering threats against biodiversity in Norway. 2017 can be considered a good year for this activity as many years work in countering Gyrodactylus salaris *was rewarded by confirmed eradication of this parasite from the river Lærdalselva and 9 rivers in the Vefsna region. In both regions the Norwegian Veterinary Institute has played a central role in development of treatment methodologies, surveying of infected regions, eradication of the parasite and not least conservation and re-establishment of local strains of salmonid fish. In this edition of the 'Health situation in salmonid fish', we describe this work in detail and provide a retrospective historic glimpse into this work.*

Genetic contamination via escaped farmed salmon and the negative effects of salmon lice are considered the most serious farming related threats to wild salmon. It has been decided at the political level that salmon farming must be sustainable and regulated by so-called sustainability indicators. The 'traffic light' system was introduced in 2017 by the Ministry of Trade, Industry and Fisheries with salmon louse infection pressure as the only indicator.

The Norwegian Veterinary Institute has, together with other research institutions, contributed to the knowledge base upon which political decisions have been made through development of a model for infection pressure and salmon-louse induced mortality in migrating wild salmon smolts.

Environmental change caused by spread of infectious disease from the farming industry may be used as an important sustainability indicator in the future. Relevant knowledge and the research base is extremely limited. Several institutions including the University of Bergen, Institute for Marine Research, Nofima, NINA, Uni Research and the Norwegian Veterinary Institute, contribute annually with new knowledge on the health of wild salmonids and the interaction between farmed and wild populations.

Salmon louse. Photo: Trygve Poppe.

9.1 News from the diagnostic service

Health surveillance in wild fish is largely based on observations made by the public of sick or dying fish. The Norwegian Veterinary Institute is the public authority responsible for investigation of unexplained mortality in wild fish, but is completely dependent on information from the public at large.

In 2017, the Norwegian Veterinary Institute received only 21 submissions relating to disease in wild fish. While most submissions involved salmon; sea trout, brown trout, arctic char, cod, goldsinney wrasse and corkwing wrasse were also represented. The reasons for submission varied but included mortality in wild-caught cleaner fish (exposed to freshwater) and cod (gill parasites), signs of circulatory disturbance, parasites and ulcers.

Furunculosis in the Namsen watershed

As in previous years, the Norwegian Veterinary Institute received wild salmon in 2017 from a tributary of the river Namsen displaying clinical signs consistent with furunculosis. The fish displayed external lesions, abdominal skin bleeding and bleeding in the internal organs together with pale gills. *Aeromonas salmonicida* subsp. *salmonicida* was identified. This bacterium was also identified in a clinically healthy wild salmon used as broodstock at a hatchery in the same geographical area. The fish were caught in October and bacteriological samples taken during stripping. The fish were destroyed following stripping.

Tapeworm in freshwater fish

Identification of large white nodules in the internal organs of wild caught fish are a common reason for submission of wild fish to the Norwegian Veterinary Institute. In 2017, two arctic char and three brown trout caught in a lake in the Meløy area of Hordaland and displaying this type of pathological change were submitted for examination. The nodules contained tapeworm belonging to *Dyphillobothrium* sp. also commonly known as 'gull worms' and 'fish worms' which have fish as an intermediate host.

The development of nodules is due to an immune reaction in the fish, resulting in encapsulation of the worm, causing a so-called granulomatous peritonitis. Such changes involving tapeworm larvae are considered normal in wild freshwater fish in Norway.

Figure 9.2.1: The Norwegian Veterinary Institute commonly receives submissions related to the presence of large white nodules in the abdominal cavity of wild fish. These are caused by the tapeworm *Diphyllobothrium* sp. Photo: Roar Ektvedt.

9.2 The health status of wild anadromous salmonids

Active health surveillance of wild salmonids is based on directed programmes performed under contract from the Norwegian Food Safety Authority. Traditionally, results from this type of programme in aquaculture and terrestrial agriculture have been used to document freedom of, presence of, or prevalence trends for specific infections.

Since 2012, the Institute of Marine Research and the Norwegian Veterinary Institute have performed active health surveillance of wild anadromous salmonid fish on contract from the Norwegian Food Safety Authority.

The surveillance programme has focussed mainly on viral diseases, but has only partly followed the same structure used for other surveillance programmes. The reason for this is that repeated surveillance for agents that are only very rarely identified in wild fish, has little value when we do not understand why these agents are not detected.

Focus has been placed to a greater degree on generation of new knowledge, which has resulted in a more research-like surveillance. This contributed in 2016 to identification of poxvirus (SGPV) as widely prevalent amongst wild salmon (Figure 9.3.1).

Figure 9.3.1 Gills of Norwegian wild salmon with signs of disease consistent with SGPV on the cover of the Journal of Fish Diseases. Photo: Mona C. Gjessing, Norwegian Veterinary Institute.

The theme for the Norwegian Veterinary Institute's part of the surveillance programme for 2017 was mapping of the prevalence of the rainbow trout associated PRV-variant (PRV3) in wild salmon.

Heart and skeletal muscle inflammation (HSMI) in salmon was first identified in 1999 and the relationship with piscine orthoreovirus (PRV) unequivocally confirmed in 2017. HSMI is one of the most common viral diseases in farmed salmon and can cause significant losses, particularly following stressful events or handling. New variants of PRV have been recently described and linked to several disease conditions in salmonids e.g. melanin spots (PRV1), EIBS in Coho salmon (PRV2) and cardiac inflammation in rainbow trout (PRV3). The viral number-based designations used here, have been proposed, but not yet formally accepted.

Heart- and kidney samples from Atlantic salmon (*Salmo salar*), brown and sea trout (Salmo trutta), sea-run arctic char (*Salvelinus alpinus*) and land-locked salmon (*Salmo salar*) were analysed using real-time PCR by the Norwegian Veterinary Institute and by Patogen AS. This survey revealed that PRV3 was present in wild seatrout from 15 of 21 rivers tested. There is reason to believe therefore that PRV3 is a relatively common virus of sea trout in Norway and much more common than PRV1, which was identified in 1-3% of sea trout previously tested. Preliminary sequencing of PRV3 from sea trout indicates a close relationship with PRV3 from farmed rainbow trout.

Small amounts of PRV3-RNA were identified in four of 220 Atlantic salmon tested. Infectious challenges have previously shown that Atlantic salmon are less susceptible to PRV3 than rainbow trout. PRV3 was not identified in brown trout, sea-run arctic char or land-locked salmon. More complete information will be presented in a specific project report in the course of May 2018.

9.3 The health situation in the Gene bank for wild salmon

The Norwegian Veterinary Institute monitors the health of wild anadromous salmonids captured in rivers and utilised as broodstock for the Gene bank for wild salmon. Infectious pancreatic necrosis virus (IPNV) and the bacterium *Renibacterium salmoninarum* may be transmitted from parents to offspring. All salmonid fish used as broodstock for the Gene bank are therefore tested for IPNV and *R. salmoninarum*. There are, in addition, indications that the virus piscine myocarditis virus (PMCV) which causes cardiomyopathy syndrome (CMS) in salmon, may also transmit vertically. All salmon have since 2016 also been tested for PMCV. In 2017, 180 salmon and 68 sea trout were tested. IPNV and *R. salmoninarum* were not detected. PMCV was identified in one salmon from Hordaland and all eggs from this fish were destroyed.

Table 9.3.1. Results of PCR analyses for *Renibacterium salmoninarum*, infectious pancreatic necrosis virus (IPNV) and piscine myocarditis virus (PMCV) performed on wild caught broodstock for use in the Gene bank for wild salmon and two hatcheries.

Region	Salmon	Sea trout	Comment
Nord-Trøndelag	14		
Sør-Trøndelag	20		
Hordaland	48	68	1 salmon positive for PMCV (sea trout not tested).
Buskerud	98		
Total	180	68	

Trollveggen rises behind the Steinhølen pool in the river Rauma. This river was last rotenone treated in 2014. Before the river can be declared free of infection, the river must be monitored for the parasite for a period of five years. Photo: Trond Haukebø. County Governor in Møre og Romsdal.

9.4 The salmon louse

Risk evaluation- salmon louse induced mortality in wild salmon in 13 production zones

An expert group with members from central Norwegian research institutions has evaluated the risk of salmon-louse induced mortality in wild salmon smolts in the 13 production zones in Norway. The evaluation was based on the proportion of mortality for which lice produced directly by Norwegian aquaculture facilities is responsible. The risk evaluation took different migration routes, calculated larval settlement and probable mortality levels based on differing louse numbers, into account. Generally, there is a lower probability of louse-induced mortality in the more northerly production areas and in production area 1 (Swedish border to Jæren) where there is limited aquaculture activity. This evaluation forms the basis for advice given to NFD in relation to introduction of a new regulatory system for expansion of the aquaculture industry (the so-called traffic light system). Despite the uncertainties related to estimates of louse larval settlement and louse-induced mortality, the researchers responsible are of the opinion that this model system is well suited to comparison of year-to-year risk and comparison of production areas.

Adult female salmon louse with egg-strings on a wild salmon Photo: Ketil Skår, Norwegian Veterinary Institute.

9.5 *Gyrodactylus salaris*

Control of *Gyrodactylus salaris*

Norway is bound by international environmental agreements to eradicate *G. salaris* from Norwegian river systems. The Norwegian Veterinary Institute is the national competence centre for control of *G. salaris* and is responsible for implementation of all national eradication programmes. Eradication normally utilises rotenone, although aluminium sulphate has also been used with success. All control measures are performed under contract from the Norwegian Environment Agency.

Traditional rotenone-based eradication- a historical review

The Norwegian Veterinary Institute first became involved in Gyrodactylus eradication over twenty years ago. The campaign against the parasite had endured since the 1980's and began with initial success when treating small and medium sized rivers. The rotenone method is based upon removal of the parasites host from the river under treatment, and during the early years, few restrictions existed regarding maximum permitted concentrations of rotenone. In the nineties, treatment of larger rivers coincided with introduction of restrictions related to the maximum concentration of rotenone permitted. This resulted in several failed treatments. As a result, a group was established with a mandate to develop treatments suitable for use in larger rivers. VESO Trondheim was tasked with organisation of method development and was made responsible for future treatments against *G. salaris*.

VESO Trondheim was incorporated within the Norwegian Veterinary Institute in 2007.
Since 2002, and after considerable effort, six infected regions have been declared free of infection or are under surveillance towards this goal. This would not have been possible without continual method development and adaptation to the challenges posed by individual river systems which have included extreme water flow, extensive groundwater seepage as well as treatment of large lakes (>10km2) with depths of up to 70 meters.

The aluminium method

During the nineties, as part of research into the negative effects of acid rain on salmon, researchers at the University of Oslo (UiO) found that *G. salaris* was extremely sensitive to acidic aluminium rich water. This discovery led to extensive research on whether aluminium dissolved in water could be used as a treatment against *G. salaris* without killing the fish. The project, initially a cooperation between UiO, the Norwegian Institute for Water Research (NIVA) and the Norwegian Veterinary Institute, was completed by the latter two institutions with aluminium treatment of the river Lærdalselva in 2011 and 2012. The aluminium method involves treatment of the main and tributary rivers with an aluminium solution, while static water bodies in peripheral areas are treated with rotenone. In this way, *G. salaris* can be eradicated from a river system without wiping out the fish population.

Treatment of the river Lærdalselva was performed by applying aluminium (ca. 25-30 µg Al/l) to the river system over two fourteen-day periods in years 1 and 2. In this way, adequate mixing and spread of the chemical, with an adequate exposure time in all areas holding fish was ensured. The aluminium method represents a new tool against *G. salaris* and is promising for future use in the fight against this parasite.

Development of new eradication methods

Despite many successful treatments, seven river systems within the Driva and Drammen regions remain infected with *G. salaris*. Development of new eradication methodology is important to supplement existing methods in the fight to eradicate *G. salaris* from all Norwegian river systems.

The Norwegian Veterinary Institute, NINA and NIVA are

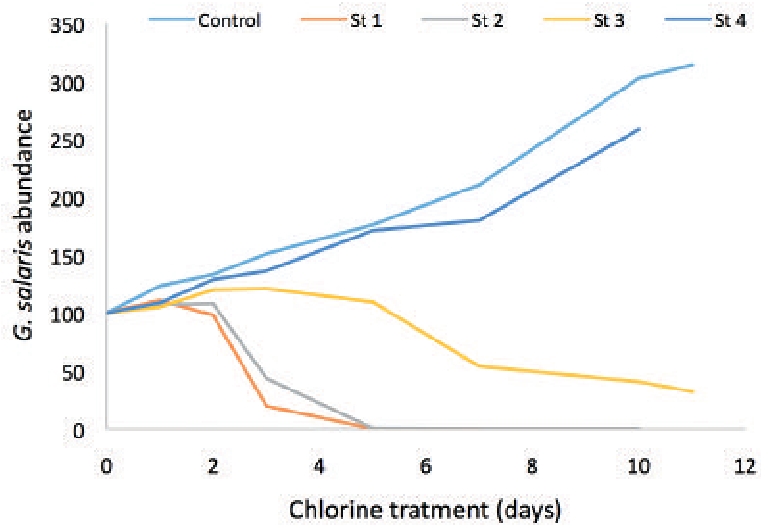


Figure 9.5.1. Development of an average infection (abundance) of *G. salaris* at the various experimental stations on the river Lierelva. At stations 1-4, 7, 20, 80 and 150 minutes following treatment (30 µg chlorine/l added as chloramine) application, respectively. Fish at the control station were held in untreated river water from the river Glitra.

currently cooperating on an investigation of the effect of chlorine compounds on *G. salaris* (and fish) in large river systems. Chlorine compounds have been found to be extremely poisonous to *G. salaris*. In laboratory experiments, it has been found that chlorine levels equivalent to those found in drinking water are sufficient to remove the parasite from juvenile salmon within a few days.

Chlorine compounds were tested for the first time in a natural river system during 2017, in the upper reaches of the river Lierelva (Glitra). During the trial *G. salaris* was removed after 4-6 days treatment from juvenile salmon at stations 1 and 2 with no significant negative effects to the fish (see graphs for St 1 and St2 in Figure 9.5.1).

The trial revealed that chlorine compounds gradually lost their toxic effect against *G. salaris* following application, but that the compounds remained active for at least one hour following release.

Gyrodactylus salaris *eradication in Norway, status in 2017*

Control measures

As part of a two-year treatment plan, treatments were performed in the Skibotn region (The Rivers Skibotnelva, Kitdalselva, Signaldalselva and Balsfjordelva) in 2015 and 2016. This work was continued in 2017 with further treatment of selected areas. Rotenone was applied to open, ice-free areas of rivers and streams. Open water in the middle of winter indicates the existence of groundwater springs. Treatment of groundwater seepage is considered critical for successful *G. salaris* treatment in the Skibotn region. Extra treatments were therefore carried out during the winter in 2017, at a time when such seepage is easier to identify. Treatment was limited to smaller defined areas. The actions are now completed and the region is under surveillance. Six rivers in the Rauma region, together with the rivers Ranaelva and Fustavassdraget are also under surveillance for freedom of infection. Treatment has not yet been initiated in the Driva and Drammen regions.

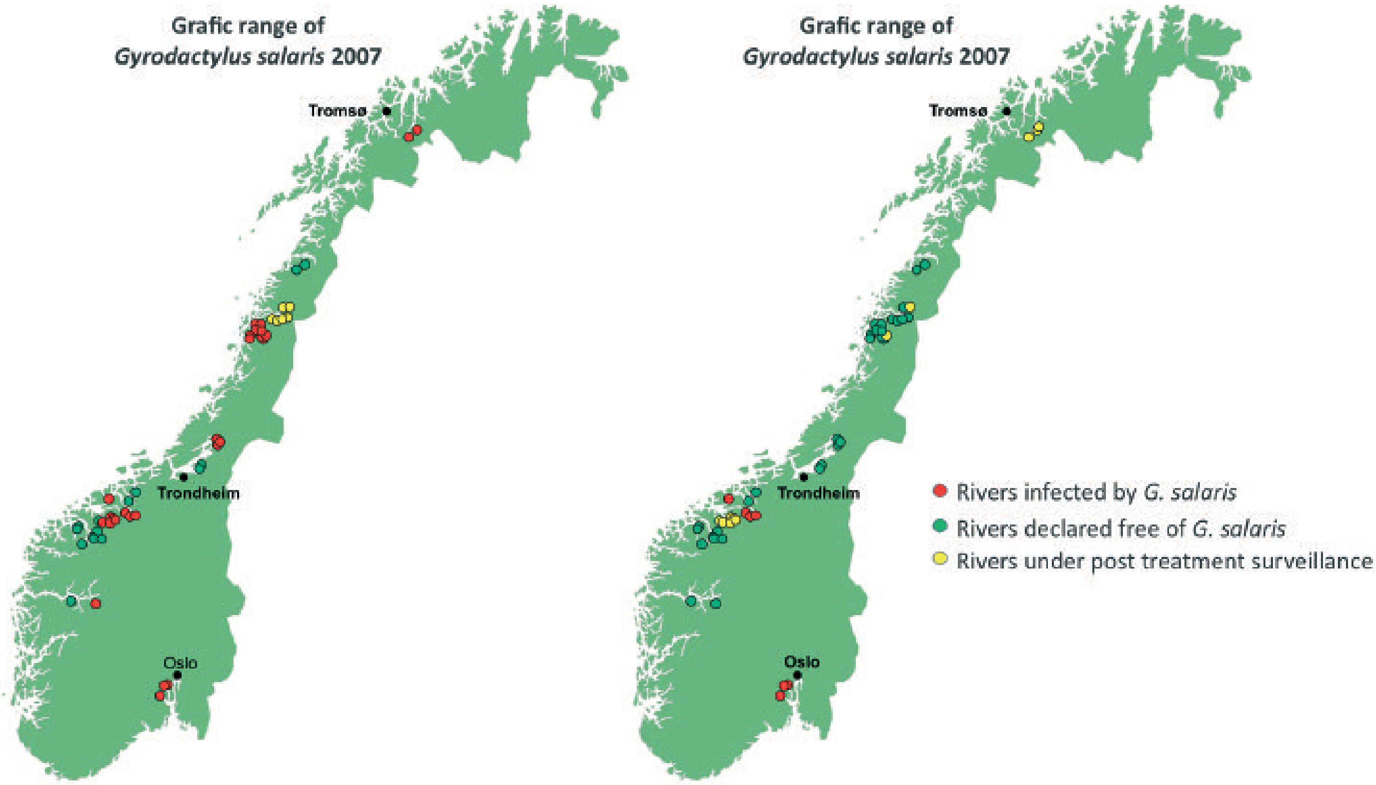


Figure 9.5.2 Geographic range of *G. salaris* in Norway, 2007 and 2017..

Surveillance and preparation for treatment

Treatment of the river Ranaelva was completed in 2015. During 2014, *G. salaris* was identified for the second time in this river. Work towards identification of the source of infection was initiated and continued into 2017, unfortunately without success.
The Norwegian Veterinary Institute performs two surveillance programmes for *G. salaris* on behalf of the Norwegian Food Safety Authority; The surveillance programme for *G. salaris* in hatcheries and river systems (OK-programme) and the 'Freedom of infection' programme (FM-programme). See http://www.vetinst.no/overvaking for more information (Norwegian language). Additional investigations into the *G. salaris* situation in the Drammen and Rana regions were performed in 2017.

In the OK-programme for *G. salaris*, 3615 salmon and rainbow trout from 110 farms and 2217 salmon from 69 rivers were examined. In the FM-programme, 2199 juvenile salmon from 20 river systems within the infected regions Vefsna (10 rivers), Rauma (6 rivers), Skibotn (2 rivers), Lærdal (1 river) and Rana (1 river) were examined. *G. salaris* was not identified in any previously uninfected river or farm in 2017.

Freedom of infection

Nine rivers in the Vefsna region of Nordland as well as the river Lærdalselva in Sogn og Fjordane were declared free of *G. salaris* infection by the Norwegian Food Safety Authority in the autumn of 2017.

The *G. salaris* free rivers in Nordland comprise the Vefsna, Drevjo, Hundåla, Halsanelva and Hestdalselva in the Vefsn council area, and Dagsvikelva, Nylandselva, Ranelva and the Leirelva in the Leirfjord council area. Treatment of the rivers and three large lakes in the Vefsna region i.e. lakes Fustvatnet, Mjåvatnet and Ømmervatnet represent the largest treatment against the salmon parasite in Norway and the largest single rotenone operation ever performed in the world.

The freedom of infection status declared in several rivers in 2017 is the result of extensive method development, planning and procedures that show that *G. salaris* may be eradicated in large watersheds containing many rivers. The river Fusta and the lakes Fustvatnet, Mjåvatnet and Ømmervatnet retain infected status. The Fusta and these lakes can only be declared free from infection following a long surveillance program that will probably start in 2021.

Infection status and changes in the threat situation

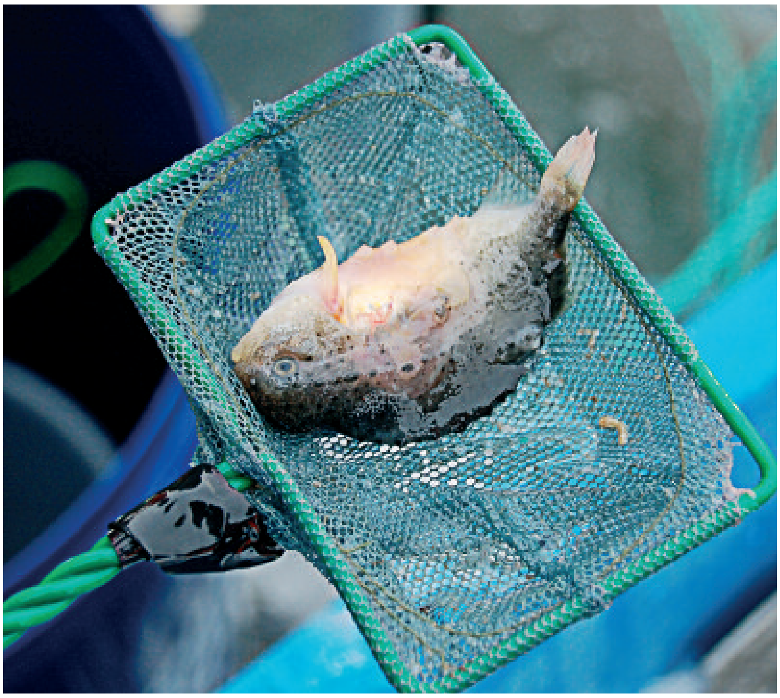
Treatments and resulting declaration of freedom of infection in a number of rivers within affected areas has reduced the geographical range of *G. salaris* in Norway. Infection pressure on rivers bordering treated regions has dropped dramatically. During the period 2007-2017, treatment has been completed in six infected regions (Steinkjer, Vefsna, Lærdal, Rauma, Rana and Skibotn). In addition, the rivers in the Rana region (with the exception of the river Rana in which *G. salaris* was confirmed in 2014 with subsequent re-treatment in 2014 and 2015), the Vefsna region (not including the Fustavassdraget), Steinkjer region and river Lærdal have been declared free of infection. Very few new rivers have been infected during the same period. At the start of 2018, seven rivers remain infected in Norway and eleven are under surveillance following treatment. In 2007, infection was identified in 24 rivers, and six were under post-treatment surveillance (see Figure 9.5.2)
As a result of these developments, the Scientific Committee for Salmon Management has reduced the threat level for *G. salaris*.

For more information on the fight against G. salaris, see: http://www.vetinst.no/dyr/villfisk/tiltak-mot-gyrodactylus-salaris-og-andre-fremmede-arter

10 The health situation in cleaner fish

By Snorre Gulla and Geir Bornø

*Use of cleaner fish (wrasse sp. and lumpsucker) as a biological means of salmon-louse removal has become more and more usual in Norwegian aquaculture. The most commonly used species are the goldsinny wrasse (*Ctenolabrus rupestris*), corkwing wrasse (*Symphodus melops*) and Ballan wrasse (*Labrus bergylta*). A large number of lumpsucker (*Cyclopterus lumpus*), which remain active as lice removers at low temperature are also used.*



Lumpsucker with skin lesions. Photo: Geir Bornø, Norwegian Veterinary Institute.

A number of farms dedicated to production of cleaner fish, mostly lumpsucker, have been established in recent years. A considerable number of wild wrasse continue to be caught during the summer in fyke nets and creels, transported on deck in tanks to land, then transported further either on lorries or in well-boats to their final destination where they are used as cleaner fish. The longest transport distances include transport of fish from the Swedish west coast and the Baltic Sea to Nordland in Norway. While wrasse species utilised as cleaner fish are predominantly wild caught (a small proportion of Ballan wrasse are farmed), all lumpsucker utilized are farmed. The broodstock are, however, almost entirely wild caught.

Common diseases/agents in cleaner fish

Bacteria

Atypical furunculosis (caused by atypical *Aeromonas salmonicida*) is one of the most important bacterial diseases of cleaner fish. *A. salmonicida* infection commonly manifests as a chronic disease with multi-organ granuloma and ulcer development. Cleaner fish infections are almost exclusively related to infection with two genetic variants of the bacterium (A-layer types V and VI). Typical *A. salmonicida* (subsp. *salmonicida*) has not been identified in wrasse species in Norway in recent years, but has been diagnosed in lumpsucker used as cleaner fish in Trøndelag in 2015 and 2016. These infections most probably represent spread from wild salmon infected with a local strain of the bacterium.

Many Vibrio species are normal members of the marine microbiota. The most commonly isolated species from cleaner fish include *Vibrio splendidus, V. logei, V. wodanis* and V. *tapetis*, but the significance of these bacteria in relation to disease is unclear. Some strains of *V. tapetis* and *V. splendidus* have been described as pathogenic to wrasse, but later infection trials have failed to confirm this in a convincing manner. It may be speculated that external factors such as transport and stresses involved in being held in a salmon cage contribute to susceptibility to bacteria that normally do not result in disease.

Tenacibaculum spp., which are also normally present in significant numbers in seawater, are commonly isolated from skin lesions of cleaner fish and often as part of a mixed flora. *Moritella viscosa* is also commonly associated with skin lesions, usually when sea temperatures are low.

Vibrio anguillarum may cause disease in all cleaner fish species while *V. ordalii, Pseudomonas anguilliseptica* and *Pasteurella* sp. have been identified as pathogenic for lumpsucker.

Piscirickettsia salmonis was identified in lumpsucker in Ireland in 2017, but has never been identified in Norwegian cleaner fish.

Development and testing of vaccines in lumpsucker is underway and many farmed lumpsucker are now vaccinated against one or more bacterial pathogens (primarily *V. anguillarum* and/or atypical *A. salmonicida*)

Virus

Previous investigations of Norwegian wild caught cleaner fish have not identified infectious pancreatic necrosis virus (IPNV), although experimental infections have shown that these fish species may harbour the virus. Viral haemorrhagic necrosis virus (VHS) has not been identified in Norwegian cleaner fish, but has been detected in wild-caught wrasse and lumpsucker in Scotland and Iceland, respectively.

A recent publication described finding nodavirus in wrasse (all three most commonly used species) caught along the Swedish and Norwegian coasts in 2014. Salmonid alphavirus (SAV) was reported from a farm in which wrasse were held in close contact with salmon during an outbreak of pancreas disease (PD). A similar situation has been described involving infectious salmon anaemia virus (ISAV). Clinical disease was not identified in the wrasse, and sample contamination cannot be excluded.

Piscine myocarditis virus (PMCV) was recently detected in wrasse held in a cage with salmon suffering cardiomyopathy syndrome (CMS) in Ireland in 2016. A method has been developed by a private laboratory for detection of Lumpfish flavivirus. This virus is detected in many cases and there are grounds to believe that it is of importance concerning lumpsucker health.

Parasites

AGD (caused by the amoeba *Paramoeba perurans*) has been identified in lumpsucker, corkwing wrasse, Ballan wrasse and other wrasse species held in cages with salmon. Tank-held lumpsucker have also been affected. The pathogenic changes to the gills are similar to those experienced in salmon.

Gyrodactylus sp. may be found on the skin and gills of lumpsucker. The prevalence of *Gyrodactylus* sp. and gill damage possibly caused by these parasites has not been studied. Such infections may cause problems in the future.
Nucleospora cyclopteri, which may be found in large numbers in the kidney of lumpsucker, has been identified as widely prevalent in Norway. Lumpsucker represents the only known host for this parasite.

The health situation in cleaner fish species is discussed below. The welfare aspects surrounding cleaner fish and their use are discussed in the fish welfare chapter.

Situation in 2017

Data from the Norwegian Veterinary Institute

In 2017, the Norwegian Veterinary Institute received diagnostic submissions related to cleaner fish from 149 farming localities. This is a slight reduction in number of cleaner fish related cases from the year before. Although fewer localities were investigated the total number of submissions from these localities increased. The main findings from last year and previous years are summarised in Table 10.1. The data represents both wild-caught and farmed cleaner fish. In some cases, there may be some confusion in the field surrounding the individual species identity amongst the various wrasse species, and a number of submissions are therefore categorised as ‘wrasse’.

Bacteria

Significant problems continued to be experienced with atypical *Aeromonas salmonicida* in both lumpsucker and wrasse spp. in 2017. The total number of positive

Table 10.1: Prevalence (number of farms diagnosed) of selected diseases/agents in cleaner fish investigated by the Norwegian Veterinary Institute 2012 – 2017.

Species	Disease/agent	Number investigated (positive farms)					
		2012	2013	2014	2015	2016	2017
Lumpsucker	Atypical *Aeromonas salmonicida*	1	8	5	51	27	24
	Typical *Aeromonas salmonicida*	0	0	0	1	4	0
	Vibrio anguillarum	7	6	8	12	12	7
	Vibrio ordalii	3	4	1	3	1	6
	Pasteurella sp.	1	16	8	14	28	23
	Pseudomonas anguilliseptica	0	0	1	4	8	15
	Moritella viscosa	2	2	3	7	19	33
	Tenacibaculum spp.	3	4	8	22	24	30
	AGD	0	0	2	2	8	2
Wrasse	Atypical *Aeromonas salmonicida*	12	13	16	32	18	14
	Vibrio anguillarum	6	6	6	2	2	2
	Pseudomonas anguilliseptica	0	0	0	0	0	1
	AGD	0	5	2	2	1	1

diagnoses made by the Norwegian Veterinary Institute for each species has however fallen slightly (14 and 24 for wrasse and lumpsucker respectively in 2017) from the previous year (18 and 27 respectively). *Aeromonas salmonicida* subsp. *salmonicida* was not identified in cleaner fish in 2017.

Pasteurella sp. has also been a problem in lumpsucker, although the number of positive localities fell slightly from 28 in 2016 to 23 in 2017.

The number of localities affected by *Pseudomonas anguilliseptica* has increased significantly on an annual basis in recent years, with the number of positive localities almost doubling from 8 cases in 2016 to 15 in 2017.

Vibrio anguillarum was diagnosed from sick lumpsucker in seven localities (primarily serotype O2) and from wrasse in two localities (serotype O1). *V. ordalii* was identified in lumpsucker from 6 localities, which is an increase from 1 in 2016.
Moritella viscosa and *Tenacibaculum* spp. were isolated from lumpsucker in 33 and 30 farms respectively. In both cases, this represents an increase from the preceding year.

A broad array of Vibrio species (*V. splendidus*, *V. logei*, *V. tapetis*, *V. wodanis*, *Vibrio* sp.), were frequently isolated from cleaner fish in 2017, often in mixed culture and the role of individual isolates in each situation is not easily identified.

Antibiotic sensitivity in bacterial pathogens of cleaner fish

Antibiotic treatment e.g. with oxolinic acid or florfenicol, of farmed cleaner fish may on occasion be necessary. Currently there are few signs of resistance development in cleaner fish pathogens. Many bacteria display various degrees of 'natural' resistance to one or more antibiotics. Even closely related bacteria may display varying degrees of sensitivity in the absence of antibiotic driven selection. For further general information, see the specific section on antibiotic resistance.

In 2017, reduced sensitivity to oxolinic acid was identified in a single isolate of *Vibrio anguillarum* isolated from lumpsucker.

Virus

No viral disease or viral agent was identified in the diagnostic material submitted from cleaner fish to the Norwegian Veterinary Institute in 2017. The Norwegian Veterinary Institute does not presently have diagnostic tools capable of detection of Lumpsucker flavivirus.

Parasites

AGD (caused by the amoeba P*aramoeba perurans*) was identified in a single population of wrasse and 2 populations of lumpsucker in 2017. Pathological changes consistent with microsporidian parasites were also identified in lumpsucker.

Sporadic identification of ectoparasites including *Trichodina* sp. and other gill-related ciliates could not be related to significant health problems. Nematodes (probably *Hysterothylacium aduncum*) within the peritoneum and internal organs are regularly identified in wild caught goldsinny wrasse.

Histopathological changes were observed during 2017, which provide grounds for suspicion of other parasitic problems in cleaner fish species. In particular, Nucleospora appears commonly identified by private laboratories, often by PCR. The significance of these diagnoses remain uncertain.

Fungal agents

Systemic mycosis was identified in a single population of lumpsucker in 2017.

Response to the survey

For cleaner fish generally, it appears that they continue to have considerable health challenges. Little seems to have changed in the last few years, however, and the problems appear to be relatively stable. Some Fish Health Services and Norwegian Food Safety Authority field officers consider that much of the mortality experienced during 2017 may be related to Lumpfish flavivirus and *Tenacibaculum* spp. Salmon-louse treatment is also considered to represent a serious threat to cleaner fish health, with high associated mortalities.

For lumpsucker, the early hatchery phases appear to be most challenging, with vibriosis the main disease involved, although atypical furunculosis is also considered problematical, particularly in the south of the country. Non-specific ‘fin rot’ was also considered the major challenge in hatchery-reared lumpsucker. AGD seems to be more of a problem in north-west and south-west Norway than in the rest of the country. *Pasteurella* is most common in the middle and southerly parts of the country.

For lumpsucker held in salmon cages, atypical furunculosis continues to provide the most significant problems. There are also problems with skin lesion development, vibriosis, fin-rot, pasteurellosis and AGD. Northern Norway seems to suffer less with atypical furunculosis but has greater problems with vibriosis in lumpsucker. In mid-Norway, atypical furunculosis represents the biggest threat, followed by vibriosis and skin lesion development. In north-west and south-west Norway, atypical furunculosis again appears to represent the major challenge, but in this area pasteurellosis is a bigger challenge than in the rest of the country. AGD is also mentioned as a significant problem in south-west Norway.

Poor welfare, emaciation and lack of knowledge appear to be the main health challenges in farming of lumpsucker. These elements appear equally important over the whole country.

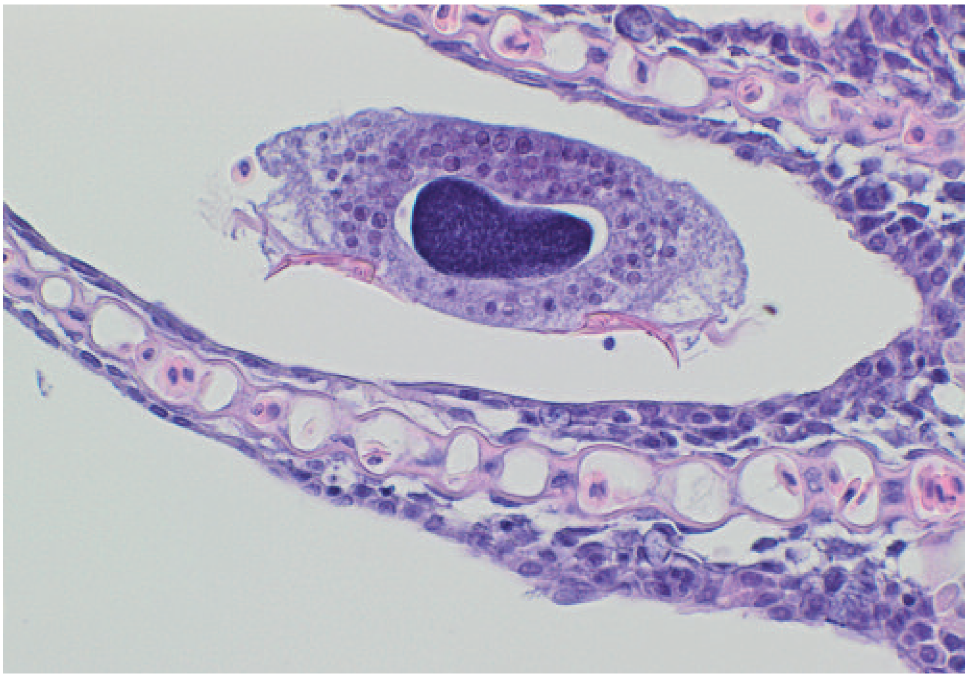
For wrasse species during the hatchery phase the most significant challenges include fin-rot and atypical furunculosis. Vibriosis was also mentioned as a problem, but appears to be less so in wrasse than in lumpsucker. Vibriosis and atypical furunculosis are considered the major challenges in northern Norway. In mid-Norway, AGD and fin-rot are considered the major challenges although atypical furunculosis and vibriosis are also mentioned. In the north-west, atypical furunculosis was most strongly weighted, with fin-rot and vibriosis the next most significant problems. In south-western area's vibriosis and atypical furunculosis are most challenging with AGD and fin-rot also mentioned. Some indicate pasteurellosis in wrasse as problematical, but this bacterium has never been identified from wrasse by the Norwegian Veterinary Institute, and it may be that fear of this disease is a larger problem than the actual disease.

Overall, lack of knowledge and poor welfare appear to be the major problems in wrasse hatcheries.

Evaluation of the cleaner fish situation

Cleaner fish are of increasing importance and there has been a formidable increase in wrasse and lumpsucker in recent years. The number of diagnostic submissions involving cleaner fish species sent to the Norwegian Veterinary Institute in 2017 increased from previous years. Private laboratories also perform diagnostic work in cleaner fish species. The number of such investigations are unknown. The increased activity in disease diagnostics involving cleaner fish species reflects the increased use of cleaner fish in the industry and that these species have their own specific health challenges. There are particular challenges related to bacterial diseases, but parasitic infections also affect cleaner fish health. Viral infections do not yet appear to have played a decisive role in cleaner fish health, but the recently discovered flavivirus in lumpsucker gives grounds for concern. Nodavirus has also been identified in wild populations of cleaner fish in our area. Both VHSV and PMCV have been identified in cleaner fish in other countries, thus highlighting the risks involved.

Generally good cleaner fish health and welfare e.g. via good nutrition, provision of cover, and minimal handling, will contribute to reduction of the impact of infectious diseases. Vaccination of farmed cleaner fish against selected bacterial agents is already underway, but there remains much optimisation work. It is our impression that most farmed lumpsucker are now vaccinated against atypical *Aeromonas salmonicida* and *Vibrio anguillarum*. There are many unsolved challenges related to cleaner fish health, both during the hatchery phase and following stocking in salmon cages, and there remains a need for increased knowledge of the health and welfare needs of these new farmed species.



Trichodina sp. on cod gills. Photo: Geir Bornø. Norwegian Veterinary Institute.

11 The health situation in farmed marine fish

By Hanne K. Nilsen

As in previous years, bacterial and parasite infections dominate the diagnostic material submitted from marine fish species.

Marine species in aquaculture

Farming of marine fish species is performed in both land-based farms and in sea-cages. Halibut require large surface areas upon which the fish may rest. Land-based farms now exist in which halibut may be held throughout the complete life cycle and production of halibut is expected to increase in 2018. Turbot grow well in warmer water and production in Norway is limited. Many hatcheries initially designed for production of cod are now used for production of cleaner fish. Most cod harvested from cages are now a result of ongrowing wild-caught cod. Coalfish are held in public aquaria. Aquaculture of wolf-fish remains in the pre-commercial phase. Spotted wolf-fish are considered a simpler species to farm than halibut and cod, but there remain challenges related to reproduction in this species.

The situation in 2017

Data from the Norwegian Veterinary Institute

Halibut and turbot

In 2017, 16 submissions involving halibut (14) and turbot (2) were submitted. Atypical *Aeromonas salmonicida* causes disease in these fish species and was diagnosed in 7 submissions involving juvenile and adult halibut.

Vibrio species such as *Vibrio (Allivibrio) logei*, *Vibrio splendidus* and *Vibrio tapetis* are frequently identified from halibut, often together with atypical *A. salmonicida*. As in previous years, problems related to gill infections involving *Ichthyobodo* sp. “costia”, and Trichodina sp. were identified. Nephrocalcinosis (calcium deposition in the kidney) is a normal finding in halibut. Sunburn was diagnosed in halibut following a period of good weather. As previously, myxosporidea were diagnosed in large halibut.

Paramoeba perurans was identified in large turbot with gill inflammation. This parasite has been previously identified in turbot in other countries but not previously in Norway.

Nodavirus infection was not identified or suspected in 2017.

Cod and coalfish

Seven submissions were received in 2017 from cod (6) and coalfish (1). The material represented wild-caught cod and fish from aquaria and commercial production (cod).

Vibrio *(Listonella) anguillarum* O2b has as previously been isolated in relation to increased mortality and ulcer development in cod and coalfish. Additional findings include the normally common *Vibrio (Allivibrio) wodanis* and *V. splendidus*. Parasites and parasite associated tissue reactions are normal findings in these species.

Francisellosis, caused by *Francisella noatunensis* subsp. noatunensis, was not identified in 2017.

Nodavirus infection was not identified or suspected in cod in 2017.

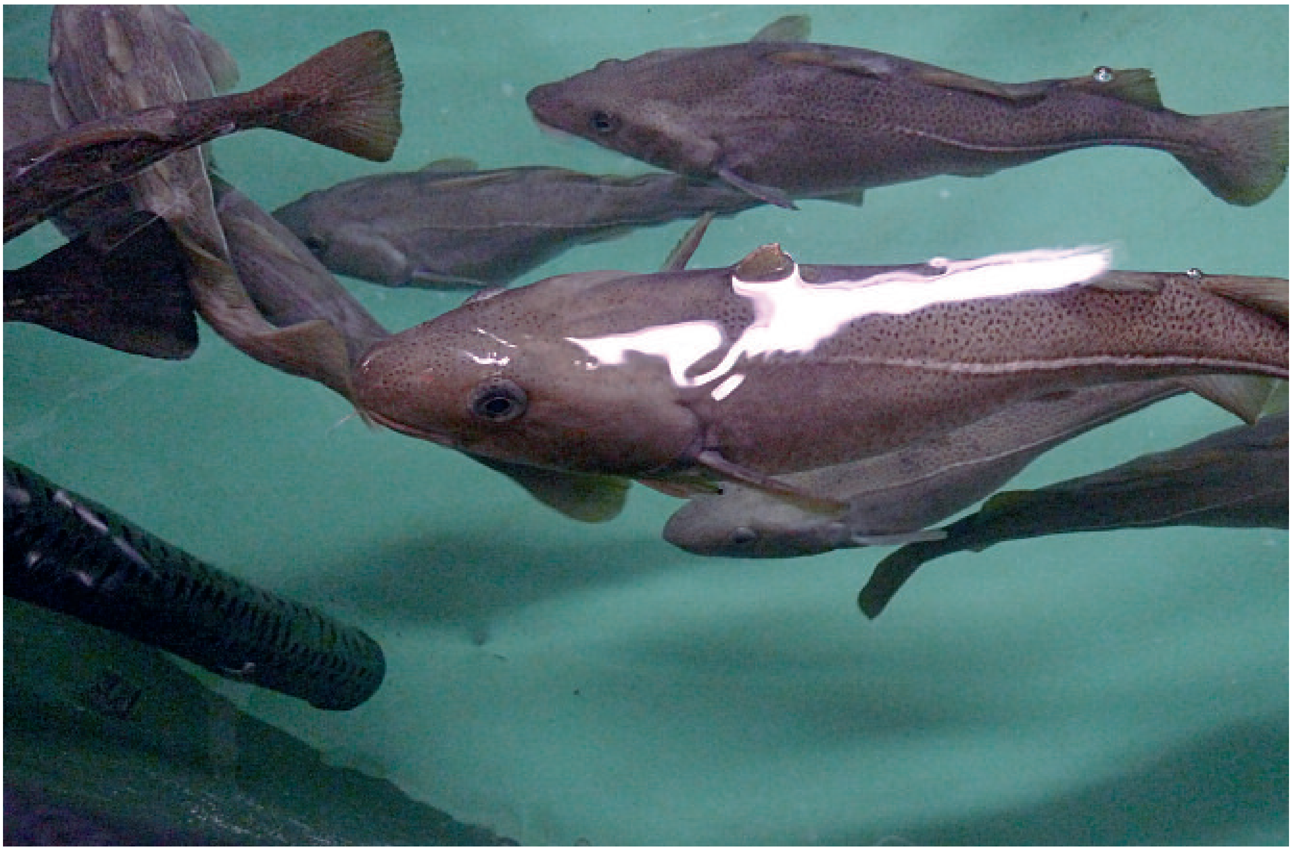
Spotted wolf-fish

Three submissions involving farmed spotted wolf-fish were submitted in 2017. There were indications of gill and kidney damage in addition to non-specific skin inflammation. There is a need for more knowledge of the diseases and preventative health measures in this species.

Survey 2017

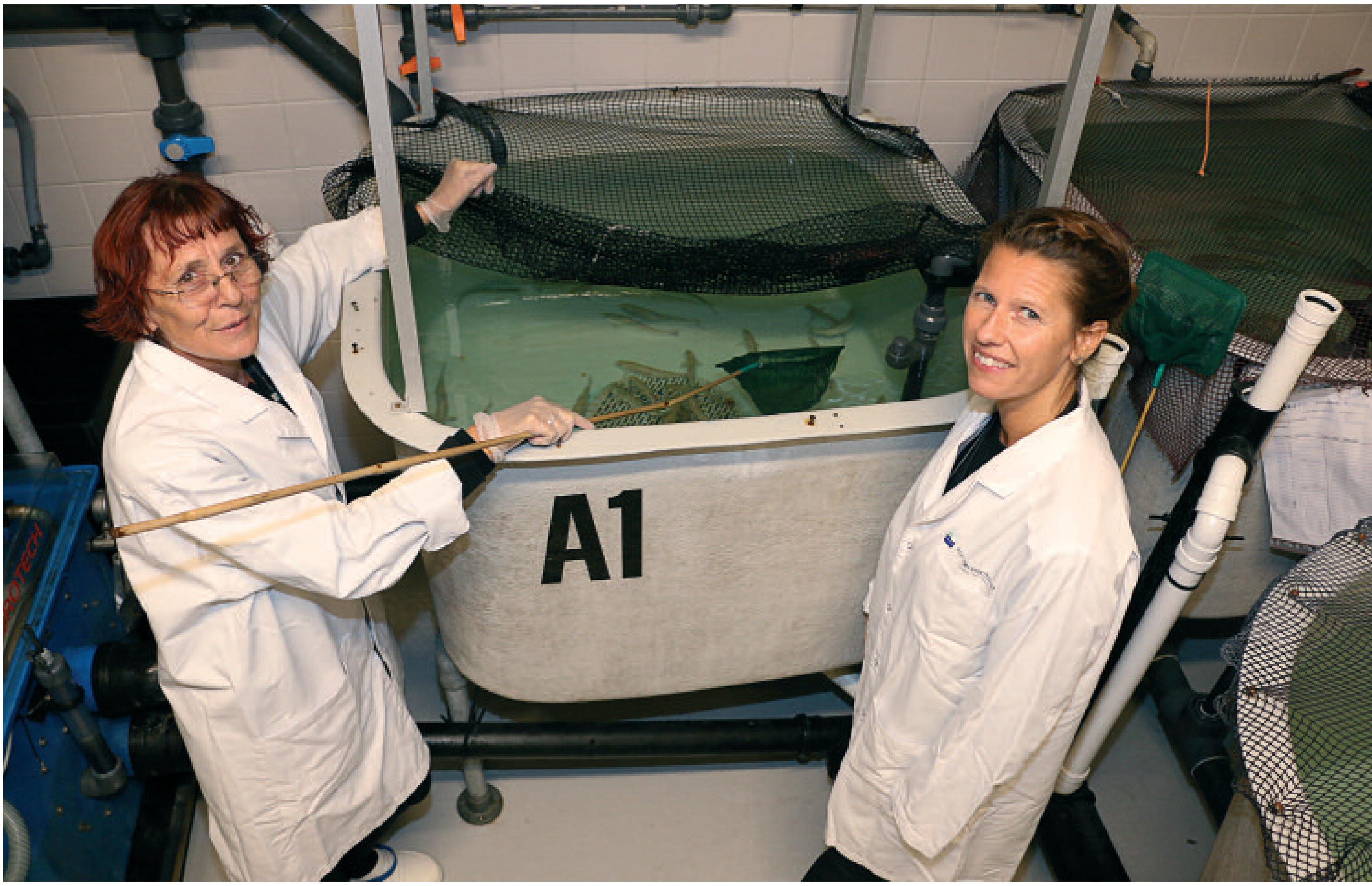
Responses to the survey indicate that mortality for cod and halibut remain at approximately the same level as previously. In cod, vibriosis is ranked higher than atypical furunculosis or francisellosis. Factors other than those caused by infectious agents are also mentioned as contributing to mortality.

For halibut, atypical furunculosis and vibriosis are considered the most important diseases by Fish Health Services in the north, mid- and north-west Norway. Fin-rot is also considered a major problem. Expansion of halibut farms (in scale) has also presented problems other than those caused by infectious agents.



Farming of cod. Photo: Geir Bornø, Norwegian Veterinary Institute.

Engineer Mari Darrud and researcher Sigurd Hytterød taking out gill samples from fish for laboratory analysis. Photo: David Strand, the Norwegian Veterinary Institute



Researchers Unni Grimholt (left) and Helena Hauge is working to develop and test a universal vaccine in the research project TarGet. Photo: Mari M. Press, the Norwegian Veterinary Institute

Researcher David Strand of the Fish Health Research Group photograhed during the fetching of samples. Photo: Trude Vrålstad, the Norwegian Veterinary Institute

Pathological changes in the gills may lead to respiratory problems and problems with ion regulation for the fish, which may make affected fish more susceptible to other infections. Photo: David Strand, the Norwegian Veterinary Institute

Photo: Colourbox.

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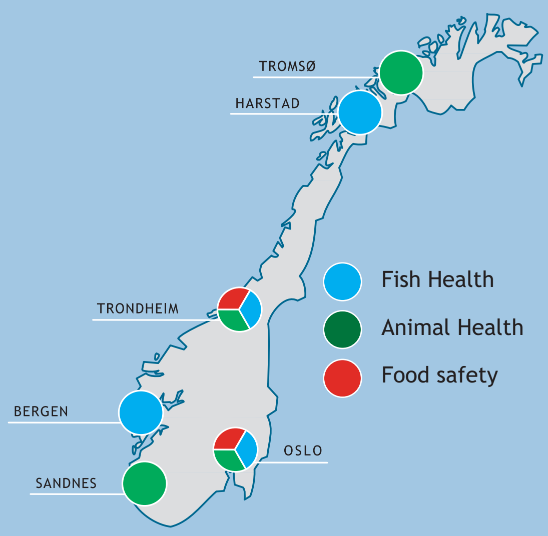
Scientifically ambitious, forward-looking and cooperative – for One Health!

The Norwegian Veterinary Institute was etsablished in Oslo in 1891 as a diagnostic laboratory for animal diseases. Today's activities encompass the entire chain from plants, via animal feed, fish, animals and food for human consumption.



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