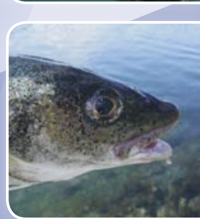
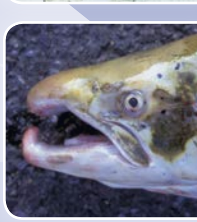
The Health Situation in Norwegian Aquaculture 2014



Veterinærinstituttet
Norwegian Veterinary Institute

Fish Health Report · 2014

Published by
The Norwegian Veterinary Institute · Pb. 750 Sentrum · 0106 Oslo

Form: 07 Media AS

Cover photographs: Tore Håstein, Trygve Poppe, Erik Sterud

To order kommunikasjon@vetinst.no
Telephone: 23 21 63 66

ISSN 1893-1480 web-edition

Citation:
Bornø G & Lie Linaker M (Eds) Fiskehelserapporten 2014, Harstad: Veterinærinstituttet 2015

Many thanks to those who have contributed to this report. Without these contributions, particularly from Fish Health Services nationwide, this report would not have been possible.

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The Health Situation in Norwegian Aquaculture 2014

During 2014 (Harvest statistics): 1,198,900 tons of salmon, 74,300 tons of rainbow trout, 3,800 (estimate) tons of cod, 1,500 (estimate) tons of halibut and 800 (estimate) tons of other species (coalfish, arctic char, turbot) were produced in Norway. These statistics are based on information from Kontali Analyse AS.

It has been a challenging year with regard to the salmon louse situation, and several areas are experiencing problems related to resistant lice. In some areas, the steadily increasing frequency of treatment, resulting in increasing stress in the fish, constitutes a welfare problem. Although new chemical treatments may become available, we are dependent on development and use of non-medicinal treatments in addition to cleaner fish. Many farmers use cleaner fish, but such use presents disease-related challenges which remain to be solved. Some alternative methods for lice control are available, but a number of new concepts under testing will require further improvement before they can be considered as satisfactory alternatives. In all probability, future lice-control will probably depend on a series of different control methodologies.

Pancreas disease (PD) is the most important viral disease in Norwegian aquaculture. Unfortunately the prevalence of PD has increased. In mid-Norway SAV2 has established and the probability of further northward spread has increased. In western-Norway, the 'core' area for SAV3, there has been a considerable increase in registered cases. Although mortality is usually limited, the disease normally results in poor growth, downgrading and significant costs related to infection control.

Amoebic gill disease (AGD) is established along the west-Norwegian coast and appears now to be colonising mid-Norway. Without rapid treatment, AGD can result in significant losses. The most utilised current treatment i.e. hydrogen peroxide can damage the fish and development of good alternative treatments is important.

Intensive aquaculture has a short history in Norway. In contrast to traditional domestic animal husbandry we must expect that new diseases will appear. This applies both to infectious- and production- related diseases. Since the 80's we have identified ISA, PD, CMS and HSMI. Prompt identification and evaluation of the threat posed by new diseases is important. Not least, we must decide whether we should attempt elimination of the disease or whether we must live with it. This process is demanding for the industry, as sharing of information and knowledge is a precondition for success. This type of cooperation has, however, been very successful in the past. In addition it is important that the authorities and supporting research institutes work together to develop more effective and predictable control strategies.

Environmental and disease problems have resulted in intensification of research and development of new production forms. Land-based 'closed' and 'semi-closed' models are under development. Recirculation technology (RAS) is becoming increasingly common in Norwegian aquaculture. These new production forms will undoubtedly contribute to further development of Norwegian aquaculture, but will also lead to new health related challenges.

In comparison to other aquaculture nations, Norway has a uniquely transparent fish health situation. This is important in order to follow trends, enable identification of emerging diseases and prioritise control and research strategies. With the establishment of several new diagnostic services in the Norwegian market, this will become more difficult. The Norwegian Veterinary Institute works hard at provision of a good, complete overview of the disease situation.

Brit Hjeltnes
Scientific Director – Fish- and Shellfish health

Summary

This annual report is based on diagnostic data from the Norwegian Veterinary Institute laboratories in Harstad, Trondheim, Bergen and Oslo, as well as information gathered from Fish-Health Services along the entire coastline. Information is also gathered from other research institutions and the Norwegian Food Safety Authority. Notifiable infectious diseases must be confirmed by a publicly authorised laboratory and the statistics for these diseases are therefore more precise than for non-notifiable diseases. The list of notifiable diseases has varied over the years.

Pancreas disease (PD) remains the most important viral disease in Norwegian aquaculture. In 2014, a total of 142 new cases were registered, which is an increase from the 99 diagnoses in 2013. There are presently two separate active epidemics of PD in Norway, involving *Salmonid alphavirus* subtype 3 (SAV3) in western Norway and SAV2 infection in mid-Norway. It is the situation regarding SAV3 in western-Norway which has worsened since 2013. The number of SAV2 infections in mid-Norway in 2014 remained high but stable compared with 2013. Nearly 90 % of the new SAV3 infections in 2014 were in Rogaland and Hordaland. The number of registrations in Rogaland was record high. The situation in Sogn og Fjordane remains favourable with few registrations in 2014.

Infectious salmon anaemia (ISA) was identified in samples from 10 sites in 2014, the same number of cases as 2013. Over half of the diagnoses were in Nordland. A number of outbreaks started with low mortality, which did not initially present a clinical picture consistent with ISA, while other outbreaks presented a more classical clinical picture. In several farms, fish with clinical ISA were destroyed and the remainder of the fish allowed to continue to harvest. In Nordland 50 % of affected farms had contact with other infected farms in the county (horizontal infection). Separation of generations and fallowing have been two important tools in limiting development and spread of ISA.

Infectious pancreatic necrosis (IPN) was identified in 48 salmonid farming facilities during 2014, which is a reduction from previous years. Fish-health services report that IPN continues to cause losses, but that these losses are significantly lower than previously. It would appear that use of QTL-roe and eradication of ‘house strains’ of IPN-virus are responsible for the reduction in number of registered IPN-outbreaks. In one area of Norway, problems relating to production of QTL-roe resulting in a low QTL ‘component’ were probably responsible for a local increase in the number of IPN outbreaks.

In June 2014, heart and skeletal muscle inflammation (HSMI) was removed from the national list of notifiable diseases. In 2014, HSMI was diagnosed on 181 farms. This is an increase from 2013 when the disease was diagnosed on 134 farms. HSMI can result in very variable mortality. Increased mortality is often reported in association with grading, transport or other management routines which may stress the fish. This can pose a considerable challenge during e.g. lice treatment. Møre og Romsdal, Sør- and Nord-Trøndelag have been the ‘core’ areas for HSMI. Since 2007 there have also been a significant number of outbreaks in northern Norway.

For the fourth year in a row the number of outbreaks of cardiomyopathy syndrome (CMS) has increased, now to a total of 107 cases in 2014. The bulk of the cases have traditionally been diagnosed in Møre og Romsdal and the Trøndelag counties. While CMS cases were identified more or less along the whole coastline, a similar trend was observed in 2014.

During the last six months of 2013 and early 2014 the Norwegian Veterinary Institute received samples from rainbow trout displaying an unusual clinical picture. Diseased fish displayed signs of circulatory disturbance. Histological examination identified a variable degree of inflammation in heart and skeletal muscle with accompanying liver necrosis. Nucleic acid sequences from a new virus, currently termed ‘virus Y’ have been identified in the blood and tissues of sick fish. The virus may be associated with the disease. The work of characterizing the virus is underway alongside concurrent investigations to identify other possible disease-causing agents.

The recognised bacterial diseases furunculosis, vibriosis and cold-water vibriosis remain well under control in salmonid aquaculture, largely thanks to vaccination. The number of sites affected by *Yersinia ruckeri* appears to be rising. Yersiniosis has also been identified in recirculating aquaculture systems for smolt production. Development of skin-ulcers during the sea-phase continues to be a welfare problem

leading to both increased mortality and reduced quality at harvest. Ulcers are typically an autumn and winter problem. Winter ulcer is linked to the bacterium *Moritella viscosa*. Other bacteria such as *Tenacibaculum* spp. and *Aliivibrio* (*Vibrio*) *wodanis* are commonly identified in association with winter ulcer. Both types of bacteria may be identified alone or in association with *M. viscosa*.

In the course of the last two years, amoebic gill disease (AGD) has become a serious problem in Norwegian aquaculture. Both outbreaks of AGD and the distribution of *Paramoeba perurans* have spread northerly in 2014 compared with 2013. It appears that both the amoeba and clinical disease arrived earlier and affected more localities over a larger geographic area than previously. Several other agents can also result in gill disease, which is one of the most significant causes of loss in salmon farming. These conditions are often multifactorial with many agents and different water quality parameters involved.

The Norwegian Veterinary Institute has now developed a real-time PCR for detection of poxvirus, which may be utilised in investigations of gill disease. In addition to acute outbreaks in hatcheries in which poxvirus had been suspected, the virus has also been identified in association with chronic, multifactorial cases of gill disease (including AGD) encountered during the sea-phase.

The salmon louse situation was characterised by relatively high louse numbers in the spring, continual high consumption of chemical therapeutants and widespread reduced susceptibility to the most commonly utilised chemical treatments.

General

In total, the Norwegian Veterinary Institute has investigated approximately 2330 diagnostic cases involving farmed fish during 2014, in addition to cases involving surveillance programs, contract work and research. The caseload is dominated by salmon (approx. 1940 submissions) although samples are received from other fish species e.g. various wrasse species, lumpsucker, cod, halibut etc. Using a combination of clinical history, pathology and agent detection, the aim is to identify the cause of disease, not merely detection of any particular agent. It is important to differentiate between what the fish dies of and what the fish dies with.

Table 1. List 2 og list 3-diseases, number of new localities with diagnosed disease

Disease	List	2009	2010	2011	2012	2013	2014
Farmed fish (salmonids)							
ISA	2	9	7	1	2	10	10
VHS	2	1	0	0	0	0	0
HSMI*	3	139	131	162	142	134	181*
PD	3	75	88	89	137	99	142
Furunculosis	3	0	0	0	0	0	1
BKD	3	3	0	3	2	1	0
Systemic infection with *Flavobacterium psychrophilum* in rainbow trout**							2**
Farmed fish (marine species)							
Francisellosis	3	8	3	3	2	1	1
VNN/VER	3	1	0	0	1	1	0
Wild salmonids (fresh water)							
Infection with *Gyrodactylus salaris*	3	0	2	1	0	1	1
Furunculosis	3	0	1	0	0	0	1
BKD	3	0	0	0	1	0	1
Crustaceans							
Crayfish plague (signal crayfish)	3					1	1

* The disease was removed from list 3 during 2014
** Systemic infection with *Flavobacterium psychrophilum* in rainbow trout was listed during 2014

Table 2. Important, non-notifiable diseases of salmonids, new sites with diagnosed disease registered by the Norwegian Veterinary Institute

Disease	2009	2010	2011	2012	2013	2014
IPN	223	198	154	119	56	48
CMS	76	53	74	89	100	107
Cold-water vibriosis	0	0	5	21	13	0
Vibriosis	9	9	8	7	4	3
Infection with *Moritella viscosa*	36	55	69	56	51	44
Yersiniosis	15	12	8	16	20	27
AGD				5	58	69
Parvicapsulosis	34	40	31	32	26	36

Commonly, diagnoses are based on a series of criteria utilizing one or more methods. The criteria used to confirm a diagnosis can change on gain of new knowledge. Changes in diagnostic criteria should be considered when comparing disease statistics over time. Diagnoses are awarded at the locality level i.e. they do not distinguish between different fish groups present in any particular site.

Recirculating aquaculture systems (RAS)

Traditionally, salmonids in Norway have been farmed in through-flow systems in freshwater and in open cages at sea. In recent years a number of recirculating (RAS) farms have been established for production of juvenile fish. There are reasons to believe that this is a trend which will continue. On the Faeroe Isles, RAS has been the main technology in use for smolt production for a number of years. In RAS, effluent water is cleaned using a biological filter, and there is minimal water replacement. This is the main difference from through-flow systems in which water is continually replaced. Properly managed, RAS can provide a more stable water quality than through-flow systems and allow good fish health. Recent production data from larger RAS-sites reveals good survival and growth following sea-transfer. Such results are dependent on a thorough understanding of the technology and surveillance of important water quality parameters such as soluble oxygen, carbon dioxide and nitrite. Correct scaling of the system is therefore critical.

The most important risk factors related to RAS in freshwater are high nitrite levels, total gas supersaturation, excessive feeding and incomplete particle removal. Biofilters may be particularly susceptible to failure during the start-up phase, prior to stabilisation of the bacterial population. To reduce production time in open sea-based cages, seawater RAS sites are under planning. Accumulation of carbon dioxide can be a greater problem in seawater compared to freshwater. For all types of RAS, control over introduction of biological material and intake water is paramount.

Infectious diseases when first present in a RAS site may be very difficult to eradicate and may result in high mortalities. In Norway, yersiniosis has caused problems and in Denmark outbreaks of typical furunculosis have resulted in significant losses.

Viral diseases

Pancreas disease - PD

Pancreas disease (PD) is a very contagious viral disease in salmonid fish farmed in the sea.
The disease has been recognised in western Norway since the late 1980's. In 2003–4 the disease spread both south and north of its core area in Hordaland. The cause of the disease is *Salmonid alphavirus* (SAV) which was, until 2010, represented by SAV subtype 3 (SAV3) alone. A new type (marine SAV2) has, since its first identification in Romsdal in 2010, spread rapidly in mid-Norway (Fig. A and B). There are currently, therefore, two separate PD epidemics in Norway, SAV3 in western Norway and SAV2 in mid-Norway.

A total of 142 new cases of PD were registered in 2014. This is a considerable increase from 2013, when there were 99 new cases, but is similar to the level identified in 2012 (Table 1). On examination of the two epidemics separately, the rise in number of PD cases can be explained by the increase in number of cases involving SAV3 in western Norway. While a considerable reduction in number of new SAV3 cases was experienced in 2013, the incidence rose again last year (Fig. C). The number of new cases of SAV2 in 2014 remained high but stable compared to 2013 in mid-Norway with 54 and 51 cases identified respectively. The statistics are based on the number of new positive sites or new PD cases following a period of fallowing. This means in effect that the real number of infected localities is in fact much higher, as fish diagnosed the previous year remain in the sea until harvest.

Twelve PD cases involved rainbow trout. These were distributed between Hordaland (six cases) and Møre og Romsdal (five cases). All involved SAV3. In Sør-Trøndelag a single case of PD involving marine SAV2 infection in rainbow trout was identified. The fish of around 500 g were held in a farm also holding salmon in which marine SAV2 had been identified. This is the first registration of marine SAV2 in this fish species. PD in rainbow trout within the SAV3 region has been a common diagnosis since 1996, with a peak of 18 affected sites in 2011.

Pancreas disease is defined here as identification of histopathological findings consistent with PD and detection of PD virus in organs from the same fish (diagnosis PD) or histopathological findings consistent with PD when samples for virological investigation are not available (suspicion of PD). The statistics represent both suspected (few) and confirmed cases. Some cases involving suspicion of SAV2 PD are based on detection of virus by PCR alone.

SAV3. All cases of SAV3 were within the SAV3 zone, south of Hustadvika. The zone was established in 2007 (legislation 2007-11-20 nr. 1315) to limit northward spread of infection, and has fulfilled its purpose well for SAV3. There have been sporadic SAV3 cases in the northern counties, with two in Finnmark in 2013. There were no new diagnoses in northern Norway in 2014. The number of cases within the zone increased significantly compared with the lower number of cases identified in 2013, but the tendency towards a southern focus within the zone continues.

Nearly 90 % of new SAV3 cases in 2014 were identified in Rogaland and Hordaland. Rogaland experienced a record number of diagnoses at 23, nearly twice the figure for 2013. In Hordaland, the 51 cases registered in 2014, represented a return to "normal" levels (40–50) post 2007. For Sogn and Fjordane the positive situation from 2013 continued with few new cases (eight compared to five in 2013). The same situation was experienced in Møre og Romsdal where PD involving SAV3 is limited to Storfjorden.

SAV2. Due to the rapid spread of SAV2 infection north of Hustadvika in 2012, separate zone legislation was developed for disease caused by this virus (legislation 2012-11-06 nr. 1056) which entered force at the end of 2012. The area between Hustadvika in Møre og Romsdal and Nordland is divided into a control zone (to the border of Nord-Trøndelag) and an observation zone/buffer zone (Nord-Trøndelag to Nordland). The main aim is to prevent establishment of PD along the northern coast. In 2014 there were three SAV2 cases in Nord-Trøndelag. In accordance with pancreas disease control strategy the sites were depopulated. SAV2 infections were diagnosed twice in Nordland. One case, diagnosed in June, was located in the far south of the county. The second case was identified in October during surveillance checks for PD/SAV2 in the area. In both cases fish were rapidly removed from the farms.

The aim of the zone legislation of 2012 was also to control the infection within the control zone. The infection has, however, continued to spread within the area (Fig. A), although most infections were identified in Sør-Trøndelag, with a similar number of diagnoses as in 2013. There were fewer new cases of SAV2 in Møre og Romsdal (13 in 2014 compared with 20 in 2013). A number of these cases involve a local SAV2 epidemic just south of Hustadvika, in the area where the first cases of marine SAV2 were diagnosed.

Marine SAV2 was identified for the first time south of Stadt in 2014. Two sites in Nordfjord were diagnosed with SAV2 PD. As one of the sites had already been diagnosed with SAV3 PD, this constitutes the first known case with infection with these two SAV subtypes at the same time on a single farm.

Pancreas disease occurs year round. For PD caused by SAV3, the number of cases in western Norway as in previous years peaked in the summer months (Fig. E). Most commonly SAV3 affects fish transferred to sea the previous year, although there is a tendency in some areas towards older fish being affected. The cases of PD caused by marine SAV2 in mid-Norway were diagnosed somewhat later in the year (Fig. D). A number of reports from the field indicate that the disease appears in smolts shortly after sea-transfer, which could indicate high infection pressure.

SAV3 related mortality varies, but is often low to moderate. For SAV2 infections, low mortality seems to be the rule. An epidemiological study published in 2014 indicated that SAV2 related mortalities were lower than those associated with SAV3. In some of the SAV2 cases, other infections, particularly HSMI, were also present and may have contributed to mortality. The most significant problem associated with PD SAV2 is the poor feed utilisation and extended production time due to prolonged appetite loss. In large fish both SAV2 and SAV3 infection leads to reduced quality at slaughter.

An infection challenge utilising Norwegian isolates of SAV2 and SAV3 performed in 2013 confirmed the differences between the two types of PD infection. Water borne SAV2 infection gave lower mortality than SAV3. At termination of the trial all SAV infected fish displayed a lower weight than non-infected control fish. The difference in weight between the two SAV infected groups was non-significant. These results may be interpreted to mean that infection with marine SAV2 may be more difficult to identify than those caused by SAV3. Nevertheless reduced growth is a serious consequence of infection by either virus type. The pathological changes are the

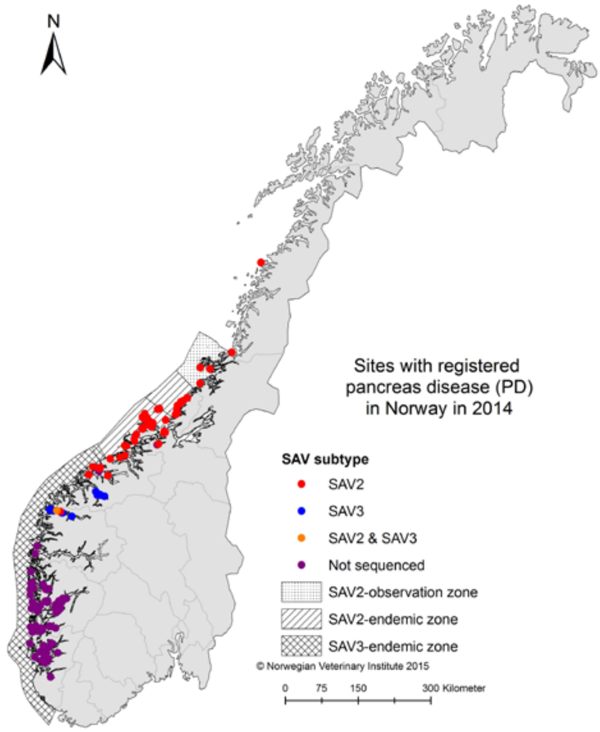


Figure A.

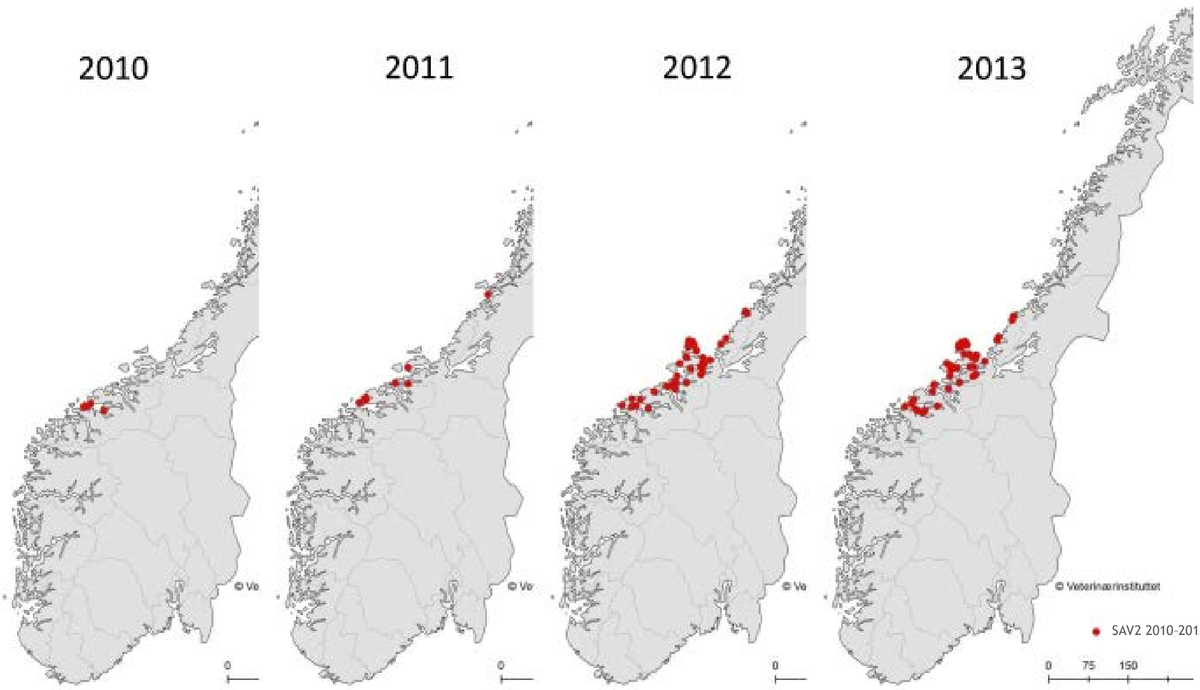


Figure B. New sites with SAV2 2010–2013.

same and can be just as serious in both types of infection.

The high prevalence of PD is a challenge for the industry and the authorities. The most important reservoir for virus is infected farmed fish. Intensive surveillance and early diagnosis of disease combined with controlled transport of smolts and fish for harvest are important measures in limiting spread of infection, as is sea transfer of smolts into larger fallowed areas. Alongside measures to reduce infection pressure, like focus on smolt quality, good locations, vaccination, reduced biomass and destruction of sick fish, it would appear that some areas within the endemic zone experience low mortality, late manifestation of clinical disease and even disappearance of clinical cases.

The effect of vaccination is much discussed. Vaccination against PD has a limited effect compared with levels of protection achieved by e.g. vaccines against bacterial infections such as furunculosis. PD vaccination has been shown however, to reduce the extent and number of outbreaks. Vaccination

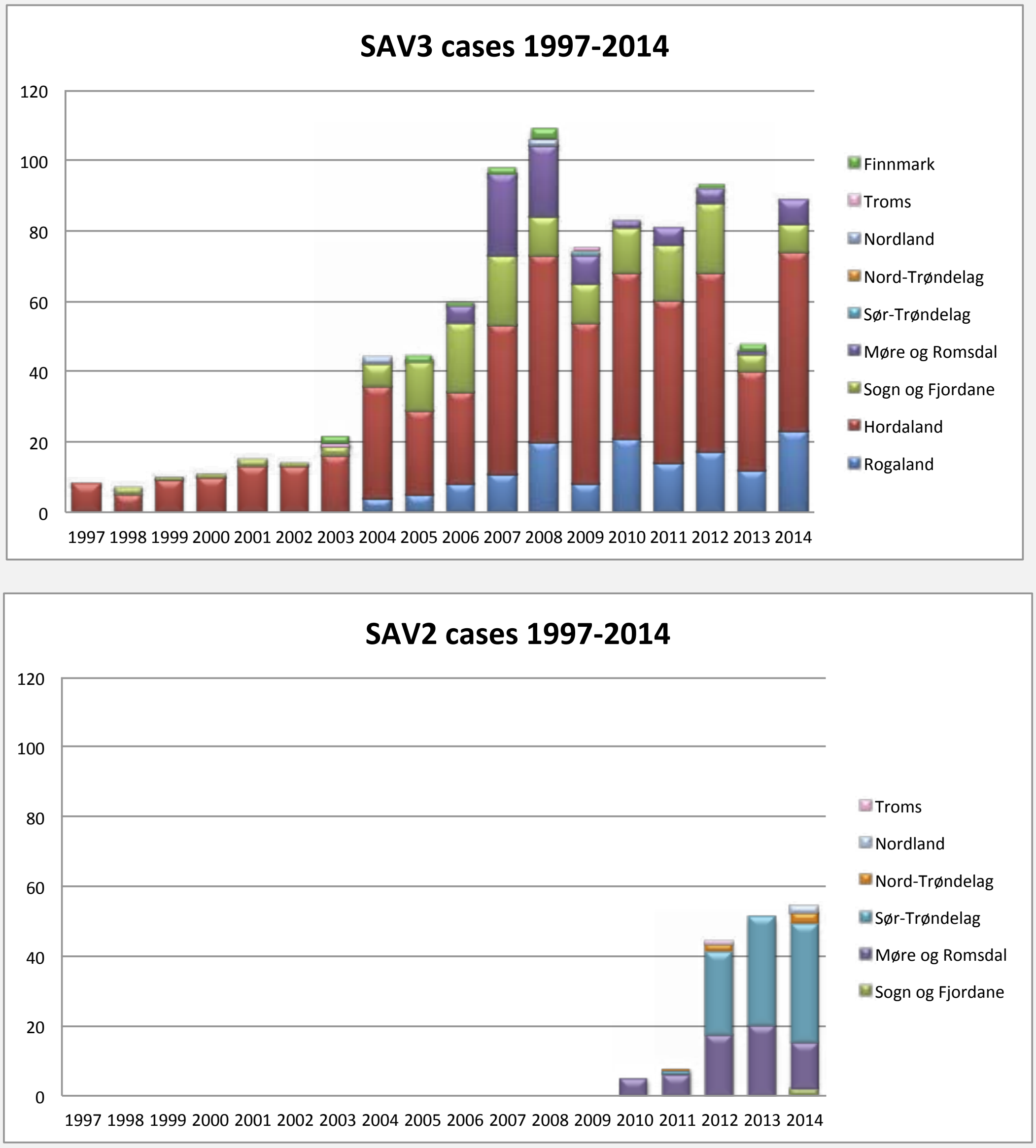


Figure C. Distribution by county of number of new cases of pancreas disease SAV2 and SAV3 1997-2014

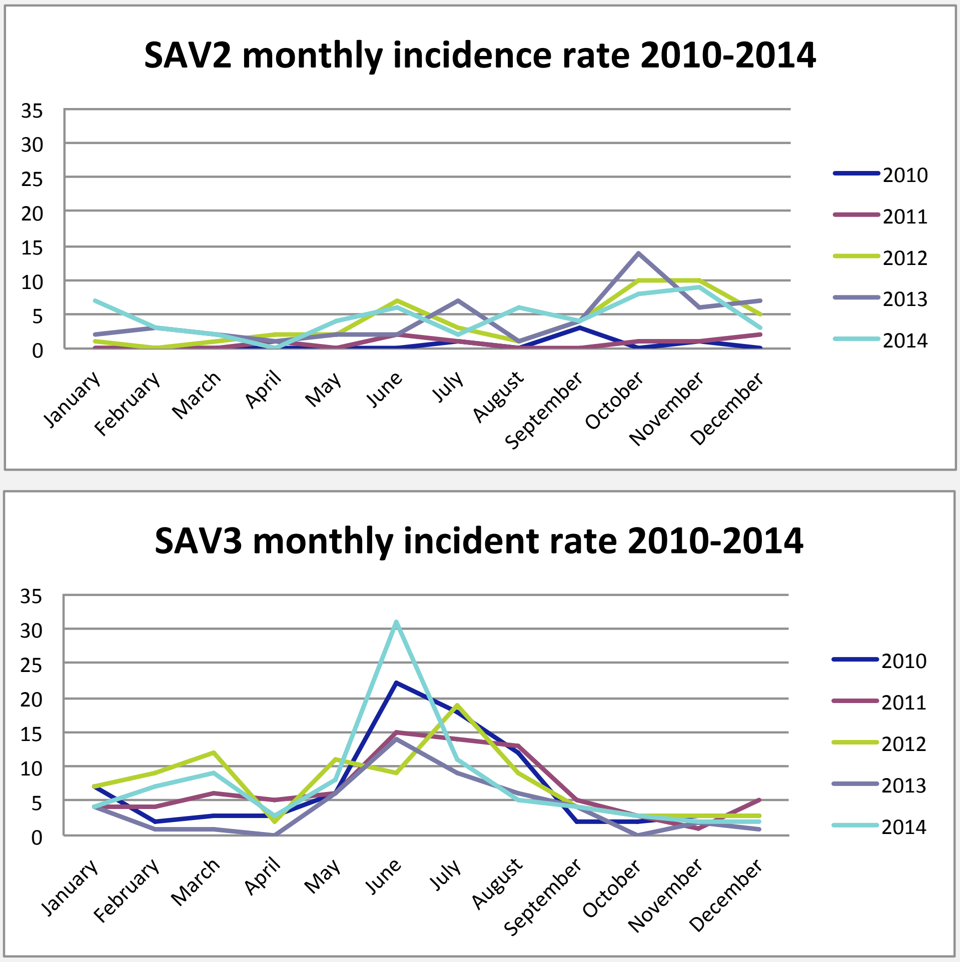


Figure D. PD, monthly incidence rate for SAV2 og SAV3

may reduce overall mortalities and reduce downgrading at harvest. The results vary somewhat from group to group.

PD is a list 3 notifiable disease in Norway. In 2014, infection with *Salmonid alphavirus* (SAV) was listed on the OIE (World Animal Health Authority) fish disease list.

To document PD-free status and thereby gain access to markets, the Norwegian Food Safety Authority coordinates a surveillance program (OK-program) in the northern part of the country (Nord-Trøndelag and northerly counties).

The Norwegian Veterinary Institute as an international and national reference laboratory for SAV cooperates with the Norwegian Food Safety Authority on daily updating of maps and monthly reports of PD diagnoses (www.vetinst.no).

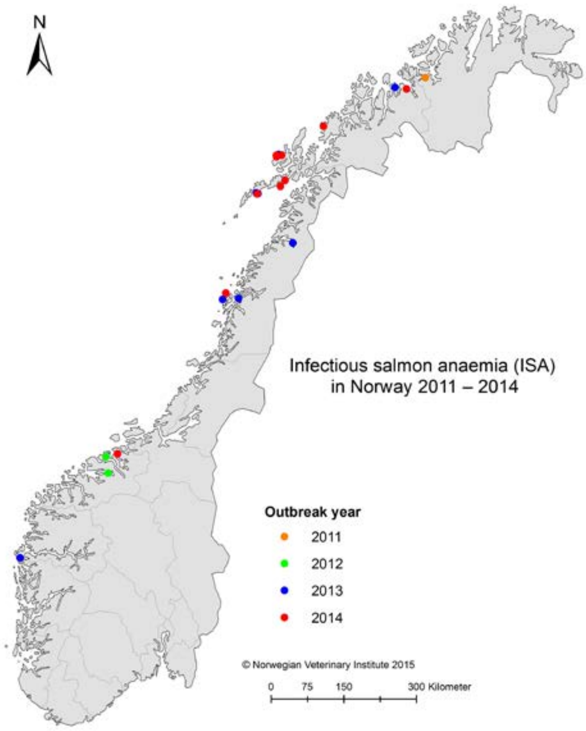
Surveillance is performed according to legislatory requirements by the industry itself and through routine health controls and disease diagnostics.

To stimulate more research and rapid distribution of new research results, a ‘Three-nation’ cooperation (www.trination.org) has been established where researchers, industry and authorities from Ireland, Scotland and Norway meet regularly.

Read more on www.vetinst.no/faktabank/PD

Infectious salmon anaemia - ISA

In 2014, 10 outbreaks of ISA were diagnosed, of which seven were in Nordland, two in Troms and one in Møre og Romsdal. This was the same number of outbreaks as in 2013. Of the 2014 cases, five outbreaks in Nordland can be linked to horizontal contact with adjacent farms with active infections. There are differences in virulence between isolates and increased virulence can probably develop over time. There is therefore every reason to monitor the disease situation closely and to increase our knowledge on the cause/s of these continual new outbreaks.



A number of outbreaks in northern Norway have started with low mortality. As initial clinical signs in some cases did not specifically indicate ISA, suspicions of ISA were not raised until histopathological investigations were performed. Other cases presented a more 'classic' clinical picture, which rapidly warranted suspicion of ISA. This is a reminder that ISA may manifest in several ways. One constant in all clinical presentations is, however, that the blood system is always affected with resultant anaemia. In a number of the affected farms the fish involved were destroyed, while the remainder of the fish were allowed to progress to harvest. The ISA outbreak in a broodstock farm in Møre og Romsdal was discovered following routine sampling.
The diagnosis was rapidly verified and fish groups on the farm are now being followed closely.

ISA-affected fish. Photo: Labora.

ISA-affected fish with dark liver and increased peritoneal fluid. Photo: Per Anton Sæther, Marin Helse

In five of the ten outbreaks, no obvious contact with known infected farms has occurred. These cases represent therefore apparently isolated outbreaks. The source can be an unknown infection reservoir, or that new virulent strains have spontaneously occurred. The hypothesis is that avirulent strains of ISA-virus (HPR0) mutate to highly virulent variants (deleted or HPR). In order to understand more of the infection dynamics and if possible 'grade' the disease-causing abilities of the different virus types, we need increased knowledge of the factors which are decisive for virulence, including those which allow HPR0 to develop into HPR.

Separation of generations and fallowing are two general and important measures of prevention of development of virulent micro-organisms. Experience has shown that this is especially important in prevention of virulence development in ISA. We have currently little knowledge of how this may be optimised or the mechanisms of importance for development of ISA-HPR from ISA-HPR0.

The OIE now distinguish between low virulent HPRO and high virulent HPR. Both genotypes remain notifiable and it is possible to apply for free-status for HPR0. The reason for listing HPR0 is that it is assumed that its presence is likely to increase the chance of development of ISA-HPR. Free-status for ISA-HPR0 must be documented via an extensive surveillance program.

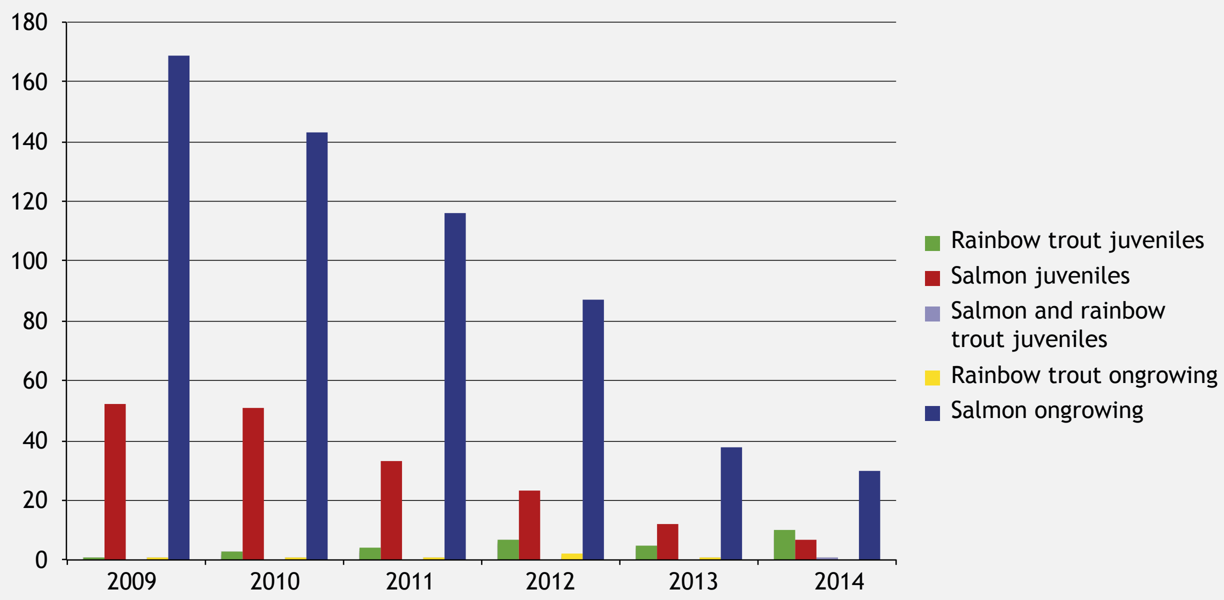
Read more on www.vetinst.no/faktabank/ILA

Infectious pancreatic necrosis - IPN

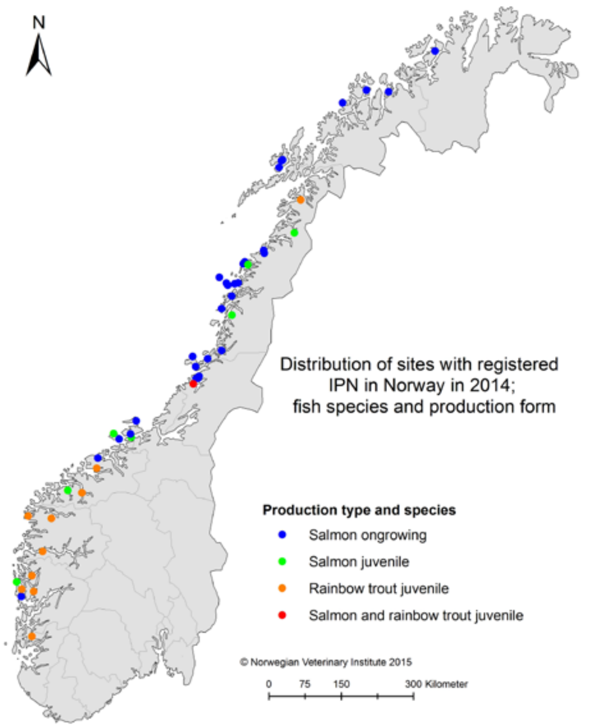
In 2014, IPN was diagnosed on 48 salmonid farms. Eleven involved rainbow trout and 38 involved salmon (one farm held both rainbow trout and salmon). Outbreaks involved both juvenile production units (19) and marine ongrowing sites (30). In 2012 and 2013 IPN was diagnosed in 119 and 56 farms respectively (Table 1). The statistics for recent years indicate a clear and significant reduction in the number of IPN cases involving salmon, from the peak in 2009 (223 cases) to 48 cases in 2014. For rainbow trout the number of registered cases of IPN has been very low for several years, but appears now to show a weak increasing trend in juvenile production.

IPN was a notifiable disease until 2008. Fish health services have, for the most part, continued to submit samples for confirmation of diagnosis. Fish health services report that IPN continues to cause losses, but that there are generally fewer problems now compared to previous years. IPN caused very high mortality on one juvenile rainbow trout farm and 10 % mortality in a single salmon farm stocked with QTL fish. While other farms report losses as a result of IPN, the disease is generally considered under control. Many describe ‘runt’ development in the wake of IPN outbreaks as the most significant outcome, rather than direct mortality. There are also reports of outbreaks in the sea caused by virus variants which have not been able to be traced back to the freshwater phase. It has been speculated that cleaner fish could possibly be responsible for introduction of ‘new’ virus variants.

Much indicates that IPN is a much less serious threat to farms stocking QTL fish. According to reports obtained by the Norwegian Veterinary Institute it would appear that use of QTL-based stocks together with increased efforts to eradicate ‘house’ strains, are important elements behind the reduction in number of cases reported in later years. Hatcheries



Number of sites with IPN, distribution in salmon and rainbow trout hatcheries and ongrowing sites 2009-2014



report the same trend, with a reduction in number of cases involving salmon, from 51 cases in 2010 to 19 in 2014. In one area of Norway, a local increase in number of IPN outbreaks has been related to a lower than desirable frequency of QTL 'component' in QTL stocks.

IPN virus belongs to the aquabirnavirus family which has a wide host-range, having been identified in many types of fish around the world. Clinical disease is largely related to farming of salmonid fish and is also a problem in other countries with significant production of farmed salmon e.g. Scotland and Chile. IPN-virus is very common in Norwegian salmon- and rainbow trout-production. As other diseases e.g. *Flavobacterium psychrophilum* and *Yersinia ruckeri* infections may result in a clinical picture similar to IPN, verification of diagnosis via laboratory investigation is important. Farmed fish are considered the most important reservoir for IPN-virus. A large proportion of fish surviving an IPN-outbreak develop a lifelong persistent infection.

Read more on www.vetinst.no/faktabank/IPN

Heart and skeletal muscle inflammation - HSMI

Heart and skeletal muscle inflammation was first discovered in 1999, and has since been diagnosed along the whole coast line. In 2014 HSMI was diagnosed in 181 farms. This is the highest number of cases registered to date (see table). The registrations are based on samples submitted to the Norwegian Veterinary Institute. As the disease is not notifiable, diagnoses may also have been made by other laboratories.

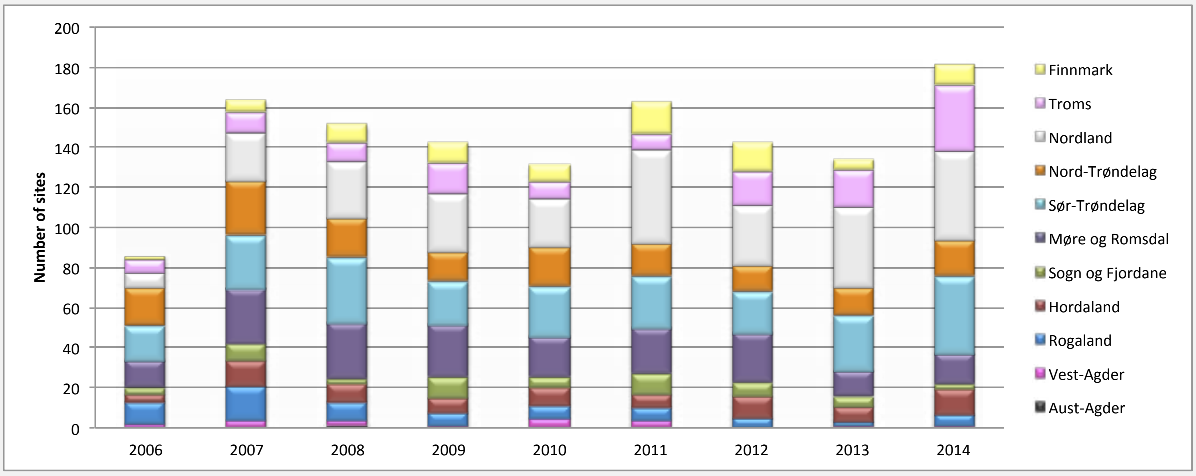
HSMI was diagnosed in 171 ongrowing sites, seven hatcheries and three broodstock farms. This is an increase from 2013 when 130 ongrowing sites, three hatcheries and one broodstock farm were affected. As the number of broodstock farms and hatcheries is much lower than the number of ongrowing sites, the increase in number of broodstock and hatchery cases is probably more important than the statistics give the immediate impression of.

HSMI was first detected in ongrowing sites in Møre og Romsdal and Trøndelag in 1999.

Salmon dying of HSMI commonly display significant signs of circulatory disturbance, which may be both macroscopically and microscopically visible. The heart is the organ primarily affected and gradually increasing changes in the heart may be observed histologically in the months prior to and following clinical outbreaks. During clinical outbreaks the fish commonly display inflammation in the skeletal musculature. Pathological changes may be observed in other tissues, most commonly the liver.

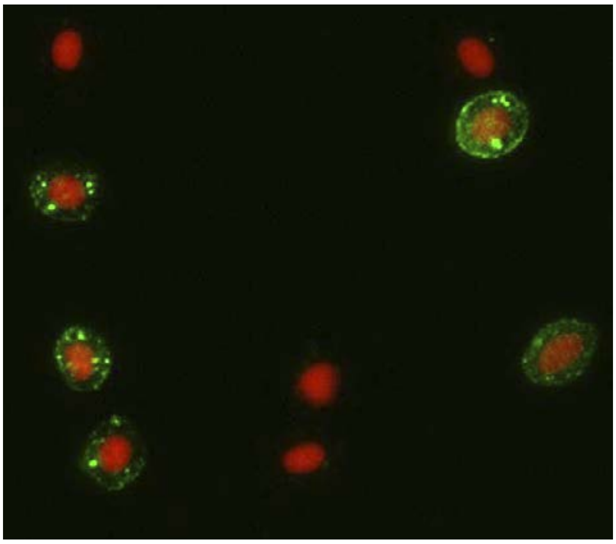
HSMI may result in very variable mortality. Increased mortality is often reported in association with grading, transport or other management routines which stress the fish. This can present significant challenges in relation to lice control and other management routines.

Piscine orthoreovirus (PRV) was identified from the tissues of HSMI affected salmon in 2010. PRV is a naked, segmented, double stranded RNA virus. The virus is widely distributed and is found both in healthy farmed salmon, wild salmon, rainbow trout and seatrout. In contrast HSMI has only been identified in farmed salmon and is associated with intensive PRV infection.



County-wise distribution of annually registered sites with HSMI 2006-2014

HSMI affected fish. Photo: Labora.



Salmon red blood cells. Green colour indicates aggregates of Piscine orthoreovirus (PRV) in the cytoplasm. Red colour represents the nuclei of red blood cells. Photo: Øystein Wessel Finstad (NVH).

In 2014 it was shown that PRV infects red blood cells in affected fish, and methodology for laboratory culture of red blood cells from salmon is under development. Infection trials have demonstrated transmission of disease both after injection of tissue homogenate from HSMI-affected fish and injection of PRV-containing red blood cell lysates. Water borne transmission has also been experimentally demonstrated. There is a clear association between HSMI and intensive PRV infection in farmed salmon. The presence of large quantities of PRV virus does not, however, necessarily result in development of HSMI. A vaccine against PRV is now under development.

Read more on www.vetinst.no/faktabank/HSMB

Cardiomyopathy syndrome - CMS

Cardiomyopathy syndrome (CMS), is a severe heart disease affecting sea-farmed salmon. As the disease most commonly affects large fish close to harvest, the economic consequences can be considerable. The Norwegian Veterinary Institute registered 107 cases of CMS in 2014. This is the fourth consecutive year in which the number of cases has increased and more than double the number of cases were diagnosed in 2014 compared to 2010. The majority of cases are identified in Møre og Romsdal (22), Sør-Trøndelag (26), Rogaland (12) and Finnmark (10). There appears to be a tendency towards an increasing prevalence in Sogn og Fjordane and Hordaland with 15 cases registered in 2014 compared to 9 in 2013. Of the remaining counties, the prevalence appears to be increasing in Vest-Agder and Nordland with 5 and 9 outbreaks respectively compared to 1 and 5 in 2013.

In 2010, a new virus was described, piscine myocarditis virus (PMCV), which appears to cause CMS. This virus belongs to the Totivirus group, which normally infect yeasts, protozoans and insects. One totivirus has been described, Infectious myonecrosis virus (IMNV) which causes skeletal muscle changes in a pacific shrimp species (*Penaeus vannamei*). The virus is a naked, double stranded RNA virus with a relatively small, non-segmented genome which appears to code for only 3-4 proteins.

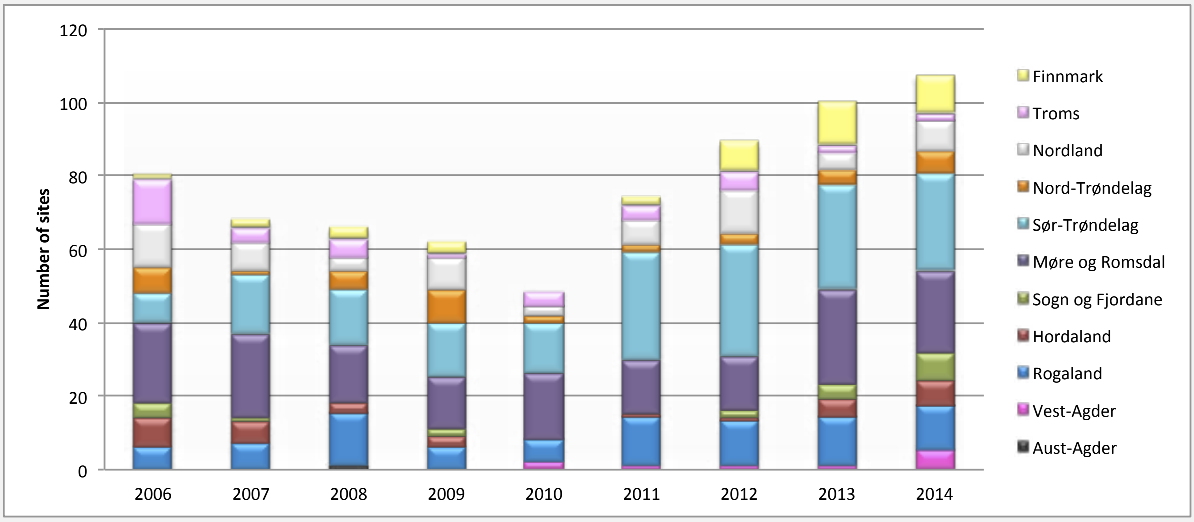
As with other naked viruses, like IPN-virus and Nodavirus, CMS-virus is probably more resistant to external factors such as temperature, low pH, disinfectants and drying than enveloped viral particles. Both IPN-virus and Nodavirus can survive for months in water or in association with organic material.

There appears to be a clear relationship between detectable virus and disease, and between quantity of virus present and pathological changes in the heart. Using specific PCR, the virus can be detected in CMS affected fish, and with specific staining of virus (*in situ* hybridisation and immunohistochemistry) the virus can be localised to areas of pathological change. CMS-virus has been detected on farms long before outbreak of disease (> nine months), but is generally detected in association with outbreaks of CMS or in salmon with CMS-changes in the heart. All Norwegian PMCV isolates, including recent isolates, which have been investigated are very similar and appear to belong to a single geno-group.

Water borne infection appears to be the most important transmission route for CMS. No virus reservoir other than salmon has been identified. The risk of CMS appears greater in farms which have experienced CMS during the previous cycle. Recent research shows that vertical transmission does not play a significant role in transmission of the virus. It has not been possible via genotyping to link virus isolates to broodstock, smolt producer, feed producer or farming company. It does not appear that fish weight at sea transfer or presence of IPN or PD within the fish group affects the risk of contracting CMS.

CMS-virus has been detected in apparently healthy wild salmon, but this appears to be a relatively uncommon finding. CMS-virus has also been identified in smelt (*Argentina silus*), although the virus from smelt appears to belong to a different genogroup than the CMS related salmon strains. Transmission of the virus from smelt to farmed salmon appears therefore unlikely.

Clinically the disease is similar to both PD and HSMI, with all three conditions causing significant circulatory disturbance. In typical cases these three



County-wise distribution of sites with registered cardiomyopathy syndrome (CMS) 2006–2014 diseases can be distinguished histopathologically by different pathological changes in the heart. Typical CMS causes large inflammatory changes in the spongious layer of both atrium and ventricle, while the epicardium and compactum are as a rule normal. CMS does not normally result in changes to the exocrine pancreas or skeletal musculature as is observed with typical PD (exocrine pancreas/skeletal muscle change) or HSMI (skeletal muscle change).

Currently, diagnosis is based on clinical and histopathological findings. Specific PCR for CMS-virus is used in difficult cases e.g. early stages of CMS, atypical CMS or in suspected mixed infections.

Research is still required to establish the role of CMS-virus in CMS outbreaks in fish farming. We need to know e.g. where the virus comes from, what it does in the fish, and why it mainly affects large fish.

Read more on www.vetinst.no/faktaark/CMS

Miscellaneous heart conditions

In addition to the viral diseases PD, HSMI and CMS which all affect the heart, other abnormalities in the heart are commonly identified. Both size and shape can differ from the pyramidal ventricle shape which is important for normal function. The most common abnormality is a small, more or less rounded heart. Inflammation on the ventricle surface (epicarditis) is a normal finding associated with PD, HSMI and CMS, but may also occur independently of other obvious disease. The importance of this inflammation is unknown, but it is generally considered that such changes have a negative effect on function and may thereby contribute to 'unexplained mortality events' and mortalities associated with lice treatments.

Abnormally shaped heart from farmed salmon.
Photo: Trygve T. Poppe. NMBU and Norwegian Veterinary Institute

Several fish health services report mortality in populations of 'fine fish', particularly in autumn smolts during their first winter at sea. Besides congestion, ascites and cardiac tamponade there are few or no specific post-mortem findings in such fish. Similarly, laboratory investigations rarely identify specific findings other than general inflammatory changes in the heart.

Viral Haemorrhagic septicaemia – VHS

Viral Haemorrhagic Septicaemia Virus (VHSV) is globally distributed and has been detected in around 80 different species of fish. Most marine VHSV variants result in low mortality in salmonid species, but the virus has the ability to change and thereby increase its virulence if it is allowed to replicate over time in a susceptible fish population. Transmission from wild fish to farmed fish may occur in open marine sites. Separation of year-classes and fallowing are therefore important measures in control of infection.

There have historically been very few cases of VHS in Norway, and the country is presently free of the disease. The last diagnosis involved rainbow trout in the Storfjord in 2007–2008. Experience has shown that rapid destruction (stamping out) of infected stocks is the most important component in controlling VHS. Continual surveillance is therefore critical to allow rapid elimination of infected fish. Current surveillance procedures are risk-based. Clinically sick fish of species with the highest probability of infection are prioritised for investigation.

In 2012, VHSV of genotype III was identified from various species of farmed wrasse in Shetland. Sequence analysis revealed significant similarity to VHSV strains identified from wild fish in the area. This is the same genotype identified in rainbow trout in the Storfjord in Norway in 2007, but phylogenetic studies have revealed a degree of difference between the Norwegian and the Scottish strains. VHSV of genotype Ib has been detected in several (wild) fish species including herring and haddock along the Norwegian coast. While VHSV genotype III has not been identified in wild Norwegian fish, identification of VHSV in wrasse in Scotland gives grounds for concern in Norway as there is currently large scale transport of wrasse from the south-coast to areas as far north as Nordland county.

Globally, VHSV of genotype IVb known from the Great Lakes area of the USA gives the greatest grounds for concern. This variant of the virus has resulted in high mortality in many species of wild fish in freshwater and is spreading steadily to new areas. No other variant of VHSV has previously infected so many different species with such ferocity. While VHS is a problem in rainbow trout farming in freshwater in Europe, an eradication program in Denmark appears to have been remarkably successful and VHS has not been detected in that country since 2009. Although several outbreaks of VHS have been diagnosed in marine farmed rainbow trout in Åland, Finland, none have been registered over the last two years.

Read more on www.vetinst.no/faktabank/VHS

New virus-associated disease in freshwater farmed rainbow trout

Samples were received in August-November 2013 from two freshwater rainbow trout farms and from a third hatchery in January 2014 in which fish displayed unusual symptoms. Affected fish were between 25–100g. While mortalities were generally moderate, one farm experienced high mortalities in individual tanks.

Affected fish had been held in freshwater or freshwater with additional seawater (<1 ‰ seawater). Fish from affected groups were transferred to sea. In two cases high mortalities were experienced after sea transfer, which tailed off with time. In two cases the disease was diagnosed several months following sea transfer. Otherwise no problems associated with sea transfer of rainbow trout have been reported.

Affected fish displayed signs of circulatory failure i.e. pale organs due to anaemia and bloody ascites. Histopathologically a varying degree of inflammation in the heart and red musculature and liver necrosis could be observed.

Samples from affected fish were investigated for known viruses using PCR. Only small amounts of IPN virus were detected in one farm. Virus-culture using conventional cell-lines was negative. Pathogenic bacteria were not identified and an antibiotic treatment trial had no effect.

Subsequently, nucleic acid sequences from a previously unknown virus, currently referred to as ‘virus Y’ were identified from the blood and tissues of affected fish. This virus is similar to the virus which causes heart and skeletal muscle inflammation in salmon, and may be associated with the observed disease. The Norwegian Veterinary Institute has developed a PCR method for detection of virus Y.

It has not yet been confirmed whether virus Y is responsible for the cardiac inflammation and anaemia observed in rainbow trout.

The Norwegian Veterinary Institute has performed a small-scale trial which showed that the viral load increases in the blood of rainbow trout injected with blood of affected rainbow trout. Water borne infection between rainbow trout was also subsequently confirmed. Although clinical disease was not identified in experimentally infected rainbow trout, results suggest that the disease is transmissible.

In injected salmon, the viral load increased but not as fast or to the same extent as that observed in rainbow trout. Salmon showed no signs of disease. Currently there are no indications that salmon may be infected by the waterborne route.

While virus Y survives in the blood of fish and transmits horizontally to rainbow trout, the relationship between virus Y and disease is not yet clarified. It is possible that virus Y alone is responsible for disease in rainbow trout or that the virus in combination with another agent is responsible. Virus Y may also represent a ‘random finding’ which is not related to disease. Further, different varieties of virus Y may exist, some of which may be non-pathogenic or of variable virulence.

Virus Y is found in rainbow trout hatcheries and contact populations, both broodstock and ongrowing. In addition virus Y has been identified in small amounts in archived material from as far back as 2011 in Hordaland and Møre og Romsdal.

Characterisation of the virus is now underway and the search for other possible agents continues. Culture of the virus is also being attempted. During 2015 two large infection trials will be initiated. The aim of these trials will be elucidation of the role, if any, of virus Y in disease and to identify whether salmon are susceptible to the disease.

Bacterial diseases

The situation regarding bacterial diseases of farmed salmonids remains favourable. Important diseases such as furunculosis and vibriosis, which in previous years resulted in significant losses, are still under control due to effective vaccination. Coldwater vibriosis is again under control after a small increase in cases in 2012/2013. It appears that the number of cases of infection with *Yersinia ruckeri* is on the increase, particularly in large recirculation smolt production sites.

Coldwater vibriosis

Vibrio salmonicida, which is the cause of coldwater vibriosis, was not identified in 2014. Coldwater vibriosis was a serious disease in Norwegian salmon farming during the 1980s, but has, for the last 25 years, been under effective control through vaccination. In 2012 and 2013, there was a moderate increase in the number of cases compared to previous years, with 21 and 13 cases identified respectively. The situation in 2014 appears to have normalised again. The reasons behind the increase in number of outbreaks have not been identified, but may have been associated with vaccine products in use and choice of unfavourable timepoint for vaccination.

Read more on www.vetinst.no/faktabank/KVV

Winter ulcer

Ulcer development during the sea-phase of culture is a welfare problem which leads to both increased mortality and reduced quality at harvest. Ulcer development is a typically autumn- and winter-problem, but can occur at any time of the year, particularly in northern areas. The term winter ulcer is related to infection with the bacterium *Moritella viscosa*, which causes ulcers and mortality in infection trials. Nearly all Norwegian farmed salmon are vaccinated against this bacterium. Other bacteria are commonly isolated from fish with winter ulcer. Both *Tenacibaculum* spp. and *Aliivibrio* (*Vibrio*) *wodanis* may dominate cultures or be found in pure culture. These bacteria are commonly identified together with *M. viscosa*. The dynamics, if any, between these bacteria remain to be identified.

While it is primarily salmon which develop ulcers, cases were again identified in rainbow trout in 2014. Ulcer development is not notifiable, and official statistics for the disease do not exist. From information gathered from Fish health services and the Norwegian Veterinary Institute regional laboratories it is apparent that ulcers are identified along the whole coast, and that the prevalence varies from area to area. Some report fewer problems than the previous year. It would appear that the greatest problems are experienced in the north of the country. One risk factor appears to be sea-transfer at low water temperatures. Commonly, ulcer development and mortality is registered some weeks following such transfer. Affected fish often display mouth rot with *Tenacibaculum* spp. dominating the bacteriological findings.

Otherwise Fish health services report ulcer development in larger fish following handling, often related to mechanical injuries received during lice treatment. Outbreaks of winter ulcer associated with *M. viscosa*, *A. wodanis* and *Tenacibaculum* spp. were also reported from land based smolt production units utilising seawater. In some cases winter ulcer was treated with antibiotics with varying success.

Infection with *Flavobacterium psychrophilum*

In 2014 the Norwegian Veterinary Institute identified *Flavobacterium psychrophilum* infection in large rainbow trout displaying ulcers and bullae on two farms in the same brackish water fjord system in which diagnoses had been made between 2008-2012. In another two farms the bacterium was identified in association with ulcer development in salmon.

In addition, the Norwegian Veterinary Institute found evidence of *F. psychrophilum* involvement in a small number of cases of ulcer development in hatchery salmon. In these cases the bacterium was not cultured.

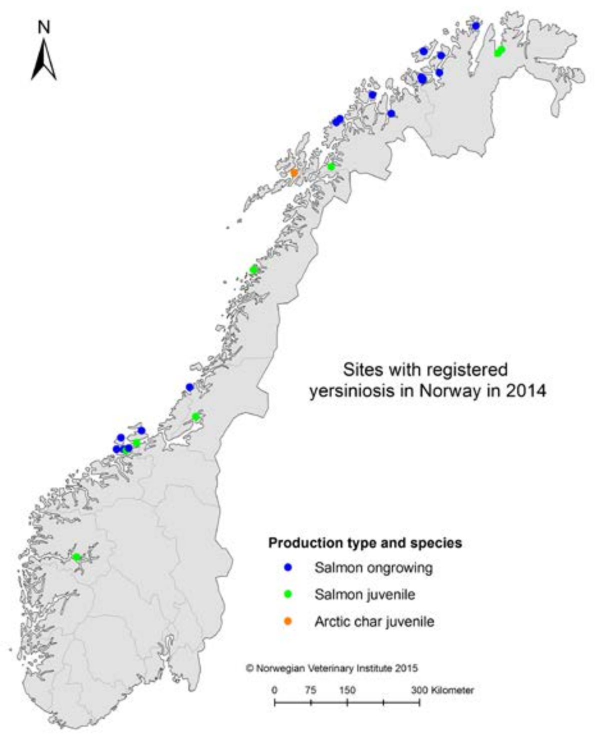
Genotyping of isolates from the last few years show that different genotypes continue to cause disease in rainbow trout and salmon.

Systemic infection with *F. psychrophilum* in rainbow trout was made notifiable in 2014. The Norwegian Veterinary Institute is involved in a European research project which aims to develop better diagnostic tools and vaccines for this disease.

Read more on www.vetinst.no/faktabank/
Flavobacterium psychrophilum

Yersiniosis

Yersiniosis is caused by the bacterium *Yersinia ruckeri*. This disease can cause increased mortality in diverse fish species, but is mainly known as a disease of salmonids, particularly salmon and rainbow trout. Yersiniosis is most common during the hatchery phase of culture, but may also follow the fish to sea where it may cause losses even in fish apparently healthy on sea transfer. Some farms have experienced mortalities up to 10 %, 1-3 months following sea transfer. Outbreaks in recirculation based farms have again in 2014 been associated with recurring episodes of acute, and some cases very high mortality. The situation in 2014, with the majority of diagnoses made during the seawater phase, may indicate distribution of infection with fish from a few freshwater sites. Several hatcheries vaccinate against yersiniosis, and in some vaccination is considered necessary to maintain production.
In 2014 yersiniosis was diagnosed on a total of 27 different sites; 8 salmon hatcheries, 18 salmon ongrowing sites and one arctic char hatchery (concurrently diagnosed with atypical furunculosis). In the cases where the isolates were serotyped, 14 involved serotype O1 and 2 involved serotype O2. Affected sites were geographically widespread. The majority of diagnoses were made in northern Norway with a smaller cluster in mid-Norway. The number of diagnoses in 2014 is an increase from 2013, when 20 sites were affected.



Yersinia infected fish with typical changes.
Photo: Per Anton Sæther, Marin Helse

Bacterial Kidney Disease – BKD

Bacterial kidney disease (BKD) is listed on the national list of notifiable diseases (list 3). The disease is now only sporadically identified in Norway, with between 0 and 3 cases per year. In 2014 BKD was not diagnosed in Norway.

Furunculosis

Furunculosis is a notifiable disease in Norway (list 3). For the first time in many years furunculosis, caused by the bacterium *Aeromonas salmonicida* subsp. *salmonicida*, was diagnosed in a marine salmon farm in Nord-Trøndelag. The fish were sea transferred in May 2014 and were vaccinated against furunculosis (multi-component vaccine). Furunculosis was first suspected in September and the diagnosis confirmed in October. Mortality was low and few fish showed signs of disease, although some fish displayed bullae and/or signs of haemorrhage in the musculature and body cavity. *Aeromonas salmonicida* subsp. *salmonicida* was cultured in significant quantity from investigated fish. The isolated bacterium displayed reduced susceptibility to quinolone antibiotics, a trait which has been observed regularly in previous years in isolates from wild salmon in Trøndelag. At the same time (September–October 2014), morbid and dead salmon were found in the Namsen river system, in Grong in Nord-Trøndelag. Macroscopic examination gave grounds for suspicion of furunculosis. *A. salmonicida* subsp. *salmonicida* was cultured from these fish. Samples were not, however, sent to the Norwegian Veterinary Institute for confirmation of the diagnosis. The affected ongrowing site is situated in the northern part of the Namsen estuary and the outbreak resulted most probably via infection from wild salmon in the area.

Other bacterial infections

Occasionally diverse members of the genera *Vibrio*, *Photobacterium*, *Alteromonas*, *Pseudoalteromonas*, *Psychrobacter*, *Polaribacter* etc. may be isolated from sick fish during disease investigations. While these isolates may be identified in significant amounts from several fish in the population, it can be difficult to interpret their role, if any, in the observed disease. They are commonly considered as opportunist environmental bacteria which invade an already weak fish. This type of flora is continually evaluated, such that novel pathogenic variants are rapidly identified.

Vibrio anguillarum serotype O1 was not identified in salmon, but was identified in three rainbow trout farms in 2014.

In 2014 *Pseudomonas fluorescens* was identified during diagnostic investigation of four salmon farms, but none could be related to serious disease in the investigated fish populations. At least one salmon hatchery utilises dip-vaccination against this bacterium.

Atypical *Aeromonas salmonicida* (atypical furunculosis) was identified in a single case involving salmonid fish (arctic char) in 2014. The char were also infected with *Yersinia ruckeri*.

Piscirickettsiosis, caused by *Piscirickettsia salmonis*, which continues to be an important disease and cause of economic losses in Chile was identified in one marine salmon farm in Norway in 2014.

Susceptibility to antibiotics in salmon farming

Although the official statistics for antibiotic use in the Norwegian fish farming industry in 2014 are not yet available, it seems that the level of antibiotic use in salmon farming in Norway continues to be extremely low. Antibiotics have in some cases been used to treat yersiniosis and *Tenacibaculum*-infection in salmon. Regular testing of fish-pathogenic bacteria isolated from farmed salmonid fish during 2014 has not, with the exception of the furunculosis case discussed above, identified new examples of reduced susceptibility towards antibacterial substances authorised for use in Norwegian aquaculture. Reduced susceptibility to quinolone antibiotics continues to be identified in *Flavobacterium psychrophilum* isolated from diseased rainbow trout from the same geographical area as previously.

Fungal diseases

As in previous years, relatively few cases of mycosis have been identified in 2014. Saprolegniosis in fry constitutes the majority of cases, although the condition may be identified at all freshwater stages. Fish health services report field diagnosis in most cases, with subsequent treatment. There are indications that recirculation based farms may be more susceptible to saprolegniosis than through-flow farms. In addition to *Saprolegnia*, some cases of mycosis caused by *Exophiala* spp. and two cases of significant mortality in farmed cleaner fish in which several species of «black yeasts» related to *Phialophora* were identified.

Parasite diseases

Salmon louse - *Lepeophtheirus salmonis*

The salmon louse situation in 2014 was characterised by relatively high louse numbers in the Spring, continued high consumption of chemical treatments and widespread resistance to the most commonly used chemical treatments.

The average weekly reported statistics for the whole country reveal slightly higher lice-numbers in the Spring of 2014, but were otherwise comparable to

Skin lesion in lumpsucker with systemic mycosis. Photo: Trygve T. Poppe, NMBU and Norwegian Veterinary Institute

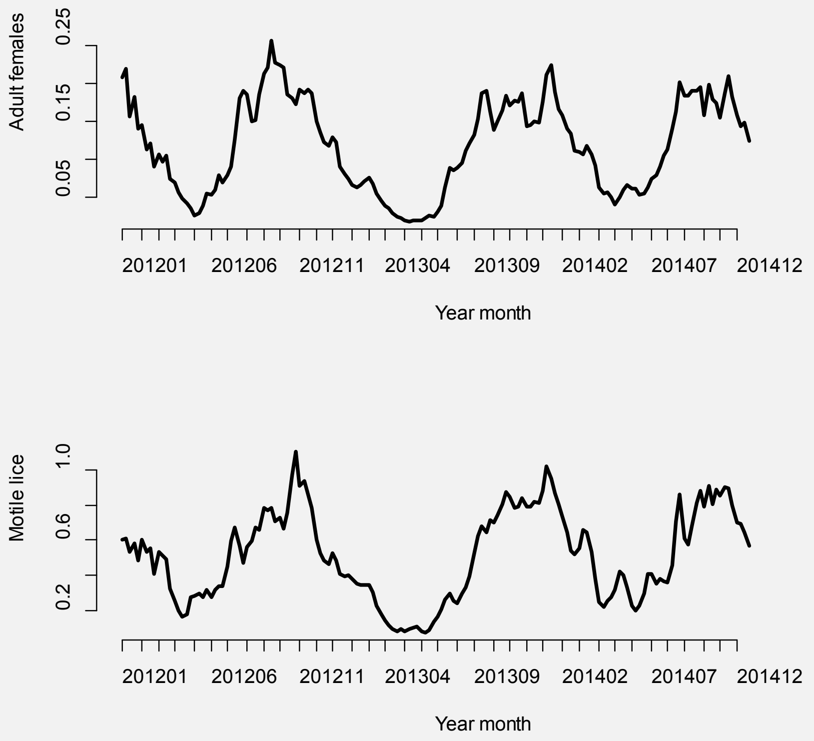


Figure F. Average weekly reported salmon-lice statistics for all marine farms for the period January 2012 - January 2015, where the upper panel describes mature females and the lower panel other motile life-stages of lice (pre-adult and adult male).

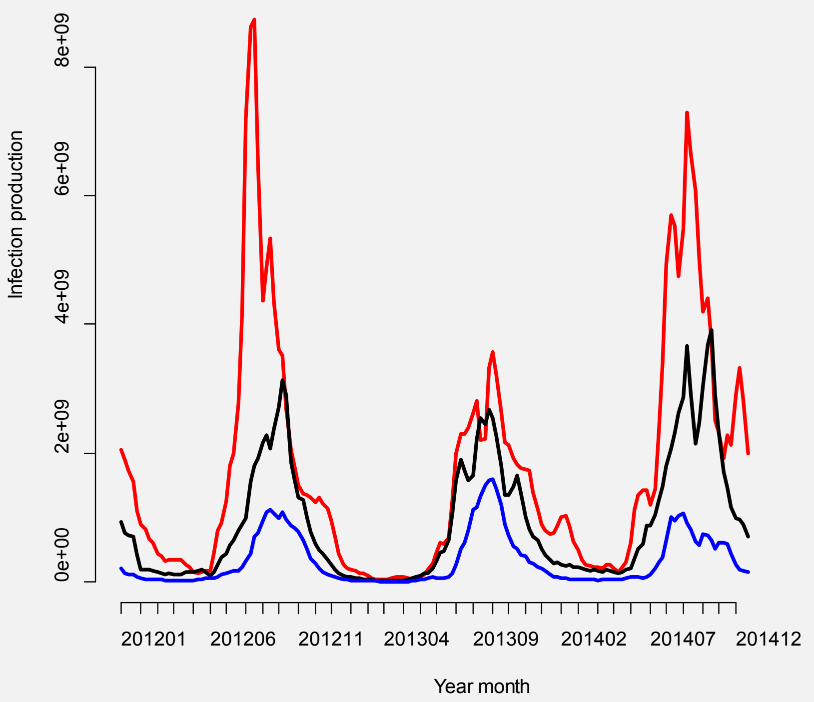


Figure G. Estimated weekly infection production (copepodites) in all sites in Southern-Norway (red line) and Northern-Norway (blue line) for the period January 2012- January 2015.

2012 and 2013, in terms of female lice and other mobile lice stages (Fig. F).

Copepodite production estimates based upon reported lice statistics, fish population estimates, temperature, knowledge of reproduction, survival and developmental cycles, (Kristoffersen et al. 2014, Epidemics 9: 31–39), have been made for southern, mid and northern Norway for 2012 – January 2015. These calculations indicate relatively high infection production in 2014 in south- and mid-Norway (Fig. G).

Infection pressure varies between site as a function of the total number of female lice on the locality and water temperature. Fig. H (upper panel) shows relative infection production (copepodites) at the locality level for the week with maximal infection production for the whole country 2012–2014.

Production of salmon lice can be used to calculate the infection pressure in different areas.
The infection pressure on any one site in a particular week is calculated by summation of production of salmon lice from all neighbouring infection generating sites after adjustment of the contribution of each site dependent on the distance to the given locality. In weeks with highest lice production in 2012–2014, the estimated infection pressure is shown in Fig. H lower panel. In 2012 the greatest infection pressure is in the south. In 2013 and 2014 there are also several areas further north which display high infection pressure.

Use of chemical treatments for control of salmon lice is summarised in Table 3.

Table 3 shows a marginal reduction in total number of lice-related prescriptions from 2012 to 2014, but there are indications of under-reporting in 2014. At the active-substance level the 2014 figures indicate that use of hydrogen peroxide, flubenzorone and emamectin benzoate has increased, while pyrethroid use has declined.

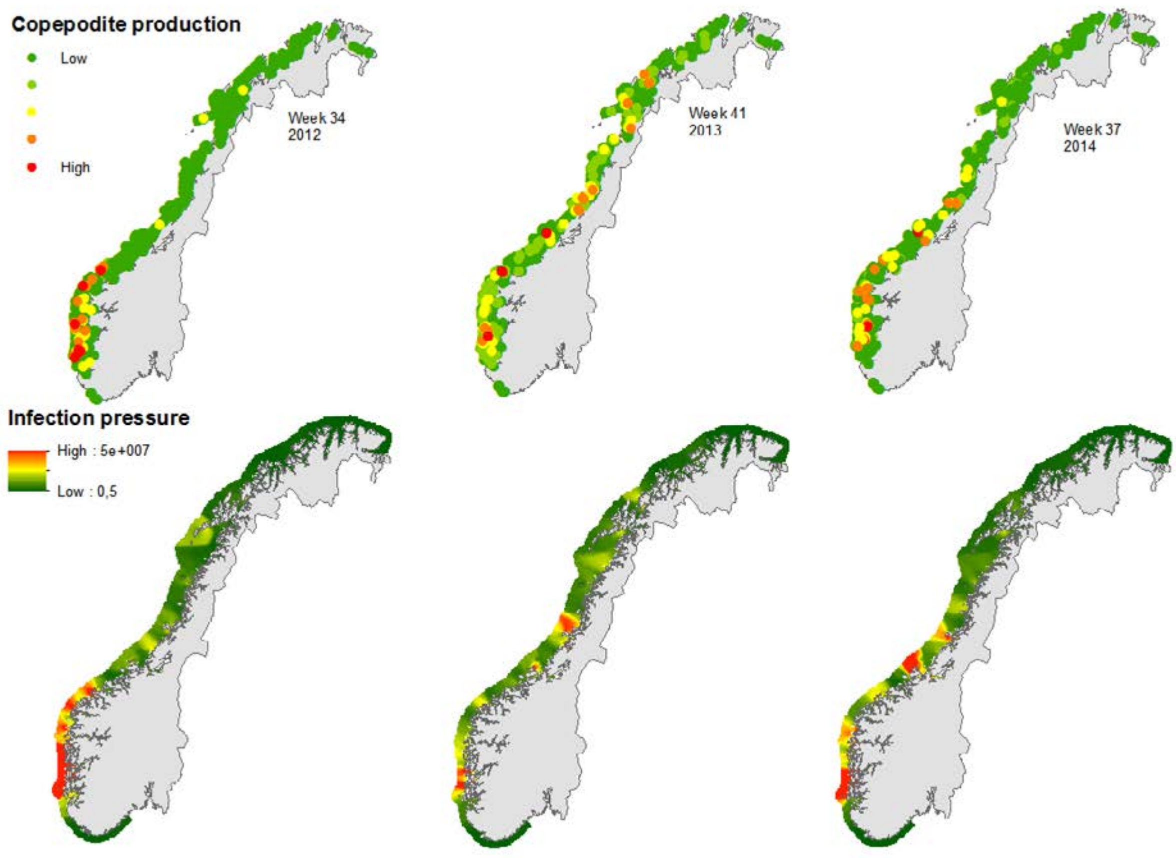


Figure H. Estimated infection production (upper panel) and infection pressure (lower panel) for the weeks with maximal infection pressure in the country as a whole in 2012, 2013 and 2014. Infection pressure is displayed as relative density of copepodites in a colour scale from low (green) to high (red)

Table 3: Total prescriptions in the medicinal register of active substances used to treat salmon lice infections

Active ingredient	2011	2012	2013	2014
Azamethiphos	451	617	448	447
Pyrethroids	501	1005	1065	567
Emamectin benzoate	245	50	47	227
Flubenzurons	167	60	68	221
Hydrogen peroxide	22	62	26	78
Total	1386	1794	1654	1540

One of the greatest risks related to frequent use of any chemical treatment is development of resistance. The Norwegian Veterinary Institute, under the auspices of the Norwegian Food Safety Authority, conducts a surveillance program related to resistance development in salmon lice. This is carried out in association with the Norwegian Environmental and Bioscience University (NMBU) and Fish health services around the coast. In 2014, elementary testing for resistance against azamethiphos, pyrethroids, emamectin benzoate and hydrogen peroxide was performed. The results (Fig. I) reveal widespread reduced sensitivity to ememectin benzoate, deltamethrin and azamethiphos in salmon lice tested at different farms along the coast. For hydrogen peroxide the map shows a tendency towards reduced sensitivity in Trøndelag and on the south-west coast.

Read more on www.vetinst.no/faktabank/lakselus

Amoebic Gill Disease (AGD) – *Paramoeba perurans*

Amoebic gill disease (AGD) is caused by the amoeba *Paramoeba perurans* (synonym *Neoparamoeba perurans*). Since the middle of the 1980s this disease has caused severe losses in salmon farming in Australia (Tasmania).

AGD was diagnosed in the Atlantic Ocean in the mid-90s and has over the last 20 years become an important pathogen and the amoeba is being detected further and further north. In 2011 and 2012 AGD was among the most important diseases in salmon farming in Ireland and Scotland. In 2013 *P. perurans* was identified in several farms in the Faroe Islands and in the last two years AGD has become a serious disease in Norwegian salmon farming.

AGD occurs in fish farmed in seawater, primarily in Atlantic salmon, but also in other species such as rainbow trout, lumpsucker and various wrasse species. Australian studies have concluded that high salinity (>32 ‰) and high sea temperatures (>17 °C) are the two most important risk factors for outbreak of AGD. They also seem to be important factors under Norwegian conditions, but outbreaks do occur in Norway also at lower salinity and significantly lower temperatures than experienced in Tasmania. AGD can be treated using freshwater or hydrogen peroxide (H_2O_2). While treatment with freshwater is less damaging for salmonid fish and has better effect than H_2O_2, limited well-boat capacity and availability of freshwater have been limiting factors for its use.

Treatment of AGD is best performed early in development of the disease. Screening for the presence of amoeba and intensity of infection by PCR is important. Gills should also be visually examined regularly. A system for classification of macroscopically visible gill changes has been developed (gill score). Together with direct microscopy of gill preparations these techniques have been important tools for Fish health services. Gill scoring can become difficult after repeated treatment and the method requires considerable experience. As a number of other factors/agents may also cause gill changes, it is important to confirm an AGD diagnosis by histological investigation.

In Norway, AGD was identified for the first time in 2006. AGD was again identified in 2012 (5 cases). In 2013 the Norwegian Veterinary Institute diagnosed AGD on 58 different farms. Two of these involved rainbow trout, two ballan wrasse and one corkwing wrasse, the rest were salmon. In 2014 the Norwegian Veterinary Institute diagnosed AGD on 69 different farms. Five of these cases involved lumpsucker and one involved ballan wrasse, the remainder involved salmon. AGD is not notifiable and the number of cases registered by the Norwegian Veterinary Institute must be considered the minimum number of actual cases. There is reason to believe that some Fish health services and/or farmers diagnose the disease themselves without sending samples to the Norwegian Veterinary Institute. In addition it is likely that various laboratories identify the amoeba using PCR in many farms where for one reason or another AGD does not develop.

In 2014 3 % of AGD diagnoses were made in Rogaland, 27 % in Hordaland, 21 % in Sogn og Fjordane, 38 % in

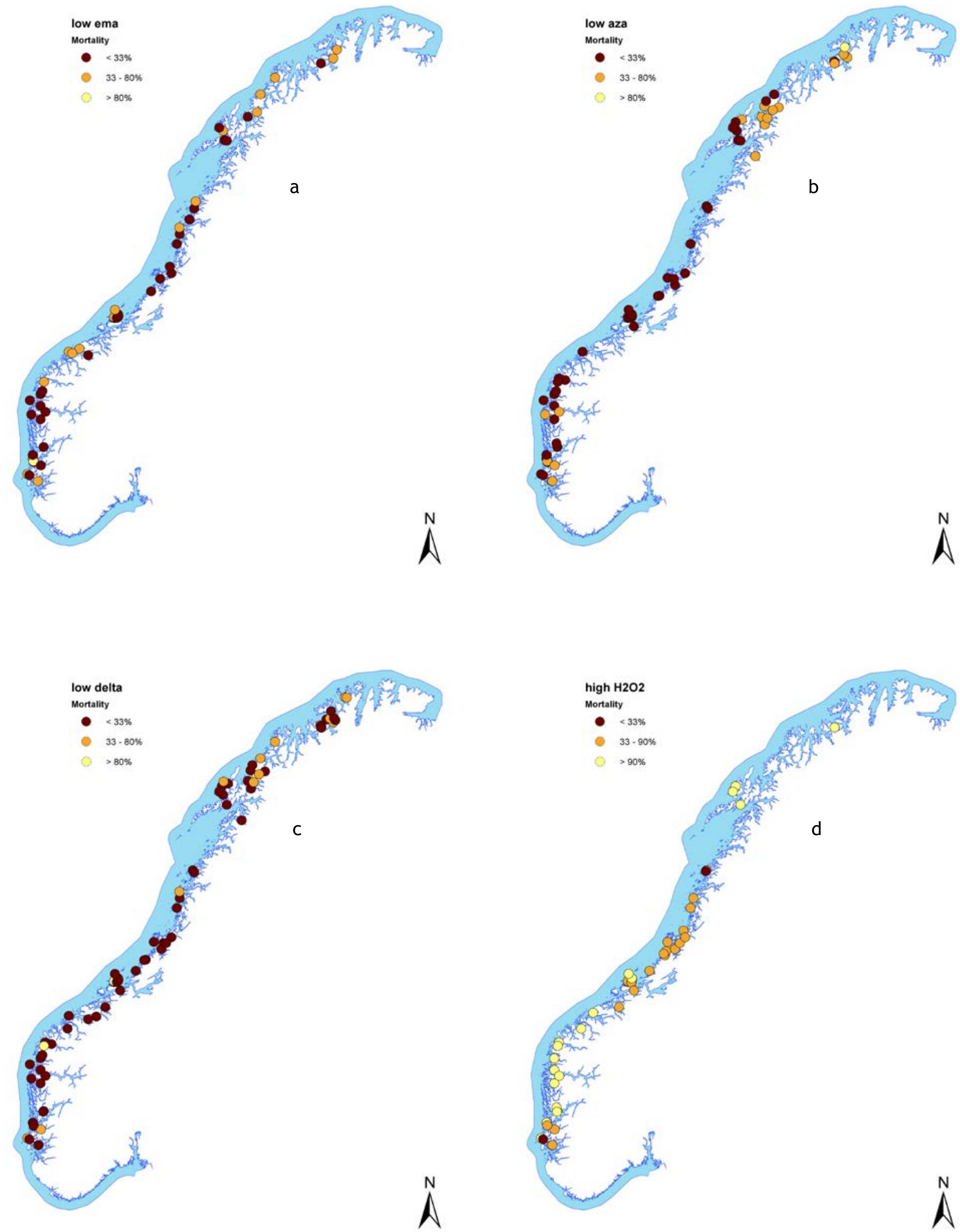
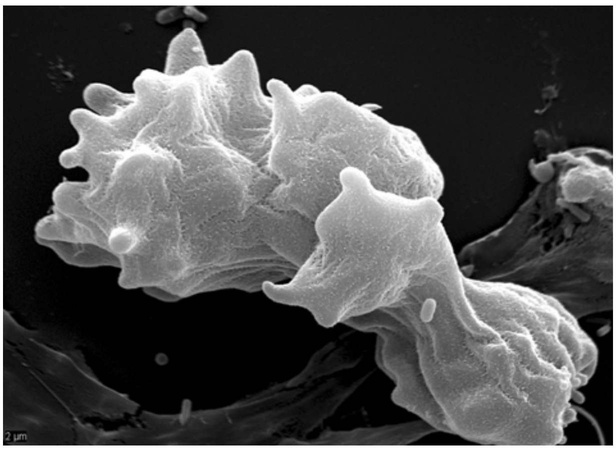


Figure I. Mortality of lice in an elementary bioassay with a) emamectin benzoate b) azamethiphos c) deltamethrin and d) hydrogen peroxide where dark colouration indicates low mortality of lice (< 33 %, lice with low sensitivity), yellow indicating high mortality (> 80 %, sensitive lice) and orange colouration indicates intermediate sensitivity/ mortality(33 – 80 %, lice with reduced sensitivity)

White spots on the gills caused by the amoeba *Paramoeba perurans*. Photo: Jannicke Wiik-Nielsen, Norwegian Veterinary Institute

Møre og Romsdal and 11 % in Sør-Trøndelag. In 2013, in excess of 70% of amoeba diagnoses were made in Hordaland. The most northern diagnoses in 2013 were in Møre og Romsdal, while 7 cases were identified in Sør-Trøndelag by the Norwegian Veterinary Institute in 2014. There are media reports of AGD in Flatanger in Nord-Trøndelag. Various factors indicate that *P. perurans* and outbreaks of AGD were more northerly in 2014 compared to 2013. In 2014 the Norwegian Veterinary Institute diagnosed AGD in equal numbers for each of the months September, October, November and December. This is comparable to the peak months in 2013. In 2014 the first outbreaks were registered in August compared with mid-September in 2013. Some diagnoses were made in early 2014 with most cases in January (10) and some in February, March and



Paramoeba perurans visualised by scanning electron microscopy (SEM). Photo: Jannicke Wiik-Nielsen, Norwegian Veterinary Institute

In typical AGD the gill tissues are locally irritated. Often two opposite sides of neighbouring filaments are affected. Photo: Anne Berit Olsen, Norwegian Veterinary Institute

April. These outbreaks are considered as the tail end of the 2013 «AGD-season». Taken together, it appears that the increased prevalence of amoeba and AGD outbreaks appeared earlier in 2014 than previously. They also affected more farms over a larger geographic area than in 2013.

Read more on www.vetinst.no/faktabank/amoebegjelle-sykdom-agd

Tape worm - *Eubothrium* sp.

In recent years an increased prevalence of tapeworms in the intestine of salmon farmed in the sea has been reported. This was also the case in 2014. Tapeworm infections result in increased intake of feed combined with reduced fish growth. Tapeworms can be found in the intestine of both salmon and rainbow trout where they attach to the pyloric caeca. In untreated fish the parasite will increase in size and can reach one meter in length. An increase in sales of praziquantel has been registered in recent years and there are concerns related to the possibility of resistance development. The Norwegian Veterinary Institute diagnosed tape worm in 55 cases in 2014.

Ichthyobodo spp. («Costia»)

In 2014 *Ichthyobodo* spp. were detected on 38 salmonid farms in Norway. These parasites are probably under-reported as Fish health services often diagnose such cases using direct microscopy and initiate treatment without reporting the case further. At least two different species exist in Norwegian aquaculture; *Ichthyobodo necator* on salmon in freshwater and *I. salmonis* on salmon in both seawater and freshwater. These parasites can infect both skin and gills. On identification in freshwater the fish are treated with formalin with good effect. Treatment in seawater is difficult for practical reasons.

Parvicapsulosis – *Parvicapsula pseudobranchicola*

The parasite *Parvicapsula pseudobranchicola* (Myxozoa) was first described in Norway following outbreaks of disease with high mortality in salmon in three ongrowing sites in 2002. The genus *Parvicapsula* also contains other species which are described as pathogens of both wild and farmed fish, causing mainly infections of the kidney and gallbladder.

The course of the disease in parvicapsulosis in salmon varies, from slightly increased to significant mortality. Parvicapsulosis is reported to be particularly problematic in Troms and Finnmark. Outbreaks in these regions may result in such high levels of morbidity that the entire sub-surface of the cage is populated by morbid fish. Mortality can also be high. Reports from Fish health services indicate that infections with *P. pseudobranchicola* are most serious during autumn and that the disease is most serious if the fish is also weakened by other diseases.

The highest densities of the parasite are found in the pseudobranch (under the gill cover), and it is here the most significant pathological changes are observed. During serious infections, large numbers of spores may be found in capillaries, epithelium and connective tissues. The parasite may also be found in the gills, liver and kidney. Fish with advanced parvicapsulosis are commonly thin, sluggish, dark in colour and display characteristic half-moon formed eye haemorrhages/cataracts. In 2014 the Norwegian Veterinary Institute identified the parasite in 36 farms, a similar number to that identified in 2010.

The diagnoses in aquaculture are made almost exclusively in the three most northerly regions, but the parasite has also been identified in Nord-Trøndelag. Troms accounts for a relatively large proportion of cases (18 farms). During 2014 the parasite has been identified exclusively in commercially farmed salmon.

Reports are published relating to identification of *P. pseudobranchicola* in wild arctic char, seatrout and salmon along the whole Norwegian coast and that one or all of these species may constitute the natural hosts. The work towards identification of the primary host continues.

Other parasite infections

Proliferative kidney disease (PKD), caused by the parasite *Tetracapsuloides bryosalmonae* (Myxozoa), was identified in juvenile farmed arctic char in 2014. This parasite is a normal finding in salmonid fish and may cause significant mortality.

Ichthyophthirius multifiliis, a parasitic ciliate which causes white spot, was also identified in a single salmon hatchery in southern Norway.

Gill Diseases

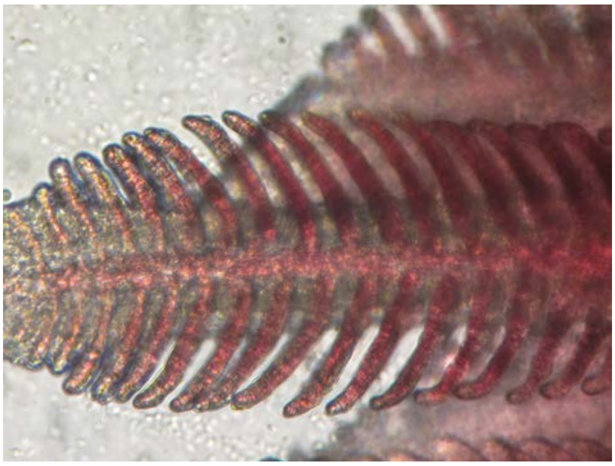
Gill diseases are one of the most important causes of production loss in salmonid aquaculture. These conditions are often multifactorial and many agents and water parameters may contribute. Gill disease is not notifiable, and it is therefore difficult to estimate the true extent of its significance.

The Norwegian Veterinary Institute has developed and now offers a specific PCR analysis for Piscine Poxvirus in salmon gills. Using «Next generation sequencing» the whole genome of the virus has been mapped from gill samples taken during an episode of acute high mortality in hatchery salmon. This is the first time a poxvirus from a fish has been characterised. Research on the virus, the disease and development of other diagnostic techniques is now being performed. The disease has been a recurring threat in several hatcheries since the late 1990s. This breakthrough may be of great significance in the fight against gill disease, both during the freshwater and marine phases of culture. There are few if any pathognomic indications of poxvirus infection. Histopathological investigation may indicate the

Multifactorial gill injuries in salmon 2014. Photo: Kristoffer Berglund Andreassen, Vesterålen Fiskehelsetjeneste

possibility of poxvirus involvement, but PCR is necessary to verify the presence of the virus. There is therefore every reason to include samples fixed for PCR analysis (RNAlater™) during investigation of gill problems.

The terms «Autumn disease», chronic gill disease and proliferative gill inflammation (PGI) are all used to describe gill disease which normally occurs in fish in the autumn of the first year in the sea. Fish with chronic gill inflammation display poor appetite, low tolerance for stress and increased mortality. In some cases of chronic gill inflammation, the proliferation of epithelial cells and inflammatory reactions are so severe that oxygen intake is severely restricted. Epitheliocysts (gill cysts) are often identified in association with this condition and several Chlamydia-related species (*Ca. Syngnamydia salmonis; Ca.* Piscichlamydia salmonis) and a proteobacterium (*Ca.* Branchiomonas cysticola), have been identified. *Ca.* B. cysticola has been identified as the dominating agent involved in Norwegian and Irish farmed salmon. The microsporidian *Desmozoon lepeophtherii* (syn. *Paranucleospora theridion*) is also a normal finding in chronically inflamed salmon gills. Microsporidia form infective spores and their life cycle may be either direct and/or involve intermediate hosts. *Desmozoon lepeophtherii* has the salmon louse (*Lepeophtheirus salmonis*) as final host and salmon as the intermediate host. The parasite has also been identified in rainbow trout and seatrout, as well as the sea louse (*Caligus elongatus).* The parasite is found along the whole Norwegian coast, but appears to be most common south of Nordland. The parasite is also found in Scotland, and has been newly identified in salmon lice in Canada. *Desmozoon lepeophtherii* can be detected by real-time PCR and while most commonly gill or kidney tissues are tested in diagnostic investigations, the parasite may be found in all tissue types. Spores



Direct microscopy of normal salmon parr gills. Photo: Grim Sand Mathisen, Marine Harvest Nord

Direct microscopy of gills with suspected POX-infection in salmon parr. Photo: Grim Sand Mathisen, Marine Harvest Nord

and other stages may be seen microscopically and are observed most commonly in inflamed tissues in the gills and body cavity. The importance of the parasite for fish health is not clear, but it does contribute to gill disease, alone or in combination with other agents and the infection is also systemic.
The parasite is extremely widespread in farmed salmon and infection is suspected in many diagnostic submissions. Requests for analysis for the presence of this parasite were however rare in cases submitted to the Norwegian Veterinary Institute in 2014. This may be related to the unknown significance of infection with this parasite and the lack of available treatment options. Both epitheliocystis and microsporidia are extremely prevalent in salmonid gills, even in apparently healthy fish from farms without disease. Both agents are, however, present in significantly higher numbers in fish displaying serious chronic gill inflammation.

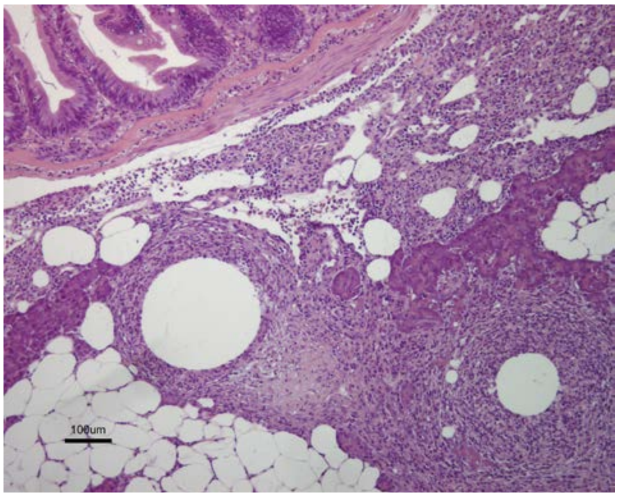
Gill disease in freshwater can be caused by fungus (*Saprolegnia* spp.), bacteria or parasites e.g. Costia (*Ichthyobodo* sp.). The primary cause is often related to poor water quality and the problem often disappears following correction of the primary environmental problem.

Other health problems

Smolt quality and runt syndrome

Increased mortality during the first period after sea transfer comprises a significant proportion of the overall mortality registered during the marine culture phase. A larger investigation undertaken by the Norwegian Food Safety Authority (2014) concluded that there are few specific causes associated with this mortality and that large regional differences exist. Individual fish groups with high mortality are responsible for the high average loss. There is significant room for improvement in the situation. The causes of mortality are almost certainly multifactorial, and there are normally few or no specific findings made during diagnostic investigations. Many of these fish develop what is known as runt syndrome.

Runt syndrome is a condition in which fish become emaciated and/or do not develop normally after sea transfer. Normal findings in these fish during histological investigations include no or limited perivisceral fat and increased melanisation in the



Histology of vaccine associated pathology. Granulomatous peritonitis surrounding oil droplets in the fatty tissues can be observed around the digestive caeca. Photo: Trygve T. Poppe, NMBU and the Norwegian Veterinary Institute

kidney, but an intact pancreas. Bacteriological and virological investigations are often negative.

In 2014 the Norwegian Veterinary Institute registered an increased prevalence of emaciated fish in mid- and northern-Norway compared to 2013.
The condition has been a problem in several farms and presents a challenge to both production and fish welfare. The causes of runt syndrome remain unknown and are probably multifactorial. Some of the cases may originate from the freshwater phase, where runts may already be observed. It is thought that problems with smoltification may be involved in development of the condition. In the seawater phase emaciation has been observed in fish surviving an IPN outbreak. Tape worm infection is comparatively common in runt fish. In a pilot investigation performed by the Norwegian Veterinary Institute in 2012, larvae of the nematode *Anisakis simplex* were identified only in runt salmon, which were not destined for human consumption. There can be several explanations for this.

Many of the fish that develop runt syndrome continue to live for extended periods and undoubtedly represent a significant animal welfare challenge. It is thought that such individuals are more susceptible to infection by parasites and disease than normal fish. It is therefore important that runt fish be removed from the farm as they pose a risk of transmission of disease.

Vaccine associated injuries

Comprehensive vaccination is a precondition for modern intensive salmon aquaculture. Generally, todays vaccines award good protection against the most important bacterial diseases of salmon and rainbow trout. Protection against viral diseases is more variable. There is an increasing requirement for good protective vaccines for cleaner fish. As a result of better vaccines and lower injection volumes it is now unusual to identify vaccine side effects which represent a health or welfare challenge to the fish. However, the main components of present vaccines remain the same and side effects in the form of granulomatous inflammation and adhesion development between the peritoneal wall and inner organs continue to be identified. To ensure good fish welfare it remains important to continually focus on vaccine quality, vaccination procedures and the incidence of side effects in vaccinated fish.

Fish welfare

There is general agreement that fish have the ability to experience pain and discomfort and that fish as a domesticated animal have the right to an environment which ensures good welfare throughout the whole life cycle. Fish health personnel and research institutions have a special responsibility to identify and work towards improved fish welfare. There is now rapid development and testing of new technology, farming methods and handling of fish. Aquaculture legislation § 20 demands that equipment and methods be documented in regard to welfare prior to being taken into use. Much focus has been placed on development of methods for prevention or treatment of salmon lice infections e.g. enclosed cages, lice skirts and different de-licing methodologies. This should also stimulate a general increase in efforts to identify the most important welfare challenges in today's fish farming and to find the best solutions.

Consideration of fish welfare is a challenge in all the different phases of production and mortality of newly sea-transferred smolts and development of runts are part of this. In larger fish high mortality due to handling and lice treatment constitutes a significant animal welfare issue.

The low treatment threshold for lice and reduced susceptibility to chemical treatments in many areas has led to frequent treatment. Episodes involving mortality of over 200 tons of salmon have been reported in some farms in relation to such treatments. We do not have enough knowledge on the extent of the problem or the risk factors involved. Bath treatments using tarpaulins in the cage or in well boats involve a series of events leading to stress, mechanical injury and possible water quality problems. Due to the problem with resistant salmon lice, trials with increased dose, increased exposure time and in many cases mixing of different active ingredients have been attempted in order to achieve sufficient effect. In addition the effects of water temperature and fish health status also affect the outcome. Handling or bath treatment of fish with serious gill disease (like AGD) or viral disease (like HSMB) is reported to result in high mortality in some cases. On use of hydrogen peroxide acute mortality episodes are often characterised by corrosive injuries on the skin, cornea and gills. Subsequently many fish may develop large ulcers. On overdose of other substance, oxygen stress or other acute stressor, there will typically be few histological signs indicative of the cause.

Fish are transported either as smolts or as harvest fish. Some fish are also graded and moved during the marine phase. These are operations involving large numbers of fish, large boats and advanced technology. There exists today little knowledge on how these operations affect fish welfare.

Fish slaughter is a large industry, and small improvements and close monitoring of fish welfare are of significant collective importance. Findings resulting in downgrading or compensation claims from customers can indicate that fish welfare is not good enough. Generally, the aim should be production of a robust, disease free smolt combined

Over eating in salmon. Photo: Harriet Romstad, Aqua Kompetanse AS with development of with good stress free production methods.

The health situation in live gene banks and stock-enhancement hatcheries

Parasites

Parasitological checks are part of routine health surveillance in gene banks and stock-enhancement hatcheries. The findings for 2014 reported to the Norwegian Veterinary Institute include members of the *Scyphidia*, *Riboschyphidia*, *Epistylis*, *Ichthyobodo* and *Trichodina*. *Gyrodactylus salaris* was not identified in either of these two types of farm in 2014.

Bacteria

During routine testing of broodstock in the spawning season of 2014, BKD was identified in four fish. These fish did not show clinical signs of disease and there were no other indications of disease.

Otherwise no other serious bacterial or viral diagnoses were made in 2014 from either gene-bank or stock enhancement hatcheries.

Fungus

Saprolegnia spp. in eggs, gills and skin are considered normal findings, and preventative work and treatment is continual. In 2014 low numbers of swim bladder and kidney mycoses were reported.

Environmental problems

Of environmental problems, management problems and other diagnoses, operculum development and fin erosion were frequent findings. Wounds/ulcers are relatively common in sexually mature broodstock, and are normally related to fighting in male fish. Otherwise, eye injuries, cataract, nephrocalcinosis, gill injury, gill inflammation and gill irritation, different deformities and emaciation/runt development are reported.

Health control of wild-caught broodstock for stock-enhancement purposes

Stock enhancement hatcheries have a particular responsibility to avoid intake, amplification and spread of pathogenic organisms with released fish. This is particularly relevant for vertically transmitted diseases such as infectious pancreatic necrosis (IPN) and bacterial kidney disease (BKD). The Health Service for Stock-Enhancement Hatcheries organises therefore health checks for wild caught broodstock for member farms and for the live and frozen gene banks for wild salmon. Broodstock checks for the gene banks encompass post mortem and PCR analysis for IPN-virus, the BKD-bacterium (*Renibacterium salmoninarum*) and the furunculosis bacterium (*Aeromonas salmonicida* ssp. *salmonicida*). For stock-enhancement hatcheries only BKD testing is compulsory, but the Health Service for Stock-Enhancement Hatcheries recommends additional PCR testing for IPNV. All PCR analyses are performed by Patogen Analyse AS. The preliminary results for the 2014/2015 breeding season are 1988 negative- and four positive samples for *Renibacterium salmoninarum* (BKD). The positive samples all came from the same river.

Table 4 presents a summary over the number of salmon, trout and arctic char brood fish which were tested for *Renibacterium salmoninarum* (BKD) and *Aeromonas salmonicida* ssp. *salmonicida* (furunculosis) during 2014/2015. A positive analysis results in destruction of the spawning products from that individual fish.

Scale reading and genetic testing identifies farmed fish

Scale analysis, conducted by the Norwegian Veterinary Institute, is compulsory for all wild caught salmon broodstock destined for production of eggs for stock enhancement or gene banks. Scale analysis is extremely important for exclusion of farmed fish in these breeding programs. Norwegian Environment Agency guidelines of 2014 include in addition to scale analysis, compulsory genetic origin testing for all salmon bred for stock enhancement. The aim is primarily to protect the genetic profile of fish in individual rivers.

Table 4 presents a preliminary overview of broodstock analyses for the season 2014/2015 providing species, number of fish and tissue type investigated. PCR-testing of either kidney tissue or egg fluid/milt for infectious pancreatic necrosis (IPN), *Renibacterium salmoninarum* (BKD) and *Aeromonas salmonicida* ssp. salmonicida (furunculosis) resulted in four positive samples for *Renibacterium salmoninarum* (BKD) from the same salmon population.

		Kidney	Egg fluid/ milt	Total
Salmon	BKD	404*	239	643*
	IPN	323	19	342
	Furunculosis	154	24	178
Trout	BKD	82	214	296
	IPN	82	192	274
	Furunculosis	9	0	9
Arctic charr	BKD	5	120	125
	IPN	5	120	125
	Furunculosis	0	0	0

Disease diagnostics in wild salmonids

Gyrodactylus salaris – NOK-programs

In 2014, three surveillance programs for *Gyrodactylus salaris* were performed.

1. Surveillance for *Gyrodactylus salaris* in farms and rivers.
2. Freedom of infection program for *Gyrodactylus salaris*
3. Mapping the distribution of *Gyrodactylus salaris* in Tyrifjorden.

In the surveillance program for *G. salaris* in farms and rivers (OK-program), which is aimed at documentation of the freedom of infection in Norwegian aquaculture facilities and river systems, approximately 2900 salmon and rainbow trout from 85 farms and 2400 salmon from 68 rivers were examined. *G. salaris* was identified in one river in 2014, the river Ranaelva in Nordland. The Ranaelva was previously treated with rotenone and declared free of infection in 2009. *G. salaris* was not identified in stock enhancement hatcheries or commercial hatcheries in 2014. Rivers in the OK-program are examined once a year at one to three localities, dependent on the size of the river. In the Tana, samples are taken at more than three localities due to the size of the river, while from the river Numedalslågen two samples are taken; one high up the river, the other from the lower reaches, due to the presence of *G. salaris* in the Pålsbufjorden. In stock enhancement hatcheries and commercial hatcheries samples are taken from approximately 90 farms each year. Samples from farms holding salmon/rainbow trout are taken on a rolling system such that all farms (30 salmon or 60 rainbow trout) are checked every second year.

In the freedom of infection program which has the intention of documentation of the absence of the pathogen from previously infected rivers following eradication treatment, approximately 1700 juvenile salmon from 14 rivers were examined. These included samples from the Steinkjer- (3 rivers), Vefsna- (10 rivers) and Lærdal- (1 river) systems. *G. salaris* was not identified in the freedom of infection program in 2014. Subsequently, three rivers in the Steinkjer region (the Steinkjer system– Byaelva and Ogna, Figga and Lundselva) were declared free of infection in 2014. The rivers in the freedom of infection program are examined twice a year. This involves collection of 10 juvenile salmon every second kilometer of the anadromous part of the river. In rivers with short anadromous stretches, 30 fish are collected from the lower reaches of the river. The period of time between completion of eradication actions and declaration of freedom of infection should be minimum 5 years. This is based on a maximum smolt age of four years, plus a one year margin of safety. In regions with a maximal smolt age of five years or more the time prior to declaration of freedom of infection should be increased accordingly.

In 2014 the work of mapping the distribution of *G. salaris* in the Tyrifjord began. The aim of this project is to establish whether the parasite is present in the fjord or in the upper anadromous stretch of the river Drammenselva. In 2014 examination of a large number of arctic char (500) from the Tyrifjord to find out whether *G. salaris* had survived on this fish species after introduction of the parasite to the Tyrifjord with farmed fish (salmon and rainbow trout in the 1980s) was planned. It was found to be more difficult than thought to catch 500 arctic char however, and the project will be concluded in 2015.

Eradication of Gyrodactylus salaris

Final treatments of the Rauma region were performed in 2014. The region now enters a freedom of infection process, together with the Lærdals region and Vefsna region which was last treated in 2012. The Steinkjer region was declared free of infection on the 24th of October following five years in the freedom of infection program. Remaining infected areas in which treatment has not yet begun are the Skibotn region, the Driva region and the Drammen region. *G. salaris* was also identified again in the river Ranaelva, 10 years after the last treatment in 2004. The parasite was not re-identified in the rest of the region and the remaining rivers in the region maintain their infection free status.

The rivers of the Rauma region were treated at the end of August, following more or less the same procedure as in 2013. This included the infected rivers Rauma including the Istra, Innfjordelva, Måna, Skorga, Breivikelva and the Henselva including the Isa and Glutra. Other smaller rivers in close proximity to the infected rivers were also treated. Every river within the Romsdals fjord was individually considered for treatment, based on their proximity to infected rivers, possibility for surveillance and size. Comprehensive sea trout conservation work has been performed in the region.

The work of planning and preparation for treatment of the Skibotn region was continued in 2014. Priority was placed on completion of survey work and identification of possible infection outside the known infected area (none was found). The larger rivers in the region are considerably affected by groundwater springs. In addition there is a considerable population of sea-run arctic char in these rivers. These can carry *G. salaris* and populate the freshwater springs to a greater degree than salmon. This poses an extra challenge to both mapping and identification of suitable treatment methodology. Conservation work relating to sea trout and arctic char continued in 2014.

As a result of the new detection of the parasite in the river Ranaelva an emergency treatment was performed in the autumn of 2014. The treatment was performed as a nearly full-scale treatment and will be followed up with a final treatment during 2015 or 2016. This will be dependent on whether ongoing investigations find that the source of the infection requires a more comprehensive treatment or longer planning period.

In other infection regions, treatments are planned further in advance and activities have not yet begun.

Cleaner fish

In Norwegian salmon farming it has become steadily more common to use cleaner fish for control of salmon lice. Important factors in this development include stricter consequences of high lice numbers and the increasing prevalence of resistance in the lice to chemical treatments. The most commonly used species are goldsinney wrasse (*Ctenolabrus rupestris*), corkwing wrasse (*Symphodus melops*) and Ballan wrasse (*Labrus bergylta*). A smaller number of rock cook (*Centrolabrus exoletus*) and cuckoo wrasse (*Labrus mixtus*) are used. In addition, a large and increasing number of lumpsucker (*Cyclopterus lumpus*) are used. Most of the cleaner fish used are wild-caught, but an increasing number are farmed. Ballan wrasse have been farmed for some years, but farming of lumpsucker has been a rapidly growing industry for the last three years. In 2014 the number of diagnostic submissions from Ballan wrasse and lumpsucker to the Norwegian Veterinary Institute was around the same as in 2013, while for the remaining wrasse species the number of submissions has declined somewhat. Samples have been received from both farmed and wild-caught cleaner fish. In some cases there has been uncertainty in the field of the species submitted and these samples have been registered as wrasse in the Norwegian Veterinary Institute database.

A large proportion of wild-caught wrasse are caught in fyke nets in the summer months and transported in tanks on deck, in well-boats or lorry to their final destination. The longest transport distances stretch from the Swedish west coast and the Baltic as far as Nordland. Given the increasing number of farmed cleaner fish, use of different cleaner fish species and extensive transport of cleaner fish over long distances, there is a need for further and better mapping of disease and causes of mortality in this type of fish.

Fish welfare

Most animal welfare studies in aquaculture have been directed at farmed salmon. Cleaner fish (i.e. wrasse and lumpsucker) comprise an important component of lice control in modern intensive farms. As such their capture, culture and use should be practiced in such a way that maintains good fish welfare. Whether this is the case in today's farming is far from certain. Capture, transport and use of these species is commonly associated with high mortalities (up to

Goldsinney wrasse with skin ulcer.
Photo: Trygve T. Poppe, NMBU and Norwegian Veterinary Institute

40 % is reported), and dead fish must be replaced with new to maintain a sufficiently high population in the cage. Mortality among cleaner fish is also high during and following handling and treatment against salmon lice. Treatment with freshwater against amoebae leads to 100 % mortality in cleaner fish species present in the cage. Despite this, knowledge of and attention towards welfare of cleaner fish has increased a lot in recent years. Surveillance during capture and transport, use of cover for the fish and not least feeding (particularly for lumpsucker) has contributed to better welfare, increased survival and therefore also better efficiency in lice removal. That the fish have a limited working life results in treatment of cleaner fish as a consumable, and this is in itself a welfare challenge which both the industry and the authorities must work together to find a solution.

Virus

In 2014 no viral diseases were identified in cleaner fish, although the number of samples analysed for virus was low. Previous studies on Norwegian wild-caught and farmed cleaner fish stocked in salmon cages have not identified VHSV, IPNV or Nodavirus. SAV is reported from wrasse stocked in a salmon cage during a PD outbreak. Whether this was a passive or active infection is not known. Several studies are under way and it has recently been shown experimentally that lumpsucker can be infected with IPN virus. There is a need for more knowledge of the capacity for cleaner fish to harbour different viruses.

Bacteria

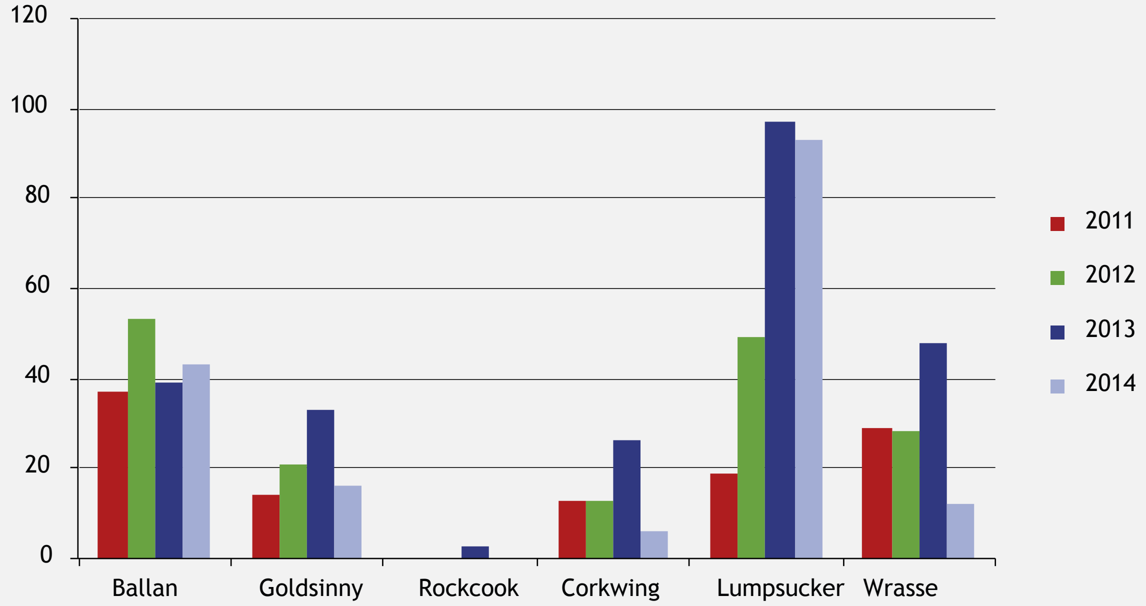
As in recent years the Norwegian Veterinary Institute has received many samples from lumpsucker, and a broad spectre of bacteria have been identified.

Various *Vibrio* species and atypical *Aeromonas salmonicida* (atypical furunculosis) have as in previous years dominated. Infection with *Pasteurella* sp. in lumpsucker was identified in 8 farms during 2014, both in hatcheries and cage farms. This is a reduction from 2013 when 16 sites were affected. Atypical *A. salmonicida* is considered to be one of the most important pathogenic bacteria in all cleaner fish types. The bacterium results most commonly in a chronic infection with granuloma development in inner organs, bullae and ulcer development.

Vibrio anguillarum was again one of the most commonly identified bacteria from cleaner fish, and was isolated from lumpsucker, Ballan wrasse and unspecified wrasse. Serovariants O1, O2α and variants which could not be serotyped according to the system in use were identified in both wrasse and lumpsucker. *Vibrio ordalii*, a well-known pathogen closely related to *V. anguillarum* was identified in one lumpsucker unit.

Many *Vibrio* species are normal flora in the marine environment. Some are well known pathogens while others are known as opportunists. The importance of several of the most commonly isolated bacteria from cleaner fish e.g. *Vibrio tapetis, V. logei, V. wodanis* and *V. splendidus*, is uncertain. Some strains of *V. tapetis* and *V. splendidus h*ave experimentally caused mortality in wrasse. Later trials performed on farmed Ballan wrasse have not been able to reproduce this pathogenicity in a convincing manner. It is speculated that external parameters during transport and the environment in salmon cages cause the fish to be more susceptible to infection by bacterial species which are normally non-pathogenic.

Fin rot in farmed Ballan wrasse remains a recurring problem. *Tenacibaculum* spp. are often associated with such outbreaks, both in pure culture or as part of a mixed culture. *Vibrio splendidus* is also commonly identified. *Tenacibaculum* is also regularly identified from other wrasse species and lumpsucker.



The number of cleaner fish submissions to the Norwegian Veterinary Institute 2011-2014

Parasites

Amoebic gill disease (AGD) continues to be diagnosed in cleaner fish, both lumpsucker and wrasse.
The Norwegian Veterinary Institute has confirmed the diagnosis. Previously AGD has been diagnosed in corkwing wrasse, Ballan wrasse and other wrasse species, both in cage and tank held fish. The pathological findings in the gills are similar to that observed in salmon. In 2014, microsporidia in the heart alongside suspected AGD, were identified in the same lumpsucker population.

Gyrodactylus sp. can be found on both the gills and skin of lumpsucker. The prevalence of *Gyrodactylus* and associated gill injuries has not been mapped, but such infections may become problematic in farming of this species.

Fungus

Suspicion of *Ichthyophonus hoferi* infection in lumpsucker with pathological changes in the gill, musculature and spleen was reported once in the course of 2014.

Susceptibility to antibiotics in farming of cleaner fish and other marine species

In farming of marine fish juveniles, particularly lumpsucker, bacterial diseases continue to cause severe problems. Vaccines are not used to any great extent. Antibiotic treatment with e.g. oxolinic acid and florfenicol are at times necessary for treatment of lumpsucker, halibut, monkfish and wolf fish. There are currently few signs of resistance development in bacteria isolated from these fish species.

Cod

In 2014 the Norwegian Veterinary Institute received seven diagnostic related submissions from cod. There has been a considerable reduction in the annual number of cases involving cod since 2009, when the institute received 350 submissions from 85 different farms. This development has occurred rapidly and mirrors the decline in number of active cod farms. Only a few farms remained in production in 2014. Many farms built for production of cod juveniles are now used for production of cleaner fish.

Bacterial infections have long dominated the disease situation in farmed cod. In 2014, infection with atypical *Aeromonas salmonicida* and francisellosis were identified in submitted samples. Classical vibriosis caused by *Vibrio anguillarum* was not identified in cod in 2014. This does not necessarily mean that this disease did not occur as it may have been diagnosed locally. Vibriosis and atypical furunculosis were previously considered the most usual infections in cod. Since the middle of the last decade francisellosis has been a significant problem in cod farming. This disease resulted in large losses and was one of the contributing factors to the decline of the industry, particularly in the south of the country. Francisellosis, caused by *Francisella noatunensis* subsp. *noatunensis*, was identified on one farm in nord-Trøndelag i 2014.

Nodavirus was not identified in material submitted in 2014.

Spleen with multiple granuloma in cod with francisellosis. Photo: Geir Bornø, Norwegian Veterinary Institute

Halibut

In 2014 the number of submissions received from halibut lay at approximately the same level as the previous year with 27 submissions from six farms. Submissions have primarily been related to increased mortality in different age groups related to certain types of bacteria. Fin rot was frequently identified. Atypical furunculosis and infections with diverse *Vibrio* spp. such as *V. logei*, *V. splendidus*, and *V. tapetis* dominated. *Pseudoalteromonas* was identified in association with disease in one farm. The effect of vaccination is reported to vary as is the effect of antibiotic treatment. Reduced sensitivity to quinolone antibiotics (oxolinic acid and flumequine) was identified in *V. logei* in one farm. Identification of reduced susceptibility to quinolones in *V. splendidus* and *V. tapetis* is a natural occurring phenomenon in these bacteria.

Infiltration of inflammatory cells in the apex of the heart was identified in a single case involving halibut. The significance of this is unknown and has previously been described as a comparatively normal finding (Fish Health Report 2006).

In late summer, during a period of high seawater temperature (20°C) bacterial gill inflammation with bacterial cells morphologically similar to *Tenacibaculum* spp. was identified in tissue sections. The bacterium was not successfully cultured and was therefore not identified. *Tenacibaculum* was identified in association with fin rot in one farm.

One halibut farm experienced increased mortality towards the end of the year. Clinical signs included an enlarged milt, necrotic liver and ascitic fluid in several fish. The material is currently being investigated for the presence of other agents e.g. aquareovirus (Fish Health Report 2013).

Nodavirus and IPN were not identified in submitted material from halibut culture in 2014.

The Norwegian Veterinary Institute is a national research institute in the fields of animal health, fish health, food safety and food hygiene, whose primary function is generation of research-based knowledge to support the relevant authorities. Preparedness, diagnostics, surveillance, reference functions, combined with scientific advice and risk evaluation are the most important fields of activity. Products and services include results and reports from research, analyses and diagnostics and reviews within these fields of activity. The Norwegian Veterinary Institute cooperates with a number of institutions both at home and abroad. The Norwegian Veterinary Instititutes' main laboratory and administration is based in Oslo, with regional laboratories in Sandnes, Bergen, Trondheim, Harstad and Tromsø.

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07 Media AS 2015