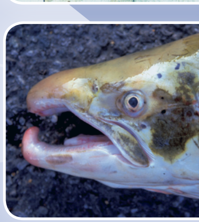
The Health Situation in Norwegian Aquaculture 2012



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Fish Health Report 2012

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Content

In 2012, 1,183,200 tons (harvested) of Atlantic salmon, an estimated 73,800 tons of rainbow trout, 8,500 tons of cod, 2,400 tons of halibut and 700 tons of other species e.g. coalfish, arctic char and turbot, were produced (Kontali Analyse AS).

Disease continues to represent one of the most important challenges to the aquaculture industry and viral diseases continue to dominate the national situation. There are however, some positive signs. The serious and notifiable viral disease infectious salmon anaemia (ISA) appears to be well under control. Infectious pancreatic necrosis (IPN) which has over many years caused considerable losses during both hatchery and post-smolt stages, now appears to be less significant. Probable reasons for this include genetically improved brood stock as well as improved hygiene during the hatchery phase.

The biggest set-back of the year came with the spread of the new pancreas disease virus variant (SAV-2) in mid-Norway. Movement of the control zone border increases the danger of northerly spread of the disease. Only strict adherence to hygienic recommendations and relevant legislation can prevent this development. Responsibility for control of this infection lies, to a large degree, with the industry.

The increase in number of cold-water vibriosis cases is a reminder of the importance of maintaining expertise related to diseases which are (in principal) under full control. The reasons for the increase have not been established, but must be followed up.

Serious problems with amoebic gill disease (AGD) in the British Isles have led to increasing fears in the Norwegian industry. Although we know that the amoeba is present in Norwegian waters, it is difficult to predict whether similar problems will develop in Norway. The industry, authorities and research institutions should, however, prepare for the possibility that Norway will be affected by the disease.

Russia has fish farming ambitions. Knowledge of fish-disease and infection/hygienic principles is, however, limited amongst Russian fish-farmers. In addition, the governmental infrastructure related to disease surveillance is under-developed, the disease situation is poorly understood, and there is little tradition for knowledge sharing within the industry. The relatively close geographical proximity between Norwegian and Russian farms as well as sharing of common utilities e.g. well-boats etc. will undoubtedly represent a disease risk for Norwegian aquaculture.

Salmon-lice infection is one of the most significant challenges for the aquaculture industry. The current situation primarily represents a threat to the wild salmon population. However, with the increasing degree of resistance and treatment failure more commonly reported, the situation could rapidly develop into a significant disease problem. We are dependent on development of effective lice treatment methodologies or culture strategies which reduce the requirement for chemical treatment.

Losses of fish between sea-transfer and harvest remain disproportionally high. Considerable variation exists between countries, regions and individual operators. The reasons are complex and include factors such as disease, transport, farm routines and smolt quality. The basis for reduction of losses during the marine phase must be established during the fresh-water phase. We are dependent on production of a robust fish and should be aware that fish have particular biological requirements and limitations. Losses in other countries operating similar industries lie under 10%. Some individual farmers have shown that it is possible to reduce this figure to nearly 5%.

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.

The northerly spread of pancreas disease (PD) is clearly the most negative health-related development in 2012. At the start of the year spread of this disease was combatted by 'stamping out' i.e. destruction of affected stocks. This strategy led to such large losses that it was departed from during the summer and the disease is now spreading alarmingly fast. The number of farms with diagnosed PD or PD-virus rose to 137 in 2012 compared with 89 in 2011. In addition to northerly spread, there is also an increase in the number of cases in Hordaland. Two epidemics of PD currently exist in Norway in separate geographical areas, each caused by different PD-viruses.

While many farms experience significant losses to PD, fish-health services report an increasing trend towards lower losses. In addition to preventative measures there has been increased focus on reduction of mortality in infected stocks. A good quality smolt, transferred to sea at the right time, thereby avoiding problems due to 'winter-ulcer' and IPN, is considered one of several important criteria required in avoiding losses due to HSMI and PD later in the marine phase. An increasing number of farming companies now screen for the presence of virus which allows identification of early stage infections and introduction of routines (e.g. careful handling etc.) to reduce subsequent losses. Harvest of fish prior to clinical outbreak is also a possibility.

No new ISA cases were diagnosed in the north of the country during 2012. It would therefore appear that coordinated fallowing and other measures which have been in place since 2007 have successfully stopped the epidemic. ISA-virus transmits easily from fish to fish, and removal of infected farmed fish has again been demonstrated as an effective measure against this disease. Two new outbreaks in Møre og Romsdal in 2012 also indicate that there remains a source of infection in the marine environment which has not been identified. Mutation of non-virulent HPR0 strains resulting in a virulent variant is one theory which several research institutions are studying. Infection from wild fish or another marine reservoir cannot be discounted. It is, however, positive that the number of cases is extremely low when infection between farmed fish is avoided.

The reduction in number of infectious pancreatic necrosis (IPN) outbreaks continues in 2012, to 119 farms compared with 154 in 2011 and 198 in 2010. Breeding for increased resistance to IPN (QTL-eggs) and eradication of 'house'-strains in hatcheries are considered two of the most important factors related to this reduction. IPN is known as a disease which results in high mortality, particularly in stressed fish. Good stress-reducing routines are important to avoid infection and to keep mortality low. A good quality smolt, transferred to sea at the right time, at the right temperature can be a significant factor in avoiding an outbreak following sea-transfer. Fish surviving an IPN outbreak may be weakened and may therefore be more susceptible to e.g. HSMI and PD. A reduction in the number of IPN cases may explain part of the lower sea-phase losses experienced in a number of farms.

While heart and skeletal muscle inflammation (HSMI) now affects the whole country, the number of outbreaks has stagnated. The disease was diagnosed on 142 sites in 2012, compared with 162 in 2011. Considerable losses continue to be reported although many farms manage to live with the disease without experiencing significant loss. Low levels of stress and optimal feeds are considered important factors during the critical phase when the heart is weakened. Lice-treatments, storms, grading etc. during the disease outbreak can precipitate large losses.

The number of cases of cardiomyopathy syndrome (CMS) increased for the second year in a row. Mid-Norway reports particularly significant losses. The number of registered outbreaks in 2012 reached 89, with northern-Norway contributing the largest increase in number of cases. Identification of the responsible virus will hopefully result in improved control of this disease.

Use of effective vaccines has resulted in a situation in which bacterial problems have been rare in Norwegian salmon farming in recent years. In 2012 however, a total of 21 cold-water vibriosis cases were diagnosed in the north. Several different vaccines were involved and so far the cause of these outbreaks has not been identified. Possible causes, including change in the responsible bacterium are now being investigated.

'Ulcers' associated with *Moritella viscosa* and/or *Tenacibaculum* remain a problem of apparently complex aetiology. Sea-transfer of smolts at very low temperature is known to predispose to such problems. Mechanical injuries caused by e.g. bad weather or rough handling are also recognised risk factors. The presence of fish with ulcers may increase infection pressure towards the remainder of the fish in the farm. In addition to avoidance of situations which are likely to result in injuries predisposing to ulcers, high infection pressure should be avoided by removal of infected fish.

Gill problems are a recurring phenomenon, particularly in the autumn, and losses are considerable. There is a real need for identification of the cause/s. Many possible agents have been identified, but their contribution, alone or together with other factors remains unclear. Amoebae, which have caused serious problems in other countries, have again been detected in Norway and there is a need for future vigilance in this respect.

The current and drastic down-scaling of farming of cod is apparent in the number of cases registered. Francisellosis remains the main problem in addition to other bacterial diseases such as atypical furunculosis and vibriosis. Only a few halibut farms remain in business and bacterial problems dominate, in addition to a serious nodavirus problem on one particular farm. In contrast, a large rise in the number of cases involving cleaner fish was experienced, and it is clear that there are more than enough new diseases to investigate in these fish.

The number of salmon lice on farmed fish is kept so low that infestation of farmed fish is in itself not a problem. However, the extensive anti-lice programs are considered one of the most significant challenges in fish farming today. Stress associated with lice treatment weakens the fish and can make them susceptible to many different diseases. Good routines for gentle de-lousing are decisive in reduction of losses in Norwegian fish farming.

General

In total 2200 cases from farmed fish were submitted to the Norwegian Veterinary Institute for investigation in 2012 in addition to cases related to surveillance, contract work and research. The majority of cases involve salmon (1909), although cases were also registered from cleaner fish, cod, halibut, turbot, wolfish etc. Through a combination of disease history, examination of pathological changes and agent identification, we try to identify not only the aetiological agent but also the reason behind the disease. In our work we differentiate between what the fish dies of- and what it dies with.

Recirculation - fresh water

Recirculation technology has become increasingly common in production of juvenile fish in Norway in recent years, and a number of new facilities are under planning. In the Faroe Isles this technology has been used for a considerable time, and more or less all smolts are produced in this way. Recir-

Table 1. Total number of sites 1998-2012 diagnosed with infectious salmon anaemia (ISA), pancreas disease (PD), heart and skeletal muscle inflammation (HSMI) and infectious pancreatic necrosis (IPN). For those diseases for which it is relevant, both "suspected" and confirmed diagnoses are included.

	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
ISA	14	23	21	12	8	16	11	4	7	17	10	7	1	2
PD	10	11	15	14	22	43	45	58	98	108	75	88	89	137
HSMB						54	83	94	162	144	139	131	162	142
IPN				174	178	172	208	207	165	158	223	198	154	119
CMS						88	71	80	68	66	62	49	74	89

culation 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 difficult to perform 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. While no particular health challenges have been associated with recirculation technology during 2012, 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 has opened up for production of smolts of up to 1 kg in weight. The decision was based on the desire to reduce the period spent 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 1kg. No special health problems have been reported in relation to these farms in 2012. There are however, only very few and small-scale facilities currently in operation.

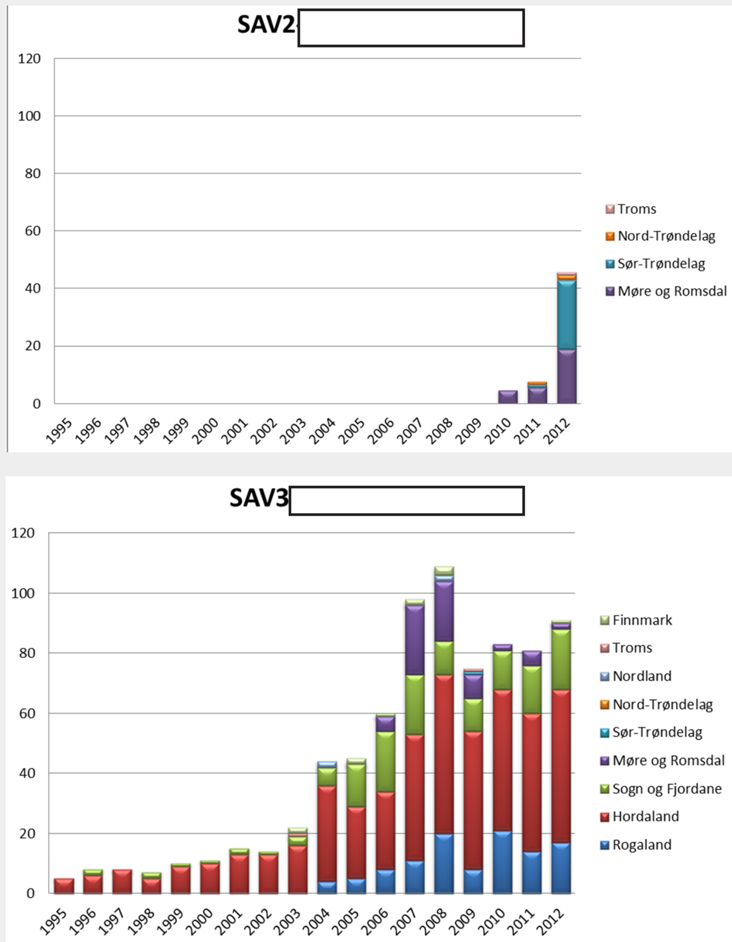
Recirculation farms allow a high degree of control over different factors including salinity and temperature. The fish are shielded from infectious agents that may be present in open cages. Experiences with this type of farm are, however, limited. Potential problems will probably be related to bacteria 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. This allows entry of agents with sea-water. The farms will have the ability to take in water from various depths. Deep intake water will contain less disease agents such as salmon-lice and salmonid alpha-virus (SAV). Intake of water from variable depths will also allow precise temperature 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.

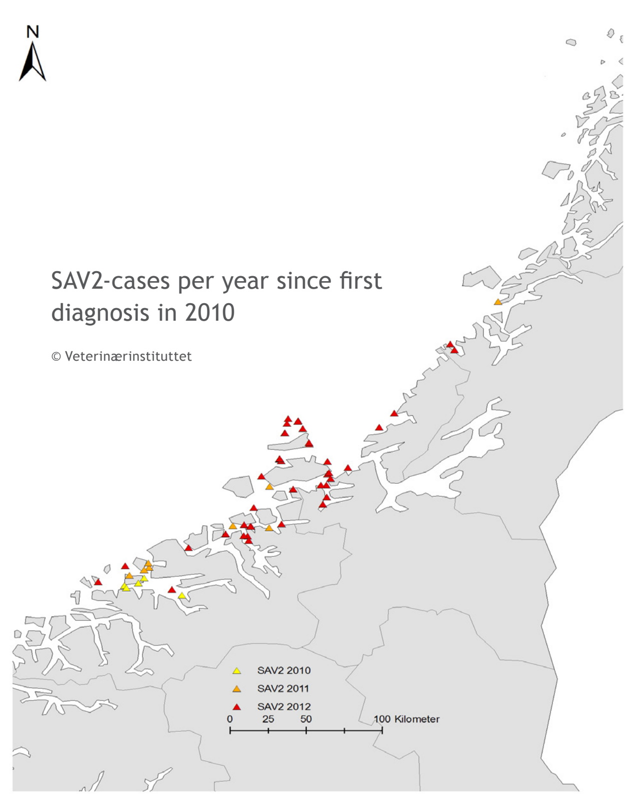
Viral Diseases

Pancreas disease - PD

Pancreas disease (PD) is an extremely infectious viral disease of salmonid fish farmed in the sea caused by salmonid alphavirus (SAV). PD has been endemic in western Norway since 2003 following spread from the core area of Hordaland. It became clear in 2012 that two nearly geographically distinct epidemics of PD are currently occurring. In total, 137 new



Regional distribution of new cases of pancreas disease (PD) with SAV2 and SAV3 1995-2012



Ninety cases were diagnosed or suspected, which compares with 85 in 2011 and 88 in 2010. In 2012, 10 of the new cases were diagnosed in rainbow trout, a reduction from the high of 18 the previous year. The number of new cases in salmon within the zone was therefore somewhat higher in 2012 than in 2011, with an increase of approximately 19% (80 compared to 67). Intensive screening may have revealed several mild cases of clinical disease that otherwise may have gone unnoticed.

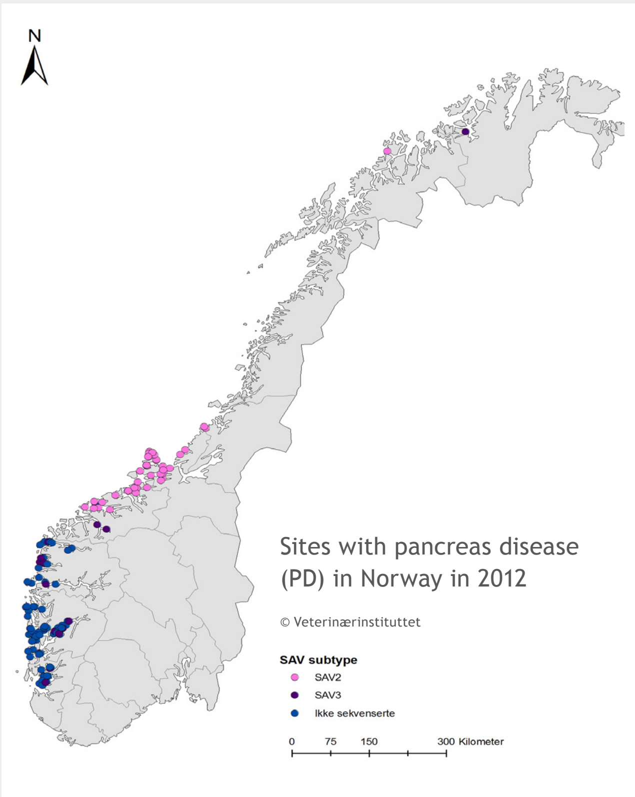
Pancreas disease is defined here as sick fish with histopathological findings typical for PD and detection of PD-virus in the same individual fish (diagnosis PD), or sick fish with histopathological findings consistent with PD for which no suitable material for confirmation of the presence of PD-virus is available (suspicion of PD). In table 1 figures for “diagnosed” and “suspected” are combined. The number of virus detections (samples positive by PCR) without overt disease are not included in the SAV3 statistics. As a result of the differing legislation for the two virus types these statistics are included for SAV2.

cases of PD were registered in 2012. There was a significant increase in the number of cases caused by the newly identified subtype SAV2 while the SAV3-epidemic appears stable within the same area as previously. Most SAV2 cases were registered north of Hustadvika while the majority of SAV3 cases, with the exception of an outbreak in the Alta area, were limited to the PD zone south of Hustadvika.

The control zone, established in 2007 (regulation 2007-11-20 nr. 1315) to hinder spread of PD (SAV3) north of Hustadvika appears to have worked comparatively well. Other than a local epidemic in Finnmark, since 2008 there have only been sporadic SAV3 diagnoses outside the zone.

Due to the rapid spread of SAV2-infection north of Hustadvika, legislation specific for SAV2 (regulation 2012-11-06 nr. 1056) came into effect in November 2012. This regulates the area between Hustadvika in Møre og Romsdal and Nordland which is split into an eradication zone (to the Nord-Trøndelag border) and an observation zone (Nord Trøndelag to the border with Nordland). The aim is to hinder northerly spread and to eliminate the infection within the eradication zone.

SAV 3. The number of localities/sea-transferred populations within the PD-zone diagnosed with PD in 2012 was similar to the two previous years.



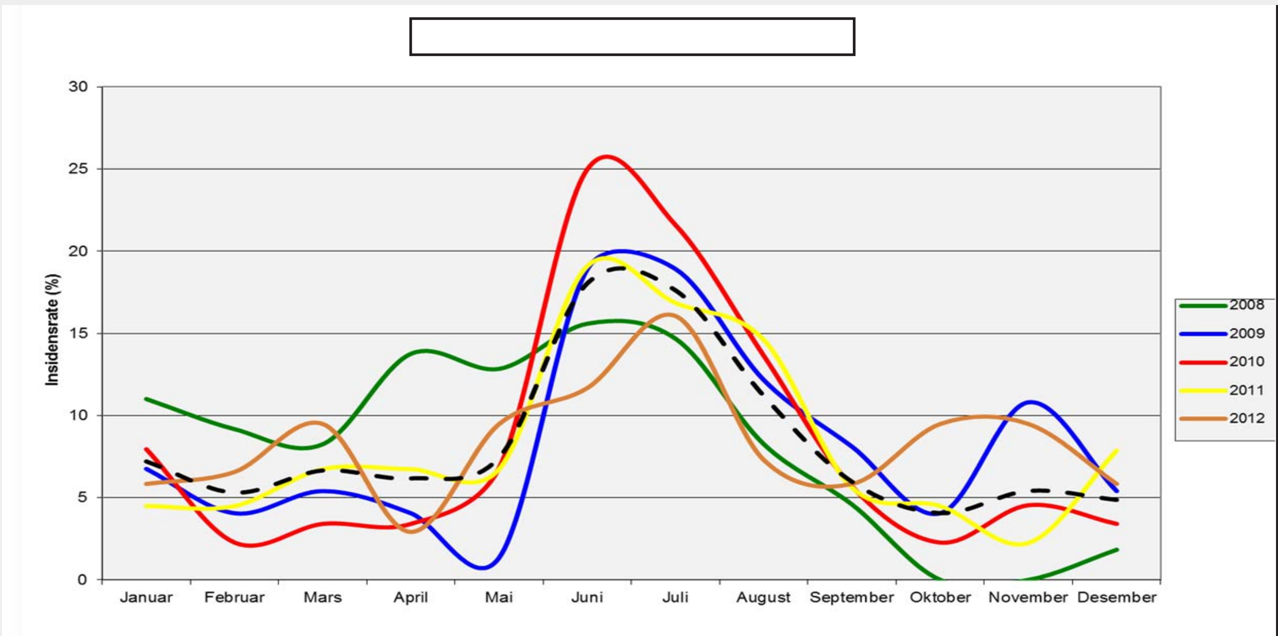
On introduction of PD to an area, a local epidemic commonly occurs due to the high risk of spread via water. One such occurrence was observed in the Hardanger fjord in 2012. Altogether 20 sites were eventually affected, with sixteen of these diagnosed in 2012. This local epidemic represented approximately 31% (16/51) of all cases of pancreas disease registered in Hordaland in 2012.

In Rogaland, the number of registered cases of PD was a little higher than in the previous year (17 compared to 14). The disease has been diagnosed more or less over the whole region. In Sogn og Fjordane the total for 2012 was also slightly higher than the previous year (20 compared to 16) and considerably higher than 2010 (13). It would appear that several local epidemics continue in this area. In Møre og Romsdal south of Hustadvika only two new SAV3 cases were diagnosed, limited to the Stor fjord, some distance from the zone border at Hustadvika. In 2011 there were seven new cases spread around the region.

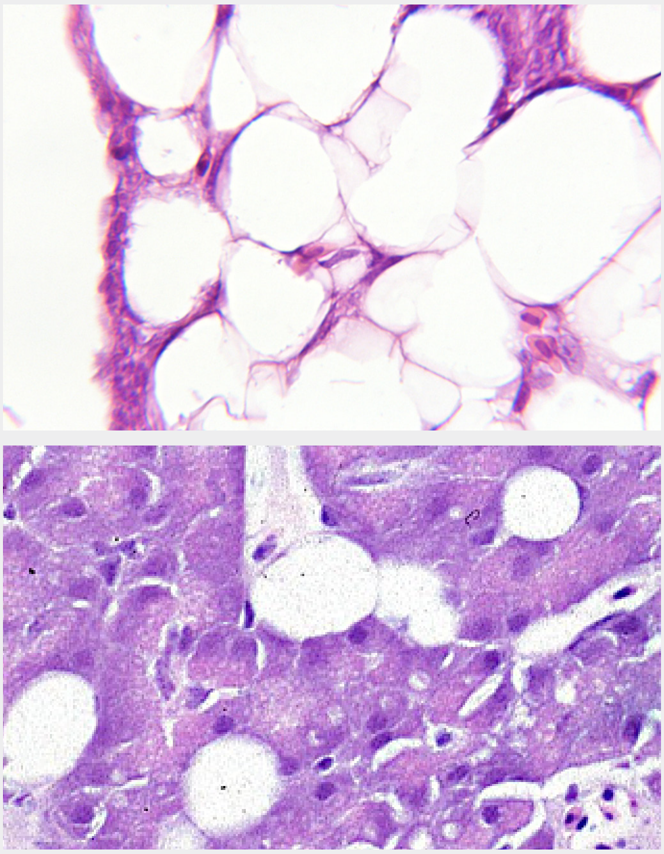
SAV2. There was a considerable increase in SAV2-diagnoses in 2012. From four cases immediately north of Hustadvika in 2011, the number of cases increased in 2012 to 46 new diagnoses, with seven identified immediately south of the zone border at Hustadvika. The remaining 39 cases are related to spread in Nordmøre and Sør-Trøndelag. Only a single case in harvest ready fish was identified in Nord-Trøndelag, There was also a single case in Troms. Of the 46 detections, clinical disease was identified in 34. In the remaining 12 cases PD-virus was identified during screening. According to current legislation, identification of clinical disease is not required to declare a suspicion of PD involving SAV2, virus identification is enough. In addition to infection via water it is probable that transport of fish between different sea farms has contributed to the rapid spread of SAV2 to new areas.

Pathological changes and diagnostic criteria for PD caused by SAV2 are the same as for PD caused by SAV3. The variant of salmonid alphavirus subtype 2 identified in Norway has a high degree of genetic similarity with a marine SAV2-variant found in Scotland. Investigations are underway to establish whether or not there is an epidemiological link between marine SAV2 in Scotland and Norway.

Pancreas disease is diagnosed throughout the whole year, but as in previous years most cases in 2012 were diagnosed during the summer months. Both aquaculture companies and fish health services



Monthly distribution of pancreas disease (PD) 2008–2012



The part of the pancreas which produces digestive enzymes (exocrine pancreas) is totally destroyed during pancreas disease (PD) (a). Normal tissues (b).
Photo: Anne Berit Olsen, NVI

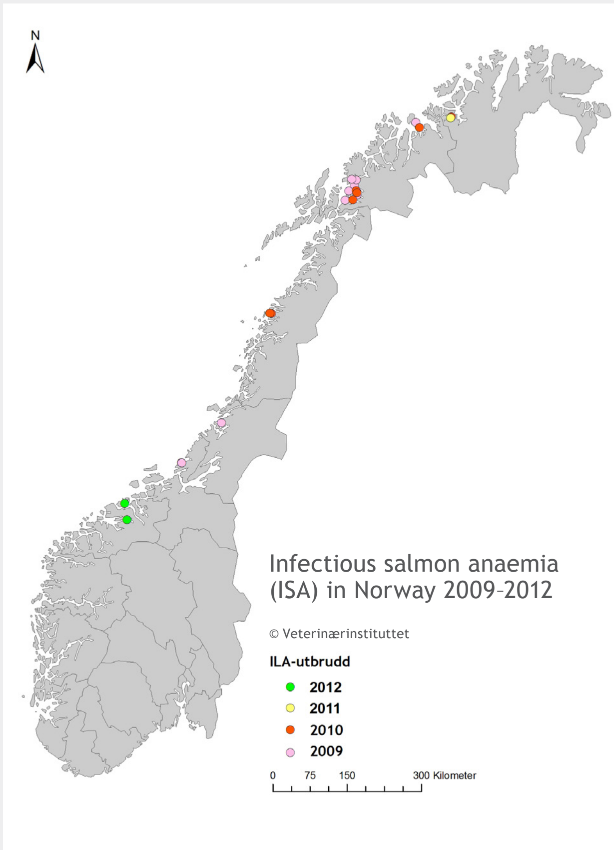
report milder PD outbreaks in recent years, although some individual farms experience large losses. During the local epidemic in Hardanger fjord, mortality levels varied from < 1% to > 20%. The underlying reasons for these differences in mortality are not known, but are under investigation. All populations of salmon south of Hustadvika are vaccinated, which has probably contributed to the lower mortality. Intensive surveillance and the increased probability of diagnosis at an early stage allowing initiation of loss reducing measures, has also probably contributed to lower overall mortalities. Loss of growth and reduced quality at harvest is reported in association with PD caused by both virus types.

PD is a notifiable disease (national list 3) and a daily updated map showing outbreaks is provided in cooperation with the Norwegian Food Safety Authority. PD diagnoses are also reported monthly on www.vetinst.no. Surveillance is performed according to current legislation, by the industry itself and through routine health control 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.

Infectious salmon anaemia - ISA

In the course of 2012 only two cases of ISA were diagnosed in Møre og Romsdal, one of the lowest prevalences in many years. One diagnosis was made in a brood stock population and the other in normal production fish. The outbreaks occurred early in 2012, and so far no further outbreaks have been identified in the area.

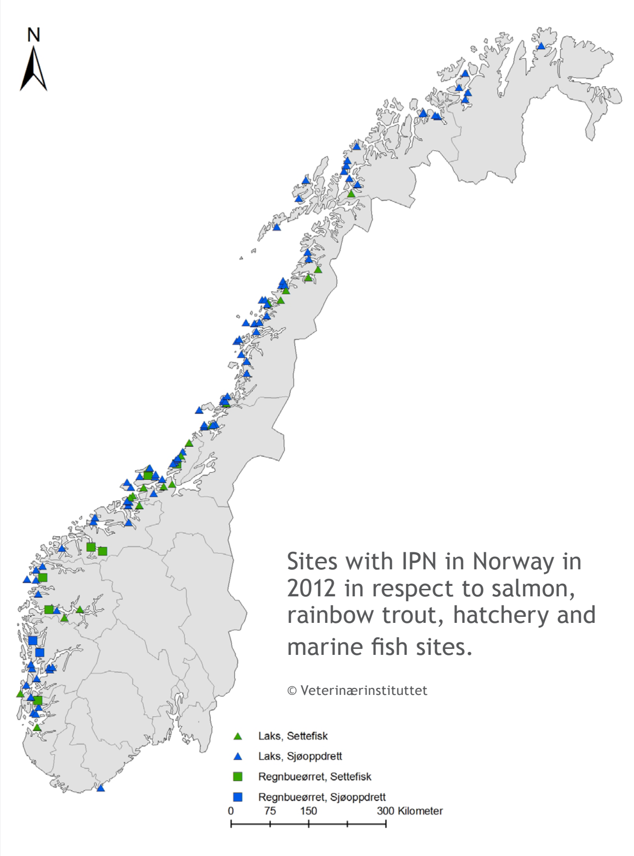


The epidemic in south and mid-Troms which started in 2007 appears to be over and the process of structural change and site placement in the area is well under way. The Norwegian Food Safety Authority will survey the ISA situation in the area for several future years.

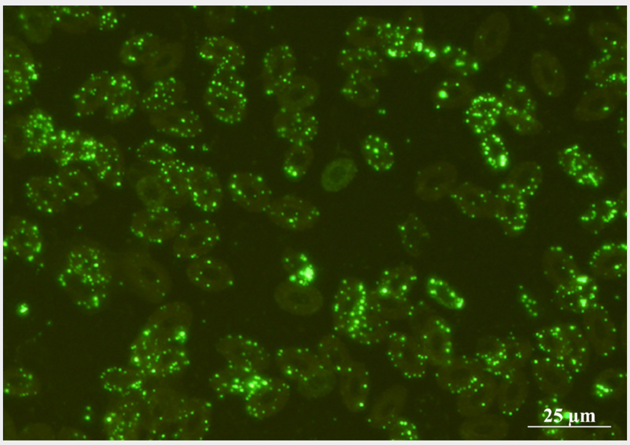
It is now easier than previously to obtain permission to vaccinate for ISA-virus. The exception being those areas or so-called segments with ISA-free status, relevant for e.g. export of brood stock, eggs etc. However, with today's favourable ISA situation, the need for vaccination against ISA is somewhat questionable.

ISA can result in high mortality and is a notifiable list 2 disease. To avoid false positives, diagnosis is based on several criteria following international guidelines issued by the OIE (World Animal Health Organisation) and the EU. Diagnosis is based on identification of typical pathological changes combined with detection of ISA-virus by at least two methods based on different detection principles. Direct detection of ISA-virus in tissues using PCR and immunohistochemistry (identifying virus-specific nucleic acids and viral antigen respectively) is the usual test combination. PCR detection alone is not enough to activate counter measures, but leads to further sampling. Suspicion of the disease ISA based on clinical history, post mortem findings or epidemiological observations may however, be sufficient to initiate preliminary restrictions until the final diagnosis is available.

Measures against ISA are initiated according to an eradication plan adapted to EU regulations and recommendations by the OIE. The main aim of removal of all fish from infected sites as rapidly as possible continues to apply. In this way, infection pressure is reduced as is the probability for further spread.



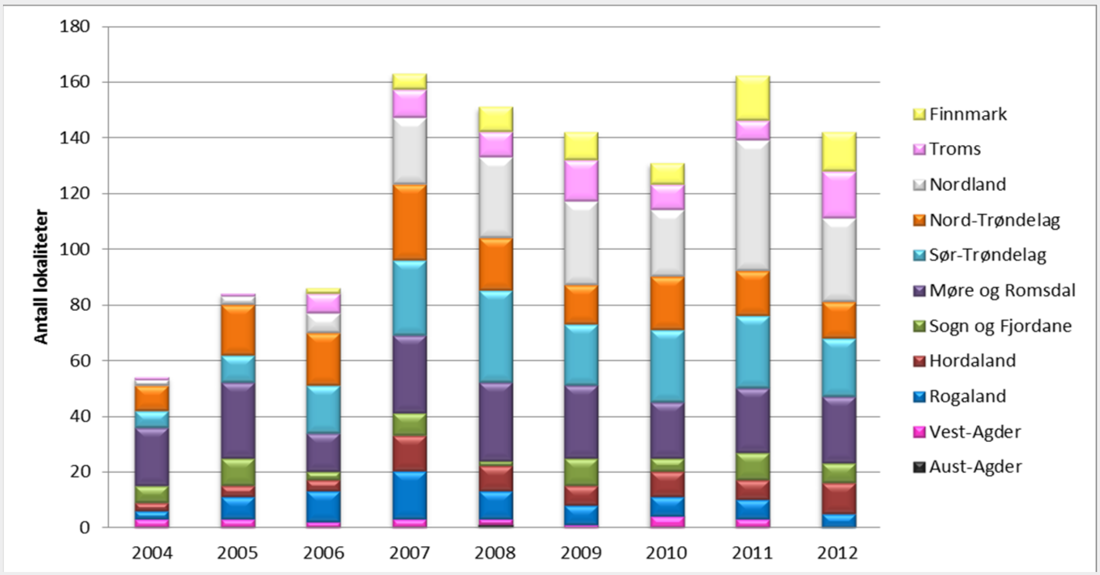
Sites with IPN in Norway in 2012 in respect to salmon, rainbow trout, hatchery and marine fish sites.



Photograph of virus attached to the surface of red blood cells Photo: Maria Aamelfot, NVI

In ISA the virus infects the cells lining the inside of blood vessels (endothelial cells). Virus particles, released from the infected cells in large numbers, are spread in the blood and also adhere to blood cells. This results in anaemia, which can be extreme, and a varying degree of haemorrhage in the final stages of disease. A surface protein, hemagglutanin esterase (HE), is an important virulence factor in ISA-virus. This protein recognizes and allows attachment to certain cell types using a lock and key mechanism. This 'key' is found in two different types in ISA virus: one short type and one long type. The short type has been found in all investigated ISA outbreaks so far, while the longer variant is commonly found in gills of healthy wild salmon and farmed fish in all important salmon producing countries. It appears that the short variant causes a generalized infection, as described above, while the long variant causes a short-lived inconsequential infection of the gills. In technical terms the short variant is known as 'hyperpolymorphic region' (HPR) while the long non-deleted variant is known as HPR0.

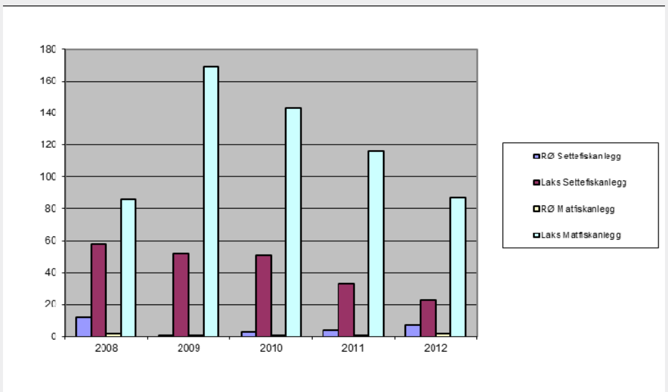
It is believed that the short HPR-variants have evolved from the long variants, but that several other changes have also occurred, which together have resulted in the virulent phenotype. Following fallowing due to ISA and re-establishment of salmon farming in the Faroe Isles in 2005, intensive surveil-



Regional distribution of localities with heart and skeletal muscle inflammation (HSMI) 2004-2012

lance over the last seven years has shown that infection with the HPR0 variant is normal and occurs as seasonal infections of short duration. Despite the ubiquitous presence of the HPR0 variant, the Faroe Isles have not experienced outbreaks of ISA over the last seven years. While the HPR0 variant is believed to be the forerunner of the pathogenic ISA variant, the risk of development of the pathogenic type from HPR0 appears extremely low. HPR0 is also commonly identified in Norway amongst farmed salmon. It is not clear whether these isolates give rise to the pathogenic variants which cause the few sporadic outbreaks for which the infection source is unknown. It is unknown whether these outbreaks are caused by an unknown infection reservoir or whether they are caused by change within HPR0 variants. Research on the functional and evolutionary differences between the non-virulent and virulent variants is important to allow evaluation of the risk of development of the virulent variant. This will allow introduction of suitable management measures to combat the disease. Management of HPRO and whether its detection should be notifiable, are now under consideration by the OIE.

The international ISA situation has not changed significantly from last year, when all salmon producing nations had to a large degree control over the disease. Generally, experience indicates that rapid destruction/harvest following outbreak of disease limits infection pressure and spread of disease. Research suggests that horizontal spread is significant. It cannot, however, be concluded that transport of eggs etc. is completely without risk.



Distribution of IPN outbreaks in salmon, rainbow trout, hatchery and marine sites 2008-2012

Infectious pancreatic necrosis - IPN

In 2012, IPN was diagnosed on 119 sites, of which nine involved rainbow trout and the remainder salmon. The IPN outbreaks were distributed between 30 hatcheries and 89 marine sites. In 2011 and 2010 IPN was diagnosed in 154 and 198 sites respectively (Table 1). Statistics for later years indicate a reduction in the number of outbreaks in salmon. For rainbow trout the number of outbreaks has remained extremely low for several years. IPN was removed from the list of notifiable diseases in 2008. There are, however, no reasons to believe that fish health services have changed routines in regard to submission of samples for confirmation of diagnosis. Fish health services report that IPN still causes significant losses, and some farms have lost a lot of fish particularly during the marine phase. Losses are related directly to IPN outbreaks and also to subsequent loss of fish weakened by IPN. Outbreaks also lead to increased handling of fish (grading) which stresses the fish and can lead to increased mortality. Otherwise, losses due to IPN in 2012 were apparently lower than those experienced in earlier years. There are several indications that IPN may be a less significant clinical problem in stocks based on so-called QTL-eggs. Several fish health services report that use of QTL-eggs combined with increased efforts to eradicate 'house strains' of IPN virus, have contributed to a reduction in the number of IPN outbreaks in salmon hatcheries, from 51 registrations in 2010 to 30 in 2012.

IPN virus belongs to the family aquabirnavirus which has a large host-range and has been identified in many types of fish around the world. 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 also give 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.

Heart and skeletal muscle inflammation - HSMB

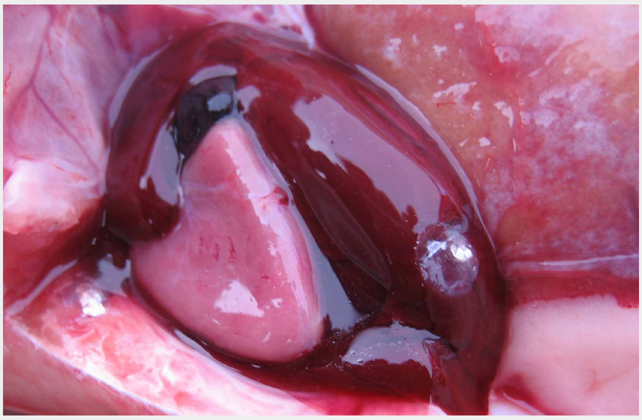
Heart and skeletal muscle inflammation (HSMI) is an infectious disease of farmed salmon which has in later years become extremely widespread. In 2012 the disease was diagnosed on 142 sites, a reduction from 2011 when 162 affected sites were registered. The disease mainly affects salmon farmed at sea, and while in 2012 two cases were registered in hatcheries, both were probably related to intake of seawater.

The disease has in previous years resulted in very variable mortality. Grading, transport or other management routines which stress the fish can readily precipitate mortality. This makes lice-treatment challenging.

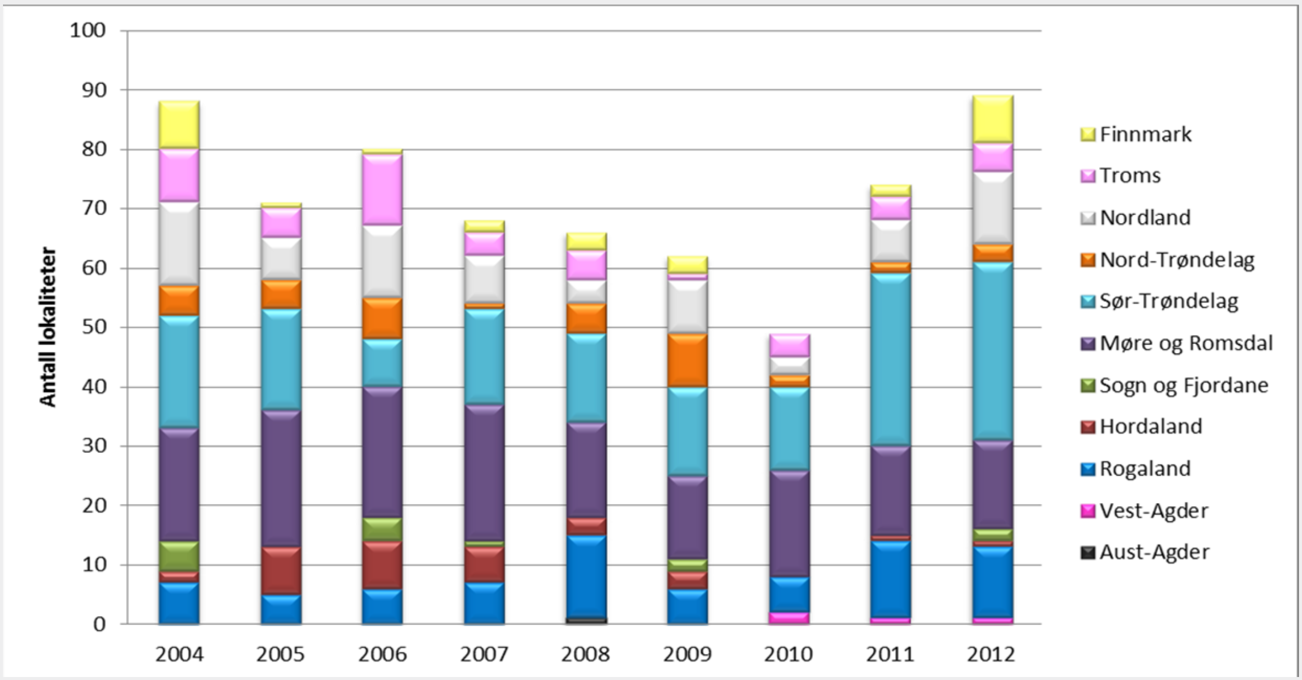
HSMI was long suspected to be a viral disease. This was verified in 2004 when an infection trial using tissues from HSMI affected fish as infective material resulted in transmission of disease. In 2010 HSMI was linked to a reovirus, with the proposed name Piscine reovirus (PRV). Virological investigations performed using RT- PCR in 2012 confirmed previous findings i.e. that PRV is widely distributed in salmon in seawater. There is a clear correlation between clinical HSMI and heavy PRV load. Salmon may, however, carry a large burden of PRV in the absence of clinical disease. HSMI is diagnosed by histopathological investigation and is based on identification of characteristic tissue changes.

Cardiomyopathy syndrome - CMS

Cardiomyopathy syndrome (CMS) is a serious cardiac disease which affects salmon farmed in the sea. As it is commonly large, harvest ready fish which are affected, the economic losses can be considerable. The Norwegian Veterinary Institute diagnosed CMS in 89 sites in 2012. This is the second year in a row in which an increase in the number of CMS cases has been reported, with nearly twice the number of cases reported in 2012 compared with 2010. The increase is particularly apparent in the north, while the greatest losses are reported from mid-Norway. The underlying reasons for these trends trend are unclear.



During CMS the heart may rupture and blood fill the space around the heart as shown.
Photo: Marta Alarcon, NVI



Regional distribution of sites with diagnosed cardiomyopathy syndrome-CMS 2004-2012.

A newly discovered virus was described in 2010, piscine myocarditis virus (PMCV), which appears to cause CMS. This virus belongs to the totivirus group. Normally totivirus infect single-cell organisms, primarily fungus, although a totivirus, infectious myonecrosis virus (IMNV), has been identified in association with muscle changes in a pacific shrimp *(Litopenaeus 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 to external influences such as temperature, low pH, disinfection and drying than capsid-enclosed viruses. 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 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 not been possible to identify any relationship between closely related virus isolates and egg origin (brood stock), smolt producer, feed supplier or Aquaculture Company.

There are reports of the presence of PMC-virus in apparently healthy wild salmon, but this appears to be a relatively rare occurrence. 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 have significant inflammatory lesions in the inner (spongious) part of both the atrium and ventricle, while the compact muscle layers of the ventricle are, as a rule normal.

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 research lies ahead in identifying 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.

Viral hemoragisk septikemi - VHS

There were no outbreaks of VHS in Norway during 2012. The Norwegian Veterinary Institute has, on behalf of the Norwegian Food Safety Authority, carried out a surveillance program for VHS in 2012 and the virus was not detected. The surveillance program is risk-based which means that the samples analysed by the Norwegian Veterinary Institute were examined due to suspicion of the disease. By testing sick fish rather than 'healthy' fish, the probability of virus detection is greater. For more information about the disease and virus see the VI fact-sheet.

Norway has VHS-free status. The last detection in farmed fish in Norway was in 2007-2008, when it was diagnosed in rainbow trout in several farms in the Stor fjord in Møre og Romsdal. The VHS virus from the Stor fjord belongs to genotype III, which had previously only been detected in marine fish species. The outbreak in the Stor fjord was the first and so far the only diagnosis of VHS caused by this genotype in rainbow trout. Detection of VHS-virus in farmed fish results in destruction of all fish on the site, independent of virus genotype.

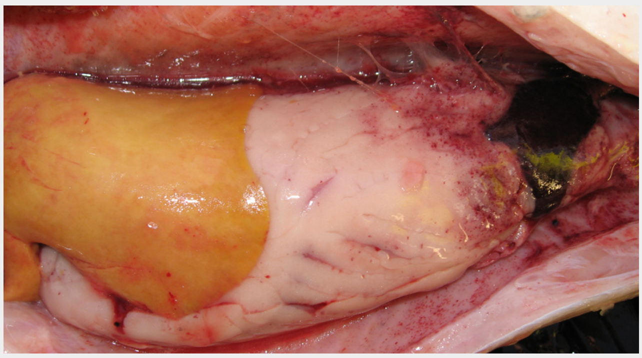
The source of the infection in the Stor fjord remains unknown, and the Norwegian Veterinary Institute has, in cooperation with the Institute for Marine Research, tested several thousand wild fish. VHS genotype III has not been identified in wild fish, but genotype Ib has been found in high prevalence in spring-spawning herring. While genotype Ib is considered to be of low-infectivity for salmonid fish, genotyping does not necessarily result in a correct picture of virulence in different fish species. Recently VHS was identified in farmed ballan wrasse in Scotland, which gives grounds for concern. The extensive transport of wrasse may therefore represent a risk for spread of VHS-virus.

Bacterial diseases

Prior to the introduction of effective vaccines post-1990, furunculosis and cold-water vibriosis caused enormous problems in Norwegian aquaculture. Today these diseases are responsible for only a tiny fraction of the total mortality in farmed salmon and rainbow trout. All salmonid fish transferred to sea in Norway are vaccinated against vibriosis *(Vibrio anguillarum)*, furunculosis (*Aeromonas salmonicida* subsp. *salmonicida*) and cold-water vibriosis (*Vibrio/Aliivibrio salmonicida*). Many are also vaccinated against winter ulcer *(Moritella viscosa)*. Rainbow trout are vaccinated against vibriosis and to a varying degree against other diseases. The comprehensive vaccination against these diseases results in a situation in which antibiotic use in Norwegian salmonid aquaculture is very low.

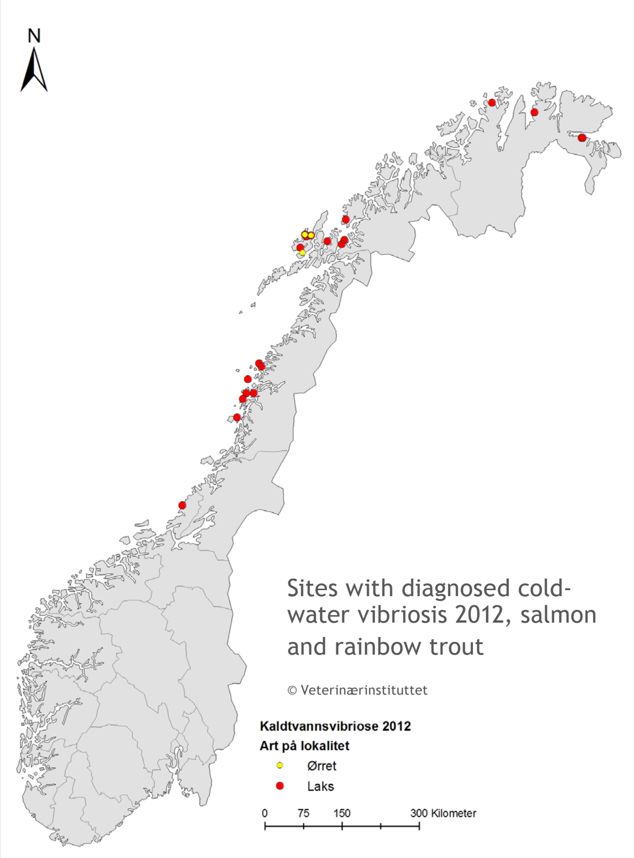
Cold-water vibriosis

Vibrio salmonicida was identified in 21 sites in 2012, and is the cause of the disease cold-water vibriosis. This was by far the most important disease in Norwegian salmon farming during the 1980's, but was effectively brought under control by vaccination. Over the last 15 years the disease has only been diagnosed sporadically. These sporadic cases have usually involved unvaccinated cod or rainbow trout as well as harvest-



Fish with cold-water vibriosis displaying yellow liver and haemorrhage in several organs.
Photo: Øystein B. Markussen, Marinhelse AS

ready salmon with presumably weakened protection long after vaccination (five cases in 2011). The 2012 outbreaks were spread between Nord-Trøndelag and Finnmark. On two sites the disease was diagnosed in both rainbow trout and salmon, in one site rainbow trout alone were affected with the remaining cases involving salmon. Mortality levels have generally been low, with antibiotics used in approximately 1/3 of outbreaks. The cause of the rise in number of cases is probably related to increased infection pressure, but the underlying mechanisms are unclear, as the natural reservoir for the bacterium remains unknown. Genetic and biochemical investigations have not identified any change in virulence or antigenicity in the bacterium itself. The outbreaks in 2012 have mainly affected fish in their first winter at sea and this may indicate that factors involving vaccination and susceptibility of the fish to infection may be important.



Sites with diagnosed cold-water vibriosis 2012, salmon and rainbow trout

Winter ulcer

Ulcers may endure for a considerable time and thereby constitute a serious disease- and welfare- problem in farmed fish. Ulcers lead to losses both through direct mortality and following down-classification at harvest. Ulcer development is a typically autumn- and winter problem and may endure well into the spring. Ulcer development may often be related to management routines which lead to scale loss and minor injury e.g. grading or de-licing. Ulcer development is often associated with transfer to sea at low temperatures and during transport through areas of cold water. Once ulcers have begun to develop, a large proportion of the fish may eventually be affected. In addition to ulceration on dorsal areas, flank and belly, ulcer development on the snout and jaws is common.

The term 'winter ulcer' is mainly related to infection with the bacterium *Moritella viscosa*, which under controlled infection trials can cause both ulcers and mortality. Vaccines have been developed against this bacterium and nearly all Norwegian farmed salmon are vaccinated. The vaccines are reported to give variable protection. It is most commonly salmon which are affected, but as in previous years some cases in rainbow trout were also reported in 2012. Tenacibaculum spp. are commonly identified from ulcerative infections in salmon and rainbow trout and can occur concurrently with *M. viscosa* or as the (apparently) sole infectious agent.

For both types of bacteria, representative culture on laboratory media can be challenging. For *M. viscosa* additional salt is required in the media while *Tenaciba-*

Salmon with 'snout' ulceration.
Photo: Renate Johansen, NVI

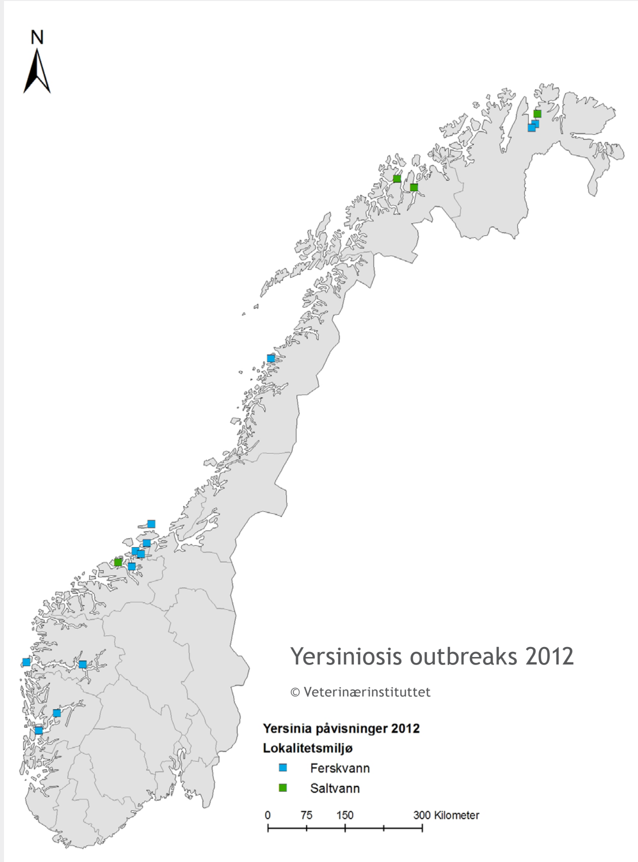
culum require a medium with many of the characteristics of sea water. Other methods e.g. histopathological investigation together with methods which can visualise the bacterial cells (immunohistochemistry) can give a truer picture of the cause. A PCR has been developed for M. viscosa, but this is not routinely used in diagnostic work.

In 2012, as in previous years, winter ulcer problems appear to be particularly problematic from mid-Norway and northwards. For some individual farming companies, winter ulcer comprises their most serious health problem. Ulcers are mainly associated with the marine phase of culture, but *M. viscosa* and *Tenacibaculum* spp. were again in 2012, identified in smolts held in land-based tanks supplied with supplementary sea-water.

Infeksjon med ***Flavobacterium psychrophilum***

In 2012 the Norwegian Veterinary Institute received material from 12 sites in which disease was related to identification of the bacterium *Flavobacterium psychrophilum*.

The diagnoses in large rainbow trout held in brackish water (three sites) were made in the same fjord system from which infections were registered between 2008 – 2011. Clinical history and symptoms were consistent with that previously described. In addition outbreaks were diagnosed in smaller rainbow trout in two inland farms. All isolates from rainbow trout exhibit reduced sensitivity to quinolone antibiotics. This is discussed further in the section on antibiotic resistance. *F. psychrophilum* was also identified from fin and skin wounds (either as pure culture or as part of a mixed culture) in five commercial salmon hatcheries in 2012. On one site open wounds developed on the fish prior to handling and the infection spread with varying degrees of severity to several tanks of fish. Around 50% of the fish died in the course of the infection, which was treated with antibiotics. The bacterium was identified in association with wound development in a brood stock site. In addition. *F. psychrophilum* was suspected to be involved in disease episodes in two salmon hatcheries and two rainbow trout sites from which the bacterium was not successfully cultured. Immunohistochemistry using antisera specific for *F. psychrophilum* gave positive results in tissues examined from these outbreaks.



For clinical descriptions and typical symptoms of infection with *F. psychrophilum*, see the 'Health Situation for Norwegian Aquaculture 2008 – 2011

Yersiniose

Yersiniosis is caused by the bacterium *Yersinia ruckeri*, and can result in mortality in salmon and rainbow trout throughout the whole juvenile phase. Infected fish transferred to sea can also die after transfer.

In 2012, yersiniosis was identified in 16 salmon farming sites spread around the country, twelve on land and four at sea. This is an increase in the number of cases compared with the downward trend experienced over the four last years. There were eight cases identified in 2011, 12 in 2010, 15 in 2009 and 16 in 2008. Some farms have experienced persistent problems with yersiniosis. Isolates from one farm continue to show reduced sensitivity to quinolones and are further discussed in the section on antibiotic resistance. Most of the isolates identified in 2012 belonged to serotype O1, although serotype O2 was also identified.

Bakteriell nyresyke – BKD

Bacterial kidney disease (BKD) is notifiable and is listed in the national disease list (list 3). The disease has occurred only sporadically in Norway over the last 15 years with between 0 and 3 cases annually. In 2012 BKD was diagnosed on two sites. In one case the disease was diagnosed in February in harvest-ready salmon in Sogn og Fjordane. BKD was identified in moribund fish from all cages on the farm, although mortality levels were low. On post mortem examination, visible granulomas were identified to a varying degree in internal organs, particularly in the liver. Rich growth of the bacterium *Renibacterium salmoninarum* was identified. The source of infection remains unknown.

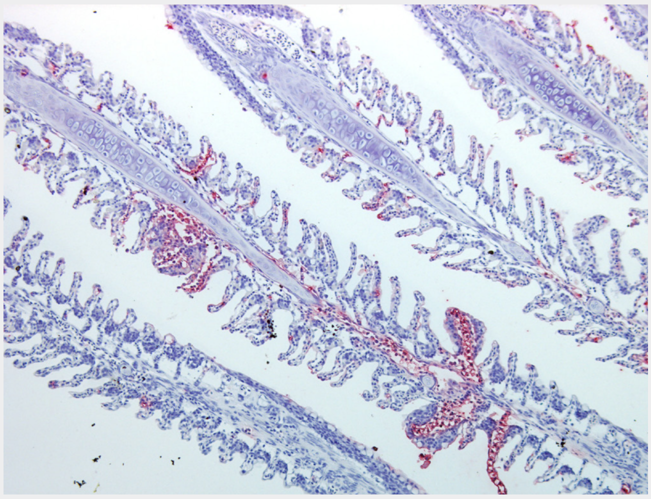
The second case, also in harvest-ready salmon, was in Finnmark. The disease was first limited to certain cages but spread later within the site. It is considered likely that the fish were already infected when imported as smolts from Iceland and that the infection gradually spread throughout the population.

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

Amongst samples sent to the Norwegian Veterinary Institute, Vibrio anguillarum serotype O1 was diagnosed in four rainbow trout farms and three salmon farms in 2012.

In 2012 infection with *Pseudomonas fluorescens* was identified in 12 farming sites. These were in the main hatcheries, but the bacterium was also identified in sea-transferred salmon. In seawater the bacterium may be related to gill inflammation. *P. fluorescens* infections have previously been related to poor water quality and have often been identified shortly after vaccination. *P. fluorescens* may be associated with clinical disease and considerable losses but the bacterium also constitutes a member of the normal water flora.



Salmon gills with inflammation caused by *Pseudomonas fluorescens*. The red staining is a result of immunohistochemical marking of the bacteria. The bacteria are transported to the gills via the bloodstream resulting in local inflammation. Photo. Renate Johansen, NVI

Disease caused by *Aeromonas salmonicida* subsp. salmonicida (furunculosis) or atypical *Aeromonas salmonicida* (atypical furunculosis) was not identified in salmonid fish in 2012. Piscirickettsiosis caused by *Piscirickettsia salmonis*, which remains a very important pathogen in Chilean fish farming, was not identified in Norwegian farmed salmonids in 2012.

Rainbow trout with *Flavobacterium psychrophilum*-infection

Photo: Hanne Nilsen, NVI

In January 2012 a *Pasteurella* sp. closely related to Pasteurella skyensis was isolated in association with eye inflammation, skin lesions, enlarged spleen and peritoneum/epicarditis in salmon from a locality in Sogn og Fjordane, in which a higher than normal mortality rate was registered. The bacterium was isolated from the kidney and other organs. Pasteurella sp. has been identified in salmon in Norway in 1989 (Troms) and 1999 (Hordaland), and the disease has been termed “varracalbmi” (lapp for ‘blood eye’). *Pasteurella skyensis* has been identified in association with disease in salmon in Scotland.

Sensitivity to antibiotics

Very few antibiotics are used in Norwegian salmon farming. Routine testing of fish pathogenic bacteria isolated from salmonids in 2012 has not identified new occurrences of reduced sensitivity for antibiotics authorized for use in Norwegian fish farming. *Flavobacterium psychrophilum* isolated from systemic infections in rainbow trout and *Yersinia ruckeri* isolated from a single individual fish farm suffering repeated outbreaks of disease, have, as in previous years, displayed reduced sensitivity to quinolone antibiotics. The molecular basis for resistance in this *Y. ruckeri* strain has been identified as a mutation in the gyrA gene. Mutations in the same gene have also been identified in Norwegian strains of *F. psychrophilum*. This type of mutation is associated with a low risk of transmission to other bacteria.

Fungal diseases

Few cases of mycosis in fish have been identified in 2012. Saprolegniosis comprises the majority of cases and has in the course of 2012 been identified in fish in commercial hatcheries, re-stocking hatcheries and in wild fish (seatrout and salmon). Information from fish health services indicate that saprolegniosis is usually diagnosed in the field following observation of macroscopically visual lesions and is usually treated with formalin. Samples are normally submitted for laboratory diagnosis only in severe and/or recurring cases. Use of formalin in aquaculture is currently under evaluation in the EU-system. Use of formalin for parasite or fungal treatment of fish, may therefore, be restricted or forbidden in the not too distant future. Development of preventative measures should, therefore, be focused upon.

Other diseases caused by fungi such as mycotic nephritis (*Ichthyophonus hoferi, Exophiala* spp.), swim-bladder mycosis (diverse fungal species) and gill mycosis are only sporadically diagnosed.

Parasite diseases

The salmon louse - *Lepeophtheirus salmonis*

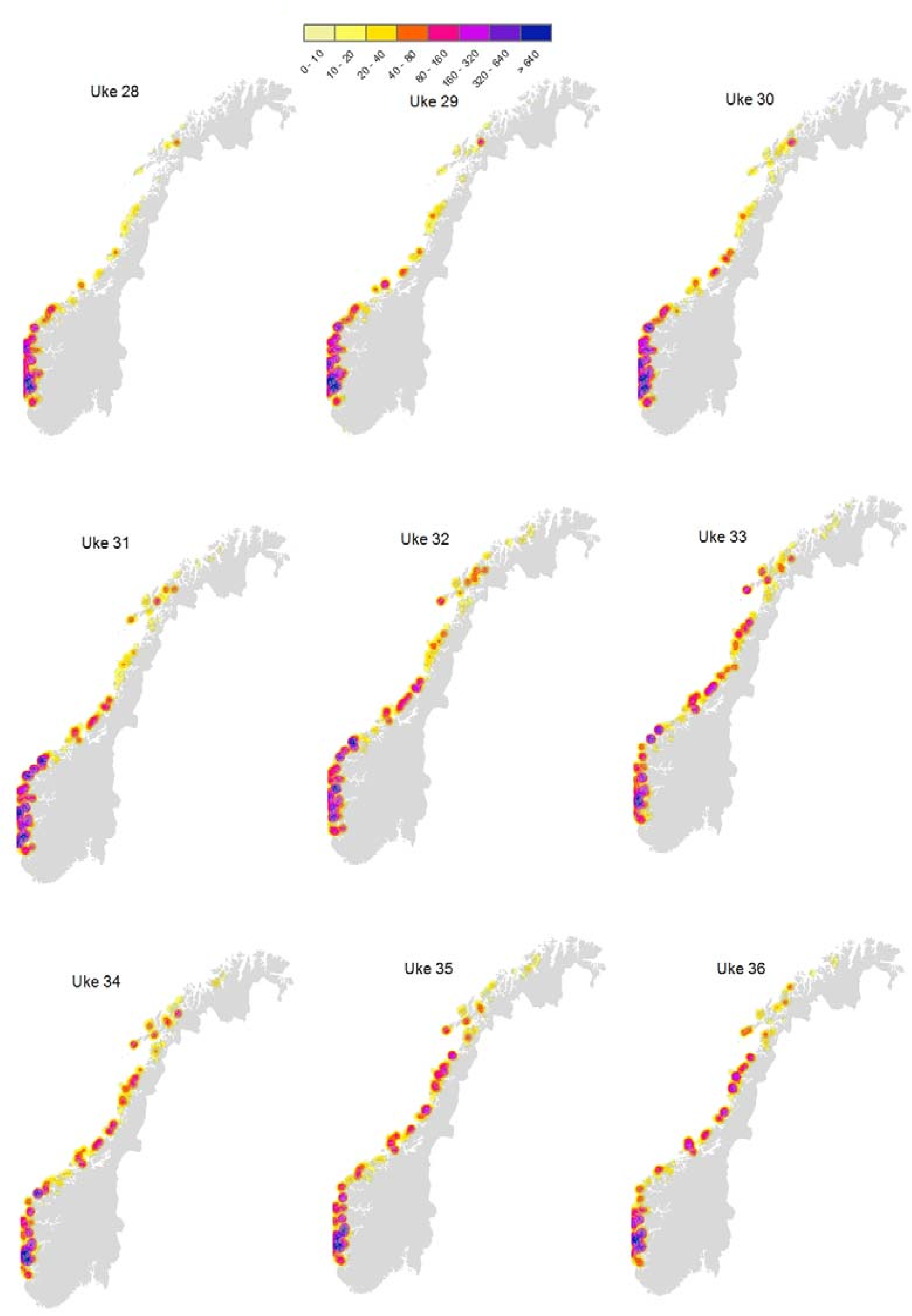
Salmon lice continued to represent one of the major challenges to Norwegian aquaculture in 2012. Control measures are aimed at reduction in infection pressure towards wild fish and prevention of resistance development. Infection pressure from the aquaculture industry varies throughout the year and infection pressures estimated by the Norwegian Veterinary Institute in weeks 19-36 are shown. The calculations show low and localised infection pressure in spring, with subsequent and rapid increase and spread throughout the summer. From week 21 infection pressure develops in a core area of the Hardanger Fjord system. High infection pressure was also later identified in several other areas along the coast.

Use of pharmaceuticals for treatment of salmon lice was significant and a survey of pharmaceutical use per farming site indicates a high risk of resistance development. The survey also reveals that bath treatments (pyrethroids and azamethiphos) were most common while use of emamectin benzoate (Slice) and hydrogen peroxide was considerably lower. The low use of Slice is almost certainly linked to a serious resistance situation and the dominating use of pyrethroids and azamethiphos give grounds for concern. Establishment of treatment regimens which minimise development of resistance are important for maintenance of effective treatment during periods of high infection pressure.

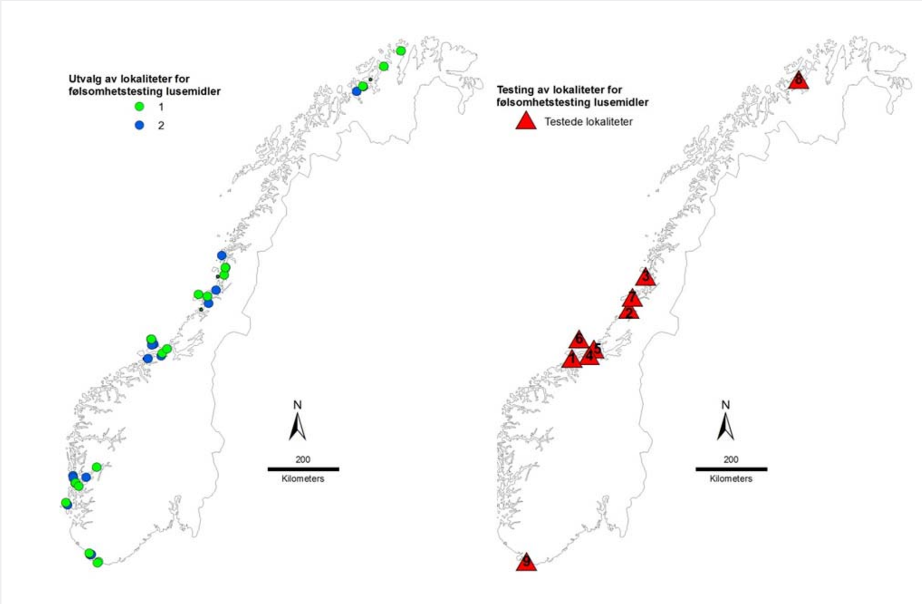
Infection pressure

In previous reports the lice situation has been based on reported lice numbers. The reporting system was changed in 2012, from monthly counts to weekly counts. Figures for 2012 are therefore not

Estimated relative densities of copepodites based on adult female lice numbers weeks 19-36.



Estimated relative densities of copepodites based on adult female lice numbers weeks 19-36.



Sites selected for lice treatment sensitivity testing (green symbols prioritised, blue symbols alternative sites) and tested sites (red triangles).

directly comparable with previous years. Average lice numbers do not, however, provide a quantitive description of real infection pressure, as they provide no information on the number of fish or density of biomass.

A new method for calculation of infection pressure has been developed by the Norwegian Veterinary Institute. The method is based on step-wise analysis of lice data and results in an estimate of the relative densities of infectious copepodites along the coast. Using this method the infection pressure in individual farms may be estimated. Combining data from individual farms allows estimation of infection pressure at any point in time for various areas around the coast. The Norwegian Veterinary Institute has contributed to the report "Risk analysis in Norwegian aquaculture 2012" (Fisken og Havet særnummer 2-2013 Institute for Marine Research) in which the model is described. Calculation of copepodite production using this model reveals particularly high infection pressure in the south of the country from mid-July and onwards. In mid-Norway the infection pressure is considered to be relatively high from mid-August onwards, while infection pressure in Northern Norway is considered low throughout the year. There appears to be a significant correlation between infection dynamics in salmon farms and wild salmon.

Surveillance for resistance

In 2011 the Norwegian Veterinary Institute performed surveillance activity related to development of resistance to various chemotherapeutics used in treatment of lice. The surveillance programme was originally divided into both active and passive surveillance. Interpretation of bioassay data in terms of resistance status is challenging, as variation in results may be significant. Bioassays can only indicate sensitivity status for an area, not for an individual farm. The variability in bioassay results may be due to several factors (see VI report 9-2011), and an evaluation of resistance trends must be based on a large sample number in relation to information related to pharmaceutical use statistics and treatment results. For this reason the passive part of the programme was established to systematically monitor information supplied by the Norwegian Food Safety Authority including reports on failed treatments, continual assessment of bioassay data from the industry and consumption of different pharmaceuticals registered in the veterinary pharmaceutical register (Vet Reg). The passive part of resistance surveillance was not performed in 2011 and 2012 due to the lack of sensitivity data reported to the Norwegian Food Safety Authority. Active surveillance was, however, performed in 2011, including bioassay testing of lice from selected sites along the coast.

Due to problems in finding enough lice on many sites, bioassay testing for emamectin benzoate sensitivity was only performed for a total of eight sites, pyrethroids in seven and azimethiphos in six (Figure a). On classification of sensitivity based on calculation of EC50-values, all three classifications; sensitive, reduced sensitivity and resistant, were identified but no geographical patterns or relationship with treatment intensity could be identified. The number of samples tested was, however, too low to further knowledge in this field. The results do, however, underline the existence of resistance in lice at several locations around the coast.

Information gathered during evaluation of zone legislation indicates a serious situation regarding resistance to several treatment types in several areas. A high degree of uncertainty surrounding bioassay results and their interpretation exists as bioassay results can deviate from treatment expectations. Until methods for sensitivity testing are further developed and validated, systematic follow up of the resistance situation for each pharmaceutical, based on bioassay and treatment results, will be required. An active surveillance program will be established in association with local fish health services.

Summary of pharmaceutical use in the Medicine Register

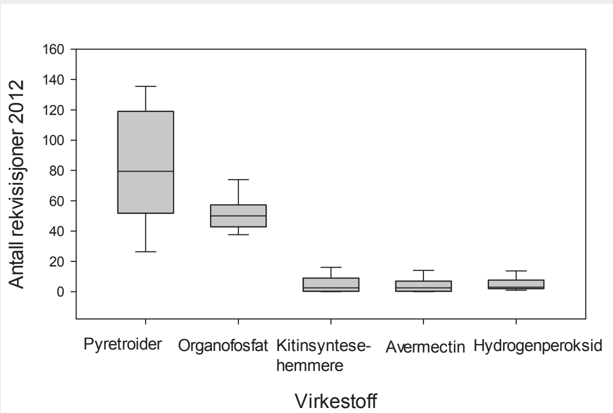
The number of prescriptions per locality is presented rather than amount/volume active substance used, due to the fact that units of amount/volume are standardised in the Medicine Register e.g. Units of g, kg, ml and piece are supplied for both pyrethroids and azamethiphos. Errors in amount and unit are probably present in the register. Figure b shows the number of prescriptions per month for different pharmaceuticals used for treatment of lice. The number of monthly prescriptions for pyrethroids varied throughout the year between around 20 and 140, with a median of 80 monthly prescriptions in 2012.

In summary, the dominating active substances utilized in 2012 were pyrethroids and organophosphates (azmethiphos). The geographical distributions of use of these substances overlap which probably reflects both site density and the fact that these substances are used in combination. Emamectin benzoate which is applied via the feed (Slice) has not been heavily prescribed in 2012 and appears particularly infrequently used in areas with dense farming activity, reflecting the reduced effect of this substance in these areas. Hydrogen peroxide and benzurons (chitin synthesis inhibitors) appear to have been limited to certain geographically areas.

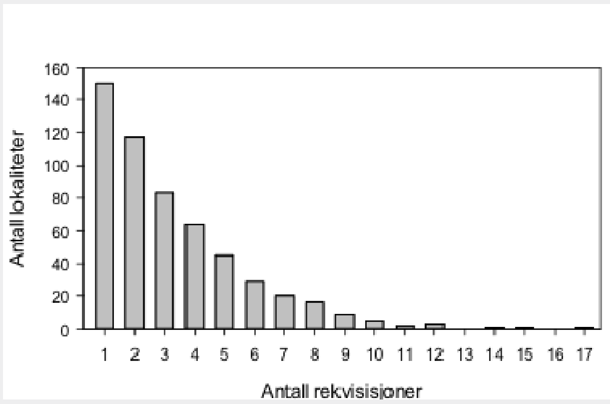
Nematodes

Nemaotode problems are primarily associated with larval stages of the roundworm species *Anisakis simplex* and *Pseudoterranova decipiens*. Larvae of these species may be found in the intestines and musculature of many marine fish species and also wild salmon. Recently *A. simplex* larvae were identified in farmed Atlantic salmon 'runts' from a farm in the South-west of the country. This finding prompted an extended survey.

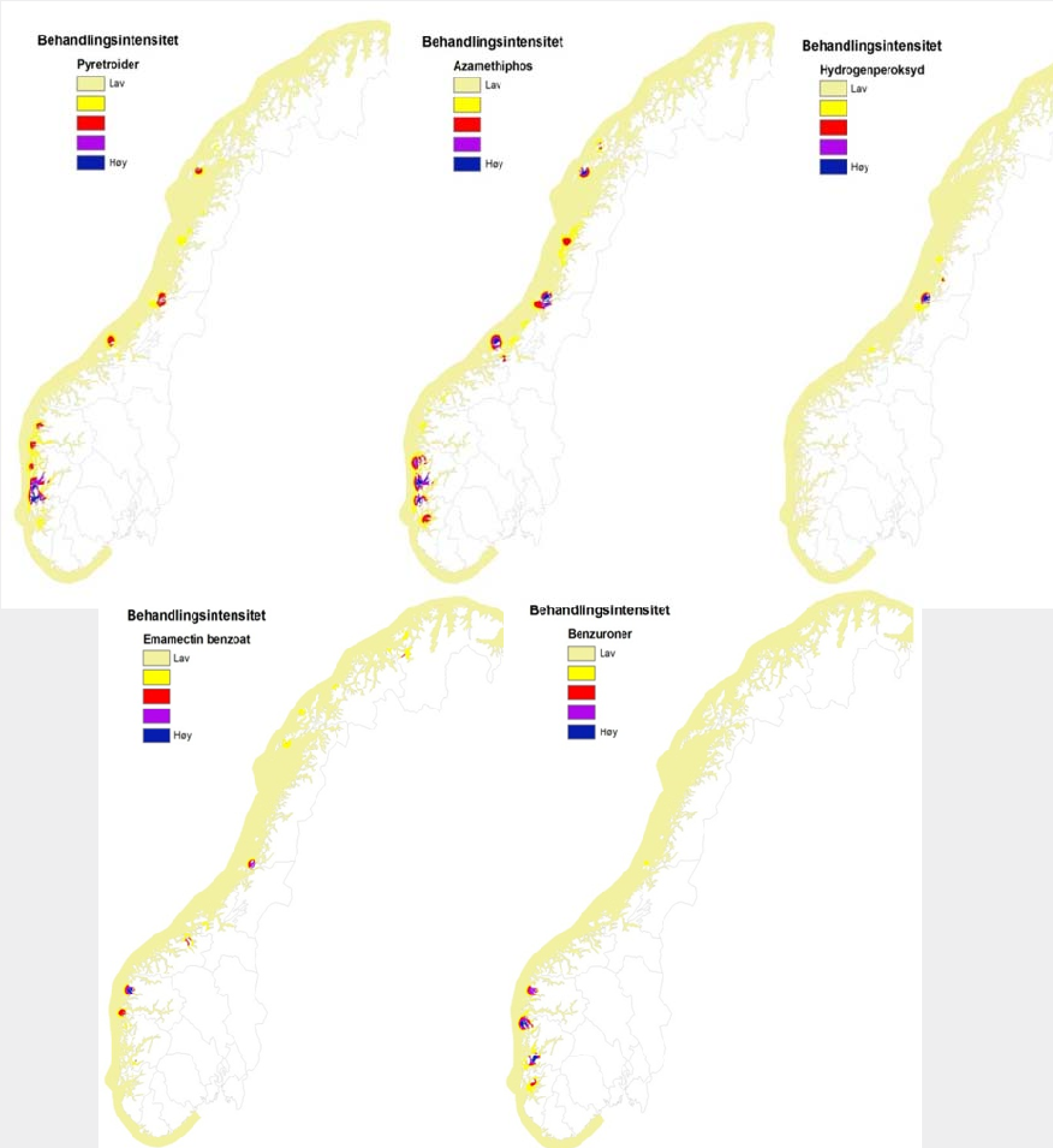
The findings show that farmed salmon may be infected with *A. simplex*. So far these parasites have only been identified in 'runts' and not in salmon destined



Box plot showing distribution of monthly prescriptions for various pharmaceuticals used in treatment of salmon lice infections in farmed salmon (the plot shows median – line; 25 – 75% quartiles – box; 5 – 95% interval-columns).



frequency distribution of prescriptions per site in 2012.



Treatment intensity as core density of number of prescriptions in the Medicine Register for 2012. It is the relative densities which are interesting. The delineation of density categories is linear. The active substances include pyrethroids (upper left panel; Alphamax and Betamax), azamethiphos (upper middle panel) and hydrogen peroxide (upper right panel), emamectin benzoate (bottom left panel) and the benzurons (lower right panel; diflubenzeron and teflubenzuron).

Table 2. Praziquantel usead against *Eubothrium*. Sales statistics from the Norwegian Institute of Public Health.

	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Praziquantel	152	232	412	122	145	94	91	29	11	137	423

for human consumption. The runts must have been infected via ingestion of infected intermediate hosts (crustaceans, fish) and this indirectly documents the fact that farmed salmon do not feed strictly on dry feed. The supposition that farmed salmon feed only on dry feeds has formed the basis for several risk analyses. Nematodes have previously been identified in wrasse and it is recognized that farmed salmon do at times eat wrasse. In late 2012, *A. simplex* was also identified in runts from a salmon farm in Møre og Romsdal.

Thin, weak salmon from a parvicapsulosis outbreak
Photo: Per Anton Sæther, MarinHelse AS

Parvicapsulosis - *Parvicapsula pseudobranchicola*

The parasite *Parvicapsula pseudobranchicola* which causes the disease parvicapsulosis, was first described in Norway following outbreak of disease with high associated mortality in salmon in three sea farms in 2002. Parvicapsulosis is particularly problematic in Troms and Finnmark.

The course of disease in salmon varies between slightly increased and high mortality. In some cases several thousand moribund fish may be 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 high numbers primarily in the pseudobranch (under the operculum) and it is here the main pathological changes may be observed. The parasite may also be observed in the gills, liver and kidney. In 2012 parvicapsulosis was diagnosed in 32 farms, compared with 31 in 2011 and 40 in 2010.

Desmozoon lepeophtherii

Desmozoon lepeophtherii is a parasite within the microsporidion group. 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 wolfish). Microsporidians form infective spores and their life cycles may be either direct or involve intermediate hosts.

D. 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 P*aranucleospora theridion*. *D. lepeophtherii* has the salmon louse 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 the sea-louse *Caligus elongatus*. The parasite is found along the entire Norwegian coastline, but appears to be most common south of Nordland. The parasite has also been identified in Scotland and recently in Canada (in salmon lice).

D. lepeophtherii is detected by PCR and while the parasite can be found in all tissues, gills and kidney are most commonly analysed. Spores may be observed microscopically in inflamed gills and the peritoneum. The significance of the parasite for fish health is unclear.

Tapeworm - *Eubothrium* sp.

After several years with relatively modest numbers of cases reported relating to tapeworm infections in salmon, an increase was reported by fish health services in 2011 and a similar pattern was reported in 2012. There are therefore, concerns relating to development of resistance. A number of treatments have been performed and an increase in sales of praziquantel has been registered.

Tapeworm infestations result in increased feed consumption and reduced growth of affected fish. Tapeworms may be found in the intestine of salmon and rainbow trout, attached by their head (scolex) to the digestive caecae. In untreated fish the worms may reach lengths of over one metre.

Amoebic gill disease (AGD) - *Neoparamoeba peruans*

Amoebic gill disease (AGD) caused by the amoeba *Paramoeba perurans* has, since 1986, caused large losses of farmed salmon in Tasmania and Australia.

The disease has also relatively recently been identified in European waters, with apparent gradual, northerly spread.

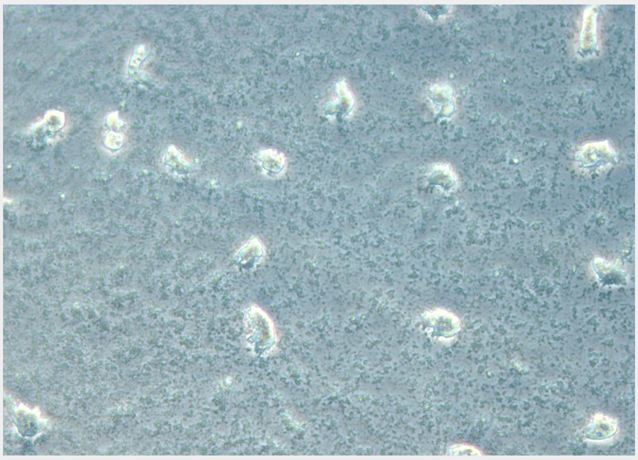
AGD has previously occurred sporadically in Irish and Scottish aquaculture, but the situation has changed dramatically in the last two years with considerably increased losses. The disease has also recently been diagnosed in the Orkney and Shetland Islands.

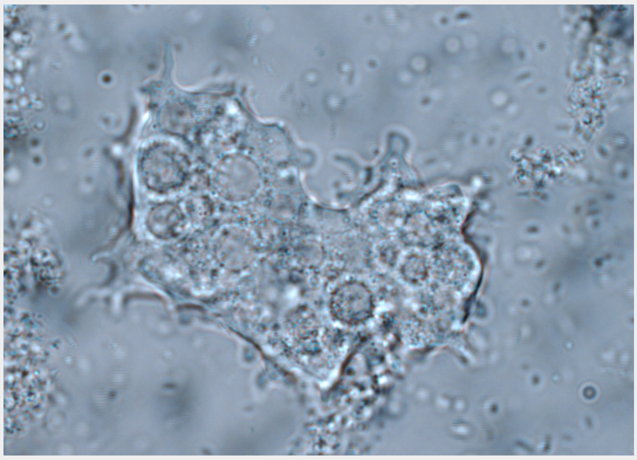
AGD may occur throughout the sea-phase of culture, but affects most dramatically post-smolts during their first autumn at sea. Outbreaks are often extended. The most important factor for outbreak of disease is high salinity (>32 ‰).

AGD is usually related to water temperatures over 17 °C although outbreaks have been observed at temperatures as low as 7oC. Little is known regarding survival of the amoebae at low temperatures. AGD can be treated with freshwater or hydrogen peroxide. Close follow up of gill status is important for optimal treatment timing.

AGD and P. perurans were diagnosed for the first time in Norway in 2006, when four farms were affected. One farm experienced losses of 80%, but the cause of loss was almost certainly multifactorial. In the three remaining farms in which AGD was considered to be the only aetiological agent present, mortalities of around 10-20% were experienced. In November-December 2012, the disease was again diagnosed in Norwegian salmon farms; five farms in total. Minor to extensive gill pathologies were observed, most probably of multi-factorial aetiology. Various other diagnoses were also made. The affected farms this time lay in Rogaland and Hordaland while the farms affected in 2006 were distributed rom Rogaland in the south to the southerly part of Møre og Romsdal in the north. Results from PCR screening also indicate a similar distribution. It isunknown whether a resident population has 'bloomed' or whether the newer outbreaks are related to an increased infection pressure related to the situation around the British Isles. Whatever the cause there may be reason to expect further outbreaks in 2013. There will be an increased awareness, diagnostic capacity and research activity related to AGD and P. perurans in 2013.

A laboratory culture of *P. perurans* has been established which will constitute an important resource for generation of more knowledge on the importance of water temperature and salinity for growth of the parasite and development of gill disease, infection pathways, prevention and control measures.





The amoeba *Paramoeba perurans* in laboratory culture
Close up of Paramoeba perurans. The bacteria upon which the amoebae feed can be observed in the background.
Photo: Terje Steinum, NVI

Gill health

Sea water sites

Gill disease has a complex aetiology in which many agents and different water parameters may play a role. Examination of samples submitted from Møre og Romsdal revealed that in 13 different sea farming localities (approximately 3% of examined cases), chronic gill disease was the dominant finding.

The majority of diagnoses were made in late summer/autumn. Classical field observations associated with chronic gill pathologies include poor appetite, low stress tolerance (e.g. during lice treatments) and in severe cases gasping for air at the surface. Gill disease is therefore a serious cause of loss in seawater farmed salmon. Research is underway to clarify the underlying causes. Four infectious agents have been associated with chronic gill disease including Branchiomonas cysticola, Piscichlamydia salmonis and the microsporidean Desmozoon lepeoptherii. The significance of each of these agents, alone or together with other underlying causes has not yet been identified. Amoebic gill disease (AGD) caused by *Paramoeba perurans* is discussed in the previous paragraph.

Cases of bleeding from the gills were again reported in 2012. In these cases blood is normally identified in anaesthetic tanks or directly on the gills. On histological investigation, fresh haemorrhages can be observed in the lamellae and occasionally between the gill filaments. The cause/s are unknown, but local algal blooms may explain some or all of these cases. The phenomenon has been observed over several years and is most common in the autumn.

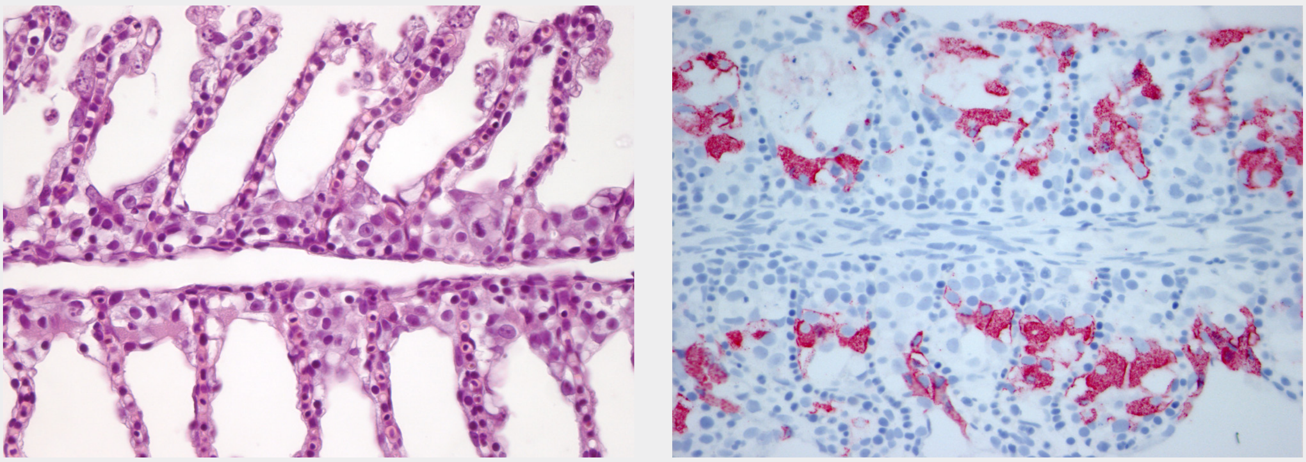
Freshwater sites

Gill problems during the freshwater stage of culture are commonly related to suboptimal water quality. Some infectious diseases such as yersiniosis and flavobacteriosis may result in gill injury. A condition in which bacteria colonise the gill epithelia probably resulting in reduced respiratory ability has been a recurring problem in a limited number of farms. The condition is probably related to poor water quality. A specific type of pathology related to high mortality has been reported in a number of farms. The fish suffer obvious respiratory distress and the pathological changes are unusual. It appears that epithelial cells die and are then sloughed. An increase in the number of chloride cells is also commonly reported.

Other Health Problems

Andre hjertelidelser

Reduced cardiac capacity may be either infectious or non-infectious in nature. While normal, good heart function is important for the function of other organ systems, minor pathologies are less commonly registered. The significance of non-infectious cardiac disease

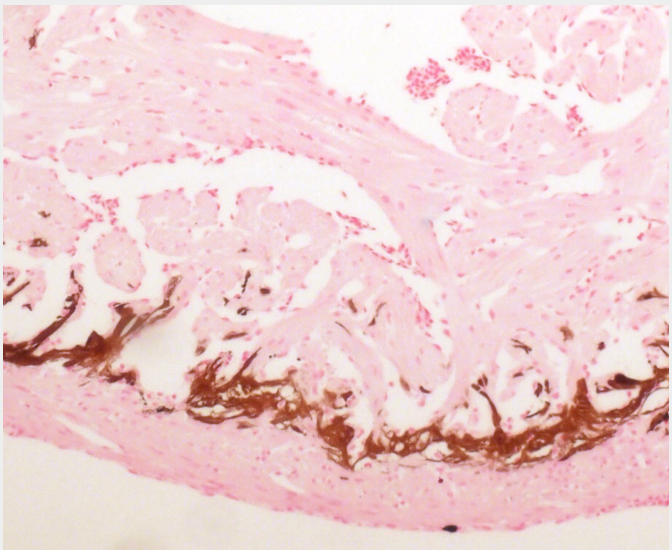


Left: Gills in salmon displaying extensive apoptosis i.e. the cells die and are sloughed
Right: Chloride cell (red colour) proliferation in salmon in freshwater. Photo: Mona Gjessing, NVI

lies, therefore, not in direct disease or mortality, but as a basis for other diseases, both infectious and non-infectious. Reduced cardiac function makes the fish less robust and more susceptible to other infections.

Abnormal shape and size are the most obvious abnormalities as well as incorrect orientation (situs inversus) and lack of a pericardial membrane (septum transversum) such that the heart lies open in the peritoneum. Functional abnormalities, are however, more difficult to identify and will often require close observation over longer periods. Fish with cardiac abnormalities are normally over-represented amongst fish lost during e.g. transport, handling, medication and suboptimal conditions. The number of cases of circulatory failure described in which other pathological changes are not registered appear to be increasing in recent years. There is therefore a requirement for better knowledge of heart function in farmed salmonid fish. In recent years there have been particularly many cases of unexplained mortality and cardiac failure in relation to lice treatment.

General soft tissue calcification in juvenile salmon may result in extensive changes in the heart and have in 2012 been identified in 4 smolt production units in Northern Norway (Figure kalk). The condition has previously occurred sporadically in various parts of the country since 1994. The cause of this condition is not known.



Calcification (brown vonkossa staining) in the cardiac wall in a salmon smolt Photo: Marta Alarcón, NVI

During routine diagnostic work, identification of a variable degree of inflammatory change on the surface of the heart (epicarditis) is extremely common. Such changes are not normally identified in wild fish unless certain parasitic species are present. The cause and significance of this epicarditis is unknown, but it is almost certainly related to subnormal heart function and/or a chronic inflammatory condition. The number of diagnoses and grade of epicarditis appeared to be the same in 2012 as in previous years.

Vaccine side-effects

The health gains associated with vaccination are undisputable, and large scale, modern salmon farming would not be possible without effective vaccination programs which give good protection against the most important bacterial diseases. Acute side-effects such as reduced appetite and morbidity for a short period after vaccination, which normalises relatively quickly, are normal. The vaccines used today are normally multi-valent and oil-adjuvanted. This combination is locally irritating and results in inflammation in the peritoneum which normally lasts until harvest. As a result of this inflammation near the injection site, adherent tissue may develop between the peritoneal wall and the inner organs. Granulomatous inflammation between the digestive caecae, pancreas and spleen is therefore a normal finding in farmed salmon during routine diagnostics. In some cases serious side-effects may develop in the form of extensive adherent tissues which undoubtedly have a negative effect on the fish.

The reasons behind the occasional high prevalence of extensive vaccine adhesion development are not known, but factors such as placement of vaccine dose, volume of vaccine dose, vaccine composition, vaccination of undersize fish and hygiene during vaccination have been discussed. Side effects registered during 2012 appear to be at a similar level to previous years. Small adhesions and granuloma between the digestive caecae, but not between the organ 'package' and the peritoneal wall appear to be more usual. Such side-effects are not evaluated with the Speilberg scale or similar. Vaccine manufacturers have reduced antigen dose and injection volume in an effort to reduce side effects, without any apparent loss in protection.

Fish welfare

Welfare of farmed fish has been a significant focus in recent years, which in itself is a positive development, also from a veterinary medicine point of view. Good animal welfare is closely related to good animal health and is therefore closely related to a good economical final result. Obligatory fish welfare courses run by fish health services for employees of large farming companies have undoubtedly contributed to an increased awareness of good fish welfare at all stages of production.
Implementation of new anaesthetic methodology prior to slaughter, delayed several times, was finally introduced in 2012. Use of CO2 prior to slaughter has been replaced by electrical anaesthesia or concussion (blow to the head). When these methods are applied correctly, they represent significantly better animal welfare than previously.

On a country wide basis, losses during the seawater phase of culture remain high, and have not been reduced during the course of the last year. The reasons behind this mortality are complex and represent considerable challenges in relation to fish welfare. In all domestic animal production a basic philosophy on the manner in which animals are treated must be developed. This is important, both for best possible production, but also because the farmed animals represent highly developed organisms capable of feeling both fear and pain. When animals are held in captivity we have a responsibility to avoid unnecessary suffering.

In fish farming, surveillance of fish welfare is extra challenging due to the fact that production occurs under water and because fish behavior is more difficult to interpret than that of warm blooded animals. Development of better equipment for measurement- and improvement- of fish welfare should be a prioritized area of research for the coming years. We must formulate and maintain a more offensive attitude in relation to fish welfare and should not be satisfied merely with fish survival and an acceptable economic result.

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

Parasites

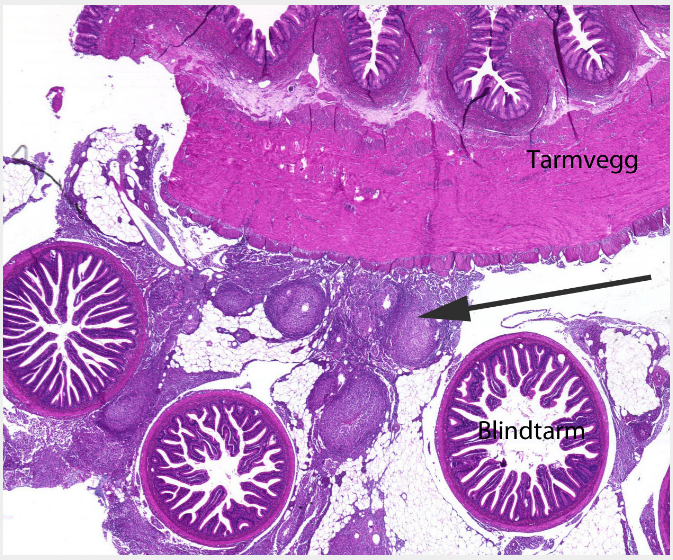
Parasite checks are part of normal routine health controls. Parasites reported during 2012 include species belonging to the following families: Scyphidia, Riboschyphidia, Epistylis, Ichthyobodo and Trichodina. Tapeworm cysts have also been identified. Gyrodactylus has not been reported from fish reared for stock-enhancement purposes in 2012.

Bacterial diseases

Flavobacterium psychrophilum was diagnosed in one salmon-rearing unit in association with skin erosion/ulceration and low mortality. Other bacteria identified included Pseudomonas spp.

Fungus

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



Small granuloma between the intestinal wall and digestive caecae in the peritoneum of salmon.
Photo: Renate Johansen, NVI

Environmental problems and production related diseases

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, runt development, and iron precipitation on the gills are also reported.

Health control of wild caught brood stock for stock-enhancement

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. In 2012 fewer fish were tested for furunculosis. This was due to an application by the Norwegian Veterinary Institute to the Norwegian Food Safety Authority for dispensation for a number of fish in the gene bank program. In addition, we no longer recommend testing for furunculosis in stock-enhancement hatcheries. Furunculosis is a non-vertically transmitted disease when egg disinfection is performed according to current legislation. All PCR-analyses are performed by Patogen Analyse AS.

The results from this year's brood stock season show that neither IPN-virus or furunculosis have been identified, while Renibacterium salmoninarum (BKD) was found (by PCR) in seven salmon, all from the same hatchery. The diagnoses have now been confirmed by the Norwegian Veterinary Institute. Identification of important pathogens such as R. salmoninarum underlines the importance of brood stock surveillance. Nematodes (Anisakis sp.), gill louse (Salminicola sp.) and tapeworm (Eubothrium sp) are among normal parasite findings this year as in previous years.

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 to 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 3750 salmon from 111 rivers and approximately 3000 salmon/rainbow trout from a total of 89 fish farms were investigated as part of the national surveillance programme (OK-programme) for Gyrodactylus salaris. The rivers in the OK-programme are investigated every year 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 2012, G. salaris was not identified during the OK-program either from samples from aquaculture facilities or from rivers. More general information on G. salaris may be found in the VI-Fact sheet.

Final treatments for G. salaris were performed in the Lærdals region and Vefsna region in 2012. These regions are now entering the process of being declared free of infection together with the Steinkjer region which was last treated in 2009. The remaining infected regions where treatment has not yet been started are the Rauma region, Skibotn region, Driva region and the Drammen region.

The second treatments of rivers in the Vefsna region were performed during 2012. This included the infected rivers Vefsna, Fusta, Drevja, Hundåla, Dagsvikelva and Nylandselva. The main treatment was performed in August while the smaller rivers Dagsvikelva and Nylandselva were treated in June. Final treatments of the Halsanelva and Hestdalselva were performed in 2011, while the final treatments of the river Leirelva and Ranelva were performed as long ago as 2006. All salmon migratory stretches of all rivers in the Vefsna region have now been treated.

Following the detection of G. salaris on arctic char in lakes above the fish barrier in the river Fusta, three lakes and surrounding streams were treated in October. Extensive conservation measures relating to char and trout have been initiated in relation to this work.

Treatment of the Lærdal region was completed in August and September. The Norwegian Veterinary Institute, under contract from the Directorate for Nature Management had responsibility for treatment of the region. Treatment was performed using the combination method, which utilises acidified aluminium as the main chemical with rotenone as the supplementary substance in water bodies of various size. The Norwegian Institute for Water Research (NIVA) had responsibility for dosage of acidified aluminium as well as overall leadership of the project. The Norwegian Veterinary Institute has participated in planning and performing the aluminium treatment as well as total responsibility for rotenone treatment, disinfection and disposal of dead fish.

Treatment of the Rauma region is planned to start in the course of 2013. As part of the preparatory work, mapping, water flow measurements and other necessary investigations were performed in 2012. Considerable conservation work relating to sea trout has also been performed in the region.

In other infected regions, only limited preparations for future treatments have been made.

National surveillance program for *Gyrodactylus salaris*
Photo: Veslemøy Oma, NVI

Table 3. Testing for IPNV, Renibacterium salmoninarum (BKD) and Aeromonas salmonicida subsp. salmonicida (furunculosis). Preliminary results from brood stock analyses season 2012/2013. PCR-testing.

		Individuals tested	Number positive
Atlantic salmon	IPNV	497	0
	BKD	675	7
	Furunkulosis	268	0
Sea trout	IPNV	227	0
	BKD	250	0
	Furunkulosis	-	-
Brown trout	IPNV	6	0
	BKD	6	0
	Furunkulosis	6	0

Cleaner fish

Use of fish species such as goldsinney wrasse (Ctenolabrus rupestris), corkwing wrasse (Symphodus melops), ballan wrasse (Labrus bergylta) and lumpsucker (Cyclopterus lumpus) is now common in control of salmon lice. Cleaner fish which eat lice, 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 distances are represented between the Skagerrak coast and Nordland. Fish health services report high level on-farm mortalities in 2012 when these fish were held together with salmon. Mortalities were related to low temperature and to various technical on-farm operations e.g. emptying the dead fish sock are reported. The committee for animal ethics has stated that such use of cleaner fish is ethically questionable, and that increased survival and welfare for these fish is desirable.

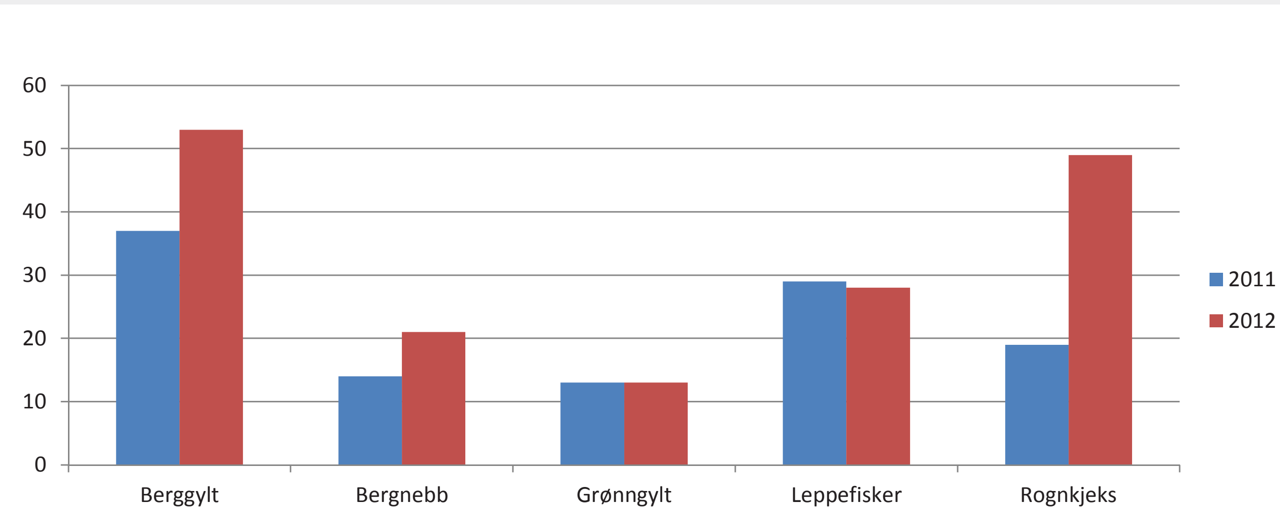
Two commercial ballan wrasse farms and five lumpsucker farms are now in operation. Increased use of wrasse and lumpsucker is reflected in the increased number of diagnostic submissions related to these species received by the Norwegian Veterinary Institute (Figures xxx and xxx)

There is a need for mapping of the diseases and causes of cleaner fish mortality. Diagnostic submissions to the Norwegian Veterinary Institute in 2012 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 investigation.

Virus

Several investigations have been performed on wild-caught fish and cleaner fish from salmon cages. So far no detections of VHSV, IPNV or nodavirus have been made. SAV is reported from wrasse sampled from a salmon cage in which the salmon were suffering PD. It is unclear whether the fish were infected with SAV or passively carrying the virus. Several studies are currently studying the susceptibility of wrasse to individual viral diseases.

In December 2012 VHS (viral haemorrhagic septicaemia) was identified in a population of ballan wrasse in a research station in Shetland. This disease is notifiable and approx. 9000 fish were destroyed. So far VHSV has not been identified in Norwegian wrasse, but so far only a limited number of randomly selected fish have been tested. The identication of VHS in wrasse in Scotland illustrates, however, the need for systematic surveillance.



Number of submissions submitted to the Norwegian Veterinary Institute 2011 and 2012, by species

Bacteria

The main bacterial findings in 2012, as in previous years, are wounds/ulcers possibly developing to systemic infection. Identification of diverse *Vibrio* spp. and atypical *Aeromonas salmonicida* (atypical furunculosis) have again dominated the situation. Atypical *Aeromonas salmonicida* is considered to be one of the most important pathogens of cleaner fish. In 2012 this disease was diagnosed in two ballan wrasse farms and in wild-caught wrasse released into salmon cages. The disease was also diagnosed in lumpsucker. The bacterium causes most commonly a chronic disease with granuloma in the inner organs as well as ulcer development.

Vibrio-species were identified in the majority of cases submitted from cleaner fish in 2012. These 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.

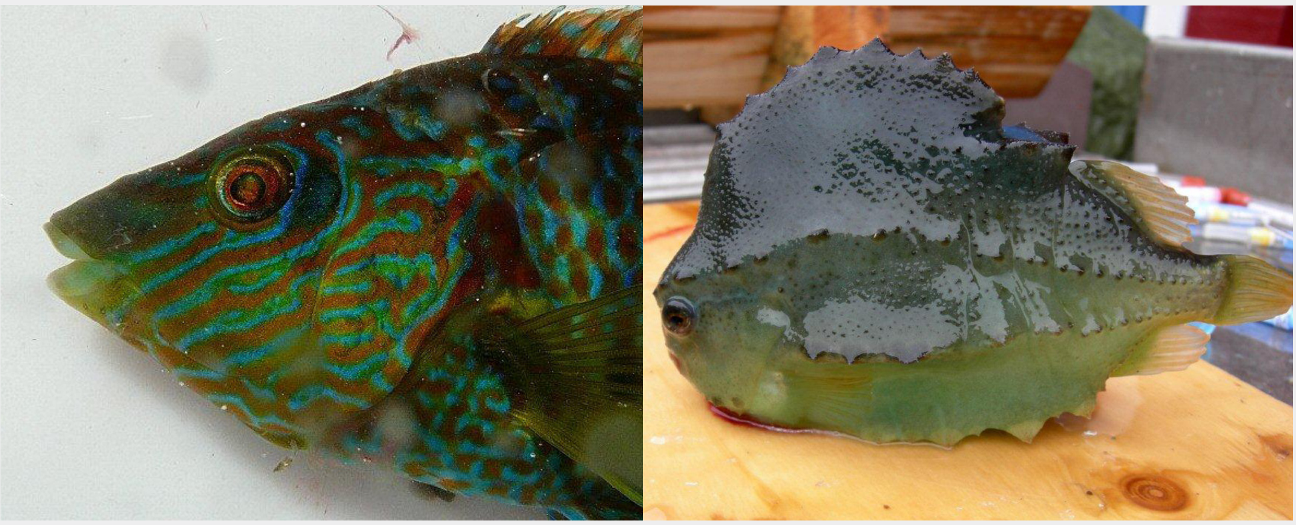
In 2012 the number of diagnoses of *Vibrio anguillarum*, which is a well known pathogen of salmon and cod, increased. The bacterium was diagnosed from diseased lumpsucker, ballan wrasse and non-speciated wrasse. Serovariants identified were O1 and O2B (lumpsucker and wrasse), O1 and O2a biotype II (ballan wrasse). Mortality levels related to *Vibrio anguillarum* infection in one case of farmed ballan wrasse sampled from a seawater cage were extremely high (up to 50%).

Vibrio tapetis, a well known pathogen of shellfish, is quite commonly identified as part of a mixed *Vibrio* flora from wrasse. *Vibrio logei*, a possible opportunist, is commonly identified from both wrasse and lumpsucker. *Vibrio wodanis*, commonly associated with winter ulcer in salmon, has been identified from both goldsinney wrasse and lumpsucker. *Vibrio splendidus* is one of the most commonly identified bacteria from material submitted from all species of cleaner fish. This species 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.

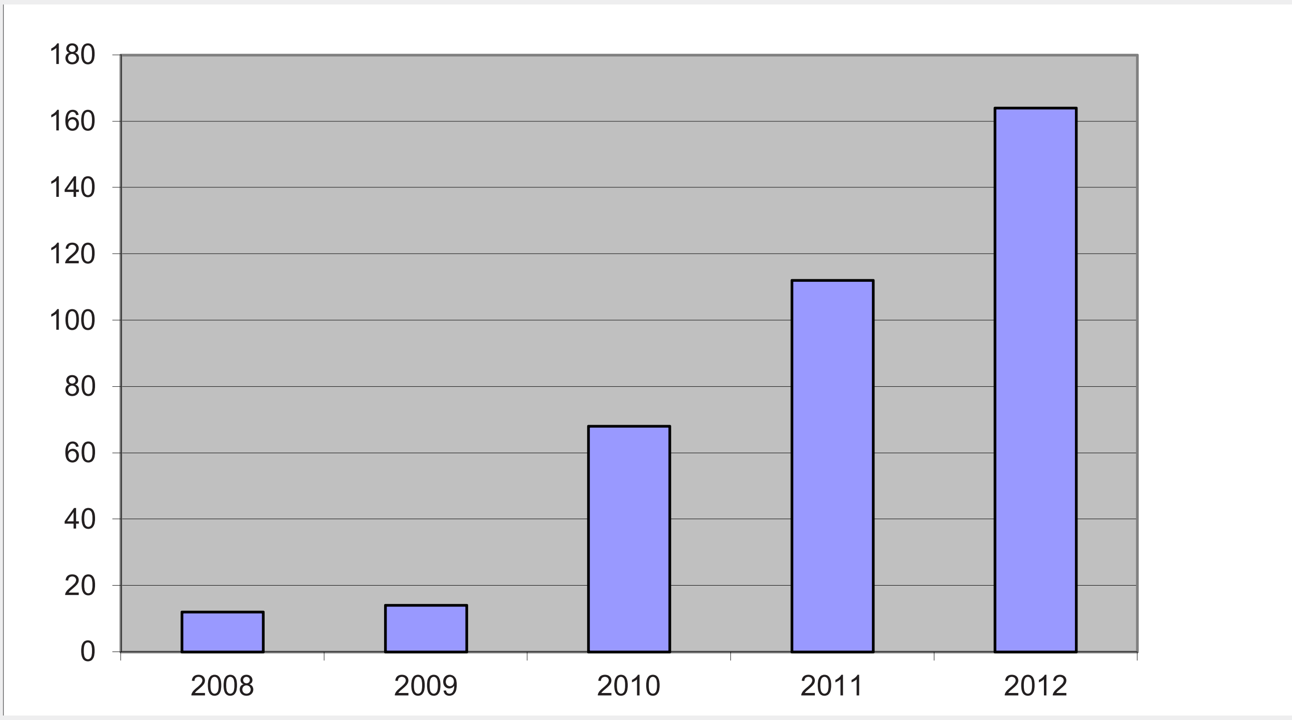
Fin rot, a recurring problem in farmed ballan wrasse has now been observed in lumpsucker. *Tenacibaculum* spp., often in pure culture but most commonly in mixed culture, may be identified in association with such outbreaks. In addition *Vibrio splendidus* is identified. *A Pasteurella* sp., closely related to *P skyensis*, was identified in lumpsucker displaying ulcers and granuloma from a farm in southern Norway. *Vibrio ordalii* was identified in lumpsucker on three sites in northern Norway. *Pseudomonas anguilliseptica* was not identified in 2012.

Parasites

Amongst the various wrasse species used as cleaner fish in salmon farming, large numbers of nematodes have on occasion been identified. While most of these nematodes are small, some are as large as the zoonotic parasite *Anisakis simplex*. The work of speciation of these nematodes is now underway. In previous



Corkwing wrasse and lumpsucker. Photo: Trygve Poppe, NVH



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

studies *A. simplex* has been identified in both ballan and goldsinney wrasse. Should *A. simplex* infection exist in small wild-caught wrasse used in Norwegian salmon farms, these fish may pose a risk of infection for the salmon within the cage (see paragraph on nematodes). It is well known that farmed salmon eat wrasse, particularly the small species like goldsinney and corkwing. If the salmon eat infected wrasse, *A. simplex* may wander into the musculature of the salmon.

Trichodina spp. have previously been registered in high numbers in farmed lumpsucker. These parasites were again identified in this species in 2012

Cod

The number of submissions to the Norwegian Veterinary Institute (NVI) reflects the decrease in number of cod farms. In 2010, 80 submissions were received from 40 farms. The following year the number fell to 50 submissions from 25 farms. In 2012 the reduction continued with 21 diagnostic submissions received from a total of 11 farms. Six of these farms were represented by single submissions. Bacterial problems dominate these cases.

Francisellosis, a chronic granulomatous cod disease, is caused by the bacterium *Francisella noatunensis* subsp. *noatunensis*. The disease is a huge problem for commercial cod farming. The disease is highly infectious and infected fish display clinically obvious changes in the form of granuloma in all inner organs and musculature. Identification of *Francisella*-positive individuals in a fish group is normally consistent with a later outbreak of francisellosis in the site. In 2012 the disease was identified in two farms, one in Møre og Romsdal and one in Sogn og Fjordane.

Classical vibriosis is caused by *Vibrio anguillarum*. This disease was identified in 5 cod farming sites in 2012. In addition, atypical furunculosis was identified in one farm.

Potential viral agents for cod are nodavirus and IPN-virus. Viral agents were not diagnosed in material submitted from cod in 2012.

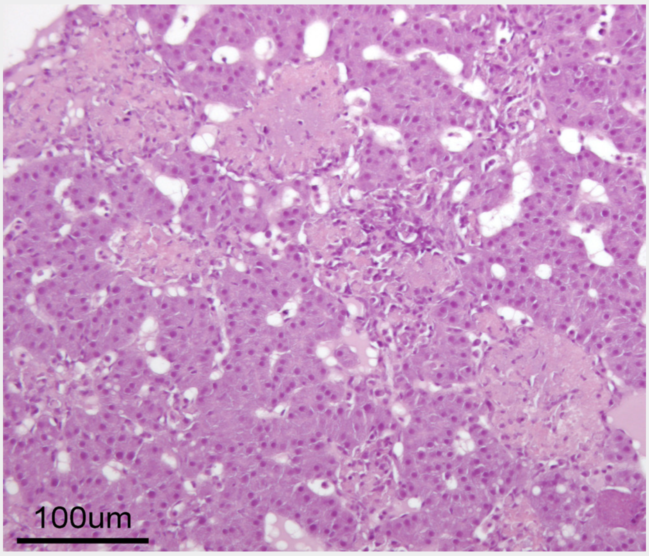
Halibut

In 2012 the Norwegian Veterinary Institute received 30 diagnostic submissions from farmed halibut. This is slightly lower activity than that experienced in 2011, 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. Three halibut farms were awarded atypical furunculosis diagnoses in 2012. Antibiotic treatment gives good effect, but poor water quality and other stress factors can contribute to new outbreaks. Moritella viscosa was identified in halibut for the first time in 2011, but there were no new identifications in 2012 and the significance of this bacterium for halibut is unknown.

One farm has experienced recurring episodes of liver necrosis and florfenicol used in artemia production was suspected to be the cause. However, similar findings in halibut juveniles which were not exposed to the antibiotic were also observed. The cause of the liver necrosis is therefore unknown. (Figure KveiteLever).

Nodavirus was identified in one farm which is now closed. IPN was not identified in 2012.



Light microscope photograph of focal inflammation and tissue death (necrosis in the liver of halibut juveniles). The cause of the problem is unknown.
Photo: Renate Johansen, NVI

Veterinærinstituttet er et nasjonalt forskningsinstitutt innen dyrehelse, fiskehelse, mattrygghet og fôrhygiene med uavhengig kunnskapsutvikling til myndighetene som primæroppgave.

Beredskap, diagnostikk, overvåking, referansefunksjoner, rådgivning og risikovurderinger er de viktigste virksomhetsområdene. Produkter og tjenester er resultater og rapporter fra forskning, analyser og diagnostikk, og utredninger og råd innen virksomhetsområdene. Veterinærinstituttet samarbeider med en rekke institusjoner i inn- og utland.

Veterinærinstituttet har hovedlaboratorium og administrasjon i Oslo, og regionale laboratorier i Sandnes, Bergen, Trondheim, Harstad og Tromsø.

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