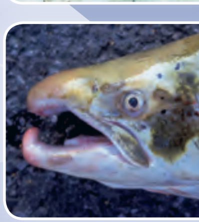
The Health Situation in Norwegian Aquaculture 2011



Veterinærinstituttet
Norwegian Veterinary Institute

Fish Health Report · 2013

Publisher
Norwegian Veterinary Institute · PO. Box 750 Sentrum · N-0106 Oslo

Form/layout: Graf AS
Text editing and completion of report:
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Front page photos:
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Order from
kommunikasjon@vetinst.no

ISSN 1893-1480 electronic edition

Suggested citing:
Hjeltnes B (ed) Fish Health Report 2013.
Oslo: Norwegian Veterinary Institute; 2014.

Thank you to all who contributed to the report. Without your input, especially from the fish health services, this annual overview of the health situation had not been possible.

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Fish Health Report · 2013

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7. March 2014

ISSN 1893-1480 electronic edition

Veterinærinstituttet
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Content

In 2013, 1,143,700 tons of salmon, 73,900 tons of rainbow trout, 6,700 tons of cod (estimate), 2000 tons of halibut and 700 tons assorted species (arctic char, coalfish, turbot etc.) were produced in Norway.

Salmon lice were once more one of the main challenges in Norwegian aquaculture in 2013, with infection pressure continually increasing from June and onwards throughout the autumn. Lice sensitivity to current chemical treatments is considerably reduced and the proportion of multi-resistant lice is increasing. As a result of failed treatments the salmon louse situation may be about to develop into a significant welfare problem, in farmed as well as wild fish. The Faroe Islands, which have never had a native wild salmon population, now have a significant problem with resistant salmon lice.

Pancreas disease (PD) is the most serious viral disease in Norwegian aquaculture. Developments in Western Norway are positive and it has been shown that it is possible to reduce the impact of this disease, both in terms of geographical distribution and associated losses. At the turn of 2013/2014, operating restrictions were only in force on a single farm in Sunnmøre and four in the whole of Sogn og Fjordane. Unfortunately the new PD variant (SAV2) has extended its geographical distribution in Mid-Norway.

Infectious salmon anaemia (ISA) has largely been under control in recent years. Several outbreaks were, however, registered in 2013. Whether this was a random development remains unknown. As this disease can result in significant losses and must be controlled, it is important to establish whether production routines contributed to this development. Culture of infected fish to market-size is now permitted as long as they remain free of clinical disease and/or do not otherwise represent a direct risk of infection to other farms.

Amoebic gill disease (AGD) now appears to be established in Norway. While the future impact that this pathogen will have on the Norwegian aquaculture industry is uncertain, experiences from countries like Tasmania, Scotland and Ireland suggest that the consequences could be significant.

Heart and skeletal muscle inflammation (HSMI) is a disease that the aquaculture industry has learned to live with. Although notifiable, the authorities have chosen not to combat the disease via enforced measures. The direct losses associated with HSMI are limited. Indirect losses can be much higher. The fish become frail, and mortality levels may increase following handling or treatment. The industry has everything to win through introduction of measures which may limit the extent and impact of HSMI and similar diseases. The industry is dependent on production of a robust fish capable of tolerating handling and variable environmental conditions.

Undefined losses during the sea-water phase remain too high, although the problem has received increased attention both from the industry and the public authorities. Production figures show that it is quite possible to reduce these losses from over 20% to well under 10%. Efficient farmers have shown that losses under 5% are also possible.

In comparison with the rest of the world, Norway has a uniquely transparent fish-health situation. This is an important factor in allowing identification of changing trends and in prioritisation of production and research agendas.

Brit Hjeltnes
Deputy Director, Fish- and Shellfish Health

Summary

To provide as complete a picture as possible of the health situation in Norwegian fish-farming, this annual report is based on diagnostic data from the Norwegian Veterinary Institute laboratories in Harstad, Trondheim, Bergen, Sandnes 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.

Pancreas disease (PD) remains the most important viral disease in Norwegian aquaculture. In total there were fewer farms diagnosed with PD or PD-virus in 2013 (99) than in 2012 (137). The epidemiological picture was dominated by two separate epidemics caused by different genotypes (SAV2 and SAV3). In western Norway, where until now only SAV3 has been identified, the trend is positive. The number of detections in Hordaland and Sogn og Fjordane has fallen and losses are reduced. In total, the reduction in number of SAV3 cases is around 47% from 90 in 2012 to 48 in 2013. While the trend is negative for SAV2, mortality levels have been relatively low. There were 31 detections in Sør-Trøndelag and 20 in Møre og Romsdal.

There were ten new cases of infectious salmon anaemia (ISA) in 2013. Eight outbreaks were identified in Nordland, one in Troms and one in Sogn og Fjordane. Several of these outbreaks were initially difficult to identify, although a clinical picture typical for ISA developed with time. The source of infection for many of the outbreaks has not been identified.

The drop in number of outbreaks of infectious pancreatic necrosis (IPN) continues, with 56 farms affected in 2013 in comparison with 119 in 2012 and 154 in 2011. Selective breeding for increased resistance to IPN (QTL-roe) is considered to be a significant factor in this development, in addition to eradication of ‘house’ strains of IPN-virus in hatcheries.

Heart and skeletal muscle inflammation (HSMI) is a very widespread disease in Norwegian farmed salmon. In 2013 the disease was reported in 134 farms, compared with 142 in 2012 and 162 in 2011. More diagnoses are made in mid-Norway than in western-Norway. The situation appears to be relatively stable. Direct mortality as a result of the disease is low, but there are clear indications that HSMI weakens the fish resulting in increased mortality as a result of other infectious diseases, handling and treatment.

For the third year in a row the number of diagnoses of cardiomyopathy syndrome (CMS) has increased. The Norwegian Veterinary Institute diagnosed 100 cases of CMS in 2013. As previously, most cases were identified in Møre og Romsdal (26) and Sør-Trøndelag (28). The economic losses may be significant as mainly large harvest-ready fish are affected.

Effective vaccines have significantly reduced the impact of bacterial diseases in Norwegian salmon farming. In 2012 an increased number of coldwater vibriosis cases (21) were registered, mainly in Northern Norway. Some cases were considered related to vaccine regime (temperature and antigen dose). Production processes were apparently adjusted and in 2013, 13 cases of coldwater vibriosis were reported.

Ulcer development remains a significant disease and welfare problem. While ulcers may occur in any region, most cases appear in the north of the country. The cause may be multifactorial, with transport/sea transfer of smolts at low temperature and mechanical injuries as contributing factors. The bacterium Moritella viscosa and/or Tenacibaculum are normal findings in such cases. If the number of fish with infected ulcers is high, the infection pressure may increase and result in ulcer development in the remainder of the fish population.

While in previous years only sporadic cases of amoebic gill disease (AGD) have been recorded in Norway, it now seems that the disease is well-established and some farms in Rogaland have required treatment. Experiences from Scotland show that gill-scoring is an important part of gill health surveillance, allowing initiation of treatment at an early stage. In addition to the gill amoeba a range of infectious agents have been identified which can give gill problems. Sub-optimal production conditions may also contribute to reduced gill health. The collective losses may be large.

Salmon lice remain a significant health challenge and a serious situation currently exists regarding development of resistance to chemical treatments. This situation has forced introduction of ‘stamping out’

in the most seriously affected areas in an effort to control numbers of resistant lice. In order to improve our understanding of the overall lice situation nationwide, a new method for calculation of the actual infection pressure has been introduced. Calculations made using this new model indicate a considerably lower infection pressure in 2013 compared with 2012. In some areas of northern-Norway infection pressure was, however, higher than in 2012.

General

The Norwegian Veterinary Institute has investigated a total of 2052 diagnostic cases in 2013 involving disease in farmed fish. In addition, cases involving surveillance, contractual work and research were also investigated. While the majority (1874) of cases involved salmon, a wide number of other fish species e.g. cleaner-fish, cod and halibut etc. were investigated. Using a combination of clinical observations, pathology and agent-detection our aim is not only

Table 1. Notifiable List 2- and list 3-diseases. Number of sites with diagnosed disease

	Liste	2009	2010	2011	2012	2013
Farmed fish (salmonids)						
Infectious salmon anaemia – ISA	2	9	7	1	2	10
Viral hemorrhagic septicemia – VHS	2	1	0	0	0	0
Heart and skeletal muscle inflammation - HSMI	3	139	131	162	142	134
Pancreas disease – PD	3	75	88	89	137	99
Furunculosis	3	0	0	0	0	0
Bacterial kidney disease – BKD	3	3	0	3	2	1
Farmed fish (marine species)						
Francisellosis	3	8	3	3	2	1
Viral nervous necrosis – VNN/VER	3	1	0	0	1	1
Wild salmonids (Rivers)						
Gyrodactylus salaris	3	0	2	1	0	1
Furunculosis	3	0	1	0	0	0
BKD	3	0	0	0	1	0
Crustaceans						
Crayfish plague (signal crayfish)	3					1

Table 2. Important non-notifiable diseases of salmonids. Number of affected sites registered by the Norwegian Veterinary Institute.

Disease	2009	2010	2011	2012	2013
Infectious pancreatic necrosis - IPN	223	198	154	119	56
Cardiomyopathy syndrome – CMS	76	53	74	89	100
Coldwater vibriosis	0	0	5	21	13
Vibriosis	9	9	8	7	4
Moritella	36	55	69	56	51
Yersiniosis	15	12	8	16	20
Flavobacterium	15	4	7	12	5
Amoebic gill disease – AGD				5	56
Parvicapsula	34	40	31	32	26

detection of the disease causing agent, but also the cause of disease. In our work we distinguish between what the fish dies of- and what the fish dies -with.

Recirculation - freshwater

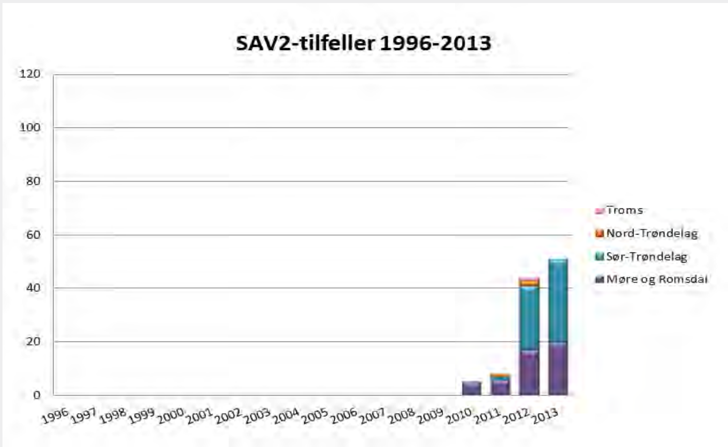
Recirculation technology (RAS) has become increasingly common in production of juvenile salmon in Norway in recent years, with a number of new facilities now in operation and more under planning. While we have relatively little experience with this technology in Norway, recirculation is well established internationally. In the Faroe Isles nearly all smolts are produced in recirculation facilities. Such facilities require considerable expertise and surveillance. Routine surveillance of important water quality parameters (solubilised oxygen, pH/ CO_2, TAN, (NH_4^+ + NH_3^+), nitrite (NO_2^-), total gas saturation and temperature) is critical to ensure good, secure animal welfare. The most important risk factors are: high levels of nitrite (NO_2^-) and total gas supersaturation, over-feeding and insufficient particle removal. Given adequate knowledge and correct use it is possible to maintain good fish health in a recirculation facility. Disinfection routines can, however, be challenging due to the requirement of a good stable biofilter. There is, therefore, an increased risk related to fish health and welfare should pathogenic parasites or micro-organisms enter a recirculation facility. Yersinia ruckeri has been identified within several RAS farms and vaccination introduced as a control measure. While no particular health challenges have been associated with recirculation technology during 2013, we should be prepared for eventual new future challenges.

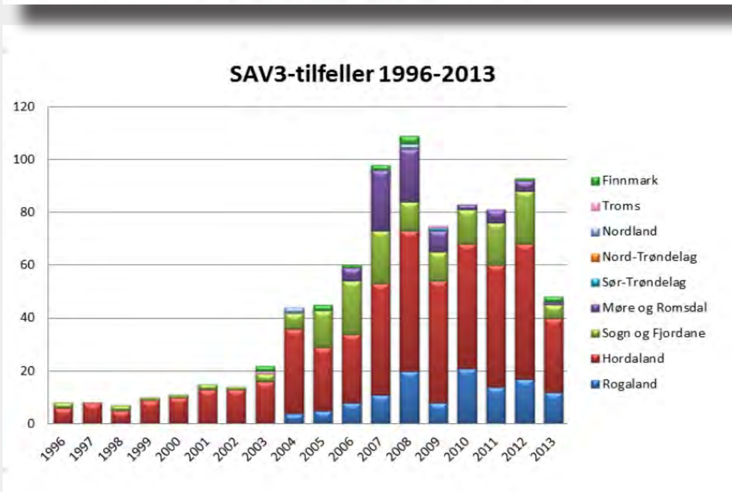
Production of juvenile fish of up to 1 kg

The Ministry for Fisheries and Coastal Affairs opened up for production of smolts of up to 1 kg in weight in 2011. The decision was based on the desire to reduce the culture period in open cages and thereby reduce the risk of escape and exposure to salmon lice and other disease agents. Several facilities for production of large smolts are now under planning and testing. There are two main types of facility: land-based recirculation farms and semi-closed floating farms. Production until smoltification will be performed as normal. Post-smolts will then be transferred to either type of facility until reaching 1kg in weight. No special health problems have been reported in relation to these farms in 2013. There are however, only very few and small-scale facilities currently in operation.

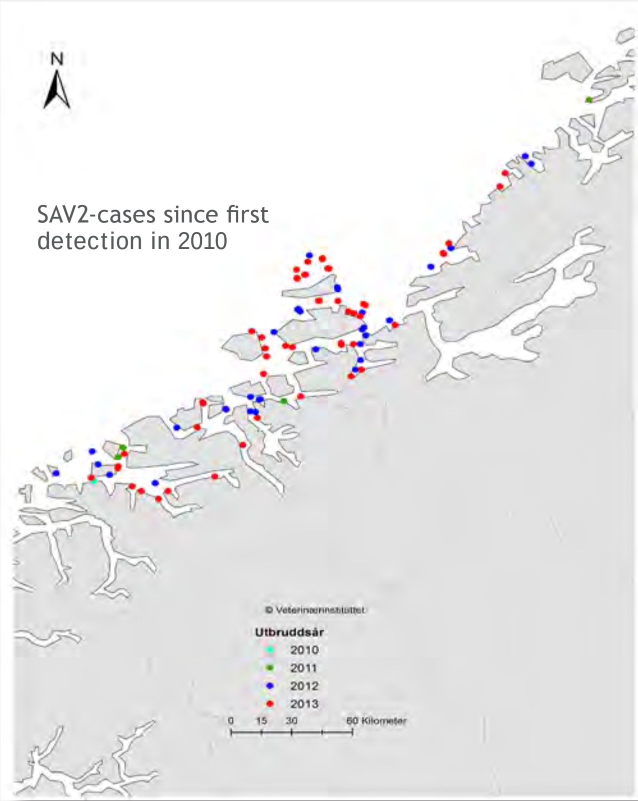
Recirculation farms allow a high degree of control over different factors including salinity and temperature. The fish are shielded from infectious agents that may be present in open cages. Experience with this type of farm is limited, although one Danish farm based on this technology is now producing salmon for consumption. Potential problems will probably be related to bacteria and the potential for biofilm based persistence cannot be discounted.

Floating, semi-closed farms are physically closed structures, which take in water from the surrounding sea, which also allows entry of agents with sea-water. Such farms will have the ability to take in water from various depths and deep intake water will contain fewer disease agents such as salmon-lice and salmonid alpha-virus (SAV). Intake of water from varying depth will also allow precise temperature





Regional distribution of the number of new cases of pankreas disease SAV2 and SAV3 1996-2013



SAV2-cases since first detection in 2010

control. Intensive production is planned in these facilities through stabilisation of temperature and increased biomass densities. From experience it is recognised that this type of production system results in an increased risk of bacterial disease, ulcer development and fin-injury.

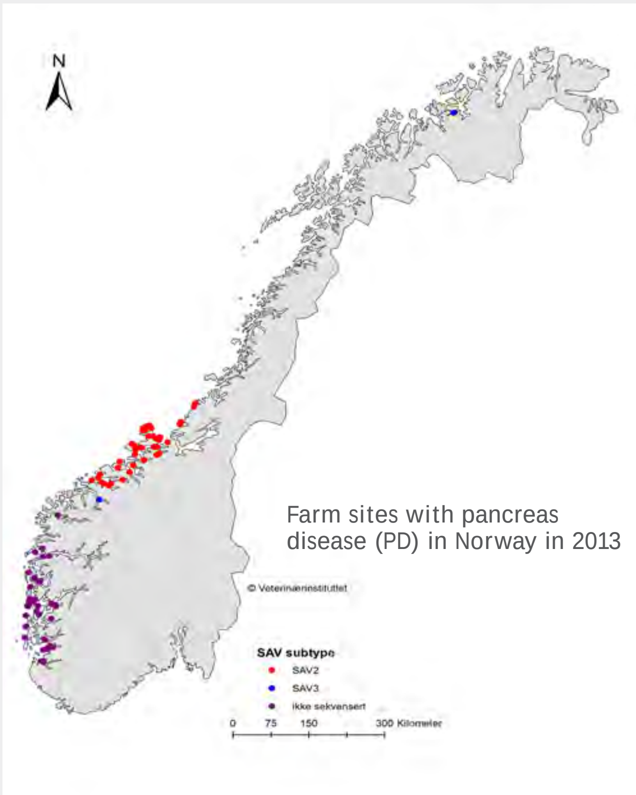
Viral diseases

Pancreas disease - PD

Pancreas disease (PD) is an extremely infectious disease of sea-farmed salmonid fish caused by salmonid alphavirus (SAV). PD has been endemic in western Norway since 2003/4 following spread from the core area of Hordaland. Since 2010 outbreaks involving a new variant of PD-virus (marine SAV subtype 2) have been experienced in mid-Norway. The total national number of PD cases in 2013 (99) is a significant reduction (28%) from the 137 cases identified in 2012. For SAV3, the virus variant responsible for PD in western-Norway, the reduction was 47%, down from 90 cases in 2012 to 48 in 2013. The level of newly registered cases approached that of 2005 (45). For marine SAV2 infections the high level of detections experienced in 2012 continued in 2013 with 51 new cases identified last year. All SAV2 cases involved salmon, while 8 of the 48 cases involving SAV3 were diagnosed in rainbow trout. PD has been identified in rainbow trout every year since 1996, with a peak of 18 affected sites in 2011.

Pancreas disease is defined here as any sick fish with histopathological findings typical for PD and detection of PD-virus in the same individual fish (diagnosis PD), or sick fish with histopathological findings consistent with PD for which no suitable material for confirmation of the presence of PD-virus is available (suspicion of PD). In the figure, “diagnosed” and “suspected” are combined. The number of virus detections (samples positive by PCR) without overt disease is not included in the SAV3 statistics. As a result of the differing legislation for the two virus types these statistics are included for SAV2.

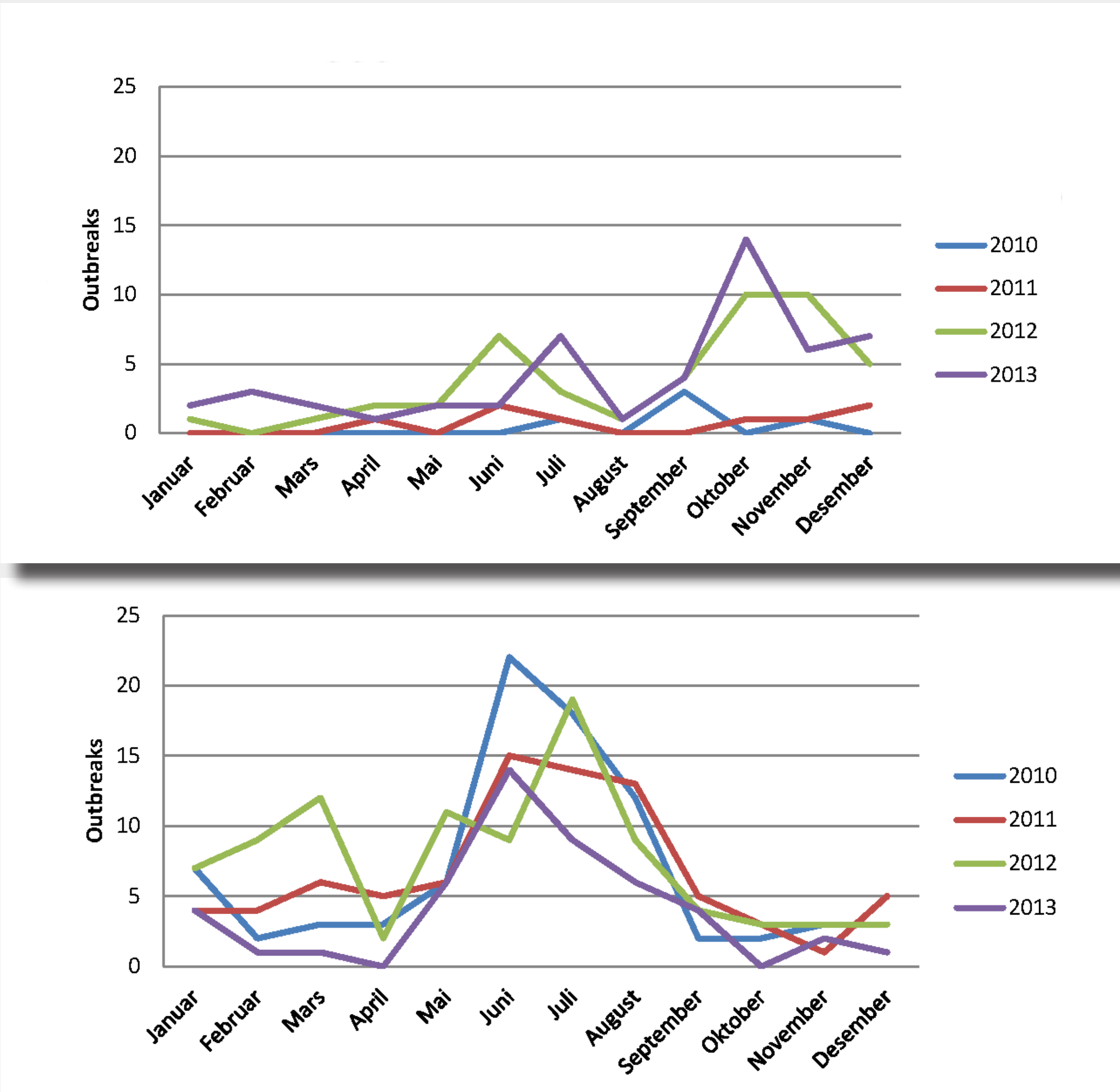
SAV3. With the exception of two outbreaks in Finnmark all cases in 2013 were diagnosed within the SAV3-zone. The zone borders, established in 2007 (legislation 2012-11-20 nr 1315) to limit spread north of Hustadvika appear to be working effectively. The ‘core’ affected area, within which the majority of diagnoses are made, appears to remain within the two most southerly affected regions. Only a single new case of PD SAV3 was diagnosed in Møre og



Farm sites with pancreas disease (PD) in Norway in 2013

Romsdal, again in the Storfjord as with the only two M+R cases in 2012. In comparison, during 2007 and 2008, over 40 cases of PD were registered in this region south of Hustadvika. Sogn og Fjordane has also experienced a significant fall in PD cases, with 20 in 2012 and 5 in 2013. In Rogaland the number of cases has remained relatively stable over the last three years with 14, 17 and 12 new cases respectively.

SAV2. Due to the rapid spread of SAV2 infection north of Hustadvika in 2012 new legislation (2012-11-06 nr 1056) regarding zone establishment for SAV2 came into force in November 2012. This regulates the area between Hustadvika in Møre og Romsdal and Nordland which is split into an eradication zone (northerly limit = the Nord-Trøndelag border) and an observation zone (Nord Trøndelag to the border with Nordland). In 2013 the most northerly detections lay within the control zone, close to the border with Nord-Trøndelag. A local SAV2 epidemic out with



PD, monthly case rate for SAV2 (above) and SAV3 (below)

Salmon with ISA. External and internal signs of disease. Photo: Tone Ingebritsen and Geir Bornø, Norwegian Veterinary Institute

the SAV2 zone, directly south of the zone border at Hustadvika, endures. The first cases of PD involving SAV2 identified in 2010 involved farms in this area. In 2013 there were eight detections in this area. Of the 51 new cases of SAV2 infection in 2013, most (45) involved clinical disease.

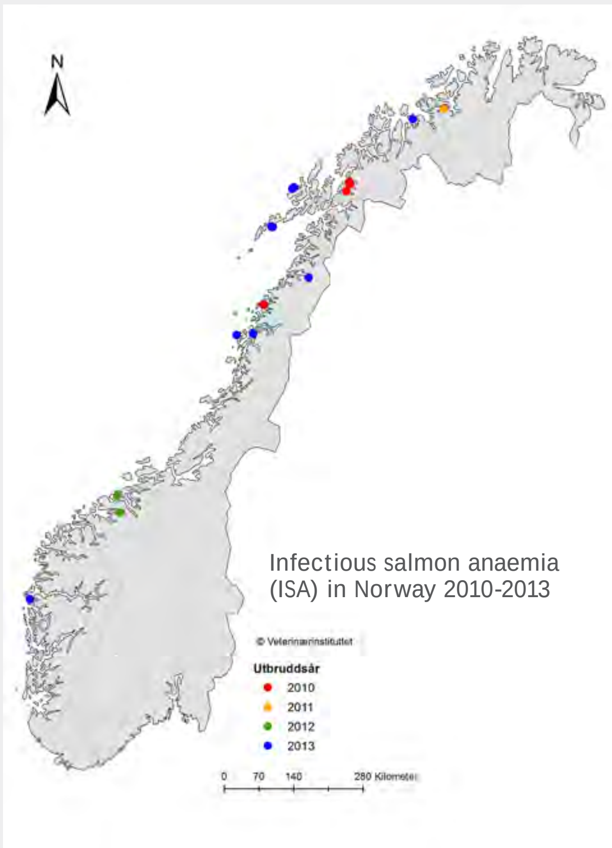
Pancreas disease is diagnosed throughout the year. For SAV3 most cases appear between May and August and involve fish transferred to sea the previous year. For SAV2 infections, many of the new cases have been diagnosed during the autumn. Last year many cases involved fish sea-transferred the same spring.

There may be reason to believe that the reduction in new SAV3 PD outbreaks is the result of many years of attempted control finally bearing fruit. There has been focus on diverse infection limiting factors related to smolt and harvest transports and as far as possible sea-transfer of smolts to larger fallowed areas. Good smolt quality, good sites, vaccination and reduction of stress have most likely also contributed to the reduction in number of clinical outbreaks, mortality and thereby the total infection pressure. Intensive surveillance with an increased probability of detection of infection at an early phase, allowing prompt introduction of control measures has almost certainly contributed.

The rapid spread of SAV2 is most likely due to water-borne transmission assisted by transport of fish during the sea-phase of culture. Most smolts sea-transferred in mid-Norway are not vaccinated against PD. Loss of growth due to appetite failure and reduced product quality at slaughter is associated with both PD types.

PD is a notifiable disease (national list 3) and a daily updated map showing current outbreaks is provided in cooperation with the Norwegian Food Safety Authority. PD diagnoses are also reported monthly on www.vetinst.no/kart. Compulsory surveillance is performed by the industry through routine health controls and disease diagnostics.

To stimulate research and rapid dissemination of research results, a tri-nation cooperation (www.trination.org) where researchers, industry and public authorities from Ireland, Scotland and Norway meet regularly has been established. This has been demonstrated to be a useful meeting place for exchange of knowledge and experiences with PD and similar diseases.
Read more www.vetinst.no/faktabank/PD



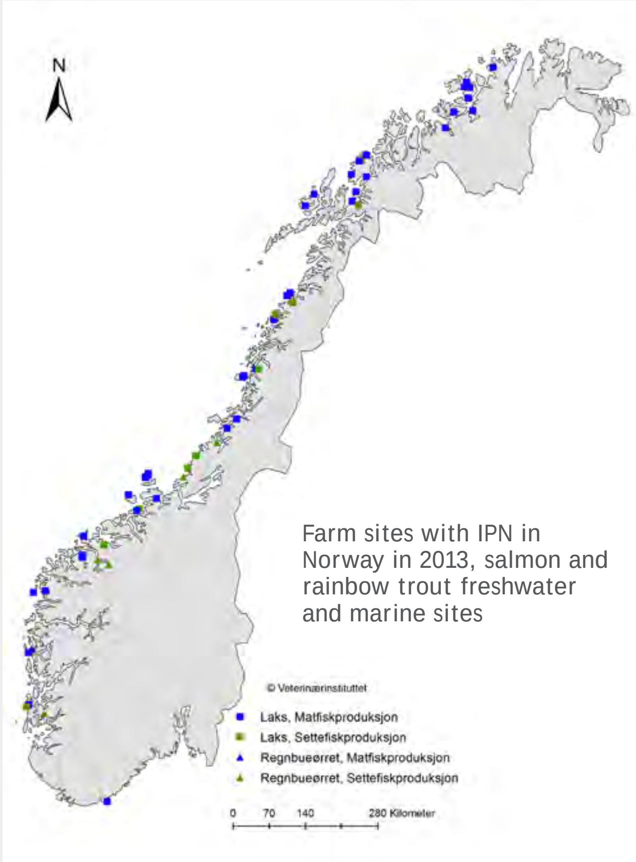
Infectious salmon anaemia (ISA) in Norway 2010-2013

Infectious salmon anaemia - ISA

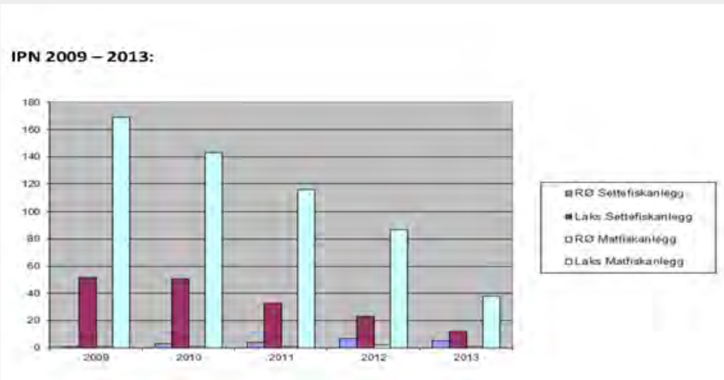
Ten outbreaks of ISA were diagnosed in 2013; eight in Nordland, one in Troms and one in Sogn og Fjordane. This is a considerable increase from 2012 when two outbreaks were identified in Møre og Romsdal. While this development is negative, the situation remains very different from that which once threatened the industries existence. Current grounds for concern include that for many of the outbreaks identified in 2013 we do not know the source of infection and that the infection manifested in several cases in a 'vague', initially difficult to recognise fashion. There is, therefore, every reason to maintain a high level of surveillance and investigate the factors surrounding these new outbreaks.

A number of the outbreaks in northern-Norway started with low mortality. The clinical picture did not initially indicate ISA. Only after histological investigation identified typical tissue changes, were investigations directed towards ISA. These suspicions were confirmed by virological analyses. The clinical presentations in these outbreaks are a reminder that ISA may manifest in a number of ways. Manifestation of ISA is always founded on the effect of the virus on the blood system which results in anaemia. In a number of farms with clinical ISA, the fish were destroyed while in others the fish were allowed to continue to harvest.

In one outbreak in western-Norway (Gulen) ISA was identified despite the fact that only a relatively small number of fish appeared to be affected in a population suffering from severe gill disease. The ISA diagnosis was quickly verified, and the fish which had been sea-transferred three months previously, immediately destroyed.
Until now no new ISA diagnoses have been made in the area and there is a hope that horizontal spread of disease has been avoided.



Farm sites with IPN in Norway in 2013, salmon and rainbow trout freshwater and marine sites

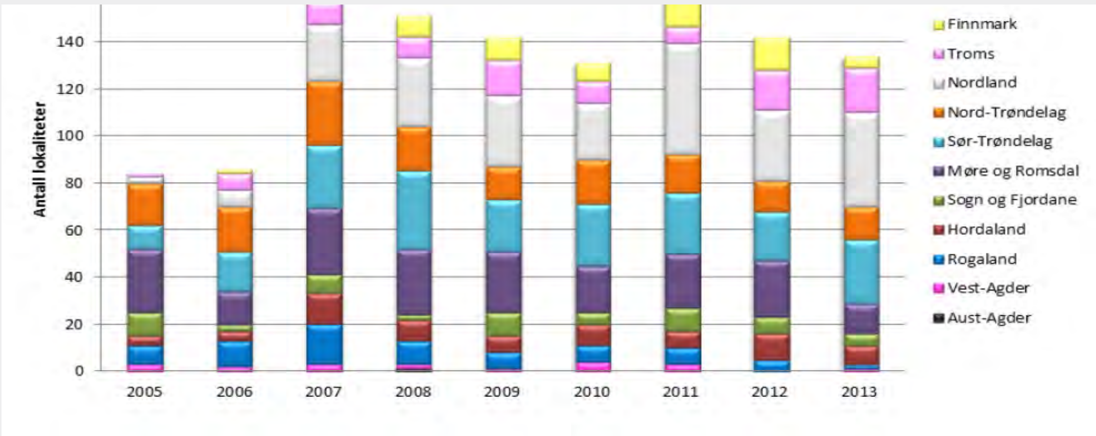


Number of sites with IPN, salmon and rainbow trout in fresh- and sea-water for the years 2009-2013.

Three outbreaks in 2013 may be related to horizontal contact with affected sites. For seven of the outbreaks no contact with known infected sites is known. These represent, therefore, apparently isolated outbreaks, for which an unknown reservoir may be responsible, or that new virulent variants of the virus have appeared. The hypothesis is that a low virulent variant of ISA-virus (HPR0) mutates to a virulent variety (deleted or HPR). To understand more of the infection pathway, and if possible the 'dangers' represented by the various virus types, we need a better knowledge of HPR0 and the factors involved in its possible change to virulent ISA.

Separation of generations and fallowing are important measures to stop development of virulent viruses like ISA-HPR. We have currently little knowledge on how this can best be achieved and the mechanisms which influence development of HPR0 to ISA-HPR.

The OIE distinguish now between low-virulent ISA-HPR0 and high virulent ISA-HPR. Both genotypes remain notifiable and it is possible to apply for free-status for HPR0. The reason for this is that the presence of HPR0 is considered likely to increase the chance of development of ISA-HPR. Freedom of ISA-HPR0 must be documented via extensive surveillance. Internationally, two outbreaks were reported from Chile and Canada involving high virulent ISA-HPR in 2013. The low virulent variety ISA-HPR0 is a normal finding in Scotland, the Faroe Islands, Canada, USA and Chile. Read more www.vetinst.no/faktabank/ILA



Regional distribution of farms with registered heart and skeletal muscle inflammation (HSMI) in the period 2004-2013.

Infectious pancreatic necrosis - IPN

In 2013 IPN was diagnosed in 56 farms, of which 6 involved rainbow trout and the remainder salmon. Seventeen were diagnosed in hatcheries and 39 in the seawater phase. In 2012 and 2011 IPN was diagnosed in 119 and 154 farms respectively (table 1). The statistics for later years indicate a clear and significant reduction in the number of IPN outbreaks involving salmon, from the peak in 2009 when 223 diagnoses were made to 56 in 2013. For rainbow trout, the number of outbreaks has been consistently low for several years. IPN was removed from the list of notifiable diseases in 2008. There is, however, little evidence that fish health services have changed practice in relation to submission of samples for confirmation of diagnosis in later years. Fish health services report that IPN remains a cause of loss, but that it appears to comprise a lesser problem than previously. Some farms report losses of fish, but describe the main problem as 'runt' development in the wake of the outbreak, as the predominant and possibly most significant problem. There are strong indications that losses due to clinical IPN are lower in so-called QTL stocks. Reports received by the Norwegian Veterinary Institute indicate that a combination of QTL use and sanitation of 'house' strains of IPN-virus are important factors associated with the reduction in number of affected farms in recent years. This trend is particularly noticeable in hatcheries, with a reduction in IPN affected localities from 51 in 2010 to 12 in 2013.

IPN virus belongs to the family aquabirnavirus 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 www.vetinst.no/faktabank/IPN

Heart and skeletal muscle inflammation - HSMI

Heart and skeletal muscle inflammation (HSMI) is an infectious disease of farmed salmon which has become extremely widespread in later years. In 2013 the disease was diagnosed on 134 farms. This is a reduction from 2012 but remains within the range identified in the last 6-7 years (Table 1). The disease mainly affects salmon farmed at sea, although last year, as in recent years, cases were also registered in hatcheries where the disease was probably related


Juvenile fish with heart and skeletal muscle inflammation (HSMI) Photo: Koen Van Nieuwenhove, Marinhelse AS

to intake of seawater. New to last year was diagnosis of HSMI in a freshwater farm in which intake of seawater could be excluded.

The heart is the primary organ affected and mild to gradually more extensive changes may be observed on histopathological examination in the months prior to clinical outbreak of disease. During clinical outbreaks inflammation is most commonly displayed within the skeletal musculature. In addition, pathological changes in other organs, most commonly the liver, can be observed. Salmon dying of HSMI often display both macroscopically and histologically visible signs of circulatory disturbance.

The disease may result in very variable mortality and a wide spectrum of associated mortality was also observed in 2013. Increased mortality is often associated with grading, transport or other production related operations which stress the fish. This can prove particularly challenging during lice treatment of affected fish. Nevertheless, lice treatment of HSMI affected fish is performed in some affected farms in the hope of achieving a lower overall loss than if lice treatment was delayed.

HSMI is a viral disease. Infectious trials published in 2004 confirmed that the disease was infectious. In 2010 HSMI was linked to a reovirus, with the initially proposed name piscine reovirus (PRV). This is a naked and robust double stranded RNA virus. A new and more detailed sequence analysis of the PRV genome published in 2013 demonstrated that PRV has several characteristics more in common with orthoreovirus than with aquareovirus. The newly proposed name is therefore piscine orthoreovirus (PRV).

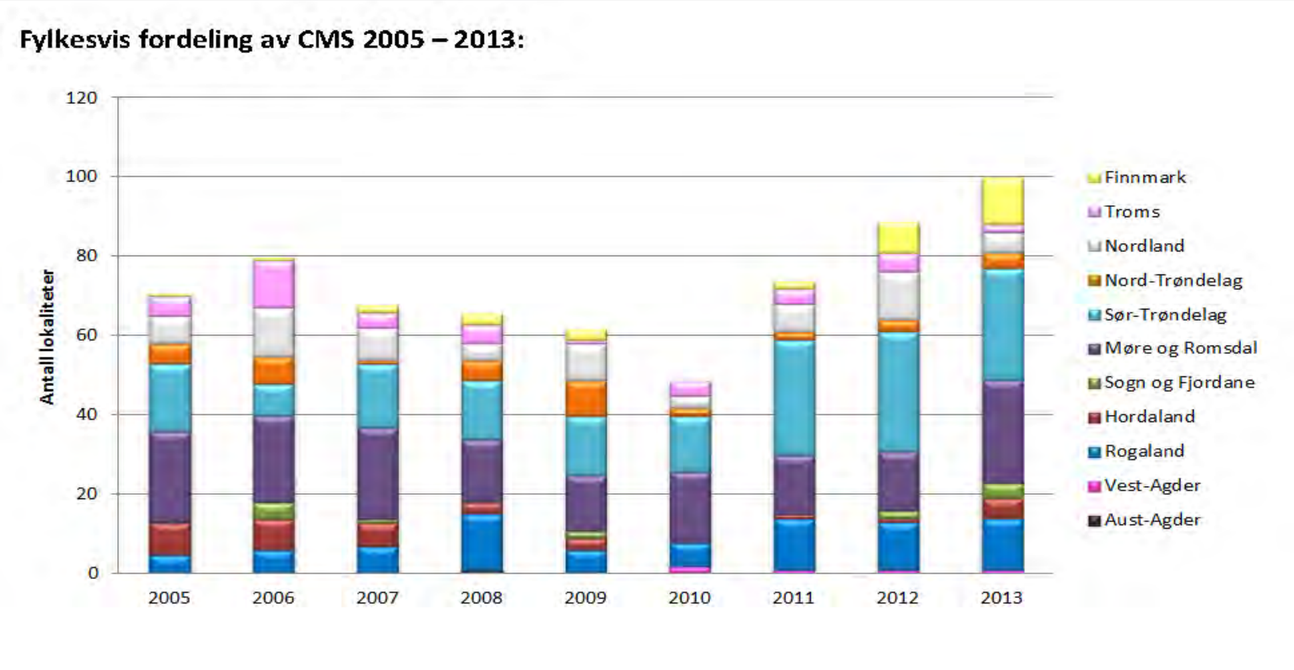
Direct detection of PRV in heart tissues supports an association between PRV and HSMI. There is also a clear relationship between clinical disease and high levels of PRV in farmed salmon. It has also been shown that high levels of PRV in fish tissues do not necessarily mean that the fish has, or has had, HSMI. This is also applicable to wild salmon where high levels of PRV have been identified in individuals without HSMI. Virological investigations performed using real time RT-PCR have shown that PRV has a wide geographical distribution and is also found in rainbow trout and sea trout. In 2013 it was reported that PRV from farmed and wild fish are so similar that it is likely that the infection may cycle between the two groups of fish.

As the virus is difficult to culture in vitro, infection models are poorly developed and investigation of the significance of the virus in development of HSMI is challenging. Research is under way to further investigate the relationship between the virus and the disease. Research into vaccine development against PRV is also under way.
Read more www.vetinst.no/faktabank/HSMB

Cardiomyopathy syndrome - CMS

Cardiomyopathy syndrome (CMS) is a serious cardiac complaint affecting salmon farmed in the sea. As large, harvest ready fish are commonly affected, the economic losses can be considerable. The Norwegian Veterinary Institute diagnosed CMS in 100 sites in 2013. This is the third year in a row in which an increase in the number of CMS cases has been reported, with more than twice the number of cases reported in 2013 compared with 2010. As previously, most positive farms were located in Møre og Romsdal (26) and Sør-Trøndelag (28), with fewer cases identified in Rogaland (13) and Finnmark (12). There may be a slight trend towards an increasing number of cases in Sogn og Fjordane and Hordaland. The number of affected farms in Møre og Romsdal increased in 2013 and in Finnmark the increase continues from 2012. The underlying causes are unknown.

A totivirus, piscine myocarditis virus (PMCV), first described in 2010, appears to cause CMS. Normally totivirus infect single-cell organisms, such as yeast, protozoa or insects, although a totivirus, infectious myonecrosis virus (IMNV), has been identified in association with muscle changes in a pacific shrimp



Regional distribution of farms with registered cardiomyopathy syndrome (CMS) in the period 2004-2013.

(Penaeus vannamei). The virus is a naked, double stranded RNA-virus with a relatively small, non-segmented genome which appears to code for only three-four proteins.

As with other naked viruses e.g. IPN-virus and nodavirus, CMS-virus is probably more resistant than capsid-enclosed viruses to external influences such as temperature, low pH, disinfection and drying. Both IPN-virus and nodavirus can survive for months in seawater or organic material. There appears to be a clear relationship between virus and disease, and between quantity of virus and degree of heart pathology: Using a specific PCR the virus has been detected in CMS affected salmon and specific virus staining (in–situ hybridization and immunohistochemistry) has demonstrated co-localization of virus and pathological changes. CMS-virus has been detected in populations of salmon well before outbreak of disease (> 9 months), but is generally detected in relation to outbreak of CMS or in salmon with CMS-consistent pathological changes in the heart. All Norwegian as well as recently investigated Irish PMCV isolates examined appear to be highly similar and belong to a single geno-group.

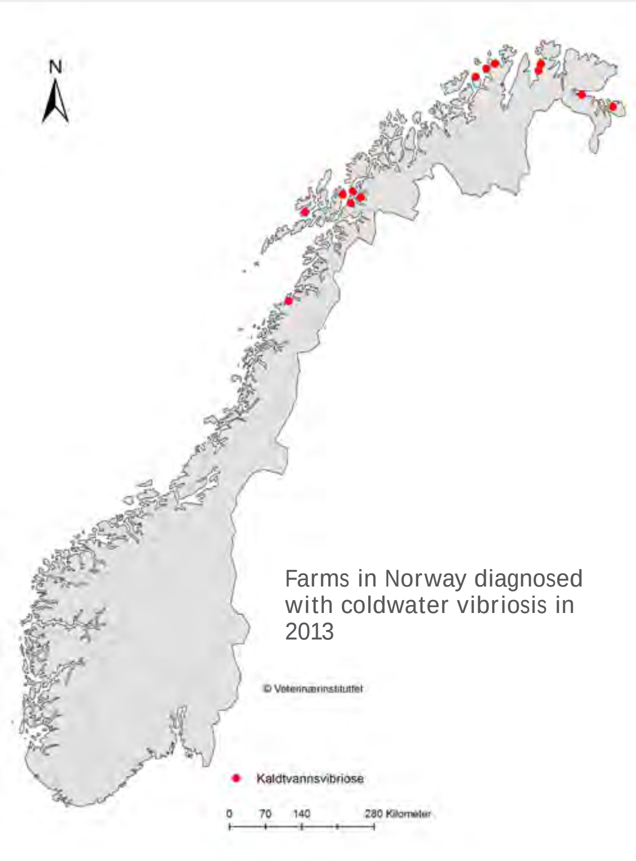
Fish to fish water-borne infection appears to be the main transmission route for PMCV. No reservoir other than salmon has been identified and recent research suggests that vertical transmission does not appear to be a significant transmission route for the virus. It has however been shown that the risk of CMS development is greater in a farm in which CMS had been diagnosed in its previous stock. Recent research has shown that vertical transmission does not appear to represent a significant route of infection for the virus. It has not been possible to identify any relationship between closely related virus isolates and egg origin (brood stock), smolt producer, feed supplier or aquaculture company. Fish weight at sea transfer or presence of IPN or PD in the population does not appear to increase the risk of CMS development.

PMC-virus has been reported in apparently healthy wild salmon, but this appears to be a relatively rare finding. While PMC-virus has also been identified in herring smelts (Argentina silus) the virus belonged to a genotype different from that associated with CMS in salmon. Transmission from herring smelt to farmed salmon is therefore unlikely.

Clinically the disease can appear similar to both PD and HSMI, which also cause circulatory disturbances. In typical cases these diseases can be distinguished histopathologically as they result in different changes, particularly in the heart, but also in the pancreas and muscle tissues. Fish with typical CMS display significant inflammation in the inner (spongious) parts of both the atrium and ventricle, while the compact muscle layers of the ventricle are, as a rule, normal. CMS does not normally result in changes in the exocrine pancreas or skeletal musculature, as is commonly seen in PD (exocrine pancreas/skeletal muscle change) or HSMI (skeletal muscle change).

Currently, diagnosis is based on clinical history and identification of typical histopathological changes. Specific PCR for CMS-virus is used in difficult cases, e.g. early stage CMS, atypical manifestation of CMS or when fish are suffering from several concurrent heart infections.

Much work lies ahead to identify the relationship between CMS-virus and CMS in aquaculture settings. It remains unclear where the virus comes from, how it causes the observed changes and why it results in problems almost exclusively in large fish.
Read more www.vetinst.no/faktabank/CMS



Farms in Norway diagnosed with coldwater vibriosis in 2013

Viral haemorrhagic septicaemia - VHS

Viral haemorrhagic septicaemia virus (VHSV) is globally distributed and has been identified in more than 80 fish species. Most marine VHSV variants give low mortality in salmonid fish, but the virus may convert to a more virulent variant (high virulent) if allowed to develop within a fish population over time. Infection pressure from wild fish to farmed fish will always exist to a greater or lesser degree in open sea farms. Important components of a prevention strategy include separation of year-classes and fallowing between culture cycles. Norway is today free of VHS, although there have been a few previous detections in Norwegian aquaculture. The last diagnoses were awarded in rainbow trout farmed in the Storfjord in 2007-8. Historical experiences show that rapid destruction of stocks (stamping out) is the most important component in control of VHS. Continual surveillance for VHS is important, such that infected fish may be removed as quickly as possible. Current surveillance is risk-based. Fish species in which the highest probability of finding the virus are prioritised and if possible, apparently sick fish are chosen for investigation to increase the chance of detection.

VHSV of genotype III has been detected in several different wrasse species farmed in Shetland. This is the same genotype identified in rainbow trout in the Storfjord in Norway in 2007, and investigations are underway to establish how closely related these isolates are. VHSV belonging to genotype III has also been identified in wild wrasse caught in Shetland, but not elsewhere in Scotland. The finding of VHSV in wrasse gives grounds for concern in Norway as we have extensive transport of wrasse from the southern coast to areas as far north as Nordland. Transport of fish may result in transport of the virus to new areas. Globally, VHSV genotype IVb in the Great Lakes of the USA gives the greatest grounds for concern. This variant has caused large scale mortalities in a number of fish species and is spreading steadily to new areas. No other VHSV variant has previously infected so many different fish species with such high mortality rates in wild fish. The consequences of eventual spread of this VHSV variant to Norwegian fauna are unknown.

In European marine aquaculture VHSV is currently the biggest problem in Åland, where outbreaks in rainbow trout with VHSV genotype Id have been experienced over the last ten years. The longer a virus variant is allowed to perpetuate in aquaculture farms, the greater the danger of development of a high virulent genotype equivalent to Ia which results in high mortality in rainbow trout.

Read more www.vetinst.no/faktabank/VHS

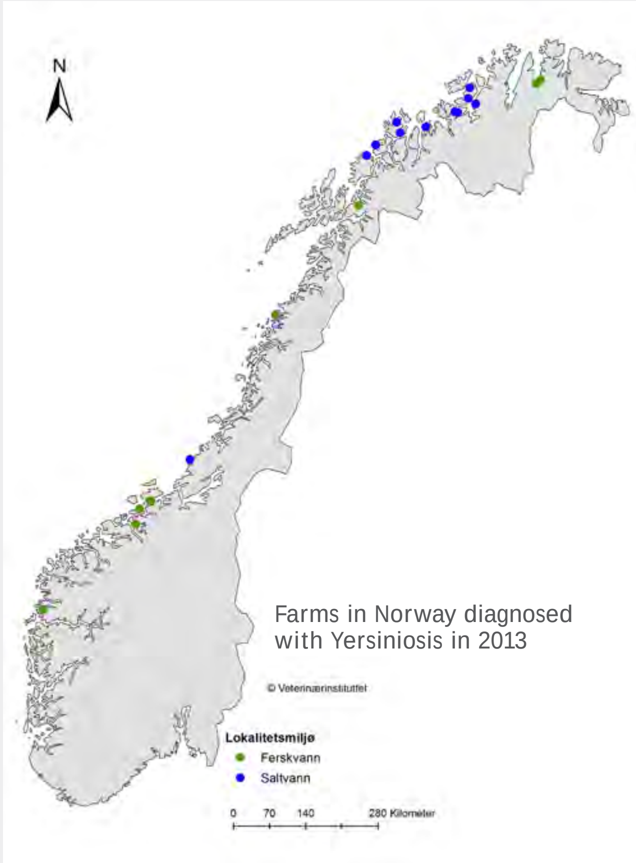
Bacterial diseases

The current situation in bacterial diseases of farmed salmonid fish in Norway can be regarded as favourable. Important diseases such as furunculosis, vibriosis and coldwater vibriosis which in previous years caused significant losses are under good control thanks to extensive vaccination. Winter ulcer for which both Moritella viscosa and Tenacibaculum spp. may be involved as aetiological agents, contribute to considerable economic losses and infection with Yersinia and Flavobacterium cause problems in some farms and areas. This situation contrasts significantly with the bacterial disease situation in cleaner fish used in biological control of salmon lice. Significant losses largely related to bacterial disease are experienced in these fish stocks. This may to a degree explain the increased antibiotic use in Norwegian aquaculture.

Coldwater vibrosis

Vibrio salmonicida, which is the cause of the disease coldwater vibriosis, was diagnosed in 13 farms in 2013. This disease was the cause of large losses to Norwegian salmon farming in the 1980's, but has been effectively controlled over the last 25 years through vaccination. In 2012, a moderate increase in the number of cases (21) was registered compared to previous recent years. The number of outbreaks in 2013 shows a clear reduction from the previous year. While both salmon and rainbow trout were affected in 2012, the disease was diagnosed only in salmon in 2013. Geographically the outbreaks were spread between Finnmark (7 farms), Troms (4 farms) and Nordland (2 farms). The reason/s behind the continued high number of affected farms compared with pre-2012 levels have not been established, but may be related to vaccination regimes (temperature and antigen dose), which have now been adjusted.

Read more www.vetinst.no/faktabank/KVV



Massive septicemia caused by Yersinia ruckeri.
Photo: per Anton Sæther, Marinhelse AS.

Winter-ulcer

Ulcer/wound development may be a chronic condition and is a significant disease- and welfare problem for farmed fish. Ulcers cause both increased mortality and reduced quality at slaughter. Ulcers are a typical autumn and winter problem, but can manifest throughout the year particularly in northern areas. Ulcer development is commonly associated with transport or handling e.g. lice treatment, which may result in scale loss or skin damage. Ulcer development, particularly ulcers associated with Tenacibaculum, is often associated with transfer to sea at low water temperatures or on transport through areas of cold water.

In 2013, the bacterium Moritella viscosa, which is related to most 'classical' winter ulcer outbreaks, was identified in association with ulcer development in farmed salmon along the entire coastline. The bacterium was, as in previous years, also identified in rainbow trout. Tenacibaculum sp. are also commonly associated with ulcerous infections in salmon and rainbow trout and may occur together with M. viscosa or alone. In 2013, cases so severe occurred in the north of the country in which whole cage populations had to be destroyed due to the severity of Tenacibaculum infection. In other areas there appear to have been fewer problems with winter ulcer than in previous years.

Infection with **Flavobacterium psychrophilum**

In 2013 the Norwegian Veterinary Institute received material from five farms in which disease was associated with Flavobacterium psychrophilum.

The bacterium was identified from large rainbow trout in three farms in brackish water in the same fjord system in which outbreaks were identified between 2008-2012. The clinical picture differed somewhat from that experienced previously, with fewer reports of pus-filled abscess and more reports of the presence of ulcer, a description perhaps more associated with other bacterial infections. On one site Vibrio anguillarum serotype O1 infection was concurrently identified.

F. psychrophilum was identified in two commercial salmon hatcheries in 2013, although the significance of these detections in relation to disease is unclear. One detection was associated with increased mortality and morbidity with few external lesions on the fish. The same fish population was also awarded other diagnoses including nephrocalcinosis, bacterial gill inflammation, ulcer development and IPN. These findings may indicate that environmental conditions were sub-optimal. Indirect detection of the bacterium using immunohistochemistry during outbreaks in several hatcheries gave grounds to suspect that F. psychrophilum was involved in the disease.

Systemic infection in rainbow trout is proposed as a notifiable disease.
Read more www.vetinst.no/faktabank/Flavobacterium

Yersiniose

Yersiniosis is caused by the bacterium Yersinia ruckeri. This disease can result in increased mortality in salmon and rainbow trout during the whole juvenile phase in freshwater, but can also result in losses following sea transfer. Several hatcheries experience recurring outbreaks, with at least one site experiencing outbreaks in three different fish groups in 2013. Some farms consider vaccination necessary to maintain production. One farm with a history of chronic yersiniosis, which carried out extensive cleaning and disinfection during the summer of 2012 has not since experienced recurrence of the disease, and several other farms are now undergoing a similar process.

In 2013 yersiniosis was diagnosed in 20 farms, and all cases involved salmon. All isolates serotyped belonged to serotype O1. The affected sites were spread over a large geographical area, but the majority were located in Finnmark. Although yersiniosis is primarily associated with freshwater, 11 of the 15 cases identified in Finnmark were in sea-transferred salmon. At least 5 of these fish populations had experienced outbreaks during the freshwater stage. The previous infection status of the remainder of the fish populations is unknown. The number of diagnoses made in 2013 is an increase from 2012 when 16 sites were affected, following a downward trend the previous four years.

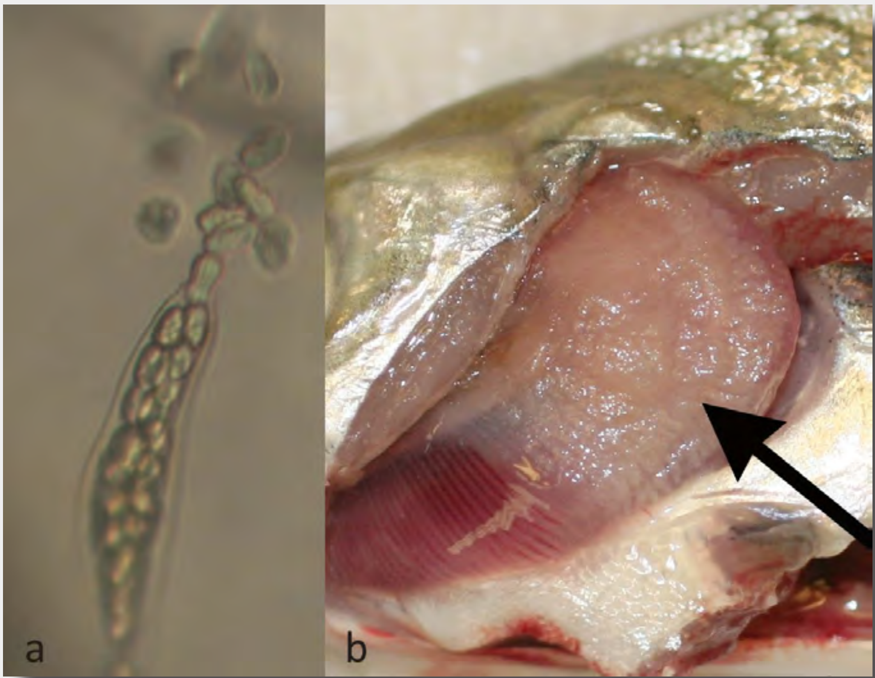
Bacterial kidney disease - BKD

Bacterial kidney disease (BKD) is notifiable and is listed in the national disease list (list 3). This disease has occurred only sporadically in Norway over the last 15 years with between 0 and 3 cases annually. In 2013 BKD was diagnosed in one sea farm in Nordland in large (approx. 4.5kg) salmon with a concurrent ISA diagnosis.

Read more www.vetinst.no/faktabank/BKD

Other bacterial infections

Occasionally bacteria belonging to the families Vibrio, Photobacterium, Alteromonas, Pseudoalteromonas, Psychrobacter, Polaribacter etc. are isolated from clinically diseased fish in the course of diagnostic investigations. Even though these bacteria may be found in large numbers and from several fish in the affected population, it can be difficult to relate these findings to the disease. Most commonly these bacteria are considered to represent opportunist environmental strains which invade an already weakened fish.



Saprolegniosis is an infection caused by an oomycetes within the Saprolegnia family (a) which may result in (amongst other conditions) gill inflammation (b). Photo: Even Thoen (a) and Renate Johansen (b).

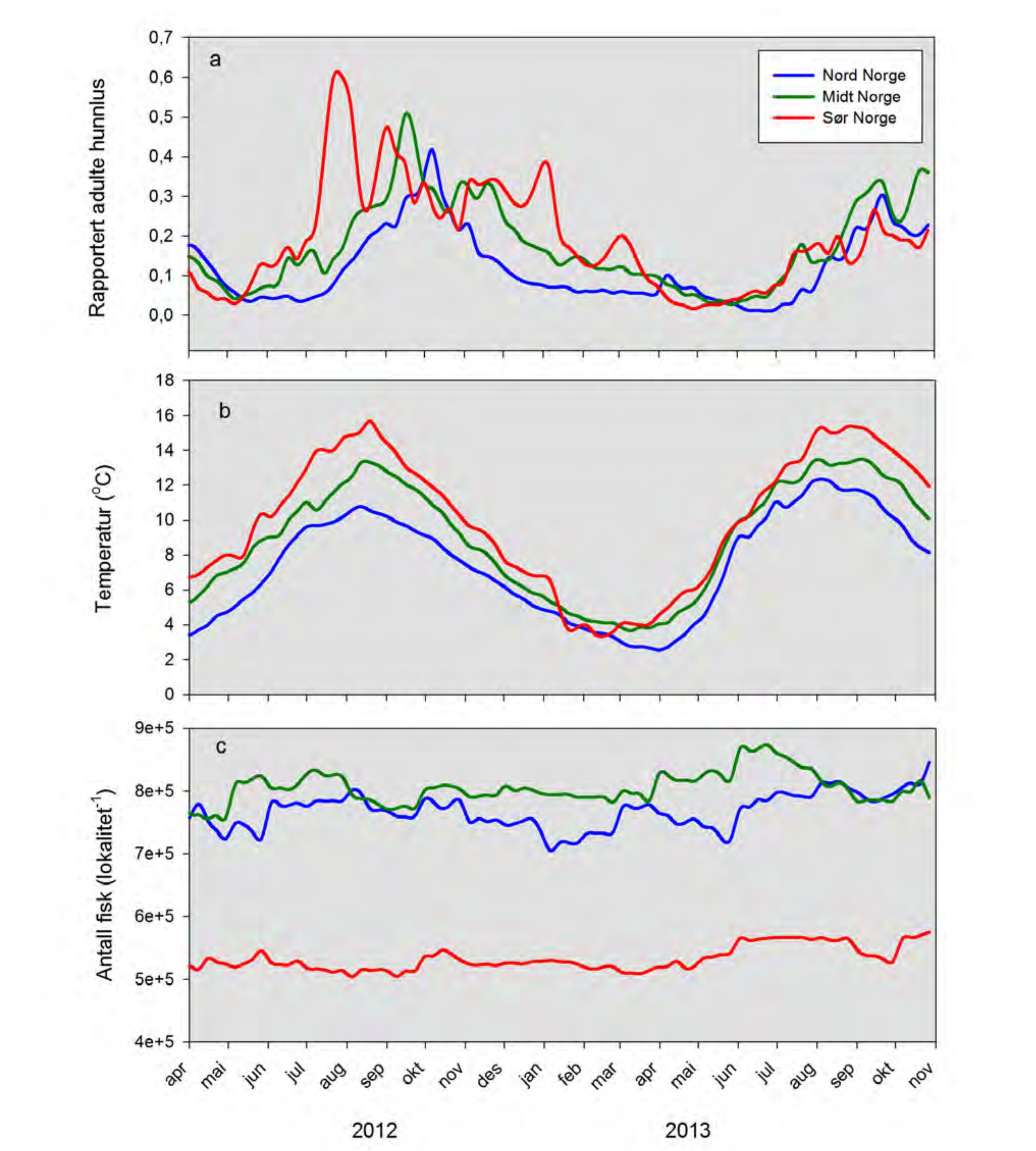
This type of flora is continually evaluated such that new emerging diseases can be identified at an early stage.

Vibrio anguillarum serotype O1 was diagnosed in two rainbow trout farms and two salmon farms in 2013.

In 2013 infection with Pseudomonas fluorescens was identified in 8 salmon farms. The majority of all serious P. fluorescens infections are identified in salmon during the freshwater phase of culture, although in some cases the infection has followed fish transferred to sea. The disease was not diagnosed in sea-farmed salmon in 2013.
While the bacterium was undoubtedly related to significant enduring losses in some farms, other identifications are undoubtedly insignificant and not associated with disease. As part of the normal water flora the bacterium is commonly identified as an opportunistic 'secondary' and relatively mild infection on fins and gills in fish held in water of poor quality.

Disease caused by Aeromonas salmonicida subsp. salmonicida (furunculosis) or atypical Aeromonas salmonicida (atypical furunculosis) was not identified in salmonid fish in 2013. Piscirickettsiosis caused by Piscirickettsia salmonis, which remains a very important pathogen in Chilean fish farming, was not identified in Norwegian farmed salmonids in 2013.

A relatively uncommon disease of salmon, so-called 'varracalbmi' (Lapp for blood-eye), caused by a bacterium closely related to Pasteurella skyensis (which causes a similar disease in Scotland), has been identified sporadically over a large geographical area from Hordaland in the south to Troms in the north, between 1989 – 2012. The last outbreak in salmon occurred in Sogn og Fjordane in 2012.



(a) Adult female lice plotted against total reported statistics / total number of reporting sites, (b) average temperature and (c) average number of fish per site for Northern-Norway, Mid-Norway and Southern-Norway respectively.

The bacterium was not identified from salmon in 2013, but another Pasteurella bacterium, very similar to the salmon pathogen, has been a relatively common finding in farmed lumpsucker in 2013 (see 'cleaner fish health').

Sensitivity to antibiotics

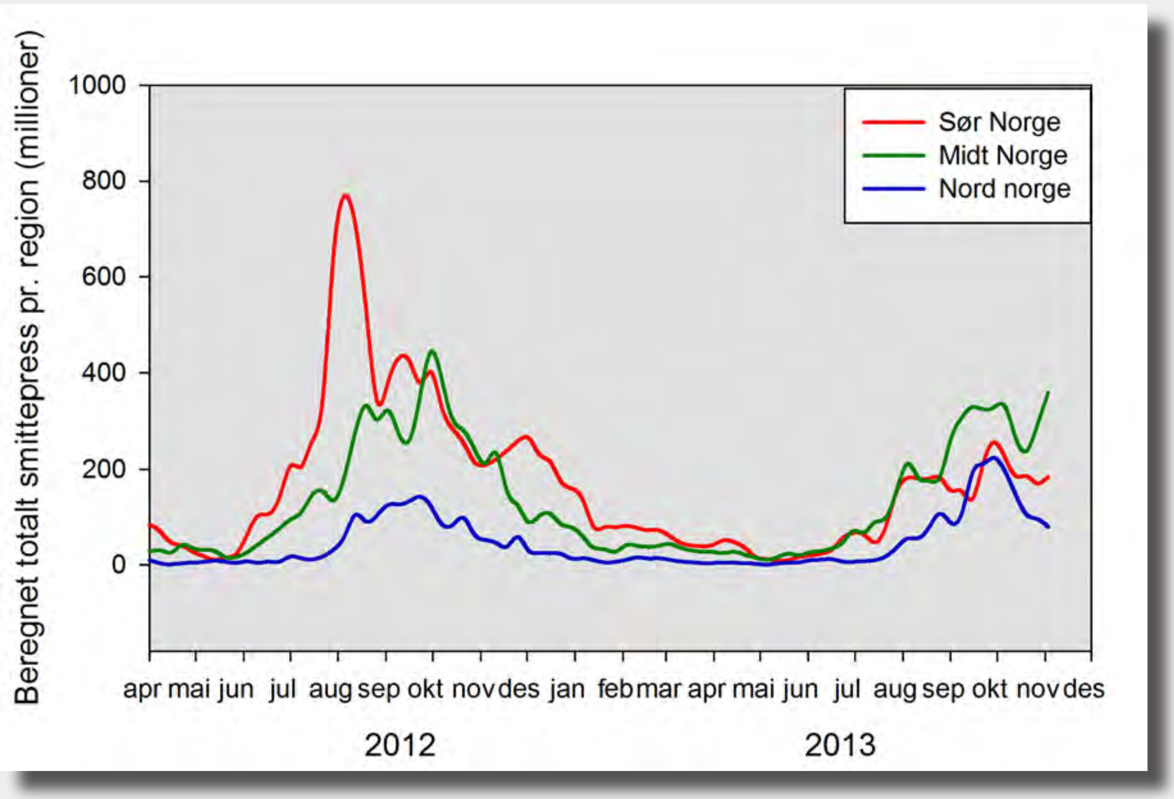
Very small amounts of antibiotics are used in Norwegian salmon farming. Routine testing of fish pathogenic bacteria isolated from salmonids in 2013 has not identified new occurrences of reduced sensitivity for antibiotics authorized for use in Norwegian fish farming. One strain of Flavobacterium psychrophilum virulent for rainbow trout, has, as in previous years, displayed reduced sensitivity to quinolone antibiotics.

Fungal diseases

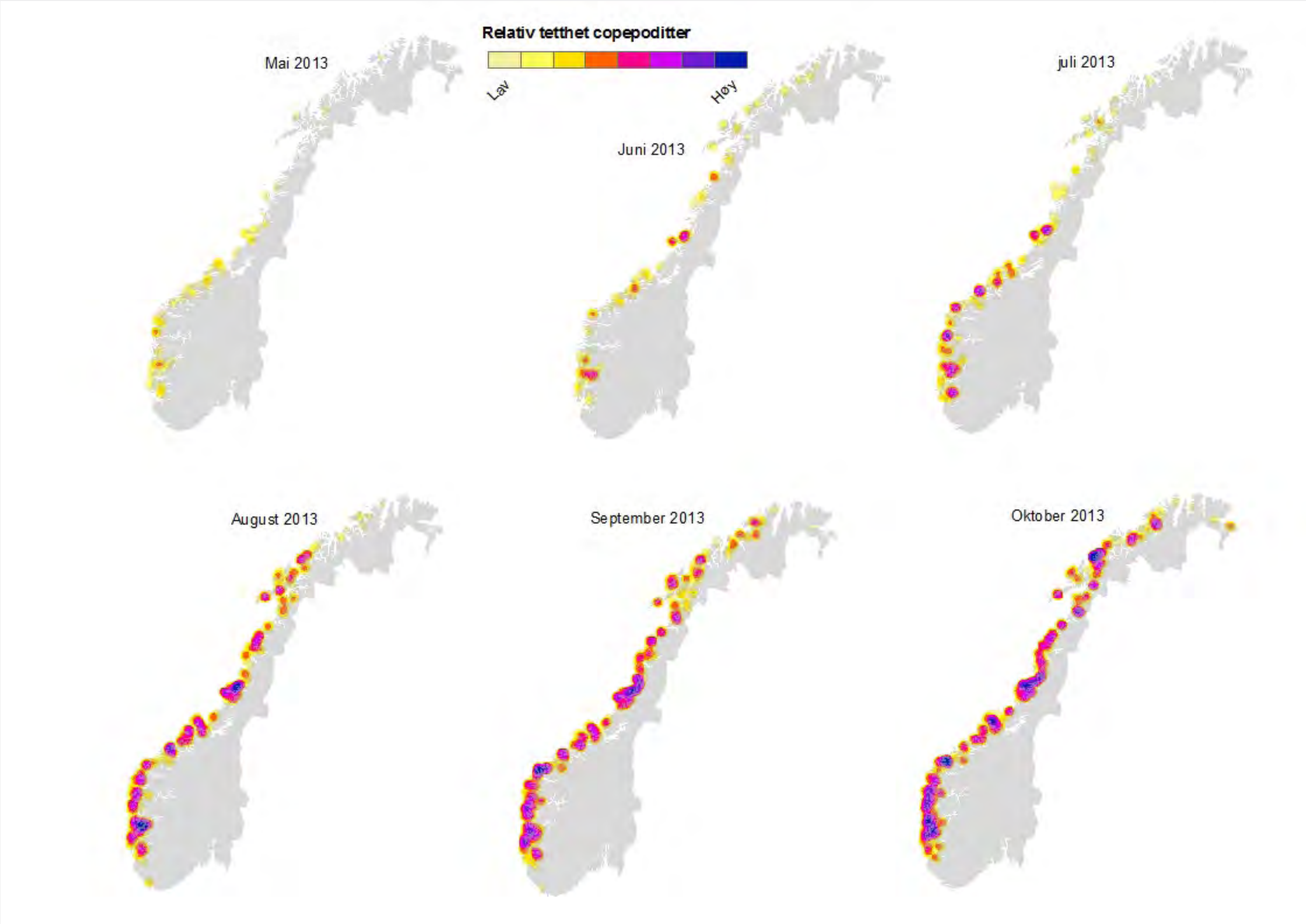
Few cases of mycosis in fish were identified in 2013. The most significant problem appears to be gill inflammation caused by Saprolegnia spp. (saprolegniosis) in salmon hatcheries. Saprolegniosis is usually diagnosed in the field following observation of macroscopically visible lesions and is usually treated with formalin or Pyceze. Repeated treatments are commonly necessary.

Submission of fungus related samples for laboratory investigation is uncommon and is mainly reserved for serious or chronic recurring cases. Use of formalin in aquaculture remains under evaluation in the EU-system. Restrictions or a ban on use of formalin as an anti-parasitic and anti-fungal treatment may be introduced in the course of the next few years and development of preventative measures will be important.

Individual cases of mycotic nephritis caused by Exophiala spp. have been identified in salmon suffering other diseases e.g. IPN and HSMI. Fungi have also been identified in the intestine or peritoneum in cases of increased mortality in which other specific agents



Calculated total infection pressure (copepodites) on all sites reporting in Northern-Norway, Mid-Norway and Southern-Norway.



Calculated salmon louse infection pressure in 2013 for the first week of each month. Infection pressure is given as relative density of copepodites in a colour scale from low density (yellow) to high density (dark blue).

have not been identified. In one case involving massive fungal infection of the peritoneum in juvenile salmon, introduction of fungus during vaccination performed 1-2 months prior to fungal detection was suspected.

Read more www.vetinst.no/faktabank/Saprolegnia

Parasitic diseases

The salmon louse - *Lepeophtheirus salmonis*

The salmon louse remains a significant threat to salmon health and there has been increasing development of resistance against chemical treatments. For this reason it has been considered necessary during 2013 to utilise 'stamping out' as a counter measure for control of resistant lice. In order to improve our understanding of the overall lice situation nationwide a new method for calculation of the actual infection pressure has been introduced. Through use of the new model, the salmon-louse infection pressure can be calculated for the whole coast and in individual farming sites. Calculations made using this new model indicate a considerably lower infection pressure in 2013 compared to 2012 in southern Norway. In some areas of northern-Norway infection pressure was, however, higher than in 2012.

Calculation of infection pressure

Reported data (lice numbers, number of fish, temperature) and knowledge of development time, survival at each stage of the lice life cycle and reproductory capacity of adult female lice allows calculation of larval (copepodite) production in farming sites. Transmission models allow estimation of the spread of larvae and calculation of the density of copepodites along the coast, which we refer to as infection pressure.

The figure on page 20 shows the mean data used in calculation of infection pressure.

From this data, total copepodite production is estimated for all farming sites in northern-, mid- and southern-Norway as shown in the figure above.

The model shows that copepodite production is lowest around May each year, followed by increasing production as the water temperature rises. Peak production was reached in southern-Norway in August 2012. Copepodite production was calculated to be considerably lower in southern-Norway in 2013 compared with 2012. This may partly be related to unusually low water temperatures during the winter/spring 2013 in southern-Norway, which were at times lower than mid- and northern-Norway. Low temperatures lead to relatively extended copepodite development. Some parts of Northern-Norway were subject to higher infection pressures in 2013 than 2012.

Estimated total copepodite infection pressure over time and space was calculated using a GIS model (core density function in ArcGIS Spatial Analyst) with a search radius of 25km and grid size of 1 km2. Using this model for copepodite spread we assume the density of copepodites is greatest at point of release (farm) and reduces in all directions (normally distributed) until a distance of 25km is reached.

The infection pressure along the coast in 2013 is shown in the maps above and it is clear that infection pressure increases from a low level in May to higher levels throughout the summer and autumn. The map also reveals a tendency for infection pressure to increase in the south earlier than in the north. In late autumn 2013 a high infection pressure was also established in northern-Norway. For more details on infection pressure calculation and information on the salmon louse situation in wild salmonids, see 'Risk evaluation in Norwegian aquaculture 2013' (Institute for Marine Research)

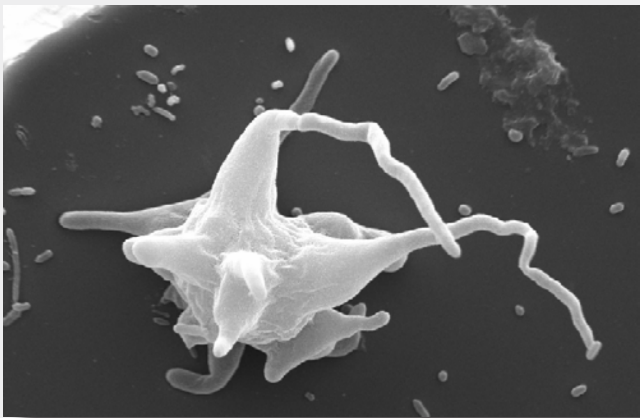
Parvicapsulosis - *P. pseudobranchicola*

The myxozoan parasite *Parvicapsula pseudobranchicola* causes the disease parvicapsulosis, and was first described in Norway following outbreak of disease with high associated mortality in salmon in three sea farms in 2002.

The course of disease in salmon varies between slightly increased and high mortality. Parvicapsulosis is particularly problematic in Troms and Finnmark, where in some cases several thousand moribund fish have been observed near the surface of affected cages. In such cases mortality can be significant. It has been reported that parvicapsulosis may lead to more significant mortality if the fish are already weakened by some other factor or disease.

The parasite is found in large numbers primarily in the pseudobranch (under the operculum) and it is here the main pathological changes may be observed. In extensive infections, large numbers of spores may be found in the capillaries, epithelia and connective tissues. The parasite may also be observed in the gills,

Damage caused by the amoeba can be seen with the naked eye as white spots on the gills, which may be confirmed by microscopy of mucus scrapes. Photo: James Harris, Aquafin AS.



Photograph of P. perurans taken using an electron microscope. Photo: Jannicke Wiik-Nielsen. Norwegian Veterinary Institute.

liver and kidney. In 2013 parvicapsulosis was diagnosed in 25 farms..

Aquaculture related diagnoses are mainly related to the two most northerly regions, but the parasite has also been identified in Nordland and Nord-Trøndelag.

P. pseudobranchicola is reported from wild arctic char, seatrout and salmon along the whole Norwegian coast and these species appear to be natural hosts for this parasite. The work of identifying the main host for *P. pseudobranchicola* continues.

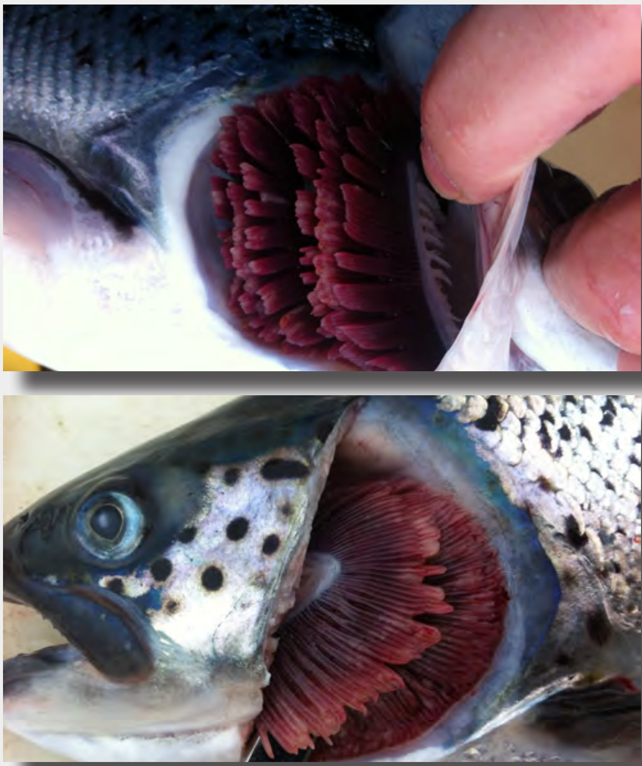
Microsporidian infection
Desmozoon lepeophtherii

Desmozoon lepeophtherii is aparasite within the Microsporidia. All microsporidians are parasites and a number of species affect fish e.g. Loma salmonis in rainbow trout, *L. morhua* in cod and *Pleistophora ehrenbaumi* in wolffish). Microsporidians form infective spores and their life cycles may be either direct or involve intermediate hosts.

Desmozoon lepeophtherii was first described in the literature in 2003 as a parasite of the salmon louse and was subsequently named in 2009. The parasite was also later described under the name Paranucleospora theridion and this name is commonly used in Norwegian literature. However, as the name Desmozoon lepeophtherii was published first this is the valid name of the parasite.

The parasite has salmon louse, *Lepeophtheirus salmonis* as its definitive host and salmonid fish as intermediate hosts. In addition to salmon the parasite has also been identified in rainbow trout and sea trout as well as in the sea-louse Caligus elongatus. The parasite is found along the entire Norwegian coastline, but appears to be most common south of Nordland. It has also been identified in Scotland and recently in salmon lice in Canada.

Desmozoon lepeophtherii is detected by real-time PCR and while the parasite causes a systemic infection i.e. can be found in all tissues, gills and kidney are most commonly analysed. Spores may be observed microscopically in inflamed gills and in the peritoneum.



Algal damage to the gills Photo: Kristin Ottesen, Helgeland Havbruksstasjon AS.

The significance of the parasite for fish health is unclear, but it contributes to gill disease either alone or together with other agents.

Amoebic gill disease (AGD)
- *Paramoeba peruans*

Amoebic gill disease (AGD) is caused by the amoeba Paramoeba perurans. The disease has over many years caused large losses of farmed salmon in Australia (Tasmania) and has in recent years also resulted in significant losses in Ireland and Scotland. Paramoeba perurans was also identified in the Faroe Islands for the first time in 2013.

AGD affects salmon farmed in the sea and the most important risk factors appear to be high salinity (>32ppt) and high sea temperature. AGD may be treated with freshwater or hydrogen peroxide. To ensure good effect of treatment gill monitoring is essential. For AGD such surveillance is usually PCR-based. A system has been developed for macroscopic scoring of gills. Together with direct microscopy of gill samples, these measures have proven valuable tools for fish health services.
After repeated treatment, evaluation of gill scoring may be difficult and require considerable experience. As a number of different agents and factors

may be involved in gill-changes, confirmation of the diagnosis by histological analyses and PCR is necessary.

In Norway AGD was identified for the first time in 2006 but was then not diagnosed again until 2012 (5 cases). In 2013 AGD was diagnosed in 56 different farms. Two of these cases involved rainbow trout, two involved ballan wrasse (Labrus bergylta) and one corkwing wrasse (Symphodus melops). The remainder of cases involved salmon.

Of the salmon farms affected, over 70% were situated in Hordaland, nearly 20% in Rogaland and the remainder in Møre og Romsdal, Sogn og Fjordane and Vest Agder. Almost 90% were identified in October-November and the remainder in either September or December. In almost 40% of the cases other gill related diseases/agents were reported in addition to P. perurans.

Gill Health

Gill disease often has complex aetiology in which many agents and different water parameters may play a role. Gill disease is not notifiable. This makes estimation of its significance difficult.

In marine farms gill problems are greatest during the autumn and typical presentation includes morbidity, increased mortality and a low tolerance for handling of any kind. Gill disease affects, therefore, both fish welfare and survival in salmon farmed in seawater. Again during the autumn of 2013, gill disease of complex aetiology was observed. However in western Norway, particularly Hordaland and further south, AGD contributed to the overall picture and was at times the dominant finding in gill associated cases.

Gill problems related to the freshwater stage of culture may be caused by fungus (Saprolegnia spp.), bacteria or parasites e.g. Costia (Ichthyobodo sp.). The primary cause, however, is commonly environmental, related to poor water quality with the problem often disappearing on correction of the environmental problem. Once more in 2013, cases of gill disease were investigated for which no clear cause could be established. One particular gill disease related to epithelial cell sloughing resulting in high mortality, was again identified in several farms in 2013. A viral aetiology is suspected. Gill health is currently a prioritised area of research. Read more www.vetinst.no/faktabank/

Other health Problems

Smolt quality/runt syndrome

There remains a significant problem in the Norwegian aquaculture industry related to overall post sea-transfer mortality, as approximately 20% of fish entering the production system never reach consumption. There are large farm to farm differences in overall survival. The reasons behind these differences appear complex and are not always obvious.

Good smolt quality is considered extremely important in relation to survival and there is an increased focus on this parameter. While many fish health services report generally good smolt quality within the industry, uneven quality remains at times a problem. Large batches of smolt of uneven size are a challenge in relation to time of sea-transfer; some fish are ready for sea-transfer and some are not. This leads to large losses directly after transfer. A proportion (often large) of surviving fish may not develop normally and end up as ‘runts’. Ulcer development immediately following sea-transfer is reported, commonly associated with mechanical injuries received at transfer. Intact skin is considered important in resisting bacterial infection and avoidance of osmoregulatory problems following sea-transfer. Gentle handling combined with a favourable environment in both the hatchery and during transport are therefore considered important.

Runt development i.e. fish which either lose weight or fail to develop normally after sea-transfer, is reported as a problem by several fish health services. This phenomenon is defined by some as a significant cause of death, contributing as much as 12% of total mortality in some farms. There remains a degree of uncertainty regarding the factors responsible for runt development, although a multifactorial aetiology is suspected of which smoltification ‘factors’ are suspected to play a role. There are commonly few conclusive findings on pathological investigation and bacteriological- and virological- investigations are often negative.

In addition to increased mortality levels, poor smolt quality and runt syndrome represent significant welfare problems to the aquaculture industry.

Vaccine side-effects

Vaccination with oil-adjuvanted vaccines causes an inflammatory reaction in the peritoneum which in practice lasts for the lifetime of the fish and is a precondition for good vaccine effect. Granulomatous inflammation in the peritoneum represents ‘background noise’ in most diagnostic investigations. In some cases this inflammation may be so serious and extensive that it undoubtedly represents a significant welfare problem for the affected fish.

Fish welfare

Many fish health services and farms have reported high mortalities related to handling and lice-treatment during the autumn of 2013. One common factor appears to be unusually ‘fragile’ fish with low tolerance for stress. Several farms have lost more than 100 tons of large salmon during treatments. Samples submitted from such fish show only non-specific organ changes and congestion, with no clear cause of death. Most affected farms were situated in areas previously affected by PD and HSMI, and it has been speculated that this may partly explain the phenomenon. Resistant lice are a problem in many areas resulting in an increased number of lice treatments and thereby an increase in treatment related mortality. Frequent lice-treatment must be considered a welfare challenge also in cases which do not necessarily result in high mortality. It is important that new technological developments also consider fish behaviour and health.

Mortality during the seawater phase has been too high for many years (15-20%). In addition to infectious diseases much of this mortality is related to smolt quality and handling. The Norwegian Authority for Food Safety, together with the industry, is in the process of investigating the causes. More knowledge in this field is necessary to increase fish welfare and reduce losses.

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

Parasites

Parasite checks are part of normal routine health controls. Parasites reported during 2013 include species belonging to the following families: Scyphidia, Riboschyphidia, Epistylis, Ichthyobodo, Trichodina, Chilodonella and Oodinium. Gyrodactylus has not been reported from fish reared for stock-enhancement purposes in 2013.

Bacterial and viral diseases

No serious bacterial or viral infections were reported in 2013.

Fungus

Saprolegnia sp. in eggs, gills and skin of brood stock is a not uncommon finding and work towards prevention and treatment of these conditions is continual.

Environmental problems

Of environmental, management and miscellaneous problems the most common are: shortening of the operculum and fin erosion. Otherwise, eye snapping, cataract, hypercalcinosis of the kidney, gill injury, gill inflammation and gill irritation, tumours in the inner organs, various deformities and runt development are also reported.

Health control of wild caught broodstock for stock-enhancement purposes

Stock-enhancement facilities have a special responsibility to avoid intake, amplification and release of (with released fish) disease causing agents. Especially important are those vertically transmitted diseases which may be transmitted from parent to offspring and in particular infectious pancreatic necrosis (IPN) and bacterial kidney disease (BKD). The Health Service for Stock Enhancement Hatcheries therefore organises health control of wild caught brood fish for member farms and for the live and frozen gene banks for wild Atlantic salmon. Brood stock control for the gene bank involves post-mortem examination, culture and PCR-analysis for detection of IPN-virus (IPNV), the BKD-bacterium (Renibacterium salmoninarum) and the furunculosis-bacterium (Aeromonas salmonicida subsp. salmonicida). Stock enhancement hatcheries are only bound by law to test for BKD, but the Health service also recommends testing for IPNV. All PCR-analyses are performed by Patogen Analyse AS.

The results from this year's broodfish season is 1 IPN positive salmon. Table 3 shows the number of fish, species and tissue types investigated.

Scale analysis identifies farmed fish

Wild salmon brood stock caught and stripped to supply eggs for stock-enhancement and gene banks are subjected to scale analysis. Scale analysis is extremely important in identification of farmed fish and for their exclusion from stock-enhancement projects. This is primarily important in protection of the genetic profile of salmon stocks in individual rivers.

Disease in wild salmonids

Gyrodactylus salaris

A total of 2075 salmon from 65 rivers and 3016 salmon/rainbow trout from a total of 89 fish farms were investigated as part of the national surveillance programme for Gyrodactylus salaris. G. salaris was not identified during the 2013 surveillance-program either from samples from aquaculture facilities or from rivers. G. salaris was, however, identified in a new river, the Breidvikelva, during rotenone treatment of the infected Rauma region (see section on Gyro eradication 2013).
The rivers in the OK-programme are investigated annually at one to three different locations, dependent on the size of the river. In the rivers Tana and Numedalslågen, samples are taken from more than 3 sites due to the size of these rivers. Samples are taken from aquaculture sites every second year.

In the 'free of infection' program aimed at documentation of the absence of the parasite in previously infected rivers following eradication programs, 1105 juvenile salmon were examined from 11 rivers in the Steinkjer region (5 rivers , 440 fish), Vefsna region (5 rivers, 250 fish) and the Lærdal region (1 river, 415 fish). G. salaris was not identified in the 'freedom of infection' program in 2013.

2013 was the fourth consecutive year of infection free status in the Steinkjer region, while the Vefsna- and Lærdals-regions were investigated for the first

Tabell 3. Foreløpig oversikt over stamfiskanalyser sesongen 2013/2014. PCR testing for IPNV, *Renibacterium salmoninarum* (BKD) og *Aeromonas salmonicida* subsp. *salmonicida* (furunkulose) resulterte i 1 IPNV positiv nyreprøve fra laks, ellers var alle analyser negative. * 1 positiv

		Nyre	Rognvæske/melke
Atlantic salmon	BKD	529	206
	IPNV	320*	30
	Furunculosis	105	0
Sea trout	BKD	53	149
	IPNV	45	99
	Furunculosis	6	12
Arctic char	BKD	45	65
	IPNV	45	65
	Furunculosis	12	0

time in the ‘free of infection’ program. The rivers in the program are investigated 2-3 times per year and ideally 10 juvenile salmon are examined every second kilometre of the anadromous zone. In rivers with a short anadromous zone, 30 juvenile salmon are collected in the lower stretches of the river. The period between treatment and declaration of freedom of infection should not be less than 5 years. This is based on a maximum smolt age of 4 years plus a one year safety margin. In regions with a maximal smolt age of five years or more, the period to declaration of freedom of infection should be delayed accordingly.

Gyro eradication 2013

Initial treatments against Gyrodactylus salaris were performed in the Rauma region in 2013. Remaining infected regions where treatment has not yet been initiated are the Skibotn region, Driva region and the Drammen region.

The rivers of the Rauma region were treated in late August and included the infected rivers Rauma, Innfjordelva, Måna, Skorga and Henselva including the Isa and Glutra. Tributary rivers were also treated. Treatment of each river was individually planned. During the treatment programme, G. salaris was identified on juvenile salmon in the river Breivikelva. This the 49th Norwegian river to be identified as positive for G. salaris. Extensive work related to conservation of seatrout in the region is currently underway.

The work of planning and preparation for treatment of the Skibotn region started in 2013. Emphasis was placed on inspection and mapping of problem areas. The rivers in the region are considerably influenced by groundwater springs and hold large populations of sea-run arctic char. These fish may carry G. salaris and habituate the freshwater springs to a greater degree than Atlantic salmon. This leads to an increased challenge during treatment. Extensive work related to conservation of seatrout and arctic char is currently underway.
In other infected regions, only limited preparations for future treatments have been made.

Read more www.vetinst.no/faktabank/Gyrodactylus

Cleaner fish

Use of fish species such as goldsinney wrasse (*Ctenolabrus rupestris*), corkwing wrasse (Symphodus melops) and ballan wrasse (*Labrus bergylta*) is now common in control of salmon lice. Use of the lumpsucker (Cyclopterus lumpus) has also recently increased considerably.

The wrasse species are most commonly wild-caught in fyke nets during the summer months and transported in tanks on deck, in well-boats or overland in transport lorries to the farm in which they will be used. The longest transport stretch is between the Skagerrak coast and Nordland.

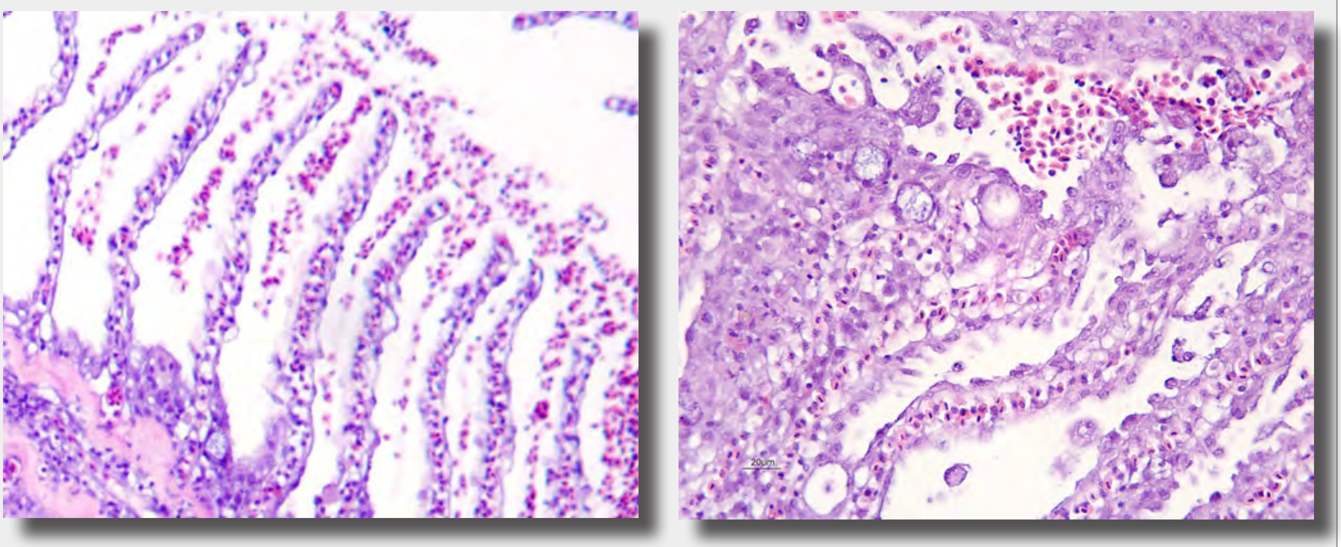
Fish health services continue to report high level on-farm mortalities in fish held together with salmon. Mortalities can be high immediately after sea-transfer, particularly if the fish were damaged during capture/transport. Removal of damaged fish prior to sea-transfer can therefore be important. Cleaner fish are dependent on suitable cover to thrive, and as a result often inhabit the dead fish 'sock', a habit which commonly leads to mortality when the sock is lifted for mort removal. Generally, corkwing wrasse appear to be less robust than the other species.

There are an increasing number of commercial farms involved in cleaner fish production. Both ballan wrasse and lumpsucker are produced. The increased use of wrasse and lumpsucker is reflected in the increased number of diagnostic submissions related to these species received by the Norwegian Veterinary Institute in 2013.

There is a significant need for mapping of the diseases and causes of cleaner fish mortality. Diagnostic submissions to the Norwegian Veterinary Institute in 2013 include material from both farmed and wild-caught cleaner fish of all four species. In some cases there exists a degree of uncertainty around species identification in the field and a proportion of the material is therefore classified as 'Wrasse' in the Norwegian Veterinary Institutes database. The material covers both fresh fish, formalin fixed tissues, bacterial cultures and in some cases viral samples.

Virus

No virus diagnoses were awarded in cleaner fish species during 2013. The number of samples subjected to virological investigation were, however, extremely low. Previous virological investigations of Norwegian wild-caught and captive cleaner fish have not identified VHSV, IPNV or nodavirus. SAV is reported in wrasse held together with salmon during a PD outbreak. Whether these detections relate to a passive or carrier infection is not known. Further studies are underway. There is a clear need for identification of the virus agents to which cleaner fish are susceptible.



Amoebic gill disease in ballan wrasse. Photo: Anne-Berit Olsen, Norwegian Veterinary Institute

In December 2012 VHS (viral haemorrhagic septicaemia) was identified in several wrasse species in Shetland. The virus has now been typed to genotype III. The authorities in Scotland consider marine fish as the most likely source of the infection.

Bacteria

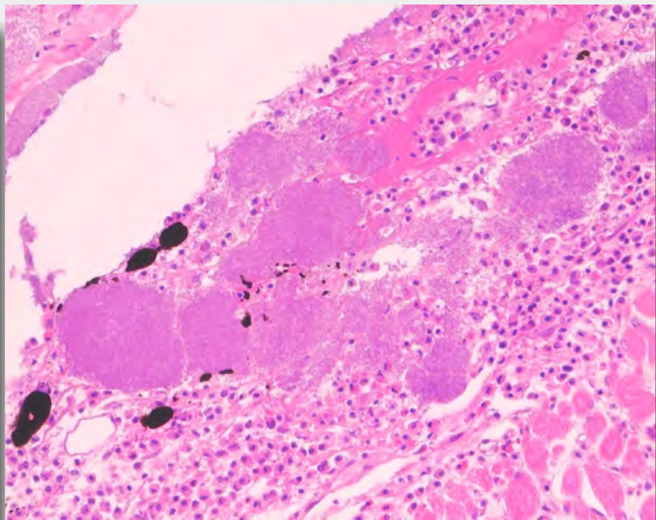
The most significant finding from cleaner fish in 2013 was the relatively large increase in the number of cases involving systemic infection in lumpsucker, caused by a Pasteurella sp. This bacterium is a close relative of that causing 'varracalbmi' in Atlantic salmon (see 'other bacterial infections' in the salmonid section of this report). Initial research performed at the Norwegian Veterinary Institute indicates differences between the lumpsucker and salmon variants of the bacterium. Disease related to this bacterium has been identified in juvenile and sea-transferred lumpsucker.

Clinical histories indicate that overt disease may be provoked by stress in relation to vaccination, transport and/or introduction to a new environment. Mortality of up to 100% has been reported. Treatment with oxolinic acid and florfenicol has been performed in some cases. Reports relating to treatment success are mixed regarding oxolinic acid, while florfenicol treatment is generally reported as successfully reducing mortality. Post treatment recurrence of infection is reported on several farms.

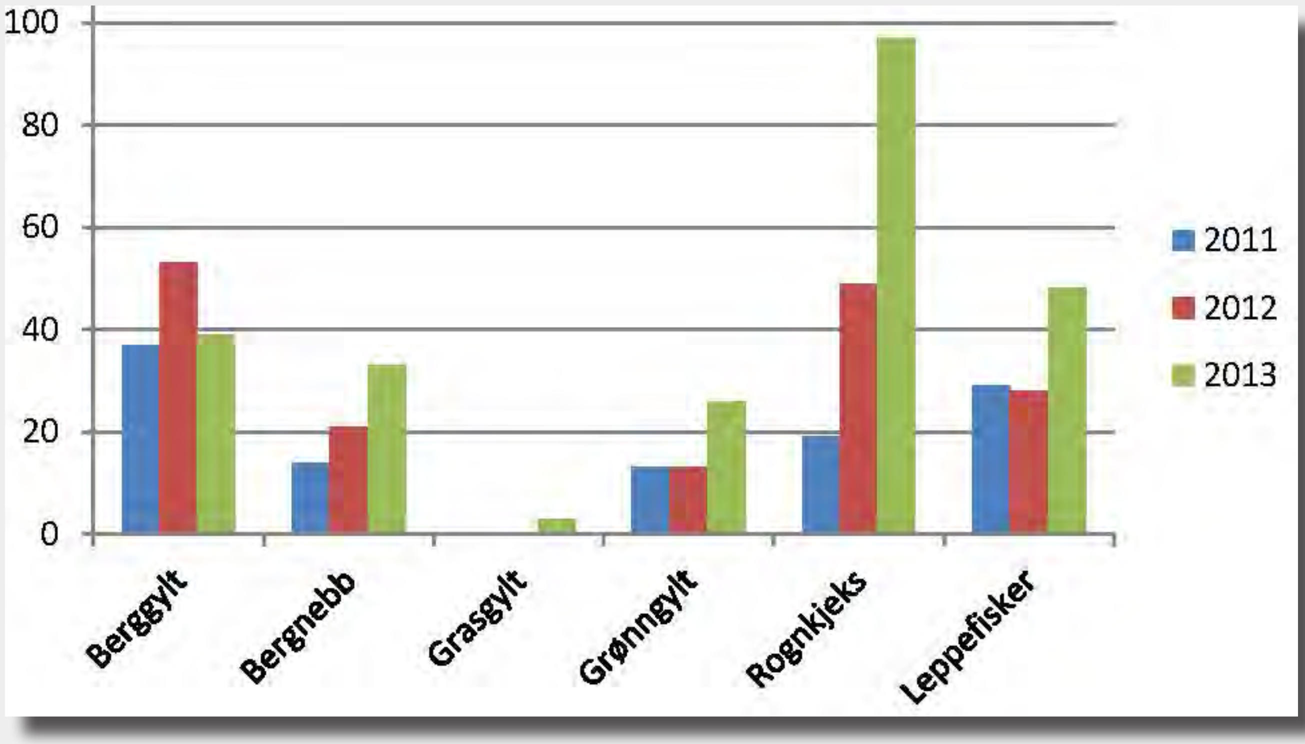
Otherwise, the main bacterial findings in 2013, as in previous years, include identification of diverse Vibrio spp. and atypical Aeromonas salmonicida (atypical furunculosis). Atypical Aeromonas salmonicida is considered to be one of the most important pathogens of cleaner fish. This bacterium causes most commonly a chronic disease with granuloma in the inner organs as well as ulcer development.

Vibrio anguillarum, a well-known pathogen of cod and salmonid fish was isolated more commonly in 2013 than in previous years. This bacterium was also isolated from diseased lumpsucker, ballan wrasse and unspeciated 'wrasse'. Serotype O1 has been isolated from lumpsucker and 'wrasse' while serotype O2a was isolated from ballan wrasse in 2013. Vibrio ordalii, a recognised pathogen was detected in lumpsucker in several farms in 2013.

Many *Vibrio* species are normal members of the marine micro-flora and many species exist of which some are well known pathogens and others are considered opportunists. Those of less certain significance include Vibrio tapetis, a well-known pathogen of shellfish, which is quite commonly identified as part of a mixed Vibrio flora from wrasse. Vibrio logei, and Vibrio wodanis are also commonly identified from material submitted from all species of cleaner fish. Vibrio splendidus, a common finding, is a typical opportunist and it may be speculated that the effects of transport and captivity in salmon cages may result in disease which may otherwise not have developed in more robust fish.



Pasteurellosis in lumpsucker: Skin lesions and histology of skin revealing aggregations of bacteria Photo: Marta Alarcon, Norwegian Veterinary Institute



Increase in number of cases submitted to the Norwegian Veterinary Institute involving cleaner fish

Fin rot remains a recurring problem in farmed ballan wrasse. Tenacibaculum spp., often in pure culture but most commonly in mixed culture, may be identified in association with such outbreaks. This bacterium is also regularly identified from other wrasse species and lumpsucker.

Pseudomonas anguilliseptica was not identified in 2013.

Parasites

Amoebic gill disease (AGD) caused significant mortality in farmed salmon in 2013. The disease was also diagnosed in corkwing, ballan and other wrasse species, both in fish held on land (in tanks) and at sea (in cages together with salmon). The pathological findings in wrasse are highly similar to those seen in salmon with AGD. Parasitic gill inflammation has also been identified in farmed and wild caught cleaner fish.

Trichodina spp. have been identified in farmed lumpsucker concurrently with other disease. In 2013 a Kudoa sp. was identified in the musculature of farmed lumpsucker. Another species in this genus, Kudoa thyrsites, is known to infect salmon and a number of other species of fish and causes muscle damage and discolouration of the fillet, resulting in considerable financial losses.

Fungus

A single case of suspected mycotic nephritis caused by Ichthyophonus hoferi was reported in lumpsucker

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

Farming of marine fish, particularly lumpsucker has obvious challenges related to bacterial diseases. Relevant vaccines are only poorly developed. Antibiotic treatment with e.g. oxolinic acid and florfenicol may therefore be necessary at times. Currently there is little sign of development of antibiotic resistance in bacteria pathogenic for marine fish. In 2013 only one case of reduced sensitivity to quinolone antibiotics in Vibrio anguillarum serotype O1 was identified from farmed lumpsucker.

Welfare

Use of cleaner fish is a valuable and environmentally friendly alternative to traditional chemical based lice-treatments. The method does however have considerable welfare related challenges. Capture and transport of wild wrasse represents significant stressors for these fish and associated losses are high. Several infectious diseases have been identified in cleaner fish and again, mortality can be high. Continual replacement of dead cleaner fish with new fish is necessary to maintain the anti-lice effect during the salmon production cycle.

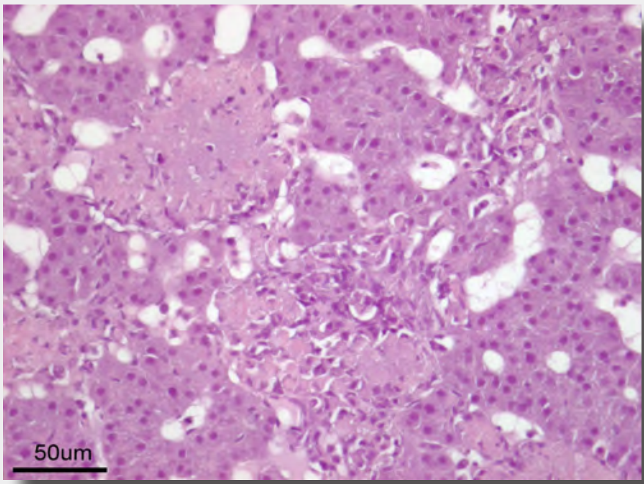
Cod

In 2013 the Norwegian Veterinary Institute investigated 12 diagnostic submissions from a total of eight different farms involving cod. There has been a considerable reduction in number of submissions since 2009 when over 350 investigations were performed from more than 85 different farms. This development mirrors the decline of cod farming in Norway. According to the Directorate for Fisheries there were 84 cod farms in operation in 2012 compared with 240 in 2007.

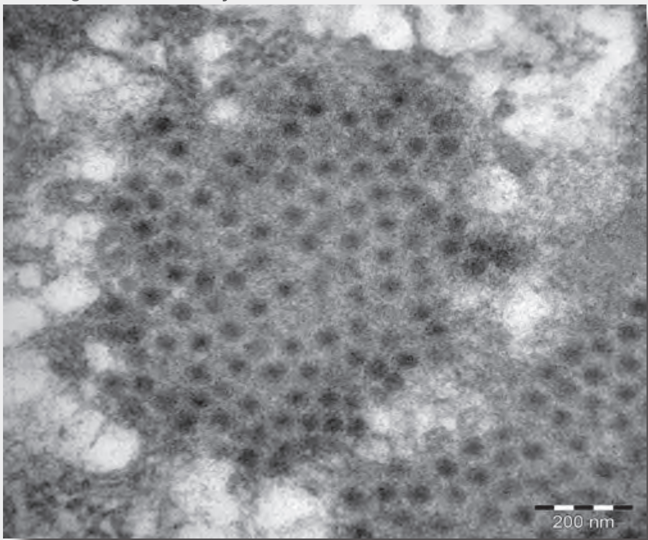
Bacterial infections have long dominated the disease picture in farmed cod. In 2013 various Vibrio species such as V. logei and V. splendidus were identified in submitted samples. Photobacterium spp. and Carnobacterium spp. were also identified in cod. The significance of these findings is unclear in relation to disease development. Classical vibriosis and atypical furunculosis caused by Vibrio anguillarum and atypical Aeromonas salmonicida respectively, were, however, not identified in material submitted in 2013. This does not mean that these bacteria did not cause losses in 2013, as they may well have been diagnosed by individual fish health services.

Francisellosis, one of the most significant diseases in modern cod farming, caused by Francisella noatunensis subsp. noatunensis, was diagnosed on one site in Sogn og Fjordane in 2013.

Nodavirus and IPN-virus were not identified in material submitted



Light microscopy photograph of necrosis and inflammation in diseased halibut. Photo: Renate Johansen, Norwegian Veterinary Institute



Electron microscope photograph of aquareovirus-like particles in the affected areas of the liver in diseased halibut. Photo: Hilde Kolstad, Imaging Centre, Campus Ås

Halibut

In 2013 the Norwegian Veterinary Institute received 26 diagnostic submissions from 6 halibut farms. This is a slightly lower figure than the previous year, and no significant changes in the disease situation have been identified. Bacterial problems dominate with atypical furunculosis and diverse Vibrio-species the most common findings. Atypical furunculosis is a recurring problem in halibut farming and this disease can be difficult to control in land-based farms. Four halibut farms were awarded atypical furunculosis diagnoses in 2013.

One halibut farm has experienced repeated episodes of increased mortality in juvenile fish associated with liver necrosis. Similar findings have been registered in halibut juveniles in Scotland and Canada in association with aquareovirus infections. Aquareoviris-like particles have also been observed by electron microscopy in Norwegian samples, but molecular biological tests for aquareovirus were negative. Further investigations are necessary to verify whether the Norwegian halibut are infected with aquareovirus and the significance of such an infection.

Aquareovirus are a group of viruses identified in a range of fish species in many parts of the world. The significance of aquareovirus in development of disease is under discussion. In most cases the virus is considered a contributory factor in weakening infected fish, which may make them more susceptible to other infections. Aquareovirus has been identified in Atlantic salmon and other salmonid species in e.g. USA and Australia, but is unknown in Norwegian aquaculture. We need increased knowledge relating to the prevalence and significance of this virus group in Norwegian aquaculture. Nodavirus and IPN were not identified in material submitted from halibut in 2013.

Risk situation: spread of infection

This section discusses the changes during 2013 in risk and spread of infectious disease in aquatic organisms, primarily farmed salmon, in Norway. The status for salmon-lice is discussed separately. The number of cases of any particular infectious disease, listed or non-notifiable, will constitute an indicator of infection pressure. In addition, changes in production technology and legislation will lead to change in the risk situation.

Disease statistics and infection pressure in 2013 - notifiable diseases

Only a few diseases in aquatic organisms are notifiable (Table 1) and result in compulsory restrictions with obligatory infection-limiting counter measures. A range of differing measures are, however, used by individual companies within the industry to control spread of infection and reduce losses. Such measures are practised either independently or in cooperation with the authorities and are in addition to those required by the public authorities. The positive participation by the industry is extremely important for the collective reduction of disease related losses and spread of infection.

Statistics relating to the number of localities diagnosed with notifiable diseases (table 1) show, with the exception of PD and HSMI, stable low figures. There has also been a noticeable increase in the number of ISA cases in 2013 compared with the two previous years.

Pancreas disease (PD) was diagnosed in fewer farms in 2013 than in the year before, when the highest number of outbreaks was registered to date (table

PD-virus subtype / region	2009	2010	2011	2012	2013
SAV2					
Troms		0	0	1	0
Nord-Trøndelag		0	1	2	0
Sør-Trøndelag		0	1	24	31
Møre og Romsdal		5	6	17	20
Sum SAV2		5	8	44	55
SAV3*					
Finnmark	0	0	0	1	2
Troms	1	0	0	0	0
Sør-Trøndelag	1	0	0	0	0
Møre og Romsdal	7	2	5	4	1
Sogn og Fjordane	11	13	16	22	5
Hordaland	46	47	46	52	28
Rogaland	7	21	14	18	12
Sum SAV3	72	83	81	97	48

Table 4. Number of sites per region with suspected or diagnosed pancreas disease of the different subtypes.

4). However, the situation development for the two sub-types, SAV2 and SAV3 is very different. The SAV2 area includes the endemic zone from Hustadvika in Møre og Romsdal to the regional border between Sør- and Nord-Trøndelag, defined by SAV2 legislation of November 2012, together with Romsdal. There has been a seriously negative development in the number of new cases following introduction of the new SAV2-subtype to Romsdal in 2010. The infection spread northwards over the old PD zone border at Hustadvika in the autumn of 2011. Following change to the control strategy defined by the new SAV2 legislation in 2012, this development has accelerated. In 2013 there were more PD cases caused by SAV2 in Møre og Romsdal and Sør-Trøndelag than there were SAV3 cases between Rogaland and Sunnmøre.

The endemic area for SAV3 had the lowest number of detections since the disease was made notifiable in 2007. At the turn of the year 2013/2014 restrictions were in place in one farm in Sunnmøre and only four in the whole of Sogn og Fjordane. Only a few sites were subject to restrictions in the Romsdal area and Rogaland region (Table 5). That the number of affected sites in any one particular area can be reduced to so few indicates that it may be possible to eradicate the disease from that area.

Region / area	No. of sites	No. from 2012
Finnmark	3	1
Sør-Trøndelag	49	9
Møre og Romsdal		
Nordmøre	12	2
Romsdal	7	1
Sunnmøre	1	0
Sogn og Fjordane	4	1
Hordaland	24	3
Rogaland	12	2
Sum	**112**	**19**

Table 5. Number of sites subjected to operational restrictions due to pancreas disease per region/area at the turn of the year 2013/2014 and the number of these with restrictions in place from 2012 (expected to have restrictions lifted in the near future).

On introduction of PD-legislation in 2007 together with establishment of the endemic zone for PD between Rogaland and Hustadvika, all localities subsequently diagnosed with PD outside this zone were subjected to strict restrictions including stamping out. Also within the zone, diagnosis resulted in declaration of infection, which allowed other operators to reduce contact with the infected site. The industry has also introduced its own measures in infected sites. These include minimal handling, reduced biomass density, use of 'health-feed' etc. Vaccination against PD is also widespread within the zone in Western Norway, but is as yet less common in Sør-Trøndelag and Nordmøre.

That the number of PD cases caused by SAV2 and SAV3 virus types are developing in very different directions may indicate that biosecurity measures relating to management routines, site localisation in relation to currents and other aquaculture sites, infection-limiting measures at slaughter, together with other preventative measures are fundamentally different in the two areas. Introduction of zone-based production, introduced largely in relation to salmon-lice control, may also have had an effect on PD in western-Norway. It cannot be discounted that the two virus types possess different transmission characteristics. Such factors need further study.

Infectious salmon anaemia (ISA) was identified in 10 salmon farms in 2013, while in 2011 and 2012 only one and two outbreaks were identified respectively. Seven cases in 2013 can be considered as 'primary' outbreaks, while the three remaining may be explained by horizontal transmission. An increase to seven 'spontaneous' outbreaks can lie within the bounds of normal variation for ISA.

The current model/theory relating to the occurrence of spontaneous ISA is based upon mutation of the low-virulent variant, HPR0 to a so-called HPR-deletion variant, which may cause disease. HPR0 is a common finding in farmed salmon, and the risk of outbreak of ISA may therefore lie latent in salmon in the sea. It is not known how often such mutations may occur, and the degree to which outbreak of disease is dependent on the susceptibility of the salmon population and other contributory factors related to the affected fish population.

Heart and skeletal muscle inflammation (HSMI) is currently a notifiable list 3 disease, but it has been proposed removed from the list. In 2013 HSMI was diagnosed in 132 sites, slightly fewer than in the previous year. Piscine reovirus is described and related to development of HSMI. This virus is common in farmed salmon and it remains unknown which factors lead to clinical outbreak. Possible factors include environmental parameters, differences in fish populations or viral strain differences. Despite the fact that HSMI has for many years been one of the most commonly diagnosed diseases in salmon farmed in seawater, the consequences of the disease and the high prevalence of the virus amongst farmed fish, has not been investigated.

Important non-listed diseases

Non-notifiable diseases with infectious or suspected infectious aetiology are listed in Table 2.

For infectious pancreatic necrosis (IPN) developments have been very positive during the last five years, for which selective breeding of resistant (QTL) fish is assumed to represent an important factor, while improved sanitary measures during the hatchery phase have also probably contributed.

For cardiomyopathy syndrome (CMS) there has been a gradual increase in the number of cases in recent years. A viral agent, piscine myocarditis virus, has been described and outbreaks of CMS appear to be related to the presence of the virus. It is not known whether the number of increased cases is related to spread of infection or whether it is a result of increased focus on the disease.

Coldwater vibriosis has been a marginal disease in salmonid fish following introduction of a vaccine at the end of the 1980's. Only sporadic cases have been reported, mostly in harvest-ready fish in northern-Norway, probably due to reduced immunity long after vaccination. In 2011 there was a tendency towards an increasing number of cases, and in 2012 the number of cases increased significantly with 21 diagnoses. Most of

	2009	2010	2011	2012	2013
Number of sites					
Salmonids, concessions, juvenile	256	249	247	235	230
Salmonids, registered, on-growing	988	991	990	963	959
Marine fish, registered, on-growing	281	218	163	122	110
Biomass at end of year, tons					
Salmon	607'	621'	678'	706'	724'
Rainbow trout	35'	32'	43'	43'	42'
Harvest statistics, ton					
Salmon	862'	940'	1 065'	1 232'	1 144' *
Rainbow trout	74'	55'	58'	75'	74' *
Cod	21'	21'	15'	10'	7' *
Juveniles, total in millions					
Salmon	239	257	281	279	
Rainbow trout	17	20	21	20	
Cod	7,7	5,0	6,9	2,6	
Losses, total in millions					
Salmon	46	47	51	39	38
Rainbow trout	2,7	3,2	2,5	3,3	2,9
Cod	7,3	3,5	2,8	1,4	
Losses, %					
Salmon	19	18	18	14	
Rainbow trout	16	16	12	17	
Cod	95	70	41	54	

Table 6. Production data for salmonid fish, statistics from the Directorate for Fisheries (pr 30.01.14)

* Preliminary figures Kontali analyse (pr 30.01.14)

** Proportion of fish lost from production between sea-transfer and harvest.

the fish affected were in their first year at sea. In 2013 the number of cases reduced to 13, all in northern-Norway. Several factors have been considered as possible causes of this epidemic including vaccination-related factors (time point, water temperature, antigen dose), increased infection pressure, and other underlying disease. No conclusions have been reached in relation to cause, and it is unlikely that one factor alone can explain the epidemic.

Amoebic gill disease (AGD) is caused by the amoeba Paramoeba perurans and caused in 2011, and particularly in 2012, significant problems in salmon farming in the British Isles. The disease was first diagnosed in Norway in 2006, in four farms in western-Norway. It was not registered again until late autumn 2012, when 5 localities in Rogaland and Hordaland were affected. In 2013 the increase has been dramatic with AGD diagnosed in 56 farms, including a minority in rainbow trout and cleaner fish. The majority of cases were located in Hordaland and Rogaland, with a few in Vest-Agder, Sogn og Fjordane and Møre og Romsdal. Mortalities associated with outbreaks has ranged from insignificant to over 50%.

The AGD epidemic has apparently spread over northern Europe over the last 2-3 years. Outbreak of disease is related to salinity and water temperature, occurring at high salinity and temperatures > 7oC. It is uncertain whether different variants of P. perurans with varying virulence exist. In Scotland AGD has been less problematic in 2013 than in previous years.

The factors driving this epidemic are unknown. There is a need for surveillance and study of both the amoeba and production and environmental parameters to gain a better understanding of and allow control of the disease. Paramoeba perurans was also associated with gill disease in ballan wrasse in 2013. Studies are underway to establish whether P. perurans isolated from wrasse are also pathogenic for salmon.

The Norwegian Authority for Food Safety has asked the Norwegian Scientific Committee for Food Safety (VKM) to evaluate the risk AGD poses to the aquaculture industry and wild populations of aquatic organisms in Norway.

In 2008 a serious epidemic involving Flavobacterium psychrophilum infection occurred in several hatcheries in Hordaland. The infection followed fish to sea and now appears to be established in rainbow trout in a fjord system in western-Norway, with a significant number of outbreaks in 2009. The number of cases fell in following years and in 2013 systemic infection with F. psychrophilum was identified in only 3 rainbow trout and two salmon farms.

Systemic infection with F. psychrophilum in rainbow trout is proposed added to the national list 3, notifiable diseases. Addition to the list will allow imposition of operating restrictions by the authorities which will increase the chances of elimination of this disease within the affected fjord system, and limit the chances of development of an equivalent situation in the future.

Table 7. Regional production and sea-transfer of smolts. Statistics from the Directorate for Fisheries.

	2009			2010			2011			2012		
	Smolt Prod	Smolt Utsatt	Indeks	Smolt Prod	Smolt Utsatt	Indeks	Smolt Prod	Smolt Utsatt	Indeks	Smolt Prod	Smolt Utsatt	Indeks
Finnmark og Troms	15,7	40,4	0,39	18,5	42,7	0,43	21,3	52,8	0,40	24,6	57,3	0,43
Nordland	50,4	40,7	1,24	60,2	48,8	1,23	64,2	48,8	1,32	65,6	47,8	1,37
Nord-Trøndelag	26,0	15,5	1,68	30,5	24,5	1,24	34,8	19,1	1,82	31,9	27,6	1,16
Sør-Trøndelag	25,8	32,7	0,79	25,6	28,7	0,89	26,7	44,0	0,61	24,5	23,4	1,05
Møre og Romsdal	34,7	28,6	1,22	36,2	28,1	1,29	41,0	25,4	1,61	46,0	37,8	1,22
Sogn og Fjordane	19,1	19,0	1,01	18,8	21,8	0,86	23,0	21,6	1,06	17,3	22,5	0,77
Hordaland	44,3	39,8	1,11	50,3	36,2	1,39	57,7	47,2	1,21	57,6	40,5	1,42
Rogaland	14,1	18,8	0,75	14,8	23,2	0,64	15,6	18,0	0,87	13,6	19,0	0,72
Sum	**230,1**	**235,5**		**254,9**	**254**		**284,3**	**276,9**		**281,1**	**275,9**	

Infection pressure and biomass

Spread of infection from a farming site will depend on the number of infected fish in the site. The collective infection pressure within an area will therefore be directly dependent on the number of production sites (biomass) which lie close enough to each other to influence other farms through water contact. Production of salmon in recent years has increased by around 10 – 20% per year, with a tendency towards stagnation in 2013 (preliminary production figures, Table 6), while the number of marine sites shows a slight reduction. The increased production is a result of increased biomass in individual sites. This is combined with a concurrent concentration of farms within defined zones, due in part to salmon-lice control. Effective prevention of spread of infection and outbreak of disease, in light of increased biomass within limited geographic areas, requires effective surveillance of health and infection status, in addition to good epidemiological understanding of the mechanisms of spread of infection. An increase in production per site combined with a reduction in the total number of sites is also observed in freshwater.

Production of rainbow trout varies more than salmon, and following a low in 2010, production has increased steadily. Production of cod shows a clear drop in recent years, while production of other marine species (halibut, turbot, arctic char) remains stable with a collective production of over 2000 tons per year (estimate 2013: 2700 tons, Kontali Analyse).

Losses during the seawater phase of salmon farming include mortalities associated with disease and as a result of operational factors e.g. loss due to predation and escape, together with fish graded out at harvest (runts) as well as unregistered losses. Total losses for the industry are high, but after having lain at over 20% for many years has entered a positive phase during the last two years with levels of 13-14% in 2012 for salmon. The same positive trend is not observed for cod and rainbow trout.

A national cooperative project between the Norwegian Seafood Research Fund (FHF) and the Norwegian Food Safety Authority followed salmon smolts transferred to sea in the autumn of 2010, together with spring and autumn transferred smolts in 2011. The material represented 80% of all sea-transfers during the study period and included >300 million smolts in total. Preliminary results show collective losses between 15 – 18% in different coastal regions. Infectious disease caused around one third of losses, while around 20% were due to poor smolt quality. Other causes included mechanical injury and environmental conditions.

An equivalent project carried out by the Norwegian Food Safety Authority in 2009 in mid-Norway showed that up to 40% of registered mortalities were related to transfer of smolts and a similar proportion resulted from handling and mechanical injury while 20% were caused by disease.

The results of the two studies indicate that a reduction in losses in salmon over the last two years may be explained by an improvement in the quality of- and handling of- sea-transferred smolts.

Spread of infection via live fish transport

Transport of smolts and harvest-ready fish, is considered one of the most significant risk factors for spread of disease. Although smolts may be considered to be free of significant disease causing agents when leaving the hatchery, any population may be covertly infected. Infection may be introduced during the smoltification process e.g. seawater supplementation may expose the fish to PD virus in the freshwater phase. The actual infection status at any particular time may be unknown in both the dispatching farm, the transport route and in the destination farm. Transport of fish over larger distances occurs following production of smolts in one region to be ongrown in another region, and following transport of harvest fish to central harvesting facilities. Well-boats are almost the only form of transport used in such cases.

Comparison of regional smolt production with numbers of fish transferred to sea can give an indirect estimate of inter-regional smolt transport (Table 7). In northern-Norway the total number of fish transferred to sea was 15 million smolts more than were produced in that region. In mid-Norway (Trøndelag, Møre og Romsdal) the opposite situation was identified, with a total smolt production of 13 million greater than the number of sea-transferred smolts. Of the remaining three regions in western-Norway, Hordaland produced 17 million more fish than sea-transferred, while Sogn og Fjordane and Rogaland each showed a negative balance of 5 million smolts.

Factors other than distance to hatchery are decisive in influencing the origin of smolts transferred to individual ongrowing sites; large companies favour their own smolts even if distances are large. For smaller operators, buying smolts from other companies, other factors including price will naturally be important in the decision on where the smolts are bought.

Transport of infected fish leads to contamination of well-boats and equipment and to spread of infection to the surrounding water during transport. Well-boats are considered a significant risk factor for spread of infectious disease. The risk of infection is greatest during handling or transport of large fish. This includes both chemical bath treatments and transport of harvest fish.

Infectious materials may be released to the environment along the transport route, especially when the transport is performed with open valves. Fish under transport may also be infected via intake of untreated water. In this way infection may be spread to new areas, particularly under transport of smolts. Harvest-ready fish are also transported over large distances. Infections may also be spread around harvest facilities, particularly when fish are held in 'waiting cages' prior to slaughter. The sea area around a harvest facility may also constitute a high risk area for infectious agents.

Transport of fish is regulated by legislation relating to transport of animals in aquaculture. This legislation is currently under review/change with particular focus on the technical requirements relating to disinfection of transport water and tracking of well-boat movements. It is proposed that the new legislation will not come into force until 2019, due to the need for further development of methodology and technology. It is nevertheless likely that future requirements will have consequences for new ship builds and upgrading of existing ships prior to introduction of new legislation.

A requirement for automatic registration and reporting of well-boat position and whether sea-valves are open or closed is proposed. Such requirements are relatively simple to implement and relatively easily policed. Such tracking will also make tracing of infection and documentation of different infection reduction measures possible. Development of legislation and technological innovation which results in a lower risk of infection to and from fish in transport, will contribute to a significant reduction in release of infectious material and spread of disease from well-boats. Changes in aquaculture infrastructure which result in fewer long transports of fish, may also constitute valuable contributions in this area.

Infection risk from cleaner fish

Goldsinney-, corkwing- and ballan wrasse are the most common wrasse species used as cleaner fish against salmon lice. Lumpsucker have also been introduced in recent years, primarily to regions of the country where wrasse are not naturally found i.e. Nordland and northwards, although lumpsucker are also being used in other areas. Wrasse use can make a significant contribution to control of salmon lice numbers, particularly during the first year at sea. Development of resistance to chemical treatments makes this biological control extremely important. In 2010, approximately half of all salmon farms used wrasse.

Nearly all wrasse used are wild-caught, although some are produced commercially from wild-caught broodstock. A considerable number of wild-caught wrasse are imported from the Swedish west coast. Sale of wrasse is not covered by legislation and they are traded freely. A number of wrasse are also re-used i.e. populations of wrasse may be moved between different salmon farms and different generations of fish.

If cleaner fish can carry infectious agents capable of infecting salmonid fish, then they may constitute a risk of introduction and spread of disease, both from Sweden, along the Norwegian coast and between different populations of farmed fish. Screening for different salmon-pathogenic viral agents has so far been negative and no association has been made between disease in Norwegian farmed salmonids and use of cleaner fish. The Norwegian Veterinary Institute has, however, concluded that wrasse caught in endemic PD

Ballan wrasse swallowed by a salmon.Photo Trygve Poppe, NVH areas, may be able, with moderate to high probability, to act as mechanical vectors and that PD-virus may be present in transport water or directly on the wrasse (NVI report 4-2010). An outbreak of VHS caused by marine VHS-virus variant 3 was reported in Shetland in 2012 in four wrasse farming sites. This genotype was also responsible for the VHS outbreak in rainbow trout in Norway in 2007. This demonstrates that cleaner fish may represent a risk factor for introduction of some viruses pathogenic for salmon.

In 2013 the gill amoeba Paramoeba perurans was identified in ballan wrasse displaying gill disease. Studies are underway to establish whether P. perurans from wrasse are also pathogenic for salmon.

Infection pressure on wild fish

We have previously shown that piscine reovirus-PRV- is widespread in wild Atlantic salmon entering river systems to spawn. On a countrywide basis approximately 14% of returning salmon are PRV positive, and recent research shows that the virus is the same in both farmed and wild fish. If wild salmon live in geographically distinct populations with no infectious contact between these populations, viral sequences should represent the different geographical fish populations. Analyses indicate however that the virus variants from wild and farmed salmon from geographically distinct areas are closely related.
Lack of a geographical 'pattern' is probably caused by extensive exchange of PRV between populations of farmed fish. PRV is extremely common in Norwegian farmed salmon and the industry has almost certainly contributed to long distance transport of infectious agents between farmed populations and to wild fish. Despite extensive migratory activity, wild salmon will probably only have played a minor role in spread of infection due to low density and the low probability of carrier status.

We cannot today estimate the significance of spread of infection of PRV from farmed to wild salmon. The results of investigation of a limited number of PRV-positive broodfish did not reveal signs of HSMI. This was, however, expected as sick fish would most probably not successfully ascend a river to spawn. If wild fish are steadily infected from a farming reservoir, an increased risk of mortality cannot be discounted. It remains uncertain whether PRV from marine fish species is related to the variants identified in salmon and whether transmission of infection between more distantly related fish species is possible.

Salmon lice infection pressure

The national salmon louse surveillance performed by the Institute for Marine Research, NINA and UNI-Miljø on behalf of the Norwegian Food Safety Authority concluded that infection pressure along parts of western- and mid-Norway during the spring and early summer of 2013 was lower than the previous year. The louse challenge to migrating seatrout- and salmon-smolts was lower. In Nord-Trøndelag the infection pressure was higher than in recent years and the same tendency was observed in Finnmark. Over the summer the numbers of lice on seatrout in intensive farming areas increased to levels significantly higher than in areas without farming, and negative physiological and ecological consequences are probable. Increased levels of resistance to chemical treatments in farms poses a significant problem in relation to wild fish.

Transmission of infection to humans - Food Safety

During the autumn of 2011, larvae of the nematode Anisakis simplex were found in farmed salmon. Anisakis occurs normally in marine fish, but is also found in wild salmon. A. simplex can cause disease in humans following consumption of raw fish products. Freezing kills the larvae, but the presence of the dead larvae may cause an allergic reaction.

In 2012 in a pilot study performed in a single salmon farm, nematodes were found in 20% of 'runt' fish investigated but not in normal fish. Sea mammals are the main host for anisakis. Both wild and farmed salmonid fish can be infected following ingestion of infected crustaceans, but also by eating infected fish. Anisakis is found in wrasse species used as cleaner fish in salmon farms and wrasse are occasionally eaten by the salmon, which may thereby be infected. These findings show that from a food safety perspective there is a need to survey the occurrence of nematodes in farmed salmon.

What development can we expect?

The geographic distribution of the SAV2 variant of PD-virus gives serious grounds for concern. The reason for this negative development is based in the abandonment of the control strategy outlined in PD-legislation of 2007 and its replacement by the current SAV2 legislation. This defines Nordmøre and Sør-Trøndelag as an endemic zone and identification of PD in this area has not led to sanitary control measures other than fallowing following harvest. PD has spread over large areas of the coast in Sør-Trøndelag and there are several sites with PD (or suspicion of) close to the border with Nord-Trøndelag which constitutes the observation zone according to the legislation. There are no clear measures described in the legislation which should apply on identification of PD or PD-virus in or close to the observation zone although both stamping out and early slaughter, as in the endemic zone, are possible. SAV2 outbreaks in the northerly part of the endemic zone represent a significant risk of northerly infection spread.

While Hustadvika has shown itself to be an effective geographical barrier against spread of SAV3, it is uncertain how Nord-Trøndelag as an observation zone will work in practice. Localities which lie near the border between the endemic and observation zone (Nord-Trøndelag) should be under intensive surveillance combined with rapid enforcement of necessary counter measures if the risk of northerly spread of SAV2 northwards is to be minimised.

AGD was for the first time a serious problem for several fish farms. There remains a significant lack of knowledge of this disease and the environmental conditions necessary for appearance and spread of the disease. Salinity and temperature are considered two important parameterbedre og gjennomføre nødvendige forebyggende tiltak.

International factors - threat scenario - legislation

Of the notifiable diseases not present in Norwegian aquaculture, viral haemorrhagic septicaemia (VHS) is considered to represent the most significant threat. We had an outbreak of VHS in Møre og Romsdal in 2007, and only in 2012 could Norway again declare its freedom of infection. VHS is widespread in continental Europe and is also found in Finland. Denmark has eradicated the disease from its farmed rainbow trout and can now be considered free of VHS. With free status and limited import of living organisms, the risk of import of VHS is considered small. VHS is, however, found amongst wild marine fish along the Norwegian coast, which represent a significant risk of infection to farmed salmonids.

IHN is also widespread in continental Europe and an outbreak was registered in Croatia in 2013. The risk of introduction of disease through import of live material is similar to the situation for VHS. IHN virus is stable both at freezer and refrigerator temperatures and a globally increased trade of fish products which may carry virus will also increase the probability for introduction of virus with these products.

The status for VHS and IHN in northern-Russia, including the areas bordering Finnmark is unclear.

International changes in notifiable disease lists involving diseases which are present in Norway may affect national strategies for control and eradication of these diseases. Pancreas disease will be listed by the OIE from 2014. In Norway a surveillance program for documentation of freedom of this disease in the four most northerly regions is underway.

The OIE differentiates between low virulent ISA-HPR0 and high virulent ISA-HPR. Both genotypes remain listed and this allows the possibility to apply for free-status for HPR0. The presence of HPR0 is considered likely to increase the chance for development of ISA-HPR. Freedom of ISA-HPR0 must be documented.

Knowledge gaps and research requirements

There is a need for development of knowledge to provide a better basis for management of notifiable and other infectious diseases as well as operative systems and infrastructure to make the industry more robust against introduction of infection and spread of infection generally.

The following problems are particularly important:
- Strengthen biosecurity as a scientific discipline, both in relation to support of the public authorities and towards the industry for development of biosecurity plans on a national, regional and local level.
- What can explain the differences in spread and losses in the SAV2 and SAV3 areas?
- Characterise the risks associated with placement, management routines, current conditions and other factors of importance for introduction of infection and infection development.
- Study the differences between SAV2 and SAV3 variants of PD virus, virulence, pathogenesis and transmission dynamics.
- Study the importance of piscine reovirus in HSMI, identify factors of importance for development of disease following infection.
- Study the importance of piscine myocarditis virus for development of CMS. Can the disease be controlled through infection limiting measures?

- The presence of Anisakis in farmed salmon can represent a food safety problem. There is a need to evaluate the risks based on mapping of the prevalence of this organism.
- Which factors affect multiplication of the amoeba Paramoeba perurans and development of amoebic gill disease; climate, environment, gill status, other microorganisms and/or characteristics of the amoeba?
- Infectious salmon anaemia- can outbreaks of disease be influenced by differences in the virus or in fish stocks. Which factors are necessary for mutation of HPR0 to virulent virus?
- Salmon lice; requirement for research in population dynamics and resistance
- Further develop the spread of infection model (core density) to increase our understanding of the relationship between transport dynamics in aquaculture farms and other factors.
- Develop dynamic treatment thresholds for salmon lice counter measures.
- Requirement for basal epidemiological research on development of resistance in lice and use of chemical treatments and other measures.
- Document and further develop use of non-chemical treatments against salmon lice.

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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