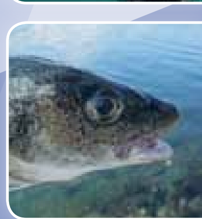
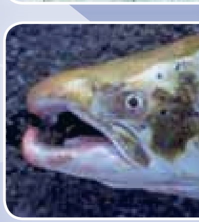
The Health Situation in Norwegian Aquaculture 2011





Veterinærinstituttet
Norwegian Veterinary Institute

In 2011, 1 005 600 tons (harvested) of Atlantic salmon, 54 100 tons of rainbow trout and an estimated 15 300 tons of cod, 2100 tons of halibut and 800 tons of other species e.g. coalfish, arctic char and turbot, were produced (Kontali Analyse AS). .
On a national scale, viral infections remain the most significant diseases in Norwegian aquaculture. In addition to direct mortality related losses, reduced growth and secondary infections in fish less resistant to handling and unfavourable environmental conditions are common. The PD situation worsened towards the end of the year, with some diagnoses north of Hustadvika, including identification of a new PD virus variant (atypical SAV2). There were however, some positive developments. The ISA situation is favourable, and new results from selective breeding and management appear to be working in relation to the IPN situation. These developments are particularly encouraging given the losses associated with IPN in Norwegian aquaculture over many years.

Salmon louse infestation represents one of the most significant challenges to Norwegian aquaculture and one which must be resolved. While this is currently and primarily a problem for wild salmonids, with the continuing increases in incidence of treatment failure in aquaculture, it has the capability of escalating to become a serious threat to farmed fish. Such a situation was experienced during the late 70's and early 90's when few therapeutic choices were available. Many current anti-lice treatments are expensive and stressful for the fish. Cleaner fish have proven to be effective tools against lice, but are not problem free. Capture, maintenance in captivity and transport of wild cleaner fish result in both ethical and disease related challenges.

In later years, there have been growing indications that smolt quality is not satisfactory, resulting in increased susceptibility to disease and poor fish welfare. Modern smolt-production is challenging in that biological factors must be manipulated to adapt to synchronised production of large numbers of fish with specific delivery dates.

Efforts to solve current environmental and disease issues in large scale smolt production and to make the production more efficient include development and implementation of new production technology. Several types of contained/semi-contained culture systems are under testing and several juvenile production units based on recirculation technology are either established or under planning. These technological developments will undoubtedly advance the industry, but will not, in the short term, solve all disease-related challenges. These new developments will undoubtedly present their own problems related to disease and welfare. We already know that an increase in 'ulcer/wound' development will be experienced in contained seawater units.

Production losses remain a significant problem in Norwegian aquaculture. The industry must develop and implement a common system for registration of such production losses. This will provide a better basis for comparison and create opportunities for identification of the main causes of loss. It is also important that the industry sets specific limits for both type and amount of loss which can be accepted. This will, in time, make a significant contribution to good fish health

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The Health Situation in Norwegian Aquaculture 2011

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- The Health Situation in Marine Fish

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Health Situation in salmonids 2011

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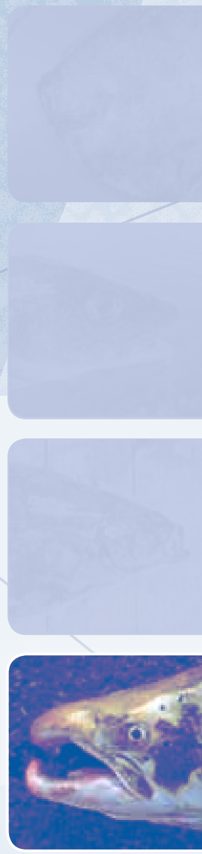

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The Norwegian aquaculture industry experiences large disease related losses. While viral infections continue to be problematical, production diseases related to smolt quality and various management related factors, contribute substantially to overall losses. The parasitic crustacean salmon louse causes large economic losses to the industry and reduced sensitivity to anti-lice treatment is a problem in some parts of the country.

Summary

The disease situation described in the present report is based on diagnostic submissions to the Norwegian Veterinary Institute and reports from fish health services nationwide. Notifiable diseases must be confirmed by an authorised laboratory. Statistics related to the occurrence of these diseases is therefore more accurate than for those diseases which are non-notifiable. During 2011, the Norwegian Veterinary Institute received approximately the same number of diagnostic cases as during 2010. There were however, some changes in the disease situation. As in recent years, viral diseases again caused large losses in 2011. There are however, some positive tendencies.

Only one case of ISA was registered in 2011, in Finnmark. In 2010 seven cases were registered nationally, all in the three most northerly regions. The ISA epidemic in south- and mid-Troms, which has existed since 2007, is now under control. Eradication measures have concentrated on the Astafjord area, which will be fallowed for at least two months from February 2012. Changes relating to industry structure within the area and post re-stocking surveillance are currently under consideration.

It is now known that ISA-virus genotype HPRO, which is not associated with disease, and is present in all major salmon producing countries, is also a normal finding in Norwegian farmed salmon.

The reduction in number of IPN cases registered in 2010 continued in 2011. During the last two years the number of confirmed IPN outbreaks has been reduced by approximately one third, from 223 to 154 cases. IPN is primarily a problem for salmon in Norwegian aquaculture. As in previous years, only a very few cases were diagnosed in rainbow trout. It is considered likely that some of the reduction in prevalence of IPN is linked to the use of QTL-roe (roe with gene-markers for IPN resistance), which were released for the season 2009/2010. Other factors, including eradication of so-called hatchery 'house strains', may have contributed positively.

The pancreas disease (PD) situation was again serious in 2011. The number of registered cases (89) was similar to that registered in 2010 (88) and all, as previously, were registered in the sea water phase of culture. In 2010 all diagnoses were made within the endemic zone south of Hustadvika in Møre og Romsdal. In 2011, four outbreaks were identified outside the zone. These comprised one case in Nord-Trøndelag in the spring, and three cases towards the end of the year, one in Sør-Trøndelag and two immediately north of the endemic zone.

The number of cases registered in salmon within the endemic area fell compared with the previous year. A larger proportion of cases were identified in rainbow trout, with 18 affected sites registered compared to 14 in 2010. This is the highest annual number of cases yet recorded in rainbow trout. The reduction in number of registered salmon cases was approximately 9%.

A new 'atypical' variant of Salmonid alphavirus (atypical SAV2) was associated with disease in 2011. The subtype of SAV most commonly associated with PD-outbreaks in Norway is SAV3. Epidemiological investigation into the atypical subtype continues and retrospective identifications from outbreaks as far back as 2010 have been made. All PD outbreaks north of the endemic 'barrier' at Hustadvika in 2011 were caused by the new atypical SAV2 variant.

There was an increase (approximately 20%) in the number of heart and skeletal muscle inflammation (HSMI) cases registered in 2011 compared with 2010 (162 compared with 131). Mid- and Northern- Norway remain the core areas for HSMI. While there is a positive relationship between the number of piscine reovirus (PRV) virus particles and HSMI, the virus is extremely widespread. Investigations are currently underway which hope to define the relationship between PRV and HSMI. The number of diagnosed cardiomyopathy syndrome (CMS) cases was similar to 2010. This disease causes significant financial losses due to the large size of affected fish. The ability of piscine myocarditis virus (PMCV) to cause CMA has been demonstrated in laboratory trials.

The salmon louse, Lepeophtheirus salmonis, remains a serious challenge to the aquaculture industry and is the primary parasitic problem in Norwegian aquaculture. For the country as a whole (according to reports submitted by farmers) there were fewer salmon lice in sea-farms in 2011 compared with 2010. For a few areas with intensive aquaculture the situation for wild salmonids was, however, worse than in 2010. Migrating wild salmon smolts in some areas of western- and mid-Norway may have been subjected to higher infection pressure than in recent years. Reduced sensitivity to lice therapeutants has been registered in Sunnhordland, Nord-Trøndelag and Nordland. In these areas, resistance to several licensed treatments currently used for lice control has been registered. Use of cleaner fish (wrasse and lumpsucker) has increased from 2010.

Of the bacterial diseases, an improvement was registered for yersiniosis and infection caused by Pseudomonas fluorescens. These infections affect mainly fresh water juvenile production units, although they may follow fish and result in mortality at sea. In ongrowing sites, there were as in previous years, a number of reports of winter ulcer, although many regarded the situation as somewhat better than in previous years. Both Moritella viscosa and Tenacibaculum spp. are associated with ulcer/lesion development in late winter and spring. Systemic infection with Flavobacterium psychrophilum was again identified in large rainbow trout in a brackish water fjord in western Norway. This disease has occurred annually in this fjord since 2008.

Bacterial kidney disease (BKD) was not diagnosed in 2010, but reappeared in 2011 in salmon in one hatchery and two ongrowing marine sites. One of the marine sites had received smolts from the affected hatchery. The fish on these two sites were destroyed.

Gill diseases again caused losses to the industry in 2011. In spring, acute mortality was associated with a “brown sea’ episode caused by the algae Pseudochatonella, and the annual autumn occurrence of mild and more serious chronic gill inflammation (PGI) was registered.

Both nephrocalcinosis and tapeworm can be considered as environmental welfare indicators. Nephrocalcinosis in salmon and rainbow trout is associated with high levels of CO_2 during the freshwater stage of culture. Intestinal tapeworms, Eubothrium sp., affect mainly weakened fish in marine sites. An increase in both conditions was experienced in 2011.

Relatively high post- sea transfer losses and conditions such as ‘smolt mortality’ (mortality following sea transfer) and ‘runt syndrome’ (fish showing loss of growth following sea transfer), indicated smoltification problems in a number of fish populations.

Background for the fish health report

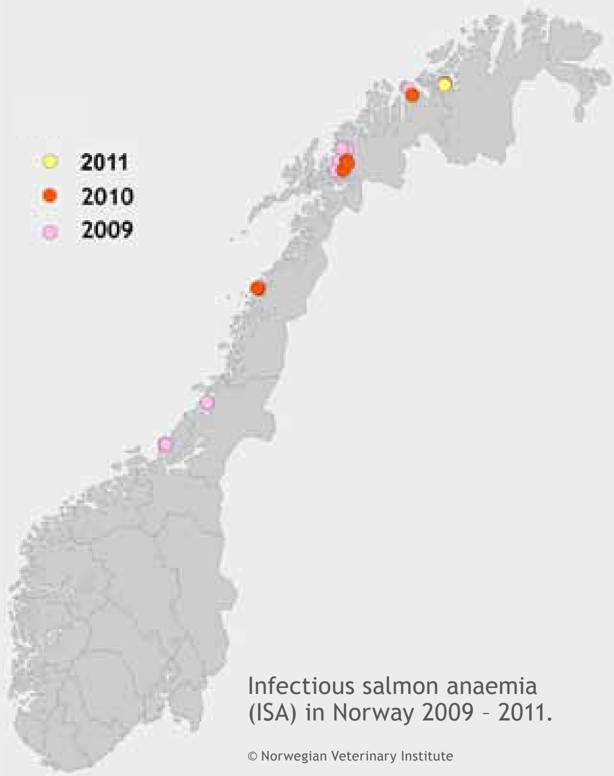
To provide a complete picture of the health situation in farmed salmonids, this report is based on both information gathered from fish health services nationwide and diagnostic data from the Norwegian Veterinary Institutes’ regional laboratories in Harstad, Trondheim, Bergen, Sandnes and Oslo. Information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

Table 1. Total number of sites 1998-2010 diagnosed with infectious salmon anaemia (ISA), pancreas disease (PD), heart and skeletal muscle inflammation (HSMI) and infectious pancreatic necrosis (IPN). For those diseases for which it is relevant, both “suspected” and confirmed diagnoses are included. Navnet på sykdommene i tabellen: ISA, PD, HSMI, IPN

	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
ISA	13	14	23	21	12	8	16	11	4	7	17	10	7	1
PD	7	10	11	15	14	22	43	45	58	98	108	75	88	89
HSMI							54	83	94	162	144	139	131	162
IPN					174	178	172	208	207	165	158	223	198	154

The criteria used for confirmation of a diagnosis inevitably changes as we gain new knowledge of diseases and disease processes. The Norwegian Veterinary Institute is therefore capable of awarding steadily more assured and precise diagnoses. 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 e.g. IPN. Although diagnostic criteria may change over time, previous diagnoses are usually confirmed by newer methodology. The various diagnostic methods currently used by the Norwegian Veterinary Institute are described under each specific disease, and possible changes in diagnostic criteria should be considered when comparing statistics relating to the number of recorded outbreaks from year to year.

The presented statistics relate to diagnoses awarded at the site (locality) level and do not distinguish between different fish groups within individual sites.



Infectious salmon anaemia (ISA) in Norway 2009 – 2011.

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 list of notifiable diseases has varied over the years. In 2008, new fish health legislation replaced the old group A-, B- and C- diseases with list 1-, 2- and 3- diseases. Norway is today free of diseases in list 1. Of list 2 diseases, infectious salmon anaemia (ISA) and viral haemorrhagic septicaemia (VHS) are most relevant. List 3 covers the so-called "National" diseases. There are a number of changes in these lists from previous years e.g. infectious pancreatic necrosis (IPN) has been removed from the lists. Those diseases which are notifiable at any particular time must be considered when the annual number of outbreaks of any particular disease is compared over time. More information on relevant legislation and the diseases included in each list can be found on http://www.mattilsynet.no.

General

In the course of 2011 the Norwegian Veterinary Institute received approximately 2500 diagnostic submissions related to health problems in aquaculture localities. The total is similar to the previous year, but the disease pattern shows some changes. Also in 2011, in a number of cases investigated, more than one disease was diagnosed concurrently, either in individual fish or within the studied population. Cases with one disease following another were also diagnosed.

The threshold for submission of samples for laboratory investigation varies and a broad spectrum of scenarios have been investigated from vague signs of morbidity to investigation of serious established diseases.

Viral Diseases

Infectious salmon anaemia (ISA)

In 2011, only one outbreak of ISA was diagnosed, in Finnmark. In comparison, seven farms were diagnosed with ISA during 2010, all in the three most northerly counties.

The epidemic in south- and mid- Troms which has existed since 2007, gradually disappeared with diagnoses limited to the Astafjord in 2010. During the autumn of 2010 the Norwegian Food Safety Authority announced that sea transfer of smolts in this area would be forbidden for 2011. Cooperation between farmers and the public authorities made identification of alternative on-growing sites outside the affected area possible.

Harvest of salmon presently stocked in three sites within the Astafjord is planned for February 2012. The Astafjord will therefore lie fallow for at least two months prior to a gradual increase in production. A process of structural change within the industry is underway and the Norwegian Food Safety Authority plans an increased level of surveillance in future years.

Conditional permission for vaccination against ISA-virus was granted by the Norwegian Medicines Agency in 2008. The permission related to salmon planned transferred to sea in the spring of 2009. The permission was initially based on the situation in south- and mid- Troms and was extended to include later generations stocked into endemic areas. During the spring and autumn of 2009 vaccinated fish were stocked into six sites in the area of highest risk. Of these six sites, ISA outbreaks occurred in three during 2010. Following a change in legislation in 2010, vaccination against ISA is now generally permitted with the exception of areas with 'ISA-free' status.

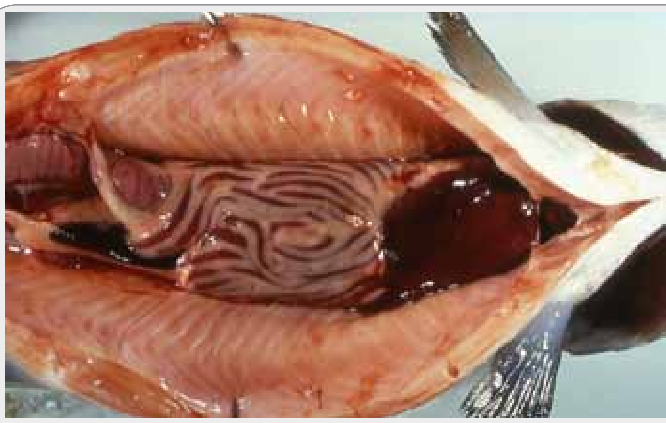
ISA is caused by an orthomyxovirus which infects and damages blood cells and cells lining the walls of blood vessels. This often results in anaemia (lack of blood) which can be extreme, with varying degrees of haemorrhage during the final stages. The disease leads to increased mortality and is a list 2 notifiable disease. Diagnosis is based on several criteria, in which identification of typical pathological changes is combined with detection of virus by at least two independent methods. These criteria are defined in international (OIE; World Animal Health Organisation and EU) guidelines. Direct detection of ISA-virus in tissues by PCR and immunohistochemistry (detecting nucleic acids and virus specific antigens respectively) is the most common combination of methods used in diagnosis of this disease. While PCR detection of ISA-virus alone is not sufficient to initiate restrictions, clinical signs and clinical history alone may be considered sufficient to initiate such counter-measures.

The surface protein hemagglutinin-esterase (HE) is an important virulence factor (i.e. ability to cause disease) for ISAV. Molecular characterisation (genotyping) of ISA-virus from classical ISA outbreaks shows that the gene coding for HE contains a deletion (shortened variant of the gene) in the hyper-variable area (HPR). HE-variants possessing full-length (without deletion), so-called HPR0-genotypes are, however, found in both healthy wild salmon and farmed salmon without classical ISA-associated disease changes. HPR0 genotypes have been identified in farmed salmon from all the major salmon farming countries. Following the fallowing and restocking of the Faroe Islands in 2005, the extensive screening for ISA infection has shown that HPR0 infection occurs as a short, seasonal epidemic in all sea farms, approximately seven – eight months after sea transfer. HPR0 infections are identified primarily in the gills, without signs of clinical disease or increased mortality. While HPR0 most probably constitutes the origin of pathogenic ISA-virus, the risk for such development is considered low within the aquaculture structure now in place in the Faroe Islands. Investigation of the prevalence of HPR0 in Norway has revealed that HPR0 is a normal finding.

At the moment, no direct connection between size of the deletion in HPR and virulence (ability to cause disease) can be identified. Recent studies have also shown that this region in the ISA-virus genome is not the only difference between low- and high- virulent strains.

Counter-measures against ISA follow a contingency plan adapted to EU regulations and OIE (world animal health organisation) recommendations. The OIE is currently reviewing handling of HPR0 detections and whether such primary detections should represent a notifiable event.

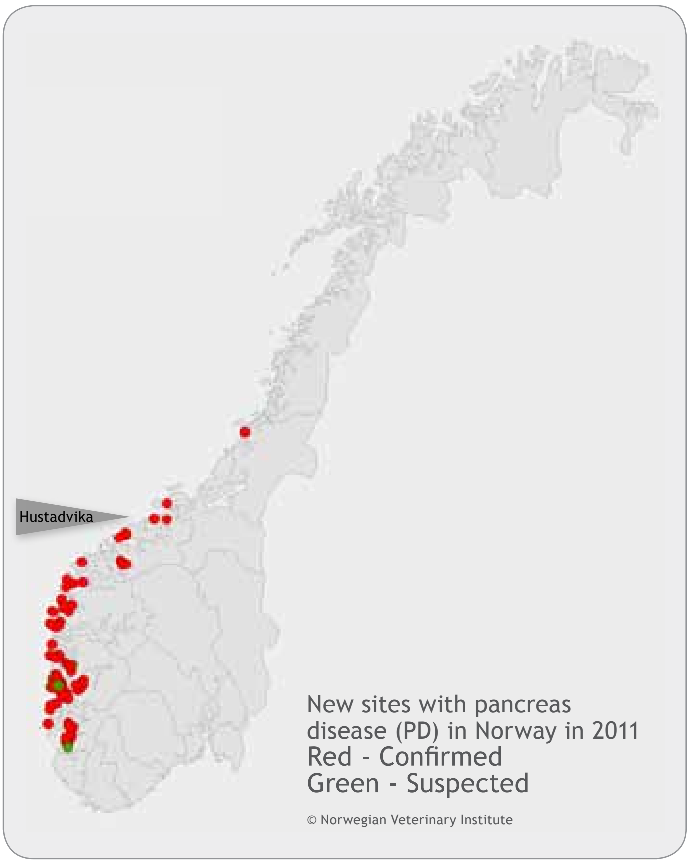
Since diagnosis of ISA in Chile in 2007, the country has experienced extensive problems with this



Mørk, blodig lever og blodige tarmer hos laks med infeksiøs lakseanemi (ILA) disease. Chilean ISA isolates from 2007 and onwards are closely related to Norwegian isolates. Epidemiological studies in Chile indicate, in accordance with previous studies performed in Norway and North America, that horizontal transmission is significant for spread of infection. A series of new laws and regulations have been introduced to help control the disease in Chile. ISA was diagnosed only once in Chile in 2011.

Previously ISA is known from the east coast of north-America, the Faroe Islands, Shetland and Scotland. The disease appears to be under control in the Faroe Islands, Shetland and Scotland. The Scottish and north-American situations indicate that rapid stamping out after outbreak of disease is an effective method of control of spread of infection. ISA was endemic in the Faroe Islands until 2005, when a comprehensive slaughtering and fallowing programme was initiated. This was followed by restocking with vaccinated fish and massive testing for ISA-virus. The results until now have been good, and ISA outbreaks have not been since detected.

The Norwegian Scientific Committee for Food Safety (VKM) has considered the possibility for vertical transmission of ISA-virus. The committee concluded as follows: "Vertical transmission of ISA-virus cannot be excluded, but is of little or negligible importance for spread of ISA in Norwegian aquaculture". This is consistent with the conclusions of a broad international panel of researchers, selected by the VKM, in a previous evaluation in 2007.



New sites with pancreas disease (PD) in Norway in 2011
Red - Confirmed
Green - Suspected

Pancreas disease (PD)

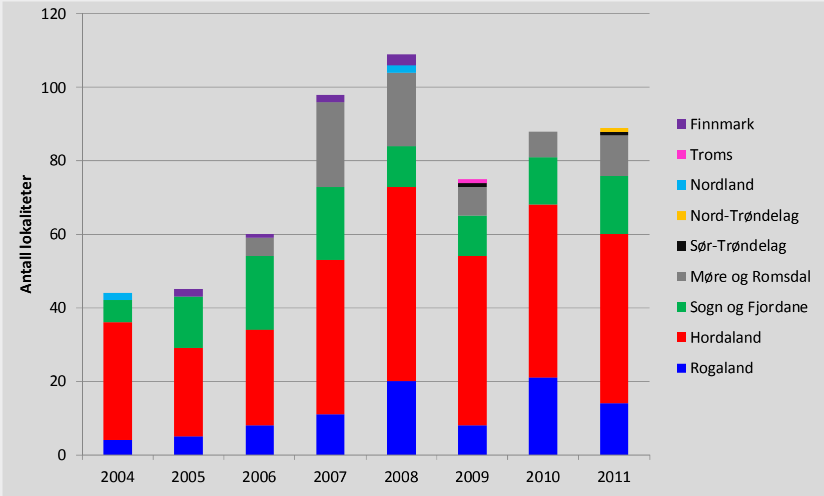
A total of 89 confirmed diagnoses and 'suspected' cases were registered in 2011 i.e. a level very similar to 2010 when 88 cases were registered (Table 1). While all cases identified in 2010 were situated within the endemic zone south of Hustadvika in Møre og Romsdal, four of the 2011 cases were outside the endemic zone. These comprised one diagnosis in April in Nord-Trøndelag and three at the end of the year, one in Sør-Trøndelag (in the Hitra area) and two in Møre og Romsdal, immediately north of the endemic zone. In recent years a few cases have been identified in Nordland, Troms and Finnmark. Between 2003-2008 PD was endemic in a limited area in Finnmark.

Within the endemic zone, a reduction in the number of cases involving salmon was registered. Outbreaks in rainbow trout comprised a larger proportion of cases compared with the previous year i.e. 18 cases in 2011 compared to 14 in 2010. This is the highest number of annual cases in rainbow trout yet registered. The fall in number of salmon cases represents a reduction of around 9% (67 cases in 2011 compared with 74 in 2010).

As in previous years, the majority of cases in 2011were once again registered in Hordaland. The number of new cases registered in this region remained high at approximately the same level as previous years (47 in 2011 and 2010, 46 in 2009 and 53 in 2008). Rogaland peaked in 2010 with 21 registered cases with a reduction in 2011 to 14 cases. Sixteen new cases were registered in Sogn og Fjordane in 2011 compared with 13 the previous year, while the equivalent figures for Møre og Romsdal are nine (2011) and seven (2010).

These statistics relate to the number of new sites with clinical PD and sites which have been re-diagnosed following a period of fallowing. This means that the real number of cases each year are actually much higher as sites exist which contain infected fish diagnosed the previous year. In addition there are infected sites containing symptom free carrier fish, which are not included in the statistics. Infection pressure is, therefore, very high within the endemic zone.

PD was diagnosed during the whole sea water phase of culture and throughout the year, but as in previous years the majority of cases were registered in June, July and August (month of submission to the Norwegian Veterinary Institute). The disease is repeatedly detected in some farms throughout large portions of the culture cycle. No complete statistics relating to overall losses or mortality due to PD are maintained. The losses are, however, clearly significant over time.



Regional distribution of new sites with pancreas disease (PD) 2004 – 2011.

Pancreas disease (PD) is only recognised as a disease in salmonid fish. The infectious agent is a salmonid alphavirus (SAV), referred to as PD-virus. There are six known genetic variants (subtypes) of SAV virus. The first recognised variant, SAV1, was described as the aetiological agent of PD in Scotland and Ireland in 1995. Subsequently, subtypes 4, 5 and 6 have also been described from sea-farmed salmon. SAV2 is the aetiological agent of a type of PD in rainbow trout in fresh water known as sleeping disease (SD). Sleeping disease-virus was imported to British fish farming with rainbow trout from Europe. In later years a variant of SAV2 has been identified in association with PD in sea-farmed salmon in Scotland.

Until recently, only one subtype, SAV3, which gives PD in both salmon and rainbow trout had been detected in Norway. During 2011 a SAV2-like variant, termed atypical SAV2, was identified for the first time in sea farmed salmon in Norway. Study of archived materials has identified the new variant in cases as far back as 2010. All outbreaks north of Hustadvika in 2011 were caused by atypical SAV2. Infection with atypical SAV2 results in the same type of organ damage as that caused by SAV3 and the disease is diagnosed through normal PD diagnostic routines.

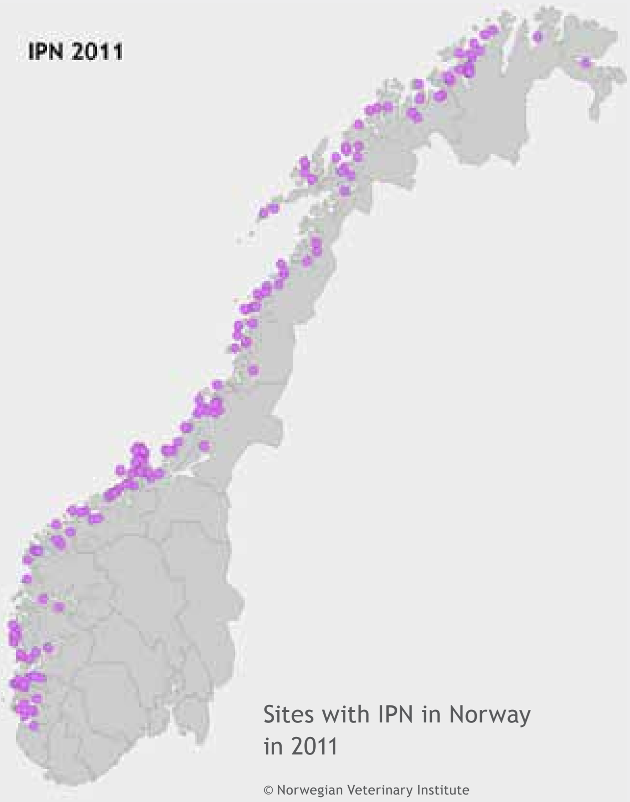
For diagnosis of PD i.e. confirm that the fish are suffering from pancreas disease and not merely non-symptomatic carriers of the virus, identification of characteristic histopathological tissue changes (microscopy of processed tissues) combined with detection of PD-virus in the same individual fish is necessary. The most common method used to detect the virus is real-time RT-PCR, in which specific parts of the viral genome are amplified and visualised. In cases of acute PD the virus may be detected in the pancreas using specific antibodies (immunohistochemistry).

The main tissues affected by PD are exocrine pancreas (the part of the pancreas producing digestive enzymes) and heart and skeletal musculature. Fish with PD may show no clinical signs of disease. The usual signs of PD include lack of appetite, with increasing morbidity and mortality. During the chronic phase fish often aggregate near the surface, maintaining their position against the water flow.

Low levels of peritoneal fat in salmon with chronic pancreas disease (PD) . Photo: Øyvind Vågnes, NVI.

Infected farmed fish are considered to represent the main reservoir for PD-virus. The virus can be demonstrated with real-time PCR until 18 months post initial outbreak. The fish may also be infected for some time prior to manifestation of disease. In a Norwegian study PD virus was detected between 18-71 weeks prior to diagnosis of PD on the farm concerned. It is now known that the virus is shed in faeces and in skin mucus, and the virus has also been demonstrated in fat shed from dead fish. The virus spreads horizontally. Using hydrodynamic modelling, it has been recently demonstrated that sea currents contribute significantly to spread of PD-virus between farms.

PD is a list 3 disease, and maps displaying current PD outbreaks are updated on a daily basis and lists of diagnosed cases are published monthly in cooperation with the Norwegian Food Safety Authority on www.vetinst.no. Surveillance is performed by the aquaculture industry itself and by routine health control and disease diagnostics. The Norwegian coastline is split (geographically at Hustadvika) into two management zones according to legislation introduced in 2007. The management strategy within the 'endemic' zone i.e. south of Hustadvika, is based on limitation of disease within the zone and prevention of spread outside the zone. The aquaculture industry in western Norway has since 2007/8 been organised under the 'PD-free' project which has organised its own zoning system as an important preventative measure. An evaluation carried out by the Norwegian Veterinary Institute revealed a reduction in the number of PD outbreaks and losses associated with PD during the project period 2007-2010. Evaluation of the effect of individual measures is difficult, and it is considered that a combination of all measures introduced is probably responsible for the positive results achieved. Vaccination has been demonstrated to contribute positively. PD-vaccinated salmon showed lower overall mortality levels, although the results varied from group to group.

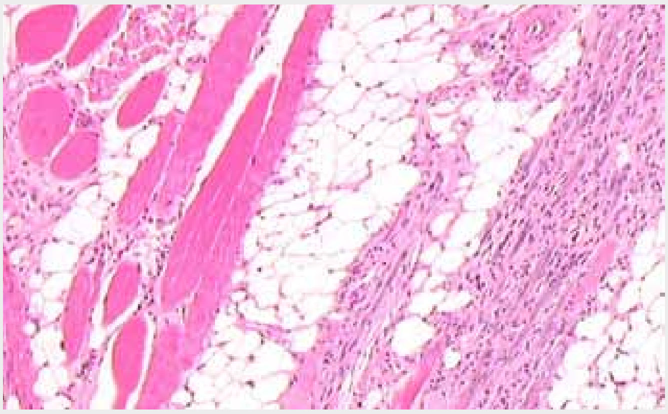


Sites with IPN in Norway in 2011

The area north of Hustadvika is considered as PD-free. Both the authorities and the industry have until now demonstrated low tolerance and have reacted strongly in a bid to stamp out new outbreaks which is in accordance with the advice from the working group "Stop spread of PD to Mid-Norway". Central to this strategy is limitation of spread and establishment of PD outside the zone.

Taken together it would appear that the combined effects of the authorities and the industry's handling of the situation has limited the disease to the endemic zone.

To stimulate more research in this area and rapid dissemination of research results, a "Trination" cooperation has been initiated where researchers, the industry and national authorities in Ireland, Scotland and Norway meet regularly. This has been found to be a useful meeting place for research cooperation and exchange of experiences with PD and similar diseases.



Histological micrograph of chronic muscle inflammation in fish with pancreas disease (PD) (normal muscle is stained an even red colour). Photo: Anne Berit Olsen, NVI.

Infectious pancreatic necrosis (IPN)

In 2011, IPN was diagnosed in a total of 154 sites, of which five involved rainbow trout, with the remainder affecting salmon. The outbreaks were distributed between 37 freshwater juvenile production units and 117 marine farms. In 2010 and 2009, IPN was diagnosed in 198 and 223 sites respectively (Tables 1 and 2). It would appear, therefore, that the prevalence of IPN in farmed salmon has fallen over the last three years.

For rainbow trout the number of registered IPN cases has remained low over several years (Table 2). IPN was delisted as a notifiable disease in 2008. There are however no grounds to believe that fish health services have changed their practices regarding submission of samples for confirmation of diagnosis in later years.

Fish health services report that IPN remains one of the most significant causes of loss, and that some farms, particularly in the sea phase, have experienced significant losses. Losses are both directly associated to IPN and indirectly through secondary infections. Outbreaks also result in a greater degree of handling (grading) of affected fish. This results in extra stress for the fish, which may again lead to mortality in weakened fish.

Otherwise, lower overall IPN-associated losses are reported for 2011 compared with 2010. Fewer IPN problems are reported in so-called QTL salmon stocks (see below). Several fish health services consider that use of QTL-roe and introduction of sanitary measures directed at eradication of 'house strains' of IPN virus have contributed to the reduction in the number of IPN outbreaks in salmon juvenile production units, from 51 cases in 2010 to 33 in 2011.

IPN-virus is a member of the Aquabirnavirus family to which a wide spectre of fish species around the world are susceptible. Clinical disease associated with IPN-virus is mainly associated with salmonid species in aquaculture, and is also a problem in other countries in which large scale farming of salmonids is practised e.g. Scotland and Chile. IPN-virus is very prevalent in farmed Norwegian salmon and rainbow trout. Mortality on outbreak of clinical disease is commonly higher during the freshwater phase of farming than in the seawater phase, but the economic losses are probably higher at sea. Susceptibility to IPN-virus is dependent on the age of the fish. Juveniles and post-smolts appear to be most susceptible. Variation in mortality may also be due to differing host susceptibility, viral virulence and environmental factors.

An IPN diagnosis is based on demonstration of necrosis (cell death) in liver and/or the pancreatic tissues responsible for production of digestive enzymes (exocrine pancreas) on histological investigation of formalin fixed tissues. This is combined with positive immuno-marking (immunohistochemistry) for IPN-virus in affected tissues. Culture of virus particles from kidney tissues is also possible, as is detection of virus particles by real-time RT-PCR. As asymptomatic IPN carrier fish are common, it is critical that disease diagnosis is not based on identification of the virus alone.

Affected fish in freshwater and during the early stages of sea-culture often display abnormal swimming behaviour. Other diseases e.g. infection with Flavobacterium psychrophilum and Yersinia ruckeri may present clinically similar pictures and laboratory verification of diagnosis is therefore important.

	Smolt plants		Ongrowing sites		
	RAinbow trout	Salmon	Rainbow trout	Salmon	Total
2008	12	58	2	86	158
2009	1	52	1	169	223
2010	3	51	1	143	198
2011	4	33	1	116	154

Table 2. Distribution of sites with IPN in relation to fish species (Atlantic salmon and rainbow trout), freshwater and seawater for the years 2008-2011

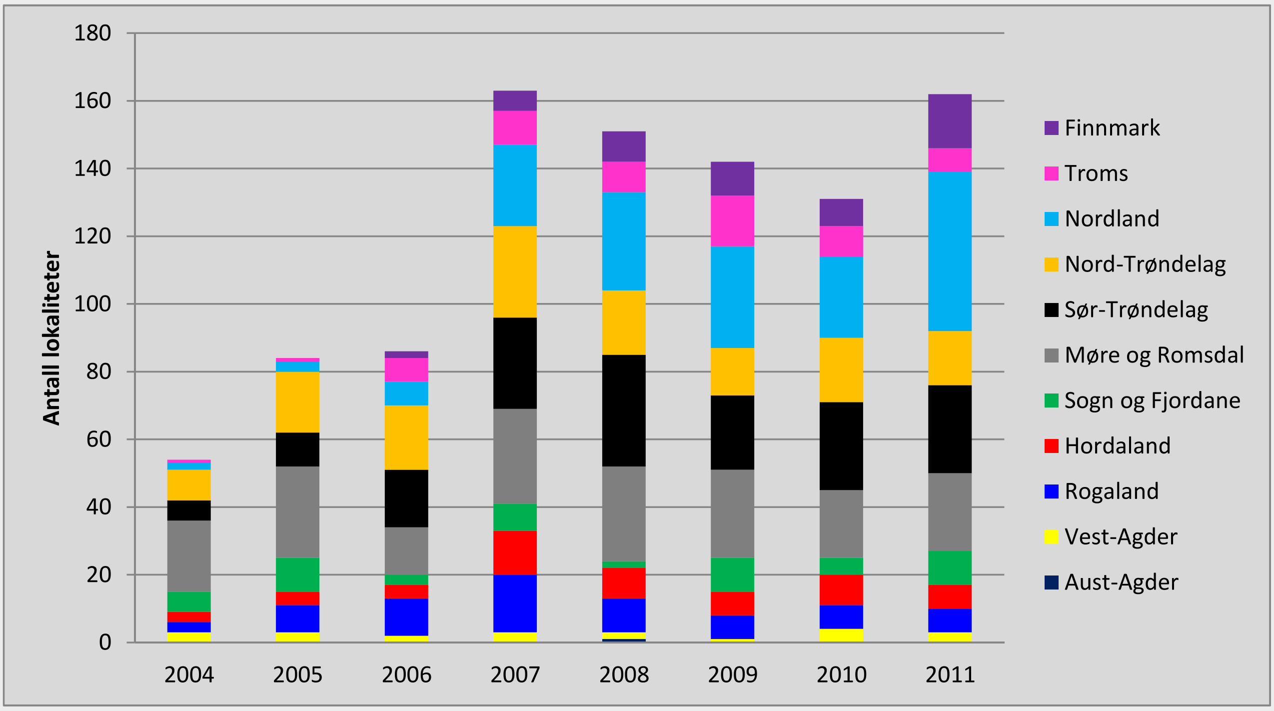
Rainbow trout juvenile with IPN. The abdomen is distended due to accumulation of mucus in the digestive tract. Photo: Freddy Jensen, FoMAS

Farmed fish are considered to comprise the most important reservoir for IPN-virus.
A large proportion of fish surviving initial IPN-virus infection remain infected for the remainder of their life. The virus is shed in faeces and urine, and can thereafter transmit horizontally. Survival of IPN-virus in water is very high, particularly at low water temperatures. Farm equipment may also act as a vector for transmission of IPN-virus. Results from several studies indicate that the virus transmits vertically (from parents to offspring) in Atlantic salmon. IPN-virus follows the fish from fresh- to salt-water, although fish may also be infected at sea.

Recent anti-IPN measures have, supported by recent research and experience, focussed on the freshwater phase of culture.

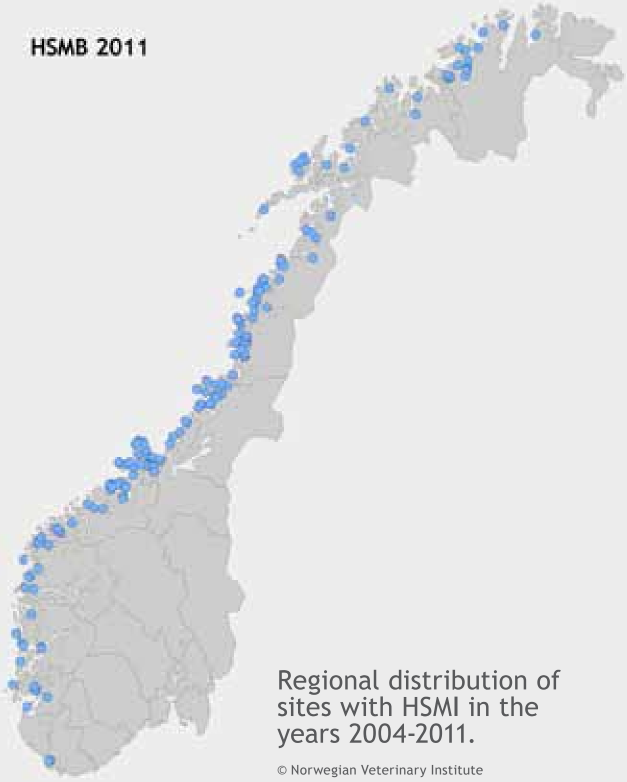
Selective breeding for IPN-resistance in farmed salmon started in the 1990s and considerable inter strain variation in heritable resistance has been demonstrated. IPN-resistance based breeding has until recently been based on traditional selection based on infectious challenge results. Gene markers for IPN resistance have now been identified (QTL markers). Salmon which are extremely resistant to IPN-virus in laboratory experiments have now been bred based on QTL selection. Field data is limited, but the available results are promising.

Most Norwegian farmed salmon are vaccinated against IPN. The effect of the vaccine compared with other preventative measures is much discussed. The latest vaccines most probably lead to reduced losses on outbreak of disease, but do not prevent development of carrier status, with the consequent risk of new outbreak of disease.



Regional distribution of sites with HSMI in the years 2004-2011.

There is little available documentation on the effect of management factors in avoidance or reduction of IPN outbreaks. Increase of water temperature has been used to control IPN outbreaks during the juvenile production phase. The effectiveness of this strategy is uncertain, as there are reports of serious outbreaks at sea in stocks which have been treated in this manner.Functional feeds are also proposed to represent a further method for prevention and control of IPN, but little documentation is available as yet on their effect.



Regional distribution of sites with HSMI in the years 2004-2011.

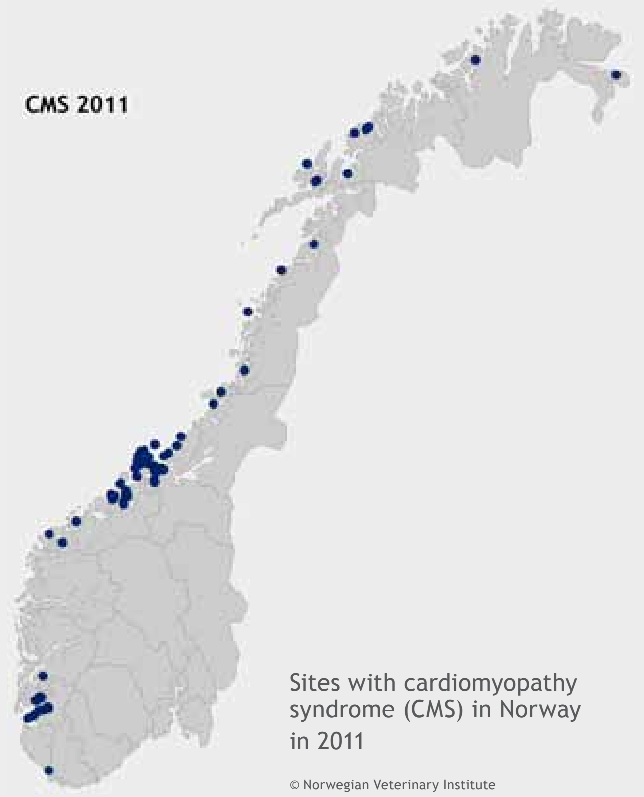
Heart and skeletal muscle inflammation (HSMI)

Heart and skeletal muscle inflammation (HSMI) is an infectious disease in farmed salmon which has in recent years become extremely widespread. In 2011 the disease was diagnosed in a total of 162 sites, most in the seawater phase (Table 1). This is an increase of approximately 20% in registered cases compared with 2010. In some regions 'nearly all' seawater sites were affected by the disease. HSMI outbreaks were also diagnosed in two juvenile production units with seawater intake.

The disease can result in very variable mortality. Episodes of significant mortality were again reported in 2011. HSMI also manifested in a less obvious way and was often reported following grading, movement and other management events which may have stressed the fish. Such a situation leads to challenges in relation to lice treatments etc.

The heart is the primary organ affected and sparse to gradually increasing changes in the heart may be observed histopathologically in the months prior to clinical outbreak. During clinical outbreaks, inflam-

Salmon with heart and skeletal muscle inflammation (HSMI) from one of the first cases in 1999. The fish had circulatory failure with haemorrhagic fluid in the pericardial and peritoneal cavity. Photo: Torunn Taksdal, NVI.



Sites with cardiomyopathy syndrome (CMS) in Norway in 2011

mation in the skeletal musculature is often observed. In addition, pathological changes in other organs, most commonly the liver, may be observed. Salmon dying with HSMI often display significant circulatory disturbances which may be both macroscopically and histopathologically visible.

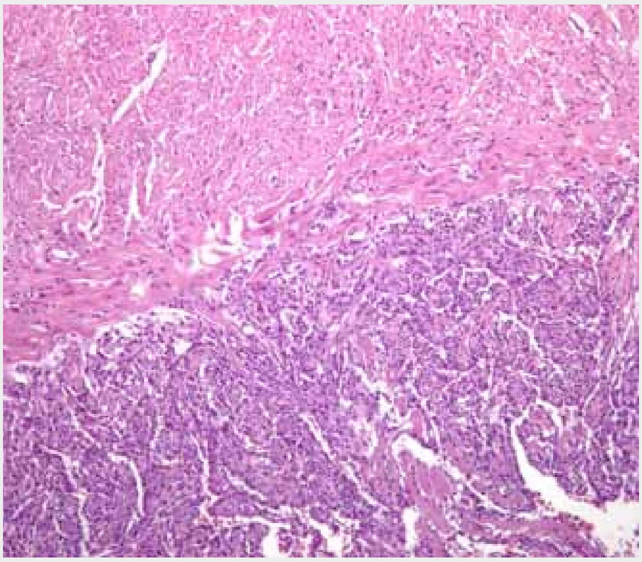
A viral aetiology for HSMI has long been suspected, and an infectious challenge published in 2004 confirmed its infectious nature. In 2010 HSMI was related to the presence of a virus, Piscine reovirus (PRV). This is a naked, robust, double stranded RNA virus. Real-time PCR investigations have shown that PRV is extremely prevalent and is found in both healthy and diseased farmed salmon, wild salmon and rainbow trout. There exists however a clear relationship between clinical disease and the amount of PRV in farmed salmon and direct detection of the virus in heart tissues of diseased fish supports a relationship between PRV and HSMI. It has also been revealed, however, that the presence of large amounts of PRV does not necessarily mean that the fish has or has had HSMI. Clearly more research is required to understand the relationship between virus and disease.

As the virus is extremely difficult to grow in cell culture, a good infectious model has not been available. Vaccine development is underway.

Cardiomyopathy syndrome (CMS)

The Norwegian Veterinary Institute diagnosed cardiomyopathy syndrome (CMS), also known as 'heart rupture' on 74 sites in 2011. This is a slight increase over recent years.

CMS is a serious heart complaint of salmon farmed in seawater, most often towards the end of the production cycle, when the fish are large and almost harvest ready. Episodes of stress such as handling, lice treatments and transport may precipitate



Cardiomyopathy syndrome (CMS) with widespread inflammation in the inner spongious layer (bottom of picture) of the heart, while the compact, outer wall (top of picture) is largely normal. Photo: Marta Alarcón, NVI.

Salmon with cardiomyopathy syndrome (CMS). The atrium is distended to the point of rupture and there is a layer of fibrin on the liver. Photo: Trygve T. Poppe, Norwegian School of Veterinary Science.

increased mortality. Occasionally accumulated mortality levels may reach 30%, but are usually much lower. Although the number of fish affected may be low, as they are large fish, the economic impact can be considerable.
The disease was first described in Norwegian farmed salmon in the mid-eighties. Similar clinical pictures have been observed in Scotland, Canada and The Faroe Islands. Clinically CMS can be similar to both PD and HSMI, but in typical cases the three diseases can be easily distinguished by histopathological investigation. Fish with typical CMS have considerable inflammatory changes in the inner, spongious parts of both atrium and ventricle while the compact tissues are, as a rule, normal. CMS has generally a chronic course and affects primarily the heart, with secondary circulation failure and liver damage.
There have been many theories on the cause of CMS. Its transmittable nature was demonstrated in 2009, and this supported the notion that a virus was probably involved. In 2010, two different research groups identified a new virus, Piscine myocarditis virus (PMCV), which seems to show a strong association with CMS: Cell cultured PMCV gives typical histopathological changes in the heart. The virus can be detected by PCR in CMS affected salmon and within the areas of pathological change using specific viral staining. The reservoir for the virus is unknown, as is why the disease only appears to affect older fish. The new knowledge on the relationship between virus and disease opens up opportunities for vaccine development.
Currently diagnosis is based on clinical findings and typical histopathological changes. Various molecular biology based diagnostic methods are under development and testing. This should provide valuable support for future CMS diagnostics.

Viral haemorrhagic septicaemia (VHS)

There were no outbreaks of VHS in Norway in 2011. The Norwegian Veterinary Institute has, under instructions from the Norwegian Food Safety Authority, performed a risk-based surveillance programme for VHS in 2011, also with negative results. Diagnostic samples submitted to the Norwegian Veterinary Institute have been utilised by the surveillance programme. By testing sick fish rather than random, clinically healthy fish there is a greater probability of detection of the virus.

VHS is caused by an RNA-virus of the family Novirhabdovirus. VHS-virus can be differentiated into four genotypes, of which 1-3 have been identified in Europe. Genotype 1a can cause very high levels of mortality in rainbow trout, and this is the reason that VHS is a list-2 disease. Detection of VHS-virus in farmed fish leads to destruction of all fish in the affected site. In 2007-2008, VHS was diagnosed in rainbow trout in several sites in Storfjorden. The VHS-virus from Storfjorden was identified as genotype 3, and this is the first and only identification of this VHS type in this fish species. Genotype 3 is previously identified from wild fish such as herring and cod.
The source of infection in Storfjorden remains unknown and several thousand wild fish have been tested. No genotype 3 virus has been identified in wild fish, although many genotype 1b have been found in herring. While the infectivity of genotype 1b is considered low for salmonids, genotype does not in itself provide a comprehensive picture of how dangerous a VHS variant is for different fish species. The outbreak of VHS in rainbow trout caused by genotype 3 illustrates the risks represented by marine variants of the virus.

Bacterial Diseases

Winter ulcer

Moritella viscosa is considered an important aetiological agent of winter ulcer, but other bacteria, mainly *Tenacibaculum* spp., have to an increasing degree been linked to this condition. The total aetiological picture

Winter ulcer in Atlantic salmon.
Photo: T. Poppe Norwegian School of Veterinary Science.

Large ”boil” in rainbow trout infected with *F. psychrophilum* from brackish water
Photo: Øyvind Vågnes, Norwegian Veterinary Institute

remains unclear. In addition to direct losses resulting from mortality, the disease may result in down-grading at harvest, thereby resulting in significant economic losses. Fish can also survive long periods with ulcers and the problem thereby contributes to reduced welfare for the farmed fish.

In 2011 the Norwegian Veterinary Institute registered isolation of M. viscosa from 69 marine farming sites, 62 from salmon and 7 from rainbow trout. This was an increase in the number of salmon sites compared with 2010 (47 sites). Infection with M. viscosa is not a notifiable disease and as such must not therefore be confirmed by the Norwegian Veterinary Institute. The real prevalence of M. viscosa infection is therefore unknown. More than 95% of all Norwegian salmon are vaccinated against M. viscosa.

Despite the fact that the Norwegian Veterinary Institute has isolated more Tenacibaculum spp. from fish with winter ulcer (mainly salmon but also rainbow trout) during 2011 than in previous years, this must be considered in light of an increased focus on Tenacibaculum spp. and use of agar suited for isolation of these bacteria. Tenacibaculum isolations were, in the main, limited to the spring (February, March and April with a few in May and June). Some cases were also identified in juvenile units with intake of seawater. As previously, Tenacibaculum spp. were primarily associated with lesions/ulceration on the flanks and the head region. These bacteria, in contrast to M. viscosa, are not associated with systemic infection.

Despite the increase in number of registered affected sites, fish health services nationwide considered the winter ulcer situation as variable with several reporting a situation as no worse and possibly improved over earlier years. Losses associated with winter ulcer were in most areas stable or lower in 2011 compared to previous years.

Infection with *Flavobacterium psychrophilum*

There were few diagnoses concerning Flavobacterium psychrophilum in Norwegian aquaculture in 2011. An increase from 2010 was, however, registered in rainbow trout farmed in brackish water. The identification of F. psychrophilum infection in large rainbow trout in four brackish water sites occurred in the same fjord system which has experienced outbreaks in the years 2008 – 2010. Fish transferred to sea in this fjord system are vaccinated with an autogen vaccine. The disease was also identified in a site containing rainbow trout near the border of the brackish water area. The infection was identified both in fish transferred to sea in the spring of 2011 and autumn of 2010. The clinical picture was similar to previous cases. Outbreaks were identified together with, or following PD and/or other bacterial diseases e.g. Vibrio anguillarum (vibriosis), Tenacibaculum spp. and Moritella viscosa. Outbreaks of systemic F. psychrophilum infection were also identified in smaller rainbow trout in a land-based site which has previously experienced problems with this bacterium.

F. psychrophilum was identified in salmon in two commercial juvenile production sites in 2011. In one of these sites the finding was considered secondary to a fungal infection. In the other site the bacterium was identified in an environmental sample taken during stripping of brood fish. There are large differences in host specificity and virulence in this bacterium.

Infection with ***Pseudomonas fluorescens***

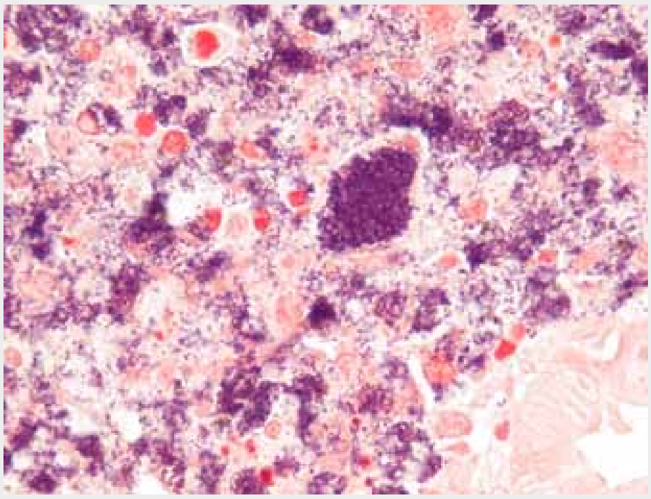
In 2011, infections caused by Pseudomonas fluorescens were registered in approximately 10 farming sites, mainly juvenile production units. Some cases were associated with considerable mortalities following sea transfer of infected fish groups. Many field workers considered the problem to be less than in previous years. Successful disinfection of affected fresh water sites was reported. P. fluorescens problems have commonly been related to poor water quality and infections have often been diagnosed in relation to vaccination. Over the last few years several fresh water sites have experienced significant losses and bacteria isolated from these outbreaks have caused high mortalities in laboratory trials.

Infection with *Yersinia ruckeri*

Yersiniosis is caused by the bacterium Yersinia ruckeri and can result in increased mortality in salmon and rainbow trout throughout the freshwater phase of culture. Considerable mortality may also occur when infected fish are transferred to sea. There have, however, been no diagnoses from sea sites in 2011. During 2011, yersiniosis was diagnosed in salmon in eight freshwater units, four fewer than in 2010, which was also a reduction from 2009. Some sites have experienced extended problems with Y. ruckeri. Reduced sensitivity to quinolone antibiotics has again been demonstrated in isolates from one such site. Most of the tested isolates belong to serotype O1.

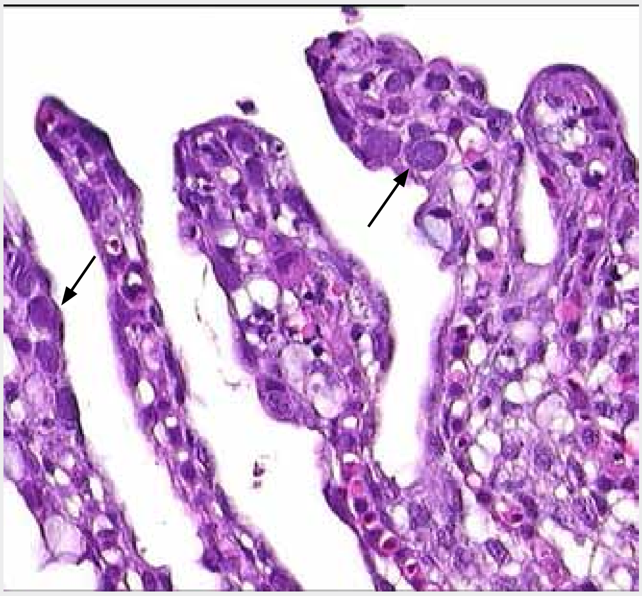
Bacterial Kidney Disease (BKD)

Bacterial Kidney Disease (BKD) was identified in salmon in three commercial aquaculture sites in 2011, two ongrowing marine sites and one freshwater juvenile production site. Fish diagnosed in one of the marine sites had been supplied by the affected freshwater site. Fish in both of these sites were destroyed. The source of infection to the freshwater site was not identified.



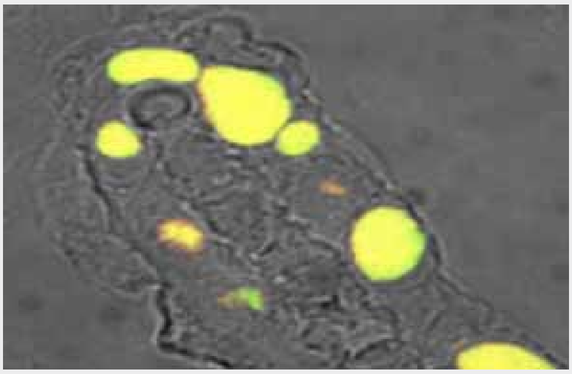
Massive infection with *Renibacterium salmoninarum* (stained blue) in the kidney of Atlantic salmon with bacterial kidney disease (BKD)
Photo: Cecilie Sviland, Norwegian Veterinary Institute

BKD was particularly problematical in Norwegian aquaculture in the period 1987-1993. Since 1998, the normal rate of diagnosis has been between 0 – 3 outbreaks annually. The number of outbreaks has been significantly reduced through good routines for broodfish testing and imposition of operating restrictions on diagnosed sites. The bacterium can be found in covertly infected wild fish, and the danger of horizontal infection is constantly present.



Epitheliocysts in gills stained positive by specific test (FISH) for the bacterium *Branchiomonas cysticola*

Photo: Anne Berit Olsen, Norwegian Veterinary Institute



Histological micrograph of gills with proliferation of gill epithelium and epitheliocysts (arrows)
Photo: Susie Mitchell, Vet-Aqua International

BKD is caused by the bacterium Renibacterium salmoninarum. Special medium is required for culture and growth is extremely slow. Infection does not always lead to clinical BKD, and apparently healthy carriers constitute an important source of infection. Clinical BKD commonly has a chronic course, and the period between infection and development of clinical disease may be extended. While infected fish may eat and behave normally, the internal pathological changes may be extensive. Systemic infection in parr and smolt may result in acute high mortalities with macroscopically visible changes including swollen, grey/pale internal organs. In older fish, which normally have a higher resistance. the disease manifests more commonly as a chronic inflammation and white nodulation of the inner organs.

A surveillance program, initiated by the Norwegian Food Safety Authority, has since 2006 been performed by the Norwegian Veterinary Institute. The program is now cancelled. BKD is a list 3 disease.

Epiteliocystis- *'Candidatus* Branchiomonas cysticola'

Epitheliocysts in salmon gills associated with proliferative gill inflammation (PGI) have for many years been exclusively associated with Chlamydia-like bacteria, e.g. 'Candidatus Piscichlamydia salmonis' in the seawater phase of culture. In later years it has not been possible to identify a relationship between the number of histologically visible epitheliocysts and the estimated number of 'Ca. P. salmonis'. A previously undescribed betaproteobacterium has now, however, been found to dominate in epitheliocysts in seawater farmed salmon in Norway. The name 'Ca. Branchiomonas piscicola' has been proposed. There are indications that this bacterium may be related to pathological changes in salmon gills and this relationship is now the subject of further research.

Andre bakterieinfeksjoner

All Norwegian farmed salmon are vaccinated against vibriosis, cold water vibriosis and furunculosis. Rainbow trout are vaccinated against vibriosis and to a variable degree against other diseases.
The Norwegian Veterinary Institute diagnosed vibriosis caused by Vibrio anguillarum serotype O1 in eight rainbow trout localities during 2011.
The infections were identified in August and September in 1.5 kg fish transferred to sea in the spring of 2011 and in large rainbow trout of up to 4 kg, transferred to sea in 2010. A number of fish displayed classical signs of vibriosis including a 'liquified' spleen and bloody 'boils' in the musculature. Vibrio anguillarum serotype O1 was isolated from salmon in one case in 2011 and also from wrasse held together

'Liquified' spleen in adult rainbow trout with classical vibriosis (infection with *Vibrio anguillarum)*
Foto: Øyvind Vågnes, Veterinærinstituttet

with salmon in the same site. Vibriosis is to a degree diagnosed in the field, without laboratory confirmation.

Cold water vibriosis, infection with Vibrio salmonicida, was diagnosed in salmon in five marine sites from Nord-Trøndelag and northwards. The diagnoses were made in April and May and were associated with (in part) considerable mortality. There are usually none or very few cases of cold water vibriosis diagnosed in salmonid fish in Norway.

Disease caused by Aeromonas salmonicida ssp. salmonicida (furunculosis) or atypical Aeromonas salmonicida (atypical furunculosis) was not identified in salmonid fish in 2011. Piscirickettsiosis, caused by Piscirickettsia salmonis, which remains an important pathogen in Chilean aquaculture, was not identified in Norwegian farmed salmonids in 2011.

Antibiotic resistance

Routine testing of fish pathogenic bacteria isolated from fish in aquaculture during 2011 did not identify new instances of reduced sensitivity to antibiotics licensed for use in Norwegian aquaculture. Yersinia ruckeri isolates with reduced sensitivity to quinolone antibiotics continue to be isolated from a single farm. The supposedly high virulent strains of Flavobacterium psychrophilum isolated from systemic infections in rainbow trout, have in 2011, as in previous years, shown reduced sensitivity to quinolones. Research has shown the molecular basis for this resistance to be a mutation in the gyrA gene, thus a low risk of transmission of this resistant phenotype to other bacteria exists. Some bacteria display a varying degree of 'natural' resistance. For example Pseudomonas fluorescens, and other related bacteria generally show low sensitivity to several antibiotics, while Tenacibaculum spp. display reduced sensitivity to e.g. quinolones.

Parasitic diseases

The salmon louse - *Lepeophtheirus salmonis*

On a national basis, according to on-farm registrations (www.lusedata.no), the number of salmon lice reported in existence in Norwegian salmon farms during 2011 was lower than in 2010. The level of mature females registered per fish was similar to the previous year until June, but was clearly lower from July – November. The total number of mobile stages i.e. pre-adult and adults of both sexes, was also lower in August – November 2011 than in 2010. Spring de-lousing (April 2011) under the direction of the Norwegian Food Safety Authority was clearly effective: In May the number of adult female lice was under 0.025 lice per fish on a national basis. The Norwegian Food Safety Authority reported an increasing number of lice in late autumn 2011,

The salmon louse *(Lepeophtheirus salmonis)*
Photo: Trygve T. Poppe, Norwegian School of Veterinary Science

particularly in Hordaland, Sogn og Fjordane, Møre og Romsdal and Trøndelag, although average levels continued to lie below the treatment threshold. An average of less than 0.2 adult females per fish was registered in the Troms/Finnmark and Rogaland/Agder regions during September – November 2011.

The Norwegian Food Safety Authority regulates the industry's anti-louse activity through salmon lice legislation and separate legislation applying to zones and periods of treatments etc. New legislation relating to salmon lice was introduced in January 2011. According to the new legislation, bath treatments must now be performed within completely enclosed cages, and not within a 'skirt' as previously. Treatments performed during 2011 using complete enclosure were considered successful both in effect of treatment and in practical terms. Legislations relating to zones have been introduced, one for south-Hordaland and one for parts of Sør- and Nord-Trøndelag. Effects of this legislation include improved coordination of treatments and improved reporting of lice numbers and resistance statistics. This legislation is now under evaluation.

The Norwegian Food Safety Authority summarises the resistance situation as follows: reduced sensitivity to salmon lice therapeutants is registered in Sunnhordaland, Nord-Trøndelag and Nordland i.e. areas which experienced the largest problems in 2010. In these areas, resistance against several types of medicament used in louse control was registered. According to farm-based reports approximately 25% of all sites were treated during spring, while approx. 10% of sites were treated in the following months. During autumn the number of treated sites increased to 15-20% (www.lusedata.no). The proportion of sites reporting use of wrasse as a louse control method increased from 20% in May to 50% in September-October. Capture of wild wrasse is regulated in relation to spawning periods for the various species of wrasse.

In 2011, the Institute for Marine Research coordinated a surveillance program for salmon louse load in wild salmonid fish. The Norwegian Institute for Nature Research (NINA), consultant biologists and UNI environment participated in the study. The results from this study were presented in a report to the Norwegian Food Safety Authority. The wild fish data discussed below are sourced from this document. One of the main aims of control measures enforced by the Norwegian Food Safety Authority is minimisation of infection pressure from farmed fish to wild smolts migrating to sea and in fjord areas as a whole (seatrout and sea run arctic char) during spring and summer. The infection pressure on seatrout during May, June and July 2011 seemed to be above acceptable levels in some areas from Rogaland to mid-Norway (the north of Ryfylke, Hardanger, parts of Sognefjord, Trondheimsfjord and Namsenfjord). In some areas of the southern Ryfylke, in Møre og Romsdal and Nordland, fewer lice were found on seatrout in 2011 compared to 2010.

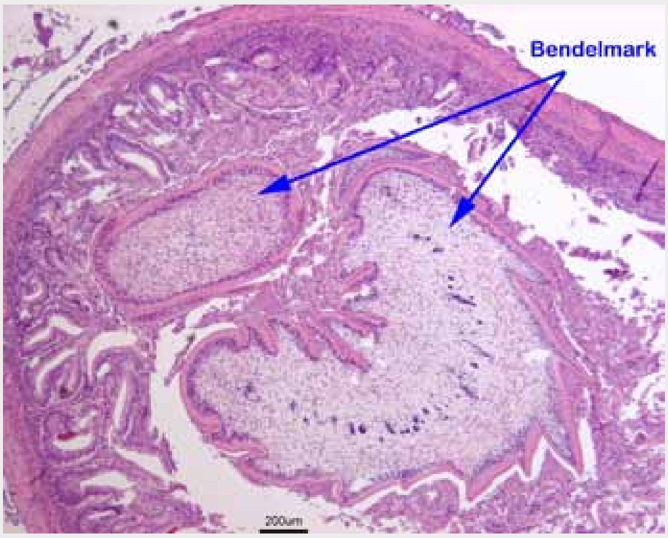
Salmon smolts migrating from some areas of western- and mid-Norway can have experienced greater infection levels in 2011 than in previous years. This applies in particular to Hardanger, Sognefjord and Trondheimsfjord. It would appear that the synchronised spring lice treatments in some intensive farming areas did not result in low infection pressures during some outward migration periods. This may be related to use of SLICE (emamectin benzoate) with its longer duration of effect, resulting in difficulties with synchronisation of the time of maximal effect and the 'window 'specified by the Norwegian Food Safety Authority.

Fallowing of the outer part of Hardangerfjord according to the new zone legislation, does not appear to have had the desired effect on the fjord as a whole. In the outer areas, which have previously been associated with heavy infections in wild salmonids, relatively few lice were found on seatrout in 2011. Seatrout in the central part of the fjord were however, heavily infected. In the course of 2010-2011 a large biomass of farmed salmon was allowed to develop in this area, such that fallowing had little effect on the number of salmon lice hosts in the fjord as a whole. The low production of louse larvae in the outer fjord was thus balanced by increased production in mid-Hardanger. The burden per fish has not increased but the number of hosts within the fjord was much higher than in previous years. This indicates that migrating wild smolts may have departed the fjord system with a high lice burden.

In northern Nordland, Troms and Finnmark, the infection pressure on wild seatrout and sea run arctic char was substantially greater in most investigated localities in 2011 compared with 2010. The increase was however, registered late in the summer, so salmon smolts may have managed to clear the fjords without too high a louse burden. A high louse burden was identified in seatrout around the mouth of the Trondheimsfjord in the second week of June while a higher level of lice was detected in inner fjord areas compared with previous years. Large louse burdens have been identified in some seatrout around Hitra during the summer. Greater numbers of lice than in 2010 were also identified in parts of the Sognefjord during 2011. On the whole, the salmon louse situation in wild salmonid fish in a number of intensive farming areas along the Norwegian coast would appear to be worse in 2011 compared with 2010.

Parvicapsulosis - *Parvicapsula pseudobranchicola*

The parasite Parvicapsula pseudobranchicola was described in Norway for the first time following 3 outbreaks of disease in farmed salmon associated with high mortalities in 2002. P. pseudobranchicola is a myxozoon within the family Parvicapsula, a family which also contains other species pathogenic for both wild- and farmed- fish. This parasite affects mainly the kidneys and bladder. The result of disease in salmon varies between slightly increased mortality levels to severe mortality. There are reports suggesting that the chances of disease development are increased if the fish stocks are weakened by e.g. other diseases. The parasite is found in highest numbers within the pseudobranchs (under the gill covers), and it is here that the major histologically detectable pathological changes may be observed. The parasite may also be detected in the gills, liver and kidney. In 2011, parvicapsulosis was identified in 31 farming localities, which is a reduction from the 40 identified in 2010. The disease is mainly diagnosed in the two most northerly regions. Newly published results indicate that P. pseudobranchicola is found in wild arctic char, seatrout and salmon along the whole Norwegian coast and that these species of fish represent the natural hosts for the parasite. The work towards identification of the main host for this parasite continues.



Tapeworm in the digestive caecae of Atlantic salmon
Photo: Renate Johansen, Norwegian Veterinary Institute

Costia – *Ichthyobodo* sp.

This parasite is probably under-reported, as it is commonly diagnosed on-site by fish health services via direct microscopy. Several species of this parasite within the family Ichthyobodo are recognised and they can cause disease in both skin and gills of fish in both fresh and saltwater.

Infection with *Desmozoon lepeophtherii*

Desmozoon lepeophtherii (synonym Paranucleospora theridion) is a microsporidian which has the salmon louse as its main host and Atlantic salmon as its intermediate host. Investigations indicate that an increased number of the parasite may at times be identified in farmed salmon. Increased levels may be associated with gill inflammation and in some cases, with the aid of specific visualisation methods, the parasite may be observed in association with damaged gill tissues.

The significance of the infection is however unclear. The parasite is prevalent along a large proportion of the Norwegian coastline. The Norwegian Veterinary Institute investigates the infection status of this parasite following indications of its involvement by e.g. histological investigation, or following a request by fish health services.

Tapeworm - *Eubothrium* sp.

After a number of years in which the prevalence of tapeworms (Eubothrium sp.) has been low, the problem increased in 2011. It would appear to have particularly affected smolts transferred to sea during the spring of 2011. Tapeworm infections were one of the most commonly registered findings associated with so called ‘loser syndrome’, discussed elsewhere in this report. Treatment has been undertaken in some cases and an increase in sales of praziquantel has been registered. Resistance against this medication has been registered in previous years. The tapeworm Eubothrium sp. may be found in the intestine of both salmon and rainbow trout. In untreated fish the worm may increase in size and diameter and reach more than a metre in length. Tapeworm infestation results in increased feed consumption and reduced growth in the affected fish

Fungal diseases

Diseases caused by mycological agents have again been identified during the course of 2011. As previously Saprolegnia spp. dominate the species identified. The cases with highest registered mortalities are typically in fry following first feeding. Infection with Saprolegnia spp. can affect skin, gills and intestine and is generally associated with sub-optimal environmental conditions. Both international and Norwegian findings indicate that fungal infections are a greater problem in recirculation systems compared to through-flow systems. Other agents such as Exophiala sp. and Ichthyophonus hoferi have been identified but not related to disease outbreaks

Acute injury to the gill epithelium (arrow) caused by the algae *Pseudochatonella* (ring).
Photo: Mona Gjessing, Norwegian Veterinary Institute

Gill health

As gill diseases may have a complex aetiology and are non-notifiable, compilation of statistics is difficult as is identification of trends and significance. Review of approximately 400 submissions from Møre og Romsdal and Agder regions identified serious, chronic gill inflammation as the most significant (21 submissions from 16 farms) type of gill complaint. Most gill problems are registered in autumn and winter seasons. The most dramatic losses in relation to gill disease occur as acute mortality episodes usually characterised by gaping gill covers as the main indication of disease. The effects of algal poisoning are dramatically acute, and acute mortality is also observed in cases in which histopathologically identifiable long term chronic gill inflammation is followed by another unidentified trigger factor.

Brown seas caused by the algae Pseudochatonella caused the acute loss of approximately 40 tonnes salmon in April 2011. Many of the affected fish were good quality, large fish with no other signs of disease. Pseudochatonella is most easily identified on gills by direct microscopy as small ‘raspberries’, due to their partial disintegration during formalin fixation. The histological picture is unusual however, with clearly visible destruction of the epithelial cell layer. Although large amounts of Pseudochatonella resulted in high mortalities, the cell damage was such that it is suspected that even smaller concentrations of the algae may result in gill damage which may allow entry of other pathogens. This episode also revealed the lack of a good reporting and warning system in the industry in general.

Chronic gill inflammation often termed PGI, appears to have again been important in many coastal areas in 2011. The condition appeared, as usual, in the late summer and autumn. Several reports of associated mortality, at times significant, were received. Mortalities have been associated with low oxygen levels or following lice treatment of fish with chronic

gill inflammation. PGI with mild associated pathological changes has also been identified. Some farms experience annual autumnal outbreaks.
PGI as a descriptive term for chronic gill inflammation, denotes more or less end-stage pathological changes. Inflammation and proliferation of cells between the gill lamellae are so extensive that oxygen uptake is severely restricted. Many infectious agents are involved in PGI e.g. epitheliocysts, endo- and ecto-parasites, virus and bacteria. Several of these agents have not been cultured or characterised to a satisfactory degree and the significance of each agent is poorly understood. Environmental conditions and the intrinsic health status/resistance of the fish will also play a significant role in how serious these infections become. Each autumn, cases involving gill haemorrhage of unknown cause are observed. This makes continued research into gill disease necessary. One new and valuable development was the recent discovery that the identity of the causal bacterium for the most commonly observed epitheliocysts is Branchiomonas cysticola. B. cysticola is more closely described under bacterial diseases.

Losses increase when chronic gill inflammation occurs concurrently with diseases affecting the heart. In 7 of the 21 PGI cases described previously, the fish were also affected by heart disease. Evaluation of gills in fish which have died with 'ruptured heart' is challenging as these fish are often in a state of decay.
Besides direct mortalities, loss of growth must be expected with chronic gill inflammation and with extensive changes in gill tissues, total losses can be considerable.
Amoebic gill disease (AGD) was not identified in 2011, although large losses due to this disease were reported from Ireland and Scotland. The last reported outbreaks in Norway (2006) were associated with especially high water temperatures.
Gill problems can also result in considerable losses during the freshwater stage of culture. The cause/s are often related to water quality and may therefore be resolved by improvement in water quality. One gill problem observed annually is the colonisation of gills by an unidentified bacteria on the gill epithelial cells, causing these cells to swell. Systemic bacterial infections may also affect the gills e.g. Pseudomonas fluorescens.

Other health problems

Intestinal health

From 2005 – 2008, intestinal tumours (adenocarcinoma) were epidemic in broodfish of both salmon and rainbow trout. The prevalence has fallen with each subsequent year. In the course of 2011, the Norwegian Veterinary Institute has received only two such submissions from salmon brood fish. It would appear that changes have been made to the feed. As samples from the mid- and distal- intestine are not normally included in routine diagnostic submissions, estimation of the prevalence of early stage tumours or associated inflammatory lesions is very difficult.

Of factors associated with intestinal changes, proliferation of abnormal flora in the intestine of fry/ juvenile salmon is commonly seen. Fungal infections can be most aggressive with penetration into the peritoneal cavity as a common occurrence. Other cases appear to involve either excessive proliferation of bacteria or the observation of tissue lesions in association with bacteria. The causal factors behind intestinal problems appear therefore to vary and may be caused by either e.g. proliferation of undesirable (dysbiotic), but not particularly pathogenic bacteria which leads to digestive disturbances, or a more pathogenic bacterium directly injuring the intestine. Other observations include small calcifications of unknown cause in the intestinal wall.
Both laboratory observations and field reports from fish health services would suggest that there is a clear increase in tapeworm prevalence (see 'parasitic diseases').
'Floating faeces' is a condition associated with abnormally fatty faeces ('cheesy pops') in the distal intestine and in the sea, with a 'mayonnaise-like' content in the digestive caecae. Histologically visible concentrations of fat drops may be observed in epithelial cells. The extent of the problem within the industry as a whole is not known. Moderate levels of histologically observable pathological changes consistent with those observed in 'floating faeces' may be present without observation of 'floating faeces'. This may indicate that the problem may occur to differing degrees and that only the extreme cases are identified.
'Obstipation' i.e. blockage of the intestine, has been observed on some salmon farms in Trøndelag. An undigested feed pellet is normally found blocking the

pylorus (transition between stomach and intestine), such that the stomach fills with fluid and the abdomen becomes distended.

Intestinal health in farmed fish is an area of study which has been overshadowed by the necessary focus on serious, infectious diseases. Economically, however, intestinal health is an important area in all intensive animal production.

Other heart conditions

Various conditions related to the heart and circulation are in all probability under-diagnosed in most salmon producing countries, including Norway. Abnormalities and functional disabilities related to the heart tend to be overshadowed by infectious diseases with a clear cause and high associated mortalities. Under-dimensioned hearts, abnormal shape and reduced function result in a reduced stress threshold and thus higher mortality levels in affected fish. Many of these conditions are considered to be environmental and may be related to both activity level and diet. It has been recently demonstrated in controlled trials that interval training of fish during the freshwater stage of culture increases feed conversion and survival following IPN-infection. Such 'lifestyle' conditions include arterial constriction, poor development of the outer muscle layer, inflammation, and metabolic abnormalities. During 2011, changes consistent with arterial sclerosis followed by death, were observed in individual salmon. Diagnosis is often difficult as the area of the heart in which arterial constriction most commonly occurs is not normally submitted and when submitted the actual constriction may not be histologically sectioned. Fish health services should be observant for this type of complaint in cases of diffuse mortality and take appropriate sample material. This is particularly applicable to large salmon.

Tumours

Very few tumours are diagnosed in farmed fish, due in part to the low ages achieved (the risk of tumour development increases with age), but also to the controlled conditions under which they are held. Only a few cases involving single fish, from diverse geographic locations have been registered. All are salmon brood fish. The fish concerned have not shown clinical signs of disease and the tumours have only been discovered during routine controls following stripping/harvest.

Haemorrhage and pale gills in Atlantic salmon smolts with hemorrhagic smolt syndrome (HSS).

In one salmon of 7 kg, white nodules observed in the liver were subsequently identified as tumerous and probably cancerous.
In another fish, fatty, tumerous tissues observed on post mortem were found to comprise gland-like cells in a fibrous stroma; possibly adenocarcinoma. Adenocarcinoma were diagnosed in brood fish from 2005-2008 (see also intestinal tumours under intestinal health).
On routine slaughter-line control a tumour of 26 x 11 cm was observed attached to the kidney of a single fish. The tumour could be detached from surrounding tissues and had a fatty surface. Histopathological investigation of the submitted material revealed a benign tumour of the ganglioneurom type.

Hemorrhagic smolt syndrome (HSS)

Hemorrhagic smolt syndrome (HSS), also called hemorrhagic diathesis (HD), results in mortality in salmon smolts in freshwater. The disease is characterised by haemorrhage and anaemia. One typical histological change is the presence of blood in the lumen of the kidney drainage system i.e. the fish has bloody urine. During 2011, the Norwegian Veterinary Institute diagnosed HSS on 51 farms, which is representative of the level observed in recent years. The disease is commonly diagnosed on-farm by fish health services during routine post-mortem of dead fish.

Most HSS cases are registered between January and May in association with minor losses.
Macroscopically, HSS can be confused with the serious viral disease VHS, which can result in extensive circulatory disturbances. It is therefore desirable that the diagnosis is verified by histological and/or virological investigation.

The cause of hemorrhagic smolt syndrome is unknown, but is probably related to the smoltification process and affects primarily the largest and best fish. Mortalities fall and disappear on sea-transfer. A similar disease is also found in Scotland.

"Smoltsyndrome"

Problems were again reported in 2011 from several farms involving problems in smolt; mortality following sea transfer and poor growth/development, often involving ulceration. The condition may be related to poor smolt quality and sea transfer at low water temperature. The problem appears to have been increasing during 2010 and 2011.

"Loser syndrome "

Several farms have experienced a significant number of fish developing into what are termed 'losers' or 'loser fish'. These are fish which initially grow normally, but become thin 'pin-heads' lacking peritoneal fat. Several sites report large scale losses associated with this syndrome, both salmon and rainbow trout. The problem would appear to be greater in salmon which have survived an IPN outbreak, although the aetiology remains unclear and has several possible explanations.

Loser fish can be difficult to capture and may therefore be present in the population for a considerable time. It is likely that these fish harbour a greater number of parasites and disease in general than normal fish in the cage and are therefore undesirable in relation to transmission of disease.

Nephrocalcinosis - kidney stones

Nephrocalcinosis is registered annually in rainbow trout and salmon particularly during the freshwater stage of culture, but also after sea transfer. The Norwegian Veterinary Institute has registered an increased frequency of nephrocalcinosis in submitted materials in 2011 compared with 2010. The condition is associated with high levels of CO_2 in the water. Nephrocalcinosis can also be an associated finding to hemorrhagic smolt syndrome (HSS).

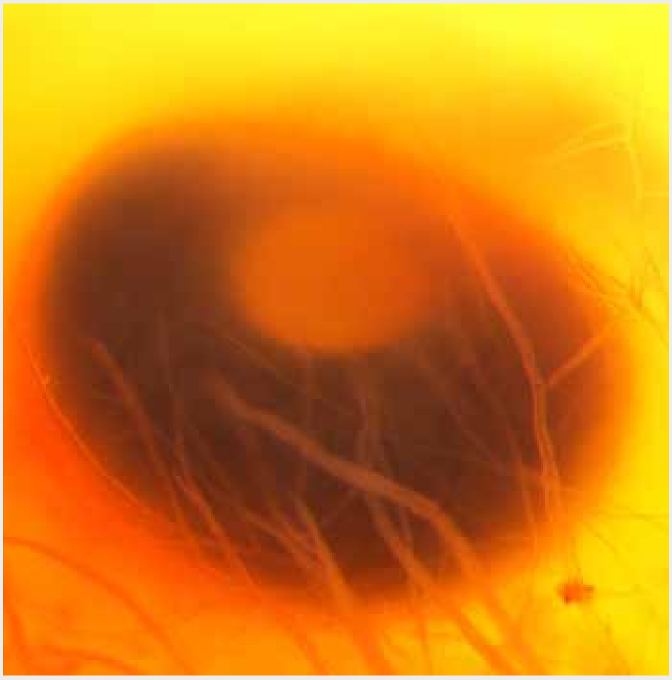
Vaccine side-effects

All Norwegian farmed salmon are vaccinated by intraperitoneal injection and this has resulted in enormous health-related rewards in relation to protection against e.g. furunculosis, vibriosis and coldwater vibriosis. However, these vaccines can result in undesirable side-effects such as inflammation in the peritoneal cavity (peritonitis).

The degree of vaccine related injury is evaluated according to the Speilberg scale, which grades the different levels of adhesion development between the peritoneal wall and the inner organs. In later years the level of vaccine side-effects have generally appeared lower as evaluated using the Speilberg scale, although extensive inflammation between the intestinal organs may still be observed histologically. It is not unusual to see extensive adhesions in some areas of the peritoneum while the remainder appears normal. In 2011, reports of both visibly mild peritoneal inflammation and more serious cases were reported.

Predator problems

As in previous years fish health services reported problems with predators e.g. cormorants, herons, seals, whales and otters during 2011. Predators often cause injury and damage to the fish which may allow entry of bacteria, leading to development of winter ulcer and other complaints. Diseases such as IPN may also result in increased predator problems due to the attraction of morbid fish. Predator attacks also result in increased stress levels, which may result in depressed immune function in the fish.



Saprolegnia hyphae in live eyed eggs
Photo: Even Thoen, Norwegian Veterinary Institute

Mechanical injury

There were several reports of mechanical injury in relation to handling, net changing, transport and de-lousing. Bad weather and extreme currents may contribute to mechanical injury of the fish. At low temperatures even small ‘scrapes’ lead to infection with ulcer-related bacteria and development of ‘winter ulcer’.

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

Parasites

Parasite checks are part of normal routine health controls. Parasites reported during 2011 include species belonging to the following families: Zoothamnium, Riboschyphidia, Epistylis, Ichthyobodo, Oodinum and Trichodina. Gyrodactylus has not been reported from fish reared for stock-enhancement purposes in 2011.

Bacterial diseases

Flavobacterium psychrophilum was diagnosed in two salmon-rearing units following culture from eroded fins on Ordals medium. Other bacteria identified included Pseudomonas sp., Enterococcus sp. and Carnobacterium sp.

Fungus

Swimbladder mycosis, gill mycosis and mycotic nephritis (kidney fungus) were registered in individual farms and individual fish. Saprolegnia sp. in eggs, gills and skin of brood stock is a not uncommon finding and work continues towards prevention and treatment of these conditions.

Environmental problems and production related diseases

Environmental, management and miscellaneous problems reported during 2011 include: shortening of the operculum, fin biting, eye snapping, gas

Table 3. Results of brood fish screening for the season 2011/12. Fish from 31 rivers and lakes are investigated. When this is written results from 16 arctic char and 20 brown trout are missing.

		Tested	Positive
Atlantic salmon	IPN	440	3
	BKD	568	0
	Furunkulosis	340	0
Sea trout	IPN	233	6
	BKD	267	0
	Furunkulosis	124	0
Brown trout	IPN	0	-
	BKD	30	0
	Furunkulosis	0	-
Char	IPN	0	-
	BKD	1	0
	Furunkulosis	0	-

supersaturation/ gas bubble disease, cataract, hypercalcinosis of the kidney, various deformities and iron precipitation on the gills.
Two situations involving high mortality of broodfish were reported in 2011. In one situation high levels of nitrate/nitrite were suspected but were not confirmed by blood analysis. Mortality levels subsequently dropped without identification of the cause of death. In a different case, acute mortalities were experienced in a brood fish population. Histological investigations indicated acute gill injuries as the main cause of death. Nephrocalcinosis was identified in several fish as were low chloride levels in the blood of moribund fish, together with moderate liver damage and fungus and bacteria in the gills. These findings may represent complications secondary to the primary gill damage caused by gas removal failure, disturbed ion balance and secondary infections. Mortality levels fell without a definitive diagnosis.

Field investigation of wild broodfish
Foto: Norwegian Veterinary Institute

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

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

Scale analysis identifies farmed fish

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

Screening for IPN-virus (IPN), *Renibacterium salmoninarum (*BKD) and *Aeromonas salmonicida* subsp. *salmonicida* (furunculosis)

Results from the year's brood fish season reveal that the bacteria causing BKD and furunculosis were not detected. IPNV was detected in nine individual fish. This reflects an increase for IPN compared to last year when only one IPNV positive salmon was identified. The increase was, however, due to positive identification in six seatrout captured in the Vefsna region in the course of re-establishment work performed in the wake of G. salaris control. Of the three positive salmon, one was classified as wild, one as a stocked fish while one was of uncertain classification. Nematodes (Anisakis), gill worm (Salmincola salmoneus) and tapeworm (Eubothrium sp.) were also normal findings in brood fish in 2011.

Disease in wild salmonids

Gyrodactylus salaris

A total of 3783 salmon from 112 rivers and approximately 3106 salmon/rainbow trout from a total of 93 fish farms were investigated as part of the national surveillance programme (OK-programme) for Gyrodactylus salaris. The rivers in the OK-programme are investigated every year at one to three different locations, dependent on the size of the river. In the rivers Tana and Neiden, samples are taken from more than three sites due to the size of the rivers. Samples are taken from aquaculture sites every second year in association with the OK-programmes for IHN/VHS in freshwater.

In 2011, G. salaris was identified in one new locality, the river Måna in Møre og Romsdal. The identification was a result of sample analysis taken during the OK-programme. The Måna was last rotenone treated in 1993 together with four other rivers in the Romsdals region. The parasite was re-detected in the four other rivers during the last half of the 1990's.

Eradication of *Gyrodactylus salaris*

Chemical treatments i.e. rotenone, against G. salaris were performed in the Vefsna region in Nordland. The first treatment of the larger rivers, initially planned for 2010, was postponed until 2011 due to the identification of G. salaris in lake Fustavatn and lake Ømmervatnet.

Treatment of rivers in the Halsenfjord were concluded with treatment of the rivers Hestdals and Hundåla at the end of June. Simultaneous treatments were performed in the rivers Dagsvik and Nylands. The larger rivers (Vefsna, Fusta, Drevja) were treated for the first time together with a number of smaller rivers in August.

These treatments will be followed up by a final treatment in 2012. Treatment of infected lakes in the Fusta watercourse will be performed in 2012. In preparation for this, the lakes and surrounding areas were surveyed in 2011 and a simulated treatment performed in lake Ømmervatnet in October. Parallel work included conservation work for sea trout, char and sea run arctic char in the region.

The river Lærdal was treated during August and September with acidified aluminium as the primary treatment and rotenone as a supplementary treatment in smaller backwaters etc. Treatment was performed over two fourteen day periods separated by three weeks. The treatment will be followed up by a concluding treatment in 2012.

Large areas of the Rauma region were surveyed in the course of the year in preparation for treatment start in 2013. Sea trout conservation work also continued.

Treatments planned for other infected regions lie further in the future and little thought has as yet been given to these activities

Chemotherapeutant use

Most diseases caused by bacteria and parasites can be treated medicamentally. From (and including) 2011, all medicament use in fish must be reported to the Norwegian Authority for Food Safety. Consumption of antibiotics in the salmon farming industry is extremely low. An increase in sales of praziquantel for use against tapeworm was registered. Statistics relating to consumption of pharmaceuticals in fish farming in 2011 were not available at the time of press.

Fish Welfare

There is a direct relationship between health and welfare of fish. There is an average post sea-transfer mortality of 15-20%. Much of this loss is related to non-specific mortality, including what is termed ‘smolt mortality’ and ‘loser syndrome’. Poor fish welfare is undoubtedly responsible for a proportion of these losses. The causal relationships are complex, but part of the problem may start during the freshwater phase of culture. The movement towards industrial production of juvenile fish is difficult to balance with the complex biological demands of the fish. Smoltification is a complex process and achievement of synchronised smoltification in millions of fish is not easy.

Many diseases, not least production related diseases, have clearly negative implications for fish welfare. Winter ulcer, infection with Tenacibaculum and gill inflammation are examples of such diseases. Fish can live with these diseases for several months prior to dying of osmotic stress, blood loss and/or secondary infections. Vaccine related adhesions continue to be a problem, and form a diffuse base for many production related diseases.

The different species of cleaner fish (wrasse and lumpsucker) have special requirements, both environmental and management, and we lack knowledge of the basal welfare requirements for these fish species. In the course of the previous year, all personnel working with farmed fish in Norway should, according to legislation, have attended local courses in fish welfare. Knowledge and understanding of the relationships between biology, welfare and health are key factors for ethical and sustainable production.

The ban on use of CO_2 as an anaesthetic will come into force from June 1st 2012. Concussion or electric shock are therefore about to replace CO_2. This is a considerable step forward for fish welfare.

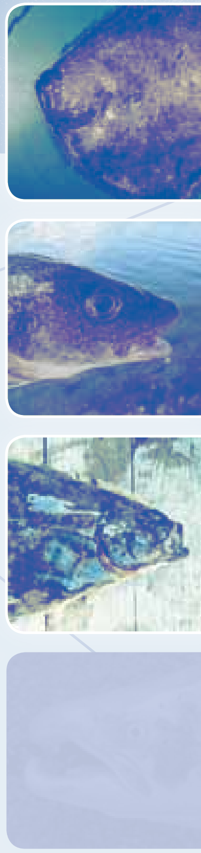
Many thanks to everyone who has contributed to this report, particularly the many fish health services nationwide. Without their contribution this annual report would not be possible.

Wild female brood salmon with roe. The fish was investigated due to its emaciated condition.
Photo: Øyvind Vågnes, Norwegian Veterinary Institute

Health Situation in Marine fish 2011

Hege Hellberg (ed)

Duncan Colquhoun
Samuel Duodu
Hanne K. Nilsen
Cecilie Sviland
Øyvind Vågnes



Veterinærinstituttet
Norwegian Veterinary Institute

Submissions relating to marine fish species reflect the dynamic nature of the marine fish aquaculture industry. The number of submissions from cod continues to fall, while the number from halibut remains stable. For cleaner fish a considerable increase in the number of submissions was registered, including a new species, the lumpsucker.

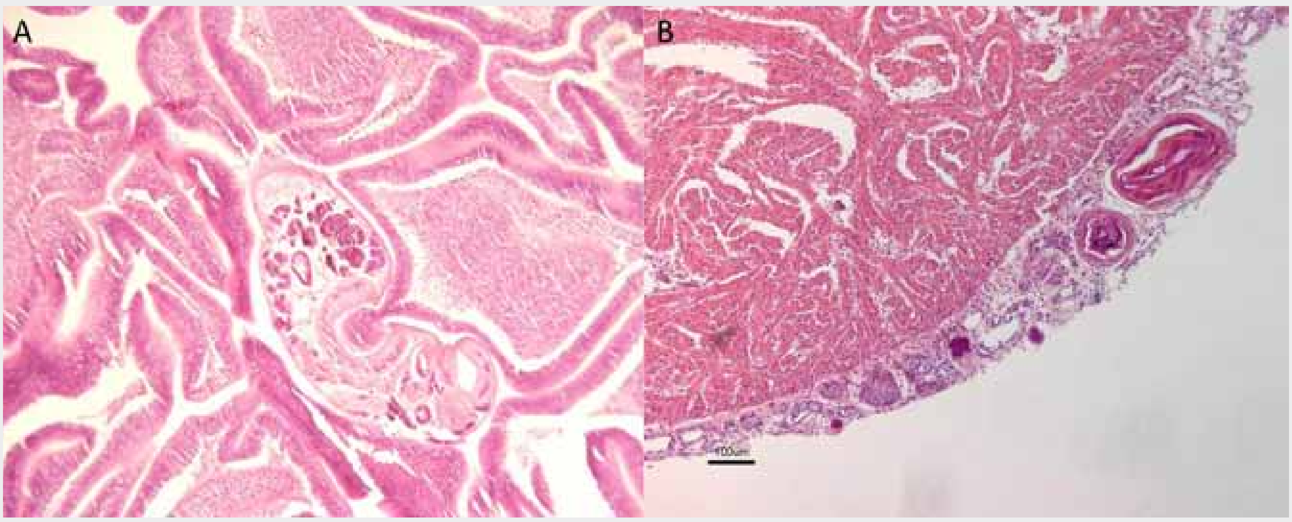
Cleaner fish

Use of wrasse such as goldsinney- *(Ctenolabrus rupestris)*, corkwing- *(Symphodus melops)* and ballan-wrasse *(Labrus bergylta)* for control of salmon lice has increased in recent years. Recently, lumpsucker *(Cyclopterus lumpus)* have also been introduced as cleaner fish for salmon. Cleaner fish used in salmon farming are wild caught in fyke nets or creels during the summer months. They are then transported by tank or well-boat to their final destination. The use of wrasse as cleaner fish is well established and initial experiences utilising lumpsucker as cleaner fish are promising, even at low water temperatures. Fish health services do report however, high in-cage mortalities for wrasse. Field reports suggest that falling temperature often precipitates high mortalities and that corkwing wrasse seem particularly susceptible.
Culture of cleaner fish is in its infancy and the main supply of working fish is still based on wild capture. Although routines for capture, transport and use of cleaner fish have been improved, high losses continue to be experienced at each stage. The Council for Animal Ethics considers current practices ethically unsound in relation to both sustainability of wild stocks and fish welfare in general. Capture, transport and use of wild caught cleaner fish must be refined to increase survival, quality and welfare of the fish involved. Routine health control should be performed at each stage of the process from capture to use.

There is a considerable and general requirement for a survey of diseases and causes of mortality in cleaner fish. Wild caught cleaner fish experience a triple exposure to disease causing organisms: in their original environment, when held with other cleaner fish after capture and in their 'working environment' i.e. the salmon cages. We have little current knowledge of the range of diseases which may occur during farming of the 'new' species, lumpsucker and ballan wrasse. There are now three commercial ballan wrasse farms and three lumpsucker farms in Norway

Wrasse

The increased use of wrasse is reflected in the increase in submitted samples from these species to the Norwegian Veterinary Institute (Table 1). Submissions relate to both wild caught wrasse (ballan, corkwing and goldsinney) and farmed ballan wrasse. Differentiating between species is not always easy



Trematodes in formalin fixed preparations from wild caught corkwing wrasse.
A. Intestine. Photo: Øyvind Vågnes. B. Heart. Photo: Trygve Poppe

and a number of samples are simply labelled ‘wrasse’ in the field and registered as such in the Norwegian Veterinary Institutes database (Table xx). Diagnostic submissions generally comprise fresh fish, formalin fixed tissues, bacterial cultures and in some cases samples for virological investigation

Parasites

Parasites have not been identified as the major cause of disease in cleaner fish during 2011. Trematodes are commonly identified in formalin fixed intestinal samples from wild caught wrasse. Their significance is, however, unknown.

Virus

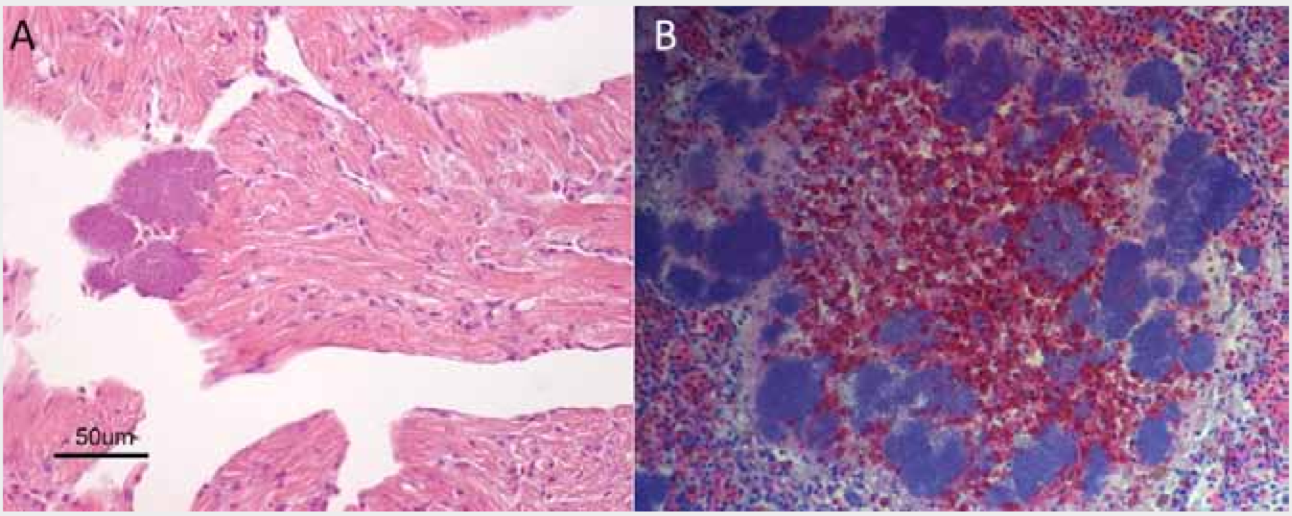
No viruses have been detected in samples submitted from wrasse. A limited number of submissions have been investigated for infectious pancreatic necrosis virus (IPNV), with negative results.

Bakteria

Wild caught wrasse

The main findings from wild caught wrasse in 2011 were as in previous years: Ulcerative lesions and subsequent systemic bacterial infection. Rapid post mortem decomposition (autolysis) is frequently observed in wrasse, a factor that complicates the evaluation of samples from morts. The role of bacteria isolated from such fish in the cause of death can therefore be difficult to establish. The bacteriological findings in 2011, as in previous years, were commonly dominated by a mixed flora including various *Vibrio* spp. isolated from from ulcers and internal organs, in addition to detection of atypical *Aeromonas salmonicida* from individual fish. Fewer cases are distinguished by the isolation of a single bacterium from both internal organs and external lesions. In a very few cases disease outbreaks have been associated with more uncommon types of bacteria (see below).
Atypical *A. salmonicida* which is one of the most commonly isolated pathogenic bacteria from wrasse was detected in 30 submissions in 2011, both from skin lesions and from internal organs of wild caught wrasse. This bacterium most commonly causes a chronic infection characterised by external lesions and granulomas in internal organs

Vibrio species were identified in 62 submissions from wrasse in 2011. These bacteria are common in the marine environment and many species exist. Some are well known fish pathogens e.g. *Vibrio (Listonella) anguillarum*, a serious pathogen of salmon and cod and *Vibrio tapetis*, a recognised pathogen of molluscs. Other species such as *Vibrio splendidus* and *Vibrio logei* are normally considered opportunists which may result in disease in weakened individuals. Some strains



Atypical Aeromonas salmonicida in corkwing wrasse. A. Micro-colony in the heart muscle. Photo: Trygve Poppe.
B. Micro-colonies in the spleen with aggregation of eosinophilic granular cells. Photo: Øyvind Vågnes

Wild caught corkwing wrasse. Tenacibaculum sp. was cultured from lesions in combination with a systemic infection with Vibrio anguillarum O1. Photo: Øyvind Vågnes, Norwegian Veterinary Institute

of *V. splendidus* and *V. tapetis* have been shown to increase mortality in corkwing wrasse experimental infections trials.
V. splendidus is considered a typical opportunist, and is the most commonly isolated bacterium in samples submitted from wrasse. External stress factors such as transport and co-localization with salmon in sea cages may result in an increased susceptibility to infection by bacteria which would otherwise normally not be pathogenic. Genetic typing of *V. splendidus* isolates may constitute a suitable approach for identification of virulent strains and thus provide the basis for selection of strains for infection trials and vaccine development. *V. anguillarum* serotypes O1, O2a and O2a biotype II have been isolated in some cases. *V. tapetis* has been identified in individual fish from submissions of corkwing, goldsinney and ballan wrasse nationwide.

Vibrio wodanis is normally associated with winter-ulcer in Atlantic salmon, but was during 2011 identified from both ballan wrasse and lumpsucker as well as samples related to unspecified 'wrasse'. *V. logei,* a close relative was also identified.

Tenacibaculum spp. were also identified from external lesions in association with various *Vibrio* spp.

Farmed ballan wrasse

A common diagnosis in farmed ballan wrasse was 'fin rot'. In some cases, possible intestinal bacterial proliferation was observed. Investigation of samples from diseased fish revealed bacterial growth dominated by various *Vibrio* species such as *V. logei*-like and *V. splendidus* (see comments relating to *Vibrio* in paragraph above). *Tenacibaculum* spp. have been identified in relation to fin rot. It is uncertain whether the isolated bacteria are primary pathogens, but *Tenacibaculum* sp. have been associated with skin lesions in salmon.

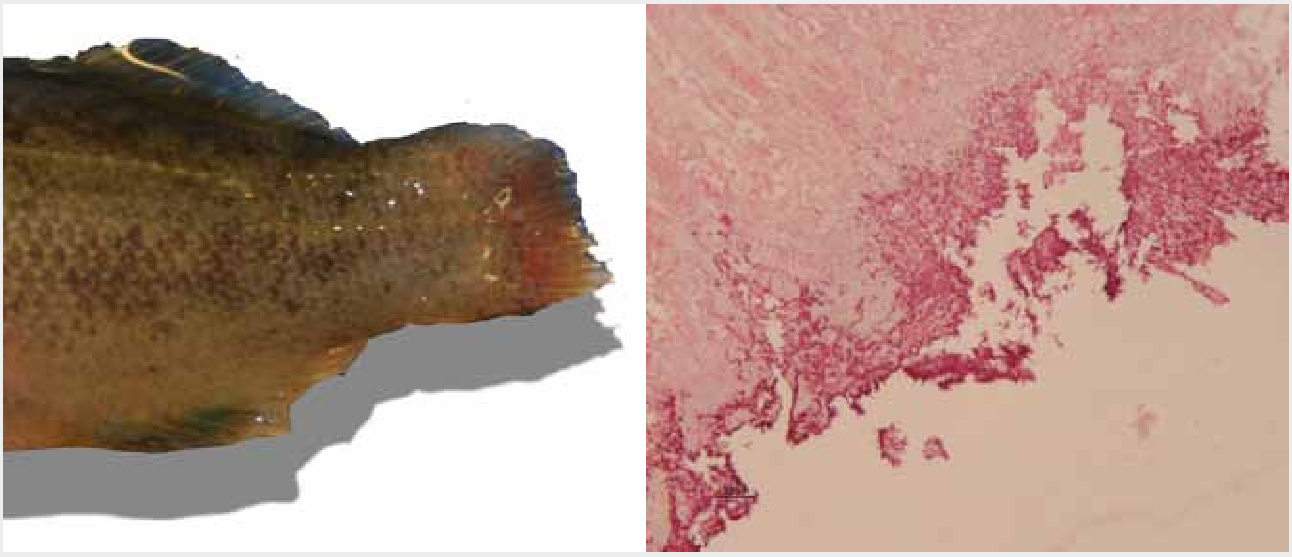
Vibrio anguillarum serotype O2a has been identified from farmed ballan wrasse as has atypical *A. salmonicida.*

Lumpsucker

Bakteria

In 2011, the Norwegian Veterinary Institute received 19 diagnostic submissions involving lumpsucker from seven different sites. Atypical *A. salmonicida* was associated with high mortality levels in wild caught fish. The bacterium is isolated regularly from both internal organs and exterior lesions. *V. logei* and *V. wodanis* have also been isolated from lumpsucker

Vibriosis caused by *V. anguillarum* serotype O1 was identified in a population of 5g lumpsucker. The fish had been dip-vaccinated twice against vibriosis. Resistance-testing of the isolate did not reveal reduced sensitivity to licensed antibiotics. Pseudomonas anguilliseptica was identified in a population of farmed lumpsucker with tail fin rot. The fish weighed between 2 – 6 grams and the external macroscopic findings were summarised as a variable



Farmed juvenile ballan wrasse with fin rot. *Tenacibaculum* sp. detected by immunohistochemistry in skin lesion from the same fish. Photo: Øyvind Vågnes, Norwegian Veterinary Institute

degree of tail fin rot in which most of the inter fin-ray soft tissues were eroded. Two individuals also displayed colour changes and loss of mucous layer covering the rear 1/3 of the body. A patchy loss of epidermis was also observed, exposing the underlying dermis. Direct phase-contrast microscopy of lesions revealed large numbers of long, thin bacterial cells, often aggregated in 'columns'. Some fish displayed slight haemorrhage of the tail fin and mandible and/or slight ascites (fluid in the peritoneal cavity). *P. anguilliseptica* is a recognised pathogen of many species of fish around the world e.g. eel, herring, tilapia, sea bream but more importantly for Norwegian aquaculture, salmon, rainbow trout and cod. This is, as far as we are aware, the first isolation of *P. anguilliseptica* in Norway.

Vibrio ordalii was isolated from two disease outbreaks in lumpsucker (Mid- and Northern Norway). In one outbreak losses were first registered following grading when fin erosion and rot were noted in a few fish. The fish developed ulcers and significant losses over a two month period were experienced. On examination of formalin fixed samples from the beginning of the outbreak, large numbers of short, rod-shaped bacteria were observed in the blood and internal organs. *V. ordalii* was cultured in large numbers from subsequent submissions. *V. splendidus* was cultured concurrently. The fish were medicated with oxolinic acid and losses fell. The few remaining morbid fish were characterised by fin rot, specifically the caudal fin. Treatment with oxolinic acid was repeated in a group of small fish and the situation stabilised after approximately three months. *V. ordalii* is known as a serious pathogen of salmon in various parts of the world, but has until now only been diagnosed a very few times in farmed cod in Norway.

Tenacibaculum sp. has also been identified in connection with dorsal fin erosion/ulceration in lumpsucker.

Parasites

In formalin fixed samples from small lumpsucker, parasites consistent with nematodes have been identified. There are also field reports of large numbers of *Trichodina* sp. on skin, fins and gills. *Gyrodactylus* spp. have also been identified in lumpsucker. The significance of *Trichodina* is unknown, but fish with large numbers of these parasites could be seen rubbing themselves against the tank/net wall which may lead to skin erosion and subsequent bacterial invasion. Skin lesions and *Tenacibaculum* infection have been observed following heavy *Trichodina* infestations. Formalin has been used to good effect (in tanks) for treatment of *Trichodina*.

Virus

No viruses have as yet been detected in cleaner fish. A limited number of fish have been analysed for the presence of IPN-virus with negative results.

Lumpsucker. Upper left; wild caught lumpsucker. Photo: Øyvind Vågnes. Upper right; Tail fin rot. Photo: Trygve Poppe. Lower left; Ascites and fluid-distended stomach. Photo: Solveig Stavenjord, FoMAS. Lower right; Kidney granulomas associated with atypical A. salmonicida. Photo: Øyvind Vågnes.

Cod

Submissions from cod reflected the fall in number of active cod farms from 2010 to 2011. In the course of the year the Norwegian Veterinary Institute received approximately 50 diagnostic submissions from approximately 25 sites (compared to 80 submissions from 40 sites in 2010). The submitted material comprised single submissions from 13 sites, with two or more submissions from the remaining sites. Bacterial infections once more dominate the findings, e.g. atypical furunculosis (infection with atypical *Aeromonas salmonicida*), classical vibriosis (infection with *Vibrio anguillarum*) and francisellosis (infection with *Francisella noatunensis* subsp. *noatunensis*). Francisellosis is a chronic, granulomatous disease which has developed into a serious problem for cod farming in Norway. Acute outbreaks with high mortality are rare and the disease is normally characterised by its chronic nature, reduced growth and continual low mortality rate. While infected fish develop granulomas (nodules) in internal organs and musculature, small skin lesions may be the only external sign of francisellosis. In 2011, francisellosis was diagnosed on three sites, two in Møre og Romsdal and one in Sogn og Fjordane. There was in addition a strong suspicion of francisellosis on a farm in Hordaland. There are several current research projects focusing on *Francisella* spp. and francisellosis. One has recently analysed seawater samples collected between Kirkenes in the north and Oslo in the south. Bacteria related to but not identical with the cod pathogenic species were detected in approximately 30% of all samples, mainly south of the arctic circle, with the highest prevalence in southern and western Norway. Recent research has also identified several evolutionary similarities between *F. noatunensis* subsp. *noatunensis* (cod pathogen) and *F. tularensis* subsp. *tularensis* (human and animal pathogen)

In addition to classical vibriosis, infections with other *Vibrio* species e.g. *V. wodanis, V. splendidus, V. logei and Moritella viscosa* (associated with winter ulcer in salmon) have been identified from cod during 2011. The significance of these bacteria is somewhat unclear and they are mostly identified as co-infections with more serious pathogens e.g. atypical *A. salmonicida* or *V. anguillarum*. This situation is confirmed by fish health services who also list egg-bound females, emaciation and intestinal problems (colic, inflammation and evagination of distal intestine) as significant causes of loss during ongrowing. So-called 'floaters' continue to be observed during the larval and juvenile phase. Problems with spine- and head/jaw- deformities have been considerably reduced from previous years. Cannibalism is a well-known problem in cod culture, particularly if there is a large spread in fish size. Nodavirus and IPN-virus were not detected in submitted samples.

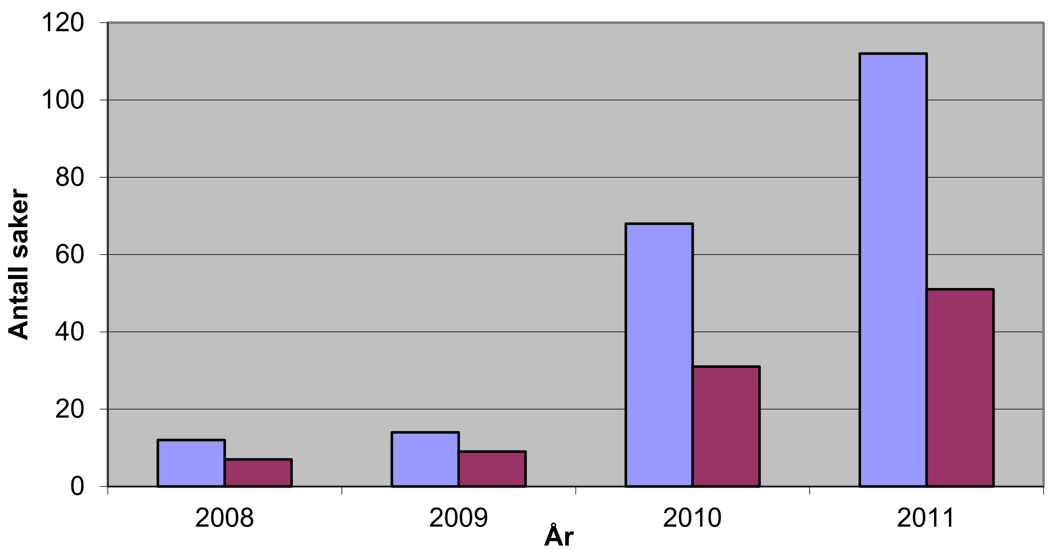
Halibut

During the course of 2011 the Norwegian Veterinary Institute received 40 submissions from 14 halibut farms. This is a similar number to the previous year and no major changes in the disease situation have been observed. Single submissions were received from eight farms, with the remaining farms submitting twice or more. On those farms submitting more than once, it would appear that bacterial infections e.g. atypical *A. salmonicida* and various *Vibrio* spp. dominate.

Atypical furunculosis is a repeated find in halibut farming and can be difficult to eradicate from infected land based sites. Antibiotic treatments have been used to good effect, but poor water quality and other stress factors may lead to new outbreaks. Moritella viscosa was identified from halibut for the first time in 2011, but the bacterium was not considered to be the primary pathogen identified in that case.

Emaciation, eye injury and development of ulcers are registered during the juvenile phase. Various *Vibrio* spp. have been associated with increased mortality e.g. *Vibrio logei*. In addition, *Tenacibaculum* sp. commonly associated with skin lesion development have been identified.

Nodavirus and IPN-virus have not been identified in submitted samples



Submissions to the Norwegian Veterinary Institute from cleaner fish (blue) and number of sites (red) 2008 – 2011.

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

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

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

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