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The Health Situation in Norwegian Aquaculture

2016

Veterinærinstituttet
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The Health Situation in Norwegian Aquaculture 2016

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Contents

-It is important that Norway maintains a complete and transparent view of the health situation in our farmed animals, says Norwegian Veterinary Institute Director for Fish Health and Editor in Chief for the current report, Brit Hjeltnes. This photograph was taken at the Salmon Lice Centre, a centre for science-based innovation at the University of Bergen. It is part of the marine 'knowledge cluster' on Marineholmen, to which the Norwegian Veterinary Institute Bergen will relocate during 2017. Photo: Eivind Senneset

Production statistics 2016
Estimated harvest volumes 2016 (2015 in parentheses):
1 171 200 tons of salmon (1 234 200), 84 500 tons of rainbow trout (71 500), zero tons (zero) of farmed cod, 6 - 7000 tons (6000) of captive wild-caught cod, 1 600 tons (1 500) of halibut, 1 400 tons (1 500) of mussels, 500 tons (500) of arctic char and 2 - 300 tons (2 - 300) of halibut.

Cleaner fish (individuals): 24 - 25 million lumpsucker (13 - 14 million), approximately 1 million ballan wrasse (4 - 500').

Statistics from Kontali Analyse.

Everyone is served by good fish health

This years report documents the health and welfare challenges faced by Norwegian aquaculture in 2016. It is important that Norway maintains the best possible overview of animal health.

The vast majority, but not all farmed fish in Norway, enjoy robust health. The aquaculture industry generates significant revenues from what has become our major domesticated animal. There remains significant potential for increasing these revenues in the future.

The Norwegian Veterinary Institute has for several years warned that the salmon louse is not merely a problem for wild salmon, but is also a problem for farmed salmon. Today, treatment of salmon lice infections costs billions of kroner annually and resistance towards chemical treatments gives cause for concern. Likewise, introduction of non-chemical, alternative treatments has resulted in new health related challenges for the fish. Paradoxically, cleaner fish species like the lumpsucker are now suffering from lice and other disease problems.

Total losses between sea-transfer and harvest continue to give grounds for concern. Twenty percent of all fish transferred to sea die or disappear before harvest. This is a huge loss considered in terms of fish welfare, economy and sustainability. A rough estimate based on a sales price for salmon of 60kr kg^{-1} suggests that reduction of these losses by 50% would result in an 8-9 billion kr increase in revenue. Total losses of 10% are greater than those currently experienced in the Faroe Isles. Some Norwegian producers also manage to produce salmon with total loss during the sea phase as low as 2%. While there would be costs involved in farming these fish to harvest and the effect on total profit is therefore difficult to estimate, the savings would be undoubtedly greater than an equivalent increase in overall production allowing/accepting the current level of loss as an integral part of the production model.

When costs related to treatment of salmon lice pass 5 billion kr annually, in addition to significant losses attributed to other diseases and injuries, it is worth considering the value of good fish health. An analysis of the socio-economic value of the Norwegian Veterinary Institutes work in aquaculture health (Nøstbakken, L. m fl 2016), concluded that the institute contributes significantly to the Norwegian economy.

What does the future hold? Rapid introduction of technological advances is common in the aquaculture industry. Recirculation is rapidly becoming the standard for juvenile and 'large smolt' production and new technologies such as enclosed ongrowing facilities are under trial. To succeed, the developers must understand the basic requirement for good fish health and consider this when designing new systems.

New disease problems will always emerge. The more fish in the sea, the higher the probability of disease development. We must therefore be ready, through research, education and preparedness for emergence of new diseases.

The 'Health Situation in Norwegian Aquaculture' report has since 2003 aimed to contribute to the national overview and to provide insight into the threats and risks associated with fish health. It is one of many contributions which allow the industry, the authorities and others to prioritise future resources. This years report is, as previously, based on statistics from surveillance and diagnostic services provided by the Norwegian Veterinary Institute. In addition we have sourced information, particularly in regard to non-notifiable diseases, from external laboratories. Due to confidentiality agreements, such statistics cannot be fully quality assured, but we thank these laboratories for their constructive contributions.

We hope that the 'Health Situation in Norwegian Aquaculture' report is a valuable aid to those interested in Norwegian fish health. Please feel free to contact the editorial board if you have suggestions or views relating to the format of future reports.

Brit Hjeltnes, Editor

Summary

The 'Health situation in Norwegian aquaculture' report has since 2003 provided an annual status and risk evaluation of the fish health situation in Norway. The salmon louse is, as previously, one of the most significant threats to the aquaculture industry. As many fish die or are injured during de-licing treatments, this represents a serious health and welfare issue. Of the viral diseases, pancreas disease (PD) and infectious salmon anaemia (ISA) are the most significant.

The salmon louse

The overall statistics for salmon lice in 2016 were similar to those for 2015. While higher numbers of lice were recorded in the southern part of the country, lower numbers were recorded in mid-Norway. This resulted in higher production of louse eggs and concomitantly higher infection pressure in southern areas, compared with 2015. Troms and Agder experienced higher infection pressures in 2016 compared to 2015.

The resistance situation remained serious along the whole coast during 2016. Resistance has developed over several years, but peaked in 2016, with treatment failure and lice damage recorded on several farms. The registered number of chemical based treatments fell by 41% in 2016 while use of mechanical de-licing methodologies increased more than six times compared to the previous year. Development and increase in use of mechanical lice treatments is strongly linked to widespread resistance to chemical treatments.

In 2016, fish health personnel reported that mechanical de-licing resulted in an increased level of mechanical injury and death in treated fish. Ninety three percent of fish health personnel had experienced 'significant mortality' as a result of non-chemically based de-licing treatment. In comparison, 65% had registered 'significant mortality' during chemical based treatment. Against this background, we have reason to believe that lice treatment will also prove challenging in 2017.

Use of alternative de-licing and production technologies resulting in lower exposure to infectious agents, combined with development of new pharmaceutical products, may improve the situation. Such new measures must, however, consider fish welfare and not excessively stress or damage the fish.

Table of total number of lice treatments 2011-2016. The table shows a marked change from treatment with pharmaceutical products to alternative treatments e.g. mechanical, warm water or fresh water based) from 2015-2016. See chapter 7.1 and table 7.1.1 for more information.

Lusebehandlinger	2011	2012	2013	2014	2015	2016
Medikamentelle behandlinger	1348	2249	2185	3477	3269	1941
Ikke-medikamentelle behandlinger		136	110	176	185	1174
Sum behandlinger	1348	2385	2295	3653	3454	3115

Virus diseases

Pancreas disease (PD) remains the most serious virus disease in sea-farmed salmonids. Two PD epidemics currently exist in Norway; marine SAV2 in Møre og Romsdal and Sør Trøndelag and SAV3 in western Norway. In total, 138 new sea-farms were registered affected in 2016, a level similar to 2015. There was a reduction in the number of cases in western Norway and an increase in north-western and mid-Norway.

Following movement of the 'management border' from Hustadvika, PD has become established in Sør-Trøndelag. Sporadic detection of PD in the northern part of Nord-Trøndelag and southern part of Nordland has resulted in significant challenges in terms of control/eradication.

Infectious salmon anaemia (ISA) was diagnosed in 12 farms in 2016 compared to 15 farms in 2015.

The majority of the affected farms were situated in Nordland and several of these farms appear to have been infected with a closely related strain of virus. Late identification of the disease and delayed harvest of the affected fish population, may have contributed to spread of local epidemics. Fallowing and systematic surveillance of all farms stocked with salmon and rainbow trout within defined zones in northern Norway in 2015 and 2016 are expected to lead to an improvement in the situation in the region. So far, new outbreaks have not been identified in Lofoten and/or Vesterålen, two areas which in later years have had many outbreaks.

Heart and skeletal muscle inflammation (HSMI) is a virus disease of Norwegian farmed salmon. In 2016 HSMI was diagnosed in 108 farms, the majority of which were ongrowing sites.

Cardiomyopathy syndrome (CMS) was diagnosed in 90 farms in 2016. This represents a slight reduction from 2015 to 2014 levels. The number of affected farms registered by the Norwegian Veterinary Institute is most probably an underestimate as the disease is non-notifiable and may be diagnosed by other laboratories.

Infectious pancreatic necrosis (IPN) was diagnosed in 27 salmonid farms in 2016. This is a slight reduction from 2015, but clearly lower than the peak year of 2009 when IPN was diagnosed in 223 farms. Use of QTL strains of salmon combined with increased focus on eradication of 'house strains' of virus are probably the most important reasons behind the reduction in number of cases in recent years.

Other health-related challenges
Amoebic gill disease (AGD) - is caused by the parasitic amoeba *Paramoeba perurans* (previously known as *Neoparamoeba perurans*). In 2016 the amoeba was identified throughout the whole year from Agder to Nordland and development of the disease followed the same pattern as in 2015. While AGD remains an important parasitic infection, the disease was not as severe in 2016 as it was in 2014. Gill disease occurs during all phases of salmonid culture. Chronic gill inflammation is a particularly significant and recurring problem. Bacterial ulcers continue to be a problem in farmed fish particularly in northern Norway.

Yersiniosis continues to affect an increasing number of farms and in recent years there appears to be an increasing trend towards clinical outbreaks in large sea-farmed salmon.

In 2015, almost 26.4 million cleaner fish were utilised in salmon farming, two million more than in 2014. There is an increasing requirement for disease diagnostics in cleaner fish. Disease problems include atypical furunculosis, classical furunculosis and AGD. Recently it has become apparent that the lice-eaters are themselves susceptible to sea-lice (*Caligus elongatus*) attack.

The total volume of antibacterial substances used in Norwegian fish farming in 2016 was equivalent to 212 kg active substance. This is the lowest reported volume since the mid-1970s, prior to the fish farming boom. According to statistics released by the Norwegian Food Safety Authority (Vetreg) the majority of prescriptions relate to treatment of cleaner fish, with only a small proportion prescribed for ongrowing salmonids.

A number of recirculation based aquaculture systems (RAS) have recently been built for production of juvenile salmon. RAS is a well established technology which saves considerable quantities of water and energy, but which may exacerbate certain types of disease. In the 2015 report a case in which ISA-virus spread from a RAS hatchery was described. In a similar case in 2016, spread of ISA from a RAS hatchery cannot be discounted. In other RAS hatcheries non-virulent HPR0 ISA-virus has also been detected. It can be difficult to eradicate pathogenic organisms from RAS farms. Infectious agents may become established in biofilters or in areas which are difficult to physically clean or disinfect. In 2017 the Norwegian Veterinary Institute will perform, on behalf of the Norwegian Food Safety Authority, a risk evaluation on this type of threat.

Recurring outbreaks of yersiniosis have occasionally caused significant levels of mortality in RAS hatcheries. In 2016 virulent ISA-virus spread from a RAS hatchery. In other RAS hatcheries avirulent ISA-virus (HPR0) has been identified in biofilm.

Lice counting on TV. Norwegian Veterinary Institute researcher Arve Nilsen, can with satisfaction inform the interviewer that not a single louse is to be found on this fish which has just been netted from an enclosed cage run by AkvaFuture in Velfjorden, an area just outside Brønnøysund. Photo: Asle Haukaas, Norwegian Veterinary Institute.

1. Statistical basis for 'The Health situation in Norwegian Aquaculture 2016'

By Mona Dverdal Jansen

The statistics presented in the current report are obtained from four different sources; official data, data from the Norwegian Veterinary Institute, data from external laboratories and data based on responses to a questionnaire sent out to Fish Health Services and the Norwegian Food Safety Authority. In each section of the report the information source upon which the statistics and the author's evaluation of the situation are based, is clearly indicated.

Official data
According to current legislation all notifiable diseases must be reported to the Norwegian Food Safety Authority. In addition, the 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'.

The health inspection shall be performed by a veterinarian or fish health biologist. The Norwegian Food Safety Authority shall be notified immediately on 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, it is certain that List 1 diseases do not exist in Norway today. For numbers of farming localities affected by diseases on Lists 2 and 3, see Table 1.

Table 1.1 is based on data from the Norwegian Veterinary Institute which continually supports the Norwegian Food Safety Authority by maintaining an overview over the prevalence of notifiable diseases. These statistics include both diagnoses made by the Norwegian Veterinary Institute and diagnoses made by other 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 in 2016 following fallowing. The actual number of affected sites may therefore be higher, as some farms may contain fish diagnosed the previous year.

Data from the Norwegian Veterinary Institute
The Norwegian Veterinary Institute receives samples for diagnostic investigation from a number of Fish Health Services nationwide. These samples are investigated 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).

For the current report, data from PJS is used to generate tables, graphs, maps and text. The data is sorted such that only results of diagnostic investigations are included. Samples submitted for research, quality assurance testing or surveillance programs are excluded. The number of individual sites affected by each disease/agent is 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 the previous year, so the statistics do not necessarily describe the number of new cases. The exception is for notifiable diseases, as described above.

For non-notifiable diseases, the data from the Norwegian Veterinary Institute alone will not provide a complete picture of the national

situation. Several private laboratories analyse the same types of sample and generate their own statistics.
It is difficult to estimate precise overall statistics, but the Norwegian Veterinary Institute has in the course of 2016, received diagnostic submissions from 556 salmon farms compared to 593 in 2015 and 757 in 2014.

Data from the questionnaire
As in the previous year the Norwegian Veterinary Institute sent out an electronic questionnaire to obtain the views of Fish Health Services along the whole coast as well as officers of the Norwegian Food safety Authority. In the questionnaire

Table 1.1 Registered outbreaks of notifiable diseases on national lists 1, 2 and 3.

Sykdom	Liste nummer	2012	2013	2014	2015	2016
Oppdrettsfisk (laksefisk):						
ILA	2	2	10	10	15	12
VHS	2	0	0	0	0	0
PD	3	137	100	142	137	138
Furunkulose	3	0	0	1	0	0
BKD	3	2	1	0	0	1
Oppdrettsfisk (marine arter)						
Francisellose (torsk)	3	2	1	1	0	0
VNN/VER	3	1	1	0	0	0
Furunkulose (rognkjeks)	3	0	0	0	1	4
Viltlevende laksefisk (vassdrag):						
Gyrodactylus salaris	3	0	1	1	0	0
Furunkulose	3	0	0	0	2	1
Krepsdyr:						
Krepsepest (signalkreps)	3		1	1	2	2

personnel were asked to rank the importance of different diseases in salmon and rainbow trout in hatcheries and ongrowing farms, as well as diseases affecting cleaner fish species. The questionnaire was sent out to a total of 29 Fish Health Services and a response was received from 19. In some cases several workers from the same Fish Health Service responded and a total of 37 questionnaires' were completed. Ten Norwegian Food Safety Authority inspectors completed and submitted the questionnaire. All who contributed to the survey 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 is used in relevant sections throughout the report.

2. Changes in infection risk

By Atle Lillehaug, Edgar Brun 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 each of the most significant infectious diseases. For each individual disease this situation is described in the chapter dedicated to that disease, while the health status for wild salmonids is presented in a dedicated chapter. In this chapter devoted to risk, we will discuss production related factors within the aquaculture industry in 2016, which may have been important for fish health and transmission of infectious diseases in farmed fish in Norway, primarily salmon.

Consumption volumes for different pharmaceutical products e.g. antibiotics and products for control of salmon lice and other parasites, provide a good basis for evaluation of the status of different types of infection. Production statistics, fish biomass, number of active farming sites together with regional production of salmon smolts constitute important information which allows us to form a picture of the risks for transmission of disease and exchange of infection.

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
Production of salmon in Norway has increased annually by 10-20% over several decades. In recent years production has stabilized, although preliminary sales figures for 2016 indicate a moderate fall in production (table 2.1). Biomass reported in the sea phase at the end of 2016, together with preliminary figures for sea-transfer of smolts and juveniles produced, indicate a similar total production level in 2017.

There has been a concurrent slight increase in the number of concessions for farming of salmonids compared to 2016, both in fresh- and sea-water.

Marine production of rainbow trout and other species e.g. halibut, turbot, and char remains comparatively stable in relation to previous years. The exception is cod, which is nearly out of production. For 2016, approximately 2250 tons (preliminary statistics from Kontali analyse), were produced compared to approximately 1713 tons in 2015. We have observed and continue to observe significant annual increases in the numbers of wild caught and farmed cleaner fish stocked. This shows that the industry is focused on use of non-medicinal lice control.

Almost 26.4 million cleaner fish were stocked in salmon cages during 2015, 2 million more than in 2014. 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 are prescribed for treatment of cleaner fish (Table 2.4).

A significant proportion of all fish transferred to sea are lost before harvest. These losses may be attributed to disease, handling, predation, ecape and fish rejected on the harvest line as well as unregistered losses. Infectious diseases are one of the most important biological and economically significant causes of loss. The total loss between sea-transfer and harvest is a direct indicator of fish welfare and an indirect indicator of fish health. Mortality resulting from any management related factor must be considered a serious welfare problem.

Post sea-transfer losses for the industry as a whole are high. After a number of years with losses of over 20%, there was a more positive trend in 2012 and 2013 with losses of 13-14% for salmon. The two following years revealed an increasing trend, and in 2016 total losses between sea-transfer and harvest were close to 20% for salmon and even higher for rainbow trout.

It is thought likely that mortality associated with use of new mechanical and physical (e.g. warm water) anti-lice treatments has contributed to increasing total losses in the last year.

Table 2.1 Production statistics for farmed fish. Source: Directorate of Fisheries

	2012	2013	2014	2015	2016*
Antall lokaliteter					
Laksefisk, tillatelser, settefisk	235	230	222	214	220
Laksefisk, tillatelser, matfisk	963	959	973	974	990
Marin fisk, ant. lokaliteter i sjø	122	110	105	79	69
Biomasse ved årets slutt, tonn					
Laks	709 000	726 000	761 000	722 000	738 000
Regnbueørret	43 000	42 000	43 000	47 000	31 000
Slaktetall, tonn					
Laks	1 232 000	1 168 000	1 258 000	1 303 000	1 179 000
Regnbueørret	75 000	71 000	69 000	73 000	80 700
Marine arter (kveite, røye, torsk, andre)	12 355	5 626	3 140	1 713	2 250**
Settefisk utsatt, ant. millioner					
Laks	252	270	281	287	280
Regnbueørret	17,4	18,0	19,1	15,7	14,4
Rensefisk	13,9	16,2	24,5	26,4	~25**
Svinn i sjø, ant. millioner					
Laks	39	38	47	46	53
Regnbueørret	3,0	2,9	3,7	3,8	3,5
Svinn, i prosent***					
Laks	15	14	17	16	19
Regnbueørret	17	16	19	24	24

*Preliminary statistics, Directorate of Fisheries, February 2017

**Preliminary statistics, Kontali Analyse, February 2017

***Proportion of fish lost from production between sea transfer and harvest, % of the number of fish transferred to sea the same year

Bath treatments with pharmaceutical products against lice and amoeba may also have contributed to these losses. Reduction of overall losses from levels currently experienced must be a clear goal for the industry.

Spread of infection with transport of live fish
Movement of wild cleaner fish to salmon cages (production fish and broodstock) comprises a significant risk for introduction of disease. A complete switch to use of farmed cleaner fish would constitute an important biosecurity measure.

Transport/movement of live fish, including smolts and harvest ready fish is considered to be one of the greatest risk factors for spread of disease. Even if smolts are considered free of infection on departure from juvenile production units, the risk of hidden infection is real. 'Marine' infections may be introduced to juvenile production units via use of seawater.

Long distance transports normally involve transport of smolts from one region to another region and transport of harvest ready fish to central slaughter facilities. Regional smolt production statistics may be compared to the number of smolts transferred to sea within the same region and thereby constitute an indirect indicator of the requirement for transport of smolts over regional borders (table 2.2). Figures for 2016 are as yet unavailable, but in 2015 the total number of sea-transferred smolts in northern Norway was 11 million individuals greater than smolt production in that region, compared to 13 and 14 million greater the two previous years. There appears to be a greater degree of self-sufficiency in smolt production in that region.

Well-boats are an almost indispensable transport form for live fish. New technology reduces the risk related to spread of disease via well-boat use. This includes disinfection of intake and effluent water, and more extensive use of closed wells i.e. the whole or part-journey is performed without intake or release of water. New well-boats are constructed to allow efficient cleaning of holds, pipes and pumps between contracts. Through the recently completed TRESS project (HAVBRUK/245477 - Preventive measures for reduction of spread of infection between farming sites and boat traffic) a new system has been developed for quantitative evaluation of the risk of infection to and from farming sites and ship traffic. This is based on data relating to potential risk factors, such as shipping activity which varies over time and simulated tidal currents. In other words 'analysis of shipping activity in time and space'. Contact between farming site and shipping is analysed via network analysis.

One hypothesis is that farm sites placed within a tight network with a high degree of contact will have a greater degree of risk of being infected and of spreading infection to other sites. The results of network analysis are used to identify farms with a potentially high risk for spread of infection as well as ships which may be key actors in spread of infection. The probability that two sites may be linked through contact and physical placement may also be identified. The results may be used to predict the possible risks on future contact and thereby constitute a basis for introduction of preventative measures.

Development of public regulatory strategies, technological solutions, improved design for cleaning and disinfection etc. will all contribute to a lower risk of well-boat associated infection spread. There also appears to be a change in attitude and practice within the aquaculture industry in that well-boats are to a greater degree specializing in either smolt or large fish transport and operating in geographically restricted areas.

Table 2.2 Regional production and sea-transfer of smolts (million), with a calculated index relating smolt production and smolt sea-transfer in each region. Statistics from the Directorate of Fisheries.

Fylke	2012			2013			2014			2015			2016*
	Smolt prod	Smolt utsatt	Indeks	Smolt prod	Smolt utsatt	Indeks	Smolt prod	Smolt utsatt	Indeks	Smolt prod	Smolt utsatt	Indeks	Smolt utsatt
Finnmark og Troms	24,6	57,3	0,43	23,9	56,1	0,43	26,5	60,4	0,44	29,7	66,0	0,45	62,6
Nordland	65,6	47,8	1,37	72,8	54,9	1,33	78,7	57,8	1,36	83,3	57,6	1,45	62,2
Nord-Trøndelag	1,9	27,6	1,16	38,1	20,9	1,82	36,2	25,9	1,40	39,1	25,6	1,53	14,8
Sør-Trøndelag	24,5	23,4	1,05	27,1	53,9	0,50	32,4	16,1	2,01	33,4	53,2	0,63	18,0
Møre og Romsdal	46,0	37,8	1,22	44,7	14,1	3,20	44,6	47,2	0,94	53,8	15,0	3,59	42,4
Sogn og Fjordane	17,3	22,5	0,77	14,5	22,9	0,63	15,1	23,8	0,63	15,8	24,2	0,65	20,6
Hordaland	57,6	40,5	1,42	54,3	46,6	1,17	57,4	41,0	1,40	54,9	45,9	1,20	39,3
Rogaland	13,6	19,0	0,72	15,6	19,1	0,82	13,2	19,1	0,69	15,1	19,4	0,78	20,6
Sum	281,0	275,9		291,1	288,5		304,3	291,3		325,1	307,0		280,4

*Preliminary statistics, Directorate of Fisheries, February 2017

In mid-Norway (Trøndelag, Møre og Romsdal) the opposite situation is the case with smolt production 32.5 million individuals greater than transferred to sea, compared to a 24 million surplus in 2014. For the remaining three west-Norwegian regions there was an under-supply of 3.7 million in 2015 compared to over-supply the year before.

-The work of the Norwegian Veterinary Institute is decisive for maintenance of a sustainable aquaculture industry, Norway's second largest export industry. Good fish health and welfare cannot be taken for granted. This continual hard work has great value for the nation and the industry, is important in terms of public opinion and for continued profit, says State Secretary Roy Angelvik, Ministry of Trade, Industry and Fisheries, in his speech given on the Norwegian Veterinary Institute 125th Anniversary 12. October 2016. Photo: Eivind Røhne

The health situation in enclosed and semi-enclosed farms

Traditionally, salmonids farmed in Norway have been farmed in through-flow systems in freshwater and in open cages in the sea. In recent years a number of large recirculation based (RAS) juvenile production units have been built. In 2013 there were 23 RAS farms in Norway and since then the number has steadily increased and more are under planning. There is good reason to believe this trend will continue. RAS is a well established technology which saves both water and energy. In the Faroe Isles RAS is now the sole method of juvenile salmon production. There is an increasing international requirement for fish adapted to RAS conditions.

New production data from larger RAS sites demonstrate good survival and growth following transfer to sea. Important preconditions for success include a good understanding of the technology and surveillance of important water parameters including oxygen, carbon dioxide and nitrite. Correct dimensioning of RAS facilities in relation to maximum biomass is crucial. The most important risk factors in recirculation facilities in freshwater are high levels of nitrite, gas supersaturation, over feeding and insufficient particle removal. Biofilters may be particularly sensitive to changes in water chemistry during start up, before a stable microflora is established.

To reduce the time fish are held in open cages, land-based RAS sites have been established for 'large smolt' production. These fish may weigh up to one kg. Recirculation of seawater can lead to problems with high carbon dioxide levels. Recognised production problems related to this type of facility include early sexual maturation.

Infectious agents may be more difficult to eradicate in RAS facilities compared to through-flow systems. Infectious organisms may become established in the filter systems or in other areas difficult to clean and disinfect. Yersiniosis has caused repeated outbreaks with (at times) extremely high mortality in RAS facilities for juvenile salmon production. In the Health situation in Norwegian Aquaculture report for 2015, a case of spread of virulent ISA-virus from a RAS facility was described. In 2016 a similar case cannot be discounted. The degree to which RAS technology itself is responsible for such cases is not known. Not unsurprisingly, avirulent ISA-virus (HPR0) has been demonstrated in other juvenile production sites and in biofilm in RAS sites. In 2017 the Norwegian Veterinary Institute, under contract from the Norwegian Food Safety Authority, will perform a risk analysis of such cases.

We know that HPR0 can be identified in juvenile production facilities, but whether RAS technology increases this risk or stimulates mutation of the avirulent form of the virus to the virulent form is not currently known. In Denmark, furunculosis is related to large losses in salmon farmed in RAS facilities. Fish Health Services nationwide are observant to the health challenges in seawater RAS systems, particularly those related to bacterial infections of the skin.

In addition to land-based RAS technologies, there exist a series of 'concept' technologies for enclosed and semi-enclosed sea farming sites either under development or in trial. The common aim for all such systems is to prevent exposure to infections following sea-transfer, primarily salmon lice. Experience from the field suggests that salmon lice may have greater difficulty in establishing infections in cages protected with a 'skirt'. Unfortunately this type of technology may have other challenges. In 2016 it was reported that in cages with a 'lice skirt', AGD infections progressed faster than in cages without a skirt. This may indicate that this type of infection may be more serious in enclosed/semi-enclosed constructions.

Manipulation of smoltification allows sea-transfer of smolts throughout the whole year. This means that smolts are transferred to sea at temperatures as low as 0 - 2ºC, which may lead to skin damage and subsequent infection (*Tenacibaculum* spp. and other bacteria), increased mortality and poor fish welfare. New technological developments may allow 'effective' operation, but such developments must be adapted to the basal biology of the fish.

For the last two years (ending 20.11.2017) it has been possible to apply to the Directorate of Fisheries for 'developmental farming concessions'. Such concessions relate to farming operations with integral testing of innovative technologies and production forms. The aim is to reduce the environmental and areal impact associated with current aquaculture technologies. In 2016, applications were received for 37 such projects, of which many include new production technologies directed at reducing or eliminating the impact of salmon lice.

Bacterial infections - Antibiotic consumption
Statistics describing prescription of antibiotics are a good indicator of the prevalence of bacterial diseases. Since the development of vaccines against coldwater vibriosis and furunculosis in the late 80's and early 90's the annual consumption of antibiotics in Norwegian aquaculture has been extremely low. From 1996 onwards between 0.5 and 1.5 tons active pharmaceutical substance has been used.

In 2016, a total of 212 kg antibacterial substances were used to treat farmed fish in Norway. This is the smallest quantity reported since the mid-1970's, prior to the rapid expansion of fish farming in Norway (table 2.3). According to data from the Veterinary medicine register (Vetreg), the majority of prescriptions were written for treatment of cleaner fish, with a very small proportion being prescribed for ongrowing salmon (Table 2.4). The biomass of the treated cleaner fish is, however, low compared to that of salmon and the quantities of antibiotic prescribed are, therefore, relatively modest.
The reason for cleaner fish prescriptions are most commonly unspecified 'bacterial infections'. The most common bacterial infections of cleaner fish diagnosed through the Norwegian Veterinary Institute diagnostic service are atypical *Aeromonas salmonicida*, various *Vibrio* spp. including *V. anguillarum* and *V. ordalii*. *Pasteurella* sp. and *Tenacibaculum* spp. are also identified in lumpsucker and the various wrasse species.

What developments can we expect?
The salmon louse is currently the largest challenge to Norwegian salmon farming and development of resistance against pharmaceutical treatments the single largest problem. Non-medicinal methods for treatment of lice are becoming increasingly used and we register a steadily decreasing quantity of pharmaceutical products sold for treatment of lice (table 2.3). Despite this, overall sales remain high and must be reduced significantly if resistance is not to be further stimulated. Use of alternative de-licing methodologies and new farming technologies incorporating protection against exposure to infection as well as development of new pharmaceutical products are measures which may together improve the situation.

Some alternative de-licing technologies require relatively extensive fish handling resulting in stress and physical damage which can in turn lead to direct or indirect mortality.

Table 2.3 Pharmaceutical products used in treatment of farmed fish (kg active substance). Source: Norwegian Institute of Public Health.

Antibakterielle midler	2011	2012	2013	2014	2015	2016
Florfenikol	331	191	300	403	194	138
Oksolinsyre	212	1399	672	108	82	74
Oksytetracyklin	1	1			(25)	
Sum antibiotika	544	1591	972	511	276	212
Midler mot lakselus						
Azametifos	2437	4059	3037	4630	3904	1269
Cypermetrin	48	232	211	162	85	48
Deltametrin	54	121	136	158	115	43
Diflubenzuron	704	1611	3264	5016	5896	4824
Emamektin	105	36	51	172	259	232
Teflubenzuron	26	751	1704	2674	2509	4209
Hydrogen peroksid (tonn)*	3144	2538	8262	31577	43246	26597
Midler mot innvollsorm						
Praziquantel	137	423	460	625	942	518

*Total consumption of hydrogen peroxide not related to treatment of salmon lice alone, also used for treatment of amoebic gill disease. Lakselus= salmon lice; innvollsorm = tapeworm

All new technologies related to farming of salmon in the sea must take into account the need for better control of intake and release of salmon lice larvae.

Following definition of Nordmøre and Sør-Trøndelag as endemic for PD, five diagnoses of PD were made further north in 2014. In 2015 only one case of PD was identified in Nord-Trøndelag, while in 2016, two cases were identified in Nord-Trøndelag and two in Nordland. Limitation of spread has been attempted either through stamping out or by movement of affected stocks into the SAV2 zone. These measures appear to have been effective.

The number of ISA cases has been relatively stable in recent years with between 10 and 20 cases identified annually since the turn of the century. In 2016, ISA was identified in twelve farms which appear to constitute four separate outbreaks. The outbreaks in Lofoten and Vesterålen are now stamped out and new outbreaks will be intensively combatted. It is expected that combat measures will be optimized through intensive surveillance and rapid stamping out within the control zone established around new outbreaks.

It may therefore be possible to maintain the four most northerly regions as PD-free, as well as limit the number of ISA outbreaks to a relatively modest level.

The majority of today’s egg production is based on marine farmed brood stock. This presents a challenge in relation to hygiene status regarding important infectious agents found in the marine environment. These agents are considered to be under good control during the freshwater phase of the broodstock cycle and during stripping, fertilization and incubation of eggs. Disinfection of eggs is a central biosecurity measure.

Table 2.4 Annual number of antibiotic prescriptions prescribed for various categories of farmed fish. Source: Veterinary Medicines Register (Vetreg)

Kategori oppdrettsfisk	2011	2012	2013	2014	2015	2016
Laks, matfisk og stamfisk	3	21	15	11	8	11
Laks, yngel og settefisk	32	57	35	39	24	21
Regnbueørret og ørret	3	2	1	5	0	1
Marin fisk (torsk, kveite mm)	14	18	18	18	29	30
"Andre arter" (rensefisk)	16	21	38	59	108	126
Sum	68	119	107	132	169	189

However, the danger of infection and establishment of possible latent, carrier infections in the sea contributes to an increased risk of infection for eggs and fry. Establishment of a totally land-based broodstock production cycle is, therefore, desirable.

The industry today is experiencing very high salmon prices. This makes salmon farming in Norway very profitable, despite significant health related production costs. The industry possesses good knowledge relating to biosecurity and preventative measures. It is therefore important that the incentives to maintain good biosecurity remain in place. Further investment should be directed towards development of profitable, sustainable production methods capable of sustaining good fish health, even under less favourable market conditions.

The international situation- threat situation- regulative framework

Of the notifiable diseases not found in Norwegian fish farming, viral haemorrhagic septicaemia (VHS) and infectious hematopoietic necrosis (IHN) pose the most significant risk.

VHS is widespread in continental Europe and is also found in Finland. Denmark successfully eradicated the disease from its rainbow trout farming industry and is now considered free of VHS. Given Norway’s free status and the generally limited import of live fish stocks, the risk of import of VHS is considered small.

VHS is, however, found in wild marine fish along the Norwegian coastline. This constitutes the most significant VHS infection risk for farmed salmonids.

IHN is also widespread in continental Europe. The risk of introduction of disease through import of live fish is considered similar to that for VHS. IHN-virus is stable under frozen and chilled conditions. Global transport and trade in fish products capable of carrying the virus increases the chances of import of the virus with these products.

The VHS and IHN status in northern Russia, including areas bordering Finnmark, is unclear and may represent an infection risk to Norwegian waters. Changes in lists of internationally notifiable diseases present in Norway may influence national strategies for control and eradication.

Pancreas disease was listed as notifiable by the OIE in 2014. A surveillance program was therefore established in Norway to document PD-free status in the four most northerly regions of the country. Important export markets may require documentation of freedom of infection for specific diseases in Norwegian farmed fish, particularly diseases listed as notifiable by the OIE. In todays situation this relates mainly to ISA and PD. Countries importing farmed fish or their products from Norway, may, dependent on the infectious status of their own country and their own risk analysis, require documentation of freedom of infection in the area of origin. This applies to all trade in living materials e.g. eggs juvenile and adult fish and consumable products.

Salmon from PD-free areas may be allowed access to particular market segments, should this be desirable. Further, rapid and effective control measures against ISA are necessary to maintain international trust in the health status of Norwegian farmed fish.

Knowledge gaps and research needs
There is a need for knowledge development in the fields of management of notifiable and other infectious diseases, further development of production systems and infrastructure in the aquaculture industry. There is also a need to make the industry generally more robust against introduction and spread of infection.

The following themes are of particular relevance:

- Evaluate the effects and consequences of technological developments in relation to control of infection, fish health and fish welfare.
- Increase knowledge of effective biosecurity measures and introduce incentives which will contribute to increased implementation of such measures.
- 'Health steered' production
- Documentation of the financial consequences of different control strategies against PD and ISA for the farming industry as a whole.
- Development of good strategies and methods for salmon-lice control.
- Identify causes of fish loss following sea-transfer with the ultimate goal of reducing post sea-transfer losses.

The ability to perform research on diseases and welfare under novel farming conditions on a commercial scale has unique value. The photograph shows Akvafuture enclosed sea cages near Brønnøysund containing approximately 1 million salmon. The Norwegian Veterinary Institute is a research and development partner. Photo: Asle Hauukaas, Norwegian Veterinary Institute.

3. Fish welfare

By Kristine Gismervik, Arve Nilsen, Kristoffer Vale Nielsen and Cecilie M. Mejdell

Most researchers consider fish to be able to register sensory stimulation and can therefore experience feelings such as fear, pain and discomfort. Farmed fish are subject to the animal welfare act and have the same right as other domestic animals to an environment which ensures good welfare throughout the whole life cycle.

Animal welfare represents the quality of life for an animal and may be defined in several ways. Three ways in which animal welfare can be considered are 1) The animal's biological function (with good health and normal development), 2) the animal's experience of the situation (weighted towards fear and pain) or 3) a most natural life. When evaluating fish welfare it is sensible to consider all these approaches as the conclusions made are likely to be more broadly accepted.

Fish health personnel and research institutions have a special responsibility to work towards better fish welfare and to influence general attitudes towards fish within the industry and the population in general. Good health is a precondition for good welfare. Disease has a negative effect on welfare, but the degree will vary between diseases dependent on the organs and functions affected.
Both intensity and duration of pain and discomfort must be considered when evaluating animal welfare. A disease with a chronic course may therefore affect welfare to a greater degree than an acute disease with similar or higher mortality.

Welfare indicators

It is normal to base evaluation of fish welfare 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 will present different challenges and require use of different welfare indicators.
Practical and economical factors limit the number of welfare parameters that can be examined.

There is therefore a need to identify the indicators which are most suitable to measure/observe whether welfare needs are met and whether environmental conditions and health status are within acceptable welfare limits. Welfare indicators should also be reproducible and simple to perform and interpret.

It is important to be able to identify acceptable limits for each environmental parameter e.g. water temperature, oxygen saturation and fish density. Biology is complex and it is not always easy to identify the demarcation point between poor and acceptable welfare based on an analysis of several welfare indicators. In many cases welfare registrations are used to document the absence of poor welfare. Identification of indicators which document that the fish themselves experience their own welfare as good, and not merely document the absence of poor welfare, may be challenging.
This requires more knowledge of the fish preferences and behaviour in relation to tolerance limits which may also be difficult to identify.

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 split into environmentally based (available resources such as water quality and husbandry) and 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, deformities and disease. Animal based indicators may be subjective and scoring systems have been developed in several cases which helps reproducible grading and registration. See the 'welfare poster' on the next page which shows a scoring system developed by the Norwegian Veterinary Institute for registration of acute external injuries in fish (fin injuries and gill bleeding are included but not shown here).

The welfare poster (in Norwegian) developed by the Norwegian Veterinary Institute

Velferdsregistreringer, ytre akutte skader

Skjelltap 0= ingen tap av skjell	**Hudblødning**[1] 0= ingen blødning på kropp	**Sår**[2] 0= ingen sår	**Snuteskader**[3] 0=ingen skade	**Øyeskader/blødning**[4] 0= ingen skade/blødning	**Gjelleblekhet** 0= rød og fin gjelle
Score 1 Tap av enkeltskjell 	**Score 1** Små blødninger/ farge en-dring, ofte buk 	**Score 1** Ett lite sår, ikke ned til muskel 	**Score 1** Liten skade på snuten over/ under 	**Score 1** En liten blødning eller svak blakking av hornhinna 	**Score 1** Lysere felter i enden av lamellene 
Score 2 Skjelltap i små felter[5] 	**Score 2** Et større område med blødninger, ofte og skjelltap 	**Score 2** Flere små sår 	**Score 2** Skade og rifter i hud på snute 	**Score 2** Større blødninger i øyet/ tydeligere blakking av horn-hinna 	**Score 2** Fargeforandringer på inntil 50% av gjelleoverflaten
Score 3 Skjelltap i større områder 	**Score 3** Ferske blødninger ofte med be-tydelig skjelltap, sår og ødemer i hud 	**Score 3** Store, betydelige sår 	**Score 3** Betydelige, dype/store skader, så alvorlige at fisken avlives. Kan omfatte hele hodet 	**Score 3** Store blødninger og/ kraftig blakking av hornhinnen. Kan ha "punktert" øye og avlives 	**Score 3** Fargeforandring på >50% av gjelleoverflaten, tydelig blekhet 

[1] Hudblødning på kroppen unntatt på finnebasis og finner.
[2] Definisjon av sår: område med overflatiske eller dypere skader i overhuden og i noen tilfeller blottlegging av underhud og muskulatur. «Lite sår» = inntil kronestykkestort, gitt fisk på 2-3 kg. Sår som perforerer inn til bukhula vil uavhengig av størrelse betegnes som betydelige og dermed gis score 3.
[3] Definisjon av snuteskade: Sår på snutepartiet som omfatter fremre del av over- og underkjeve.
[4] Definisjon: Øyeskader omfatter blødning i øyet og blakking av hornhinnen. Verste utfall er punktert øye.
[5] «Små felter» = inntil kronestykkestort (2cm diameter), gitt fisk på 2-3 kg.

Veterinærinstituttet
Norwegian Veterinary Institute

Foto: K. Gismervik, I.K. Nerbøvik (gjelleblekhet score 1, sår score 3, skjelltap score 2 og 3), R. Andersen (øyeskade score 3), I. Simeon (øyeskade score 1), B. Tørud (sår score 1 og øyeskade score 2)

Operational welfare indicators may be used for practical on-farm monitoring and quantification of fish welfare. The FISHWELL project is currently conducting a review of such indicators and in the course of 2017 a handbook should be available on the suitability of various indicators for different production systems and handling situations.

Development of good methodology and technology for monitoring fish behaviour and welfare will contribute to earlier 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 population as a whole 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 losses of recently sea-transferred smolts are too high. The great variation between farms shows that it is possible to reduce many such losses.

In larger fish, high mortality is commonly related to repeated handling and anti-lice treatment. During all stages of the farmed fish's life, a balance must be reached between production, financial, technological, and biology/welfare aspects. Development of good, scientifically based welfare protocols covering the whole production cycle is therefore important.

This should also stimulate to generally increased efforts to identify the most important welfare challenges in today's fish farming and to identify the best solutions.

Welfare challenges and new technology
Technology aimed at optimization of production and handling of fish is under rapid and constant development. All new technology must, by law, be documented as providing acceptable animal welfare before it can be 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 not been strictly policed. Changes to relevant legislation are currently in progress and include clearer demands for welfare documentation. This will be an important step towards harmonisation of welfare documentation of new technologies.

It is important that personnel with both technical and welfare based competence work together during development and testing of new equipment, such that rapid modifications may be made before new technologies are launched on the market. Through standardization of welfare indicators used for such documentation the results achieved will be better and more comparable.

Handling should be reduced as far as possible as it poses a risk of injury and stress. Introduction of new technology increases this risk as the various compartments such as pumps, water baths etc. are often not finely adjusted for their purpose. It is therefore important that the '3 R's' (replace, reduce and refine) are followed during developmental work in order to reduce the impact on fish welfare as much as possible (see fig. 3.1).

To ensure good fish welfare there will be a requirement that developers of new technology must apply for a licence or dispensation from current legislation.

Due to widespread resistance to chemical de-licing treatments, many new technologies have been directed at novel ways to remove lice from salmon. New technologies preventing lice infestation have also been introduced e.g. enclosed cages. Such technologies can also help 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 the 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.

Welfare challenges related to salmon lice and mechanical de-licing in particular
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.

Compulsory treatment of farmed salmon populations with > 0.5 sexually mature female lice per salmon has, in combination with significantly reduced sensitivity to chemical lice treatments, led to extensive testing of mechanical methods and increased numbers of treatments.
The treatment threshold value is set so low primarily to hold the infection pressure towards wild salmon as low as possible, not to prevent injury to the farmed fish. Low numbers of lice represent a minor welfare challenge to farmed fish. Treatment is, in contrast, a significantly negative welfare experience for the fish, particularly if weakened by other infections. The Norwegian Food Safety Authority received 400 reports of lice treatment associated mortality in excess of 0.2% during 2016. The number of reports increased during the second half of the year following the industry being

informed of their reporting responsibility by the Norwegian Food Safety Authority.

We have, however, a limited overview of the extent of the problem and all relevant risk factors. Both mechanical and chemical treatments include a series of situations in which stress, risk of mechanical injury to gills, fins, eyes, skin etc. can occur. Injurious changes in water quality and fall in oxygen saturation are also common.

Water temperature may be decisive in relation to ulcer development. Underlying or active disease e.g. AGD and HSMI are reported to cause high mortality. In 2016 there was an overall reduction in number of chemical bath treatments, but attempted treatments continue to use increased doses and exposure times. Such treatment may result in toxic effects and serious welfare consequences.
The public authorities have stated that cocktails of various active ingredients must be better documented before use.
There is little data on how the number of anti-lice treatments and inter-treatment interval affect the fish. On top of other management procedures e.g. net changing, movement of fish between cages or sites

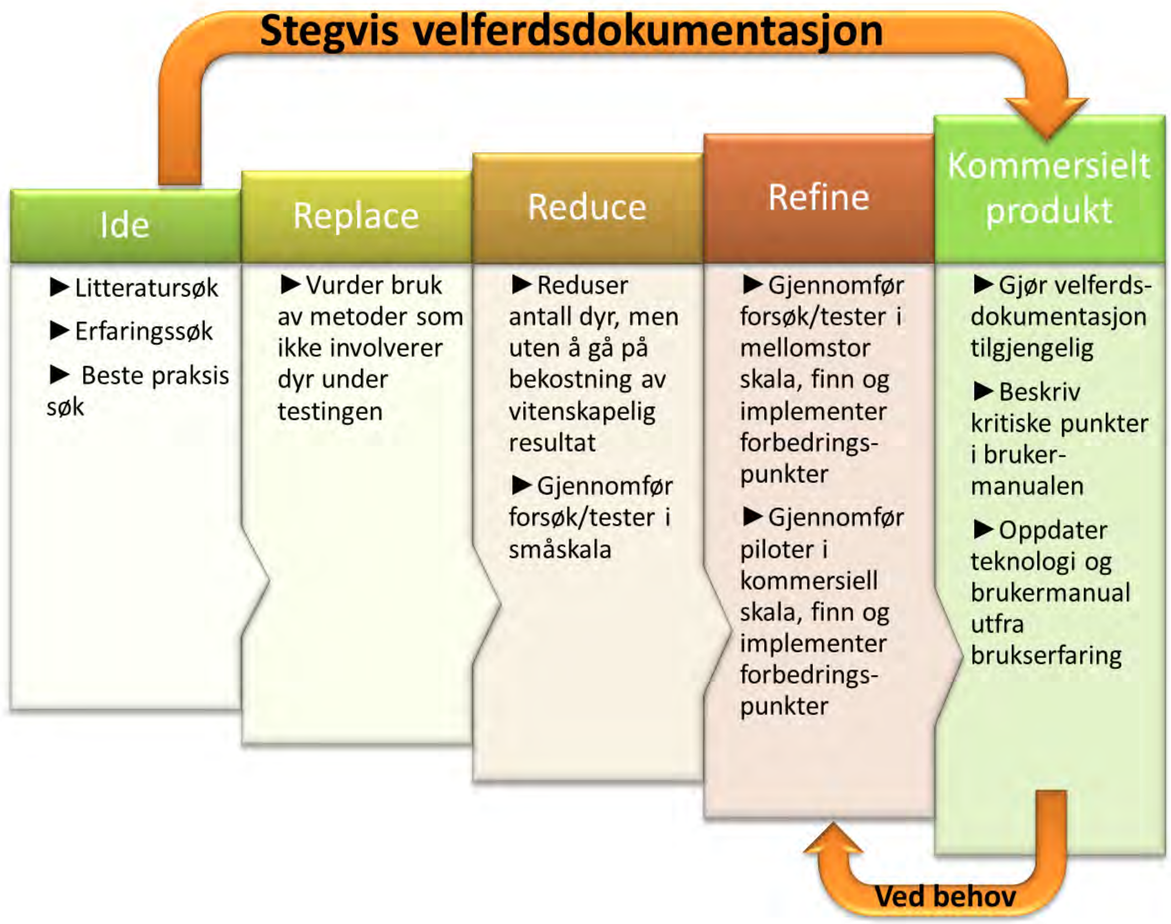


Figure 3.1 Step by step welfare documentation from idea to commercial product, implementing the ‘3R’s’ (Replace, Reduce, Refine) while developing new technology. Before any new technology can be marketed it is important that it has been tested and found to provide acceptable fish welfare. Illustration by Kristine Gismervik, Norwegian Veterinary Institute.

there is reason to believe the tolerance limits of the fish are overstepped in many farms.
This is particularly applicable to the greatly increased use of mechanical de-licing in 2016. These methods use heated water, water jets or a combination of water jets and brushes to remove the lice. One factor common for all treatments is

the need to 'crowd' the fish prior to pumping them through the system. These systems are comparatively new, are under continued development and limited scientific documentation exists in relation to fish welfare.

To gather information on this theme a questionnaire directed at experiences related to mechanical de-licing was sent out to Fish Health Services, fish farming companies and the Norwegian Food safety Authority.

The questionnaire was sent out to thirty Fish Health Services (including fish health personnel employed by farming companies) and the Norwegian Food Safety Authority. In total 47 responses including 8 from Norwegian Food Safety Authority employees, relating to 952 sea farms in 2016 were received. As only 794 sea farms were registered active by the Norwegian Directory of Fisheries in 2016 it is clear that some farms were reported from more than one source.
Figure 3.2. displays therefore, the number of farms reported by each source category.
The total number of responses from each source category varies in different areas of the country.

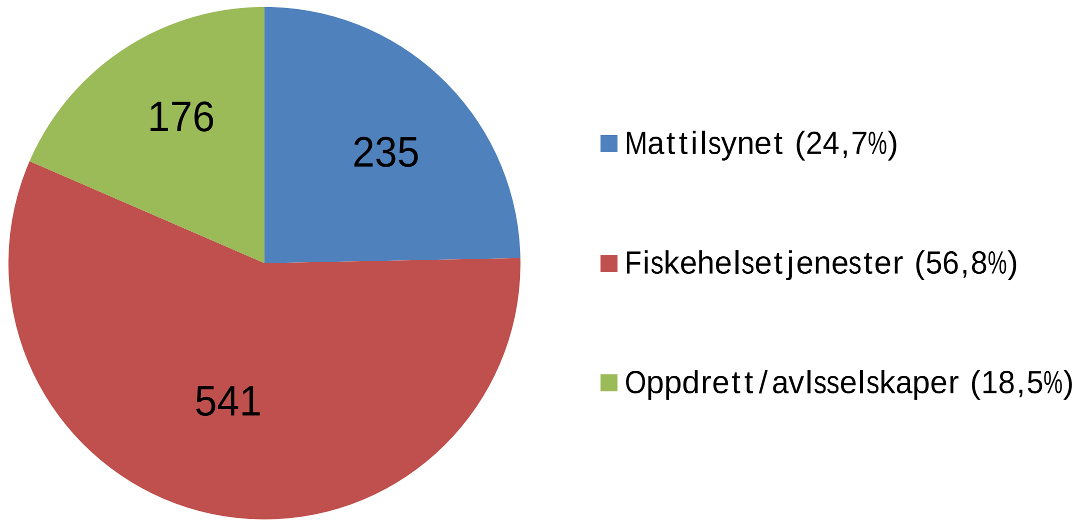


Figure 3.2. Shows the distribution of the number of farms (total = 952) reported by The Norwegian Food Safety Authority, Fish Health Services and Farming companies.

Northern Norway N=20 (282 farms), Mid-Norway N=10 (202 farms), North West 'Southern Norway' N=5 (117 farms) and South West 'Southern Norway' N=12 (351 farms).

The sources were asked to report the average number of lice treatments (chemical and non-chemical) per fish group following and including the 2016 spring de-licing until the end of November 2016. Figure 3.3 summarises the results for fish transferred to sea in 2015 and figure 3.4. summarises results for fish transferred to sea in 2016.

It appears that most treatments per fish group transferred to sea in 2015 were performed in mid-Norway. For the whole country 44.7% of correspondents stated that the total number of de-licing treatments increased from 2015, while 38% reported no increase in number of treatments and 17% did not know.
There appear to be regional differences in answers from correspondents. Expressed as a percentage, mid-Norway had twice as many correspondents who answered that the number of de-licing treatments had increased compared

to those who answered that they had not increased, although this was based on a low number of completed questionnaires'.

An overview of the various de-licing methods for which 41 correspondents had experience in 2016 is presented in fig. 3.5. Nearly all had experience with oral treatment, while many fewer had experience with the newer technologies for mechanical de-licing.
When asked to estimate the period between mechanical de-licing (Thermolicer/Optilicer/FLS-avluser/Hydrolicer/Skamik) and return to pre-treatment lice levels, most (31.7%) answered 3 weeks. A large proportion (24.4%) answered 'don't know'. A further 9.8% answered 2 weeks, 14.6% answered 4 weeks, 9.8% answered 5 weeks and 9.8% answered ≥ 6 weeks (most in this group were from northern Norway).

The effectiveness of mechanical de-licers can be dependent on many factors, including the underlying principals for each type of machine, how the machine is adjusted on any individual day, or the model or modification state of any particular machine. Other parameters may also affect efficiency such as 'crowding' and the biomass of fish treated per unit time.

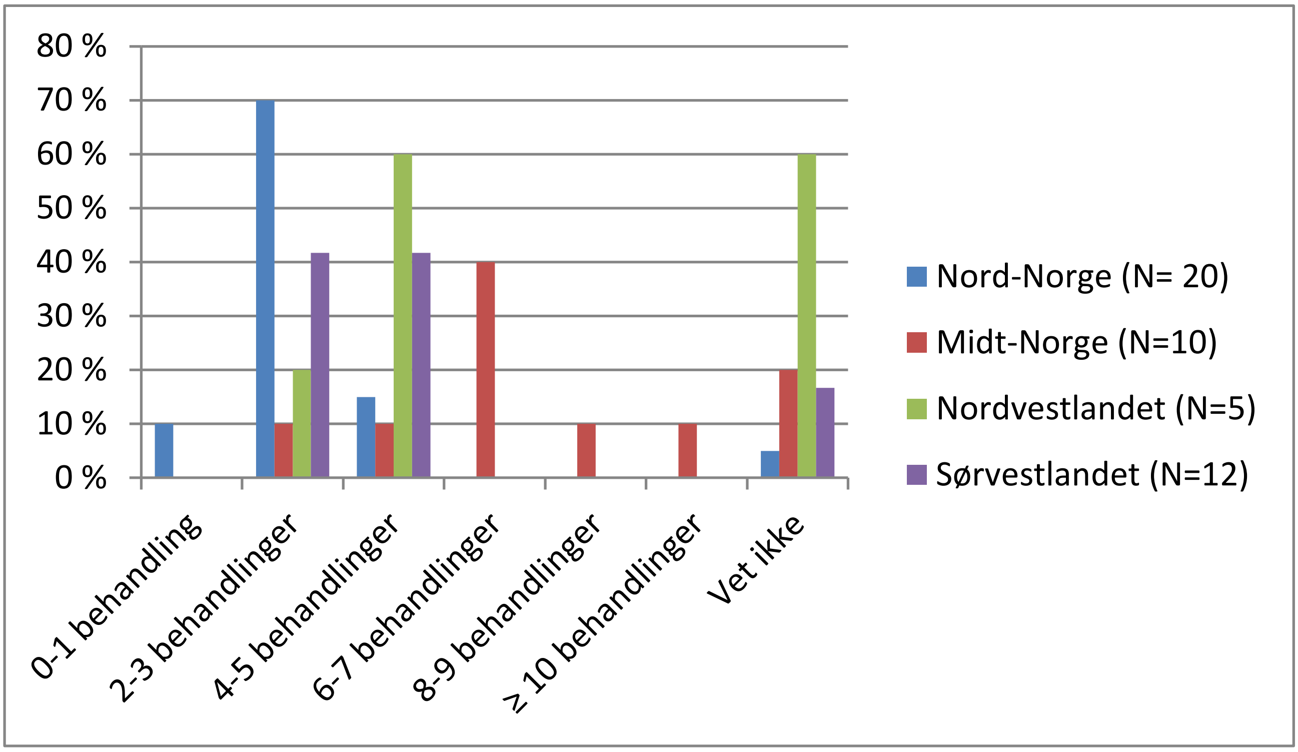


Figure 3.3. Estimated number of de-licing treatments (chemical and non-chemical) per fish group from and including spring de-licing 2016 until the end of November 2016 for fish transferred to sea in 2015. The Y-axis represents % response (N=47) based on geography, and is non-adjusted for the number of farms reported.

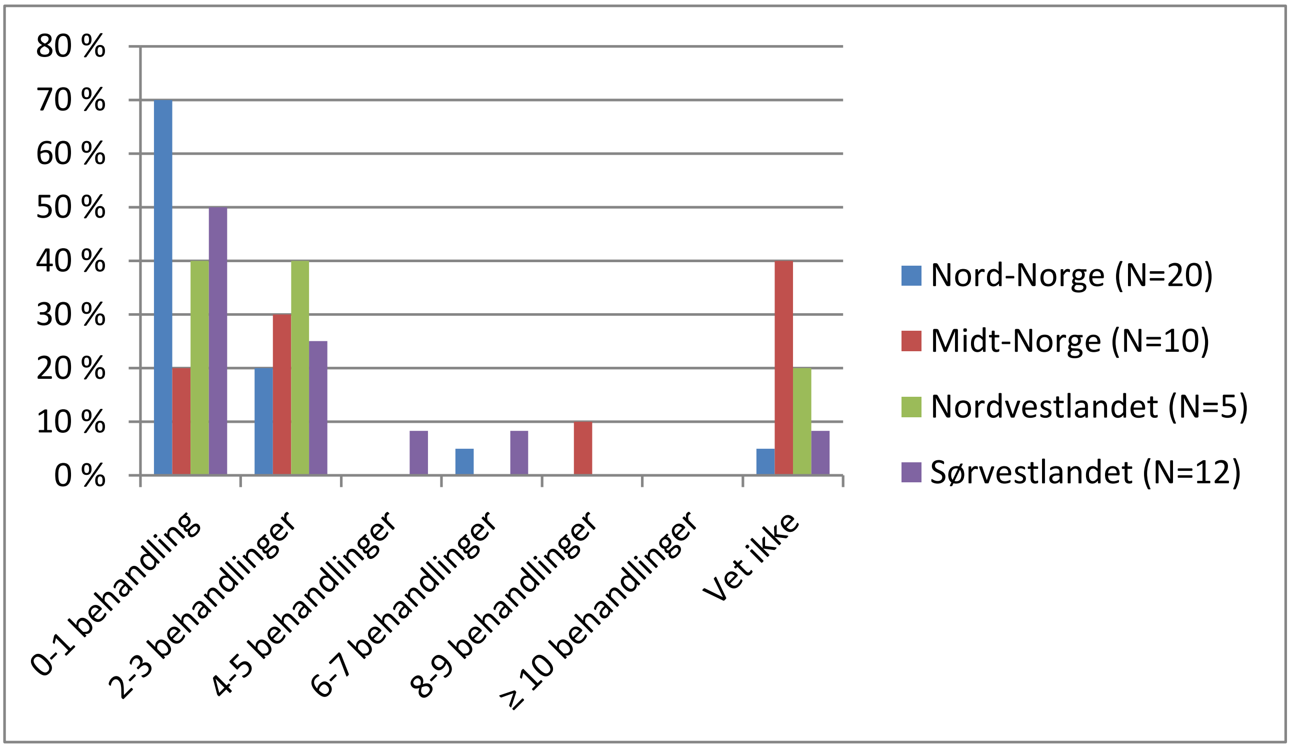


Figure 3.4. Estimated number of de-licing treatments (chemical and non-chemical) per fish group from and including spring de-licing until the end of November 2016 for fish transferred to sea in 2016. The Y-axis represents % response (N=47) based on geography, and is non-adjusted for the number of farms reported.

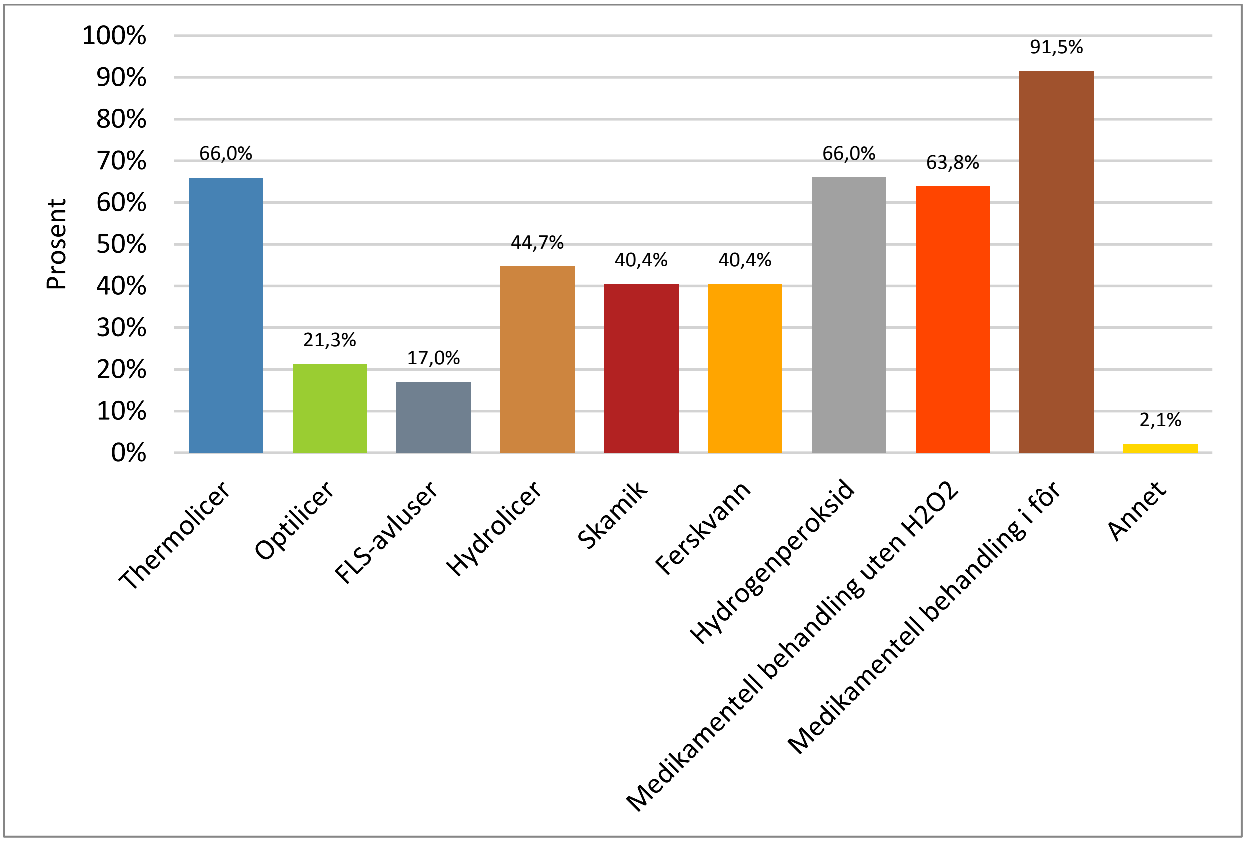


Figure 3.5 provides an overview of the various de-licing methods used in 2016 and reported by Fish Health Personnel surveyed. The Y-axis describes response in percent (N=47).

When questioned on what they considered the average reduction in motile and sexually mature lice following mechanical de-licing, most (48.8%) answered between 80-90% (see figure 3.6). The effect of mechanical de-licing on attached lice stages is uncertain. (figure 3.7).

Correspondents were also questioned regarding the frequency of injury or mortality experienced in relation to the various de-licing methods on a scale from 1= observed on nearly all fish, to 4= never or seldom observed. It was possible to answer 'don't know'. It is also important to note that these are experiences from 2016. Such technology is under continual improvement, and the situation can change considerably as the technology 'matures'. Water jets combined with brushing scored worst according to many parameters considered (scale loss, skin bleeding, wounds, fin damage and increased delayed mortality), while warm water scored badly due to acute mortality.

There was variation among the various de-licing methodologies, but generally most correspondents had crossed off 'don't know' in relation to 'visible gill bleeding', 'gill injury' and 'delayed mortality'.

For chemical based treatments no differentiation between well-boat treatments or those performed in cages was made.

Other injury/side effects which were related to mechanical de-licing included reduced appetite lasting several days, eye injury, damaged opercula, mortality related to weak fish/ gill problems, reduced mucus production and poor skin health/ulcer development. In relation to chemical treatments, overdosing/toxic effects following hydrogen peroxide treatment and pyrethroids were reported. Eye damage was reported following hydrogen peroxide treatment and two cases of increased mortality involved ulcer development and gill damage following well boat treatment (summer season).

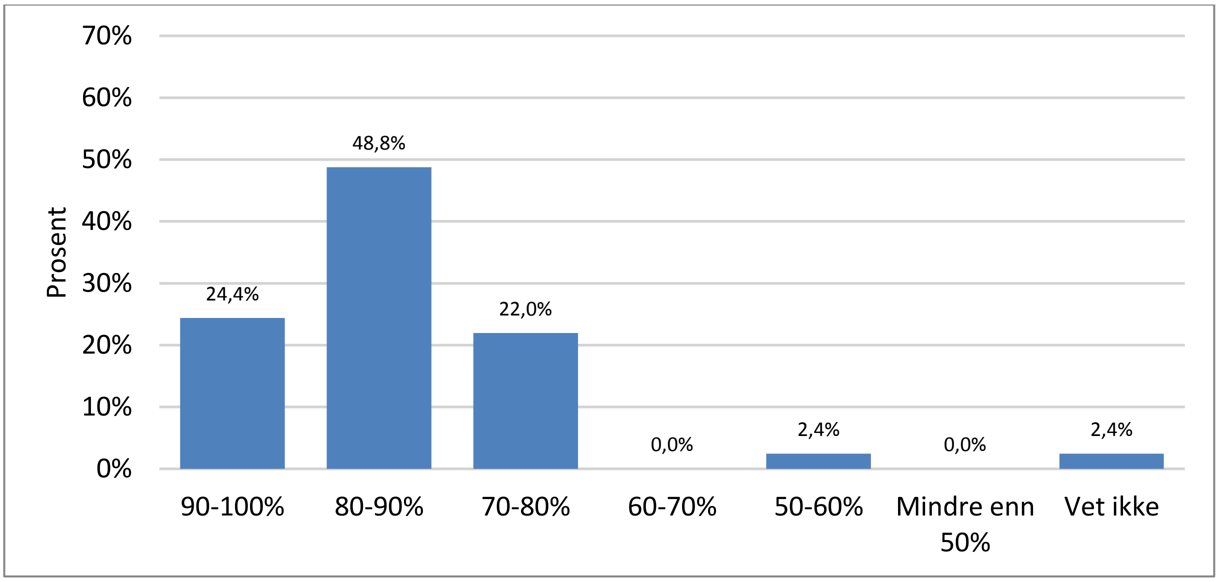


Figure 3.6. Overview of the estimated average reduction in motile and sexually mature salmon lice following mechanical de-licing. The Y-axis provides the registered response in percent (N=41), and the x-axis describes the response alternatives.

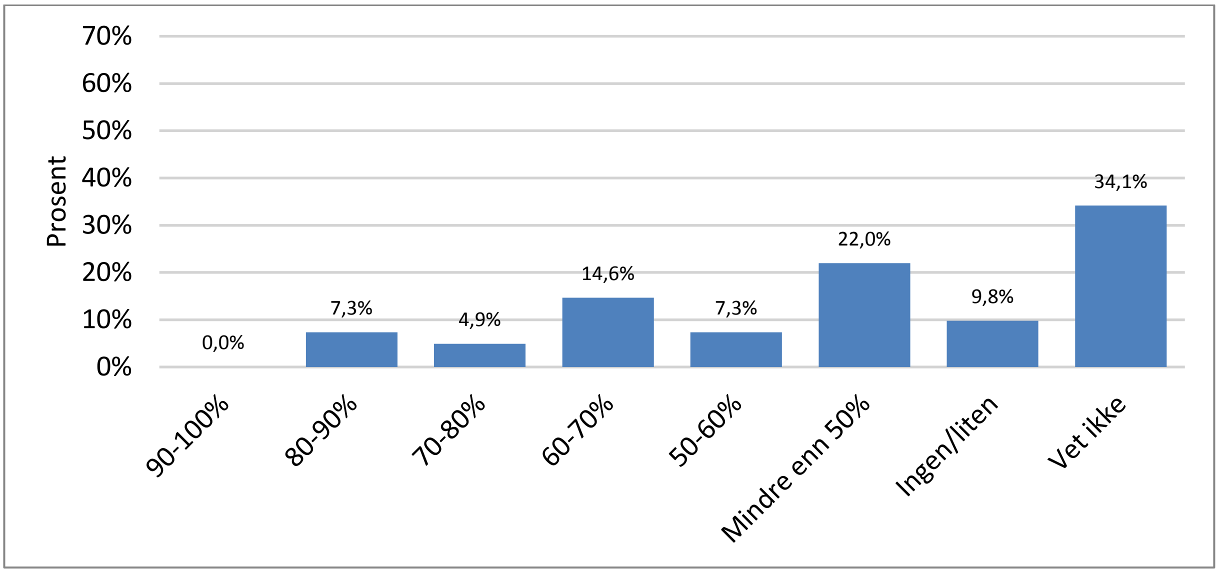


Figure 3.7. Overview of the estimated average reduction in attached life stages of salmon lice following mechanical de-licing. The Y-axis provides the registered response in percent (N=41), and the x-axis describes the response alternatives.

Fresh water was considered to be a mild form of treatment, but external injuries related to crowding were considered common. Season and sea temperature may also be important factors in relation to ulcer development.

Generally correspondents considered it difficult to differentiate between injury caused by crowding e.g. scale loss and reddening of abdominal skin, and injury caused by the de-licer. Crowding is considered one of the greatest risk factors (Figure 3.8) and this is also dependent on weather conditions, operator, de-licer capacity, crowding time, oxygen levels and more. Extended and frequent crowding remain the norm in relation to mechanical de-licing and unless milder crowding techniques are developed this problem will continue to follow mechanical de-licing.

Fish health prior to de-licing is also considered to be extremely important. Comments were received relating to the challenges involved on de-licing acutely sick fish. In these cases fish welfare considerations indicate that treatment should be delayed.

Emergency harvesting of acutely sick fish involving pumping onto well-boats, transport, storage in cages and handling at the slaughter house is rarely a practical alternative to treatment. Comments were received indicating that a combination of the risk factors listed in Figure 3.8 often combine and result in reduced fish welfare. Other risk factors mentioned, include oxygen levels in the sea, starvation in advance of treatment, quality and scale of equipment testing and biological quality assurance during construction and pumps unsuitable for fish larger than ca. 4.8kg.

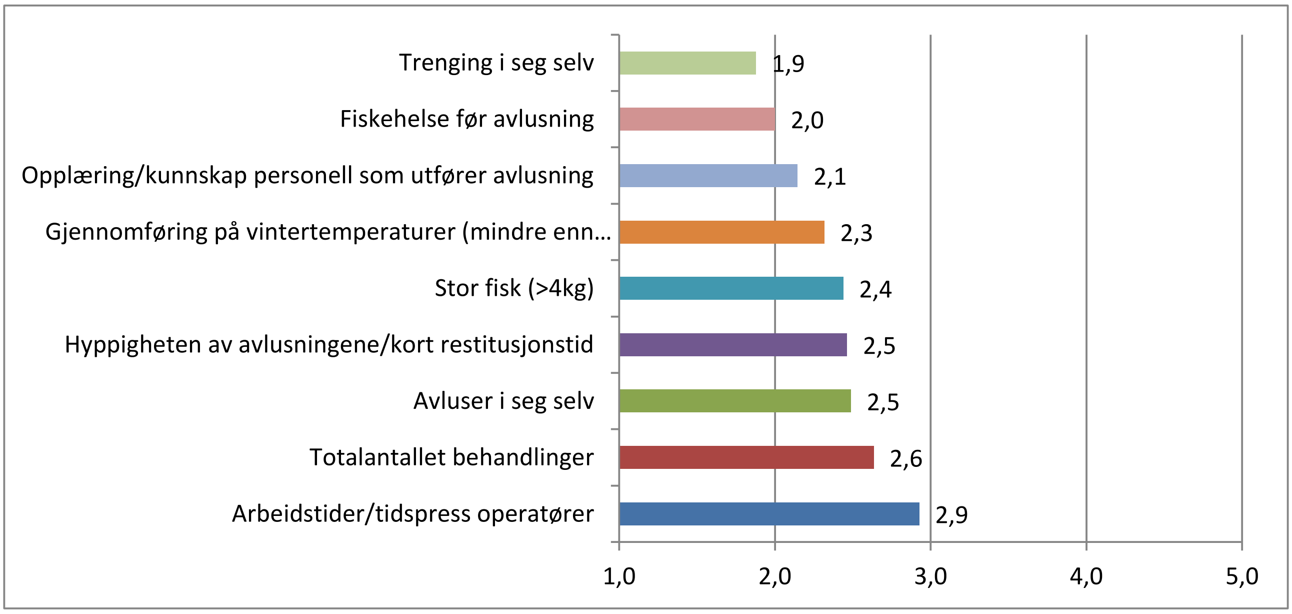
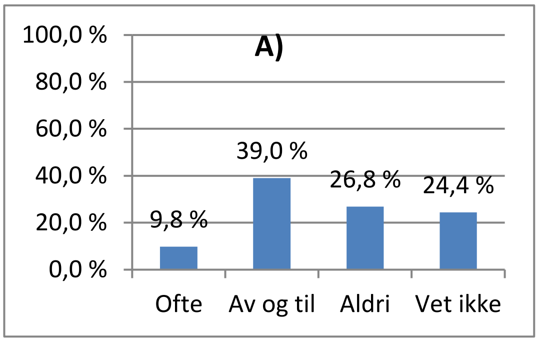


Figure 3.8. Average estimated importance of risk factors, from most important (1) to least important (5) related to mechanical de-licing. Contributors were asked to use the whole scale, but several parameters could be awarded the same score.

When asked whether individual fish were scored before, during or after mechanical de-licing, 61% of correspondents stated that Fish Health personnel scored the fish and 51% stated that the machine operator scored the fish. Twenty four % of correspondents stated that such registrations were not commonly performed and 7% answered 'don't know' to this question (N=41). Generally, the degree to which such scoring is performed the type of person performing the scoring varies to a great degree. Lice counting often provides an opportunity for other types of investigation. Correspondents were asked the degree to which mechanical de-licing is performed on fish scoring grade 3 external injuries (=serious, see welfare poster) prior to treatment. The results are summarized in figure 3.9A.

Correspondents were also asked how often external injuries scoring 2 and 3 (see welfare poster) were observed following mechanical de-licing. In 2016, 76.6% of correspondents experienced that mechanical de-licing had to be stopped due to serious fish welfare concerns. Of those who answered yes, this had most commonly occurred between 1-5 times. Most (73.2%) had not experienced cases in which the farmer had performed de-licing despite advice to the contrary from Fish Health personnel, while 26.8% had experienced such cases, most commonly between 1 - 5 times. In 2016, 66% of correspondents experienced early harvest due to poor fish welfare and increasing numbers of lice, as the fish were considered unlikely to tolerate mechanical de-licing.

Of those who answered yes, the majority had experience this between 1-5 times (77.4%), while those who had experience with the largest number of sites had experienced this situation more than ten times.



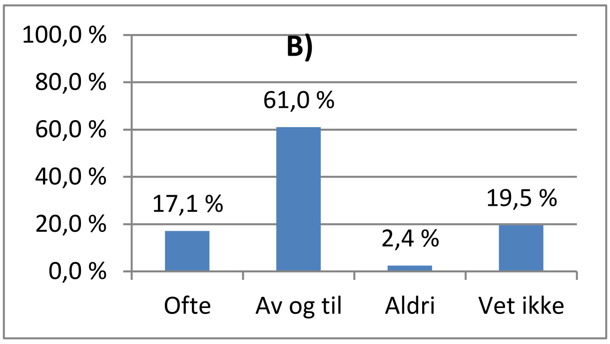


Figure 3.9. A) The degree to which mechanical de-licing is performed despite fish displaying grade 3 (=serious) external injuries prior to treatment, and B) the degree to which external injuries of grade 2 and 3 are registered after mechanical de-licing. The Y-axis describes reply percent (N= 41), and the X-axis describes the reply alternatives. For details of injury scoring see the 'welfare poster'.

Correspondents were asked to state their general impressions of the fish welfare consequences of mechanical de-licing compared to traditional chemical-based treatment. The majority (65.9%) considered that mechanical de-licing resulted in much greater or slightly greater negative consequences. (figure 3.10).

General knowledge and experiences shared via the questionnaire indicate that frequent mechanical de-licing is extremely challenging in respect to fish welfare. Of the individual systems, water jets combined with brushes appear to generate the greatest problems (particularly skin lesion development). Warm water based de-licing was also identified as problematic in relation to acute mortality. While many fish farmers already work systematically with fish welfare, others should be encouraged to focus more on this area.

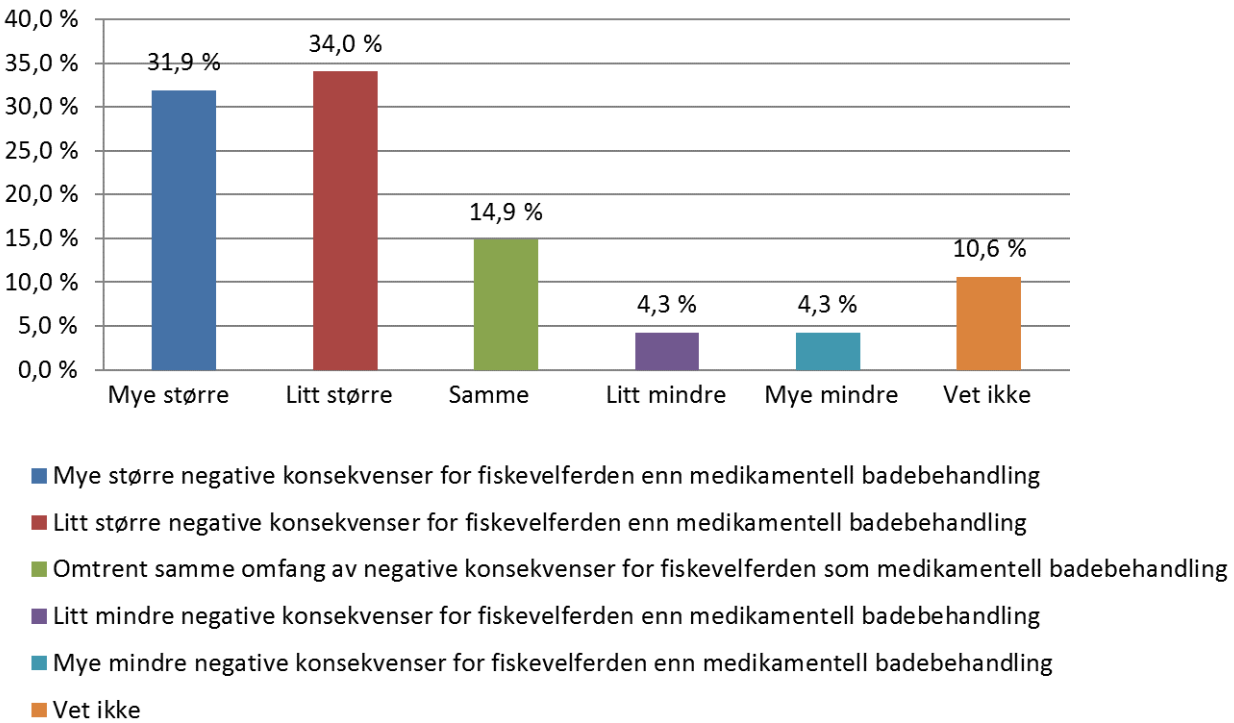


Figure 3.10 Subjective evaluation by Fish Health Personnel of the fish welfare consequences of mechanical de-licing compared to traditional chemical-based bath treatment. The Y-axis describes reply percent (N=47).

Welfare challenges associated with transport

Farmed salmon are transported as smolt and as harvest ready fish. Some may be graded and moved during the sea-phase. The operations involve many individual fish, large boats and advanced technology. Presently there is little knowledge of how these operations are performed and how they affect fish welfare. Factors such as downgrading and customer complaints may represent indications that welfare is not acceptably maintained. It is important to produce as robust, disease free smolts as possible and concurrently develop non-injurious production and handling methods. Fish which are stressed under transport to the slaughter house will represent a reduced quality product.

Wrasse are particularly challenging. These fish are caught on a large scale by local fishermen along the coast from Østfold to Sørlandet and are sent to farms in the west and north. Handling and transport can be rough, with extremely high mortality (up to 40% mortality has been reported). These fish can also suffer from sea-sickness.

Welfare challenges at harvest

All forms of harvest have an inherent risk of suffering including factors mentioned previously e.g. crowding, pumping, chilling, time out of water etc. Some sedation techniques such as swim-in tanks prior to being stunned by a blow to the head are based on the fish’s own motivation to swim out of the tank towards the killing machine, and requires fish which are relatively unstressed.

Sedation methods permitted for fish i.e. electricity or physical stunning (or a combination), are satisfactory in terms of fish welfare as long as the systems are used and maintained properly. For sedation methods which result in a reversible loss of consciousness it is essential that the fish are bled correctly and rapidly after sedation. Cutting of a single gill arch results in a slower bleed than severing of both gill arches.

Slaughter of fish has become highly automated. Small improvements and close monitoring of welfare are of importance for both the collective welfare and quality of the product. All automated systems require manual control and back-up systems. Requirements for training of personell contribute to a raised consciousness of fish welfare. Fish which are stressed before harvest rapidly enter rigor mortis and develop a stronger rigor, which reduces the opportunity for pre-rigor filleting. These fish also have a higher fillet pH, which reduces the shelf-life of the product.

To reduce the impact on acutely sick/stressed fish, efforts should be made to further develop the ability to perform ‘on site’ slaughter. The welfare consequences of well-boat pumping, transport to the slaughter house combined with a possible holding period prior to slaughter are considered significant.

Feed and feeding related welfare challenges
Correct nutrition is essential for normal development and growth of all animals. Nutritional requirements change throughout the life cycle, and individual needs may also 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 particularly poorly understood. Changes in feed recipes due to change in ingredient price or environmental concerns e.g. vegetable ingredients for salmon, may result in health related side-effects (intestinal problems) as well as welfare concerns.
Feeding technology may affect the behavior of the fish directly, due to competition for feed leading to aggression. Starvation is common in relation to transport and handling, with the aim being reduction of metabolism. The effects on fish welfare are poorly understood.

Welfare challenges for novel species
Salmon is the most important farmed species and has therefore attracted the most research and knowledge generation. The various fish species farmed may have widely varying biology and therefore different welfare requirements.

Cleaner fish i.e. wrasse and lumpsucker, are used in control of salmon lice in modern fish farms. Capture or farming of these cleaner fish must be performed in a way that assures good fish welfare. Whether this is the case in todays fish farming industry is very uncertain. Capture, storage, transport and use of these species commonly leads to extremely high mortality and dead fish must be replaced in order to maintain a sufficiently high density of cleaner fish in the cage. Cleaner fish mortality commonly increases dramatically following handling and anti-lice treatments. On treatment of AGD with freshwater, all cleaner fish will as a rule, die.

Knowledge of and attention towards the welfare issues surrounding cleaner fish use have, however, increased dramatically in recent years. Monitoring of capture and transport, use of cover and feeding (particularly lumpsucker), have contributed to increased fish welfare, increased survival and thereby better salmon lice control. The fact remains that individual fish have a limited working life and turnover remains high. This in itself represents a serious welfare problem for which both the industry and the authorities must together find a solution. Capture of wild cleaner fish often leads to physical injury and it remains a problem to hold these fish alive in captivity. The effect on the ecosystem as a result of the large scale capture of wild cleaner fish is also debated. There is also a risk of disease transmission. The reliance on wild-captured fish may decline or end in the future. Regional farming of cleaner fish may lead to stabilization of quality, better fish welfare and a lower risk of transmission of disease between species and regions. Cleaner fish should in addition be vaccinated against the most important bacterial diseases (atypical furunculosis, vibriosis) which commonly result in extremely high mortality following stocking.

Even if the principles behind welfare evaluation are alike, it is absolutely necessary to satisfy the biological needs of individual species. Lack of this type of knowledge is a common problem. As an example it has proven difficult to identify a satisfactory method for sedation of halibut.

Evaluation of fish welfare in 2016

Fish farmers must find a balance between economy, technology and biology/welfare throughout the whole production cycle. To find the optimal solutions it is necessary to obtain a better overview of the current routines and problems. As the aquaculture industry is so large, improvements that provide even marginal reductions in injury or disease will result in many fewer affected fish.

Society at large is taking an ever greater interest in the aquaculture industry, often with a critical view of environmental consequences and fish welfare. Post sea-transfer losses are considered by many to be unacceptably high. We must work systematically to identify causes of such loss, and to identify ways that these losses may be avoided. Fish welfare concerns which do not necessarily lead to fish death must also be prioritised. Scientifically based welfare protocols should be established for the complete farming cycle.

In 2016 serious lice damage was identified in some farms. Such extensive lice-related injuries have not been documented on a Norwegian farm for many years. High mortality and frequent injury related to handling and lice treatment remains a challenge.

2016 has seen the increasing use of mechanical de-licing methods despite a lack of documentation relating to acceptable frequency of treatment and restitution time required between treatments. This has resulted in mechanical injuries to the treated fish in many cases. It is also a welfare challenge that sick or stressed fish must be handled during de-licing, which also in turn leads to increased mortality.

One conclusion can be made. It is clear that specific legislatory requirements, such as the upper limit for acceptable lice infestation, may challenge fish welfare. This is particularly so in the light of a general lack of a common understanding of what good fish welfare is, that there are no requirement for documentation of fish welfare for specific treatments, and that legislation regarding fish welfare is very general and vague. In 2017 a new cooperative project will be established between the Norwegian Veterinary Institute, the Institute for Marine Research, NTNU and UiO. The project will study the effects alone and in combination of the various legislator requirements on fish welfare and fish health.

-After 125 years the Norwegian Veterinary Institute remains a highly relevant source of expertise to the Norwegian food producing industries. The scientific knowledge generated on salmon makes the institute one of the most important cooperative partners for the aquaculture industry, said Petter Arnesen of Marine Harvest at the Norwegian Veterinary Institute 125th anniversary celebrations 12. October 2016. Photo: Eivind Røhne

4. Viral diseases in farmed salmonid fish

A brief summary of the situation in 2016 is given in the table under (Table 4.1). Each individual disease is described in detail in a later specific section. The statistics for notifiable diseases are the official statistics. For the other diseases the statistics relate to the number of cases registered via the Norwegian Veterinary Institute system. Diagnoses made by private laboratories are not included in this table.

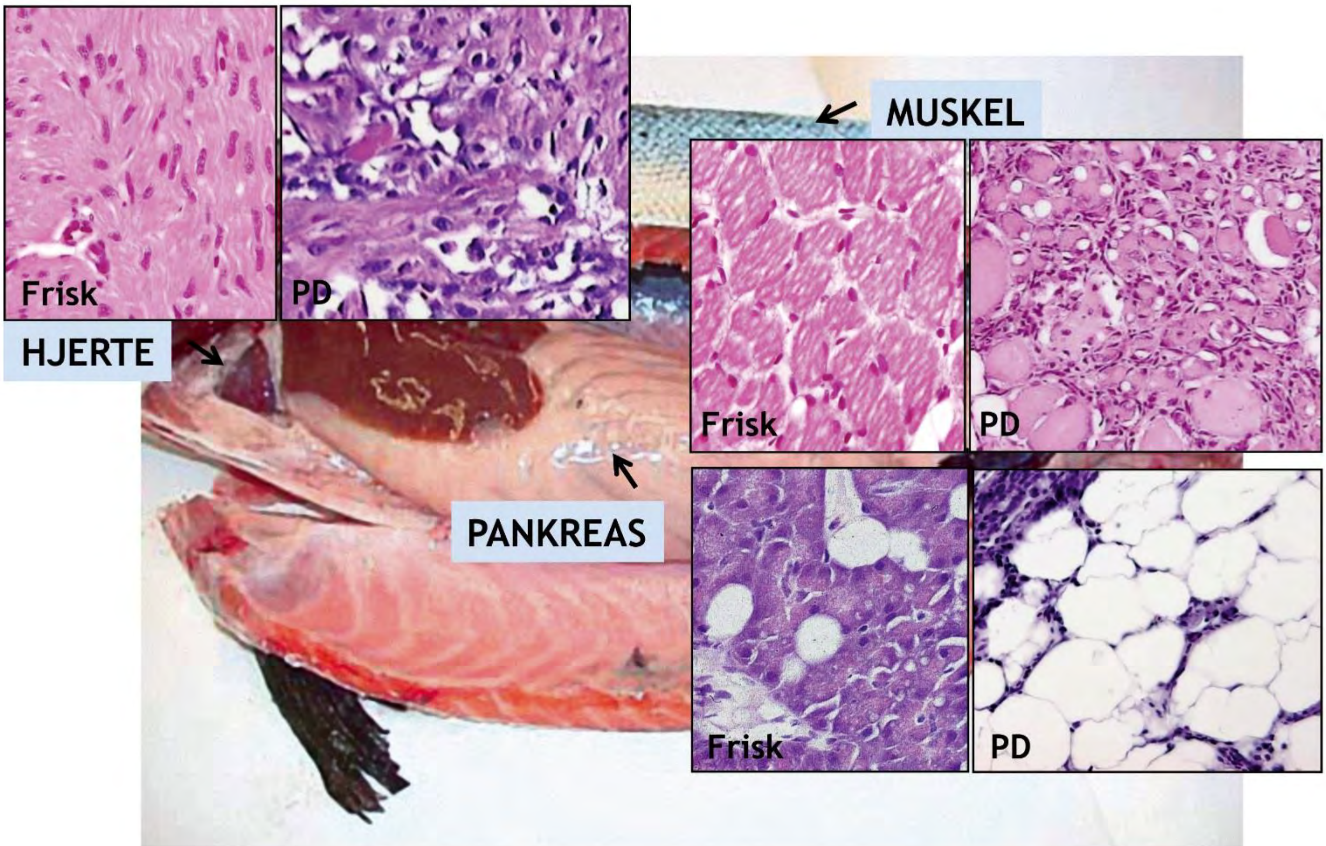
Table 4.1 Frequency of different viral diseases in farmed salmonids 2001-2016. The statistics for non-notifiable diseases are based on Norwegian Veterinary Institute records.

	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
ILA	21	12	8	16	11	4	7	17	10	7	1	2	10	10	15	12
PD	15	14	22	43	45	58	98	108	75	88	89	137	99	142	137	138
HSMB				54	83	94	162	144	139	131	162	142	134	181	135	101
IPN		174	178	172	208	207	165	158	223	198	154	119	56	48	30	27
CMS				88	71	80	68	66	62	49	74	89	100	107	105	90

General evaluation of the viral disease situation in 2016

Aside from 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 both economically and biologically. The number of affected farms was similar in 2016 to the previous year.
The number of farms affected by infectious salmon anaemia (ISA) was also similar to the year before with the disease diagnosed on 12 farms, with a further 3 suspected cases.
The situation in Lofoten has improved following coordinated fallowing and extended health surveillance. New outbreaks have been identified in Nordland and Sør-Trøndelag.
It is difficult to say whether there has been any change in the heart and skeletal muscle inflammation (HSMI) situation over the last two years, but the disease may be increasing in importance during the freshwater phase.

For cardiomyopathy syndrome (CMS), statistics from the Norwegian Veterinary Institute and other laboratories indicate that the increase in number of affected farms continues.



This illustration shows the three main organs affected by PD in healthy and diseased fish respectively. Illustration: Anne Berit Olsen, Norwegian Veterinary Institute.

4.1 Pancreas Disease (PD)

By Anne Berit Olsen, Hanne R. Skjelstad 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.

Subtype SAV3 has been endemic in western-Norway since the virus spread from the Bergen area in 2003-4. A new subtype, marine SAV2 was introduced in 2010. PD caused by this subtype has since spread rapidly in mid-Norway. There are currently two PD epidemics underway in Norway. The majority of cases of PD caused by SAV3 occur south of Stadt, while nearly all cases of SAV2 are registered in Møre og Romsdal and Sør-Trøndelag.

The Norwegian Veterinary Institute is both international and national reference laboratory for SAV. The Norwegian Veterinary Institute works closely with the Norwegian Food Safety Authority on daily updating of maps and monthly reporting of PD diagnoses which are published on www.vetinst.no. Surveillance is performed according to legislation and by the industry itself through regular health controls and disease diagnostics.

See the Norwegian Veterinary Institute fact sheet for more information on pancreas disease.

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

To hinder spread of infection, two pieces of legislation have been introduced. In 2007 legislation was introduced to hinder spread of infection north of Hustadvika. Following introduction of the new subtype SAV2 to mid-Norway, new SAV2 specific legislation was introduced in 2012. The aim of this legislation was to prevent northerly spread of PD.

The largest reservoir of infection is infected farmed fish. Important anti-disease measures include intensive health surveillance to identify early stage disease, focus on transport of smolts and harvest ready fish and restocking within large fallowed areas.

Vaccination against PD is normal practice in western-Norway, but is practiced less frequently in Trøndelag. The effect of vaccination is questionable 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 lowers overall mortality. The vaccine will also result in lower viral shedding from infected fish.

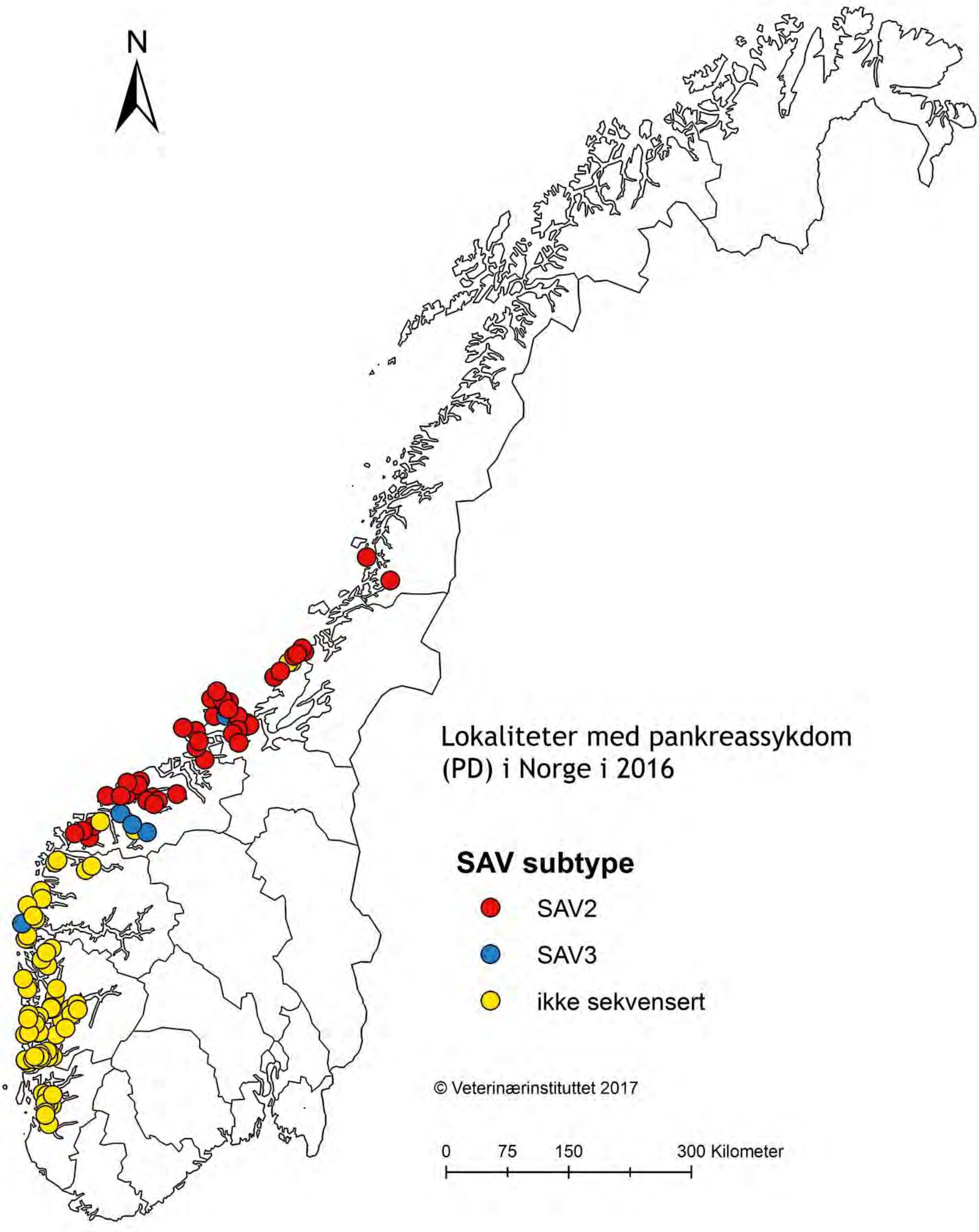


Figure 4.1.1 Map of new sites affected by pancreas disease caused by subtypes SAV2 and SAV3 in Norway in 2016.

Health situation in 2016

Official statistics
In 2016 a total of 138 new cases of pancreas disease (PD) were registered. For SAV3 in western-Norway the number of diagnoses fell from 94 in 2015 to 84 in 2016. For SAV2, the number of outbreaks increased from 43 to 54 in north-western (south) Norway and in mid-Norway. In 2016 two cases of SAV3 were registered north of Hustadvika (Sør-Trøndelag) and two diagnoses of SAV2 were made in Nord-Trøndelag and two in Nordland.

Considered as a whole the situation is comparatively unchanged since 2012, when infection with subtype SAV2 spread in mid-Norway.

Most cases of PD in 2016 were diagnosed in salmon and the disease affected fish during the whole sea phase. Only five new cases were registered in rainbow trout, all involving SAV3. In comparison there were 13 diagnoses made in rainbow trout in 2015 and 12 in 2014 (of which one was subtype SAV2).

PD occurs throughout the year. In west-Norway there was as usual, a peak in SAV3 diagnoses in June-July. For SAV2 in mid-Norway the cases are rather more evenly spread throughout the year, but as previously most diagnoses were made during the autumn.

Mortality associated with SAV3 usually varies between low to moderate, but may occasionally be high. Low mortality appears to be the rule with SAV2 associated cases, again with exceptional cases of high mortality observed. SAV2 infections are normally associated with an increased feed conversion rate, development of 'runt' fish and longer production time due to the extended period of loss of appetite. Associated losses commonly include reduced quality at harvest.

Questionnaire
The Norwegian Veterinary Institute's questionnaire to Fish Health Services and inspectors of the Norwegian Food Safety Authority showed that there was a high state of alert for PD along the whole coastline.
Fish Health Services from mid-Norway southwards considered PD as important/extremely important in ongrowing fish. In mid-Norway PD is considered to represent the same level of threat as HSMI, CMS and chronic gill disease. Salmon lice are clearly the most important threat in this area. In south-west Norway PD is considered extremely important and on a level with chronic gill disease. In this area both diseases scored slightly higher than salmon lice.

More on SAV3 and SAV2

SAV3
PD caused by SAV3 occurs mainly in Hordaland and Rogaland i.e. in the southernmost part of the SAV3 control zone. In 2016 nearly 80% of diagnosed SAV3 cases occurred in these two regions (78% in 2016 and 77% in 2015). The number of new cases in Hordaland in 2016 remained unchanged compared to previous years (around 50 cases), while the number of new cases in Rogaland fell compared to the two previous years (10 in 2016, 19 in 2015 and 23 in 2014). Sogn og Fjordane also saw a slight reduction in new cases in 2016 compared to 2015 (14 compared to 18 cases).

There were few cases of SAV3 PD in Møre og Romsdal. Since the rapid spread experienced in 2007-8 with over twenty cases in a single year, there have only been a few annual cases associated with a limited epidemic in Storfjorden. In 2016 six new cases were identified compared to three the previous year.

SAV3 PD was identified for the first time in Sør-Trøndelag in the autumn of 2016 in two neighbouring farms. In these cases fish had been transported from the SAV3 zone by well-boat. The farms were quickly emptied of fish following identification of disease.

SAV2

The number of new diagnoses of SAV2 infection increased again in 2016 from 43 to 54. The number of cases registered between 2014 and 2016 in Sør-Trøndelag fell by 26% (from 34 to

25). Møre og Romsdal has experienced an almost doubling in number of cases from 13 in 2014 to 25 in 2016. A large number (18/25) of the cases in this region were identified south of the zone border at Hustadvika. The local epidemic directly south of the zone border has continued and there are continued outbreaks in the southern part of the region following its introduction to this area in 2015.

SAV2 PD was diagnosed in January and June 2016 in two farms in Nord-Trøndelag, outwith the PD control zone, but within the observation zone. The farms were quickly emptied of fish following identification of disease.

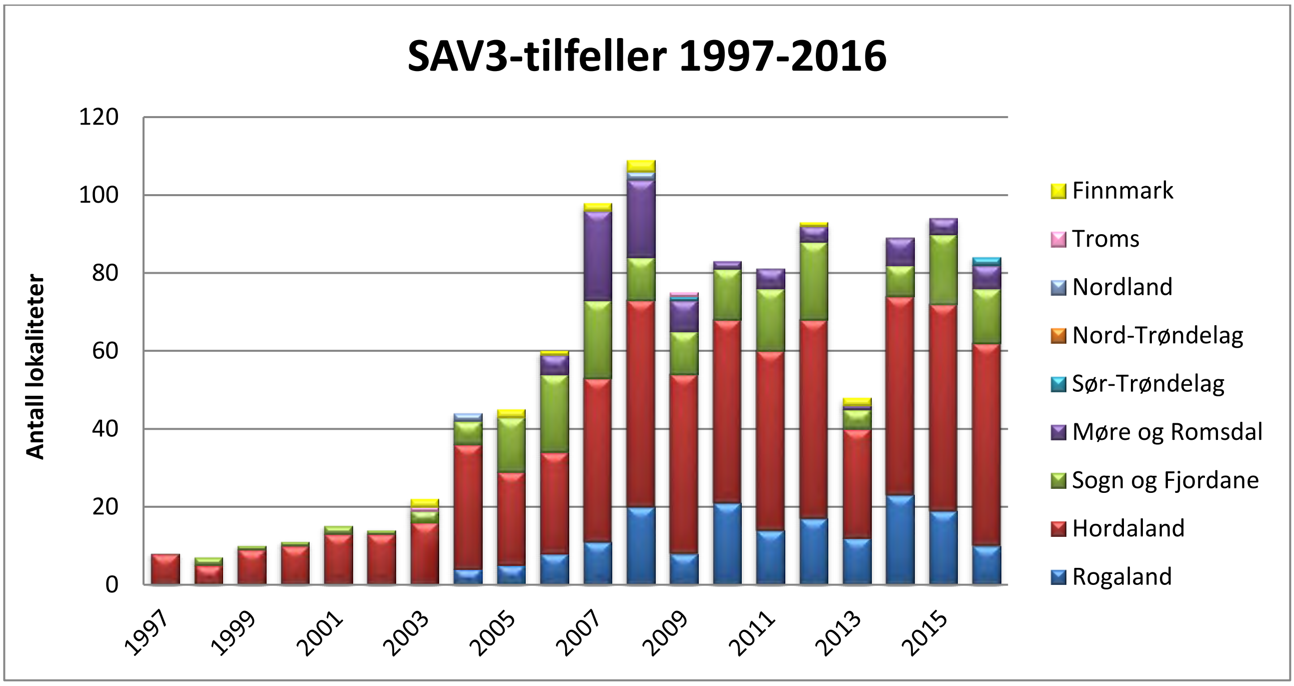


Figure 4.1.2 Regional distribution of new PD outbreaks per year from 1997 until 2016, subtype SAV3.

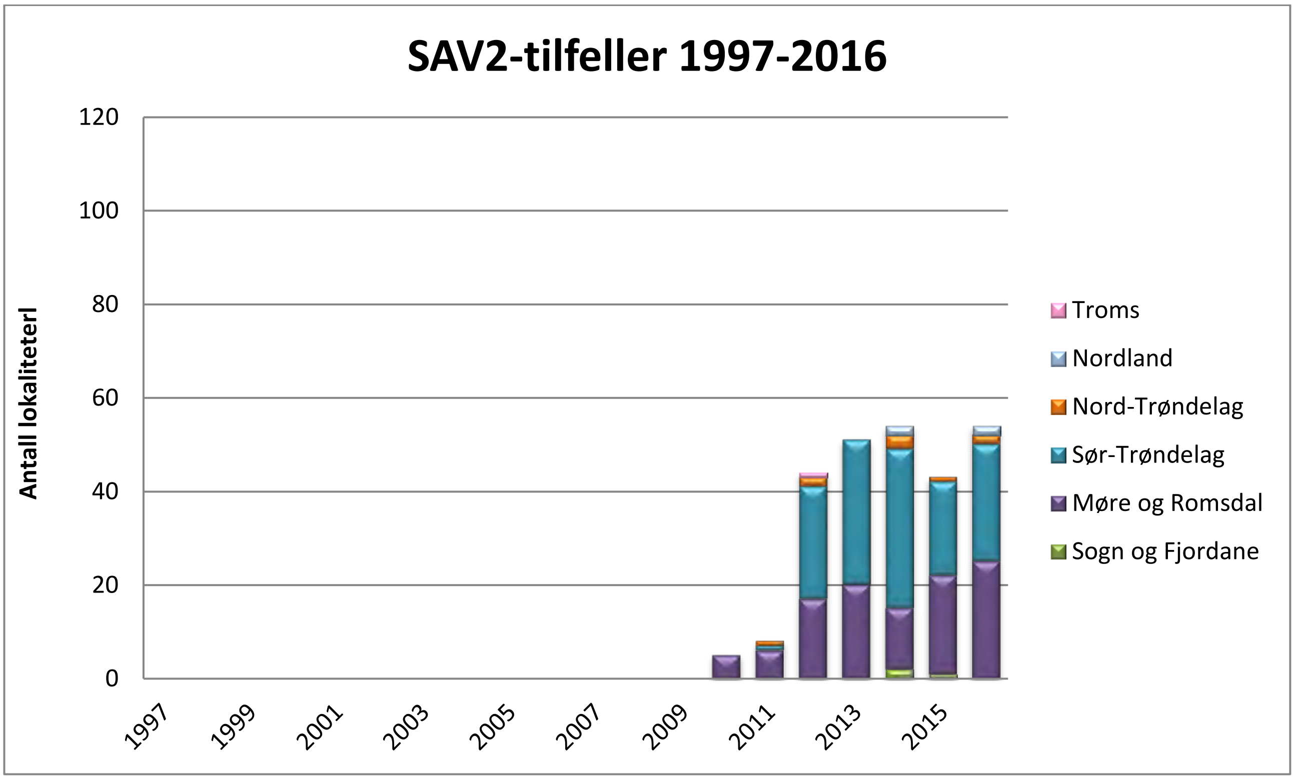


Figure 4.1.3. Regional distribution of new PD outbreaks per year from 1997 until 2016, subtype SAV2.

In October 2016 PD virus was detected during routine screening in Nordland. This occurred on two farms owned by the same company in the counties of Bindal and Brønnøy. PD caused by SAV2 was later confirmed in both farms in November. Some mortality was registered on one farm but no clinical signs of disease were observed. Fish were removed from one farm during December and the other in January 2017.

Statistics and diagnosis
The statistics reported here are based on the number of new positive diagnoses during the period. A 'new' diagnosis on a previously diagnosed farm is awarded only after destocking and following a period of fallowing. This means that the actual number of farms affected at any one point in time is higher than reported here, as infected fish transferred to sea and diagnosed the previous year are not considered in this years statistics.

Pancreas disease is defined here as histopathological changes consistent with PD and detection of PD-virus within the same individual fish (positive diagnosis- PD) or histopathological changes consistent with PD, but without positive identification of PD virus (due to lack of sample material) (suspicion of PD). In the statistics presented here both positive diagnoses and suspicions are presented together. In some SAV2 cases the suspicion of PD is based on PCR virus detection alone.

Evaluation of the PD situation
The high prevalence of PD is a significant challenge to the industry and the disease has high associated costs (VI report series; 2015 nr 5 ISSN 1890-3290).

The disease is highly infectious and is not always obvious. The infection spreads in the sea, with transport and movement of infected populations between sea sites. Fish may be infected with the virus for a considerable period prior to development of visible signs of disease. Frequent screening of fish is therefore important to identify the disease as early as possible. It should be borne in mind that a farm may be infected even if the screening result is negative.

PD is a typical stress-related disease. A sub-clinical infection may develop into a serious outbreak following a stress-related event e.g. lice treatment.

The number of PD outbreaks has been relatively stable over the last five years. It can appear, therefore, that the efforts of both the industry and the regulatory authorities to control and avoid northerly spread of PD caused by SAV3 and SAV2 have succeeded.

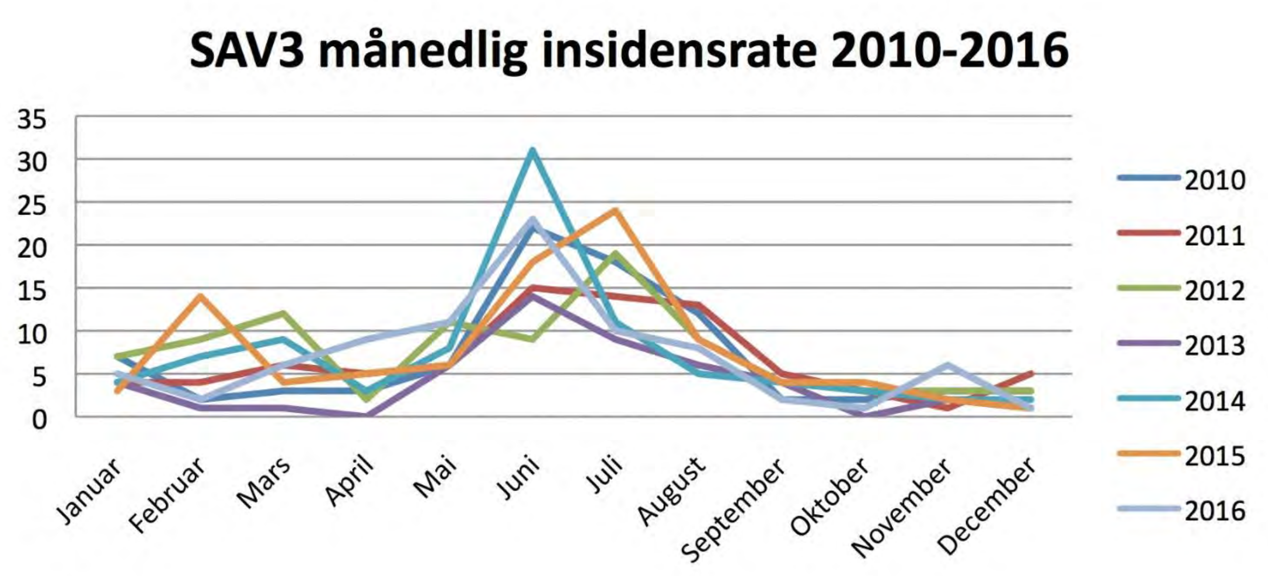


Figure 4.1.4. Monthly incidence rate of sites with SAV3 PD 2010 - 2016.

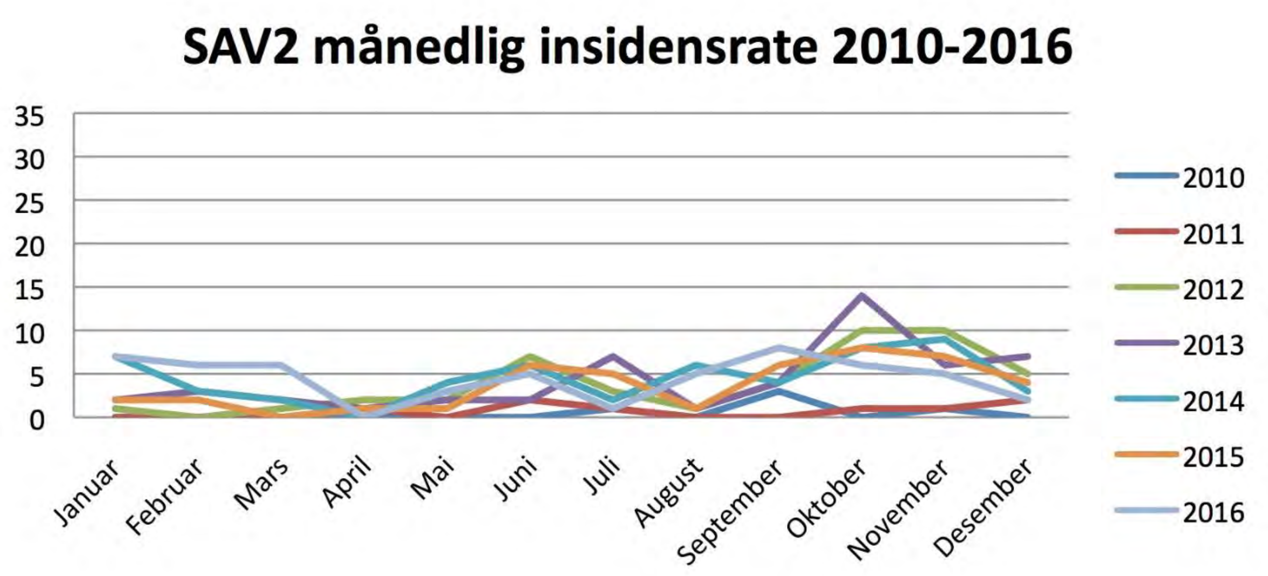
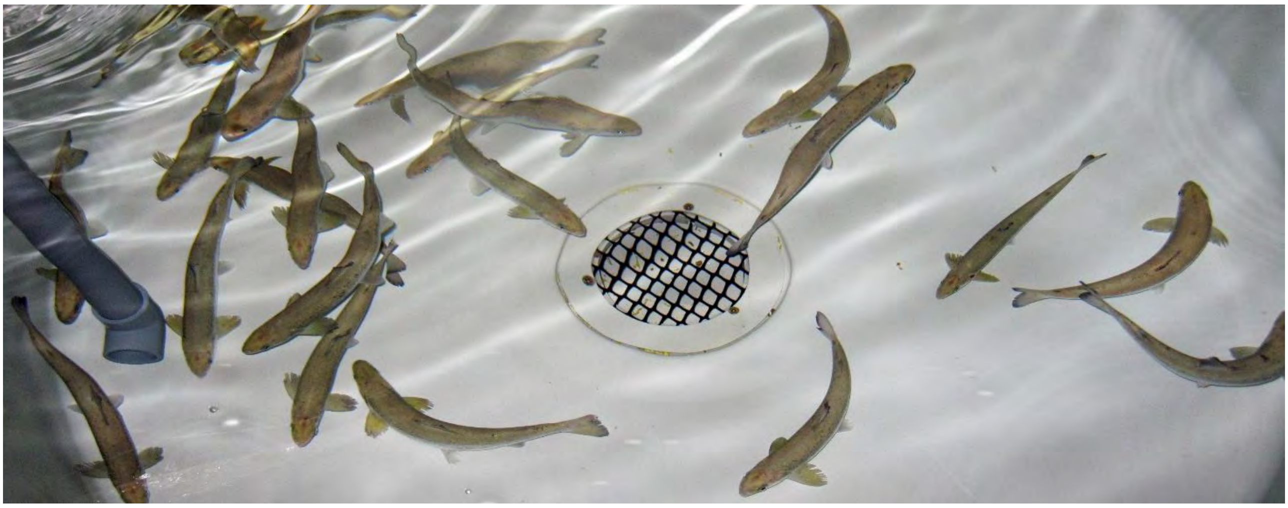


Figure 4.1.5. Monthly incidence rate of sites with SAV2 PD 2010 - 2016.



Salmon photographed during an infection trial to generate new knowledge on infectious salmon anaemia (ISA) Photo: Norwegian Veterinary Institute

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 an orthomyxovirus. Natural outbreaks of ISA have only been identified in farmed Atlantic salmon. The virus primarily attacks blood vessels. On post mortem the main findings include organ palour (due to serious anaemia), ascites and haemorrhage in the skin and inner organs.

ISA may be compared to a 'smouldering fire'. This is due to the sometimes extended period during which the fish population may be infected prior to outbreak of clinical disease. 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%.

Non-virulent ISA (ISAV-HPR0) and virulent ISA (IS-HPR-del) are differentiated on the basis of the amino acid sequence in the hyper-variable region (HPR) of the gene coding for hemaglutinin esterase. It is now generally accepted that virulent ISAV-HPR-del originates from ISA-HPR0, and that the presence of ISA-HPR0 infection is a risk factor for further development of ISA. The likelihood/probability of conversion from HPR0 to HPR-del is, however, not known.

Control
ISA is a notifiable disease in Norway and is also listed by the World Organisation for Animal Health (OIE). Outbreaks of ISA are combatted through implementation of strict counter measures. As a rule, a zoning system is established around the affected site, composed of a control zone and an observation zone.

Control measures will vary according to the geographical location of the outbreak, and whether the outbreak lies inside an ISA-free zone or not. Following a period of two years without detection of new cases in the area the restrictions are raised by the Norwegian Food Safety Authority and the zones are abolished. Since the autumn of 2015, systematic surveillance within ISA control areas has been performed such that new cases can be identified as early as possible.

Se the Norwegian Veterinary Institute fact sheet for more information on the disease ISA

The health situation in 2016

Official statistics
In 2016 ISA was confirmed in a total of 12 farms, eight in Nordland, three in Sør-Trøndelag and one in Finnmark.

The ISA-situation
In recent years a significant proportion of ISA cases have been identified in northern-Norway. This trend has continued and the area around Rødøy in Nordland was particularly prominent in 2016.

Eight outbreaks were identified in Nordland which were distributed between Rødøy (6), Gildeskål (1) and Nesna (1). Three outbreaks were identified around the island of Frøya in Sør-Trøndelag and one in Hammerfest in Finnmark. ISAV-HPR-del was also detected on two farms in Frøya and two farms in Rødøy, but disease diagnosis has not been confirmed by the Norwegian Food Safety Authority.

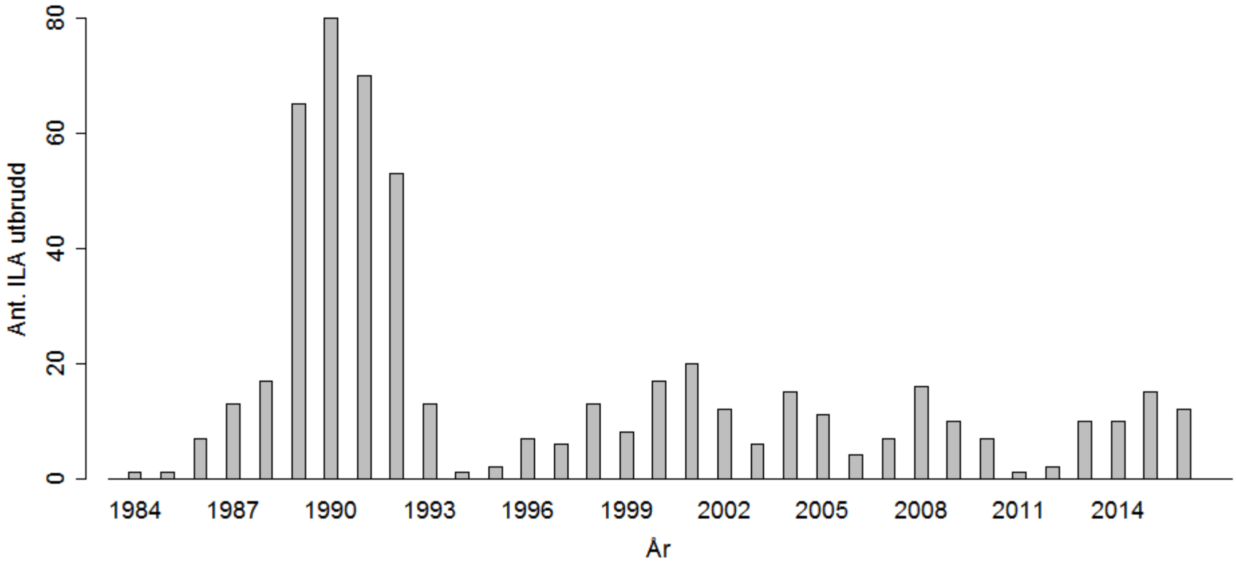


Figure 4.2.1 Number of annual outbreaks of ISA in Norway 1984 - 2016.

Phylogenetic analyses performed by the Norwegian Veterinary Institute show that the ISA-virus from the different Rødøy outbreaks are highly related, which is consistent with a situation in which the virus has spread from farm to farm in this area. The virus from Rødøy is also highly related to that behind the outbreaks in Gildeskål and Nesna.

The amino acid sequence of the hypervariable segment of segment 6 (the HE gene) of the ISA-virus found in Gildeskål and Nesna is different from that found in Rødøy. Direct, horizontal transmission from Rødøy to the farms in Gildeskål and Nesna is therefore unlikely to have occurred. Comparison of ISA-virus from the ISA outbreaks in Gildeskål and Nesna indicates, however, that a common source of infection is possible. The fish in the Gildeskål farm were transferred to sea only a few weeks prior to diagnosis of ISA, and retrospective analysis of samples taken four days after sea-transfer revealed the presence of virulent ISA-virus at this point in time. This indicates that this fish population was infected before sea-transfer to Gildeskål.

Investigation of samples taken at the farm which supplied the fish population in question have not identified virulent ISA-virus.

Phylogenetic analyses are consistent with a scenario in which the two Frøya ISA outbreaks identified in June 2016 may be epidemiologically related to two outbreaks in Møre og Romsdal in 2014 and 2015. The third outbreak on Frøya in 2016 is considered most likely to represent a new primary outbreak. The same situation applies to an ISA outbreak identified in December 2016.

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. The surveillance includes monthly inspections and sampling for ISA in order to identify new infections at an early stage. In the course of 2016 deleted ISA-virus was detected on a farm on Frøya.

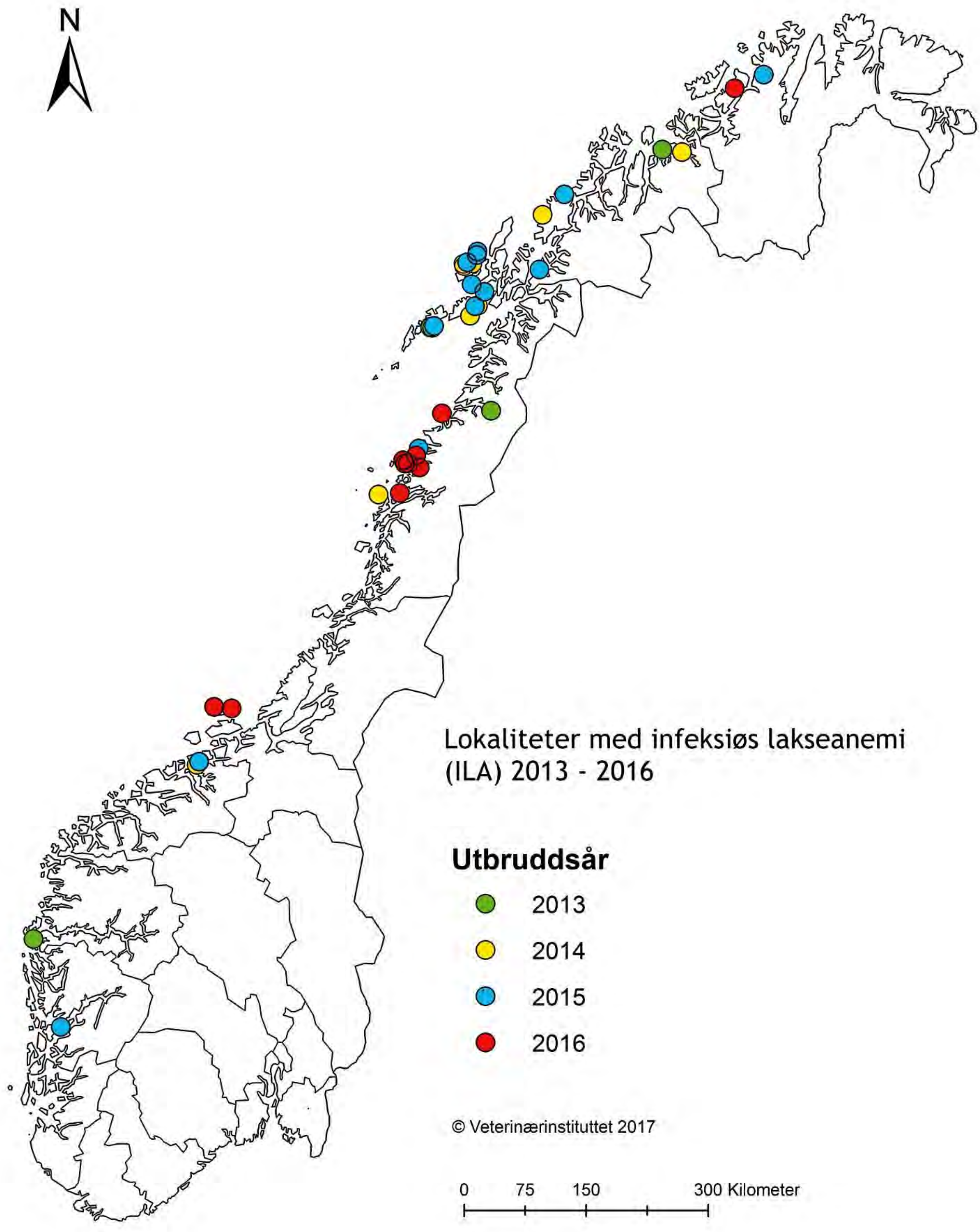


Figure 4.2.2 map of sites with infectious salmon anaemia (ISA) in Norway 2013 - 2016.

Farmed salmon. Archive Photo: Trygve Poppe, Norwegian Veterinary Institute

4.3 Infectious pancreatic necrosis (IPN)

By Torfinn Moldal and Geir Bornø

The disease

Infectious pancreatic necrosis (IPN) is a viral disease which is primarily associated with farmed salmonids. The IPN virus belongs to the genus Aquabirnaviridae in the Family Birnaviridae. Juvenile fish and post-smolts appear to be most susceptible and mortality can vary between negligible and 90%. Different strains of IPN virus vary in virulence and mortality rate can also depend on strain of fish and other environmental and production related parameters. A significant proportion of IPN infected fish develop a life long, persistent infection

See the Norwegian Veterinary Institute fact sheet for more information on IPN

Control

There is no publically organised control program for IPN in Norway. Within the industry, avoidance of infection during the hatchery phase is important. A genetic marker for resistance to IPN has been identified and makes possible selective breeding of (QTL) salmon which have a high degree of IPN resistance. This type of stock is now widespread in Norway, and recently advances have been made in developing stocks of resistant rainbow trout. In addition, eradication of 'house strains' of IPN virus has had good effect.

While a large proportion of Norwegian salmon are vaccinated against IPN-virus, the protective effect of vaccination is uncertain.

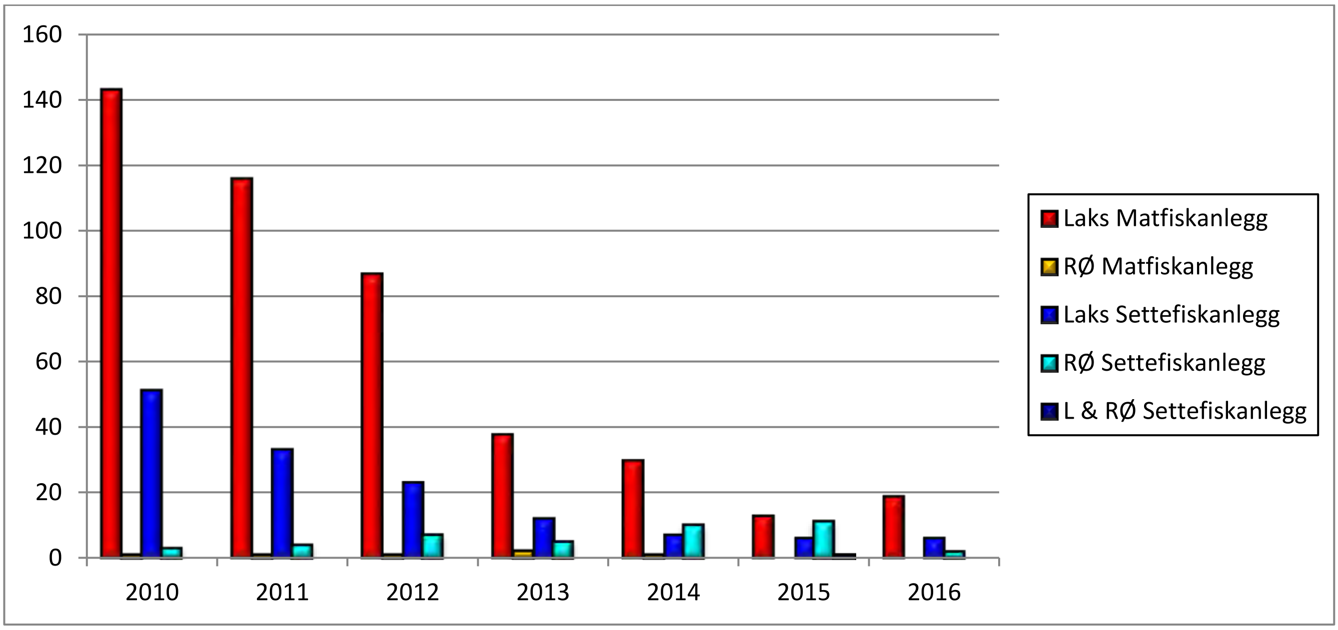


Figure 4.3.1. Distribution of registered IPN-outbreaks in Norway 2010 - 2016

The IPN situation in 2016

Data from the Norwegian Veterinary Institute
In 2016 IPN was diagnosed in a total of 27 salmonid farms. This is a slight reduction from 2015 when IPN was diagnosed in 30 farms. For salmon there was, however, a slight increase as 25 salmon farms were diagnosed. These outbreaks involved six hatcheries and 19 ongrowing sites in 2016 compared to a total of 19 sites in 2015.
For rainbow trout there was a marked reduction from 2015 with IPN only identified in two hatcheries in 2016 compared to 11 in 2015. Nearly half of all IPN outbreaks were identified in the three most northerly regions of the country.

Questionnaire
Replies to the questionnaire indicate that IPN is generally considered of little importance, but with some regional variation. Several Fish Health Services reported IPN-outbreaks with low mortality. QTL salmon stocks are used in all areas of the country, and nearly all salmon are vaccinated against IPN. QTL rainbow trout stocks appear to be most commonly utilised in western Norway which is an important production area for this species. The degree to which QTL stocks of rainbow trout are used in mid- and northern-Norway is not known.

Evaluation of the IPN situation
After several years of decreasing numbers of outbreaks, the situation appears now to have stabilized. The reduction in number of IPN outbreaks in rainbow trout can, in all probability, be credited to use of QTL stocks. One private laboratory diagnosed IPN in eight farms and another has identified IPN infections with low PCR Ct values in ten farms. The identity of these farms is unknown so there may be some overlap and 'double reporting' of individual outbreaks.

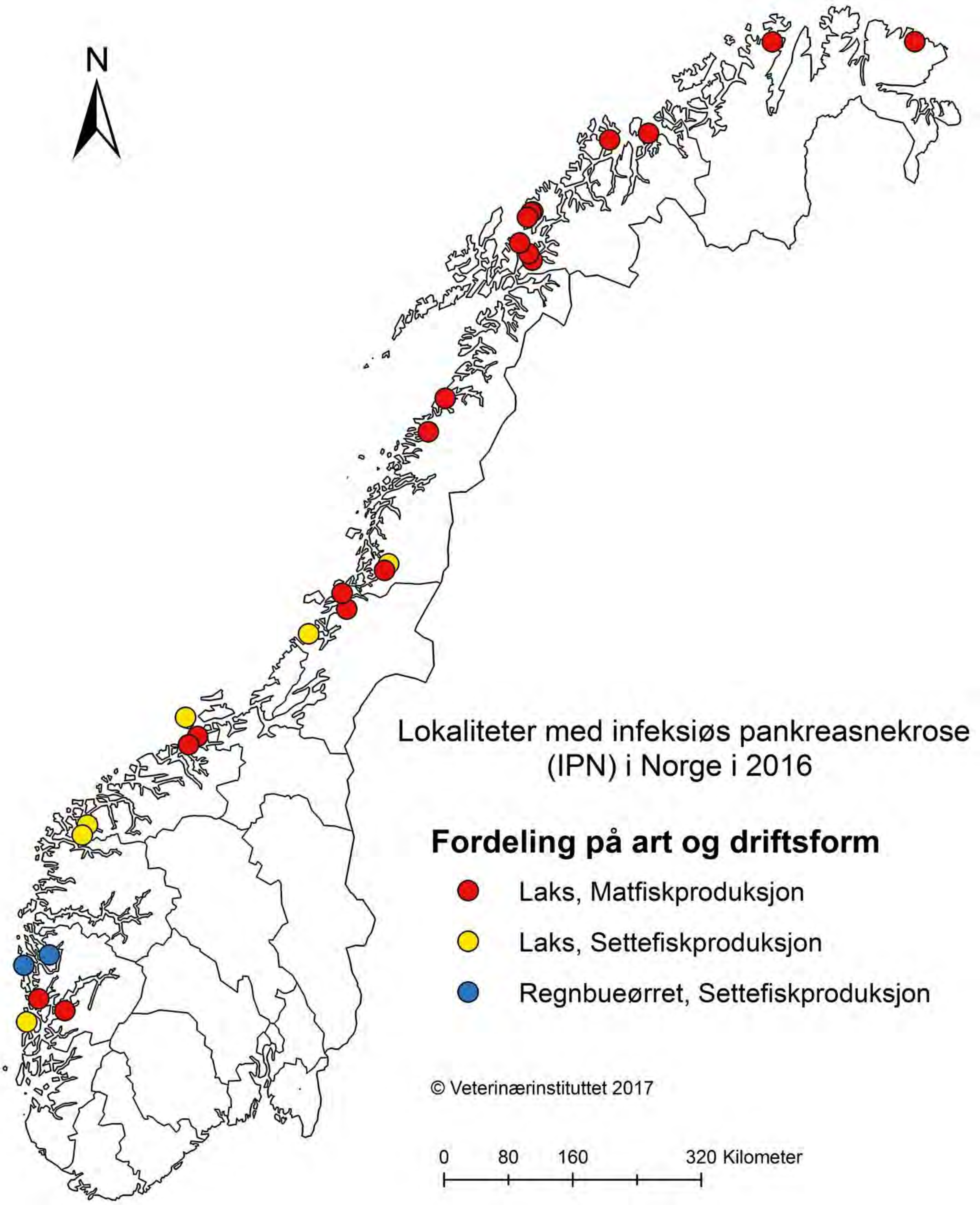
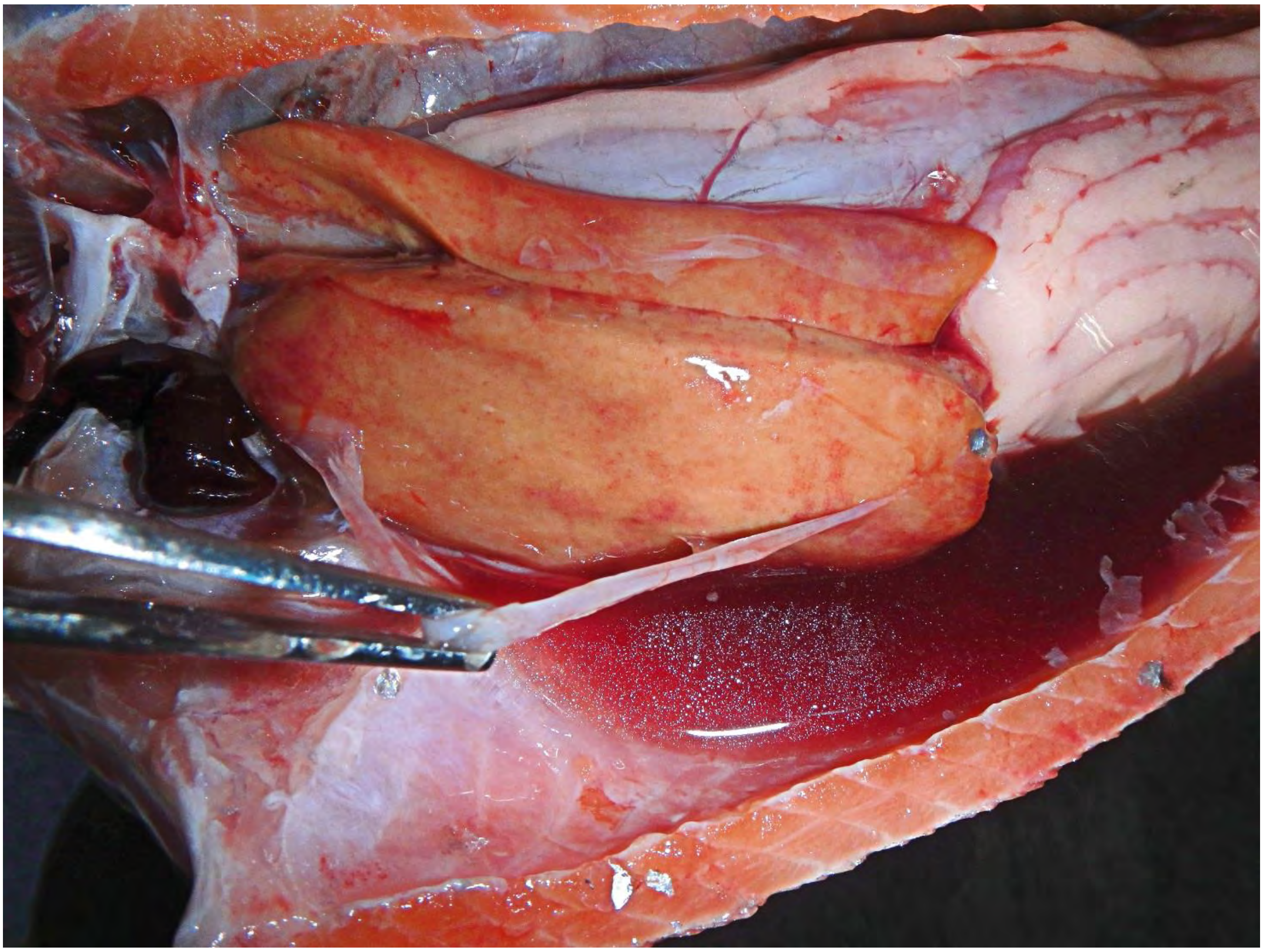


Figure 4.3.2 Map of IPN-outbreaks in Norway in 2016



Heart and skeletal muscle inflammation (HSMI) in salmon. Photo courtesy of Marin Helse.

4.4 Heart and skeletal muscle inflammation - HSMI

By Torunn Taksdal, Maria Dahle and Marta Alarcon

The disease

HSMI is today one of the most common infections in Norwegian farmed salmon. The disease is most commonly diagnosed in salmon during the first year of seawater culture and may persevere over a considerable period of time following initial diagnosis. The heart is the organ which is primarily affected. Sparse inflammation, becoming gradually more severe may be observed histologically in the months prior to and after clinical outbreak.

During clinical outbreaks affected fish display extensive inflammation in the heart and often in the skeletal musculature. HSMI can result in very variable mortality levels. Losses are commonly reported following management procedures which stress the fish. Salmon dying of HSMI often display signs of circulatory failure.

HSMI was first identified in 1999. Piscine orthoreovirus (PRV) was identified in 2010 in tissues from fish suffering from HSMI. Infection trials have considerably strengthened the association between PRV and the disease. The virus is extremely widespread and may be found in both wild and farmed salmon. PRV infected fish do not always develop HSMI. PRV infects red blood cells and may be detected in most organs. In 2016 it was reported from Norway that experimentally PRV infected salmon were less sensitive to SAV infection than salmon uninfected with PRV. This has so far only been identified under experimental conditions. Experimental studies have also shown that PRV may infect the fish via the intestine and can also be detected in the faeces of infected fish.

Much indicates that genetically different PRV strains result in different outcome following infection and that different families of salmonid may display various grades of susceptibility. Canadian infection trials indicate that Canadian PRV does not give HSMI in salmon. In contrast, work published in 2016 described a PRV variant similar to Norwegian strains which gave HSMI in Atlantic salmon in Chile. Another strain of PRV gave HSMI in Coho salmon in Chile, but with tissue pathology different from that observed in Atlantic salmon. (continues next page)

Control

There is no public control program for eradication of HSMI. There is no treatment, and no commercial vaccine is available. Vaccine development work is underway.

The most important counter measure against HSMI in seawater is avoidance of management routines which are likely to stress the fish.
In hatcheries, avoidance of seawater use can be an important prevention strategy. Experience shows that the vast majority of outbreaks occur during the seawater phase of culture and that the most important source/s of infection are in seawater. Some farmers have initiated work directed at eradication of PRV infection from juvenile production units.

See the Norwegian Veterinary Institute fact sheet for more information on HSMI.

The disease (continued)

Several variants of PRV have been identified in other fish species. 'Erythrocyte inclusion body syndrome' in Coho salmon in Japan is caused by a variant of PRV. A PRV variant has also been found in rainbow trout in Norway which gives HSMI-like inflammation in the heart and anaemia (see the chapter on PRV page 60).

The health situation in 2016

From the Norwegian Veterinary Institute

In 2016 HSMI was diagnosed by private laboratories in 101 farms and suspicion of infection in a further 8 farms. Whether these cases relate to separate cases or overlap partly or wholly with cases diagnosed by the Norwegian Veterinary Institute is unknown. There may also be an overlap in individual cases diagnosed by the various private laboratories.

Questionnaire
Both Fish Health Services and the Norwegian Food Safety Authority consider HSMI to represent a serious problem. On a scale of 1-5 (of increasing importance) correspondents to the field questionnaire ranked HSMI as score 3.6. Fish Health Services in Northern- and mid- Norway consider this disease a greater problem than in the remainder of the country and ranked the disease as 4.4 and 3.8 respectively. The remainder of the country ranked HSMI as 3.0.

HSMI is considered less serious in juvenile production sites with an average score of 2.8/2.3 (Throughflow/RAS). There are also regional differences in regional score in juvenile production sites.

Evaluation of the HSMI situation
HSMI continues to represent a serious problem in salmon farming. Fish Health Services from all parts of the country report serious HSMI problems. It is considered one of the most serious health threats to sea-farmed salmon and to a lesser degree during the fresh-water stage of culture, particularly in northern- and mid-Norway.

That fewer cases were recorded in official statistics does not necessarily mean that the situation is improving compared to previous years. Removal of HSMI from the list of notifiable diseases may be one possible reason behind the fall in number of registered cases.

HSMI diagnoses made by private laboratories (101 in 2016) are not included in official statistics. Considered together the number of HSMI diagnoses in 2016 appear roughly at least as high as the previous year. HSMI affected fish do not seem to tolerate management procedures which result in stress and HSMI appears to be a significant factor associated with de-licing and handling related mortality episodes.

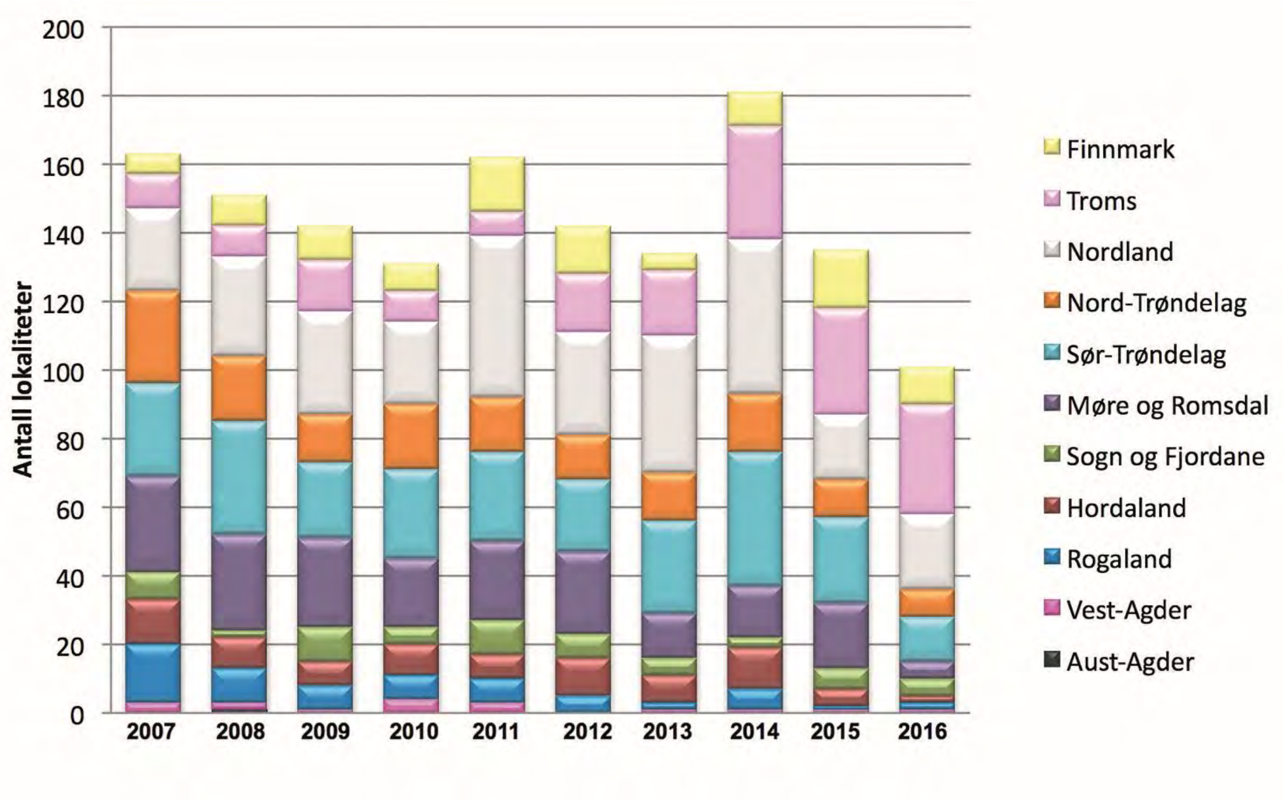
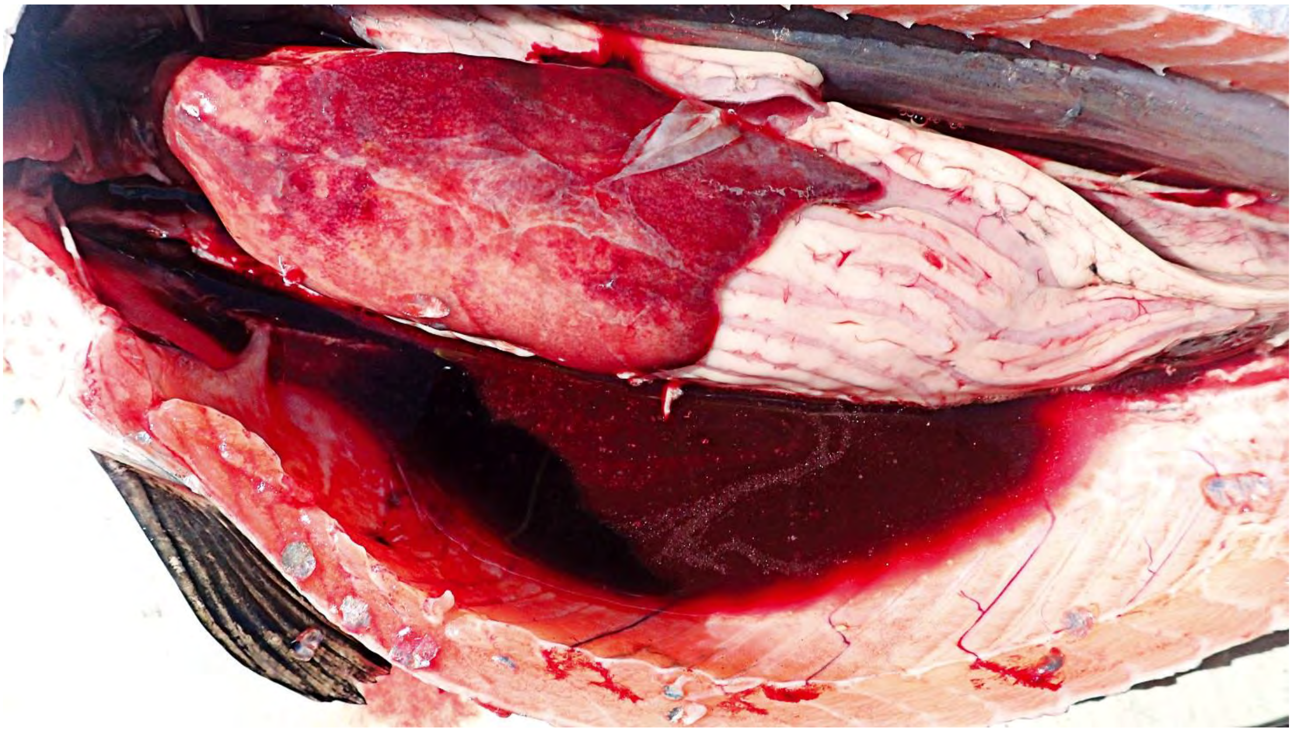


Figure 4.4.1 Regional distribution of HSMI outbreaks 2000 - 2016.



Autopsied fish (above) and dead fish (below) with clear signs of CMS. Photos: Per Anthon Sæther, Marin Helse.

4.5 Cardiomyopathy Syndrome (CMS)

By Julie Christine Svendsen and Camilla Fritsvold

The disease
Cardiomyopathy syndrome (CMS) is a serious heart complaint affecting sea-farmed salmon. Fish are typically affected during their second year at sea. The economic impact of the disease may therefore be significant.

The disease is caused by the totivirus *Piscine myocarditis virus* (PMCV), a naked double stranded RNA-virus with a relatively small genome. Typical clinical findings include inflammatory changes in the inner, spongious parts of the atrium and ventricles, while the compact muscle layers of the heart are relatively unaffected. In extreme cases the wall of the heart may effectively burst. The disease results in similar pathological changes as PD and HSMI, but CMS does not normally result in changes to exocrine pancreas or skeletal muscle tissues.

Water borne, fish to fish transmission of the virus has been demonstrated. Studies of possible vertical transmission are now underway.

Control
CMS is not a notifiable disease, either in Norway or for the World Organistion for Animal Health (OIE). There is no official control program for CMS in Norway.

It is known that stress during e.g. de-licing, transport etc. may trigger outbreaks and associated mortality. Following a CMS diagnosis, all management routines which lead to stress 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.

See the Norwegian Veterinary Institute fact sheet for more information on CMS.

The health situation in 2016

Data from the Norwegian Veterinary Institute
The Norwegian Veterinary Institute diagnosed CMS in 90 farms during 2016. All were ongrowing or brood stock farms. The number of cases registered at the Norwegian Veterinary Institute indicate a possible reduction in relation to the previous year when the disease was diagnosed in 105 farms. The 2016 level is equivalent to that experienced in 2012, but diagnoses made by other laboratories must also be considered (see below).

Data from other laboratories
Other laboratories have reported a total of 108 CMS diagnosed farms in 2016. Whether these farms are in addition to, or overlap partly or completely with farms diagnosed through the Norwegian Veterinary Institute system is not known. It is impossible therefore to say with any certainty whether the total national impact of CMS is greater or lesser than in previous years.

Questionnaire
Correspondents to the national questionnaire sent out by the Norwegian Veterinary Institute to Fish Health Services and officers of the Norwegian Food Safety Authority considered CMS, along with HSMI to represent one of the most significant infectious threats to salmon health in Norway during 2016, with only salmon lice considered of greater importance. There are regional differences in considered importance however, with CMS considered most important in northern-Norway. This may be

related to the variable yet generally increasing number of cases reported from the three most northerly regions since 2010.

Evaluation of the CMS situation

In 2016, 38% of all diagnosed cases of CMS were situated in Nordland, Troms and Finnmark. This differs from previous years during which the CMS situation was dominated by cases from mid-Norway. There is probably an overall increase in number of disease outbreaks compared to previous years.

The slight reduction in number of cases registered by the Norwegian Veterinary Institute is probably offset by an increasing number of cases diagnosed by private laboratories since 2015. Although there may be an overlap between cases registered by private laboratories and the Norwegian Veterinary Institute, it is considered likely that the total number of cases registered nationwide show an increase.

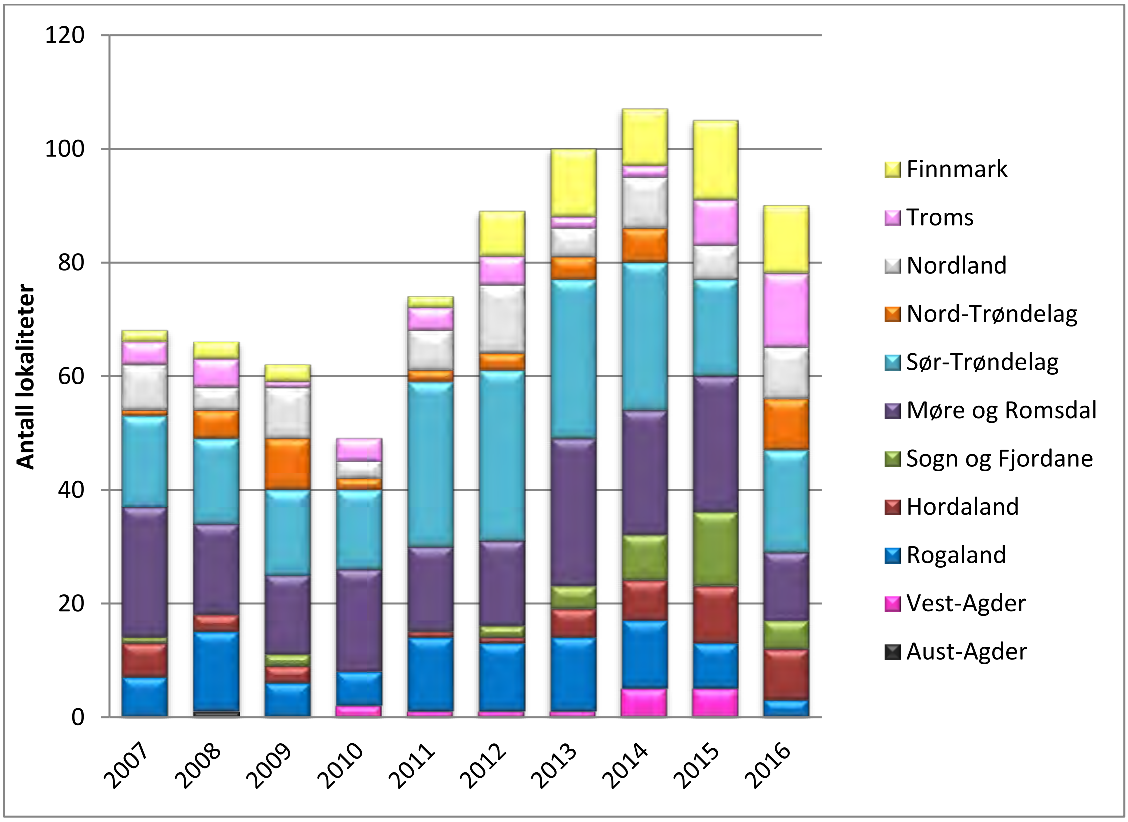


Figure 4.5.1: Summary of number of farms in which CMS has been registered 2007 - 2016, in different regions.

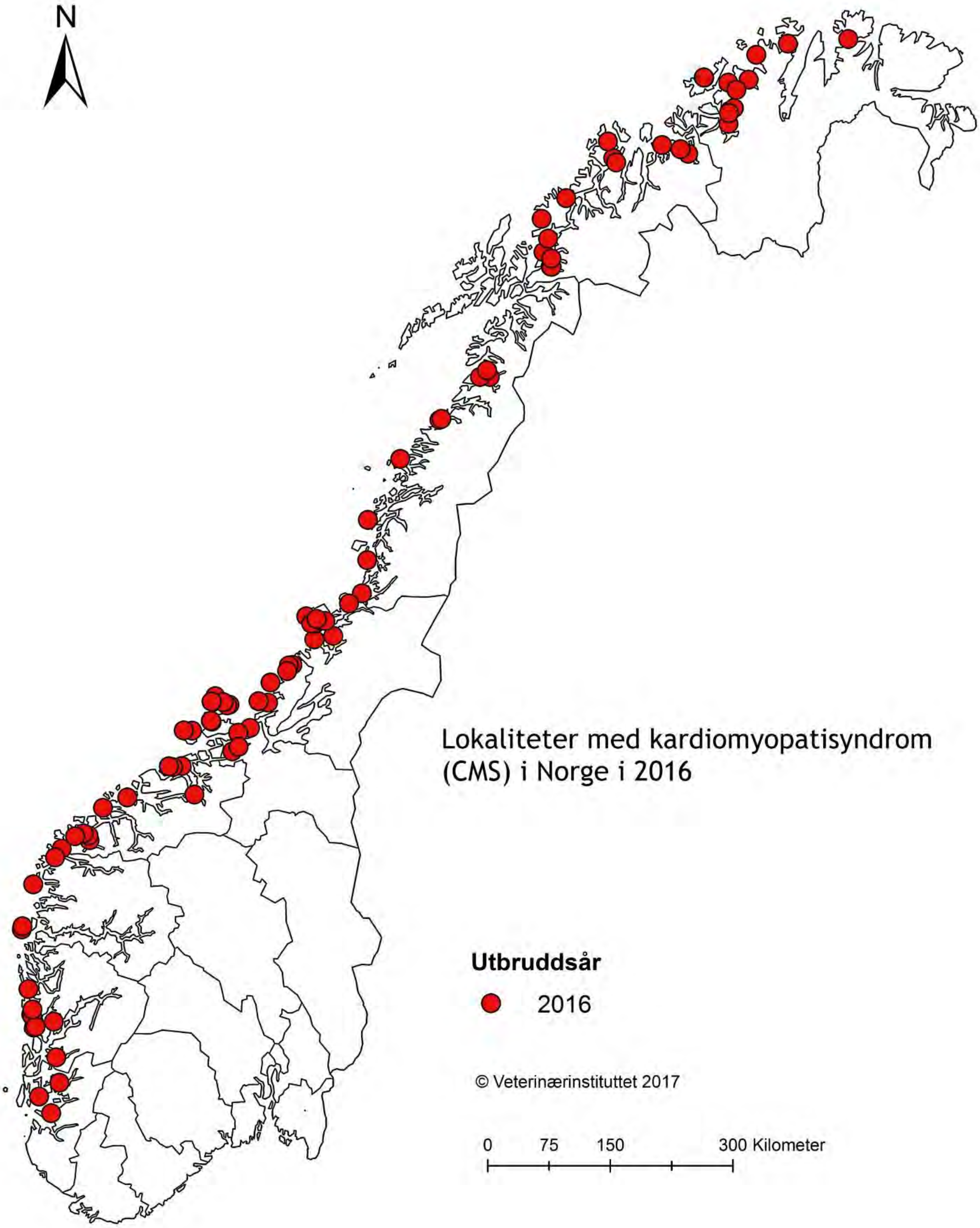


Figure 4.5.2. Map showing farms affected by CMS in 2016.

4.6 Viral Haemorrhagic Septicaemia (VHS)

By Torfinn Moldal

The disease
Viral haemmorhagic septicaemia (VHS) is a viral disease which 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 bulging eyes, hemorrhage, anaemia and abnormal behavior involving spiral swimming. 'Flashing' is also observed.

Control
VHS is a notifiable disease (list2 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, which is based on examination of samples sent in for rutine diagnostic investigation. Following diagnosis of VHS, control and observation zones are established. Vaccination is not relevant for the Norwegian situation.

See the Norwegian Veterinary Institute fact sheet for more information on VHS.

The health situation in 2016

Official data
VHS was not identified in Norway during 2016. The last Norwegian diagnosis was made in rainbow trout in Storfjorden in 2007-2008.

Evaluation of the VHS situation
Considering the consequences of an outbreak of VHS, surveillance of Norwegian farmed fish is important such that infected fish may be removed from the farm as rapidly as possible. The current surveillance program is risk-based and prioritises investigation of the fish species which pose the greatest risk of infection.

4.7 Infectious hematopoietic necrosis (IHN)

By Torfinn Moldal

The disease
Infectious hematopoietic necrosis (IHN) is a viral disease which 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 14ºC. Externally, exopthalmus is common. Internally, hemorrhage in internal organs, swollen kidney, ascites and destruction of haemopoetic tissues are commonly observed.

See the Norwegian Veterinary Institute fact sheet for more information on VHS.

Control
IHN 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, which is based on examination of samples sent in for rutine diagnostic investigation. Following diagnosis, control and observation zones are established. Vaccination is not relevant for the Norwegian situation.

The health situation in 2016

Official data
IHN has never been diagnosed in Norway.

Evaluation of the IHN situation
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 in the western parts of 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.

Spread of IHN appears to be related to sale of infected eggs and juvenile salmonid fish. The virus has, however, also been detected in wild populations of marine fish species. These species may represent a reservoir of infection.

Salmon farming. Archive photo: Mari M. Press, Norwegian Veterinary Institute

4.8 Virus associated disease of rainbow trout - PRVom

By Anne Berit Olsen and Anne-Gerd Gjevre

The disease
The disease was first described between the autumn of 2013 and January 2014 in four juvenile rainbow trout (*Oncorhynchus mykiss)* production units. The farms were situated in western Norway. Moderate to high mortality rates were observed in freshwater and during the first days after sea-transfer. All affected farms had received eggs and juvenile fish from the same broodstock.
Typically, affected fish displayed circulatory failure, anaemia and inflammation in the heart and skeletal musculature. With the exception of anaemia, the pathological changes observed were very similar to HSMI in salmon.

A variant of *Piscine orthoreovirus* (PRVom) is associated with the disease. In laboratory trials, the virus transmits via water between rainbow trout and from salmon to salmon. Salmon appear to be less susceptible to infection than rainbow trout. Experimental infection has not resulted in clinical disease or mortality but a number of fish have developed inflammation in the heart.
The disease has not been diagnosed in rainbow trout since 2014. While disease associated with PRVom has never been identified in farmed salmon, only a limited number of fish have been investigated.
No primary outbreak has yet been identified in rainbow trout held in seawater, but spread of PRVom in seawater is likely. We have no knowledge of the prevalence of PRVom in wild salmonids in Norway.

Control
Good biosecurity is recommended in combination with regular health surveillance and diagnostic work, particularly during the juvenile production stage in freshwater.
Diagnosis is based on light microscopy (histology) of tissue samples and PCR analysis.

The disease cannot be treated and a vaccine is not available

See the Norwegian Veterinary Institute fact sheet on the disease for more information.

Health situation in 2016.

Official data
In 2015 and 2016 the Norwegian Veterinary Institute undertook a surveillance program on behalf of the Norwegian Food Safety Authority. Infection with PRVom was identified in a total of 15 rainbow trout sea farming sites during this two year period. None were associated with clinical disease. Six sites tested positive for the presence of the virus in both years.

Evaluation of the situation for disease associated with PRVom

The disease is not notifiable. Based on today's level of knowledge the Norwegian Veterinary Institute considers that the disease represents a low general risk for the health of Norwegian farmed fish. There is much to indicate that the disease may be eradicated and controlled in freshwater farms. Spread of the virus to new areas should, however, be avoided.

Economic analysis

-The government desires considerable growth in the aquaculture industry in future years. Sustainable growth is important and we must avoid serious outbreaks of disease. In light of this, it is clear, in my opinion, that the value of the Norwegian Veterinary Institute - which we consider in our report to be considerable - will continue to be significant, said Professor Linda Nøstbakken from NHH during the 125th Norwegian Veterinary Institute anniversary celebrations.

Together with Frode Skjeret from the Centre for Applied Research (SNF) at the Norwegian School of Economics, she presented an economy -based analysis of the contribution of the Norwegian Veterinary Institute to the Norwegian economy on the 12th of October 2016. The economists consider the value of the Norwegian Veterinary Institute is greatest where the market fails and where no other actors offering the same services exist. Nøstbakken also pointed out that the industry is under consolidation and that larger actors are becoming increasingly self-sufficient.

-There are several critical functions for which we clearly need an actor external to the industry. An actor which creates and conveys knowledge and which ensures sustainable growth within the industry, said Nøstbakken.

- The government desires considerable growth in the aquaculture industry in future years. Sustainable growth is important and we must avoid serious outbreaks of disease. In light of this, it is clear, in my opinion, that the value of the Norwegian Veterinary Institute- which we consider in our report to be considerable - will continue to be significant, said Professor Linda Nøstbakken from NHH during the 125th Norwegian Veterinary Institute anniversary celebrations. Photo: Eivind Røhne

5. Bacterial diseases of farmed salmonids

On the whole the situation regarding bacterial diseases of farmed salmonids is fairly good. In contrast to the situation for cleaner fish (see later), the situation is reasonably stable.

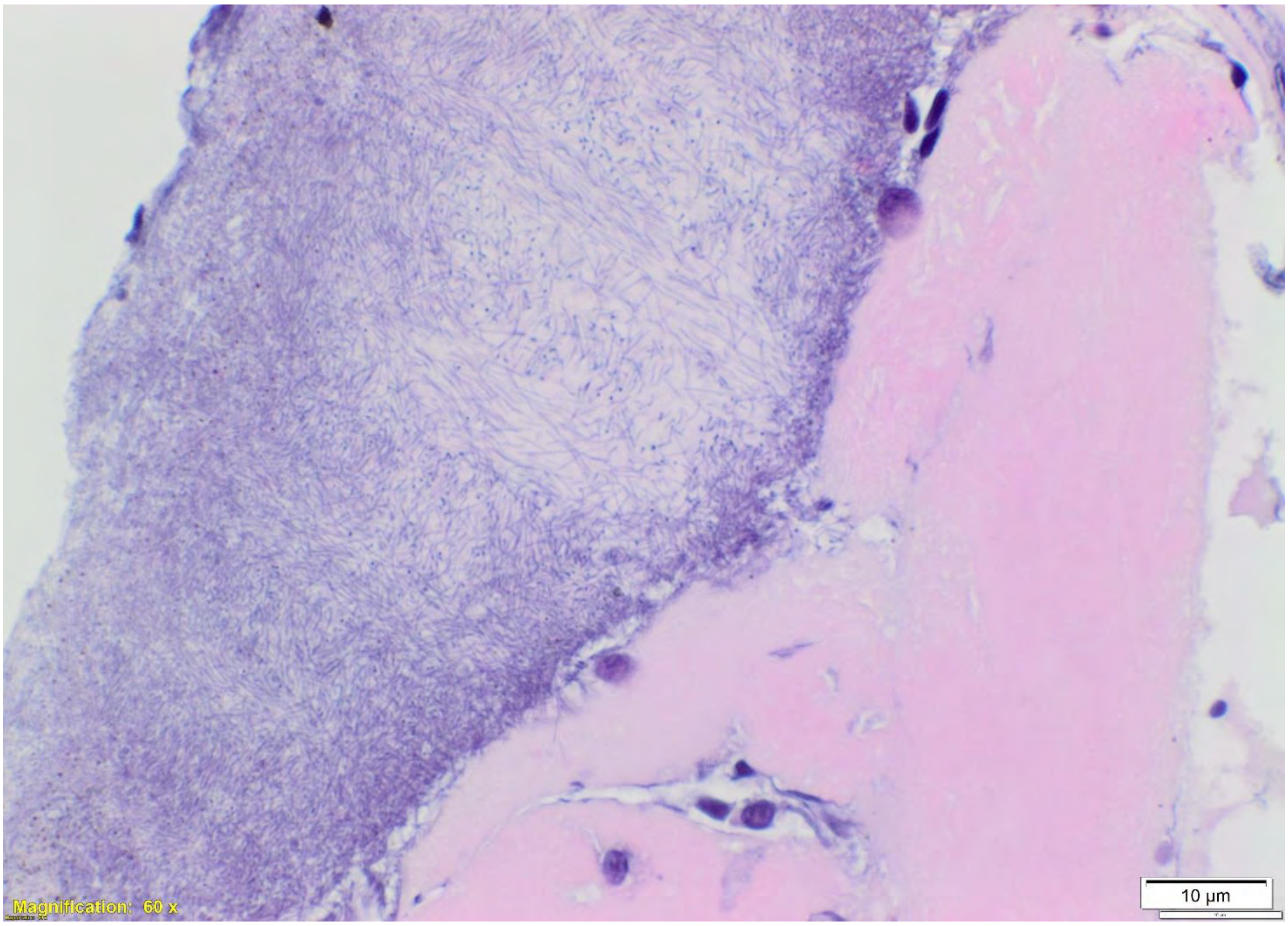
Winter ulcer is the bacterial disease which gives the greatest grounds for concern and in some cases represents a serious welfare problem. Important diseases such as furunculosis and vibriosis, which in earlier years caused serious losses, are under control, thanks to extensive vaccination programmes. Cold water vibriosis is now again under control following a slight increase in number of outbreaks during 2012/2013.

The numbers of outbreaks of notifiable diseases are the officially gathered statistics. For the remaining diseases, the number of diagnoses registered by the diagnostic service of the Norwegian Veterinary Institute are presented. Diagnoses made by other laboratories are not included.

General evaluation of the status of bacterial diseases 2016

Winter ulcer remains the most important bacterial disease nationwide and in some areas represents a considerable problem. The number of cases of yersiniosis has increased in recent years, and while the situation now appears to have stabilized somewhat, a number of farms were affected in 2016.

Individual diseases are discussed in separate sections below.



An example of injury to the skin and musculature caused by a bacterial infection. Photo: Geir Bornø, Norwegian Veterinary Institute.

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 not unusual finding in skin conditions in salmon *Salmo salar* L. farmed in freshwater.
Particular genotypes of the bacterium are associated with serious outbreaks off flavobacteriosis in rainbow trout. Other genotypes are found in salmon.

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, personell 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).

See the Norwegian Veterinary Institute fact sheet for more information on flavobacteriosis

The health situation in 2016

Official data
In 2016, systemic infection in rainbow trout was diagnosed in four farms in the same fjord system which has previously been affected. In addition, systemic disease was suspected in one further farm.
The four outbreaks all involved the same genotype (ST2). As previously recognized in this genotype, all isolates displayed reduced susceptibility to quinolone antibiotics.
ST2 belongs to a group of closely related genotypes which cause serious disease in rainbow trout around the world.

New for 2016 was identification of disease in 50g rainbow trout farmed in freshwater in Trøndelag. The fish developed skin ulcers and were morbid. Typical internal pathological changes consistent with systemic *F. psychrophilum* infection were not identified and *F. psychrophilum* was not identified in the internal organs of affected fish.

F. psychrophilum isolated from this outbreak belongs to a sporadically occurring genotype which we have previously associated with salmon. On one site flavobacteriosis was suspected in 40 g salmon but the bacterium was not cultured. *F. psychrophilum* was identified in association with ulcer development in one juvenile production unit and in 20g parr in a restocking hatchery. The genotype identified in both cases is a normal finding in salmon.

Evaluation of the situation for Flavobacteriosis
In the fjord system in which *F. psychrophilum* has been identified in later years, we consider the situation as stable. Identification of a sporadically occurring genotype in rainbow trout with clinical disease in another area of the country is, however, a new development. Such

genotypes are considered less virulent and more environmentally adapted than those closely related to genotype ST2. The situation should be monitored.

Successful management and combat of serious outbreaks of flavobacteriosis are dependent on close cooperation between industry, Fish Health Services, the Norwegian Food safety Authority and Research 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 which is found on the surface of the bacterium. Twenty-one different A-layer types have now been identified.

Despite identification of many different types of *A. salmonicida*, on the basis of economic importance, subsp. *salmonicida* continues to be known as 'typical' or 'classical', and the remaining strains as 'atypical'.

All variants of *A. salmonicida* are non-motile almost coccoid, 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 to be 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 vaccines introduced in the early 1990's have contributed to the effective disappearance of the disease from Norwegian aquaculture. Today the disease is under extremely good control, and very few outbreaks are registered.

See the Norwegian Veterinary Institute fact sheet for more information on furunculosis.

The health situation in 2016

Official data

Furunculosis was not identified in farmed salmonids in 2016, but *A. salmonicida* subsp. *salmonicida* was isolated from wild salmon sampled during collection of eggs in the river Bogna (detailed in section on wild salmon health). *A. salmonicida* subsp. *salmonicida* infection was also identified in farmed lumpsucker in four different salmon cage farms (detailed in section on cleaner fish health). The salmon held in the same cages as the infected lumpsucker did not show signs of disease.

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 now 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. In Norway BKD was first identified in 1980 in juvenile fish produced from wild broodstock. BKD outbreaks have been most frequently identified in western Norway where several rivers are considered to be 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 (*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
BKD is a notifiable disease and counter measures may have significant economic consequences. The diagnosis must, therefore, be verified.This is done by identifying pathological changes consistent with BKD and 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.

See the Norwegian Veterinary Institute fact sheet for more information on BKD.

The health situation in 2016

Official data
Bacterial kidney disease (BKD) is now only sporadically identified in Norway with between none and three cases occurring annually. In 2016 BKD was diagnosed in large salmon in a single farm in Sogn og Fjordane. Increased mortality was not registered in relation to the infection. Samples were taken during a screening program for PD virus.

Evaluation of the BKD situation
Todays BKD situation is favourable. It is, however, important that we remain vigilant, particularly during broodstock health surveillance.

Salmon with coldwater vibriosis. Archive photo: Marta Alarcon, Norwegian Veterinary Institute

5.4 Other bacterial infections of fish

By Duncan J. Colquhoun

Most bacterial infections of fish are a result of the interplay between the bacterium, the fish and the environment. A broad spectrum of bacteria may be isolated from sick fish, both recognized pathogens, opportunistic pathogens and presumed 'environmental contaminants'.

Even when a particular bacterium is found in significant quantities from several fish in the same population, it can be difficult to relate detection of the bacterium directly to disease. Examples of such bacteria isolated from clinically sick fish during 2016 include diverse members of the genera *Vibrio*, *Photobacterium*, *Alteromonas*, *Pseudoalteromonas*, *Psychrobacter* and *Polaribacter*. This type of bacterial flora is continually evaluated, such that new, emerging pathogenic types are rapidly identified.

Rhodococcus spp. have been confirmed to be related to post-vaccination infections in salmon. The bacterium was identified in three different salmon farms in 2016. One outbreak involved large sea-farmed salmon of approximately 3kg.

Coldwater vibriosis, caused by *Vibrio salmonicida,* was not identified in salmon in 2016. Coldwater vibriosis was, prior to introduction of effective vaccines, an extremely serious threat to salmon farmed in cold seawater in Norway. Following a modest increase in number of diagnoses in 2011-2013, almost certainly related to vaccine strategy, the number of cases has now normalised again.

Vibrio anguillarum serotype O1 infection was diagnosed in one salmon hatchery which utilised seawater and in large sea-farmed rainbow trout in a single farm in 2016.

Pseudomonas fluorescens was identified during diagnostic investigations in four salmon farms. None of these detections could be related to serious disease in the investigated fish populations.

Atypical *Aeromonas salmonicida* (atypical furunculosis) infection was not identified in farmed salmon during 2016.

Piscirickettsiosis, caused by *Piscirickettsia salmonis*, was identified in one farm in Norway in 2016. The bacterium remains a serious threat to salmon farming in Chile.

Winter ulcer in salmon is related to bacterial infection in cold seawater most commonly during the autumn or winter. Photo: Per Anthon Sæther, Marin Helse

5.5 Winter ulcer

By Duncan J. Colquhoun and Anne Berit Olsen

The disease
Ulcer development during the sea-phase of culture is a 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* results in ulcer development consistent with the disease, other bacteria including *Tenacibaculum* spp. and *Aliivibrio (Vibrio) wodanis* are often found during diagnostic investigations. The skin lesions are found primarily on the flanks of affected fish.

'Atypical' winter-ulcer or 'tenacibaculosis' is somewhat less usual. 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 apparent pure culture.

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.

The health situation in 2016

Data from the Norwegian Veterinary Institute
Information from Fish Health Services and the Norwegian Veterinary Institute regional laboratories show that ulcers were also prevalent in Norwegian farmed fish along the whole coast during 2016. The prevalence varies from area to area, but most identifications of both *Moritella viscosa* and *Tenacibaculum* spp. related to ulcer development in salmon were again made in northern Norway. This is presumably related to water temperature.

Questionnaire
In response to the questionnaire sent to Fish Health Services and the Norwegian Food Safety Authority, winter ulcer scored 3.0 on a national

basis (scale 1-5). Northern Norway scored highest (3.6), Mid-Norway (2.8), North-western (southern) Norway (2.0) and south western Norway (3.0)

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.

Field reports indicate that outbreaks of winter ulcer are commonly associated with de-licing treatments and other management procedures involving handling or stress.
It is therefore important to avoid management procedures which may predispose to ulcer development. The situation in the industry as a whole is considered to be relatively stable in recent years.

5.6 Yersiniosis

By Snorre Gulla

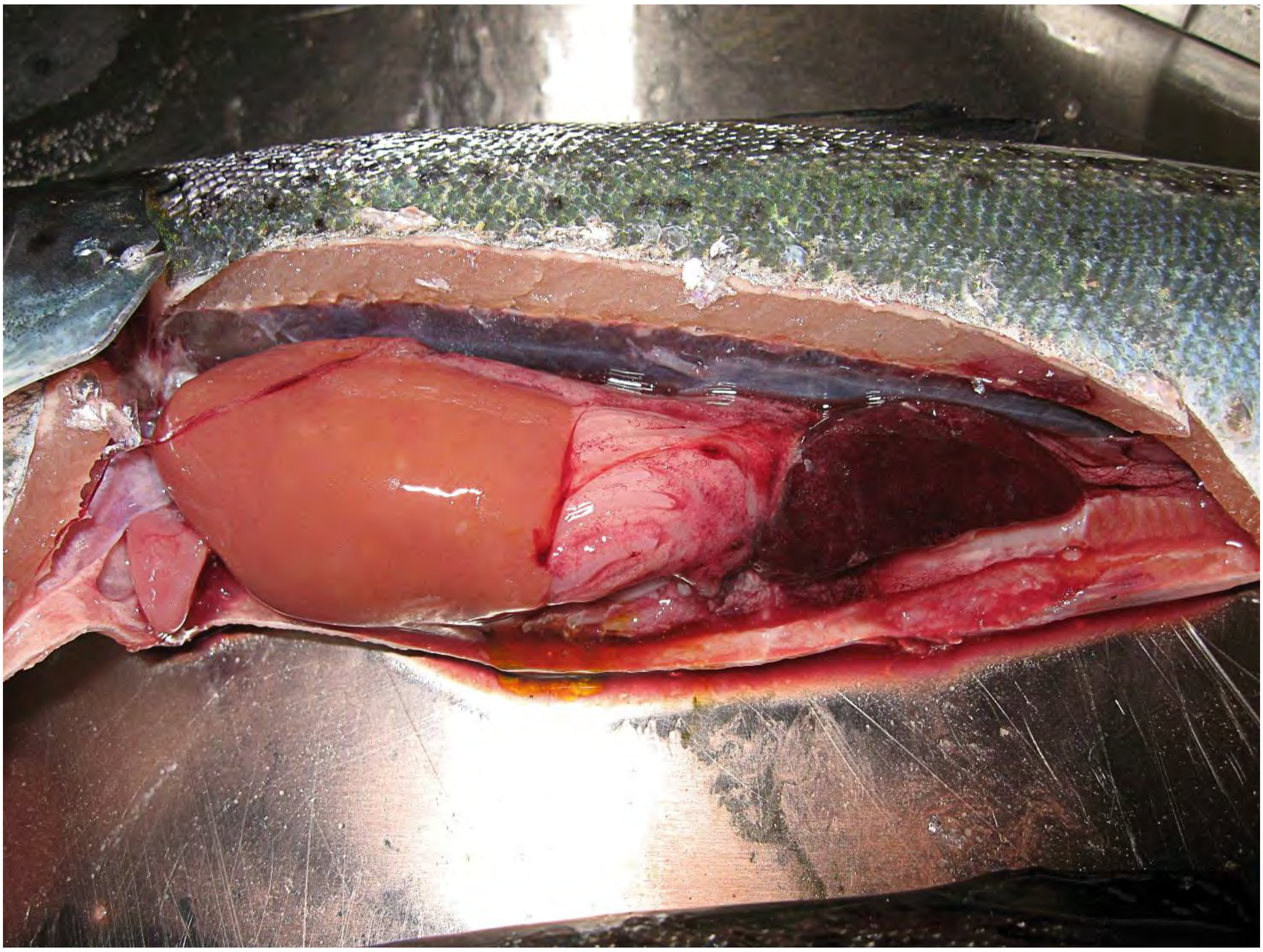
The disease

Yersiniosis, also known as enteric redmouth disease, is caused by the bacterium *Yersinia ruckeri*. The disease is recognized in several types of fish, but is most common salmonid fish. In Norway the disease is almost exclusively associated with farmed Atlantic salmon, manifesting with classical signs of systemic bacterial disease, (see photo below).

The disease may occur before and after sea-transfer, but infection is presumed to primarily occur during the freshwater phase. 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. *Y. ruckeri* can form biofilm and it is probable that such biofilms help the bacterium survive disinfection and other hygienic measures. It appears that some hatcheries are infected with 'house strains'.



Salmon with yersiniosis. The spleen is considerably enlarged. Photo: Per Anton Sæther, Marin Helse AS

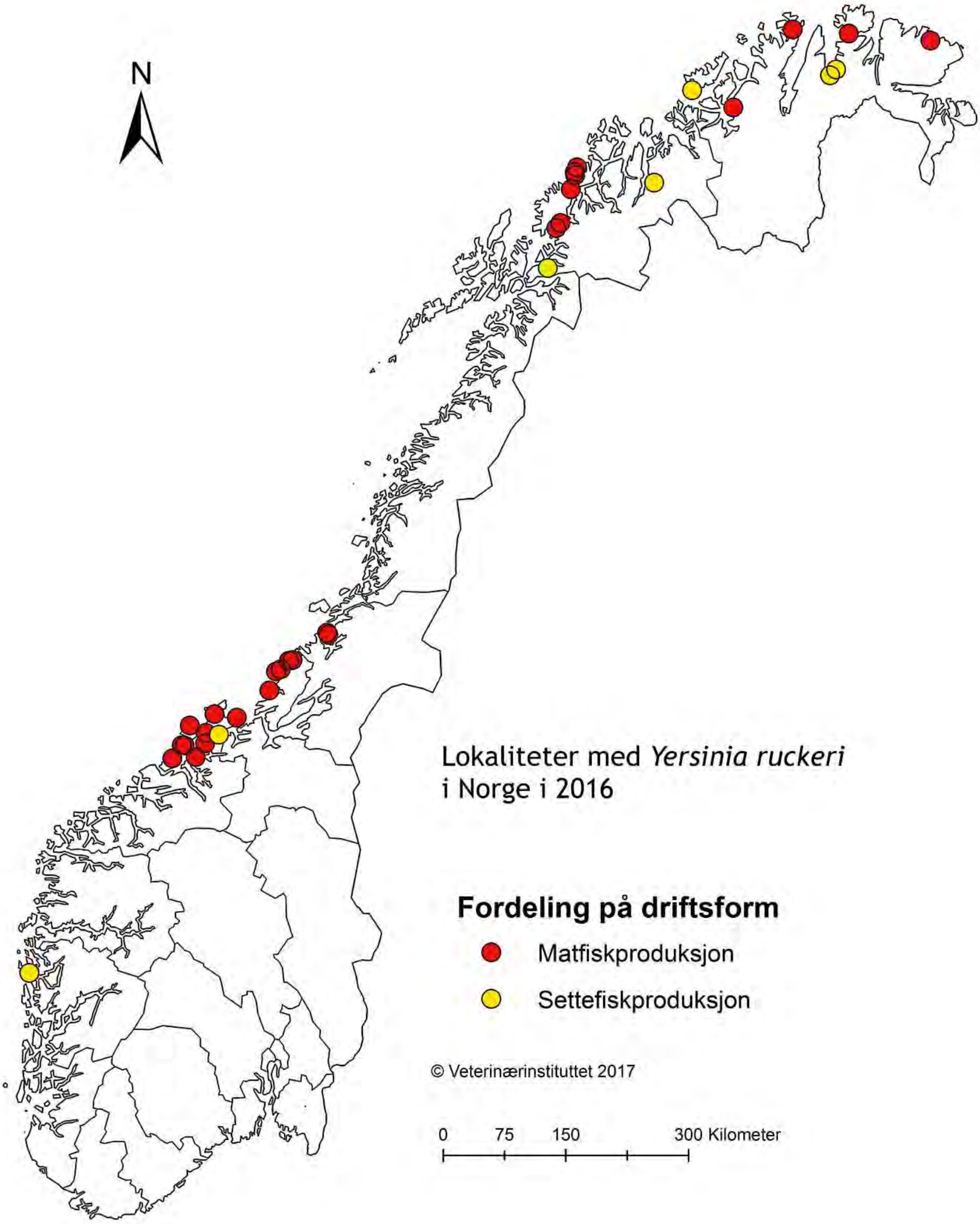


Figure 5.6.1: Distribution of *Y. ruckeri*-positive farms in Norway in 2016, based on cases diagnosed by the Norwegian Veterinary Institute

The health situation in 2016

Official data
The number of farms in which the Norwegian Veterinary Institute has identified *Y. ruckeri* held stable between 2015 and 2016 with 34 farms diagnosed both years. For 2016 these diagnoses were made in 27 ongrowing sites and seven hatcheries. *Y. ruckeri* infection was also identified in corkwing wrasse (a single individual) in one sea-farm, some months before the disease was registered in salmon. As far as we are aware this is the first detection of this bacterium in a cleaner fish species.
Most isolates submitted to or cultured by the Norwegian Veterinary Institute are serotyped. Of the isolates which were serotyped in 2016, 29 farms were associated with serotype O1, two with serotype O2 and in two farms both serotype O1 and O2 were identified.

With one exception all outbreaks of yersiniosis identified by the Norwegian Veterinary Institute occurred north of Sogn og Fjordane (Figure 5.6.1).

Evaluation of the yersiniosis situation
While the number of cases from 2015 and 2016 were alike, later years have seen a steady increase in the number of yersiniosis cases. (Figure 5.6.2). The largest increases are registered in ongrowing marine sites. The number of juvenile production sites affected shows a slight decline since 2012.

Around half of the juvenile production sites affected since 2007 also experience outbreaks the following year. It is likely that the number of juvenile sites experiencing recurring outbreaks is higher, but are not included in the Norwegian Veterinary Institute statistics as later diagnoses may be made in other laboratories. If this is the case, the increase in number of cases may be larger than we can presently document.

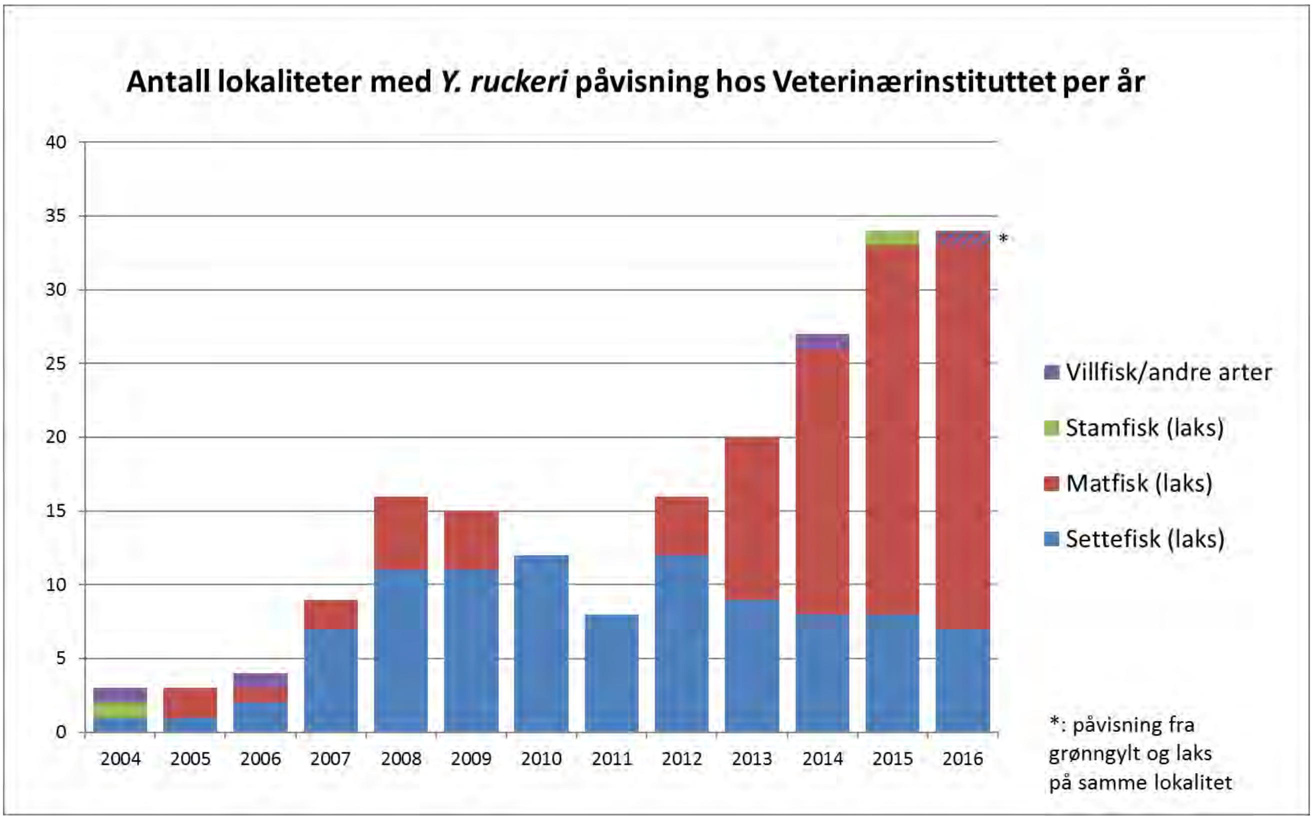


Figure 5.6.2: Annual number of *Y. ruckeri* diagnoses made by the Norwegian Veterinary Institute in recent years. Only one diagnosis is included for each farming site per year.

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Questionnaire

The questionnaire reveals that Fish Health Services and Norwegian Food Safety Authority personnel from north-west (southern) Norway and northwards consider yersiniosis as a much larger problem than their colleagues further south. Most consider infections in juvenile production units, particularly RAS, as most serious. Outbreaks during the sea-phase in the absence of previous freshwater outbreaks in the same population are also reported.

While it has long been clear that *Y. ruckeri* serotype O1 dominates the Norwegian situation, a genotyping method (MLVA) recently developed by the Norwegian Veterinary Institute reveals that a particular variant of serotype O1 has completely dominated all outbreaks of yersiniosis in Norway over the last twenty years. This MLVA type has not yet been identified outside Norway. It may be hypothesized that this MLVA variant represents a host-adapted clone with high virulence for Atlantic salmon. The small number of O1 isolates typed from clinically healthy Norwegian broodstock salmon do not belong to the same MLVA type.

Using MLVA the Norwegian Veterinary Institute has also identified sub-types of the main clone which have been associated with specific juvenile production units over several years. These subtypes are also identified in subsequent outbreaks at sea. These results also support the theory that some hatcheries are infected with 'house strains' of *Y. ruckeri*. The Norwegian Veterinary Institute is also currently studying other aspects of the yersiniosis problem including control of *Y. ruckeri* in biofilm.

Yersiniosis represents today one of the most important bacterial diseases in Norwegian salmon farming. While most outbreaks were registered during the sea-phase of culture in 2016, some without any previous *Yersinia* history in freshwater, it is considered that in most cases the initial infection occurs in freshwater. It is possible that 'house strains' are established in these hatcheries which may be difficult to eradicate using present eradication techniques. Several farms have, however, reported lower losses after introduction of intraperitoneal vaccination. The main route of infection into hatcheries is not currently known.

5.7 Antibiotic sensitivity in bacterial salmon pathogens

By Duncan J. Colquhoun

Antibiotic use in Norwegian aquaculture remains at a very low level, although antibiotic use is at times necessary in treatment of bacterial disease.

Antibiotic resistance is a naturally occurring phenomenon in environmental bacteria. Identification of bacteria 'naturally resistant' to certain classes of antibiotic is a regular occurrence e.g. *Tenacibaculum* (oxolinic acid) and *Pseudomonas* (most antibiotics).

Bacteria of clinical importance in which reduced sensitivity to oxolinic acid has been identified in 2016 include *Flavobacterium psychrophilum* isolated from diseased rainbow trout. *Yersinia ruckeri* displaying reduced sensitivity to oxolinic acid was also identified from three salmon farms as was *Vibrio anguillarum* serotype O1 isolated from a single salmon farm.

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 considered low.

Reduced sensitivity to quinolone antibiotics has again been identified in an *Aeromonas salmonicida* subsp. *salmonicida* strain isolated from wild salmon sampled during stripping in the river Bogna (see chapter on wild salmonid health for further details). This strain has been isolated from wild salmonids in this area for a number of years, and has again in 2016 been isolated from diseased cage-held lumpsucker in the same region (see cleaner fish health chapter).

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 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-like layer spreading across the skin. Diagnosis, based on macroscopic investigation is, therefore, comparatively easy. Fish die as a result of osmoregulatory failure. Cases are observed in which the gills alone appear to be the main organ affected. It is considered likely that fish affected in this way die by suffocation.

The disease occurs mainly in fish in which the mucus layer or skin is already damaged or which are exposed 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. Over the last two years or so, outbreaks of systemic mycosis have been identified in farmed lumpsucker. No causal relationship has yet been established in such cases.

The health situation in 2016
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
There was an increase in the number of diagnoses relating to fungal disease in 2016 compared to earlier years. The increase is entirely related to cases of saprolegniosis. The reason for the increase is unknown, but may be related to regulation of the use of formalin as an anti-fungal treatment. This situation may lead to an increased requirement for laboratory confirmation of diagnoses which previously may have been performed in the field.

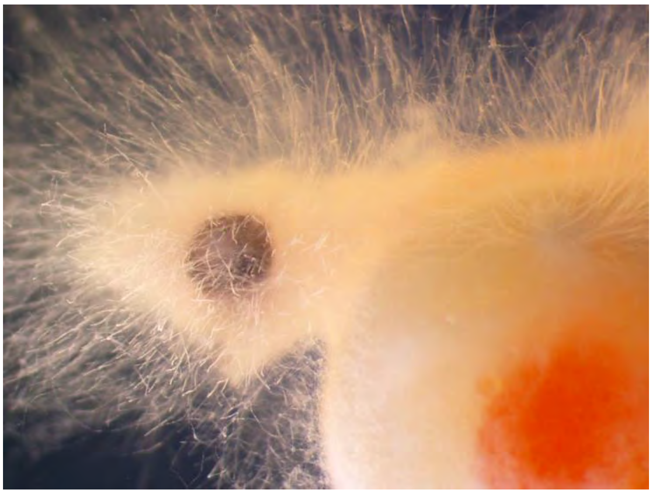
The registered cases are distributed between wild and farmed fish from all stages of freshwater culture but mainly fry and parr. It is noteworthy that several cases of saprolegniosis of the gill (mycotic gill inflammation) are diagnosed in fish with concurrent salmon gill pox virus (SGPV) infection. This combination is also reported from the field. Mycotic gill inflammation may therefore indicate a need for SGPV analysis. The virus has also been identified in marine species, both experimentally and during wild fish surveillance. These species may therefore act as a reservoir.

Transmission appears to be related to trade in infected salmonid eggs and fry.

See the Norwegian Veterinary Institute fact sheet for more information on saprolegniosis.

Parr with saprolegniosis

Brown trout with saprolegniosis of the eye and operculum



Yolk sac larvae with saprolegniosis

All photos; Even Thoen

7. Parasite diseases in farmed salmonids

The salmon louse represented by far the most significant parasite threat to salmonid production in 2016. It also represents one of the greatest limiting factors in production of salmonids with high costs associated with the extensive and frequent treatments required. Development of resistance and high mortalities associated with de-licing are an increasing challenge to the industry. The situation for AGD appears similar to the previous year.

Injuries caused by salmon lice. Photo: Silviya Spirova, HaVet *fiskehelsetjeneste*

7.1 The salmon louse - *Lepeophtheirus salmonis*

By Kari Olli Helgesen and Peder Jansen

The parasite

The salmon louse (*Lepeophtheirus salmonis*) is a naturally occurring crustacean parasitic for salmonid fish in marine environments in the northern hemisphere. The lifecycle comprises eight developmental stages which are separated by exoskeleton shifts. 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 kilometers. The last five stages are all parasitic on anadromous salmonid fish in the sea.

Lice 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 injury and anaemia in the fish.

Lesions may then 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 louse represents one of the most serious problems in Norwegian aquaculture today.

Control

The maximum permitted lice burden is defined in legislation. Lice numbers are monitored and reported regularly. Current legislation states that salmon lice must be controlled to ensure the maximum permitted lice burden is not exceeded. The main control measures have traditionally been pharmaceutically based, but increasing levels of resistence have led to a situation in which alternative methods are starting to dominate. Farmers commonly now use a combination of preventative measures, continual de-licing (mainly cleaner fish) and both pharmaceutical and non-pharmaceutical methods.

The increased frequency of treatment and increased use of non-pharmaceutical control methodology has led to a considerable increase in production costs in farming of salmonids in open cages, as there is a risk of injury and mortality related to every treatment.

See the Norwegian Veterinary Institute Fact Sheet on salmon lice for more information.

The health situation in 2016

Official statistics

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.

The situation for 2016 was, on the whole, similar to previous years. As in 2015, spring lice levels were somewhat higher than previous years, but the peak levels were slightly lower than previously. For 2016, the peak numbers of adult females and other motile stages were registered in September (Figure 7.1.1).

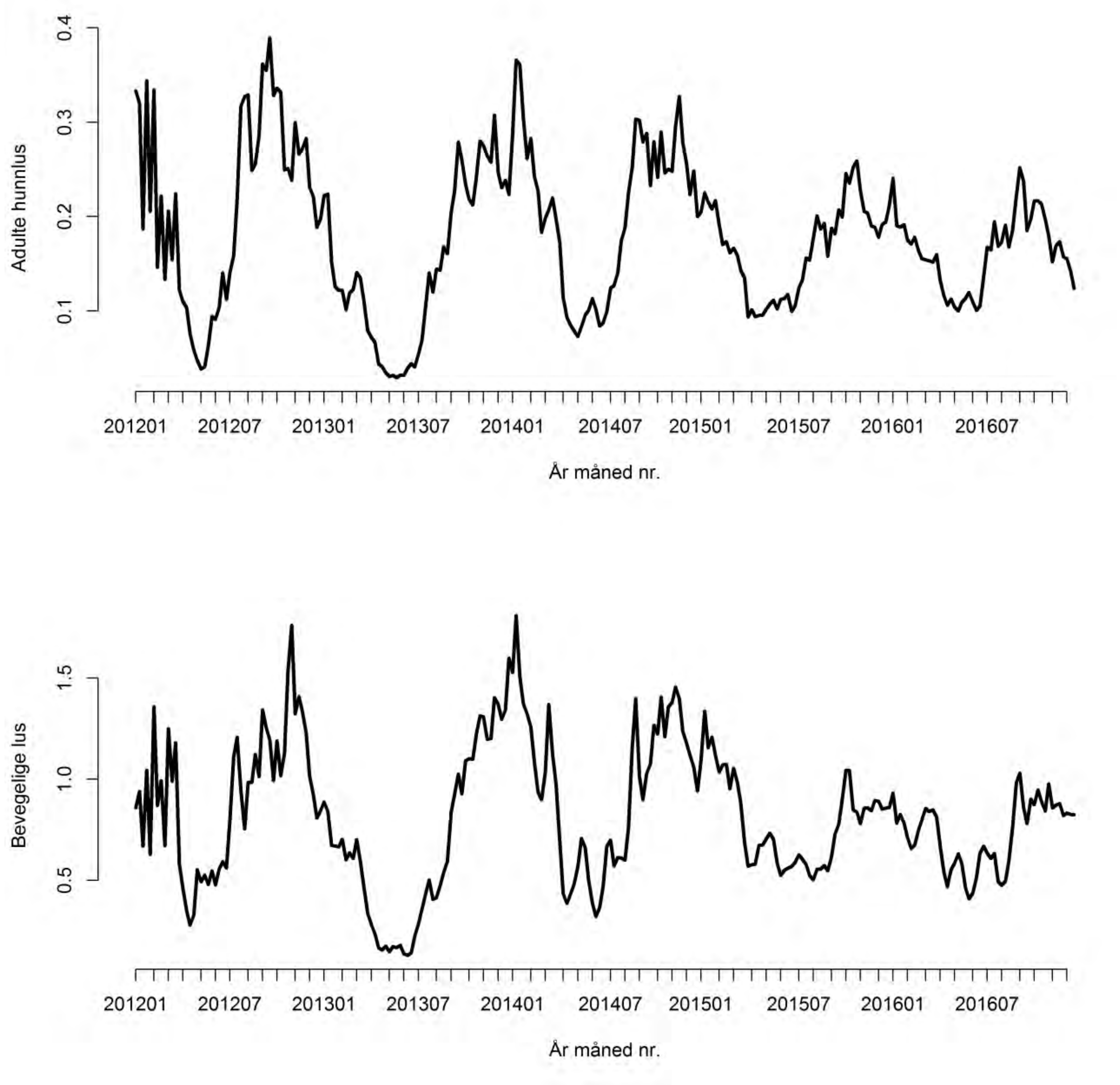


Figure 7.1.1. Average weekly reported lice counts for all marine farms holding salmon and rainbow trout, for the whole country between January 2012 and December 2016. The upper panel describes reported figures for adult female lice and the lower panel describes reported figures for other motile stages (pre-adult and adult male lice).

To be able to evaluate the lice situation in more detail, we have calculated production of salmon louse larvae in southern-, mid- and northern-Norway for the period 2012-2016. These calculations reveal a change in the situation (Figure 7.1.2), in which production of larvae increased in southern areas and reduced slightly in mid-Norway in comparison to 2015. Taken together, total production in these areas was similar in 2016 to the previous year, but the peak in production was slightly earlier in the southern area compared to mid-Norway. Production in the northern region remained at similar low levels as in previous years.

Calculation of lice production is based on reported lice statistics, number of fish and sea temperature, together with knowledge of reproductive capacity, developmental time and survival of the various developmental stages (Kristoffersen et al. 2014, Epidemics 9: 31-39).

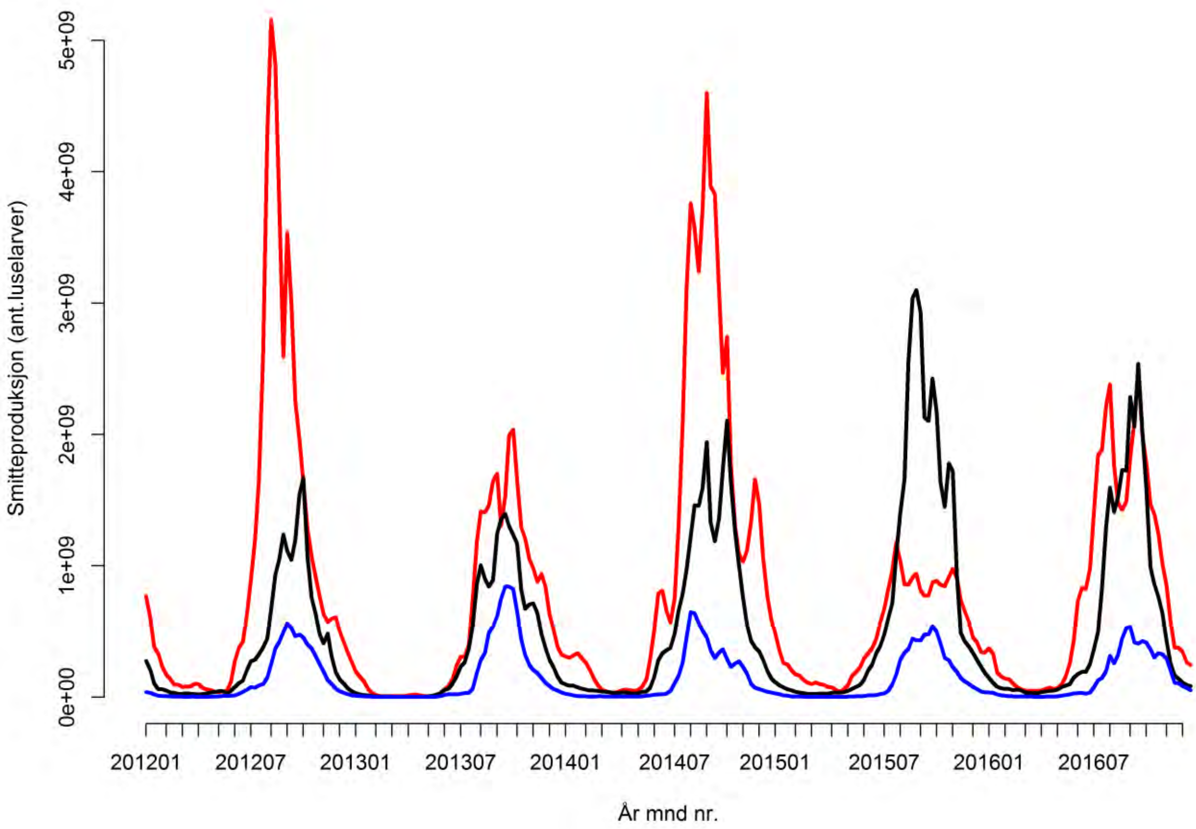


Figure 7.1.2 Estimated total production of louse larvae per week on all farms in southern (red line), mid (black line) and northern (blue line) areas for the period 2012 - 2016. The northern area includes all sites north of latitude 66.85 the southern, south of latitude 62.55

The upper panel in figure 7.1.3 shows total production of louse larvae. The figure shows that in 2016 louse production, as in the previous figure, was greatest in the mid- and southern areas of Norway. The Norwegian Veterinary Institute has developed models for theoretical calculation of infection pressure which allow estimation of future infection pressure for all individual farming sites along the Norwegian coastline. Through modelling of infection contact taking into account the distance between farms, the ‘internal' infection pressure produced by individual farms and the ‘external' infection pressure towards other farms (and from other farms) may be estimated. The lower panel of figure 7.1.3 displays the average infection pressure experienced by farms along the coast during 2016. These areas are consistent with the areas in which production of louse eggs was highest. Compared to the two previous years, both Agder and Troms experienced a higher average infection pressure in 2016.

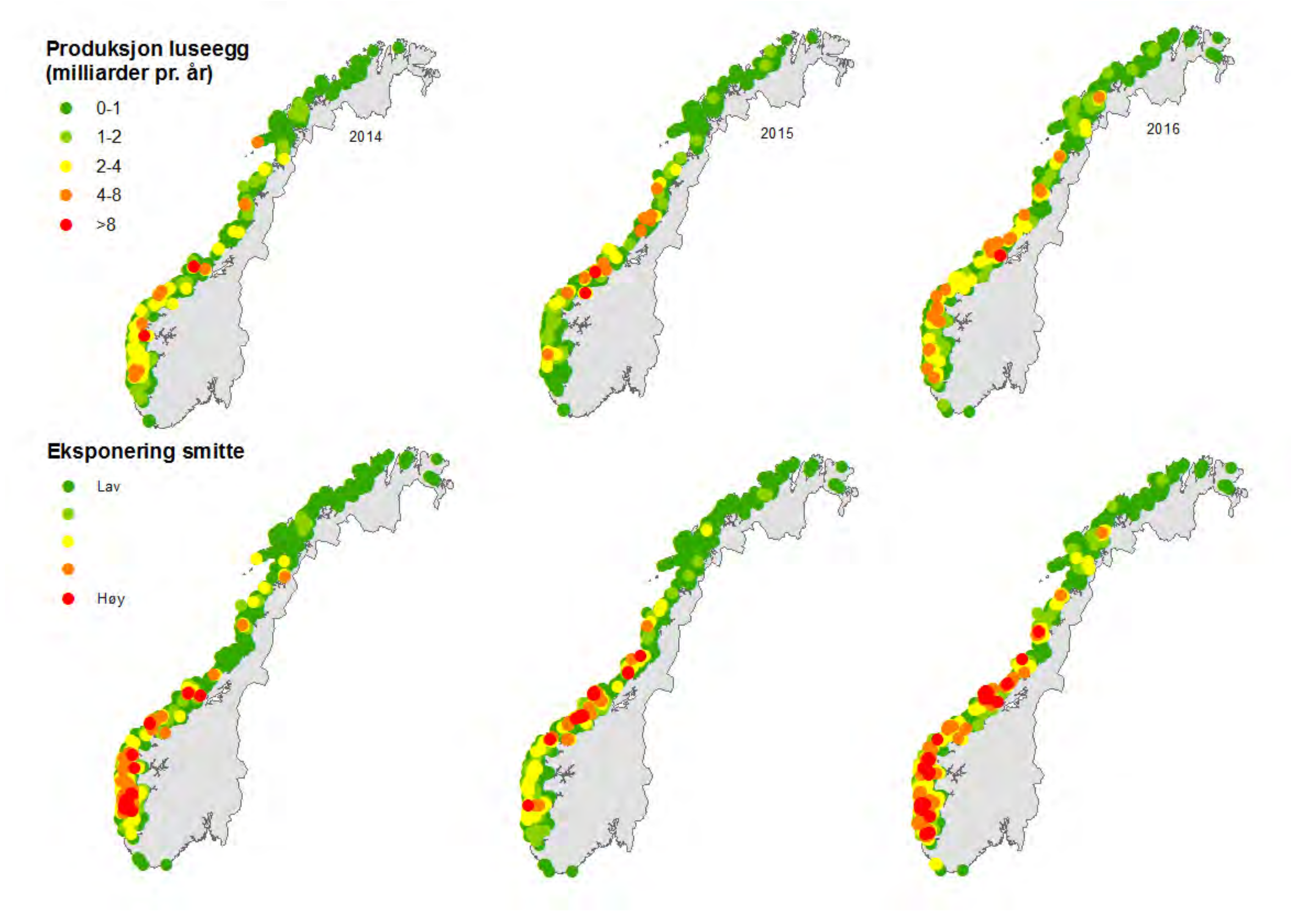


Figure 7.1.3: The upper panel shows the annual number of louse eggs produced per farm between 2014 and 2016. The lower panel shows the average infection pressure for the same period. Infection pressure is presented as relative copepodite density, from low density (green) to high (red).

In August 2016 a situation developed in several farms around the island of Frøya in Sør-Trøndelag, where lice numbers could not be controlled. Farms in the area were forced to initiate emergency harvesting. Some farms were unable to harvest quickly enough to avoid lice injuries to infested fish. Some weeks in advance of the high lice counts, the farms involved had experienced high infection pressure (see figure 7.1.4). Other areas also experienced high infection pressures during the autumn of 2016, but we are unaware of similar cases of injury to fish.

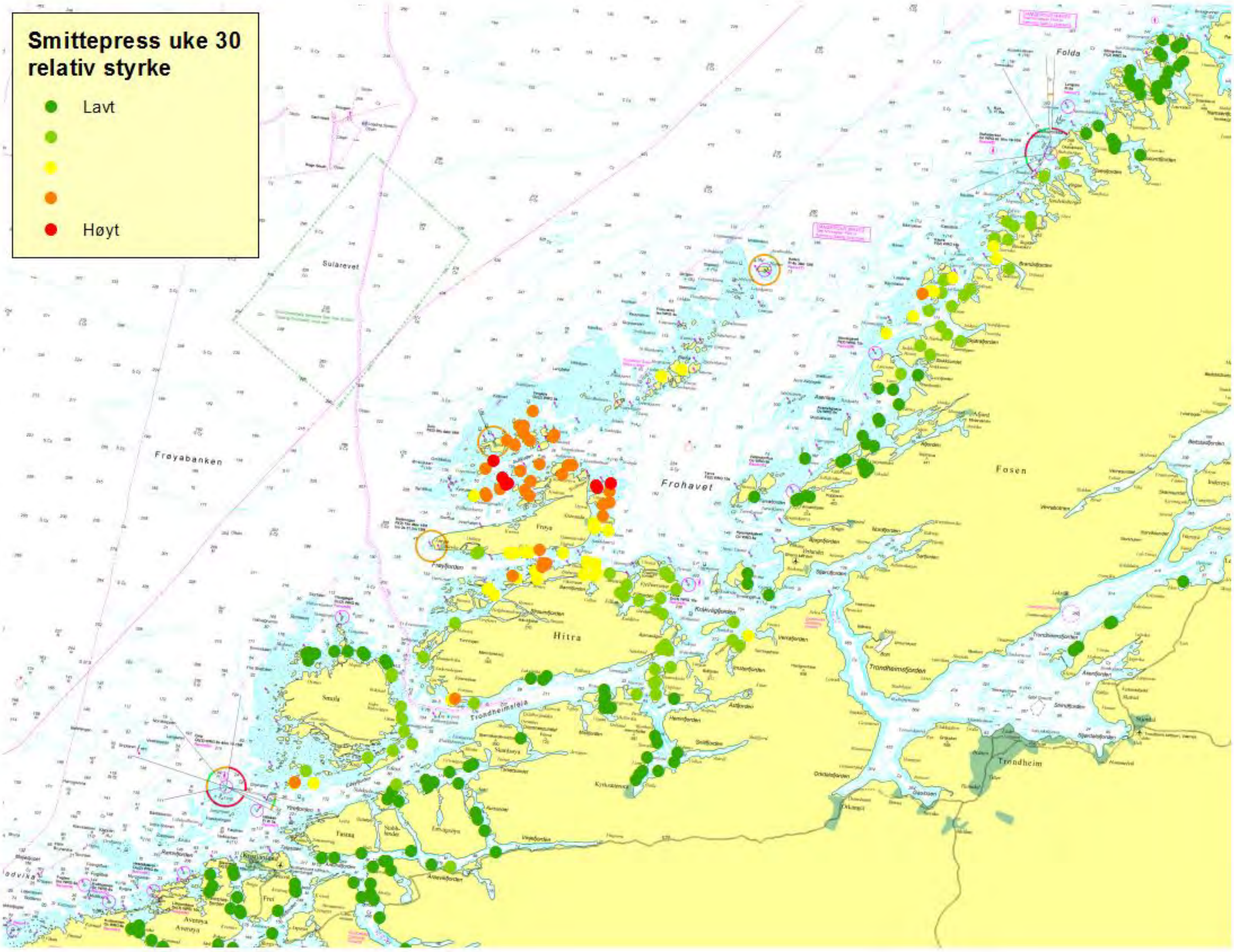


Figure 7.1.4: The map shows infection pressure towards farms in Trøndelag and Møre og Romsdal during week 30 in 2016. Infection pressure is given as relative density of copepodites in a colour scale from low density (green) to high (red).

The number of treatments against salmon lice in 2016 is summarized in Table 7.1.1. Pharmaceutical treatment totals are based on the number of registered prescriptions in the Medicine register, while the non-pharmaceutical treatment totals are based on treatments registered as mechanical during weekly reporting of lice burden to the Norwegian Food safety Authority. Non-pharmaceutical treatments include both thermal and mechanical de-licing as well as freshwater treatment.

The table shows that the number of pharmaceutical treatments was vastly reduced in 2016 compared to previous years. At the active ingredient level use of pharmaceutical products such as azamethiphos, pyrethroids and hydrogen peroxide was considerably reduced, while use of flubenzurones was somewhat reduced.

The statistics do not distinguish hydrogen peroxide used for salmon louse and AGD treatments. Emamectin benzoate was the only active ingredient which was prescribed more commonly in 2016 than in 2015. This continued increase in use is related to the use of emamectin benzoate to prevent copepodite attachment, in addition to treatment of infected fish.

The reduced prescription of pharmaceutical products for treatment of salmon lice infection is probably based on several factors. One factor is the reduced effect due to increasing resistance against such products. Increased use of mechanical methodology is another. In addition there is increasing use of preventative measures and methods aimed at continual removal of lice e.g. cleaner fish.

Table 7.1.1 Number of prescriptions for each category of active substance for treatment of lice between 2011 and 2016, including non-medicinal treatments

Virkestoff kategori	2011	2012	2013	2014	2015	2016
Azametifos	409	691	480	749	616	257
Pyretroider	456	1155	1123	1043	660	275
Emamektin benzoat	288	164	162	481	522	607
Flubenzuroner	23	129	170	195	201	173
Hydrogenperoksid	172	110	250	1009	1270	629
Sum legemidler	**1348**	**2249**	**2185**	**3477**	**3269**	**1941**
Ikke-medikamentelle behandlinger		136	110	176	185	1174
Sum alle behandlinger	**1348**	**2385**	**2295**	**3653**	**3454**	**3115**

Figure 7.1.5 shows the results of surveillance of salmon louse resistance performed by the Norwegian Veterinary Institute on behalf of the Norwegian Food Safety Authority. This program utilized bioassays (research methodology in which the toxic effect of pharmaceutical agents is tested on living lice) of azamethiphos, the pyrethroid deltamethrin, emamectin benzoate and hydrogen peroxide. The maps show extensive resistance against emamectin benzoate, deltamethrin and azamethiphos in salmon lice sampled from different sites along the coast. For hydrogen peroxide the map shows a certain degree of resistance in some areas and sensitivity in other areas.

Questionnaire 2016

In the questionnaire sent to Fish Health Service and Norwegian Food Safety Authority employees, these sources identified salmon lice as the main health related threat to salmon and rainbow trout. The salmon louse scored an average of 4.8 (maximum score = 5) for salmon farms and 4.5 for rainbow trout farms. The same situation is reported for broodstock farms for salmon (average score 4.0) and rainbow trout (average score 4.2).

Mechanical injuries following de-licing were also scored as a serious problem, with an average score of 4.0. Sixty five percent of correspondents had experienced ‘considerable mortality’ following pharmaceutical based treatment. Forty percent had experienced this in ‘a few sites’, while 25% had experienced this in ‘some’ or ‘many’ sites. Ninety three percent had registered ‘significant mortality’ following non-pharmaceutical treatment. Twenty eight % of these had registered this in ‘a few sites’, while 65% had experienced this in ‘some’ or ‘many’ farms.

In addition to the general questionnaire the Norwegian Veterinary Institute has also conducted its own questionnaire on the welfare challenges related to mechanical de-licing. The results of this questionnaire are discussed in the ‘welfare’ section of this report.

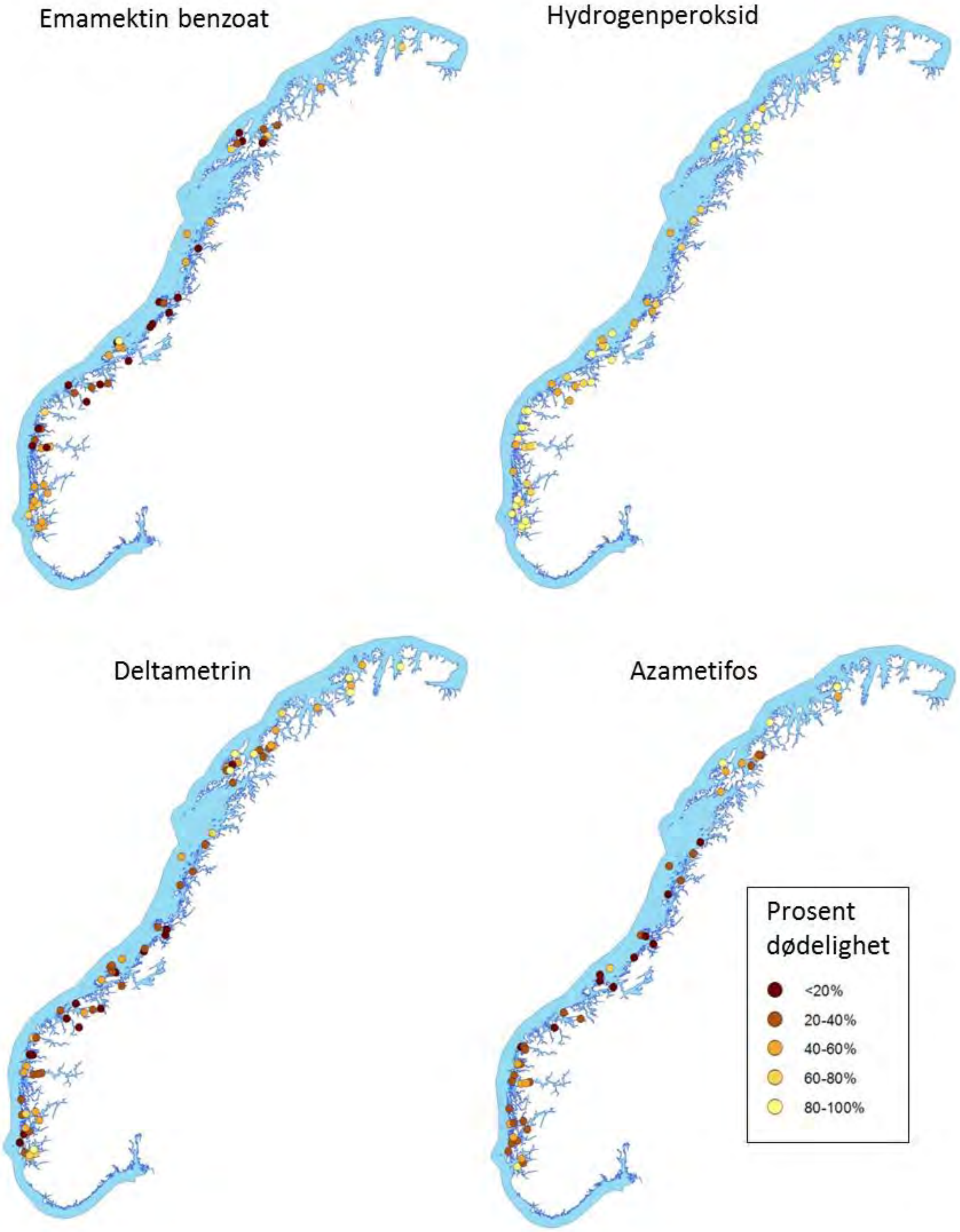


Figure 7.1.5: Mortality of lice in a bioassay for emamectin benzoate, hydrogen peroxide, deltamethrin and azamethiphos, where dark colour represents lower mortality (resistance) on exposure to a certain concentration of the active substance.

Evaluation of the salmon louse situation

The situation for 2016 has changed somewhat since 2015. For the whole of the country the numbers of lice were similar to previous years, but with an increase in egg production and infection pressure in southern areas and a decrease in the middle of the country. Troms and Agder also experienced a higher infection pressure in 2016 than in 2015.

The number of pharmaceutical based treatments fell by 41%, while the number of non-pharmaceutical treatments increased significantly.

The resistance situation remained serious along the whole coast in 2016. Direct lice injuries became apparent in some farms, demonstrating the limitations of current counter lice strategies. This may account for the increase in use of non-pharmaceutical treatments. While both pharmaceutical and non-pharmaceutical treatments against salmon lice may result in significant mortality it is most commonly associated with non-pharmaceutical treatments. Given the changes in treatment practice between 2015 and 2016, there are grounds for concern regarding future mortality levels in relation to treatments performed in 2017.

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 not in subsequent years. Since 2012 it has, however, caused considerable losses. AGD affects fish farmed in seawater, primarily Atlantic salmon but also other farmed species such as rainbow trout, lumpsucker and various wrasse spp.
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 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 (H_2O_2) or freshwater. Neither treatment form appears to be 100% effective and treatment must often 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 H_2O_2.

Treatment of AGD has best effect when it is performed in the early stages of disease development. This reduces the probability for 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 visual study of the gills.

A scoring system has been developed for classification of macroscopically visible changes associated with AGD. This scoring system, together with direct microscopy of gill scrapes constitute important tools for Fish Health Services. Scoring of gills can be difficult after 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.

See the Norwegian Veterinary Institute fact sheet on AGD for more information.

The health situation in 2016

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 by AGD. However, during the autumn of 2016 the Norwegian Veterinary Institute obtained continuous situation updates from Åkerblå AS, FoMas - Fiskehelse og Miljø as, PatoGen Analyse AS, Labora AS and Pharmaq Analytiq AS (Fish Health Services and commercial diagnostic laboratories).

In 2016 *P. perurans* was detected by qPCR from Vest-Agder in the south to Nord-Trøndelag in the north. AGD has as yet not been identified north of Nord-Trøndelag. There is limited sampling performed in this part of the country, but screening is performed in exposed sites with high salinity. Towards the end of August the first signs of disease were registered and an increasing number of farms were affected throughout September. The first treatments were performed at this time.
In October the number of reports of disease increased from Rogaland and northwards.

A number of treatments were performed during September and October with some sites being treated several times. In Rogaland and Hordaland only two treatments were reported (with salmon lice being the dominant finding), while in northern west Norway there was a considerably higher frequency of treatment. The AGD situation began to ease by the end of November.

Questionnaire
The importance of AGD as a disease varies from 'very important' for salmon farming in the southern part of Norway (score of 3.8), with a lower weighting farther north. AGD as a threat to rainbow trout is also considered greater in the south than the north, but is generally considered a lesser threat to rainbow trout than salmon.

Evaluation of the AGD situation
Generally the situation in 2016 appears to be similar to that experienced in 2015. Whether this may be related to climatic conditions or other factors is unknown. An important factor may be that farmers are becoming more experienced at managing AGD outbreaks, particularly in relation to the necessity and timing of treatments. Reports from the field indicate that treatments are more regularly performed in the northern part of western Norway than farther south.

7.3. Other parasite infections

By Haakon Hansen

In addition to the most common parasites such as the salmon louse and *Paramoeba perurans* there are several parasites which may infect and cause disease in fish. The most important agents are considered here.

Desmozoon lepeophtherii (syn.Paranucleospora theridion)
Desmozoon lepeophtherii is a microsporidean first identified as a parasite of the salmon louse, but later associated with 'Autumn disease' in farmed salmon. These parasite are very small and may have previously been overlooked during histological investigations. The parasite has a high prevalence in farmed salmon but is only considered of clinical importance by a few correspondents to the annual questionnaire. The significance of the infection is as yet uncertain.

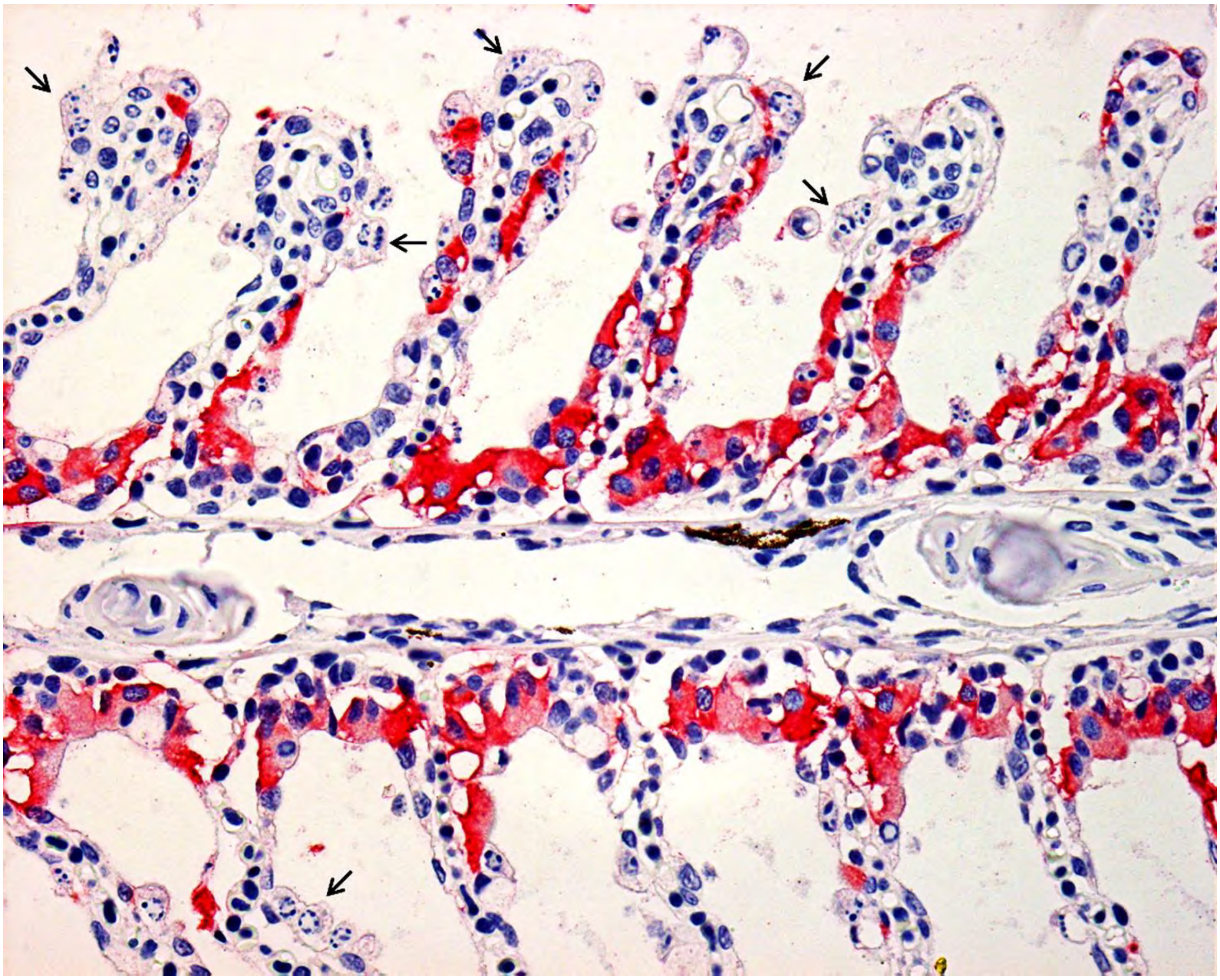
Parvicapsula pseudobranchicola (parvicapsulosis)
Parvicapsulosis, caused by *Parvicapsula pseudobranchicola* may result in high mortality in ongrowing salmon. The parasite has a broad geographical range and is found at a high prevalence in wild salmonids. Parvicapsulosis is only reported as problematic in farms situated in Troms and Finnmark. In 2016 the Norwegian Veterinary Institute identified the parasite (mainly via histological investigation) in 39 salmon farms and a single wild fish (Trøndelag). Diagnoses in commercial fish farms in 2016 were restricted to the three most northerly regions, with 19 situated in Finnmark, 17 in Troms and 3 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* is as yet unknown, but the search to identify it continues.

Ichthyobodo spp. *(«Costia»)*
There are at least two species of this parasite 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. on 53 farms in Norway in 2016. Most diagnoses related to salmon, both in juvenile production sites and in ongrowing sites. *Ichthyobodo* spp. were also identified in rainbow trout, halibut, ballan wrasse and lumpsucker.

Tapeworm - Eubothrium spp.
An increasing prevalence of intestinal tapeworm in sea-farmed salmon has been reported in recent years, and again in 2016 several Fish Health Services reported problems associated with this parasite. Tapeworm infestations may lead to increased feed consumption and decreased growth of the affected fish. Infestations 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 by Fish Health Services. The Norwegian Veterinary Institute identified tapeworm in 40 sites in 2016. No diagnoses were made north of Nord-Trøndelag.

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) will be discussed.



Salmon pox virus is a microorganism which can cause gill disease. Photo: Mona Gjessing, Norwegian Veterinary Institute.

8.1 Gill disease in farmed salmonids

By Anne-Gerd Gjevre and Mona Gjessing

The disease
Gill disease affects salmon farmed in both freshwater and seawater. While various environmental factors and microorganisms may be involved the role of the various factors and agents is poorly understood. Organic and inorganic substances in the water may have a negative effect on gill health. 'Epitheliocystis' is caused by bacteria living within cells on the surface of the gills. *Branchiomonas cysticola* is one such bacterium. Other microorganisms which may cause serious disease are the microsporidean *Desmozoon lepeophtherii*, salmon pox virus, 'Costia' and the amoeba *Paramoeba perurans* which causes ameobic gill disease (AGD). In many cases several agents are present and the pathological changes to the gill may vary. Disease caused by salmon pox virus often manifests as an acute disease with high mortality during the juvenile phase of production. We have also identified disease problems involving salmon pox virus many months after sea transfer. *P. perurans* only causes disease in sea water farmed fish. *B. cysticola* may also cause gill disease in both juvenile production units and during ongrowing. Gill diseases often have a chronic course and cause considerable losses particularly during the marine phase. Algal and zooplankton blooms as well as fouling organisms e.g. hydroids released during net cleaning, may also damage fish gills.

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

Focus on biosecurity is important. Disinfection of biofilters in RAS farms should be considered in cases of recurring gill disease. On outbreak of disease caused by salmon pox, 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.

See the Norwegian Veterinary Institute Fact Sheet on chronic gill inflammation in salmon and salmon pox for more information.

Health situation in 2016

Official statistics
Gill disease is non-notifiable. It is therefore difficult to estimate how many farms are affected each year. Figure 8.1.1 shows the farms in which pox virus was identified by the Norwegian Veterinary Institute in 2016.

Evaluation of the gill disease situation
The prevalence of gill disease appears to vary from year to year, but it remains one of the most persistent and serious diseases of Norwegian sea-farmed salmon. Rainbow trout appear to be less affected than salmon.

Ongrowing farms and broodstock

The salmon pox virus situation in ongrowing and broodstock sites appears similar over the whole country, with the virus scoring an average 2.2 nationwide. This is a similar score to IPN, tapeworm, algae and jellyfish.

For chronic gill inflammation and other gill diseases, the problem is considered least important in the north and greatest in western Norway, where it was awarded a score of >4. In comparison AGD scored 3.9 in the same region.

Juvenile production units

Disease caused by salmon pox virus is considered a greater problem in juvenile production units in the north than in the remainder of the country. Some farms have a really serious problem with the virus. The disease appears to be worse in throughflow systems (score 2.5) compared to RAS (score 2.0).

Some consider *D. lepeophtherii* to represent a moderate threat (score 3) to juvenile salmon. The microsporidean was also reported during this phase of culture in 2015. The significance of such infections is not well understood. Non-specific gill problems occur in both throughflow and recirculation based culture systems.

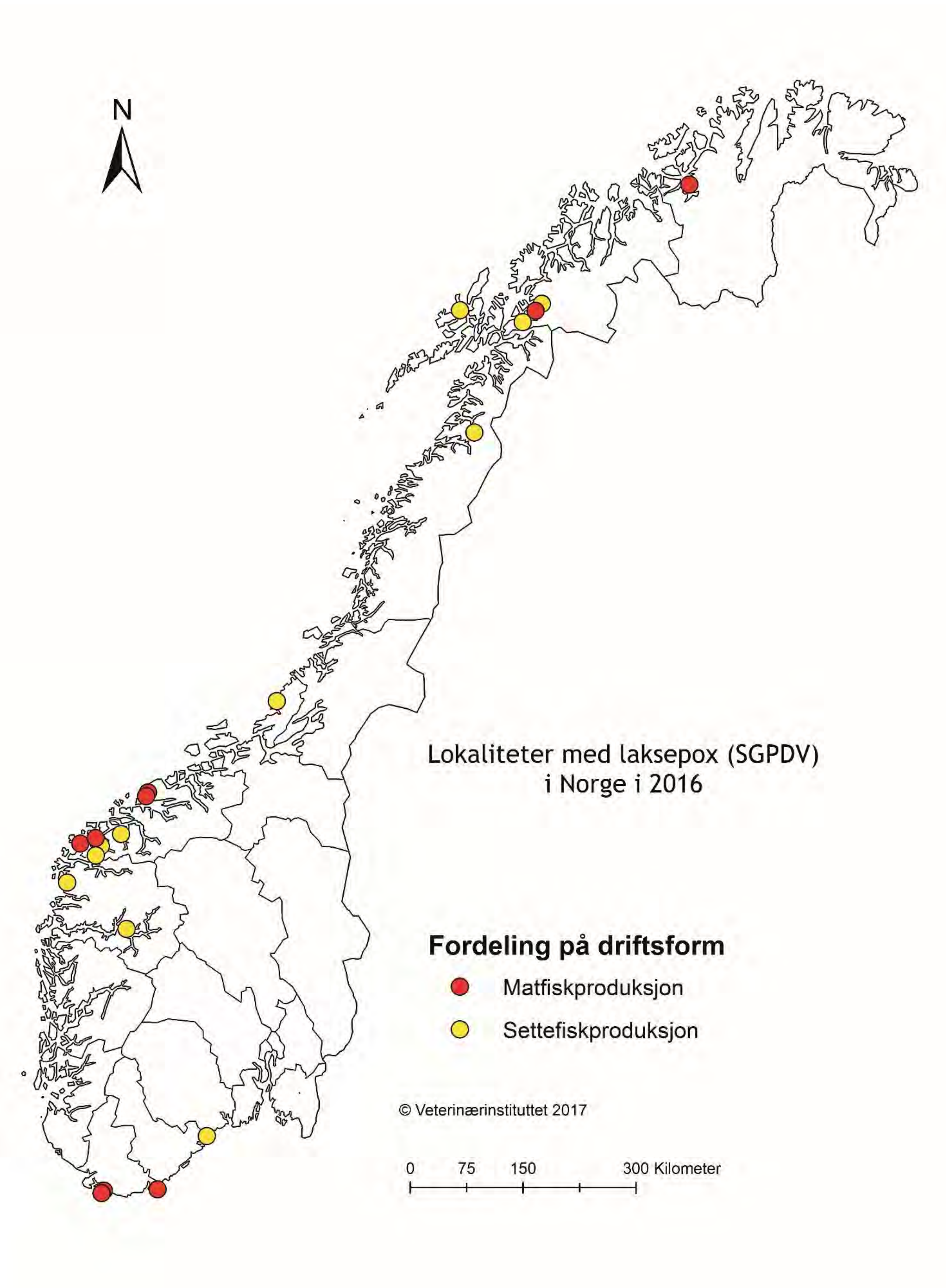


Figure 8.1.1. Sites in which salmon pox virus was diagnosed in 2016.

8.2 Poor smolt quality and runt syndrome

By Hanne R Skjelstad and Karoline Sveinsson

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. Optimal smoltification and sea-transfer at the correct time are important for normal development, growth and health of salmonid fish. In mid-Norway runt development has been associated with previous PD SAV2 infection.

During the sea-phase it has been observed that fish surviving an IPN infection may become emaciated. It has been hypothesized 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 including tapeworms, and should be removed from the population to reduce transfer of infection.

The health situation in 2016

Norwegian Veterinary Institute data
In 2016 the Norwegian Veterinary Institute diagnosed 'emaciation' in sea-farmed salmonids in 45 farms. The majority of these cases were identified in Northern and mid-Norway.

In 2015, 'emaciation' was registered in 41 farms and in 2014 50 farms. Common findings included minimal perivisceral fat and parasite infections.

Questionnaire
'Runt syndrome' is reported as both a production and welfare problem in a number of farms along the whole coast, although the Norwegian Veterinary Institute has identified most cases in mid- and northern- Norway. For both farms and Fish Health Services, the lack of knowledge regarding this phenomenon is unsatisfactory. Some farms reported fewer affected fish in 2016.

The size of hatchery produced smolts is constantly increasing and this may lead to problems with early smoltification, subsequent de-smoltification and re-smolitification. While many farms appear to have good smolt quality, poor quality smolts continue to be reported. These may be small or of variable size, may have fin damage or varying degree of smoltification.

Poor or variable smolt quality probably increases the risk of abnormal development, growth and health, and may contribute to runt development.

Vaccine side effects in fish. Photo: Kristoffer Vale Nielsen, Norwegian Veterinary Institute

8.3 Vaccine side-effects

By Kristoffer Vale Nielsen

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 is also the method which generates the most significant side-effects.

Current aquaculture legislation (§63) requires that Atlantic salmon be vaccinated against furunculosis, vibriosis and coldwater vibriosis. In addition to these diseases, it is normal to vaccinate against winter-ulcer (*M. viscosa*) and 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.

Vaccine side-effects following injection vaccination in salmonid fish normally consist of growth of connective tissues between the inner organs and the peritoneal walls, melanin deposition, reduced appetite and growth, increased frequency of deformity, 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, to 6, which represents huge change. Grade 3 and above in the Speilberg scale represents injury which is considered to be 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 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 general 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 focus remains on reduction of vaccine related side-effects. Vaccine formulations must be continually improved, vaccine administration must be performed under optimal conditions and vaccine side-effects should be monitored in all fish groups.

Questionnaire 2016

Fish Health Services and the Norwegian Food Safety Authority do not consider vaccine side effects to be one of the major fish health issues. In response to the questionnaire, only 12% indicated that they consider vaccine side-effects to represent a fish welfare problem 'to a degree' while 40% answered 'not at all'.

Vaccine side-effects with a Speilberg scale value of greater than 3 were registered to a 'minor degree' (61%), and 'to a degree' (7%) in ongrowing salmon.

8.4 Other heart complaints

By Cecilie S. Walde and 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-licing.

In addition to the viral diseases PD, HSMI and CMS which all affect the heart, there a number of different heart conditions that are regularly identified.

The salmon heart is composed of the atrium, ventricle and bulbus arteriosus. Abnormalities relating to both the shape and size of the ventricle i.e. deviation from the normal pyramidal shape, are relatively commonly identified.
The most commonly identified abnormalities are small and more or less rounded or bean shaped hearts. Subepicardial hypercellularity (epicarditis) is a normal finding in relation to PD, HSMI and CMS, but also appears to manifest as an independent condition which cannot 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-licing.

Recently foci of cartilaginous tissues were identified at low prevalence in the bulbus arteriosus in both healthy and diseased salmon. The aetiology behind this condition is uncertain. The salmon heart does not require cartilage for normal function and it is possible that its presence may have a negative effect on normal function.

Further research is required to understand this condition better.

The health situation in 2016
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.

Wild salmon. Photo: Colourbox

9 The health situation in wild salmonid fish

By Åse Helen Garseth, Sigurd Hytterød, Karoline Overn Sveinsson and Asle Moen

The Norwegian Veterinary Institute has a clear responsibility and considerable activity within the field of wild salmonid health. The activities include disease diagnostics, health surveillance, control of exotic species, preservation work, stock re-establishment and running the genebank for wild salmon. In addition, the Norwegian Veterinary Institute performs surveillance for escaped farmed salmon which are considered the most serious threat to wild Atlantic salmon (*Salmo salar* L).

The river Signaldalselva in Storfjord in Troms with Parastind in the background. This river was treated with rotenone to eradicate the parasite G. salaris in 2016. Photo: Håvard Lo

9.1 From the diagnostic service

The Norwegian Veterinary Institute has public responsibility for diagnosis of disease and unexplained mortality in wild salmonids. This work creates increased knowledge of the health and diseases of wild fish and is important for maintenance of healthy wild populations. Diagnostic work on wild fish provides a valuable insight into the relationships between diseases of wild and farmed salmonids and also provides an important contribution to the Institute's general state of preparedness.

In 2016 the Norwegian Veterinary Institute received a total of 38 wild Atlantic salmon (*Salmo salar* L). The reasons behind the submissions varied from tumours in individual fish to significant mortality events. Normal findings include emaciation, fin erosion and skin lesions of varying severity. Emaciation and parasite infections such as tapeworm, gill lice and *Myxidium* are not uncommon in migrating sexually mature fish. In one case tapeworm infection was associated with granulomatous peritonitis, in which the parasite was identified encapsulated within the peritoneum. Furunculosis (*Aeromonas salmonicida* subsp. *salmonicida)* was again identified in salmon in the Namsen watershed.

During the late summer wild salmon with tumours in the peritoneal cavity were submitted to the Norwegian Veterinary Institute Trondheim. The fish originated from two rivers in the Trondheimsfjord area. Photo: Åse Helen Garseth, Norwegian Veterinary Institute.

Mortality in spawning fish in the river Håelva in Rogaland

In October, extensive numbers of dead sexually mature sea trout (*Salmo trutta*) and salmon were identified in the river Håelva in Rogaland. A serious ulcerative dermatitis caused by the fungus *Saprolegnia parasitica* was identified. Reports also came in of high mortality in brown trout in September in lake Melsvatnet which drains into the river Håelva (see photograph).

More than 200 dead wild salmon and trout were registered in the course of the breeding season in the river Håelva in Rogaland. In this photograph a dead male fish displays symptoms consistent with a fungal infection. Photo: Svein Åge Haarr.

Proliferative Kidney Disease (PKD)
During contract work the Norwegian Veterinary Institute investigated 38 salmon and 26 trout juveniles for proliferative kidney disease (PKD). PKD was confirmed in a number of trout and salmon. The disease PKD is a result of a powerful immune reaction in fish infected with spores of *Tetracapsuloides bryosalmonae*, a parasite which transmits via a bryozoan. The immune reaction results in serious tissue changes, mainly in the spleen and kidney.

Clinical signs include palour of the gills, a very enlarged kidney and finally swollen abdomen. The parasite has been identified in a number of Norwegian rivers. The disease occurs as a rule following a period of increased water temperature, often during periods of low water. This is a disease we may expect to see more of as a result of climate change.

9.2 The health status of wild anadromous salmonids

The main aim of the Norwegian Food Safety Authority's programme for surveillance of the health status of wild salmonid fish is to identify the source and prevalence of pathogenic agents in this type of fish. The Norwegian Veterinary Institute has responsibility for salmonids in the freshwater phase, while the Institute for Marine Research has responsibility for salmonids in the marine phase. The present report presents results for both 2015 and 2016.

Health status surveillance work in 2015 comprised three elements. The first element was identification of the freshwater reservoirs of piscine reovirus (PRV) by screening non-anadromous salmonids. The second element comprised investigation of transmission of PRV infection between wild and farmed salmonids through phylogenetic analysis of virus from wild and farmed fish populations. The third element involved investigation of whether wild/farmed hybrid fish showed a higher prevalence of infection than truly wild fish.

Is piscine reovirus (PRV) found in brown trout and land-locked salmon?

The aim was to investigate salmonid fish which had not been in contact with anadromous fish. Wild-caught land-locked salmon and brown trout from nine restocking hatcheries were investigated with a PRV-specific PCR (Patogen AS). The results are shown in Table 9.2.1

Table 9.2.1 The table shows the results from surveys of of PRV among salmon with no contact with androne fish.

	Reliktlaks	Brunørret
Lokaliteter/anlegg	2	9
Antall tested fisk	55	272
Antall positive fisk/anlegg	0	4/2

PRV was not identified in land-locked salmon. PRV was identified in two brown trout of thirty tested in two hatcheries, which is equivalent to a prevalence of 7% in each hatchery. These prevalence's are consistent with those previously identified in anadromous brown trout (sea trout).

The positive brown trout were infected with low numbers of virus (Ct values between 34 and 36). Due to the limited amount of material and the high Ct values attempts to sequence the virus were not successful. It may be concluded however, that brown trout in restocking hatcheries and land-locked salmon do represent a significant reservoir for PRV.

Transmission of infection between wild and farmed salmonids

Through phylogenetic analysis the likelihood of transmission of virus from wild and farmed salmonids may be estimated. In 2015 such phylogenetic analyses were performed for infectious pancreatic necrosis virus (IPN), infectious salmon anaemia (ISA), salmonid alphavirus (SAV) and piscine myocarditis virus (PMCV).

The analyses revealed that virus from wild salmonids cannot be easily distinguished from farmed fish viruses and that these viruses probably transmit between the two fish populations.

A relationship between cross-breeding and infection status?

Escaped farmed fish are considered to be one of the greatest threats to wild salmon as a result of the effects of cross-breeding on the wild fish gene pool. It is considered likely that such cross-breeding also affects other biological systems. As part of surveillance work performed in 2015, the infection prevalence in fish with a varying degree of 'farmed/wild' genetic mix was investigated. The investigation identified a trend towards virus positive individuals having a greater degree of 'farmed' genetic influence, although a significant difference was not identified. The underlying data was, however, limited.

Salmon gill pox virus (SGPV) in wild salmonids

The main theme for health surveillance in 2016 was salmon gill pox virus (SGPV). Gill samples from Atlantic salmon, brown trout, sea trout, sea-run arctic char (*Salvelinus alpinus* L) and land-locked salmon were PCR investigated for SGPV.

SGPV was not identified in brown trout, sea-run arctic char or land-locked salmon. The survey revealed however, that SGPV infection is widespread in wild Atlantic salmon. Histopathological investigation showed further that virus positive fish also displayed pathological changes in the gills consistent with SGPV. Low amounts of virus (high Ct-values) were also found in sea trout, but only in fish which had been held in tanks together with Atlantic salmon prior to stripping.

To investigate the possible natural occurrence of the virus in trout, a further 60 sea trout and 60 brown trout from four different localities were analysed. SGPV was not identified. This strengthens the hypothesis that SGPV does not occur naturally in trout. More extensive results will be published in an independent report in May 2017.

9.3 The health situation in the Genebank for wild salmon

Norwegian salmon strains possess unique characteristics which have evolved as a result of adaptation to local environmental conditions. A number of threats such as the parasite *Gyrodactylus salaris*, acid rain and escaped farmed fish have resulted in extinction of a number of local strains while others are threatened. The Norwegian authorities established a national genebank for wild salmon in 1986 with the purpose of conservation of threatened populations. In later years the genebank has also taken in several strains of sea trout and sea-run arctic char.

The local fish stocks of many river systems are threatened or extinct as a result of natural or anthropogenic influences. Conservation and re-establishment of anadromous fish populations is a long term strategy which is used to support or re-establish such stocks. Re-stocking should where possible be based on local fish strains. In the three to five years before re-establishment can be started, fertilised eggs from local broodstock are taken in to the genebank for wild salmon. In this way a suitable number of quality assured broodstock in terms of both genetic lineage and breadth, is built up prior to initiation of re-stocking.

Production of eggs and fish for release is based mainly on eggs and milt from the live genebank, but is also supplemented with milt from the frozen genebank. Health controls are performed on all wild fish collected for inclusion in the genebank and includes salmon, trout and char. The health controls include testing for IPNV and *Renibacterium salmoninarum* (Bacterial Kidney Disease), as these infections may transmit vertically from parent to offspring. The aim is to avoid introduction, amplification and spread of these diseases from the genebank. The results of this years health control are presented in Table 9.3..

Table 9.3.1 The table shows the number of brood stock of wild salmon, seatrout and arctic char tested for IPNV and BKD in relation to genebank and stock re-establihment work. The figures, which include results from two normal restocking hatcheries are split into regional statistics. In 2016 IPNV was identified in one seatrout in Hordaland.

Fylke	Laks	Sjøørret	Sjørøye	Resultat
Troms	5		13	
Nord-Trøndelag	19	-	-	-
Sør-Trøndelag	15	-	-	-
Hordaland	82	143	0	IPNV på en sjøørret
Buskerud	79	0	0	-
Totalt	200	143	13	1 IPNV

Conservation and re-establishment

Most re-establishment programmes in which the Norwegian Veterinary Institute is involved are related to *G. salaris* control, although there is also some involvement in re-establishment of stocks threatened in other ways e.g. in the Hardanger region and rivers of Møre og Romsdal. The work is financed by the Norwegian Environment Agency and is performed in close cooperation with local agencies.

In 2016 broodstock of salmon, sea trout and sea-run arctic char were stripped in the Skibotn region. Conservation work has been performed in this area for several years. Re-establishment work starts in 2017 with introduction of fertilized eggs originating from the genebank for wild salmonids and release of yolk-sac larvae raised in local hatcheries.

Conservation work started in the Drammen region during 2016 with collection and stripping of salmon from the rivers Drammenselva and Lierelva. This conservation work is performed in parallel with surveys related to the possibility for extermination of *G. salaris* in the region. In the Hardanger region the work of conservation of salmon and trout in several rivers continues. Salmon and trout populations in this region are threatened by the salmon farming industry. No decision has yet been taken as to whether the collected material will be included in future re-establishment of the threatened stocks.

With Trollveggen in the background, the river Rauma was last rotenone treated in 2014. To be declared free of G. salaris infection the parasite must not be found during a surveillance period lasting five years. Photo: Trond Haukebø, County Governor, Møre og Romsdal.

9.4 *Gyrodactylus salaris*

The disease
Gyrodactylus salaris is a parasite found on the body and fins, particularly the pectoral and dorsal fins, of infected fish. Several different genetic and morphological variants of the parasite exist in Norway and all, with one exception are deadly for Norwegian Atlantic salmon. *G. salaris* is an exotic species to Norway and is considered a serious threat to all Norwegian wild salmon strains.

Fish with gyrodactylosis often display a whitish colouration as a result of excess mucus production and thickened skin. Fish typically 'flash' during the early stages of infection, but become increasingly morbid as the infection develops. Mortality is probably related either directly to damage caused by the hooks used by the parasite to attach to the skin of the fish and ingestion of the skin by the parasite, or by secondary infection e.g. fungal infection.

The Norwegian Veterinary Institute is the national competence centre for control of *G. salaris* and is responsible for implementation of all national eradication programmes.

The Norwegian Veterinary Institute is also the OIE reference laboratory for *Gyrodactylus salaris*. See the Norwegian Veterinary Institute Fact Sheet on *G. salaris* for more information.

Control
Norway is obliged in relation to international environmental agreements to eradicate *G. salaris* from Norwegian river systems. Eradication is normally performed with rotenone, although research continues at the institute into alternative treatment methods. So far only rotenone has proven effective in removing the parasite completely. Aluminium sulphate treatment has also been tested in the Lærdal watershed in 2011 and 2012 and with only one year remaining of post treatment surveillance, the treatment appears so far effective.

As part of a two year treatment plan, anti-*G. salaris* treatment performed in the Skibotn region in 2015 was followed up with a new treatment in 2016. Treatment of the Lærdal-, Vefsna-, and Rana-regions is now completed and these regions are now under surveillance. Remaining regions in which treatment has not yet commenced are the Driva region and the Drammen region.

The rivers in the Skibotn region were treated in August/September 2016. This involved the infected rivers Skibotnelva, Kitdalselva, Sigdalselva and Balsfjordelva. Smaller tributaries were also treated. Individual evaluation of rivers draining into the Storfjord was based on proximity to infected rivers, size and possibility for effective surveillance.

Treatment of the river Ranaelva was completed in 2015. Work aimed at identification of the source of that infection was initiated the same year under contract from the Norwegian Food Safety Authority. This work has so far not identified a probable source of infection and will be continued in 2017.

The Norwegian Environment Agency has initiated construction of a fish barrier in the river Driva and has established an expert group for evaluation of possible eradication strategies for rivers in the Drammen region. Eventual treatment of these rivers will be initiated some years in the future.

The Norwegian Veterinary Institute's work relating to *G. salaris* goes beyond performing of the practical treatment alone. Each treatment programme is dependent on several years of preparatory work involving thorough surveillance of the river systems and conservation and breeding of local stocks of salmon, trout and char.

Following treatment, several years of re-stocking work then commences.

The health situation in 2016

Official statistics

Gill diseases are non-notifiable. It is therefore difficult to estimate the number of sites affected each year. Figure 8.1.1 displays sites in which the Norwegian Veterinary Institute identified Salmon Gill Pox Virus in 2016.

The Norwegian Veterinary Institute undertakes two surveillance programmes for *G. salaris* under contract from the Norwegian Food Safety Authority; The surveillance programme for *Gyrodactylus salaris* in hatcheries and rivers (OK-programme) and the 'Freedom of infection' programme (FM-programme). See http://www.vetinst.no/overvaking for a closer description (Norwegian language) of these programmes. In addition two areas are under evaluation for *G. salaris* status and possible treatment; the Drammen region and the Rana region.

In the OK-programme for *Gyrodactylus salaris*, 2622 salmon and rainbow trout from 80 farms were investigated as were 2263 salmon from 69 rivers. In the FM-programme a total of 2096 juvenile salmon from 18 river systems were examined in the Vefsna- (10 rivers), Rauma- (6 rivers) Lærdal- (1 river) and Rana- (1 river) regions.

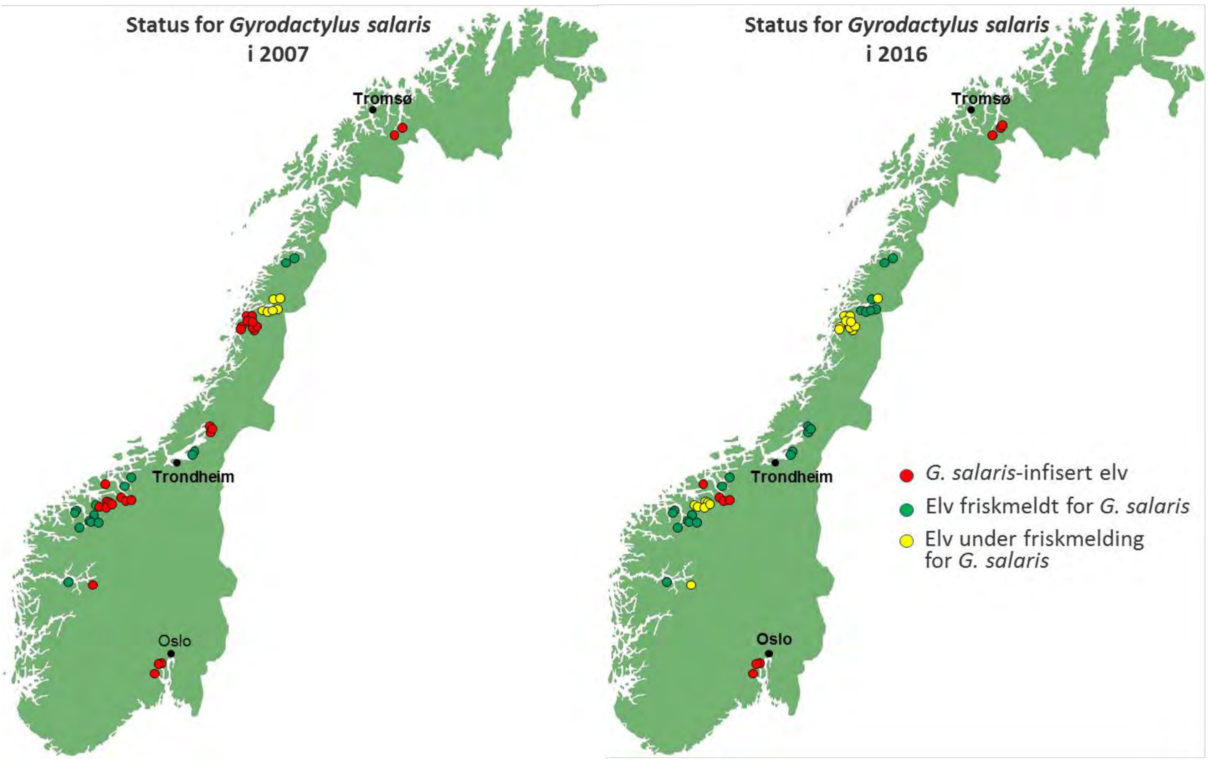


Figure 9.4.1. G. salaris was not identified in new rivers in 2016. As of 31 December 2016 10 rivers continue to have infected status, while 18 rivers are under 'freedom of infection' surveillance. The figure shows the geographical distribution of *G. salaris* infected rivers in Norway in 2007 and 2016.

Evaluation of the Gyrodactylus situation
Recent years have seen a considerable change in the *G. salaris* situation in Norwegian rivers. Eradication programmes with subsequent 'freedom of infection' surveillance have substantially reduced the geographical range of this parasite. Infection pressure towards neighbouring river catchments has thus also been reduced.

In the period between 2007 and 2016 treatment of five regions has been completed (Steinkjer, Vefsna Lærdal, Rauma and Skibotn). In addition, the Rana region (with the exception of the river Rana in which *G. salaris* was identified in 2014) and the Steinkjer region have been declared free of infection.
New infections have been identified in very few rivers in the same period. In 2007 24 rivers were infected and six were under post-treatment surveillance.

As a result of these developments the scientific committee for wild salmon management have lowered the threat level of *G. salaris* infection from non-stabilised threat to stable threat.

Rotenone treatment of an entire river system is a large operation requiring many personnel, extensive preparation and many years post-treatment work to re-establish fish populations. This photograph was taken during treatment of the Skibotn region in Storfjord in Troms in 2015. Photo: Asle Haukaas, Norwegian Veterinary Institute

10. The health situation in cleaner fish

By Geir Bornø and Snorre Gulla

Use of cleaner fish as a biological means of salmon-lice 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.

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

Virus

Previous investigations of Norwegian wild caught cleaner fish have not identified VHS, IPN or nodavirus.

Salmonid alphavirus (SAV) was reported in wrasse from a farm in which the salmon were experiencing an outbreak of pancreas disease (PD). Infectious salmon anaemia virus (ISAV) was also identified in wrasse in a similar situation. Clinical disease was not identified in wrasse in these cases and contamination of samples cannot be discounted. Experimental trials have shown that both lumpsucker and wrasse may be infected with IPN. A method for detection of the newly discovered flavivirus in lumpsucker has been developed. This virus is identified commonly but its importance as a disease causing agent is uncertain.

Bacteria

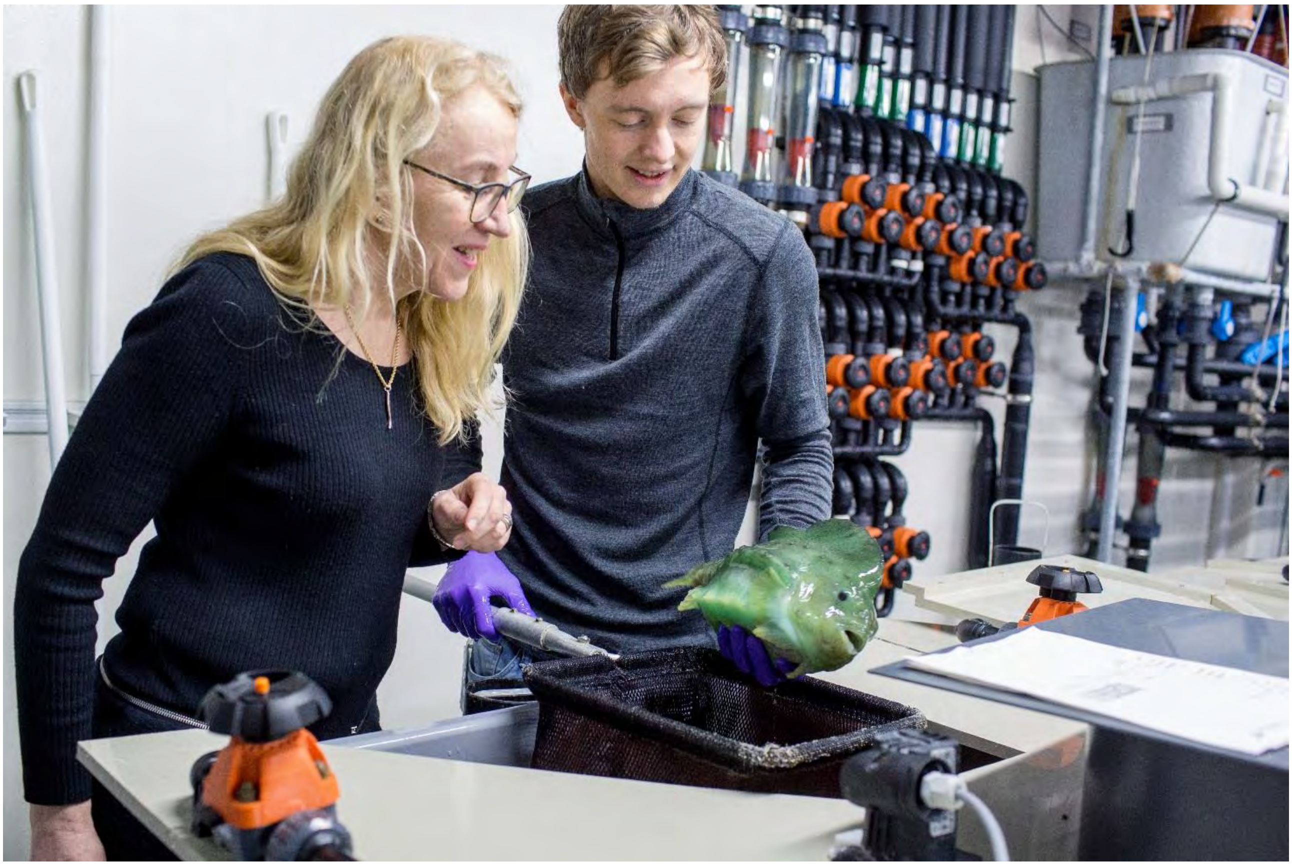
Atypical furunculosis (caused by atypical *Aeromonas salmonicida*) is one of the most important bacterial diseases of cleaner fish. *A. salmonicida* infection commonly manifests as a chronic infection with multi-organ granuloma and ulcer development. Cleaner fish infections are almost exclusively related to infection with two genetic variants of the bacterium (A-layer types V and VI).

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 which normally do not result in disease.

Vibrio anguillarum can cause disease in all species of cleaner fish, while *Vibrio ordalii*, *Pseudomonas anguilliseptica* and *Pasteurella* sp. (the latter being a relatively newly discovered species) appear restricted to disease in lumpsucker.

Fin rot is a recurring problem in farmed ballan wrasse. *Tenacibaculum* spp. are commonly identified in association with such outbreaks, both in mixed and pure culture. *Vibrio splendidus* is also a relatively common finding. *Tenacibaculum* spp. are also identified from other wrasse species and lumpsucker.

Development and testing of vaccines for lumpsucker are underway and most farmed lumpsucker are vaccinated against one or more bacterial agents (primarily *V. anguillarum* and/or atypical *A. salmonicida*).



The Director for Fish Health, Brit Hjeltnes, being introduced to lumpsucker held in the Industry Laboratory (ILAB) in Bergen. This research laboratory is one of the research facilities within the 'marine research cluster' on Marineholmen where the Norwegian Veterinary Institute Bergen will soon relocate. Photo: Eivind Senneset

Parasites

AGD (caused by the amoeba *Paramoeba perurans*) has been identified in lumpsucker, corkwing wrasse, ballan wrasse and other wrasse species which have been 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. Cleaner fish welfare is discussed in the welfare section of this report.

The health situation in 2016

Data from the Norwegian Veterinary Institute

I 2016 The Norwegian Veterinary Institute received 295 diagnostic submissions involving cleaner fish from a total of 159 different farms. This is a similar number to that received in 2015 but a considerable increase from 2014 when 170 submissions from 92 farms were received. The main findings from last year together with those of earlier years are summarized in Table 10.1. The statistics cover both farmed and wild-caught cleaner fish.

In some cases there may be some uncertainty in the field regarding the species identity of some submissions involving the various wrasse species. Some submissions are, therefore, simply categorized as 'wrasse'.

Table 10.1 Occurrence (number of diagnosed sites) of selected diseases/agents in cleaner fish investigated by the Norwegian Veterinary Institute

Rensefiskart	Sykdom/agens	Antall positive lokaliteter				
		2012	2013	2014	2015	2016
Rognkjeks	Atypisk *Aeromonas salmonicida*	1	8	5	51	27
	Aeromonas salmonicida subsp. *Salmonicida*	0	0	0	1	4
	Vibrio anguillarum	7	6	8	12	12
	Vibrio ordalii	3	4	1	3	1
	Pasteurella sp.	1	16	8	14	28
	Pseudomonas anguilliseptica	0	0	1	4	8
	AGD	0	0	2	2	8
Leppefisk	Atypisk *Aeromonas salmonicida*	12	13	16	32	18
	Vibrio anguillarum	6	6	6	2	2
	AGD	0	5	2	2	1

Bacteria

Atypical furunculosis continued to represent a serious disease of cleaner fish in 2016. (Table10.1), although the number of registered positive farms fell significantly from 2015 both for lumpsucker (from 51 to 27) and wrasse spp. (from 32 to 18). As in the previous year *Aeromonas salmonicida* subsp. *salmonicida* was once again diagnosed in farmed lumpsucker farmed in the Namsenfjord area (three farms). These outbreaks almost certainly represent transmission of a local strain of the bacterium from wild salmon. The bacterium was also identified in one farm in Sør-Trøndelag.

During 2016 *Pasteurella* sp. was identified from lumpsucker in 28 farms and *Pseudomonas anguilliseptica* from 8. Both statistics represent a doubling in affected farms from 2015.

Vibrio anguillarum (serotypes O1 and O2) was identified in sick lumpsucker in 12 farms and in wrasse from two farms (serotype O2). *V. ordalii* was identified in lumpsucker from a single farm.

A broad array of *Vibrio* species (*V. splendidus, V. logei, V. tapetis, V. wodanis, Vibrio* sp.), together with *Tenacibaculum* spp., are frequently isolated from cleaner fish, 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 even in the absence of antibiotic driven selection.

Virus

ISAV was identified by a private laboratory in goldsinny wrasse from a single farm in 2016. There were no clinical signs of disease in the wrasse which were held in the same cage as ISA-sick fish. Sample contamination cannot be discounted.

The much discussed lumpsucker flavivirus has been identified repeatedly in farmed lumpsucker. The Norwegian Veterinary Institute does not at the moment have access to diagnostic tools capable of detection of this virus.

Parasites

AGD (caused by the amoeba *Paramoeba perurans*) was identified in a single population of ballan wrasse in 2016 and 8 populations of lumpsucker (two hatcheries and six salmon ongrowing sites). Pathological changes consistent with microsporidean parasites were also identified in lumpsucker.

Sporadic identification of ectoparasites including *Trichodina sp*. and other gill-related ciliates were made but 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 2016 which give 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.

Sea-lice

Infestations with *Caligus elongatus*, a parasitic crustacean have been identified in lumpsucker. These parasites, like the salmon louse, live on the skin of fish in sea water. *Caligus elongatus* has a wide host range, including salmonids, but is also common on members of the cod family. Lumpsucker comprise one of the main hosts for this parasite. While infestations may lead to skin damage, this parasite is generally less damaging to the host than the salmon louse.

Fungus

Fungal disease, in this case *Exophiala* sp., was identified in a single submission involving lumpsucker.

Data from the questionnaire

Nodavirus was not identified in Norwegian cleaner fish during 2016 and is not now considered a major threat to the industry. Atypical furunculosis remains the most problematic pathogenic agent, closely followed by vibriosis. In some areas pasteurellosis is also considered an important threat. Vibriosis and fin rot are considered important during the hatchery phase. AGD which was identified in cleaner fish in 2016, is considered challenging, particularly in the south, where it is reported as second only to atypical furunculosis in importance.

There appears to be extensive agreement in the industry that we lack much general knowledge regarding farming of cleaner fish. The new flavivrus which was identified in lumpsucker for the first time in 2016 was identified as an important problem.

Statistics from diagnostic work performed in 2016 indicate some changes, with fewer farms identified with atypical furunculosis, and an increasing number affected by pasteurellosis and *Pseudomonas anguilliseptica*, compared to 2015. This demonstrates that bacterial problems remain the most serious challenge and that atypical furunculosis continues to constitute the single most serious problem.

Cleaner fish mortality

Mixed reports are received regarding survival of individual cleaner fish populations, but it is generally accepted that mortalities are high. Some sources report mortality levels in 2016 to be similar to those experienced in 2015 while others report higher mortality in 2016. Some sources report longer survival. Bacterial diseases are considered the main challenge to survival in lumpsucker and other cleaner fish, but environmental and nutritional problems are also reported to contribute to mortality.

Evaluation of the cleaner fish situation

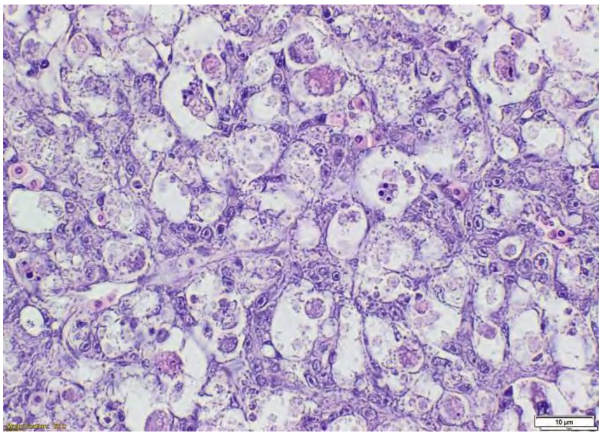
Cleaner fish are increasingly important as farmed fish and production has increased significantly in recent years. The Norwegian Veterinary Institute has also experienced a significant rise in the number of diagnostic submissions from these species with a doubling in the number of submissions involving lumpsucker between 2014 and 2016. In addition private laboratories also undertake an undefined amount of diagnostic work involving cleaner fish.

The diagnostic situation is certainly linked to the increasing number of cleaner fish used by the industry and that there are significant health problems related to domestication of these fish.

There are particularly significant challenges related to bacterial diseases, but also parasites appear to affect the health of cleaner fish. Viral diseases appear to have had limited impact until now, but the newly discovered flavivirus of lumpsucker gives grounds for concern.
In 2015 VHSV was identified in a population of lumpsucker in Iceland. The farm concerned had utilized wild-caught broodfish, thus highlighting the health related challenges such fish represent. VSHV infection has also been identified in wrasse in Scotland.

Generally good cleaner fish husbandry and welfare will, however, regardless of infectious agent, contribute to improved resistance and survival of farmed fish stocks. Vaccination of farmed cleaner fish against certain bacterial diseases has been initiated, and further development of these vaccines continues. A significant proportion of todays farmed lumpsucker are vaccinated against atypical *A. salmonicida* and *Vibrio anguillarum*. It is unknown whether the reduction in number of atypical furunculosis cases is related to current vaccination practices.

There are many unsolved health challenges related to farmed cleaner fish, both during the hatchery phase and during the cage based phase. Much remains to be understood about their health needs and welfare requirements.



Microscopy revealing necrosis in the liver of farmed lumpsucker. Photo: Muhammad Yousaf, Norwegian Veterinary Institute

Cleaner fish have specific health challenges. This lumpsucker was used in a research project at the Industry Laboratory at the University of Bergen. Photo: Eivind Senneset

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
Ongrowing of halibut is performed in both land-based farms and in sea-cages. Halibut require deep cages with shelves which provide a large area upon which the fish may rest. Land-based farms now exist in which halibut may be held throughout the complete life-cycle until harvest at 5-6 years of age.

Turbot grow well in warmer water. Farmed cod production is currently modest with few farms active in 2016. Many hatcheries 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 than halibut and cod, but there remain challenges related to reproduction in this species.

The health situation in 2016

Data from the Norwegian Veterinary Institute

Halibut and turbot
In 2016 44 submissions involving halibut (39) and turbot (5) from nine different farms were submitted. Atypical *Aeromonas salmonicida* causes disease in these fish species and was diagnosed in 10 submissions received during the late winter, spring and summer.

Vibrio species such as *Vibrio (Allivibrio) logei*, *Vibrio (Allivibrio) wodanis* and *Vibrio splendidus* are frequently identified from halibut, often as part of a mixed flora including atypical *A. salmonicida* from small and juvenile halibut experiencing acute mortalities.

As in previous years, problems related to gill infections involving *Ichthyobodo* sp. "costia", *Trichodina* sp. and/or bacterial gill inflammation were identified. Nephrocalcinosis (calcium deposits in the kidney) and changes in the epicardium are normal findings in farmed halibut.

Tenacibaculum maritimum was identified for the first time from a mouth lesion in turbot. Large numbers of long, thin bacteria were visible in the lesion. *Tenacibaculum maritimum* was cultured and identified by sequencing. *Tenacibaculum maritimum* causes large losses in farmed marine fish species around the world.

There have been no grounds for suspicion of nodavirus infection in 2016. Two submissions from halibut were investigated for the presence of IPNV, but the virus was not identified.

Cod and coalfish
Ten submissions were received in 2016 from cod (8) and coalfish (2). The material represented wild-caught cod, cage-held for ongrowing, fish from aquaria and commercial production (cod).

Vibrio (Listonella) anguillarum O2b has previously been associated with increased mortality and ulcer development in cod and coalfish. In 2016 an isolate which cross-reacted with O2b and O2a antisera was identified from cod. Parasites and parasite associated tissue reactions are normal findings in these species.

Francisellosis, caused by *Francisella noatunensis* subsp. *noatunensis*, was not identified in 2016. Nodavirus infection was not suspected in cod.

Spotted wolffish

Eight submissions involving farmed spotted wolffish were submitted in 2016. *Trichodina* spp. were identified in association with skin and gill pathologies. Post-treatment ulcers have been observed. There is a need for more knowledge of the diseases and preventative health measures in this species.

Questionnaire 2016

It would appear from the questionnaire that mortalities in cod and halibut are approximately the same as in previous years. In cod, vibriosis is considered more important than atypical furunculosis and francisellosis. Factors other than infectious agents are also reported to contribute to the overall mortality picture. In halibut, atypical furunculosis and vibriosis are considered by Fish Health Services to be most important in northern-, mid- and north-western Norway. Fin erosion is also considered an important problem.

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Scientifically ambitious, forward-looking and cooperatively oriented – for integrated health

The Norwegian Veterinary Institute is a national research institute that operates in the fields of animal and fish health, food safety and feed hygiene; its primary task is to provide the authorities with independently generated knowledge.

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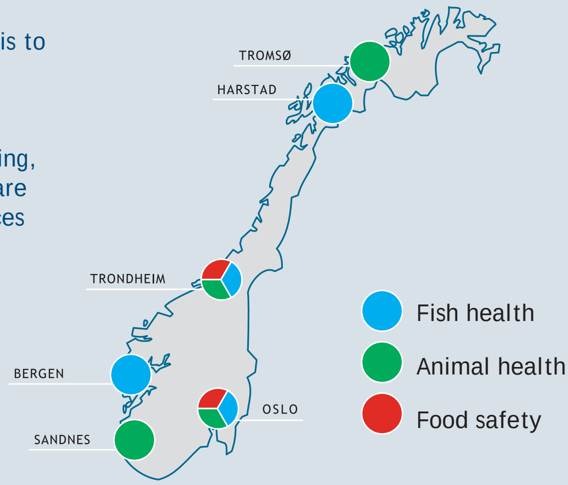
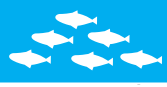
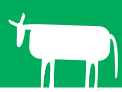


Fish health



Animal health



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