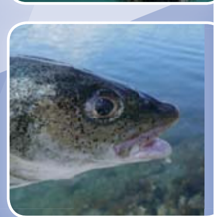
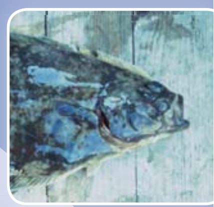
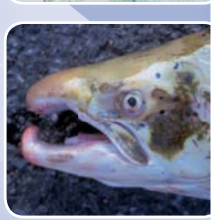
# The health situation in Norwegian aquaculture 2008







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# Directors introduction

In the course of 2008, Norwegian aquaculture produced 740 000 tonnes of salmon, 80 000 tonnes of rainbow trout, 14 000 tonnes (estimate) of cod and 5300 tonnes (estimate) of other marine species, representing a considerable increase from last year. For many years Norway has experienced a relatively favourable disease situation in farmed fish. The situation has, however, become slightly more complex in recent years.

In salmonid fish, pancreas disease (PD) gives grounds for concern. The industry has, however, united and implemented a series of concerted measures in an effort to eradicate this disease. Although it is too early to say whether the measures initiated by industry and the authorities have been effective, there are indications that the negative trend may have been stopped. This work is important not only in relation to eradication of pancreas disease, but also in relation to building a more robust infrastructure within the industry regarding fish health and control of future disease problems.

There is an increasing problem with salmon-lice resistance to various therapeutic treatments. Should this situation continue to develop it will have significant negative consequences for both wild and farmed fish. Salmon-louse control should be based on a broad range of methodologies and optimisation of existing treatments, as well as development of new control strategies. Both the industry and the authorities have increased efforts in these areas, but there is a need for even larger co-ordinated efforts over an extended period of time.

Transparency regarding the disease situation in individual farms is a basic necessity for maintenance of fish health on a national basis. Then and only then, may spread of disease be controlled. The National Veterinary Institute works towards compilation and quality assurance of disease related data. This report constitutes in part, dissemination of this data.

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# The health situation in farmed salmonids 2008

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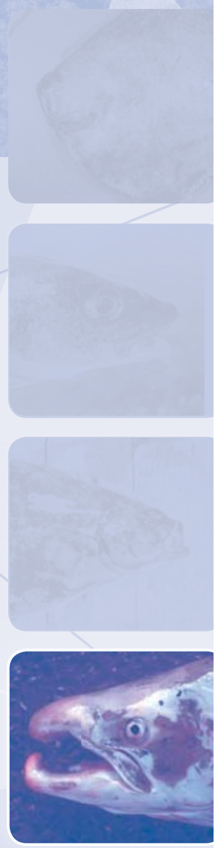

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*The health situation in farmed salmonids in Norway is relatively good, although significant losses to many diseases of both known and unknown aetiology continue to occur. The fact that there remain many diseases of unknown aetiology mean that disease diagnostic work remains challenging. As an example, during the last few months of 2008, a possibly new disease was registered in a total of 25 salmon farms.*


## Summary

Infectious pancreas necrosis (IPN) and gill-associated disease continue to account for the largest losses during the fresh water phase of culture. Of new trends for 2008, there has been a slight but marked increase in the number of registered infections caused by *Yersinia ruckeri* in salmon and *Flavobacterium psychrophilum* in rainbow trout.

The largest disease related losses during the seawater phase of culture were registered following outbreaks of pancreas disease (PD) and heart and skeletal muscle inflammation (HSMI), with both of these diseases apparently spreading to new areas. Following sea transfer, significant losses to IPN continue to be registered, although these losses are reported to be lower than in previous years. Gill disease of largely unknown aetiology during the seawater phase of culture, is an increasing problem.

Infectious salmon anaemia (ISA) has been particularly problematical in an area of south- and mid-Troms during 2008, and special measures including vaccination have been introduced in this area in an effort to control the disease. The unique isolate of viral haemorrhagic necrosis virus (VHSV) which was detected for the first time in Norway in 2007, has now been detected in several farms within the same fjord system. This isolate, now confirmed as the cause of disease and mortality in rainbow trout, is unique on a world-wide basis, as it belongs to a genotype which has previously only been known to cause disease in marine fish.

Detection of bacterial kidney disease (BKD) in a brood stock farm illustrates the importance of continued surveillance for this disease. Several fish health services have indicated that they consider development of resistance in salmon-lice as the factor of most concern for the future. The salmon-lice situation for 2008 as a whole was better than previous years, despite an increase in lice numbers towards the end of the year.

The fact that a large number of cases of a new disease of as yet unknown aetiology, in seawater reared salmon, were registered towards the end of 2008, give grounds for concern. Based on the clinical presentation, several fish health services conclude that this must be new and previously unregistered. The histopathological findings are varied, and the disease is currently being described and the causes investigated.


## Background for 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. 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.

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 hemorrhagic 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 on each list can be found on www.mattilsynet.no.

# Viral diseases

## Viral hemorrhagic septicaemia - VHS

Since 1994 all salmonid aquaculture facilities have been tested for VHS-virus every second year as part of a national surveillance programme. The virus has not yet been detected. Norway has therefore been considered a VHS-virus free zone. The first detection of VHS-virus in Norwegian aquaculture since 1974 was made in a rainbow trout farm in Storfjorden in Møre og Romsdal in November 2007. The disease was also diagnosed in two other farms in the same fjord system in 2007 and in a further two farms in 2008. The latest detection was in December 2008, when the virus was detected by immunohistochemistry, PCR and in cell-culture. All rainbow trout within this fjord system are owned by the same company and all farms have been followed closely in regard to virus detection. VHS-virus has been cultured from every outbreak and all have been found to belong to genotype III.

The same genotype was detected in an escapee rainbow trout in Storfjorden. All aquaculture sites in the fjord system containing, cod, coalfish and salmon were examined in the course of 2007 for VHS-virus without positive identification. During the same period around 260 wild fish (> 50% herring) caught around affected sites were investigated without detection of the VHS-virus. Another genotype (Ib) was however, identified in herring caught in the outer part of Storfjorden and off the Ålesund coast.

VHS is a serious infectious disease primarily affecting rainbow trout, although it has also been diagnosed in other species, both wild and farmed. Outbreaks can lead to large mortality related losses and the disease is a list 2 disease which is normally combated by stamping out. The acute stage of the disease is commonly associated with haemorrhage in the skin, musculature and inner organs. The fish display pale gills (anaemia), exophthalmia and distended abdomen. Abnormal swimming behaviour e.g. spiral swimming and flashing are registered, either as sole symptoms (nervous form) or in combination with haemorrhage (haemorrhagic form). The disease is diagnosed by detection of the VHS-virus by culture, PCR and immunohistochemistry with associated histologically observed pathological changes.

VHS-virus belongs to the novirhabdovirus family, and has a single-segment RNA genome. VHS-virus can be split into four genotypes, I-IV (and at least seven sub-groups), of which genotypes I-III have been detected in Europe.

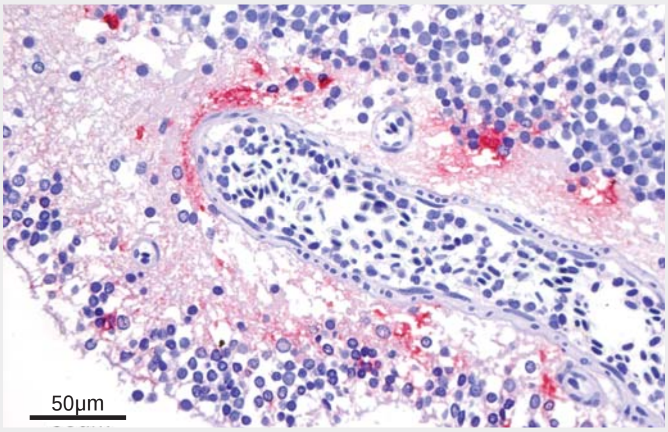


**Figure 1.** Rainbow trout brain tissue displaying inflammation caused by viral hemorrhagic septicaemia (VHS). The red colour is immuno-staining of VHS-virus. Photo: Renate Johansen, National Veterinary Institute

Genotype III has only previously been detected in marine species, and the Norwegian isolate is the first detection of this genotype in rainbow trout. Identification of disease in salmonid fish caused by virus of this genotype is unique on a world basis. Infection trials have confirmed that the new Norwegian virus isolate can result in significant mortality in rainbow trout and that the situation is serious. Most RNA-viruses have the capability for adaption to new hosts and environments, therefore rapid stamping out of infected populations is considered important to reduce spread of the virus. The fact that this unique virus continues to be detected with spread to new sites gives grounds for concern.

On introduction of new fish health legislation in 2008, VHS was moved from "group A" to "List 2". In some media, this has been referred to as a "reduced classification" for this disease. It is therefore important to state that this is not the case. Diseases in List 2 must be monitored and treated at least as seriously as previously.

## Infectious salmon anaemia - ISA

During 2008, ISA was confirmed in 17 different Norwegian salmon farming sites, and this is considered a significant increase in relation to previous years (Table 1). There have been outbreaks in several areas of the country, from north-Troms in the north to Sunnmøre in the south (Figure 2.) The disease has been particularly problematical within a relatively limited geographical area of south- and mid-Troms. This has occurred over a two year period, involving a total of 13 sites, of which 8 were in 2008. Outbreaks have affected both fish in the first year of sea

**Table 1.** Numbers of sites 1998-2008 with infectious salmon anaemia (ISA), pancreas disease (PD), heart and skeletal muscle inflammation (HSMI) and infectious pancreas necrosis (IPN). Where relevant, both "suspect" and "confirmed" sites are included.

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

culture and large, harvest-ready fish. These outbreaks have resulted in significant financial losses for the farmers concerned and make future production planning in this area difficult. Operating restrictions have been introduced relating to introduction of fish to this area as a result of the current situation, and it is reasonable to suppose that this area will have further problems in 2009. Measures to gain control of – and hopefully in the longer term eradicate – the disease in this area include vaccination against ISA-virus of all fish transferred to sea in combination with fallowing. Most of the affected fish populations have been harvested in the course of 2008, and the remaining populations will be harvested in early 2009.

Escaped farmed salmon are caught in several rivers in the aforementioned region of south- and mid-Troms, and ISA-virus has been detected in some of these fish (Figure 3). This is an extremely unfortunate situation which has resulted in a significant degree of media attention. In addition to the risk of transmission of ISA to wild salmon, escaped salmon pose a risk of infection to salmon farms over an area larger than that possible by water-borne infection.

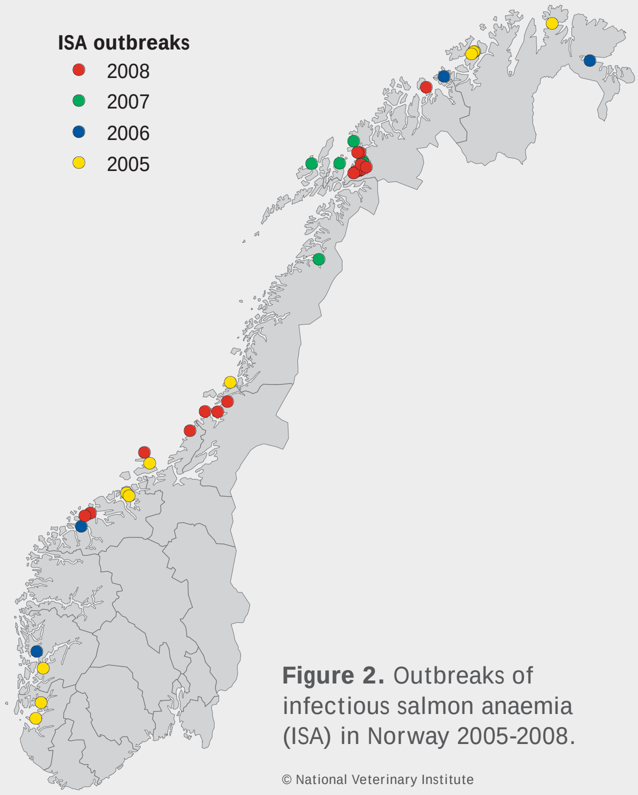


**Figure 2.** Outbreaks of infectious salmon anaemia (ISA) in Norway 2005-2008.



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. 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.

Measures to counter ISA are initiated according to 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, remains. During 2008, on several farms in Trøndelag, fish in cages with active outbreaks of ISA were harvested, while fish in unaffected cages were left unharvested over longer periods. ISA was subsequently diagnosed in several of these cages.


**Figure 3.** Escaped farmed fish with infectious salmon anaemia (ISA). Haemorrhagic liver and spleen, and pale gills. Photo: Geir Bornø, National Veterinary Institute

There have been extensive problems with ISA in Chile during 2008, and a large proportion of the aquaculture industry in that country has been affected. In addition to Norway, ISA is previously known from the east coast of Canada/USA, the Faroe Islands and Scotland. The farmed salmon population of the Faroe Islands was until 2005 considered to be comprehensively infected. Since then, extensive sanitary and fallowing measures combined with vaccination against ISA have been practised. The results in 2008 were good, and no outbreaks of ISA were diagnosed. A variant of ISA virus known as HPR0, which is considered to be of low virulence, has been detected in several salmon producing countries.

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 suggested change 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 is the most important. Otherwise, the group also considers well-boat transport of fish an important risk factor for transmission if ISA-virus.

## Pancreas disease - PD

Pancreas disease (PD) is caused by a salmonid alphavirus, normally referred to as PD-virus. Diagnostic criteria for PD include histological identification of characteristic tissue changes, together with detection of PD-virus either by cell-culture or PCR. As PD-virus may also be detected in clinically healthy carrier fish it is important that pathology and viral detection are performed on the same individual fish, in order to differentiate between an outbreak of disease and carrier fish.

Previously, a PD-diagnosis was based solely on histological findings. Today, histopathological findings consistent with PD result only in a “suspicion” of PD, requiring virology based verification. From experience, presumptive diagnoses based on histology are to a high degree supported by subsequent verification within the National Veterinary Institutes’ diagnostic system. To enable comparison of the numbers of outbreaks over time, we have therefore chosen to include both suspected and confirmed cases (Table 1 and Figure 4)

PD was registered on a total of 108 sites during 2008, mainly in western Norway, although a few were also registered in northern Norway. Only seven of the affected populations were rainbow trout, with the remainder comprising salmon. Figure 4 shows the distribution of cases per region over the last four years. With the exception of the region Sogn og Fjordane, where the number of registered cases fell, a general increase in number of cases was registered.

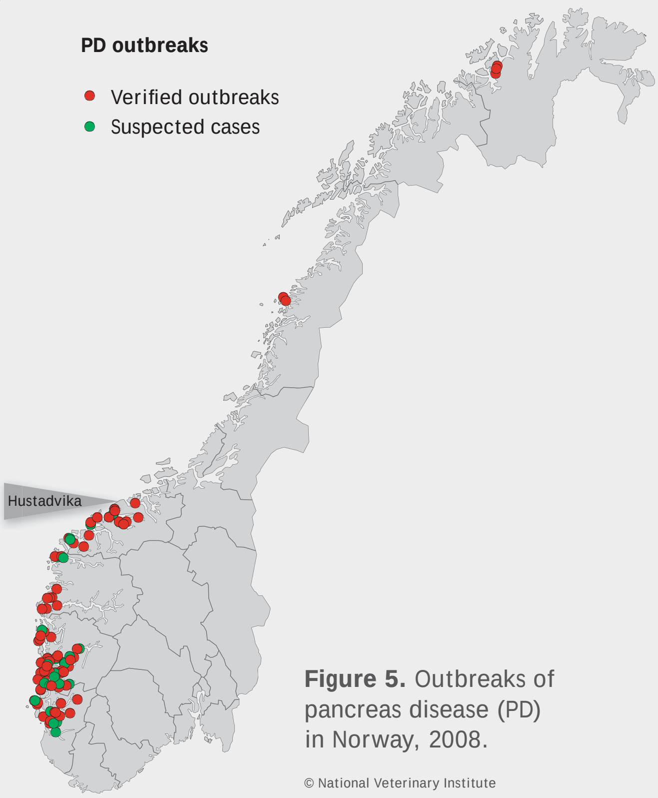


**Figure 5.** Outbreaks of pancreas disease (PD) in Norway, 2008.



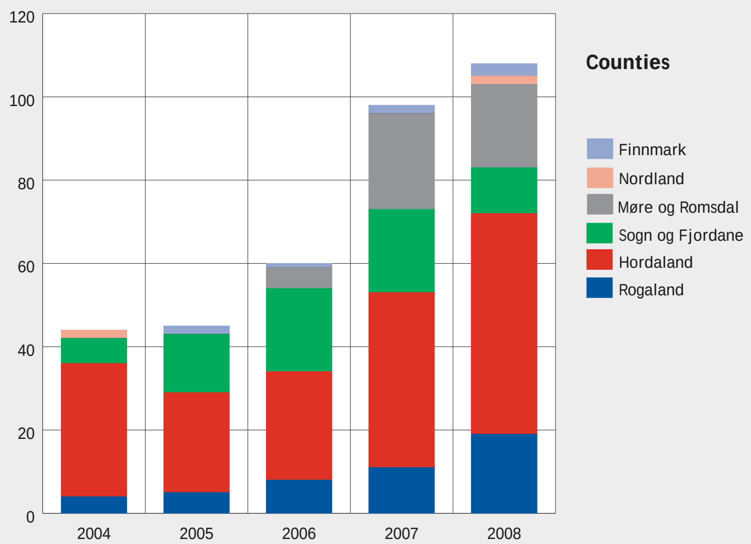


**Figure 4.** Annual distribution, registered per Norwegian region, of sites affected by PD 2004-2008.

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 (Figure 5). Hustadvika has until now acted as a geographical barrier for “natural” northward spread of disease. PD was diagnosed on one farm in Nordland and the fish destroyed immediately following diagnosis. An area near Alta which has experienced several outbreaks in recent years experienced three new outbreaks in 2008. The need to gain control over outbreaks in the Alta area is urgent, to avoid spread to new areas.

Despite the many registered cases of PD, reports from field fish health services indicate lower losses to this disease in fish transferred to sea during 2008 compared to those transferred in 2007. The Norwegian Food Health Authority has introduced a control plan for pancreas disease and the industry has united in an action plan against the disease (www.pdfri.no). Measures include synchronised fallowing, increased focus on separation of different generations, transport restrictions, disease surveillance and vaccination. The hope is that these measures will reduce losses and allow control of the disease. Vaccination of "0+" smolts in endemic areas has been extensively practiced in the autumn of 2008. The availability of vaccine has been limited and not all farms have been able to source supplies. The current vaccine strategy requires i.p. injection of PD vaccine 3 weeks in advance of i.p. injection of multi-vaccine, and as a consequence the fish must be anaesthetised and injected twice. The effect on vaccine side-effects i.e. adhesions will first become clear in 2009. New trials performed by several vaccine manufacturers indicate that equal effect may be generated by two separate injections given at the same time. This may lead to changes in future vaccine strategies.

### Infectious pancreas necrosis - IPN

As from August 2008, IPN is no longer a notifiable disease. Although this may have resulted in a greater degree of under-reporting compared to previous years, information gathered from fish health services nationwide indicate that most will continue to send in material for verification of IPN. In 2008, IPN was registered in a total of 158 sites which experienced variable losses. While there remain sites experiencing significant losses, particularly during the freshwater stage of culture, the overall picture for 2008 is one of lower overall losses than in previous years, during both the fresh- and seawater-phases of culture (Table 2). In addition to direct mortality, IPN may also result in poor growth in a proportion of fish. It is important that such fish are removed from the facility as these individuals can pose a risk of further infection.

An IPN diagnosis is based on demonstration of necrosis in pancreatic tissues and positive immuno-marking for IPN-virus in affected tissues (Figure 6). 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 (Alphaject 6-2, Pentium Forte Plus and Norvax-Minova 6). 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*

There was a dramatic increase in the number of outbreaks of systemic infection with *Flavobacterium psychrophilum* in rainbow trout in 2008 (Figure 7). Previously in Norway, this bacterium has been mainly

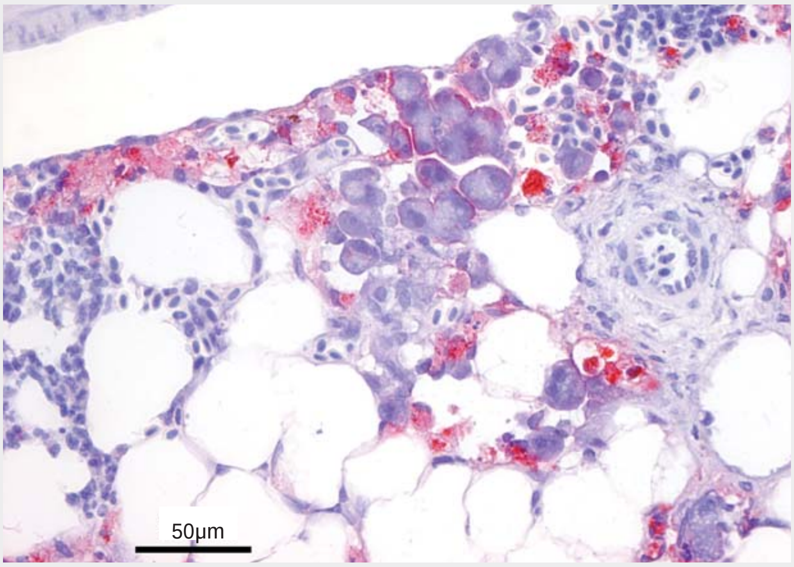


**Table 2.** Total sites with IPN outbreaks in salmon and rainbow trout farmed in fresh- and sea-water.

| Number IPN-outbreaks | Salmon | Rainbow-trout |
|---|---|---|
| Freshwater | 58 | 12 |
| Sea phase | 86 | 2 |
| Total | 144 | 14 |

**Figure 6.** Tissue section of pancreas from a fish with infectious pancreas necrosis (IPN). Degeneration and necrosis of pancreas cells are characteristic for the disease. The red staining is immuno-marked IPN-virus. Photo: Renate Johansen, National Veterinary Institute

linked with surface complaints such as ulceration and fin rot. A total of 10 hatcheries/juvenile production sites were affected in 2008, for the most part in Hordaland and Sogn and Fjordane. The outbreaks were initially registered in March and peaked in May/June. The most serious cases were observed in fry of less than 5g, while larger fish experienced milder outbreaks. Mortality levels of up to 90% were registered in the smallest fish. All affected juvenile farms had sourced eggs from the same farm, and a possible link to the brood stock farm is under investigation.

Losses to *F. psychrophilum* were also registered in rainbow trout after sea transfer, both in stocks previously affected during the freshwater phase and in stocks from unaffected fresh water farms, thus indicating horizontal transmission in the sea phase.

**Figure 8.** *Flavobacterium psychrophilum* infection in sea farmed rainbow trout can result in large ulcers.
Photo: Øyvind Vågnes, National Veterinary Institute

Towards the end of the year, an outbreak of disease associated with *F. psychrophilum* was diagnosed in salmon in a juvenile production facility. The fish appeared apathetic and displayed extensive haemorrhage in the musculature. Bacteria were detected in both the affected musculature and inner organs.

Internationally, the disease is normally managed through antibiotic treatment in combination with establishment of management routines which limit disease development (good water quality, hygienic barriers, lowest possible stress etc). There are currently no vaccines available on the market. Those isolates investigated from outbreaks in rainbow trout in Norway in 2008, displayed a reduced sensitivity for oxolinic acid, and were therefore treated with florfenicol. Post treatment relapses were relatively common and repeated treatments were required in some cases.

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. Diagnosis of RTFS/BCWD is based on clinical observations, post-mortem findings, histopathology, immunohistochemistry and culture and identification of the bacterium. 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. The bacterium has also been detected in several other types of fish. Clinically, *F. psychrophilum* infections in rainbow trout are often associated with spiral swimming, morbidity and reduced appetite. Juveniles may display a short "cramp" phase prior to death. In larger fish, skin infection and fin rot appear more common. Fish often display a distended abdomen, and may appear dark, later changing to a paler colour due to anaemia and/or oedema. A large blood filled, possibly semi-liquefied spleen is often characteristic.

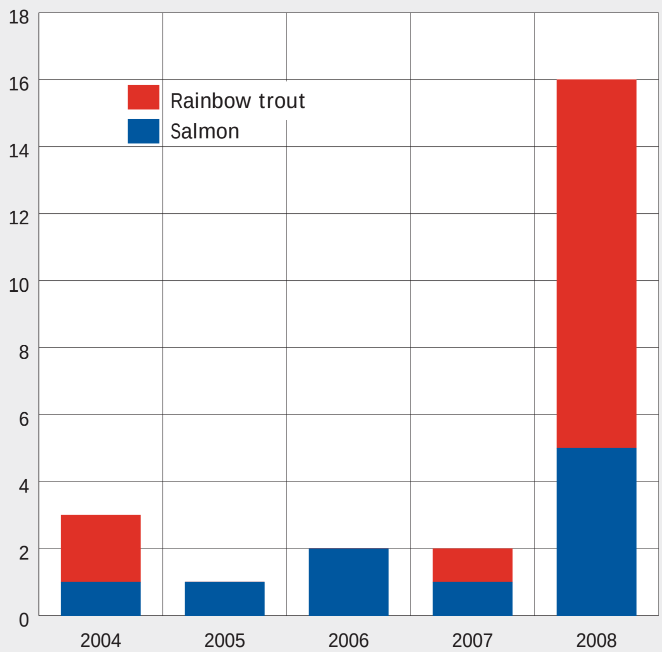


**Figure 7.** Total sites with *Flavobacterium psychrophilum*-infection in rainbow trout and salmon in Norway 2004–2008. All outbreaks in rainbow trout are systemic infections. In salmon all detections are related to ulceration and fin rot, with the exception of a single outbreak of systemic disease in 2008.

The bacterium grows only on special media and may be detected by immuno-marking (immunohistochemistry) in affected tissues.

## Yersiniosis

Yersiniosis is caused by infection with the bacterium *Yersinia ruckeri* and may result in increased mortality during the whole juvenile phase of culture. Infected fish transferred to sea may also suffer losses after sea transfer. In 2008, yersiniosis was detected in 16 sites, which constitutes an increase from the 7 sites affected in 2007. The bacterium was isolated from all stages during the freshwater phase, from start feeding fry to sea transferred smolts of 150g. Varying mortality levels were reported.

Bacterial isolates from 12 sites were identified as serotype O1, while serotype O2 was identified on 2 sites. Several outbreaks were treated with either oxolinic acid or florfenicol with generally good results. Several outbreaks have been associated with poor quality fish, high biomass, high water temperatures and low water availability. High mortality levels are reported, particularly from sites experiencing other disease problems e.g. IPN outbreak either prior to- or following- a yersiniosis outbreak.

## Winter-ulcer

The bacterium *Moritella viscosa* is considered an important causal agent in development of winter-ulcer, although other bacteria may also be isolated from such cases. The total aetiology of winter-ulcer is therefore not completely clear and much research continues into this disease. In addition to direct economic losses related to increased mortality, the disease also leads to a significant degree of product downgrading at harvest. Losses in a single farm of 20 million kroner (2 million GBP) were reported as a result of downgrading in 2008. Although *M. viscosa* was detected on this farm, it was not possible to confirm that the bacterium was responsible for the significant downgrading. From other areas of the country, low direct losses combined with significant downgrading at harvest are reported.

The National Veterinary Institute has registered isolation of *M. viscosa* from a total of 51 sites in 2008, 44 salmon and 7 rainbow trout. Reports from fish health services nationwide indicate that losses due to winter-ulcer have been lower than those experienced in previous years. All of the three most sold vaccines for salmon in Norway (Alphaject 6-2, Pentium Forte Plus and Norvax-Minova 6) contain *M. viscosa* components. It is too early to conclude whether vaccination, other preventative measures or natural variation e.g. temperature are responsible for the positive trend. Antibiotics were used to treat winter-ulcer on a few sites, and the effects of such treatments are debatable.

**Figure 9.** Salmon with yersiniosis, displaying a swollen spleen and discoloured liver. Photo: Christian Koren, Fiskehelse Nord as

## Bacterial kidney disease – BKD

Bacterial kidney disease, (BKD) was diagnosed on one brood stock farm in 2008 on which all fish in the affected group were subsequently destroyed. Nodules/granuloma were observed in a total of 25 fish, and the diagnosis verified by detection of the bacterium *Renibacterium salmoninarum* by culture, PCR, ELISA, IFAT and immuno-histochemistry. No increased mortality or other indication of disease was observed on the affected farm.

Surveillance of *R. salmoninarum* in brood stock in an effort to avoid vertical transmission of BKD has reduced the number of registered cases dramatically in the last 15 years. However, the bacterium may be found in clinically healthy wild fish so there will always be a risk of horizontal

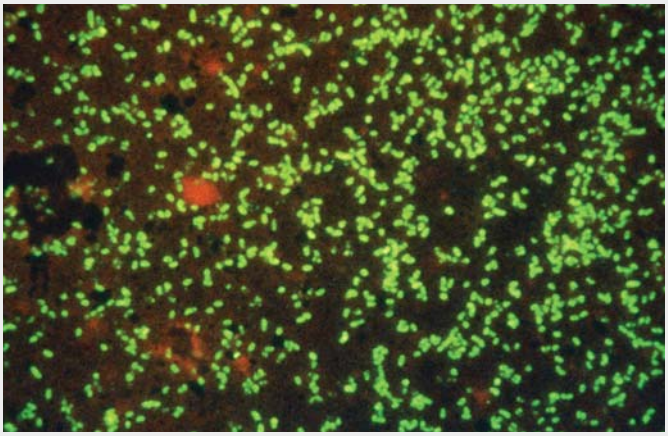

**Figure 10.** Immunofluorescense using a monoclonal antibody (4D3) on a kidney smear from a salmon with overt BKD. Photo: Ole Bendik Dale, National Veterinary Institute

transmission to brood stock. It is therefore of extreme importance that today's surveillance of brood stock is maintained. In the site affected in 2008, all dead fish in the 9 month period prior to diagnosis of BKD had been examined and over 100 samples from these fish analysed by the National Veterinary Institute without identification of *R. salmoninarum*. Following selection of brood stock, the remainder of the fish population was inspected during slaughter and no gross pathological lesions related to BKD were identified. Only following freshwater transfer of the prospective brood stock and during spawning examinations were nodules in the kidney observed and the bacterium finally identified. This shows that detection of BKD can be extremely difficult. Prevalence's down to 4‰ are reported.

### Piscirickettsiosis

Piscirickettsiosis is caused by infection with the bacterium *Piscirickettsia salmonis* and this disease is one of the most important diseases in Chilean aquaculture. Although this disease has also been identified in Norwegian aquaculture in recent years, the Norwegian isolates award much lower mortalities than those isolated in Chile. Only a single detection was made in Norway during 2008, and this constituted a "miscellaneous" finding in a fish under investigation from a PD outbreak. It does however confirm that the bacterium can still be found in Norwegian waters.

### Other bacterial infections

All Norwegian farmed salmon are vaccinated against vibriosis, coldwater vibriosis and furunculosis. No outbreaks of these diseases were detected in salmon in 2008. In rainbow trout much simpler vaccines are used against vibriosis, which normally provide good protection. However, during 2008, infections caused by *Vibrio anguillarum* serotype O1 were twice diagnosed in rainbow trout. In one case, the bacterium was isolated in pure culture from 8 of 12 vaccinated fish (approx. 500g) examined, three months following an outbreak of PD (July). In the second case, high mortality was registered in combination with an IPN outbreak in unvaccinated juveniles (hatched in the spring).

Outbreaks of disease associated with Atypical *Aeromonas salmonicida* infection were registered in three salmon farms and one Arctic char farm, all in Northern Norway. All cases were associated with increased mortality.

Detection of *Pseudomonas fluorescens* in hatcheries is not unusual, and is often associated with poor water quality. In 2008, a higher number of such diagnoses were made compared to previous years and the situation will be monitored to establish whether this bacterium is increasing in virulence.

## Gill problems

### Proliferative gill inflammation - PGI

Proliferative gill inflammation (PGI) is a term used to describe a condition which has been diagnosed in sea-farmed salmon in Norway since the 1980's. Most diagnoses occur in the autumn, between August and December, in salmon transferred to sea the previous spring. In the course of the autumn affected fish may develop serious gill injury characterised by moderate to extreme proliferation of gill tissues. Commonly associated findings include haemorrhage and tissue necrosis in the gills, while liver necrosis is not uncommon. Epitheliocysts (*Piscichlamydia salmonis* inclusions, Figure 11) are also commonly associated with this condition.

Although diverse viruses have been detected in association with PGI cases, their aetiological significance is unclear. Information received from field fish health services indicate that many farmers do not distinguish losses related to PGI from other inflammatory gill conditions. PGI is therefore considered only one of many different types of gill problem which when taken together, result in considerable losses in many farms in many parts of the country. The direct losses related to gill disease, both in relation to increased mortality and reduced growth etc. are significant and appear to be an increasing problem in 2008.

Farmed salmon in Scotland and Ireland are also affected by serious gill related problems. Researchers from these countries are currently in discussion with Norwegian researchers regarding development of a strategic joint research programme on this theme. One important initial aim will be to reach a consensus regarding diagnostic criteria for the various types of gill complaints. As further knowledge regarding PGI has accumulated, the diagnostic criteria have changed, making compiling of comparable statistics relating to outbreaks over time difficult.

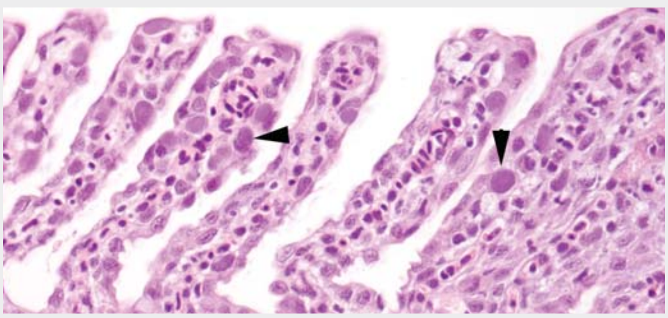

**Figure 11.** Histological section of gills with proliferative gill inflammation and epitheliocysts (arrows). Photo: Agnar Kvellestad, Norwegian School of Veterinary Science

## Other gill problems

The diagnosis “bacterial gill inflammation” is used in many farms in both fresh- and sea-water. In such cases it is always difficult to judge whether the bacteria are a primary or secondary cause (after e.g. water quality or fish weakened by some other cause). Culture of bacteria from such infected gills normally results in rich growth of mixed culture, and it may be difficult to establish which bacterium is responsible for the problem. More knowledge related to the normal bacterial flora of fish gills is required to allow more directed identification of pathogenic types. Research into this field has started and it is hoped that with time, diagnosis of bacteria-related gill disease will improve.

## Gill amoebae

Amoebal gill infection has not been registered as the cause of disease outbreaks in Norwegian fish farms in 2008. Development of improved diagnostic methods is in progress, in order to elucidate whether this is an underrated disease condition, typically hiding in the significant group of gill inflammations of unknown causes.

# Parasitic diseases

## Salmon louse - *Lepeophtheirus salmonis*

Based on farm reports, lice numbers appear to have been similar in 2008 to the previous year. The farms reported an average of 0.2 adult female lice per fish between January and September, which is lower then previously (Figure 12). This increased however from October and passed 0.4 in December.

The threshold for treatment is 0.5 adult female lice per fish. During the winter of 2007-2008, delousing was performed in certain zones in western Norway at lice densities lower than threshold, following a directive from the Norwegian Food Safety Authority. Farms in Rogaland were treated first, followed by Sogn og Fjordane and finally, Møre og Romsdal. The aim was to have so few infective lice stages as possible in the sea in the spring, thereby awarding the least possible infection pressure on migrating wild salmon and seatrout. In these four regions the farmers also reported very low numbers of adult female lice in April –May 2008. According to registrations of lice numbers on returning seatrout in rivers in western Norway, it would appear that the strategy was successful.

**Figure 12.** Adult female salmon louse with egg strings. Photo: Trygve Poppe, Norwegian School of Veterinary Science

Overall, with the exception of Hardangerfjord there were markedly fewer "outbreaks" than the previous year. A new strategic delousing will be performed during the winter of 2008-2009, with completion over one and a half months, from Rogaland in the south to Møre og Romsdal in the north.

One of the most usual medications used against salmon-lice contains the active ingredient emamectin benzoate, which is added to the feed. During 2008, several cases of "reduced sensitivity" and at least one incidence of resistance were identified in western Norway and Trøndelag. The resistant lice were effectively controlled using other treatments. The Norwegian Food Safety Authority has requested that the National Veterinary Institute design a national programme for surveillance of resistance in salmon-lice. Emamectin benzoate has been extensively utilised in strategic delousing campaigns, but will now only be used after consultation with the local representatives of the Norwegian Food Safety Authority.

Wrasse held in salmon cages eat lice on the salmon. This environmentally friendly method continues to be used and interest in this method is increasing. In 2008, between 15–20% of the countries farms used wrasse between June and December (i.e. when the fish are active).

### Parvicapsulosis - *Parvicapsula pseudobranchicola*

*Parvicapsula pseudobranchicola* is a myxozoan first described from Norwegian farmed salmon in 2002. The number of affected farms increased slightly between 2007 and 2008. Several farms experienced outbreaks of parvicapsulosis in both spring and autumn sea-transferred salmon, in some cases with significant losses. Parvicapsulosis is often registered concomitantly with other diseases, therefore the proportion of the losses attributable to this parasite is debatable. Fish are intermediate hosts, and work continues to identify the final host organism.

### Spironucleosis - *Spironucleus salmonicida*

This single celled parasitic flagellate, *Spironucleus salmonicida* (previously *S. barkhanus*), can cause systemic spironucleosis in famed salmonids.

This parasite was diagnosed in one farmed salmon site in Finnmark in 2008, and infected fish appear to be limited to a single smolt producer. Investigations performed during 2008 show that *S. salmonicida* can be found in the intestine of wild trout and char, and that this is most likely the source of infection for this parasite. Fish from three lakes in Finnmark were studied and *S. salmonicida* was found in each case. These findings indicate that *S. salmonicida* may have an extensive range, which is supported by previous outbreaks in both Norway and Canada.

### Costia - *Ichthyobodo* sp.

Both fish gills and fish skin can be infested by this group of parasites, both in fresh- and seawater. There are several different species of costia, inhabiting different species of fish. If the parasite is found to cause problems in freshwater, formalin treatment of the fish can be carried out effectively. However, treatment of fish in seawater meets practical problems.

### Tapeworm

Tapeworm belonging to the genius *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 2008.

## Other health problems

### New disease of unknown cause

During the autumn of 2008 the National Veterinary Institute received samples from a possible new disease in salmon from a number of sea sites in western Norway. A total of 25 cases have been identified between Rogaland and Møre og Romsdal. Both gills and inner organs appear to be affected. The course of the disease appears to be extended with varying mortality levels. Total mortalities of up to 20% in individual cages have been recorded along with severely reduced growth levels.

Post mortem findings have included swollen and pale gills, yellowish brown liver, congested and swollen spleen, swollen kidney and ascites. Some fish have displayed haemorrhage in the abdominal fat as well as a haemorrhagic distal intestine. Histologically, pathological changes e.g. necrosis, inflammation and circulatory disturbances, can be observed in several organs. Studies directed at establishing the aetiology of this condition are now underway.

### Cardiomyopathy syndrome - CMS

During 2007, the transmissible nature of CMS was demonstrated in laboratory trials. A viral aetiology is suspected, but is as yet not confirmed. Several research groups, both in Norway and abroad are working intensively with CMS, and it is hoped that new knowledge relating to this disease will be generated in the years to come. In addition to the search for possible aetiological agents, risk factors for infection and losses are being mapped. The possibilities for selection and breeding of resistant strains of fish are also being investigated.

A total of 75 sites with varying CMS-associated mortality were registered by the National Veterinary Institute during 2008. As the disease primarily affects large salmon in the second year of sea culture, the economic losses are often large. General impressions from the field are that CMS losses for 2008 are similar to previous years. Although large fish dominate the statistics, CMS is observed at all stages of the marine phase of culture. CMS is diagnosed by identification of typical histological findings in the muscular tissues of the heart. Improved diagnostic methodology aimed at identification of the aetiological agent (s) would obviously help in verification of the diagnosis.

## Heart and skeletal muscle inflammation - HSMI

The cause of HSMI remains unknown, although infection trials indicate that a viral agent may be involved in development of the disease. The disease is diagnosed on the basis of histopathological changes in the heart- and skeletal musculature of salmon. It is important that several fish are examined, and the absence of PD-virus detection strengthens the suspicion of HSMI. Again, establishment of diagnostic methodology aimed at detection of the aetiological agent(s) will be important in mapping this disease.

HSMI was first diagnosed in 1999 and the number of outbreaks increased dramatically until 2007 (Figure 13).

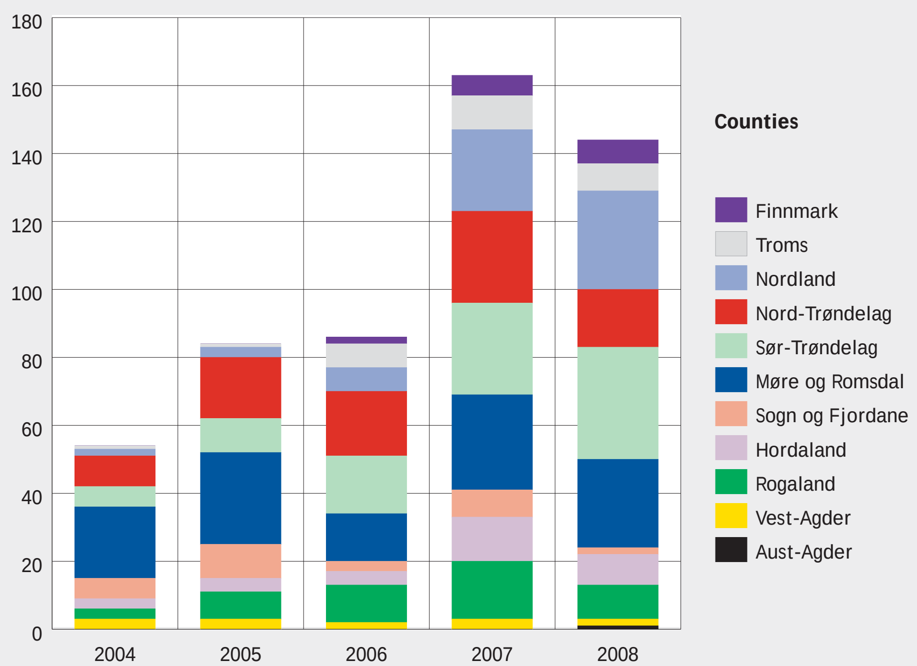


**Figure 13.** Regional distribution of registered sites with HSMI per year 2004–2008.

A total of 144 sites experienced outbreaks in 2008, with a geographic focus in the three regions north of Hustadvika (Figure 14). HSMI appears therefore, to be a larger problem in areas without PD than in areas with large numbers of PD outbreaks. The reasons for this are unclear.

Although HSMI is primarily a disease affecting fish during the first year following sea transfer, it was as previously, also diagnosed in a few juvenile farms with a seawater intake during 2008.

The disease is registered throughout the year and results most often in moderate mortality. In Trøndelag the disease is considered more unpredictable than previously, and that fish of smaller size are affected more often, including year-old fish. The extended disease course can lead to large cumulative losses over time. Investigations have shown that fish in affected farms displaying no clinical signs of disease, may display significant inflammation in the heart and skeletal musculature. It is therefore important that fish are not exposed to stress during the most critical period.

## Other heart 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 (Figure 15). Many of these conditions are probably related to the culture environment in which the salmon, an athletic predatory fish, is offered a sedate life and a diet very different from that found in nature. It has been recently shown that interval training of fish in the freshwater phase increases feed conversion and survival following IPN infection. Conditions of this type include restriction of the cranial artery, poor development of the outer muscle layer and metabolic dysfunction.

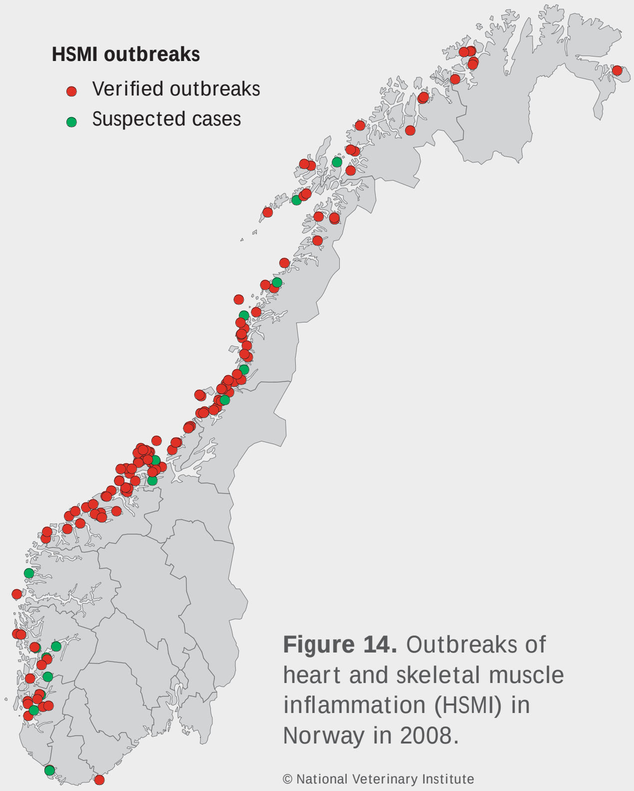


**Figure 14.** Outbreaks of heart and skeletal muscle inflammation (HSMI) in Norway in 2008.

## 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 prevalence's 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. 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. In 2008, this tumour type was diagnosed in only a few fish amongst thousands of fish examined. No detectable carcinogens have been identified which could explain the tumour development. Extended trials with feed components from the feed type related to tumour development are currently under way and should provide more knowledge on the mechanisms involved.

## Hemorrhagic smolt syndrome - HSS

Hemorrhagic smolt syndrome (HSS), also called hemorrhagic diathesis (HD), results in mortality in large, good quality smolts during the freshwater phase. The disease is diagnosed largely by the fish health services in the field following observation of macroscopic muscular haemorrhage etc. Histopathologically, extensive haemorrhage in several organs and blood in kidney tubules may be observed.

Quantification of losses attributable to HSS is difficult as this disease is not commonly reported. From interviews with fish health services, it is clear that this disease causes limited but noticeable losses in many juvenile production sites. The cause(s) of the disease are unknown, but is/are clearly associated with the smoltification process and affects particularly the largest and best fish. Mortality declines and disappears following sea transfer. Macroscopically, the disease (as with VHS) results in serious circulatory disturbances. It is therefore desirable that diagnoses are confirmed by histology and/or virological investigation.

## Deformities

In 2007, fish health services reported a reduction in prevalence of deformity in salmon. This positive trend continues in 2008.

## Jelly-fish and algal blooms

Again in 2008 several farms in south-western Norway experienced mortality related to jelly-fish and algal blooms. Clinically, the fish appeared to experience severe respiratory difficulties. Both point and linear haemorrhage were observed on the gills. In November 2008, a diatom bloom, mainly *Skeletonema* but also *Pseudo-nitzchia calliantha* and silicoflagellates (*Dictyocha*) was associated with the death of 20,000 fish in a single farm. Rapid water sampling is decisive in obtaining an accurate diagnosis, as jelly fish and algal blooms can rapidly disappear.

**Figure 15.** Hearts from farmed fish. The heart on the right is reasonably normal, while the heart on the left has an abnormal shape and coronary vessel abnormalities. Photo: Trygve Poppe, Norwegian School of Veterinary Science

## Vaccination side-effects

The degree of vaccine related side-effects is highly variable between fish groups and may be evaluated from absent up to a moderate level (Figure 16). There are no reports of increased vaccine related side-effects during 2008 in comparison to previous years. Vaccine side-effects continue to be measured using the Speilberg scale which awards a score to 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 there have been a number of publications relating to the effect of vaccines within organs, thus indicating the need for development of methods in addition to the Speilberg scale for evaluation of vaccine side-effects.

**Figure 16.** The picture shows adherences in the peritoneal cavity between inner organs and the peritoneal wall. This is a common finding related to intraperitoneal oil vaccination. Photo: Trygve Poppe, Norwegian School of Veterinary Science

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

## Stock enhancement hatcheries

Using local strains of fish, these facilities produce eggs, juveniles and smolts for release in rivers. Release of such fish is a traditional method of augmenting natural stocks, providing a harvestable surplus. Today, such production of fish is subject to strict regulation by the authorities and is almost entirely related to compensation of losses in natural production related to hydro-electric developments. Stock enhancement is also an important measure in re-establishment of fish populations following e.g. acid rain or rotenone treatment of *Gyrodactylus salaris* infected rivers. Stock enhancement hatcheries are to a large degree subject to the same regulations as commercial aquaculture facilities, including health monitoring.

## Health Services for Stock enhancement Hatcheries

The Health Service for Stock enhancement Hatcheries was established by the National Veterinary institute in 1987 and further developed by both the National Veterinary Institute and VESO Trondheim to be a nationwide health service, with member facilities from Kristiansand in the south to Pasvik in the north. The health service is today led by the National Veterinary Institutes' Section for Environment and Biosecurity Measures, and has two gene banks and 30 stock enhancement hatcheries as members. These facilities vary considerably in size and complexity, from small local facilities to large regional gene bank facilities with responsibility for several of the most threatened salmon strains in Norway. Many stock enhancement facilities are situated such that they have no immediate access to personnel with experience in fish health. The aim of the fish health service is to satisfy the requirements of the member facilities in regard to health monitoring, analysis of samples and relevant medical advice.

## The health status in stock enhancement hatcheries in 2008

The Health Service for Stock enhancement Hatcheries engages local fish health services, fish health biologists and veterinarians who perform and are responsible for health surveillance in defined stock enhancement hatcheries. These then report back to the hatcheries and to the Health Service for Stock enhancement Hatcheries leadership. Analyses of samples taken in stock enhancement hatcheries are carried out primarily at the National Veterinary Institute in Trondheim. The aim is to create a low threshold for initiation of investigation. The annual subscription for the Health service covers therefore most costs relating to such analyses. Generally, the health situation in most fish raised for stock enhancement purposes is good, without the large disease outbreaks experienced in commercial farms.

As in commercial farms, parasitic infections of the skin and gills are quite normal in stock enhancement farms. External "flaws" make up the most usual findings in fish from stock enhancement hatcheries. It is highly desirable that fish produced from these hatcheries have as natural an appearance with as few external flaws as possible. This is the measure of quality for stock enhancement fish. To this end, a database has been constructed for registration of fin erosion, operculum deformity, ulceration etc. This database allows the hatcheries to compare their own results with other facilities both for the current and previous years.

**During 2008 the following diagnoses have been reported by health personnel and the National Veterinary Institute:**

## Parasites

Monitoring parasites burdens are a routine part of health checks. Parasites registered during 2008 include species within the families *Chilodonella*, *Riboschyphidia*, *Epistylis*, *Ichtyobodo*, *Oodinum* and *Trichodina*. The tapeworm (*Diphyllobothrium dendriticum*) was found in brown trout on one site. No *Gyrodactylus* spp. were found in stock enhancement fish during 2008.

### Bacterial diseases

Bacterial diseases have been diagnosed in individual farms and individual fish. In one farm, post-spawning mortality in a small number of brood stock was related to a *Carnobacterium* sp. In another site, significant mortalities in a brood stock population were related to systemic infection with *Pseudomonas fluorescens*. This bacterium was also cultured in relation to carlin-tags in another site.

### 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- and production- related diseases

Of environmental and production related diseases, the annual occurrence of nephrocalcinosis in brood stock on one particular farm, was also registered in 2008. Fish in the same farm also suffer from cataract. Operational failures related to gas supersaturation with associated acute mortality were reported in two sites. Gas supersaturation was also suspected in relation to losses of wild caught brood stock in another farm. Mortalities in two farms during the spring were associated with iron precipitation on the gills. In addition, as previously mentioned, fin erosion, opercular deformity and to a varying degree "eye snapping" made up the remainder of registrations.

### Diseases of unknown cause

Hemorrhagic smolt syndrome (HSS) was diagnosed in one facility with low associated mortality. Otherwise only occasional single fish were identified with this disease during 2008.

## 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

**Figure 17.** Male Atlantic salmon in spawning colours.
Photo: Trygve Poppe, Norwegian School of Veterinary Science

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, 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 mainly performed by the Section for Virology and Serology and the Section for Immunoprophylaxis of the National Veterinary Institute. 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 2008, salmon, seatrout, brown trout and arctic char were investigated from a total of 33 rivers from around the whole country.

### Scale analysis identifies farmed fish

Wild salmon brood stock caught and stripped to supply eggs for stock enhancement hatcheries and gene banks are subjected to scale analysis (Figure 18). 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. After many years of such analysis the results give reason to believe that the frequency of IPNV carrier fish is higher in escaped farmed fish than in wild salmon. Scale analysis is therefore also important in disease control.

### IPNV and BKD testing

The results from this years brood stock testing are not yet fully analysed as the Fish Health Report for 2008 goes to press. Preliminary results show that Furunculosis and BKD have not been detected in this year's brood stock. The number of IPNV detections has, however, increased from the previous year. Eight individual salmon have tested IPN-positive. Of these, two were known farmed fish sent in to establish their disease status. These fish were not used to cross-breed with wild salmon. Six IPNV-positive salmon were all used as brood stock. Of these fish, 5 were classified as "not suitable for stock enhancement" by scale analysis. Hence the analysis indicates that these fish might be escapees. The reason for utilisation of these fish may be that scales for analysis were taken at stripping or post-mortem. The single fish identified as wild, which tested positive was a returning spawner i.e. had spawned in a previous year. One PCR IPN-positive, "unsuitable" salmon gave a weak and non- reproducible positive result. Two arctic char tested as a pair, gave weakly positive results. This result was non-reproducible on testing of the two fish as individuals.

As in previous years we see the IPNV-positive fish are dominated by fish which, according to the National Veterinary Institutes' scale analysis are unsuitable for stock enhancement. This work shows that scale control is important for identification of farmed fish and that the prevalence of IPNV in the tested wild fish is low.

In association with brood stock testing, both external and internal "flaws" as well as signs of disease are registered. Tissue samples are taken on indication for further analysis by histology, parasitological investigation etc. These samples are analysed by the National Veterinary Institute. Generally and unfortunately, there are few samples taken from wild brood stock

Information from health testing of brood stock is registered on a brood stock database which in addition to health related information also contains results from scale analysis and information from the scale collection envelope/ capture data.

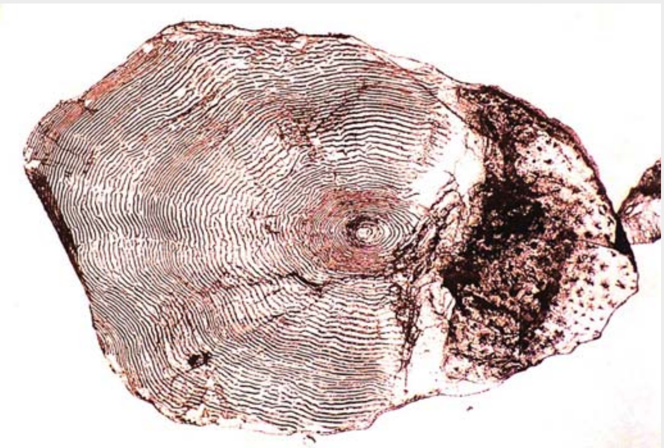

**Figure 18.** Scale analysis identifies escaped farmed fish, such that these can be excluded from stock enhancement projects. The picture shows scales from wild salmon from the river Bya. Photo: Håvard Lo, National Veterinary Institute

## Bacteriology

There were no detections of the furunculosis bacterium (*Aeromonas salmonicida* subsp. *salmonicida*) in 2008 in relation to health testing of wild caught brood stock. Local fish health personnel submit cultures for investigation on suspicion to the National Veterinary Institute. The most common findings in these cases are normal soil and water associated bacteria. In one case in 2008 a *Carnobacterium* sp. was isolated.

## Parasites

Nematodes (*Anisakis*) and gill maggots (*Salmincola salmoneus*) are normal findings during brood stock post mortem. The prevalence of tapeworm (*Eubothrium* sp.) appears to vary both geographically and from year to year, and tapeworms were also identified in brood stock during 2008. Abnormal findings including yellow nodulation of the liver and nodulation of the peritoneum were observed during post mortem of brood stock in 2008. Histological findings are consistent in these cases with reaction to *Myxidium truttae* and are associated with identification of plasmodia around larger blood vessels and excretory canals in the liver. In addition to parasitic hepatitis caused by *Myxidium truttae*, more serious infection with a probable *Myxidium* sp./*Myxozoa* was identified in a dead, wild caught brood stock salmon. This fish displayed generally pale organs, oedema in the peritoneal cavity and muscular petechiation. The parasitic infection in this fish was identified in all organs investigated, with the most significant damage in the spleen. Other parasite-related findings in wild caught brood stock include parasitic cysts between intestinal caecae, probably plerocercoids of tapeworm (*Diphyllobothrium*), together with black spot disease (*Cryptocotyle lingua*) in the gills and skin.

## Other findings

A swimbladder sarcoma was diagnosed in one brood stock salmon.

# Diseases in wild salmonid fish

## Furunculosis outbreak in the river Namsen

In August/September 2008, outbreaks of furunculosis were identified in the river Namsen and its' tributary river Sandøla as well as the river Ferga which is situated on the same fjord system. Furunculosis outbreaks are a nearly annual phenomenon in the rivers surrounding

**Table 3.** Preliminary results from brood stock testing for the season 2008/2009.

| | Atlantic salmon | | Seatrout | | Brown-trout | Arctic char | |
|---|---|---|---|---|---|---|---|
| | IPN | BKD | IPN | BKD | IPN | IPN | BKD |
| Number of rivers | 29 | 29 | 4 | 5 | 1 | 1 | 1 |
| Individuals tested | 508 | 556 | 34 | 50 | 21 | 8 | 8 |
| Total positives | 8* | 0 | 0 | 0 | 0 | 0 | 0 |
| Furunculosis detected | 0 | | 0 | | Ikke testet | 0 | |
| Comments | * Eight individual salmon tested IPN-positive. Of these, two were known farmed salmon sent in to establish their infection status. These were not used to breed with wild salmon. The six IPNV-positive wild salmon were all used as brood stock. Of these fish, 5 were classified as "not suitable for stock enhancement" by scale analysis. The reason for utilisation for these fish may be that scales for analysis were taken at stripping or post mortem. The single wild fish which tested positive was a returning spawner i.e. had spawned in a previous year(s).One PCR IPN-positive, "unsuitable" salmon gave a weak and non- reproducible positive result. | | | | | | |

the Namsen fjord. This year's outbreak was one of the more severe episodes and water flow in the Namsen was increased in an effort to reduce mortality levels.

## Proliferative kidney disease - PKD

Proliferative kidney disease was diagnosed in juvenile wild salmon in the rivers Åbjøra and Terråk in Bindalsfjord and in the river Oldelva in Fosen. Sampling was performed as part of work carried out by the Norwegian Institute for Nature Research (NINA). While the parasite had previously been identified in the rivers Åbjøra and Terråk, it was detected in the river Oldelva for the first time in 2008.

## *Gyrodactylus salaris*

A total of 2500 salmon from nearly 100 rivers and more than 2500 salmon/rainbow trout from a total of 83 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 – 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 are planned, or have been conducted. Rivers in the FM-programme are surveyed three times per year at many different localities at each time point. In 2007 the FM-programme covered one region (Rana) and a total of six rivers. *G. salaris* was not detected in any new area during 2008.

# Fish Welfare

The legislation of slaughterhouses and processing plants for organisms in aquaculture (slaughterhouse act) came into force 1. January 2007, although the directive forbidding $CO_2$ as a sedative during slaughter of fish is postponed until 1. January 2010. Work on evaluation of alternatives to $CO_2$ e.g. clubbing or electric shock is underway. A number of slaughterhouses have already phased out use of $CO_2$.

*Thanks to all who have contributed to this report, particularly the fish health services nationwide. Without their contribution this annual report would not be possible.*

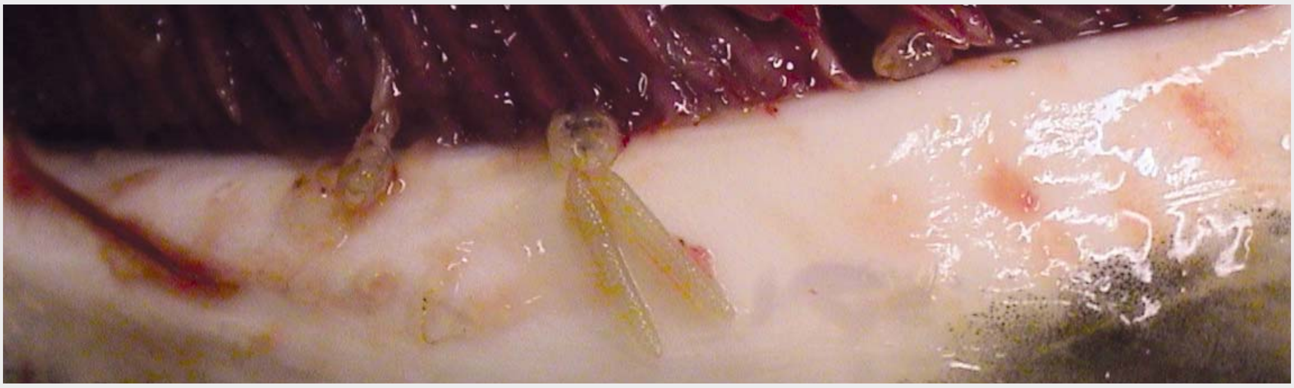

**Figure 19.** Gill maggots (*Salmincola salmoneus*) are a normal finding in wild caught brood stock. Photo: Kathrine Holten, VESO

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# The health situation in farmed marine fish 2008

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*During 2008, the National Veterinary Institute received material from more than 450 cases involving marine fish species. Material from marine fish is usually sent in for examinations due to disease outbreaks or increased mortalities in farmed fish. However, samples are also submitted in connection with research projects and surveillance programmes. Close to 80% of the samples come from cod, the rest originate from halibut, coalfish, wrasse and other species. The most important disease problems in cod in 2008 included the following bacterial infections: francisellosis, vibriosis, and atypical furunculosis. As a part of the follow-up of the outbreak of viral hemorrhagic septicaemia (VHS) in rainbow trout in 2007 and 2008, both wild and farmed marine fishes have been sampled. The following overview of the health situation of marine fish in 2008 is based on examinations of material received by the National Veterinary Institute, together with information from fish health services along the entire coast, as well as from relevant research institutions. Fish health reports from earlier years are available at www.vetinst.no.*

## Cod

The National Veterinary Institute received over 350 samples from approximately 85 different cod farming sites nationwide during the course of 2008. Of over 450 registered cod farming concessions, only 250 were active in 2008, with a total production of 13500 tons round-weight (www.torsk.net). Juvenile production is estimated to be around 20 million fish. The data available indicates that we have a reasonably good knowledge of the spectrum of diseases and causes of mortality during the ongrowing phase. However, information and knowledge relating to diseases of juvenile fish is more limited. Information from juvenile producers and fish health services indicate high mortality levels in some production batches related to, for the most part, unknown causes. Diagnostic capabilities for disease in startfeeding fry are very limited, although detection of recognised agents is possible. Although nutritional and environmental factors can be of importance in juvenile losses, the role of infectious agents cannot be discounted. Improved investigation of juvenile mortalities will in the long term lead to improved survival and improved quality.

## Bacterial diseases

### Francisellosis

Francisellosis is currently considered the most important disease problem in Norwegian cod farming. Francisellosis is a chronic disease, which in addition to increased mortality, also leads to reduced growth and downgrading of harvested fish. The fish are weakened, and francisellosis can occur in combination with other infections such as vibriosis, atypical furunculosis or VNN. Francisellosis was diagnosed in 14 sites during 2008 (Figure 1).

Infections in fish with bacteria belonging to the genus *Francisella* (francisellosis) are not new. In 2008 francisellosis was included in the national list of fish diseases (List III) in accordance with the Act relating to food production and food safety (Food Act). The earliest reference to *Francisella*-infections in fish can be found in a WHO report from 1970, in which two different types of fish were listed as susceptible to infection. The genus *Francisella* includes bacteria which are known to cause disease in many animals. The most familiar bacterium within this genus

**Table 1.** Summary of the number of cod farms with diagnosed viral or bacterial disease.

| | 2005 | 2006 | 2007 | 2008 |
|---|---|---|---|---|
| IPN | Not detected | Not detected | Not detected | Not detected |
| VNN (nodavirus) | Not detected | 3 | 6 | 3 |
| Atypical furunculosis | 3 | 13 | 9 | 16 |
| Francisellosis | 4 | 7 | 8 | 14 |
| Vibriosis (*V. ang.*) | 18 | 19 | 19 | 20 |
| Coldwater vibriosis (*Vibrio* (*Aliivibrio*) *salm.*) | 2 | Not detected | 1 | 1 |
| Infection with *Vibrio ordalii* | 1 | Not detected | 3* | Not detected |
| Infection with *Vibrio* (*Aliivibrio*) *logei*/*V. logei* -like | 2 | 1 | 2 | Not detected |
| Infection with *Photobacterium* sp. | 3 | 3 | 6 | 4 |

* Identified in pure culture in one case and in mixed culture with *V. anguillarum* O2 biotype II in two cases.

is *Francisella tularensis* which causes tularemia in hares and other mammals. The types of *Francisella* which cause disease in fish are not closely related to the tularemia bacterium and are not considered likely to cause disease in humans. The genus *Francisella* has, on the basis of genetic analyses (16S rRNA sequencing) been divided into two main groups i.e. the *F. tularensis*- (tularemia) and *F. philomiragia*-groups. The first group contains several human pathogens, which have until recently been the source of all knowledge relating to *Francisella*. The relatively newly identified fish pathogenic *Francisella*-bacteria, although differing in several characteristics belong to the *F. philomiragia*-group.

**Figure 2.** Cod with francisellosis. Granulomas (nodules) in the spleen are a typical finding in this disease. Photo: Hege Hellberg, National Veterinary Institute

*Francisella* infections in fish have been described from different geographic areas and fish species around the world, and also in other marine animals. There are two main types of *Francisella*-bacteria isolated from fish, with smaller differences identified in different isolates within these two types. The most comprehensively described fish pathogenic *Francisella* is that isolated from diseased cod in Scandinavia. This bacterium has been named differently i.e. *F. philomiragia* subsp. *noatunensis* and *F. piscicida* by two different research groups. Both names are validly published, and refer to the same bacterium.

The other fish pathogenic variant is isolated from tilapia in Costa Rica, USA and Taiwan and three-lined grunt (*Parapristipoma trilineatum*) in Japan. Although this bacterium is as yet not formally named, names such as *Francisella asiatica* and *Francisella orientalis* have been used in informal media. Again both names refer to the same bacterium. Further, a *Francisella* variant identified from Atlantic salmon in Chile is closely related to the Norwegian cod pathogen *F. philomiragia* subsp. *noatunensis*.

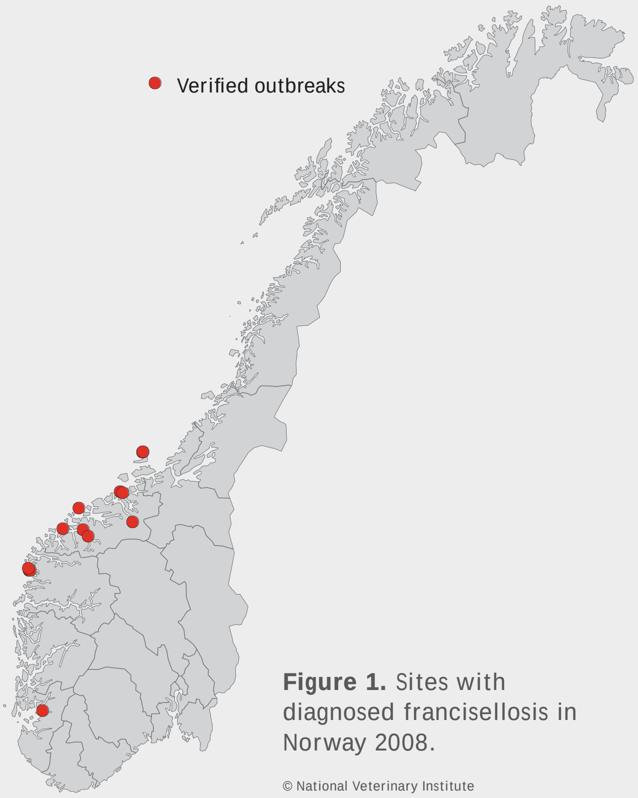


**Figure 1.** Sites with diagnosed francisellosis in Norway 2008.



*Francisella* isolated from diseased fish differ from other members of the *F. philomiragia* group in that they require addition of the amino acid cystein to the culture media, they grow more slowly, have lower optimal culture temperatures and are poorly biochemically reactive. Research performed at The National Veterinary Institute and the University of Bergen (UiB) has focussed on molecular characterisation of these bacteria. The investigations have shown that there is no detectable variation between isolates from outbreaks in Norway, which supports the hypothesis of a common source of infection. A large degree of similarity has also been identified between isolates of *F. asiatica* isolated on different sides of the Pacific Ocean. One possible explanation for this could be that the bacterium has been spread with fish or fish eggs not found naturally in South America. This is purely speculative at this point in time.

The characterisation work which has been carried out over the past four years has proved to be of importance for development of methodology for detection and diagnosis of francisellosis. An example of this are the various PCR methods used for screening and diagnosis of this disease. These methods are based upon information gained from isolates exclusively derived from diseased fish. There are only a few isolates from wild fish and the environment available for research, and we have little information regarding the diversity, survival and prevalence of marine *Francisella* in nature. Future research requires a larger number of isolates from different niches in order to better understand the factors of importance in relation to virulence in the fish pathogenic types.

Other genetic methods which can increase our understanding of the biology of marine *Francisella* spp. include Pulsed Field Gel electrophoresis (PFGE) and Variable Number of Tandem Repeats Assay (VNTR), methods currently under development at the National Veterinary Institute and UiB. These methods are important for investigation of relatedness between isolates and thereby increase knowledge relating to spread of infection and risk of transmission between sites and between infected sites and the environment. These methods will complement knowledge gained through current whole genome sequencing projects.

The molecular characterisation of *Francisella* has come a long way but is far from finished. The available knowledge has significant potential for use in mapping spread of infection in aquaculture. A major current shortcoming is the lack of available epidemiological information from cod farmers. Such data are important in identification of risk factors for transmission and documentation of effect of any combat measures introduced.

## Vibriosis

Vibriosis remains a significant problem in cod farming. (Table 2). There are no significant changes since 2007 regarding the frequencies of isolation of serotype O2 a and O2 b.

The new O2 a biotype II (also known as ”serotype O2x”) continues to be isolated. Several sites experience repeated outbreaks despite vaccination against vibriosis.

*V. anguillarum*-isolates from disease outbreaks are routinely tested for antibiotic sensitivity. Monitoring of antibiotic resistance is both an important part of disease diagnostic work and a prioritised research area for the National Veterinary Institute. Reduced sensitivity to oxolinic acid was identified in two separate isolates of *V. anguillarum* O2 b from different sites, which is a reduction from 2007. This may be due to the reduced use of antibiotics in 2007.

## Other bacterial infections

The number of cases of atypical furunculosis (atypical *A. salmonicida*) increased from 9 in 2007 to 16 in 2008. Several of these cases involved high mortality. Atypical furunculosis was diagnosed in fish with severely depressed appetite, high mortality and a high prevalence of granulomas in the heart, spleen and kidney, as early as three weeks post transfer to ongrowing sites. Combined infections involving atypical furunculosis and francisellosis have been identified, highlighting the need for thorough sampling to clarify possible differential diagnoses.

Several cases of so-called “bacterial overgrowth” in the intestine of larvae and fry have been identified. A requirement for repeated antibiotic treatment of cod juveniles prior to transfer has been reported. This can have negative effects on both development of resistance in pathogenic bacteria and for microbial dynamics within culture systems.

**Figures 3 and 4.** Cod with vibriosis. Note swollen, red fins. Photo: Tom C. Tonheim, Fiskehelse og Miljø AS (FOMAS)

**Table 2.** Summary of cod sites with diagnosed *Vibrio* (*Listonella*) *anguillarum* in the period 2003-2008. Total number of sites diagnosed (number of submissions).

| Type | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 |
|---|---|---|---|---|---|---|
| Total* | 19 (26) | 27 (37) | 18 (18) | 19 (30) | 19 (54) | 20 (57) |
| O1 | Not detected | Not detected | Not detected | Not detected | Not detected | Not detected |
| O2 a | 6 | 9 | 1 | 5 | 5 | 2 |
| O2 a biotype II | - | - | - | 3 | 6 | 2 |
| O2 b | 11 | 18 | 17 | 15 | 15 | 15 |

* Some isolates were not serotyped. On some sites more than one serotype of *Vibrio anguillarum* was identified.

Larval- and live feed- cultures often have a high density of bacteria. The types of bacteria involved may vary considerably, and may include pathogenic species. Different *Vibrio* spp. are commonly associated with increased mortality. For further information the reader is referred to Nina Sandlund's doctoral thesis "The role of opportunistic bacteria in marine cold-water larval cultures" from 2008.

## Viral diseases

In contrast to the situation in salmon farming, losses caused by viral diseases do not appear to be a major concern in cod farming at present. Viral Nervous Necrosis (VNN), caused by a nodavirus, continues to be registered. In 2008 the National Veterinary Institute diagnosed VNN on three sites compared to six in 2007. Information from the field indicates that infection with nodavirus is not considered a significant problem in ongrowing fish, and is associated with "minimal mortality". In larvae and juveniles however, losses can be higher. The reader is also referred to Kjetil Korsnes' doctoral thesis "Nervous necrosis virus (NNV) in farmed Norwegian fish species". This thesis focuses on nodavirus infections in Norwegian farmed fish, mainly salmon and cod. Infectious pancreatic necrosis (IPN) has not, as far as we are aware been registered in Norwegian cod.

**Figures 5 and 6.** Cod with atypical furunculosis. Ulcers and nodules in the skin may also be found in francisellosis. The fish involved were destroyed. Photo: Siri Giskegjerde, Fiskehelse og Miljø AS (FOMAS)

### VHS

In November 2007, viral hemorrhagic septicaemia (VHS) was diagnosed in rainbow trout in a farm in a fjord system in Møre og Romsdal. The VHS-virus (VHSV) involved was found to be a so-called marine variant (genotype III). Farming of cod and coalfish is also carried out in the same fjord system. The National Veterinary Institute has, on the instructions of the Norwegian Food Safety Authority, examined all marine sites within the fjord system for VHSV, without detection of the virus. Wild fish in the area, caught by line or net and stored on ice until sampling the same day, have also been examined. Tissues sampled for VHS analysis included brain, kidney and gill. Approximately 260 wild fish (> 50% herring, the remainder "miscellaneous species") were investigated within the fjord system without detection of VHSV.

## Parasites

With the exception of one case with high mortalities caused by an as yet unidentified gill parasite, no significant changes in the situation from last year are reported. Different species of *Myxozoa* e.g. *Zschokella hildae*, *Myxidium bergense* and *M. oviforme* have been identified in farmed populations although no definite relationship between these infections and disease or increased mortality has been established.

The cod farming network "Codlink" collects and analyses the health situation in a series of cod farms along the Norwegian coast, and during 2008 infections involving several parasites were registered. *Trichodina* is registered relatively frequently and may on occasion cause significant problems. *Gyrodactylus* infections of the gill are commonly reported. Normally *Gyrodactylus* are registered in limited numbers without particular gill pathology, although in some cases during 2008 the problem has been considered severe enough to warrant treatment. Costia (*Ichthyobodo*) has also been identified, as has the common occurrence of CUA (cysts of unknown aetiology) which may have a parasitic cause. The findings within the Codlink study are consistent with the previous three year project CodPar (see last years report).

## Diverse

Intestinal inflammation and volvulus are commonly registered conditions (Figure 7). While several different types of intestinal complaints are registered in cod, it would appear that most fall into one of the following three categories:

- Distended, pale/transparent intestine with watery content
- Irritated/red, distended intestine
- Volvulus

The last two conditions are as a rule only observed in dead fish and can represent a large proportion of registered mortality. It is commonly reported that these conditions affect "large, good quality" fish, and the economic consequences can therefore be significant. For further information the reader is referred to an article by the fish veterinarian Inge Kaada in Norsk Fiskeoppdrett nr. 10-2008 (Norwegian aquaculture trade magazine).

Lateral-line necrosis is a recognised condition of cod with a an unknown cause (Figure 8). An infectious aetiology cannot be ruled out.

Deformities such as "broken neck", stunted jaw and skeletal malformation continue to be reported, with very different batch to batch frequency. Nofima Marine, Sunndalsøra (previously Akvaforsk) have developed diagnostic methodology related to skeletal deformities in fish and are now researching the frequency and causes.

Mortalities among "egg-bound" sexually mature female cod may account for large losses in some farms.

**Figure 7.** Cod with volvulus. The affected parts of the intestine suffer infarction and necrosis, resulting in the death of the fish. Photo: Grethe Adoff, Norsk Sjømatsenter

## Halibut

Almost 30 samples were submitted from a total of eight halibut farms in 2008. There are no significant changes in the disease situation compared to previous years (Table 3).

## Wrasse

A total of twelve submissions involving wrasse were registered by the National Veterinary Institute in 2008. This is a significant increase from previous years when there have typically been submissions from one to two farms annually. The situation is dominated by various bacterial diseases, mainly vibriosis and atypical furunculosis.

## Other species

During 2008 the National Veterinary Institute received samples from three farms practising ongrowing of wild-caught coalfish. Gill inflammation was diagnosed, and granuloma identified in the spleen and liver of individual fish, without subsequent identification of specific disease causing organisms. Fishermen and divers in Trøndelag and Møre og Romsdal reported a vibriosis-like condition in coalfish. Vibriosis, caused by *V. anguillarum* O2b was diagnosed in samples analysed from Trøndelag. A *Photobacterium* sp. was also isolated.

The National Veterinary Institute has also received samples from a single wolffish farm. Gill inflammation, atypical furunculosis (infection with atypical *A. salmonicida*) and ectoparasites including *Trichodina* sp. continue to be problematical in farming of this species.

## Other research and development projects

Farming of cod is a relatively new industry, and there remains a significant requirement for new knowledge in relation to health. In addition to those subjects discussed above there are several research projects which are wholly or partly aimed at disease or disease prevention in cod.

The research project "CodVacc: Vibriosis and furunculosis vaccines for Atlantic cod: efficacy, protective antigens and specific immune responses" is a cooperative project between Nofima, the National Veterinary Institute and the Norwegian College of Fishery Science.

Vibriosis and atypical furunculosis, caused by *Vibrio* (*Listonella*) *anguillarum* and *Aeromonas salmonicida* respectively, are two bacterial diseases which cause significant losses to the cod farming industry. There is a requirement for vaccines which award good protection against these diseases. *V. anguillarum* and *A. salmonicida* exist in several variant forms, and the aim of the project is development of vaccines which give good protection against all the variants which cause disease in cod. One of the primary aims of the project is identification of all variant types and their geographic range. Isolates from outbreaks of vibriosis and atypical furunculosis are also compared with isolates currently used in existing vaccines.

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

| | 2005 | 2006 | 2007 | 2008 |
|---|---|---|---|---|
| IPN | 1 | 1 | 1 | Not detected |
| VNN (nodavirus) | Not detected | 2 | 1 | 1 |
| Atypical furunculosis (*A. salm.*) | 3 | 2 | 3 | 2 |

A project comparing different types of intraperitoneal vaccines has been initiated. This is a cooperative research project between the Helgeland Research Station, Nordland Marin Yngel AS, the National Veterinary Institute and two vaccine manufacturing companies. Intraperitoneal vaccination with a water-based vaccine and three different oil-based monovalent vaccines was performed during the autumn of 2008. The trial will proceed until summer 2009, the main goal being evaluation of possible differences in growth and vaccine side-effects between the four vaccine groups.

**Figure 8.** Lateral-line necrosis in cod. Photo: Tom C. Tonheim, Fiskehelse og Miljø AS (FOMAS)

Several projects are under way designed to identify the causes of loss and mortality in farming of cod. Codlink is a two-year, national benchmarking project for production of cod involving 15 cod farming companies, other industry partners and several research organisations as partners. The main aim of the project is registration of data related to production of cod and retrospective internal comparison of data generated. In this way it is hoped that optimal production conditions may be identified.

Codlink also includes a health related sub-project, led by the National Veterinary Institute. Health surveillance is performed in cooperation with local fish health services who collect data and samples for histological analysis, from every site involved in the project, every second month. The aim of these registrations is to map the health problems in cod farming, compare results from each site and compare the health related data with production data for each site. A further aim is comparison of health related data on a regional basis. Further, the project will hopefully identify areas for future R+D health related studies in cod. Preliminary results indicate a broad spectre of diseases/ agents within the project. Pathological changes consistent with francisellosis, atypical furunculosis and vibriosis have been observed as well as a number of different parasites on the skin and gills and epitheliocystis-like inclusions in the gills. Additional observations registered include volvulus, abnormal liver colouring, ulcer, predator marks and cannibalism.

The project "Industrial production of cod" (Incod) is a three-year cooperative project, initiated in 2008, between farmers (mainly in western Norway), feed manufacturers and other companies. The main aim of Incod is to raise the quality of intensively produced juveniles, reduce losses during the ongrowing phase and reduce disease-related mortality, with a special emphasis on intestinal problems.

The "Mort registration project" is led by the Helgeland Research Station with the National Veterinary Institute as cooperative partner. During 2008, a prototype dead fish registration form to be used daily by farm workers in ongrowing sites was developed. Use of this form was tested on five farms between September – December 2008. The results of this trial, currently under analysis, should help quantify different causes of loss. It is planned to continue this work, regionally, nationally and as a Scandinavian cooperation (NORA).

## Naming of bacteria

Awarding names (nomenclature) and placing of organisms in related groups (taxonomy) are closely related disciplines. They are important parts of scientific systematics and are in constant revision. As new knowledge is generated on bacteria and on the relationships between different species, genera and families, the need for reclassification of individual bacteria will occur. This has occurred recently for several fish pathogenic and related *Vibrio* spp.

Name changes in some fish pathogenic and related bacteria:

| Previous name | New name |
|---|---|
| *Vibrio anguillarum* | *Listonella anguillarum* |
| *Vibrio fischeri* | *Aliivibrio fischeri* |
| *Vibrio logei* | *Aliivibrio logei* |
| *Vibrio salmonicida* | *Aliivibrio salmonicida* |
| *Vibrio wodanis* | *Aliivibrio wodanis* |

Growth of bacteria in mixed culture. Photo: Kristin Aakvik Hopkins, National Veterinary Institute

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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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