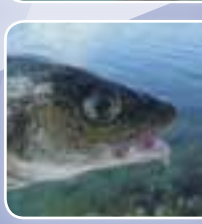
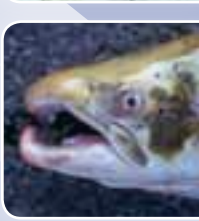
The health situation in Norwegian aquaculture 2009





Veterinærinstituttet
National Veterinary Institute

In 2009, 856 000 tons (harvest statistics) of Atlantic salmon, along with an estimated 81 000 tons of rainbow trout, 19 600 tons of cod, 1800 tons of halibut and 1600 tons of other species e.g. coalfish, Arctic charr and halibut, were produced (Kontali Analyse AS). Production related losses remain significant, and a large proportion of these losses are related to disease. Although we have good oversight of the diseases in Norwegian aquaculture, we lack knowledge relating to the overall losses caused by disease. That we have not managed to reduce these losses more than we have, is disturbing, and the industry faces a considerable challenge in this regard. Given the increased focus on fish health and more robust (in terms of fish health) production systems, it has been shown e.g. in the Faeroe Islands, that it is possible to further reduce these losses.

Pancreas Disease (PD) has been the dominant disease in salmon farming in recent years. Both the industry and the authorities have worked hard towards control of this disease. Despite registration of outbreaks outside the PD "core area", fewer outbreaks, with lower overall losses provide grounds for optimism. Although the number of infectious salmon anaemia (ISA) outbreaks is also considerably lower than previously, a core area for this disease still exists in Northern Norway.

The major fish health challenge during 2009 was that of salmon lice infestation. Problems of reduced sensitivity and development of resistance to treatment have increased and as a consequence large numbers of lice were recorded throughout the autumn. Successful salmon louse treatment is dependent on coordinated control strategies requiring extensive cooperation throughout the Norwegian aquaculture industry. While new medications are necessary, they will only provide a breathing space for establishment of other sustainable control strategies. Increased use of wrasse will constitute an important element in such strategies, but will also increase the possibility of other types of disease and disease transmission. Although a vaccine should be an important element in salmon louse control in the longer term, there remains much uncertainty related to both developmental time and effect.

"New" diseases will always present a challenge. In some cases, established diseases may change and present in new form. It is therefore important to maintain surveillance, follow trends and continually evaluate the importance of new research data.

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The health situation in farmed salmonids 2009

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The health situation in farmed salmonids in Norway is relatively good, but there remain considerable losses as a result of many diseases, of both known and unknown cause. The existence of so many diseases of unknown cause, and the annual appearance of new diseases, make disease diagnostics especially challenging.

Summary

Generally, with some exceptions, the number of diseases detected at the farm level is similar to that of 2008. There was a reduction in the number of farms affected by pancreas disease (PD) and infectious salmon anaemia (ISA), while the number of farms affected by infectious pancreatic necrosis (IPN) increased. Generally, infection with IPN-virus appears to have been a larger problem during 2009 than in 2008. The salmon louse problem has also worsened during this time, particularly in regard to the development of resistance to medicamental treatments. An increasing degree of reduced sensitivity/resistance has been registered to chemotherapeutants which have been used effectively for many years, including both emamectinbenzoate and pyrethroids. Registered lice levels in Norwegian farms, especially towards the end of the year, were the highest recorded in several years. Local fish health services have also reported difficulties in achieving successful coordinated treatments in some regions.

Viral diseases have, as in 2008, also caused serious problems in 2009. Known viral diseases and diseases of suspected viral aetiology currently present the greatest challenge related to overall losses and reduced growth. These complaints also constitute a significant welfare problem in Norwegian salmonid aquaculture. Viral haemorrhagic septicaemia (VHS) was diagnosed on one new site containing rainbow trout in Storfjorden during 2009. The fish in this site were harvest ready and were slaughtered immediately following diagnosis. The virus isolated from the outbreak in Storfjorden in the period 2007-2009 is globally unique, as it belongs to a genotype which has previously only caused disease in marine fish. Infectious salmon anaemia (ISA) has also been particularly problematical in the South- and mid-Troms area during 2009. In an effort to gain control in this region, extraordinary measures including vaccination, have been introduced. Western Norway continues to represent the "core" area for pancreas disease. During 2009, 75 sites were diagnosed with PD compared with 108 during the previous year. We see therefore a positive trend in the fight against PD, and hope for a continued fall during 2010. The number of recorded IPN cases in 2009 was a record high with confirmed diagnoses registered from 223 sites compared to 158 in 2008. Local fish health services also report IPN to have been more problematical in 2009 compared to 2008.

Of bacterial diseases, Flavobacterium psychrophilum continues to cause problems. During 2008, the industry experienced a drastic increase in the number of outbreaks of systemic infection with F. psychrophilum. The bacterium was detected in a total of 16 sites farming rainbow trout and salmon, which is around the same level as 2008. In the last year several hatcheries/juvenile production units have experienced unusually high mortalities in association with infection with Pseudomonas fluorescens, particularly following vaccination. Three cases of Bacterial Kidney Disease (BKD) were diagnosed, two of which were in rainbow trout sites situated in the same fjord system. The third case was registered in a salmon ongrowing site. Winter ulcer appears to have been less of a problem during 2009 with 38 cases registered compared to 51 in 2008, a view supported by reports from local fish health services.

The heart disease heart and skeletal muscle inflammation (HSMI) continues to represent a large problem for the aquaculture industry, with the number of sites affected in 2009 similar to 2008. Mid- and Northern-Norway continue to be the "core" areas for HSMI. The number of sites affected by cardiomyopathy syndrome (CMS) is similar to 2008.

Background to the fish health report

To provide a complete picture of the health situation in farmed salmonids, this report is based on both information gathered from fish health services nationwide and diagnostic data from the National Veterinary Institutes' regional laboratories in Harstad, Trondheim, Bergen, Sandnes and Oslo. Information is also gathered from the Norwegian Food Safety Authority and other institutions involved in fish health. By far the majority of material sent in for analysis by the National Veterinary Institute originates from farmed fish. For this reason, the present report is dominated by the health situation in fish in aquaculture. Previous health reports for salmonid and marine fish are available at www.vetinst.no.

The criteria used for confirmation of a diagnosis inevitably changes as we gain new knowledge of diseases and disease processes. The National Veterinary Institute is therefore capable of awarding steadily more assured and precise diagnoses. Our diagnoses are based on a series of criteria, normally

combining histological findings with detection of specific agents using one or more methods. Methods linking agent detection directly with development of disease e.g. immunohistochemistry, are valuable diagnostic aids for several diseases including IPN. Although diagnostic criteria may change over time, it has often been shown that previous diagnoses are confirmed by newer methodology. The various diagnostic methods currently used by the National Veterinary Institute are described under each specific disease, and possible changes in diagnostic criteria should be considered when comparing statistics relating to the number of recorded outbreaks from year to year.

Notifiable diseases must be diagnosed by an authorised laboratory. For this reason, statistics relating to the number and distribution of outbreaks of such diseases are more reliable than for other non-notifiable diseases. The number of diseases which are notifiable has varied over time. In 2008, new fish health legislation replaced the old group A-,B- and C- diseases with list 1-, 2- and 3- diseases. Norway is today free of diseases in list 1. Of list 2 diseases, infectious salmon anaemia (ISA) and viral haemorrhagic septicaemia (VHS) are most relevant. List 3 covers the so-called "National" diseases i.e. those diseases for which the Norwegian authorities have current control strategies. There are a number of changes in these lists from previous years e.g. infectious pancreatic necrosis (IPN) has been removed from the lists, which may have consequences for the number of outbreaks registered in coming years. Those diseases which are notifiable at any particular time must be considered when the number of outbreaks of any particular disease is compared over time. More information on the new legislation and the diseases included in each list can be found on www.mattilsynet.no.

Viral Haemorrhagic Septicaemia – VHS

Fish farms in Norway are now tested in a national risk-based surveillance programme for VHS- and IHN (infectious haemopoetic necrosis)-viruses. In 2007, VHS virus was detected in three sites in Storfjorden in Møre og Romsdal, and again in two sites in the same fjord system in 2008. All sites in which the virus was detected were owned by the same company. In May 2009, VHS virus was detected in harvest ready rainbow trout, again in the same fjord system. The fish were harvested immediately following diagnosis. The Norwegian Food Safety Authority inform that there are other active fish farms in Storfjorden, and that with the exception of the detection in May, samples tested from fish in this area have all tested negative for VHS virus.

VHS is a serious infectious disease which may lead to high mortality. VHS is a list 2 disease which is normally combated by slaughter or destruction. The disease affects primarily rainbow trout, but has also been registered in other fish species. During the acute phase, clinical signs often include haemorrhage in the skin, musculature and inner organs. Affected fish display pale gills (anaemia), protruding eyes and distended abdomen. Abnormal swimming behaviour e.g. spiral swimming and flashing are registered, both alone (nervous form) or in combination with haemorrhage (haemorrhagic form). The diagnosis is based on culture of VHS virus, PCR and immunohistochemistry supported by pathological findings.

VHS virus belongs to the novirhabdovirus family and has a genome consisting of a single RNA segment. VHS viruses may be divided into four genotypes, 1 – 4 (with at least seven sub-groups), of which genotypes 1 – 3 have been found in Europe. Genotype 3 has previously only been identified in marine fish species, and the Norwegian outbreak is the first detection of this genotype in rainbow trout. Identification of disease in

Tabell 1. Total number of sites 1998–2009 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.

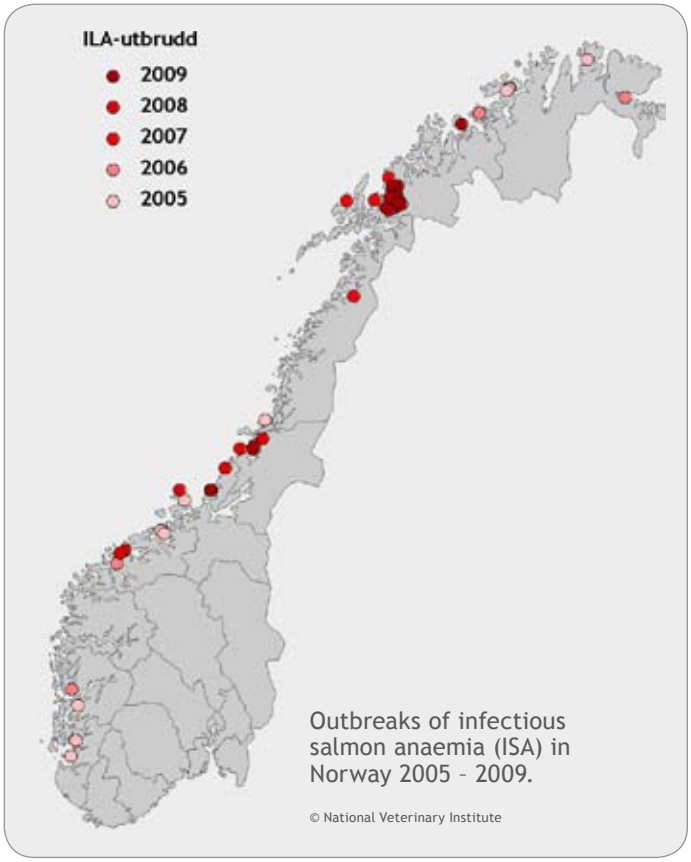
	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
ISA	13	14	23	21	12	8	16	11	4	7	17	10
PD	7	10	11	15	14	22	43	45	58	98	108	75
HSMI							54	83	94	162	144	139
IPN					174	178	172	208	207	165	158	223

a salmonid fish species caused by VHS of genotype 3 is globally unique. Infectious challenges have confirmed that the new Norwegian isolate can cause significant mortality in rainbow trout, and that the situation is serious. Most RNA viruses have the ability to adapt to new hosts and environments, therefore identification of infection and rapid destruction of infected fish is considered an important part in control of spread of this disease.

Infectious Salmon Anaemia – ISA

During 2009, ISA was detected in ten different salmon farms in Norway, constituting a reduction from the 17 affected farms in 2008. The outbreaks occurred in several different geographical areas, with six outbreaks in mid- and southern-Troms. ISA has been a recurring problem in this area over the last three years. The last registered outbreak in this area was diagnosed in July 2009. A single outbreak has been registered in north-Troms and three in Nord-Trøndelag.

ISA is caused by a virus which infects and damages blood cells and cells lining the wall of blood vessels. This often results in haemorrhage in inner organs and the fish develops anaemia (lack of blood). The disease leads to increased mortality and is a list 2 notifiable disease. Diagnosis is based on several criteria, in which identification of typical pathological changes are combined with detection of virus. Viable virus can only be demonstrated by culture in cell culture, with subsequent identification using IFAT. While PCR is also used for detection of ISA-virus, PCR detection alone is not sufficient to initiate counter-measures, although suspicion of ISA based on clinical signs alone may be considered sufficient to initiate such counter-measures.



Outbreaks of infectious salmon anaemia (ISA) in Norway 2005 – 2009.

Counter-measures against ISA follow a contingency plan adapted to EU regulations and OIE (world animal health organisation) recommendations. The main aim of the ISA contingency plan i.e. removal of all fish from infected sites, continues to apply.

There have been extensive problems with ISA in Chile during 2008 and 2009, and a large proportion of the aquaculture industry in that country has been affected. Production of Atlantic salmon in Chile has fallen dramatically during 2009 as a direct result of ISA. In addition to Norway, ISA is previously known from the east coast of Canada/USA, the Faroe Islands and Scotland. ISA appears to be under control in the Faroe Islands and Scotland. Prior to 2005, the disease was considered endemic in the farmed salmon population of the Faroe Islands. Since then, extensive sanitary and fallowing measures combined with vaccination against ISA have been practiced. The results so far are good, with no outbreaks of ISA diagnosed since introduction of these measures. Although the disease itself has not been detected, a variant of ISA virus known as the HPR0 genotype, considered to be low or non-virulent, has been detected relatively frequently (see under). ISA has been diagnosed in several sites in Shetland during 2009. The fish have been destroyed and the sites fallowed.

Macroscopic changes associated with ISA include darkened liver with pale heart and gills. The digestive caecae and proximal intestine may be dark coloured as a result of congestion and haemorrhage of the intestinal mucosa. Photo: Geir Bornø, National Veterinary Institute.

The significance of vertical transmission of ISA-virus, its reservoir and virulence factors, remain subjects of discussion. A report, commissioned by the Scientific Committee of the Norwegian Food Safety Authority, relating to identification of risk factors and possible changes to the current ISA contingency plan was produced by a broad group of internationally acknowledged experts. The group concluded that while vertical transmission cannot be discounted, the probability of such transmission is low. Further, they conclude that spread of infection cannot be traced by phylogenetic information alone, but must be considered together with other available epidemiological information in each individual case. The group also concluded that the most probable reservoir for ISA-virus is farmed Atlantic salmon and wild salmonid fish of which the brown trout and salmon are the most important. Otherwise, the group also considers well-boat transport of fish an important risk factor for transmission of ISA-virus.

Results of recent epidemiological studies performed in Norway and Chile indicate that horizontal transmission is probably the most common mechanism in spread of ISA. The Scientific Committee of the Norwegian Food Safety Authority is in the concluding stages of a new evaluation of the possibilities for vertical transmission of a series of fish pathogenic organisms including ISAV. This evaluation will be published at www.vkm.no.

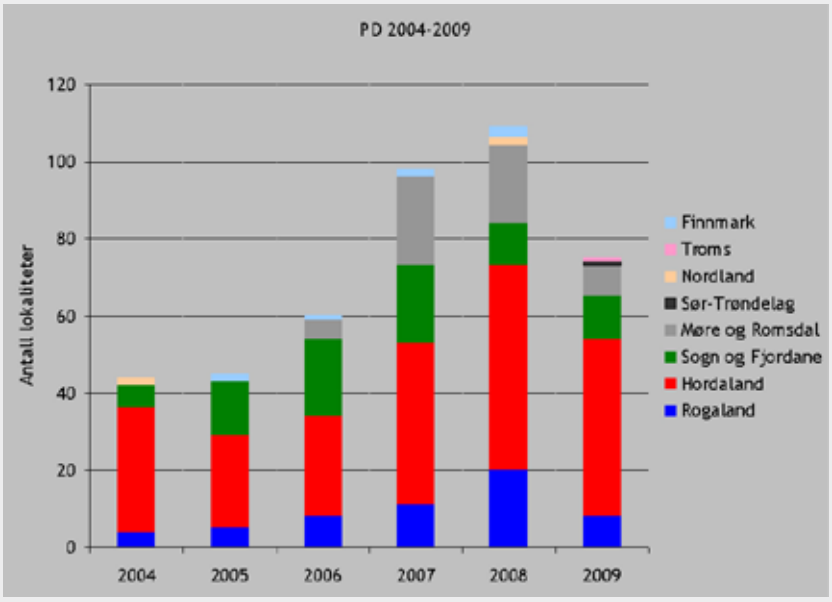
The surface protein hemagglutanin-esterase (HE) is an important ISAV virulence factor. All HE-variants related to classical ISA outbreaks display a deletion of variable size within a hypervariable area of this protein. HE-variants possessing full-length (without deletion), HPR0-genotypes are found in both healthy wild salmon and farmed salmon without classical ISA-associated clinical changes. The HPR0 genotypes have been found at various locations along the Norwegian coast, mainly in saltwater.

Pancreas Disease – PD

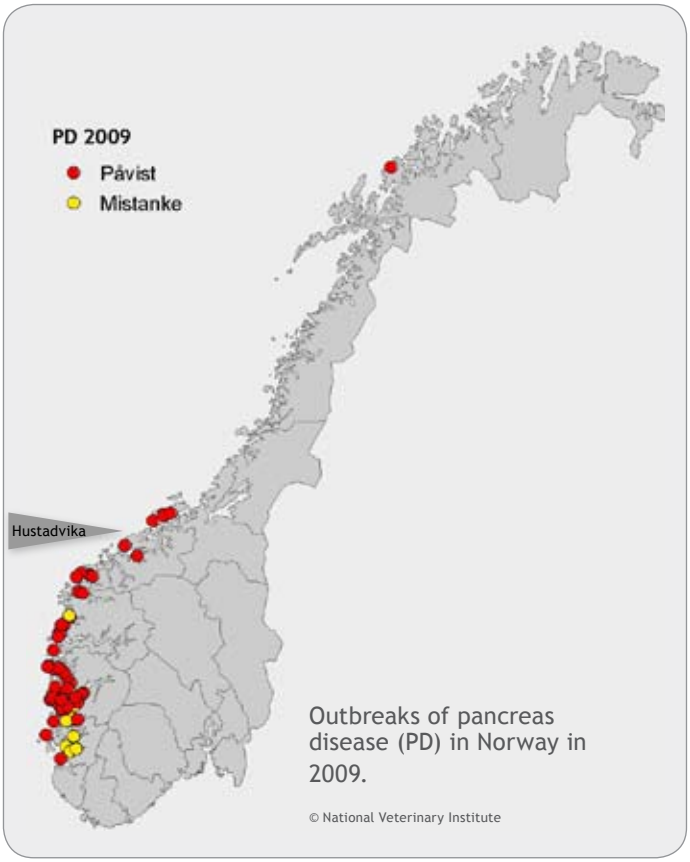
Pancreas disease (PD) is caused by a salmonid alphavirus (SAV), generally referred to as PD-virus. The Norwegian variant is one of six sub-types of SAV and is known as SAV3. Neither the Scottish/Irish PD type (SAV1) or SAV2 which causes a similar disease in freshwater farmed rainbow trout in France and Great Britain, have been detected in Norway. SAV3 is endemic in salmon and rainbow trout in important aquaculture regions in Norway. SAV4 has been detected in Ireland and Scotland, SAV5 in Ireland and SAV6 in Scotland.

The diagnostic criteria for diagnosis of PD include identification of characteristic histopathological changes together with detection of PD-virus in cell culture or by PCR-detection. As PD-virus may also be detected in healthy carrier fish, it is important that pathological changes and virus detection are demonstrated in the same individual fish in order to distinguish disease outbreak from carrier status.

Previously, diagnosis was based solely on histological findings. Today, histopathological findings consistent with PD result only in a “suspicion” of PD, and further verification of the diagnosis is necessary. Verification is based on analysis of new samples

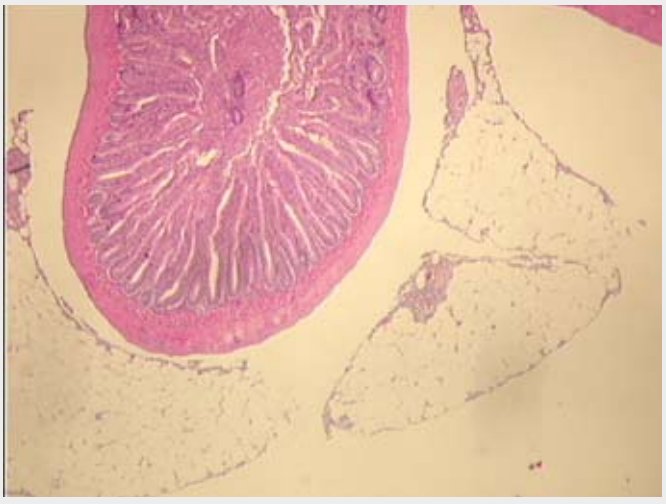


Number of PD affected sites by county in the period 2004-2009.



Outbreaks of pancreas disease (PD) in Norway in 2009.

from the site which, must be examined virologically in addition to histopathologically. From experience, presumptive diagnoses based on histology are to a large degree supported by subsequent verification within the National Veterinary Institutes' diagnostic system.



8 Necrosis and absence of exocrine pancreas in fish with PD. Photo: Geir Bornø, National Veterinary Institute.

PD was registered in 108 aquaculture sites during 2008, mainly in western Norway although a few cases were also registered in northern Norway (Nordland and Finnmark). In addition, "suspicion of PD" and "PD-virus detected" diagnoses were registered in 75 sites farming salmon and rainbow trout, mainly salmon. Western Norway continues to be the area in which most cases of PD are diagnosed. Generally, the situation is developing in a positive direction as PD was diagnosed in considerably fewer farms during 2009 than in 2008. PD has now been diagnosed north of Hustadvika, which has previously appeared to be a geographical barrier for northern spread of this disease. PD has now been diagnosed in 2 sites on Smøla in Møre og Romsdal, in 1 site on Hitra in Sør-Trøndelag and in 1 site on Senja in Troms.

PD was not registered in Nordland or Finnmark during 2009, which is considered a positive sign. Particularly pleasing is the absence of PD in the Alta area, and area which has struggled with PD over several years.
PD is a list 3 disease, and maps displaying current PD outbreaks are published in cooperation with the Norwegian Food Safety Authority on www.vetinst.no. The Norwegian Food Safety Authority has developed a plan of action against pancreas disease, and the industry is united in an effort to combat this disease. More information can be found on www.pdfri.no. Measures include synchronised fallowing, increased focus on separation of different generations, transport restrictions, disease surveillance and vaccination.

Infectious pancreatic necrosis – IPN

IPN was registered in 223 sites during 2009, representing the highest ever number of registered yearly outbreaks in the National Veterinary Institute system. IPN was diagnosed in 53 hatcheries/juvenile sites and 170 ongrowing sites in 2009 (see table). IPN is no longer a notifiable disease (since 2008), and this may have resulted in a larger degree of under-reporting compared to previous years.

Large variations in mortality are normal between outbreaks of IPN. It may appear that IPN was a larger problem during 2009 than in 2008. This view is supported by reports from several local fish health services who considered IPN to be particularly problematical in 2009. Individual sites experienced very

high levels of mortality as a result of IPN-infections, particularly during juvenile production. IPN can also be a significant problem in the form of reduced growth in fish surviving an outbreak. It is important that such fish be removed from the population as these individuals pose a threat of infection and are also prone to other diseases.
An IPN diagnosis is based on demonstration of necrosis in pancreatic tissues and positive immuno-marking for IPN-virus in affected tissues. Healthy carriers are common, and it is important that an IPN diagnosis is not based on the evidence of virus detection alone. In juveniles, infection with e.g. flavobacteria and Yersinia ruckeri may present clinically similar pictures and therefore verification of diagnosis is important.

Nearly all Norwegian salmon are i.p. vaccinated against IPN in addition to the most common bacterial diseases. In addition, a number of oral vaccines against IPN are used during the juvenile stages. The effect of vaccination in relation to other preventative measures is commonly debated. Management routines and environmental conditions may affect the outfall of a disease episode. Concurrent infections with other agents can also be decisive in relation to how large resultant losses are. As an example, in the juvenile phase, outbreaks of yersiniosis may be experienced prior to- or following- an IPN infection, which may result in significant losses.

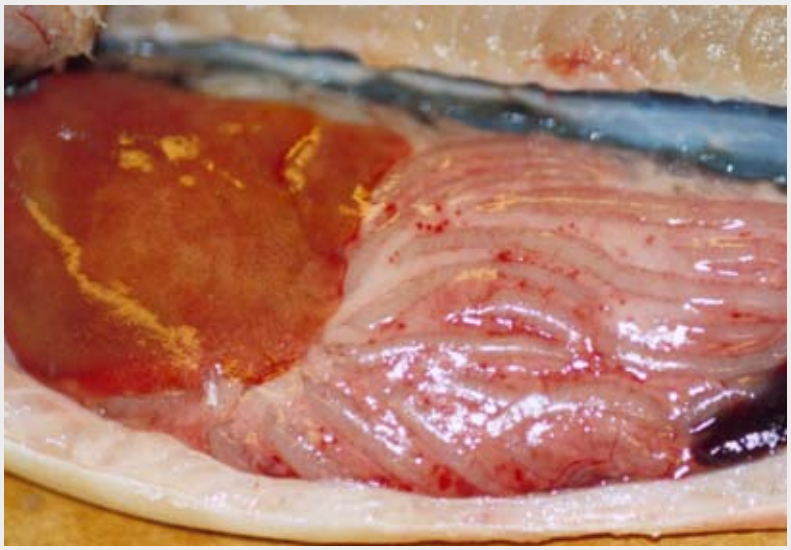
Bacterial diseases

Infection with *Flavobacterium psychrophilum*

Flavobacterium psychrophilum causes large losses in aquaculture throughout the world.
The bacterium is associated with ulcers, fin-rot and systemic infection in several species of fish. Rainbow trout (Oncorhynchus mykiss) and silver salmon (Oncorhynchus kisutch) are considered particularly susceptible.

Systemic infection with F. psychrophilum is referred to as bacterial cold water disease (BCWD) in large fish or rainbow trout fry syndrome (RTFS) in juvenile rainbow trout. Until the mid-eighties BCWD had only been reported in salmonids in North America. By the end of the eighties it had been diagnosed in rainbow trout in Germany, France and Japan. Since then the disease has been reported from all areas of the world in which culture of salmonid fish is practised.

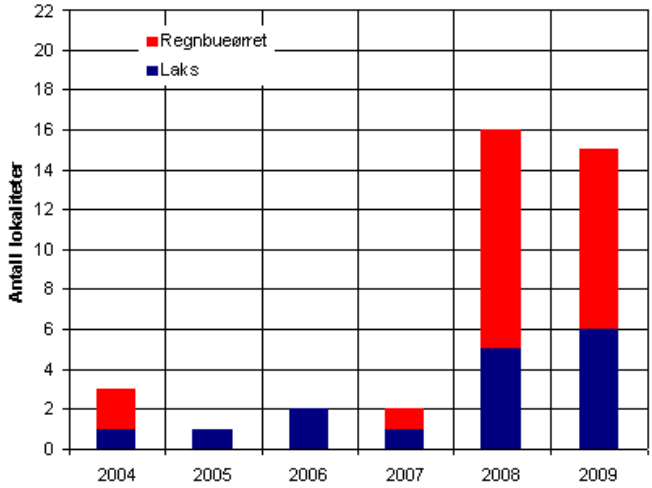
During 2008 there was a dramatic increase in the number of outbreaks of systemic Flavobacterium psychrophilum infection in rainbow trout in Norway. Previously, this bacterium has been mainly linked



Tabell 2. Number of sites with IPN-outbreaks, broken down into salmon and trout in fresh- and salt-water.

IPN-outbreaks	Salmon	Rainbow trout
Smolt plants	52	1
Sea cages	169	1
Total	221	2

Typical findings associated with IPN-infection are pallor of the inner organs, and local haemorrhage. (The intestine is often empty, and ascites in the abdomen is common. The fish often have long, white strands consisting of faeces and intestinal tissue hanging from the anal vent). Photo: Geir Bornø, National Veterinary Institute.



Number of sites with Flavobacterium psychrophilum-infection in rainbow trout and salmon in Norway, 2004-2009.

Rainbow trout juveniles with Flavobacterium psychrophilum-infection. The fish has a distended abdomen and dark pigmentation of the posterior portion of its body. Photo: Hanne Nilsen, National Veterinary Institute.

with surface complaints such as ulceration and fin rot in Norwegian salmon (Salmo salar) and brown trout (Salmo trutta).

In 2009, systemic infection with Flavobacterium psychrophilum was registered as the cause of mortality in rainbow trout in a total of nine sites: two juvenile production units, one inland site and six sites in seawater. The affected sea sites were all situated in the same fjord in Western Norway characterised by an upper layer (1m) of low salinity (4-14 ‰) water. Outbreaks in the sea occurred at temperatures between 13-18 °C and led to mortality levels of just over 2% over a 14 day period. The disease was also recorded in the same fjord during 2008, and it may be speculated that the bacterium is now established in this area.
In one site, additional diagnoses of vibriosis (Vibrio anguillarum O1) and BKD (discussed under BKD) were registered.
Spiral swimming, morbidity and reduced appetite are commonly associated with systemic infection in rainbow trout juveniles. A short period of "cramp" may occur prior to death. In larger fish, skin lesions including bloody "boils", open ulcers and fin-rot are more common. The fish often display a distended abdomen, and may appear dark in colour which may later turn pale due to anaemia and/or oedema. A large, blood-filled, possibly liquefied spleen is often characteristic.
In large sea-water cultured rainbow trout, typical findings include large pus-filled, subcutaneous "blisters" in affected fish. Microscopical investigation of affected tissues revealed necrosis, oedema and long thin bacteria in the milt. The splenic capsule is also commonly inflamed. In ulcerated fish, areas with infiltration of inflammatory cells can be seen in skin and skeletal musculature. Necrotising inflammation of the pericardium with spread to the heart musculature is also observed.

During 2009, infection with Flavobacterium psychrophilum was registered in six salmon farming sites and one Arctic charr site. In these species the bacterium was associated with ulceration, fin-rot or as an additional finding in other diseases. Systemic infection was also diagnosed in one stock-enhancement hatchery (see capital on the health situation in stock-enhancement hatcheries).
Diagnosis of F. psychrophilum infections is based on clinical observations, post mortem examination, histopathology, culture and identification of the bacterium using phenotypical testing and sequencing of the 16S-gene. The bacterium grows only on special media and may be detected by immuno-marking (immunohistochemistry) in affected tissues.

Previously investigated isolates of F. psychrophilum from rainbow trout in Norway have displayed reduced sensitivity to oxolinic acid. Such reduced sensitivity has not been identified in isolates recovered from salmon and brown trout. Genetic studies carried out at the National Veterinary Institute have shown that isolates from rainbow trout are closely related to each other and different from those isolated from Atlantic salmon and brown trout.
Internationally, systemic infections are treated primarily with antibiotics in addition to establishment of production routines which hinder development of disease (good water quality, hygienic barriers, stress minimisation etc.). Florfenicol has been used in affected hatcheries, with lack of effect reported in

one site. An autogen vaccine has been approved and taken into use in rainbow trout transferred to sea in affected fjord systems.

Yersiniosis

Yersiniosis is caused by infection with the bacterium Yersinia ruckeri and may result in increased mortality in salmon and rainbow trout during the whole juvenile phase of culture. Infected fish transferred to sea may also suffer losses after sea transfer. In 2009, yersiniosis was detected in 15 sites, which is one site less than reported in 2008. The bacterium was isolated from both the freshwater phase (eleven sites) and in sea water farmed salmon (four sites). Several cases reported from freshwater are related to long term problems, and in some sites repeated antibiotic treatments have occurred. Reduced sensitivity to oxolinic acid has been demonstrated in isolates from one site. Of the 15 affected sites investigated in 2009, isolates from 14 were identified as serotype O1, while a single serotype O2 was identified.

Winter ulcer

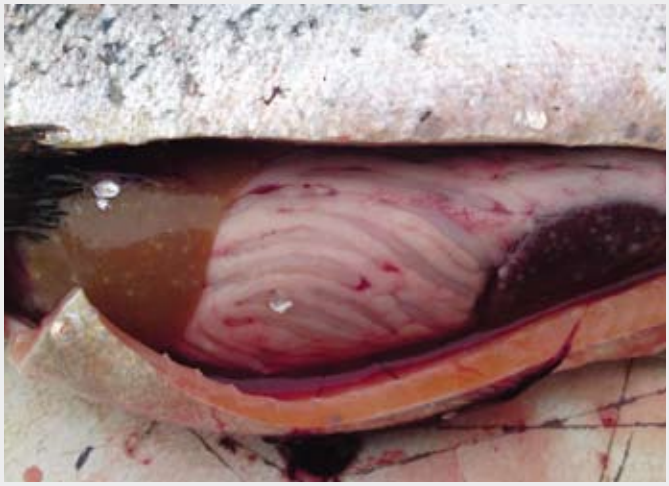
The bacterium Moritella viscosa is considered an important aetiological agent of winter ulcer, although in some cases other bacteria may also be isolated. The total causal picture is, therefore, not completely clear, and this area is now being extensively researched. In addition to direct losses associated with mortality, the disease leads to large financial losses through down-grading of the final product.
The National Veterinary Institute registered M. viscosa from a total of 36 sites in 2009. With the exception of two isolations from rainbow trout, all were from Atlantic salmon. New research has shown that strains isolated from rainbow trout are phenotypically and genetically different from those strains causing disease in salmon in Norway.
Information from local health services indicate that winter ulcer has been less problematical during 2009 than previously. It remains unclear however, whether this development is due to vaccination, other preventative measures or natural variation e.g. water temperature. Antibiotic treatments have been used in a few sites during 2009, with debatable effect.

Winter ulcer in Atlantic salmon. Photo: Geir Bornø, National Veterinary Institute.

Bacterial Kidney Disease – BKD

Three cases of bacterial kidney disease (BKD) were diagnosed during 2009, two in individual sea-farmed rainbow trout (from different farms in the same fjord system) and the third in sea-farmed Atlantic salmon.

BKD is not a significant problem in Norwegian salmon production. The number of outbreaks has drastically reduced over the last 15 years due to good brood stock testing routines. The agent can however, occur in healthy carrier wild fish, such that the threat of horizontal transmission will always exist.



Salmon infected with Renibacterium salmoninarum. Granuloma in liver and spleen with haemorrhage in visceral fat tissues. Photo: Cecilie Skjengen, Kystlab.

Piscirickettsiosis

Piscirickettsiosis is caused by the bacterium Piscirickettsia salmonis, and is one of the largest disease problems in fish farming in Chile. In recent years, this disease has been only occasionally registered in Norwegian aquaculture, and Norwegian isolates of P. salmonis are considerably less virulent than Chilean isolates. As in 2008, only one incidence of piscirickettsiosis was recorded during 2009.

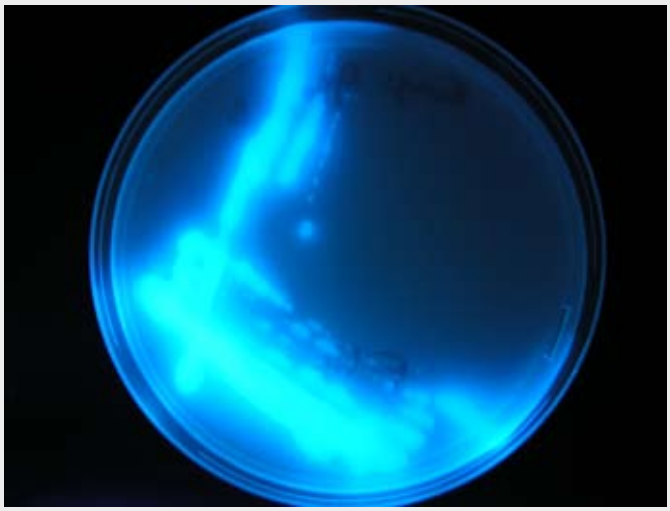
Pseudomonas fluorescens

Several Atlantic salmon juvenile production units have experienced unusually large losses due to infection with the bacterium Pseudomonas fluorescens. Especially high losses are associated with vaccination and sea transfer. P. fluorescens is commonly associated with poor water quality. Improvement in environmental quality has often solved the problem, such that the bacterium is considered opportunistic and a secondary cause of disease. Over the last year however, the bacterium has begun to be suspected as a primary problem in several farms. Systemic infections, with large numbers of bacteria, particularly in the spleen, with significant mortality, have been registered. Investigations are now underway in an effort to establish whether this is a result of changes in the fish, environment or bacterium. Results of a pilot infectious challenge indicate that the strain concerned may be particularly virulent. Further mapping of the problem is being currently undertaken.

Other bacterial infections

All Norwegian farmed salmon are vaccinated against vibriosis, coldwater vibriosis and furunculosis. No outbreaks of coldwater vibriosis, furunculosis or atypical Aeromonas salmonicida infections were detected in salmon in 2009.

Vibriosis, caused by Vibrio anguillarum serotype O1 was registered in unvaccinated salmon juveniles following intake of sea water in a freshwater hatchery and in a further eight sea water rainbow trout farms. In rainbow trout, much simpler vaccines are generally used against vibriosis, which normally provide good protection.



Pseudomonas fluorescens on Kings agar B.
Photo: Geir Bornø, National Veterinary Institute.

Gill problems

Proliferative Gill Inflammation – PGI

Proliferative gill inflammation (PGI) is a term used to describe a condition observed in farmed salmon in Norway since the 1980s. Most diagnoses are made in the autumn, between August and December, in salmon transferred to sea in the spring of the same year. As the season progresses the fish may develop serious gill injury, characterised by moderate to extreme thickening of the gills. Haemorrhage, necrosis and inflammation are also common observations. In nearly all cases epitheliocysts can be observed in affected gill tissues, but no clear causal relationship has yet been demonstrated.
Although various viruses have been detected in some cases of PGI, any causal relationship remains unclear. The direct losses resulting from gill problems are high, both in the form of increased mortality and indirect losses through reduced growth etc. Based on reports from local fish health services and the National Veterinary Institutes own registrations, it would appear that PGI has been slightly less of a problem during 2009 than in previous years.

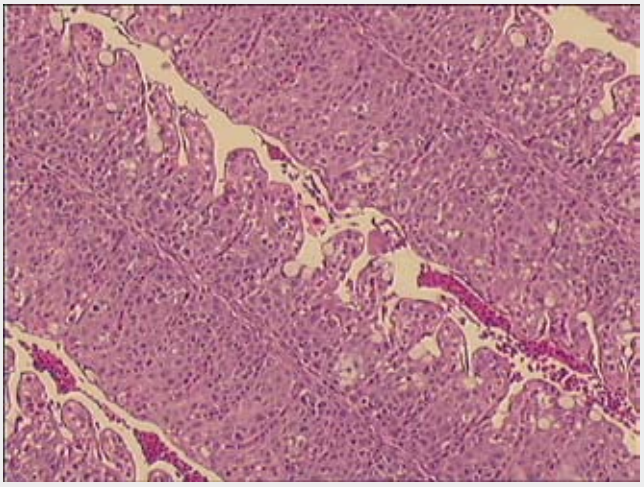
Other gill problems

The diagnosis ”bacterial gill inflammation” is awarded in many sites in both fresh- and sea- water. In such cases there is always consideration as to whether the bacteria are the primary cause or secondary to e.g. water quality, or whether the fish may have been weakened by some other factor.

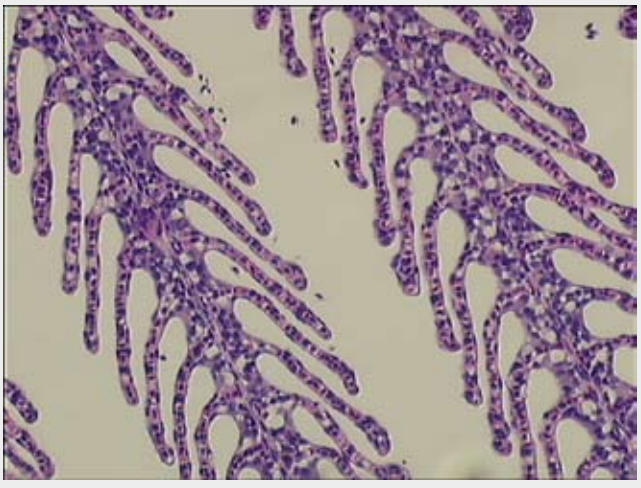
Parasite diseases

Amoeba

Again no incidence of amoebic gill disease was recorded in 2009. A PCR method for detection of Neoparamoeba perurans has now been developed, which should allow identification of the prevalence of infection and identification of possible infections which may "hide" amongst the many cases of gill inflammation of "unknown cause". Normally this type of amoeba is relatively easily identified in routine HE-stained histological sections.



Proliferative gill inflammation (PGI).
Photo: Geir Bornø, National Veterinary Institute.



Normal gills.
Photo: Geir Bornø, National Veterinary Institute.

The salmon louse- Lepeophtheirus salmonis

During the course of 2009, the highest lice numbers for several years were registered, and numbers were particularly high during the closing months of the year. According to figures reported by farmers (http://www.lusedata.no) there was an average mobile-louse burden of < 0.5 lice per fish until June, whereafter the number of lice begun to increase sharply. By September – October the average burden had reached 1.5 lice per fish. Numbers peaked in November at 2 lice per fish, followed by a slight decrease in December. These developments could be followed in reports to the Norwegian Food Safety Authority. An increase in reduced sensitivity/ resistance to those chemotherapeutants which have been in use in the last decade and which have until now been highly effective, was registered. This applies to both emamectinbenzoate and pyrethroids. Lice chemotherapeutants which have been used previously e.g. organophosphates, chitin synthesis inhibitors and hydrogen peroxide have once more been taken into use. Despite this, lice numbers have exceeded the "treatment threshold limit" in many cases. From April until September 37% of all sites had exceeded the threshold limit at least once, while 14% exceeded the limit on at least two consecutive occasions and 6% on three or more consecutive occasions. Destruction/slaughter of fish in such localities may be necessary. The National Veterinary Institute has related information from www.lusedata.no to chemotherapeutant consumption data, and the results clearly indicate that there is a positive relationship between these figures both Nationally and locally i.e. those localities using most anti-lice chemotherapeutants also report the highest lice numbers.

The louse burden in wild salmon is normally investigated during outward migration of smolts during the Spring and Summer. From these investigations there appears to have been a somewhat lower prevalence of salmon lice and much lower infection intensity in sea trout and salmon smolts examined in sea water than in 2007 and slightly lower than in 2008. The reasons for this are probably related to the relatively low numbers of lice present in salmon farms in the Spring of 2009. The numbers of lice counted on sea trout in inner fjord areas were markedly lower than those recorded from outer sea coast and outer fjord areas. This is probably related

Salmon louse female with egg strings. Photo: Trygve Poppe, Norwegian School of Veterinary Science.

to the lower salinity in inner fjord areas. In such areas salmon smolts having migrated through inner fjord areas with low numbers (possibly none) of lice travel through the outer fjord areas where they may become so louse infested that they may suffer physiological problems.

Parvicapsulosis - *Parvicapsula pseudobranchicola*

Parvicapsula pseudobranchicola is a myxozoan first described in Norwegian farmed salmon in 2002 and which causes the disease parvicapsulosis. The number of cases of parvicapsulosis rose from 29 to 34 between 2008 and 2009. Several sites have experienced outbreaks both in Spring- and Autumn- transferred salmon, and down-grading of the final product has been reported due to "loose" fillets in fish infected by P. pseudobranchicola. The economic losses related to this parasite are now significant in the two most northerly regions and the increasing number of affected sites give reason for concern. Investigations into identification of the main host for P. pseudobranchicola continue.

Spironukleosis - *Spironucleus salmonicida*

The single celled flagellate, Spironucleus salmonicida (previously Spironucleus barkhanus) can cause systemic spironucleosis in farmed salmonids. No infections with this parasite have been reported in 2009.

The parasite was detected in farmed salmon in one site in Finnmark during 2008, with all infected fish being related to a single smolt producer. Investigations performed in 2008 showed that S. salmonicida can be found in the intestine of wild trout and charr, and that these fish probably comprise the source of infection for farmed fish. Fish from three lakes in Finnmark were examined and S. salmonicida detected in all three. These findings indicate that the parasite may have a wide geographical distribution, a hypothesis supported by outbreaks occurring in both Norway and Canada.

Costia – *Ichthyobodo* sp.

According to registrations made by the National Veterinary Institute, Ichthyobodo spp. were identified in 33 salmonid farming sites in Norway during 2009, 22 of which were in Northern- Norway, 9 in mid-Norway and 5 in South- and Western-Norway. This is the same number of registrations as in 2008. The parasite is most probably under-diagnosed in the National Veterinary Institutes' system, as local fish health services often diagnose infections using direct microscopy and initiate treatment without further consultation. This group of parasites can infect both skin and gills of fish in both fresh and salt water. Many different species of Ichthyobodo sp. exist on different species of fish. On identification

of infection in fresh water, fish may be treated with formalin to good effect. Treatment in sea water is practically difficult.

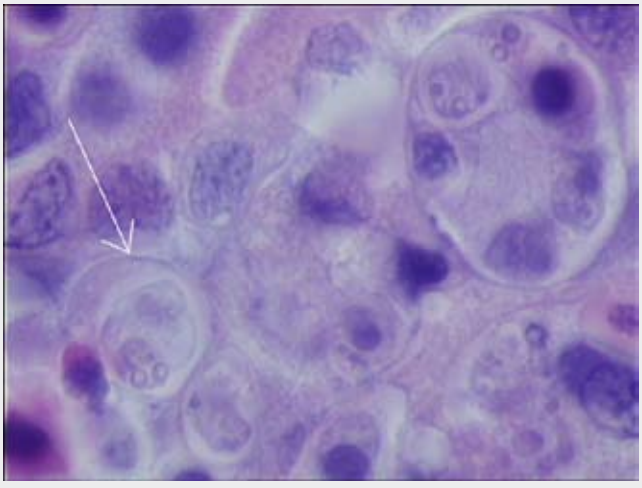
Tapeworm

Tapeworm belonging to the genus Eubothrium are only slightly problematical in fish farming today, and treatments only rarely performed. During 2006, a reduced effect of praziquantel treatment was reported. This problem was not reported in 2009.

Infections with the microsporidian Desmozoon lepeophtherii (synonym Paranucleospora theridion)

Speculations have been made during 2009 on a possible relationship between so-called "autumn disease" (see separate section) and the microsporidian parasite Desmozoon lepeophtherii (Freeman & Sommerville, 2009).

This microsporidian was first identified in 2003 in salmon-lice Lepeophtheirus salmonis in Scotland, but was not formally described and named until 2009. Early in 2010, a description of a microsporidian from salmon and salmon-lice was published and named Paranucleospora theridion. Although there are some small differences in the DNA sequences used to describe these two variants, they are considered to represent the same species.



Parvicapsula pseudobranchicola (white arrow). Photo: Geir Bornø, National Veterinary Institute..

Microsporidians are single celled, obligately intracellular parasites normally found in insects, fish, crustaceans and also in humans. These parasites spread via a spore stage which can survive long periods outside the host. A number of species have a direct life cycle, whereas others require an intermediate host. The previously recognised fish pathogenic microsporidean species Loma salmonae and Nucleospora salmonis have not been identified in Norway.

Desmozoon lepeophtherii is closely related to N. salmonis and has the salmon louse as final host and Atlantic salmon as intermediate host. The parasite is also found in the sea-louse Caligus elongatus and in rainbow trout. It has been demonstrated in all tissue samples examined from Atlantic salmon and all developmental stages of the salmon-louse. The parasite has also been detected in salmon-louse egg-strings by real-time PCR. It is therefore presumed that the parasite may transmit vertically, although the parasite has never been directly microscopically observed.

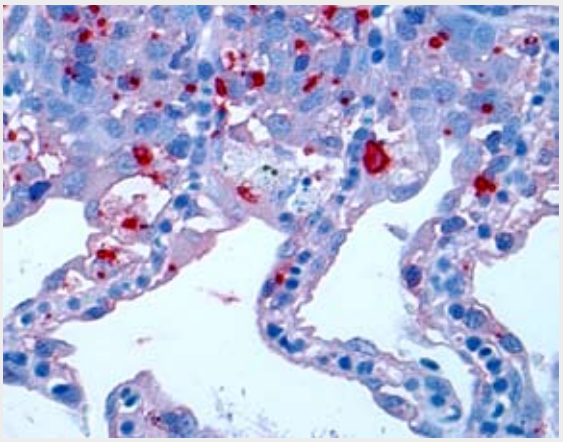
Although much is known relating to the parasites biology, much remains to be found out in relation to its role in development of disease in salmon. In order to relate presence of the parasite to pathological changes in the tissues of the fish, the National Veterinary Institute has established (amongst other techniques) in situ detection techniques, which show that hyper-infections of the parasite can be related to certain gill pathologies. For conditions other than these gill pathologies, the importance of Desmozoon lepeophtherii for the health of salmon remains for the moment unknown. Further elucidation will require thorough investigation which must also take into account the possibility of multi-factorial interactions.

The National Veterinary Institute has in the course of 2009 investigated (molecular investigations) 15 cases in relation to D. lepeophtherii, based on indications following histopathological investigation. The microsporidean was detected in 12 of these cases.

Other health problems

"Autumn disease"

During the autumn of 2008 several cases of disease, with similar clinical and histological findings were detected in farmed salmon. The cases were geographically spread from Rogaland to Møre og Romsdal. Mortality was variable with losses of up to 20% registered, in addition to reduced growth. Clinically, respiratory problems were common, with swollen pale gills, yellow-brown liver, ascites and congested and swollen spleen and kidney. The intestine in affected fish was normally empty. Microscopic investigations of tissue sections revealed necrotic and later proliferative changes in the gill. In serious cases, changes were also observed in the kidney. Inflammation of the peritoneum and inner organs with signs of increased degradation of blood cells were normal observations. Bacteriological and virological investigations gave negative results. Due to the occurrence of the disease in the autumn and lack of identification of a presumptive aetiological agent/s, the condition was termed "autumn disease". The timepoint of the first diagnosis in 2009 was almost exactly the same as that of 2008, although the number of cases reported during 2009 was lower and the pathology less severe. The cause of the disease remains unknown. The microsporidian Desmozoon lepeophtherii has been proposed to be the causal agent (see section on infections with the microsporidean D.lepeophtherii). It would appear that this parasite is transmitted to salmon via salmon-lice.



In situ-hybridisation using nucleic acid sequences (probes) from Desmozoon lepeophtherii shows severe infection (red colour) in the gill with necrosis of epithelial cells. The sequences were obtained from the study published by Freeman in 2003. Photo: Simon Weli and Ole B. Dale.

Cardiomyopathy syndrome - CMS

Cardiomyopathy syndrome (CMS) is a very serious and economically important disease of farmed salmon, first described in the mid-eighties. The condition is also referred to as "acute cardiac mortality" and "heart rupture". While daily mortalities are in many cases low, accumulated mortalities may reach 2-30%. Despite the normally low numbers of fish which die, financial losses may be considerable as it is most often large, harvest ready fish which are affected.

In 2009, the National Veterinary Institute registered CMS in 76 salmon farming sites, compared to 75 in 2008. The general impressions from the field are that CMS-losses during 2009 are more or less the same as previous years.
During 2007, the transmissible nature of CMS was demonstrated in laboratory trials. A viral aetiology is suspected, but this is as yet not confirmed.

A CMS diagnosis is based on typical histopathologically observed findings i.e. relatively specific inflammation in specific areas of the heart musculature. The availability of other, more specific diagnostic methods for detection of aetiological agents would be advantageous: The diagnosis would be more secure, and would allow identification of early stage disease and identification of atypical manifestations of the disease. Further it would allow differentiation of the disease from important notifiable differential diagnoses e.g. heart and skeletal muscle inflammation (HSMI) and pancreas disease (PD).

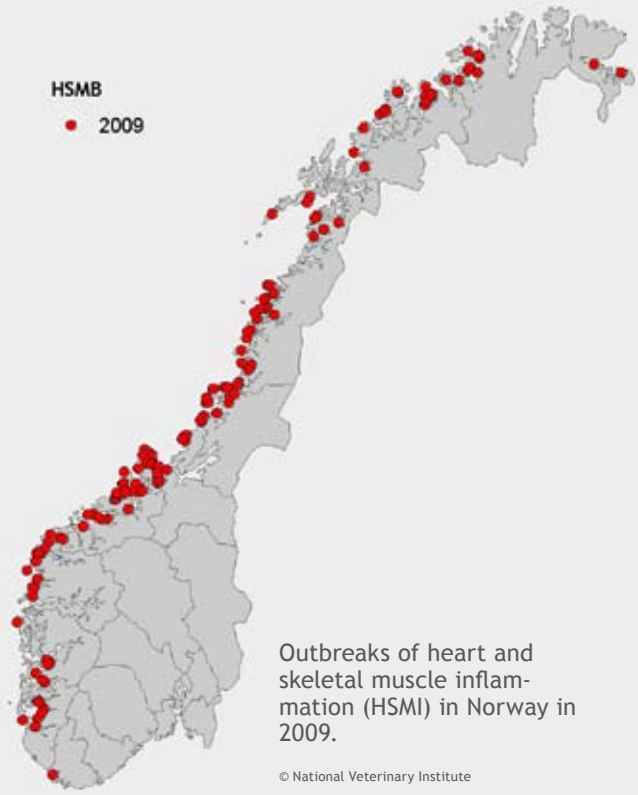
Salmon with CMS. The most characteristic macroscopic changes are most commonly a ruptured atrium, or an enlarged atrium with a blood (coagulated)-filled pericardium. Photo: Marta Alarcon, National Veterinary Institute.

Heart and skeletal muscle inflammation - HSMI

The cause of HSMI remains unclear although infectious challenge trials indicate that a viral agent may be involved in the disease. In 2009, a virus thought to be involved in development of HSMI was identified. It appears that while all farmed fish are infected with this virus, and that 20-30% of wild fish are also carriers, sick fish carry a much higher load of virus than healthy fish.

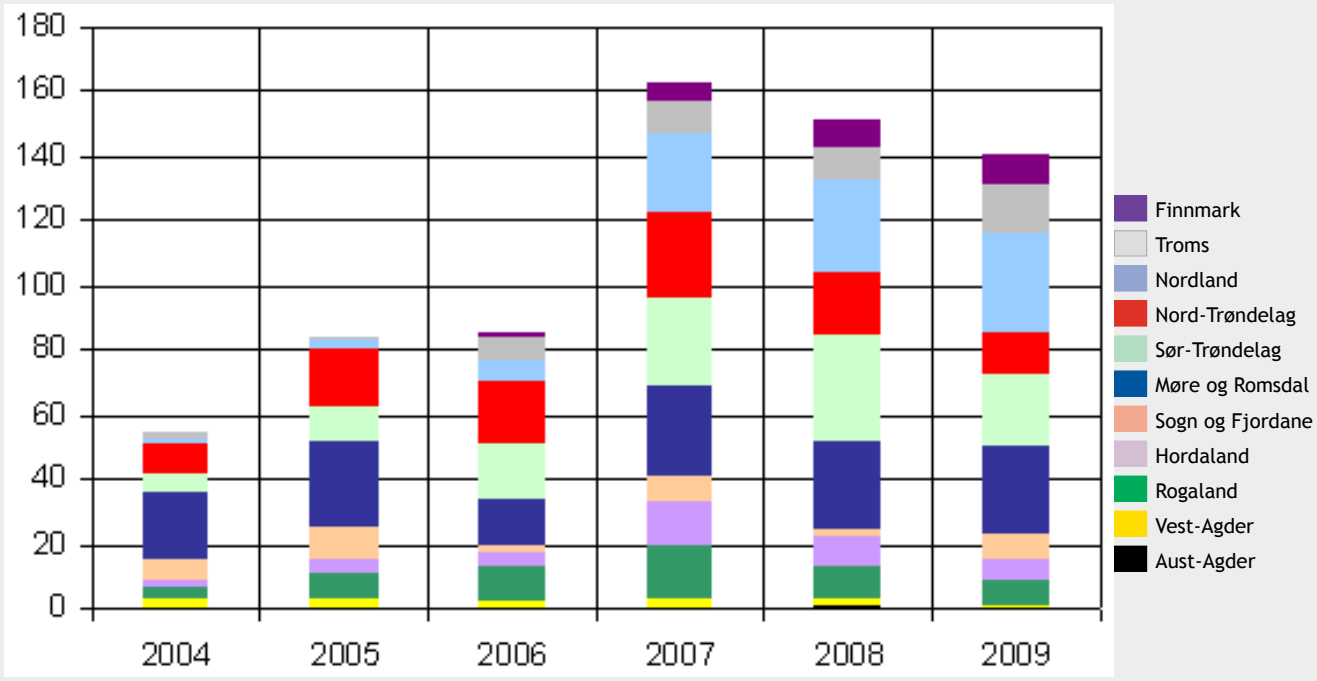
New diagnostic techniques are under development. Establishment of diagnostic techniques for detection of aetiological agents will constitute a significant step in characterisation of this disease. Today, diagnosis is based on histologically observed pathological changes in the heart and skeletal musculature of salmon. The investigation must include several fish, and suspicion of HSMI is strengthened in the absence of detectable PD-virus.

HSMI was diagnosed for the first time in 1999, and the number of outbreaks has increased dramatically every year until now. The number of sites affected by HSMI in 2009 lies at around the same level as 2008. A total of 143 sites were diagnosed with HSMI during 2009, with most affected farms situated in mid- and northern Norway.



Outbreaks of heart and skeletal muscle inflammation (HSMI) in Norway in 2009.

HSMI was not diagnosed during juvenile production in hatcheries using sea water buffering. The disease is normally diagnosed during the first year after seatransfer.



HSMI affected sites broken down into region 2004 - 2009. .

Salmon with HSMI.
Photo: Kjetil Olsen, Senja fish health service.

Arteriosclerosis in salmon, re-canalisation of blood vessels in the heart. Photo: Trygve Poppe, Norwegian School of Veterinary Science..

The disease is registered throughout the year and is associated for the most part with moderate mortality levels. The lengthy course of disease may, however, lead to large economic losses over time. Apparently clinically healthy fish in sites with diagnosed HSMI may also display significant inflammation in the heart and skeletal musculature. It is therefore important that these fish are not unduly stressed during this period.

Other cardiac complaints

Different diseases related to the heart and circulation are believed to be under-diagnosed in most salmon producing countries, including Norway. Abnormalities and functional flaws related to the heart are easily overshadowed by infectious diseases with high mortality and clear cause. Under-dimensioned hearts, abnormal form and reduced function result in a reduction of the fish's capability to resist stress and thereby result in increased mortality. Many of these conditions are probably related to culture environment, activity level and diet. Conditions of this type include restriction of the cranial artery, poor development of the outer muscle layer and metabolic dysfunction. During the course of 2009, fatal arteriosclerosis has been demonstrated in individual fish. Local fish health services have reported several cases consistent with this complaint. Confirmation of diagnosis is often difficult due to the difficulty in obtaining histological sections including the point of arterial restriction, or due to submission for histology, of areas of the heart where such pathological changes do not normally occur. On occasions of diffuse mortality, field health services should be aware of this complaint and the importance of submitting the correct sample tissues. This is particularly applicable in large salmon.

Tumours

Malignant intestinal tumours were diagnosed for the first time in 2005 in brood stock of both salmon and rainbow trout. In subsequent generations up to and including 2007, very high prevalences of macroscopically visible intestinal tumours were registered in certain groups of brood stock. The common factor in all severely affected groups was that all had been fed a particular type of feed. The results of a study relating to the prevalence of- and pathological changes associated with- such tumours have been published. During the spawning season of 2008 the frequency of detection of this type of tumour was very much reduced, probably due to the discontinued use of the suspected feed type. During 2009, the same type of tumour (adenocarcinoma) was identified in approximately 0.5% of a large broodfish population. This demonstrates that although the feed shift may have reduced the prevalence or delayed tumour development, such tumours remain a significant problem. Closer studies of the causes are difficult as the lists of ingredients for commercial feeds are not available.

No detectable carcinogens have been identified which could explain the tumour development. During 2009 only a few malignant tumours (malignant lymphoma, hepatocarcinoma) have been identified. This strongly indicates a production related cause.

Hemoragisk smolt syndrome – HSS

Haemorrhagic smolt syndrome (HSS), also known as haemorrhagic diatese (HD), causes mortality in large, apparently good quality smolts during the fresh water stage. The disease is diagnosed most often by local fish health services following observation of macroscopically visible muscular haemorrhage. Histopathologically, multiple haemorrhages in diverse organs including observation of blood within kidney tubuli, may be observed. The National Veterinary Institute has diagnosed the condition in 49 sites during 2009.

Assessment of the impact of this disease is difficult due to the lack of reporting. Information from the field indicates that this disease results in limited, but nevertheless clear losses in many fresh water juvenile production units. The cause of the disease is unknown, but is clearly associated with the smoltification process and affects the largest and "best" fish. Mortality reduces and stops following sea transfer. Macroscopically the disease is similar to VHS which causes serious circulatory disturbances, and verification by histology and/or viral investigation is desirable.

Deformities

In 2008, fish health services reported a welcome reduction in prevalence of deformity in salmon. While this positive trend continues in 2009, it is clear that some problems remain, particularly related to deformities of the jaw.

Jellyfish and algae

In 2009, significant mortality was experienced in one juvenile production unit in association with large quantities of the algae Dinobryon. As no pathological changes were observed in the gills or other organs examined, it is considered probable that the mortality was related to low oxygen levels in the water or physical suffocation by the algae.
Normal clinical signs associated with jellyfish/ algal blooms include respiratory problems and fish swimming with an open mouth. Haemorrhage may be observed in the gills. On suspicion of a jellyfish/algae problem, correct diagnosis may depend on rapid water sampling, as jellyfish and algae can rapidly disappear.

Predator problems

Local fish health services report problems associated with predation by cormorant, heron, seal and otter. Predators often injure more fish than they kill and injuries are often subject to bacterial infection which may develop into e.g. winter ulcer. Predator attacks also commonly stress the fish population, which may in turn compromise the immune defences.

Vaccine side-effects

All salmonids farmed in Norway are intraperitoneally vaccinated. This practice has given huge rewards in terms of protection from e.g. furunculosis and vibriosis. Vaccines can, however, give side-effects in the form of inflammation in the peritoneal cavity (peritonitis), which can weaken the fish. Vaccine side-effects continue to be measured using the Speilberg scale, which awards a score based on the degree of adhesion between the various organs and the peritoneal wall. Histopathologically, vaccine side-effects are commonly observed as a granulomatous inflammation between the affected organs e.g. surrounding the spleen and various parts of the intestine. In recent years, while vaccine side-effects seem to score lower on the Speilberg scale, severe inflammation may still be histologically observed in some areas around the intestine. It is not unusual to observe in individual fish, both areas of severe inflammation and other areas which appear completely normal. There have been several cases during the last year of inflammation affecting not only the peritoneal mesentery, but actually penetrating underlying tissues e.g. spleen and intestinal wall. These changes have not been related to any particular vaccine, and the possibility of other cause is now being investigated. Infection with microsporidians or an autoimmune response are two possible theories requiring further research.

Table 3. Preliminary results of brood fish testing for the season 2009/2010 (Table: Torun Hokseggen, Section for Environmental- and Biosecurity Measures).

	Atlantic Salmon		Sea Trout		Brown Trout	Artic Charr	
	IPN	BKD	IPN	BKD	IPN	IPN	BKD
Rivers	26	31	1	1	0	1	1
Individual fish tested	444	556	10	10	0	13	13
Numnber of positives	2*	0	0	0	0	0	0
Detection of furunkulosis	0		0		0	0	
Comments	* Two individual salmon tested positive for IPNV. The eggs were destroyed.						

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

Parasites

Parasite checks are part of normal routine health controls. Parasites identified during 2009 include species belonging to the following families: Zoothamnium, Chilodonella, Riboschyphidia, Epistylis, Ichthyobodo, Oodinum and Trichodina. Diphyllobothrium dendriticum has been identified in brown trout in some units. Gyrodactylus has not been reported from fish reared for stock-enhancement in 2009.

Bacterial diseases

Flavobacterium psychrophilum was diagnosed in four salmon-rearing units following culture from eroded fins on Ordals medium. This probably reflects the increased efforts in monitoring for this bacterium rather than a true increase in prevalence. Mortality related to systemic Flavobacterium psychrophilum infection was, however, experienced on one site. This outbreak was treated with antibiotics.

Fungus

Swimbladder mycosis, gill mycosis and mycotic nephritis (kidney fungus) were registered in individual farms and individual fish. 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.

Environmental problems and production related diseases

One site experienced significant mortalities in juvenile salmon, for which there was a strong suspicion of copper poisoning. The farm had two water sources, one of which travelled through a copper pipe. Mortality started when the water supply was switched to the copper pipe source. This water was also “soft” (low ion concentration) which makes the fish less robust to metal poisoning. Repeated sampling from the suspected water source showed high copper levels. Water which had been standing in the copper pipes had accumulated copper and was most likely to have caused the mortality episode. Another farm experienced considerable mortality in association with Chloramine-T treatment. While several factors may have been involved, it would appear that the most probable cause was related to a miscalculation of the water volume in which the treatment took place.

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

Stock-enhancement facilities have a special responsibility to avoid intake, amplification and release of (with released fish) disease causing agents. Especially important are those vertically transmitted diseases which may be transmitted from parent to offspring and in particular infectious pancreatic necrosis (IPN) and bacterial kidney disease (BKD). The Health Service for Stock Enhancement Hatcheries therefore organises health control of wild caught brood fish for member farms and for the live and frozen gene banks for wild Atlantic salmon. Brood stock control involves post-mortem examination, culture for detection of furunculosis and IPNV and BKD (Renibacterium salmoninarum). The health service recommends testing beyond that demanded by the Aquaculture practice legislation. IPNV and BKD analyses are performed by the National Veterinary Institute, Trondheim and the Section for Immunoprophylaxis, National Veterinary Institute, Oslo. Samples from a limited number of precocious males were analysed for IPN and BKD by Patogen Analyse AS. The facilities own personnel perform bacteriology and submit cultures to the National Veterinary Institute in Trondheim on culture of suspicious colonies. During 2009, salmon, seatrout, brown trout and arctic charr were investigated from a total of 31 rivers from around the country.

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 exclude them from stock-enhancement projects. This is primarily important in protection of the genetic profile of salmon stocks in individual rivers. Examination of material gathered during 2009 indicates the continued higher prevalence of IPNV-carrier status in escaped farmed fish compared to wild fish. Scale analysis of brood stock is therefore also important as a part of disease control.

IPNV and BKD testingl

The results from this years brood stock testing are not yet fully analysed as the Fish Health Report for 2009 goes to press. Preliminary results show that BKD has not been detected in this years brood stock. IPN was detected in two individual fish, which is a lower figure than last year. Both IPNV-positive individuals were identified as wild fish by scale and genetic testing. Routine bacteriological culture on blood agar has not resulted in identification of the furunculosis bacterium (Aeromonas salmonicida subsp. salmonicida). Nematodes (Anisakis), gill maggot (Salmincola salmoneus), tapeworm (Eubothrium sp.) and Myxidium truttae were, as usual, identified in brood fish in 2009.

Skjellkontroll identifiserer rømt oppdrettsfisk, slik at disse ikke benyttes i kultiveringsarbeidet. Bildet viser hudskjell fra vill laks fra elva Bya. Foto: Håvard Lo, Veterinærinstituttet

Disease in wild salmonids

The National Veterinary Institute receives very few cases relating to disease in wild salmonid populations.

Furunculosis

Furunculosis was not identified in wild salmonid fish during 2009.

Proliferative kidney disease

During 2009 proliferative kidney disease was diagnosed in juvenile wild salmon in the rivers Åbjøra and Terråk in Bindalsfjord. Sampling was performed as part of work carried out by the Norwegian Institute for Nature Research (NINA). PKD, caused by the parasite Tetracapsuloides bryosalmonae has been previously identified in both the Åbjøra and the Terråk.

Red vent syndrome (anisakiosis)

There has been some focus on this condition in wild salmon during 2009 and the National Veterinary Institute has received a number of samples from fish with red vent syndrome (anisakiosis).
The parasitic nematode Anisakis simplex can, as L3 larvae, result in a swollen and haemorrhagic vent, although asymptomatic infections may also occur. The condition has been observed in individual fish in several Norwegian rivers. Anisakis simplex can cause disease in humans following consumption of raw, marinated or under-cooked fish.

Miscellaneous

Miscellaneous diagnoses from wild salmonid fish made in 2009 include various parasites such as gill maggots (Salmincola salmoneus) and fungal infected ulcers.

Gyrodactylus salaris

A total of 3300 salmon from nearly 100 rivers and more than 2800 salmon/rainbow trout from a total of 88 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. Samples are taken from aquaculture sites every second year in association with the OK-programmes for IHN/VHS in freshwater. The surveillance programme for Gyrodactylus salaris (FM-programme) surveys infected regions and rivers where eradication measures have been conducted. Rivers in the FM-programme are surveyed three times per year at many different localities at each time point. In 2009 the FM-programme investigated approximately 1400 juvenile salmon from rivers in the Rana region, without detection of Gyrodactylus salaris. The Rana region was therefore declared free from Gyrodactylus salaris infection from the autumn of 2009. G. salaris was not detected in any new area during 2009.

Eradication/control of Gyrodactylus salaris

During 2009, limitation treatments were performed in rivers in the Lærdal region using the ”combination method”. The Steinkjær region was subject to full-scale treatment in 2008 and 2009. Preparatory work for full-scale treatment in the Vefsna region (planned for 2010 and 2011), was performed during 2009. This work included simulated treatment with dyes as well as physical and hydrological surveying. In efforts to preserve the sea trout population in the region, 2209 captured sea trout were genetically tested, salt treated and transported above the treatment area in the rivers Vefsna, Fusta and Drevja. The fish barrier in the river Leir in Leirfjord was completed in April 2009, and during the course of the season 1211 sea trout and 996 sea-run Arctic charr were salt treated and transported upriver.
The Rana region was declared Gyrodactylus salaris free following rotenone treatment in 2003 and 2004.

Fish Welfare

Good health is a precondition for good welfare. Many of the diseases discussed above have clearly negative implications for fish welfare e.g. gill inflammation and salmon lice. Simple registration of survival and/or mortality is not sufficient to describe the importance of the disease in terms of welfare. The welfare implications of e.g. IPN, may be as considerable for surviving fish (so called “IPN runts”) as for fish dying rapidly after infection. Knowledge relating to clinical signs and tissue changes are important in estimation of the relevance of a disease for welfare, in which both intensity and duration are important. Disease prevention/limitation measures are therefore necessary to ensure good welfare. While vaccination is one such measure, vaccine associated side-effects constitute a considerable welfare problem.

The Institute of Marine Research is the organ in Norway with official responsibility for fish welfare. The National Veterinary Institute is, however, involved in research relating to fish welfare during slaughter-related anaesthesia. Current work focuses on refining alternative methods to CO2 as an anaesthetic. Use of CO2 is forbidden in accordance with a directive relating to slaughter-houses and processing plants for aquaculture animals (Slaughterhouse act) which came into force January 1, 2007. This directive has not yet been practically enforced.

Many thanks to everyone who has contributed to this report, particularly the many fish health services nationwide. Without their contribution this annual report would not be possible.

Salmon with head injuries.
Photo: Geir Bornø, National Veterinary Institute

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The health situation in farmed marine fish 2009

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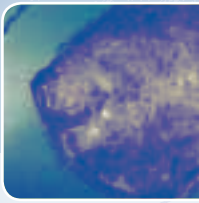

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National Veterinary Institute

There are no significant changes in the disease situation in farmed marine fish species. The majority of samples submitted are from cod, with the remainder from halibut, wrasse, turbot and other species. The bacterial infections francisellosis, vibriosis and atypical furunculosis dominate in cod-related investigations, while those involving halibut and wrasse are dominated by atypical furunculosis and infections caused by various Vibrio spp. Viral diseases appear, at least for the moment, less important in marine- than in salmonid fish

Cod

The National Veterinary Institute received over 250 samples from approximately 80 different cod farms nationwide, during the course of 2009, which is a reduction from the 350 submissions from approximately 85 farms received in 2008. The proportion of cases investigated from Northern Norway increased during 2009, which probably reflects the reduction in cod-farming in Southern Norway. Of over 450 registered cod farming concessions less than half were active in 2009, with a total production of nearly 20 000 tons (source: Kontali analysis AS).

Based on material submitted to the National Veterinary Institute, it would appear that the greatest disease problems are related to the bacterial infections vibriosis, atypical furunculosis and francisellosis. This is consistent with reports from field health services nationwide.

Bacterial diseases

Francisellosis

Francisellosis is caused by infection with the bacterium Francisella noatunensis. The disease has caused losses on such a scale in Rogaland, Hordaland and Sogn og Fjordane that many consider farming of cod in these areas to be economically unsustainable. Fish health services in Northern Norway report that losses associated with this disease seem less in the North compared to Southern Norway. It is speculated that this may be due to the generally lower water temperatures and possibly lower infection pressure from wild fish in the North.

In 2009 Francisellosis was diagnosed by the National Veterinary Institute in eight sites (figure 1).

Vibriosis

Vibriosis remains a significant problem in cod farming (table 2). There do not appear to be large changes in the proportion of serotypes O2a and O2b isolates identified. Vibrio anguillarum serotype O2b remains the most commonly identified serotype. V. anguillarum serotype O2a biotype II was not registered by the National Veterinary Institute during 2009. Reduced antibiotic sensitivity was not detected during 2009.

Vaccine development is important for reduction in vibriosis-associated mortalities. CodVacc is a four year research project (cooperation between Nofima marine, National Veterinary Institute and University of Tromsø) aimed at development of vaccines against

Table 1. Summary of cod farms with diagnosed viral and bacterial disease.

	2005	2006	2007	2008	2009
IPN	-	-	-	-	-
VNN (nodavirus)	-	3	6	3	1
Atypical furunculosis	3	13	9	16	16 **
Francisellosis	4	7	8	14	8 **
Vibriosis (*V. ang.*)	18	19	19	20	16
Cold Water Vibriosis (*Vibrio* (*Aliivibrio*) *salm.*)	2	-	1	1	3
Infection with *Vibrio ordalii*	1	-	3*	-	-
Infection with *Vibrio* (*Aliivibrio*) *logei*/*V. logei* liknende	2	1	2	-	1
Infection with *Vibrio splendidus*	-	-	-	3	2
Infection with *Photobacterium* sp.	3	3	6	4	5
Infection with *Moritella viscosa*	1	2	-	-	1

* in pure culture in one case and in mixed culture with V. anguillarum O2 biotype II in two cases.
** Atypical furunculosis and francisellosis diagnosed in the same site/outbreak in one case.

vibriosis and atypical furunculosis in cod. The project includes systematic collection and characterisation of isolates from various geographical areas, testing of experimental vibriosis and atypical furunculosis vaccines, as well as identification of bacterial components of importance for vaccine protection. In addition, the effect of vaccination (immune response and level of protection) in different populations of cod e.g. migratory and non-migratory populations, are under study. Results from CodVacc show that the immune response in cod is highly specific, and that dip vaccination of cod based on a single V. anguillarum-serotype (e.g. O2a) does not provide protection against other closely related serotypes (e.g. O2b) and vice versa. A triple vaccine, based on the three serotypes normally found in cod, does however, provide very good protection against all three serotypes.

In 2008 Helgeland Havbruksstasjon AS, Nordland Marin Yngel AS, National Veterinary Institute and two vaccine producing companies initiated a project involving testing of various types of intraperitoneal vibriosis vaccines. The aim was identification of

Fig 2. Cod with atypical furunculosis. Open and subcutaneous ulcers penetrating the musculature
Foto: Koen Van Nieuwenhove, MarinHelse AS

Fig 3.Cod with atypical furunculosis. Granuloma in the heart. Foto: Koen Van Nieuwenhove, MarinHelse AS

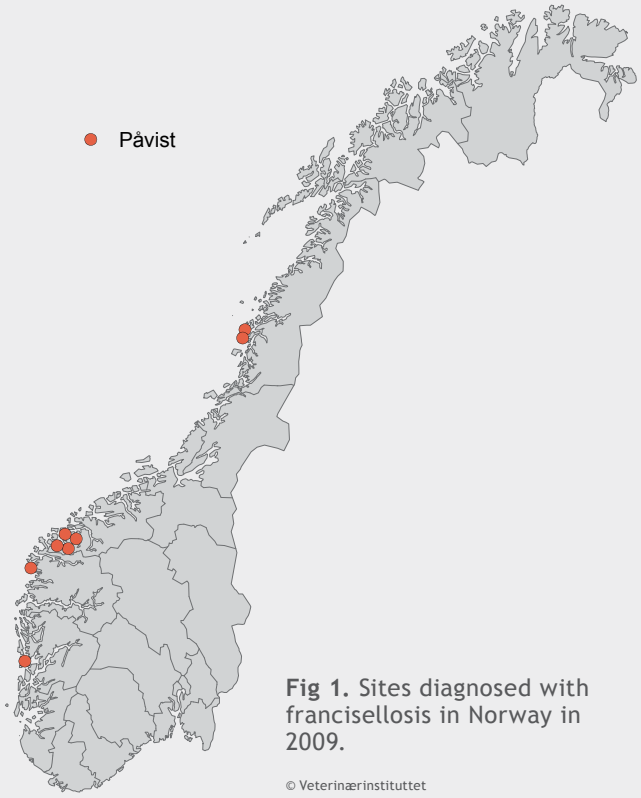

Fig 1. Sites diagnosed with francisellosis in Norway in 2009.

differences in growth and vaccine associated side-effects between one water-based and three different oil-based monovalent vaccines. The study was concluded in 2009 and revealed no significant differences in growth between the different groups during the course of the 9 month study. The oil-based vaccines did, however, result in significantly greater side-effects (adhesions) than the water-based vaccine and the negative control group. The report is available at www.vetinst.no

Atypical furunculosis

Atypical furunculosis (infection with atypical Aeromonas salmonicida) remains a serious problem in cod farming. Double infections with atypical furunculosis and francisellosis have again been identified in 2009. Atypical furunculosis in cod can give a variable clinical presentation, from chronic infections associated with high prevalence of organ granuloma, to rapid acute mortality episodes involving many fish. The outfall of such infection may depend on the age of the fish

and stress levels e.g. due to handling etc, although a clear relationship between such factors and disease development is not always obvious. Differences between isolates of the bacterium may also play a role. In the CodVacc project, A. salmonicida isolates from cod have been characterised and the immune response of the cod studied. Genetic investigations (A-layer typing) have shown that by far the majority (but not all) of A. salmonicida isolated from cod are very closely related. It has also been shown that vaccines based on A. salmonicida of a particular A-layer type award best protection against challenge by isolates of the same A-layer type.

Moritella Viscosa

The bacterium Moritella viscosa is mostly associated with winter-ulcer in salmon, but is also isolated from cod with skin lesions. According to registrations made by the National Veterinary Institute, infection with M. viscosa is not common in cod (Table 1), but has been identified at all stages of the culture cycle, from juvenile to brood stock, and from sites in Hordaland, Trøndelag and Nordland. The first isolation from cod was made from post-spawning brood stock in 2002. As a rule, lesions are observed on the flanks and on the dorsal surface behind the dorsal fin, and may penetrate the musculature.

Infectious challenges performed in Iceland have shown that juvenile cod are very susceptible to M. viscosa infection, including bath infection. In addition to ulceration, granuloma in the inner organs were also identified, similar to those occurring in atypical Aeromonas salmonicida infection. Such granuloma are not observed in M. viscosa infections in salmon. M. viscosa infection should, therefore, be considered as a differential diagnosis to atypical furunculosis and francisellosis in cod.

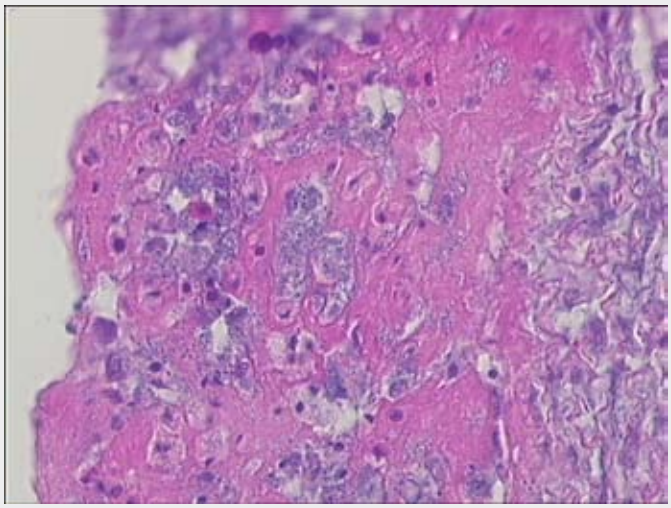

Fig 4. Cod with cold water vibriosis. Bacteria in the heart. Foto: Geir Bornø, Veterinærinstituttet

Cold water vibriosis

During the Spring and Summer of 2009, samples from three different farms experiencing increased mortality in populations of cod, were submitted to the National Veterinary Institute, Harstad.

Affected fish were between 400 – 1400g at sampling and the main clinical findings reported were associated with the heart and included what was described as an “angry” red colouration of the heart, with white nodules on the surface of- and within- the heart musculature. Adhesions within the pericardium were also identified as was a swollen kidney and spleen in one case. It would appear from these cases that cold water vibriosis in cod has a different course than that normally found in salmonid fish, where the usual findings include hemorrhage in the inner organs and musculature, focal hemorrhage and reddish-colouration of the ventral abdomen, bloody lesions and dark spotting of the operculum and dorsal areas.

Table 2. Summary of sites diagnosed with vibriosis (infection with Vibrio (Listonella) anguillarum) between 2003—2009. Number of sites (number of submissions) diagnosed.

Type	2003	2004	2005	2006	2007	2008	2009**
Totalt*	19 (26)	27 (37)	18 (18)	19 (30)	19 (54)	20 (57)	16 (22)
O1	-	-	-	-t	I-	-	-
O2 a	6	9	1	5	5	2	1
O2 a biotype II	-	-	-	3	6	2	-
O2 b	11	18	17	15	15	15	8

* Some isolates were not sub-typed. In several sites more than one sero/biotype of V. anguillarum has been detected.
** In 2009 many isolates were not sub-typed, there is therefore a degree of uncertainty regarding the prevalence of the various serotypes in some localities.

Bacteriological investigations revealed growth of Vibrio (Aliivibrio) salmonicida, the causal agent of cold water vibriosis. Histological investigations revealed a systemic infection with bacteria identified in the inner organs, especially the heart.

Vibrio (Aliivibrio) salmonicida is best cultured at low temperature and dies relatively quickly at temperatures >> 15oC. Inoculated agar plates should be stored in a refrigerator and transported to the laboratory in a chilled container. Vibrio (Aliivibrio) salmonicida grows well on blood agar plates with 2% salt (NaCl) as small, shiny, half-transparent, non-haemolytic colonies with a weak greyish colour.

Viral diseases

Viral Nervous Necrosis (VNN), which is caused by a nodavirus, was diagnosed on one site in 2009. The disease was diagnosed in juvenile cod (1 – 3 g) and high mortality was not reported.

Fig 5. Agar plate with Vibrio (Aliivibrio) salmonicida. Foto: Duncan Colquhoun, Veterinærinstituttet

Infectious pancreatic necrosis (IPN) has not according to our data, been registered in Norwegian farmed cod.

Parasites

There are no significant changes reported in the situation from last year. Trichodina can cause significant problems.

Miscellaneous

Many local fish health services and farmers consider ”miscellaneous” losses to comprise the next most significant problem after bacterial infections. While colic, deformities, egg-bound females and side-line necrosis are well-known and important categories considered under “miscellaneous”, less defined categories include “runt-development” and “emaciation”. These categories may have very different causes and the possibility of infectious disease should always be considered when investigating such losses. Cases in which bacteria-, virus- and parasitic-diseases have been discounted, do however, account for a relatively large proportion of the material submitted to the National Veterinary Institute. This indicates that there may be many factors, (including unknown contributing factors) which ultimately result in death of the fish.

Several projects financed by NCE Aquaculture have focused on cod-health, particularly in Nordland. Efforts have been made to develop regional competence in this area and a cod-health network has been established. One of these projects is the “Dead fish registration scheme”, a co-operation between Helgeland Havbrukstasjon and the National Veterinary Institute. The project has, through establishment of standardised registration and categorisation of dead fish, tried to quantify the importance of different causes of death in respect to overall losses. While the results show a large degree of variation between populations and farms, “emaciation” accounted for 30% of total registered losses. Management routines, feed, grading and quality of brood stock are identified as contributing factors.

Losses occurring in the first months following sea transfer are in the main associated with quality of the fish themselves, nutritional status and vaccination. Field experience indicates that sea transfer shortly following vaccination is negative. The quality of juvenile fish is reported to have improved significantly in recent years with fewer deformities registered. There is however a higher frequency of deformities amongst “runt” fish.

Injuries related to handling and transport can lead to significant losses. Technology and production routines developed for salmon farming cannot be directly utilised in cod farming. Cod is a cold water species and temperature-stress at water temperatures above 14oC is well known.

Table 3. Summary of the number of halibut farms with diagnosed infectious pancreatic necrosis (IPN), viral nervous necrosis (VNN) and atypical furunculosis..

	2005	2006	2007	2008	2009
IPN	1	1	1	-	-
VNN (nodavirus)	-	2	1	1	-
Atypical furunculosis(*A. salm.*)	3	2	3	2	2

Halibut

The National Veterinary Institute received over 40 submissions from 10 halibut farms during 2009, compared to 30 submissions from 8 farms in 2008. According to Kontali Analyse AS, 2000 tons of halibut were produced in 2009. There are no significant changes in the disease situation compared to previous years (table 3).

Diverse Vibrio-bacteria, including Vibrio logeii, are commonly isolated from moribund halibut with or without skin lesions. Bacterial overgrowth in the intestine and on the gills is a common finding in such fish. It is unclear whether these bacteria are the primary cause of the disease or whether they are opportunistic pathogens attacking an already weakened fish.

Wrasse

The number of submissions from wrasse has increased significantly over the last two years, with 12 submissions from 6 farms in 2008 and 14 submissions from 7 farms in 2009. Previously the annual number of submissions has been around 1 – 2 per year. Some of the increase may be due to the recent introduction of ballan wrasse farming. The term “wrasse” covers several species: goldsinney wrasse, rock cook, corkwing wrasse and ballan wrasse, of which the ballan wrasse is the largest. The increasing salmon lice problem and increased prevalence of resistance to anti-lice treatments, mean that the demand for wrasse has increased accordingly.

The disease situation in wrasse is dominated by different bacterial diseases, particularly atypical furunculosis and infection by various Vibrio-species.

Atypical furunculosis in wrasse is primarily associated with skin lesions. In ballan wrasse of 400-500g, skin lesions, hemorrhage in the swim-bladder musculature and gills, with white nodulation of the heart, liver, kidney and spleen were observed. The intestines were empty with the exception of slime in the stomach.

Anal prolapse was identified in one fish. Histologically, granuloma with centrally located bacterial micro-colonies, were found in most organs, including the gills. Aeromonas salmonicida strains isolated from wrasse are genetically different from those isolated from salmon and those isolated from other marine fish.

In the course of 2009, Vibrio spp. were identified in association with increased mortality in wrasse. In one case involving Corkwing- and Goldsinney- wrasse of around 30 g, moribund fish displayed nasal lesions and hemorrhage in the liver. Ballan wrasse juveniles (approximately 30 mm in length) were emaciated with possible jaw problems. The bacteria isolated were phenotypically similar to Vibrio splendidus, but precise identification will depend on further genetic characterisation. Previously, infection trials performed by the Institute for Marine Research have shown that Vibrio splendidus isolated from diseased wrasse are not virulent in salmon.

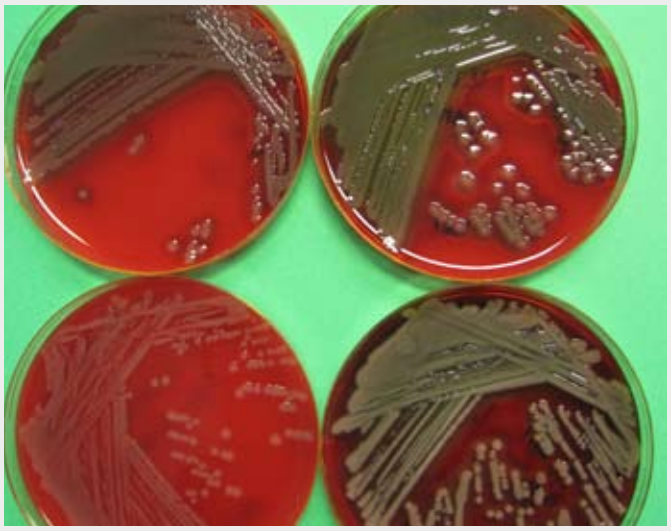

Fig 7. Agar culture of Vibrio sp. (splendidus-like). Photo: Hanne K. Nilsen, Veterinærinstituttet

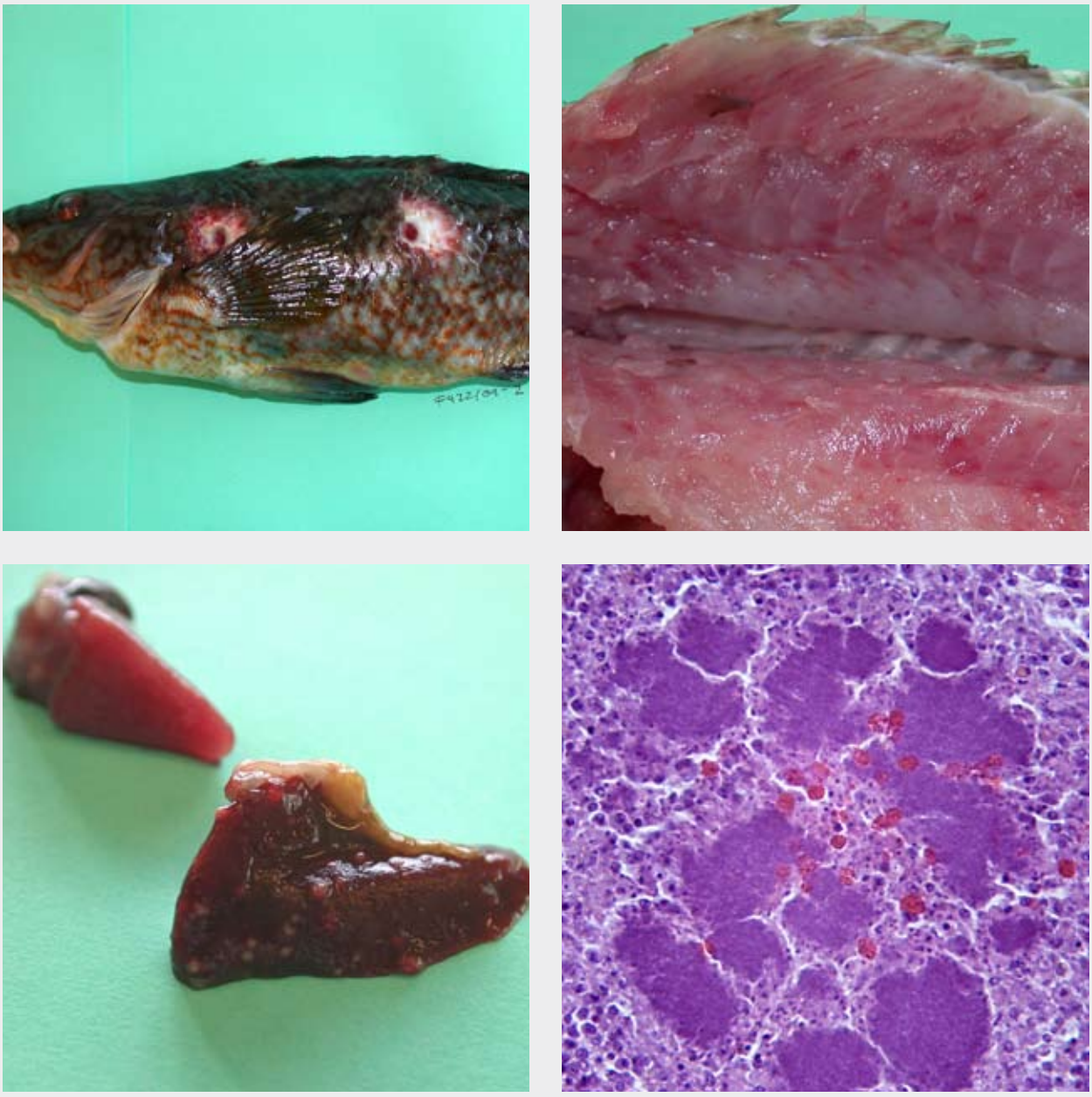

Fig 6. Ballan wrasse with atypical furunculosis. A) Skin lesion. B) Hemorrhage in musculature. C) Granuloma in the heart. D) Bacterial micro-colonies in the spleen. Photo: Anne Berit Olsen, Veterinærinstituttet

Other species

In 2009, the National Veterinary Institute received submissions from one turbot farm. Gill inflammation and bacterial infection in the intestine were diagnosed. In one case, post mortem examination revealed bleeding stomach ulcers in some fish. Histological investigation revealed extensive lesions in the stomach and intestinal-wall associated with large numbers of bacteria. A Vibrio tapetis-like bacterium was isolated from one fish, but it is not known whether this bacterium was the cause of the inflammation in the stomach and intestine.

Table 4. Summary of the number of sites (wrasse submissions) with registered bacterial infections

	2008	2009
Vibrio sp.	2	5
Vibrio anguillarum	1*	-
Atypical furunculosis(*A. salm.*)	2	2

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Notes:

The National Veterinary Institute is a national research institute in the fields of animal health, fish health, food safety and food hygiene, whose primary function is generation of research-based knowledge to support the relevant authorities.

Preparedness, diagnostics, surveillance, reference functions, combined with scientific advice and risk evaluation are the most important fields of activity. Products and services include results and reports from research, analyses and diagnostics and reviews within these fields of activity. The National Veterinary Institute cooperates with a number of institutions both at home and abroad.

The National Veterinary Instititutes' main laboratory and administration is based in Oslo, with regional laboratories in Sandnes, Bergen, Trondheim, Harstad and Tromsø.

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