Health situation of farmed fish 2005

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Foreword

In the space of a few decades, fish farming has developed into one of Norway's largest export industries. The most important fish species are salmon and rainbow trout. In 2005, Norway produced 588,000 tonnes of salmon, 60,000 tonnes of trout, and 6,650 tonnes of marine species (cod, halibut).

Maintaining good control over the health situation in fish is absolutely vital for successful fish farming. One fundamental prerequisite for this work is maintaining an overview of the most important diseases and health disorders that exist in today's farming. It is also important to get an idea of what may represent problems in the future, and whether or not existing diseases are increasing in scope and distribution. Such an overview is necessary in order to be able to provide relevant advice to the Norwegian authorities and prioritise research efforts.

As part of this work, the Norwegian National Veterinary Institute has for several years produced overviews of the health situation of salmonid fish and the health situation of marine fish. These overviews are partly based on diagnostic surveys conducted at our laboratories in Oslo, Sandnes, Bergen, Trondheim and Harstad. During 2005, the National Veterinary Institute analysed diagnostic materials from 656 salmon sites, 50 rainbow trout sites, 23 sites for other salmonid fish, 18 flatfish sites, and 88 sites for other marine species. Data from the diagnostic work is stored electronically and is providing a better and better basis for analysing disease trends.

Meanwhile, the information we obtain from the fish health service sector along the coast and from partner research institutions is just as important. The overview is not exhaustive, and we are continuously working to quality assure and improve it. It will always be difficult to obtain absolute numbers, especially for those diseases for which reporting is not mandatory. This applies to important loss causing diseases such as winter ulcer and 'new' diseases such as heart and skeletal muscle inflammation (HSMI) and cardiomyopathy syndrome (CMS).

In 2006, the Ministry of Fisheries and Coastal Affairs commissioned the National Veterinary Institute to head the development of a public system for monitoring the health and disease situations of aquatic organisms, primarily fish. The system must be able to describe losses due to diseases on the basis of collected and compiled data, and thus also identify diseases that over time affect the health of fish to such an extent that there is a reason to implement measures against the disease at either a public or private level. The establishment of the system will require extensive efforts, both by the fish farming industry and the fish health service sector. The National Veterinary Institute expects such a system to be a useful tool in the work of improving the health of farmed fish.

Health situation of salmonids 2005

The report is based on the results of diagnostic work carried out at the Norwegian National Veterinary Institute and other laboratories, interviews with employees of the country's fish health services, and information from the Norwegian Food Safety Authority.

Summary

In 2005, the welfare of farmed fish became a prominent item on the public agenda, which was reflected by, among other things, some animal welfare boards ordering sites to improve the living conditions of fish.

The health situation for salmon and trout in Norwegian farming facilities is generally good. While many bacterial diseases resulted in substantial losses a few years ago, most of them are now under control. Very little medication is used in the salmon industry in relation to the magnitude of the quantities of fish that are produced. However, viruses continue to cause extensive problems and result in major financial losses.

The viral diseases infectious salmon anaemia (ISA), pancreas disease (PD), heart and skeletal muscle inflammation (HSMI), and infectious pancreatic necrosis (IPN) appear to be the main problems in the industry.

ISA was found in only a few sites in 2005, and fewer than in 2004. The financial consequences were severe for those who received a diagnosis of ISA. There is still some discussion about how this disease should be combated.

Levels of PD were about the same in 2005 as in 2004, but with a small decrease in numbers. The number of outbreaks of HSMI is rising and there were several more cases in 2005 than in 2004. IPN was found in more sites than the other severe diseases, with about 200 sites being affected in 2005. This is an increase from last year. Vaccination against IPN is widespread, but appears to have relatively poor effect.

Cardiomyopathy syndrome (CMS) and proliferative gill inflammation (PGI) caused high losses in 2005 and were seen in association with viral diseases.

The most important bacterial disease seems to be *Moritella viscosa* infection, which causes winter ulcers. The rough treatment of fish during sorting or handling appears to predispose fish to infection with *Moritella viscosa*. There are no serious problems with other classic fish bacterial diseases, e.g. furunculosis, vibriosis, or coldwater vibriosis, due to vaccination.

Salmon lice (*Lepeophtheirus salmonis*) are still a problem, but the situation appears to be under control. There has been a decrease in the number of adult female lice and lice in general on fish year on year. Tapeworms (*Eubothrium crassum*) are still a problem, and there are reports of problems with treatment. There seems to be some resistance to the most used treatment, Praziquantel.

Pigmentation and peritonitis as a result of vaccination are still common problems.

Together with the previously mentioned diseases, these are some of the most important factors related to mortality, reduced growth and harvest quality. The geographical spread of PD and HSMI suggests that the measures undertaken for disease control are not good enough.

No new diseases were detected in 2005, but there is still much that is unknown with respect to the cause of CMS, proliferative gill inflammation, and several other diseases.

Successful disease control also requires that all levels of the industry comply with general anti-infection hygiene principles to avoid the spread of infections between sites and generations.

Viral diseases

Infectious salmon anaemia - ISA

ISA was demonstrated at 11 salmon sites in 2005, which is a slightly lower number than in 2004. In 2005, two of the sites were in Rogaland, two in Hordaland, two in Møre og Romsdal, two in Trøndelag and three in Finnmark. In 2004, altogether sixteen sites; ten sites from Trondheim Fjord and northwards to Troms and six from Hardanger to Sogn, were diagnosed with ISA. In 2003, eight sites were diagnosed with ISA.

Figure 1. Anaemia in salmon with ISA. On the left blood from a fish with ISA and on the right from a healthy fish.

The blood from the fish with ISA is lighter due to the reduced number of red blood corpuscles (low hematocrit).
A diagnosis of ISA is based on clinical findings, pathological changes caused by the disease, and the demonstration of a virus. It is demonstrated with the aid of various methods pursuant to the diagnosis criteria in the Norwegian Food Safety Authority's ISA combat plan, which in turn has been modified to take in account the EU's regulations and recommendations from OIE (World Organisation for Animal Health). All diagnoses are supposed to be confirmed by the National Veterinary Institute, which is an officially approved reference laboratory. Reliable diagnosis is absolutely vital in combating ISA.

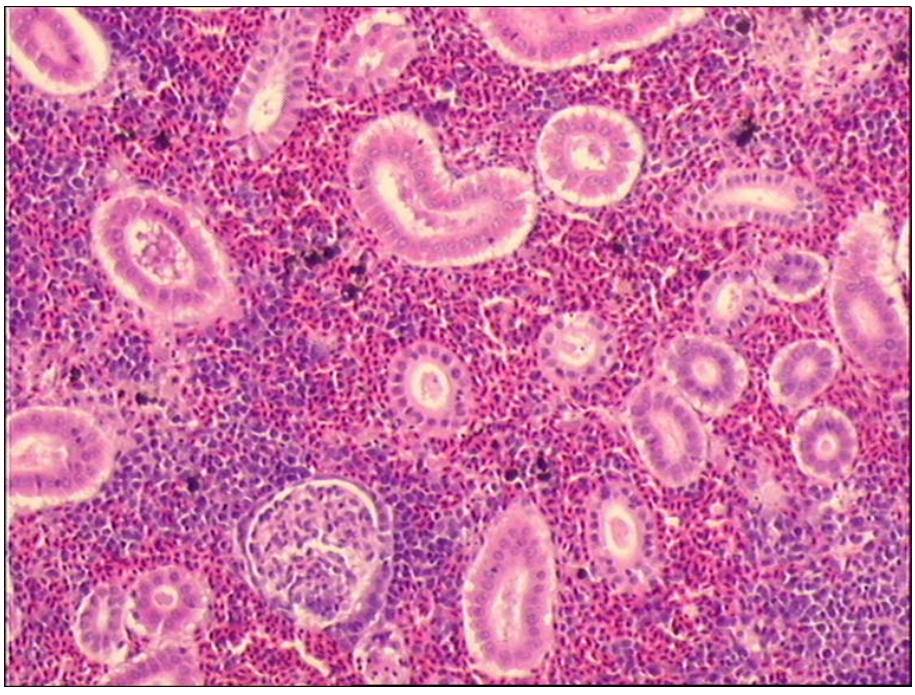


Figure 2. Kidney haemorrhages in salmon with ISA.

Infectious salmon anaemia is caused by a virus that infects and damages blood cells and cells in the blood vessel's walls. This often causes haemorrhages in internal organs, and the fish develop anaemia. ISA is transmitted via water from fish to fish. Previously it has been accepted that ISA is not transmitted via disinfected eggs, and that infection is associated with the seawater phase.

Meanwhile, there are indications that the virus can be transmitted from parent fish in which the disease has been demonstrated, to eggs (Bolaks Project). The significance of this with respect to the disease situation in Norway is unclear. In some research circles there are analyses that show that the ISA virus has been demonstrated in a significant portion of salmon smolt. However, these results have been the subject of much discussion.

Wellboats are a risk factor vis-à-vis the spreading of infection. They both transport large quantities of fish over long distances and may carry out several assignments in the space of a short period of time for different facilities. Disinfecting these boats is difficult, time consuming and expensive, which increases the risk of the virus being transported from one site to another. Wellboats take on seawater during transport. This increases the risk of the fish being infected when they are transferred to a new site.

Pancreas disease – PD

In 2005, PD was diagnosed at a total of 35 different seawater sites. This is a somewhat lower number of outbreaks than in 2004. Seven sites experienced outbreaks in rainbow trout while four sites experienced outbreaks in both salmon and rainbow trout. It appears that the disease has to some extent established itself in new geographical areas, i.e. Rogaland and Finnmark, which were both free of PD until 2003/2004. It is likely that the disease is underdiagnosed in those areas in which it is widespread. Most of the sites that were diagnosed with PD are located in Hordaland and Sogn og Fjordane. In Western Norway PD is one of the greatest challenges associated with the farming of salmonids. This development also gave cause for concern in 2005, since the disease appears to be spreading out from its core area. Internationally speaking, PD resulted in significant problems in Ireland, while in Scotland the disease picture and its significance has varied more.

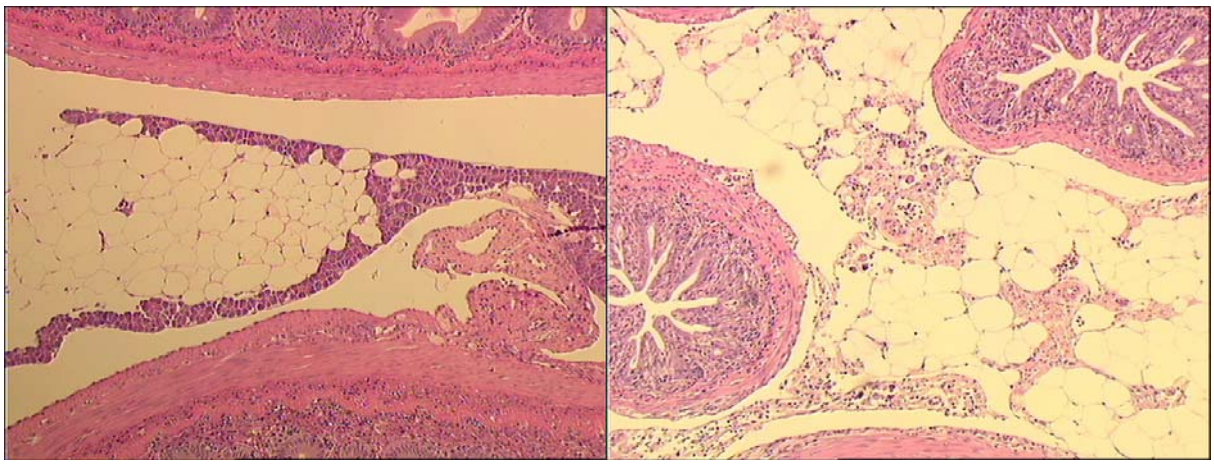
Developments within diagnostic research have simplified diagnostics. Among other things, the PD virus is now significantly easier to grow in cell cultures. Three different PD viruses are known. The virus that causes PD in salmon and rainbow trout in the sea in Norway accounts for one of these and it has been suggested that it be named *Norwegian salmonid alphavirus*.

Pancreas disease is very contagious, may have a chronic development and diseased fish may have poor growth. The accumulated mortality is often high and losses of several hundred fish have been reported by individual sites. The quality of the fish flesh may be reduced due to changes caused by the disease in the fish's musculature. PD is therefore a significant loss factor in those areas where is it most widespread.

PD diagnostics require laboratory tests and a diagnosis is made with the aid of clinical tests, as well as the demonstration of characteristic changes caused by the disease, and presence of the PD virus. A serological methodology has also been established in which one can investigate whether or not the fish has been infected with the PD virus.

Infectious pancreatic necrosis – IPN

In 2005, infectious pancreatic necrosis was demonstrated in just over 200 sites and it is the disease that has been demonstrated in most salmonids sites. Its occurrence appears to be increasing in relation to previous years since the disease was diagnosed at 36 more sites in 2005 than in 2004. Similarly, just over 300 submitted samples were recorded at the National Veterinary Institute in which a diagnosis of IPN was made and reported to the Norwegian Food Safety Authority. Other laboratories also make diagnoses, but though mandatory it is probable that not all cases are verified by the National Veterinary Institute. This means that there is some uncertainty associated with the number of sites with IPN in 2005.



Figures 3a and 3b. The infectious pancreatic necrosis virus results in cell damage in, among other places, the part of the pancreas that separates out digestive enzymes. This is the most classic finding vis-à-vis the disease. At left is a normal pancreas and at right is a pancreas destroyed by the virus.

IPN most often occurs in the summer in salmon that are transferred to sea, however IPN is also diagnosed throughout the year, and in fish of different ages from fry to fish spending their second year in the sea. Some occurrences are also demonstrated in rainbow trout.

The IPN viruses in diseased salmonids found in Norway are all closely related. However, research indicates that small, specific variations in a virus surface protein (VP2) may be of significance vis-à-vis the differences in mortality rates one sees in outbreaks of IPN in the field. There is a great deal of variation with respect to the course an IPN outbreak runs. Some facilities may experience minor problems, while other facilities can experience an outbreak that results in a high mortality rate of 50-70% of the fish. The fish that survive often experience reduced growth. Since IPN virus is apparently rife in stocks of Norwegian farmed fish, reducing the losses from the disease, which every year are probably in the hundred million NOK class, is a substantial challenge.

IPN is currently vaccinated against, but the extent of protection the vaccines provide is unclear. Reports from the field may indicate that vaccination limits losses.

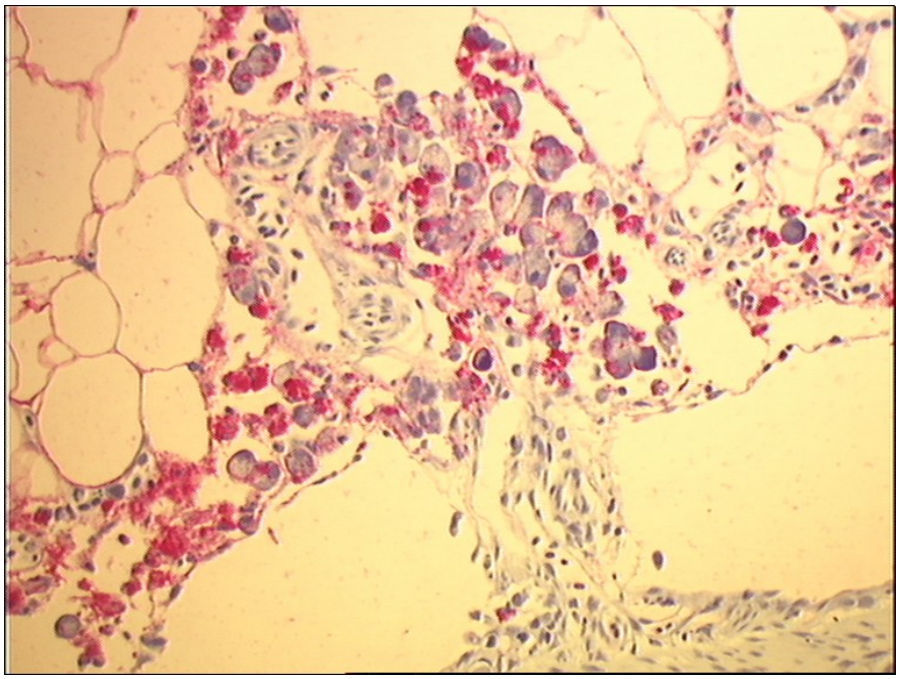


Figure 4. Immuno-histochemistry for IPN, in which the virus is marked with red dye. This is the most commonly used method for verifying/demonstrating the presence of an IPN virus in tissue damaged fish, and this method, together with normal histological tests, helps to provide a basis for making a diagnosis of IPN.

Table 1. Overview of farming facilities with demonstrated infectious salmon anaemia (ISA), infectious pancreatic necrosis (IPN), pancreas disease (PD), heart and skeletal muscle inflammation (HSMI), piscirickettsiosis, furunculosis and bacterial kidney disease, (BKD) in salmonids during the period 1997-2005.

	1997	1998	1999	2000	2001	2002	2003	2004	2005
ISA (ISA)	6	13	14	23	21	12	8	16**	11
IPN*						174	178	172	208
PD	7	7	10	11	15	13	23	44	35
HSMI								54	83
Piscirickettsiosis	1	0	6	0	1	17	5	0	0
Furunculosis	4	1	2	6	3	0	2	3***	1
BKD	15	0	3	3	3	1	1	1	2

*Figures for the years 1997-2001 are not included due to uncertain reporting.
**Two of the sites were in the same control zone, plus one site where the Norwegian Food Safety Authority established a zone after demonstrating ISA in a salmon.
***Food fish facility with salmon, wild salmon in a river, and a hatching facility for trout.

Heart and skeletal muscle inflammation– HSMI

This disease occurs in salmon and was demonstrated in at least 83 sites in 2005, in other words considerably more than the 53 sites in which it was demonstrated in 2004. The first time the condition was diagnosed in Norway was in 1999, and the rate of incidence of the disease is increasing strongly. Some fish health services record HSMI in almost all of their sites and the problem is regarded as serious. Outbreaks are reported as varying from short-term to several months. Mortality rates also vary by up to 10%.

A diagnosis is based on characteristic changes caused by the disease, clinical findings, autopsy findings, and histological changes (tissue changes). A virus from HSMI diseased fish has been isolated. This virus has been shown to cause HSMI in laboratory experiments. It is highly probable that this represents a research breakthrough that will provide opportunities for the development of more specific diagnostics, and lay the foundation for the development of a vaccine.

Nodavirus (VER)

Nodavirus has been shown to induce disease in a large number of marine fish, including halibut, turbot and European sea bass. The virus has yet to be isolated from salmonids, but in laboratory experiments it has been demonstrated that salmon infected with nodavirus from halibut develop disease. The significance of this is the subject of further research.

Bacterial diseases

Winter ulcer and sepsis (blood poisoning) due to infection with *Moritella viscosa* (*Vibrio viscosus*)

In 2005, *Moritella viscosa* was demonstrated at the National Veterinary Institute in salmon with ulcers from 34 sites. The real figure for last year is probably far higher, since materials for verification/cultivation are not necessarily submitted. Some fish health services cultivate and identify bacteria themselves. There is therefore no complete national overview of the scope of this problem.

Moritella viscosa is regarded as a principal, but perhaps not the only, cause of winter ulcer and sepsis in salmon. It is thought that winter ulcer involves a multifactor causal relationship. The bacterium is primarily diagnosed in the winter half of the year in salmon with ulcers from Vest-Agder in the south to Finnmark in the north. The bacterium is a problem in both sea facilities and in juvenile facilities that take in seawater.

Figure 5. Salmon with large ulcers that penetrate right down into the musculature. From an animal welfare perspective such ulcers are a serious problem, and for the Norwegian farming industry the disposal and downgrading of such fish constitute a significance loss.

The ulcers that occur are significant quality and animal welfare related problems. Downgrading results in major financial loss and in addition many fish die from the disease.

Some facilities experience greater problems than others. The rough handling of fish during, for example, sorting is often a contributory factor to fish subsequently developing winter ulcer. A general reduction in the general condition of fish due to other diseases such as IPN and HSMI, and injuries to skin due to attacks of lice are factors that can play a role in the development of winter ulcer. Vaccines against the bacteria have been developed, but at the moment it is uncertain how good an effect these have.

A large proportion of the antibacterial agents used in Norwegian salmonid farming are expended on treating fish with winter ulcer. Better control over winter ulcer will result in even lower consumption of antibiotics. The effect of treatment with antibiotics varies from facility to facility. Nor have laboratory experiments demonstrated that treatment with medications have a good effect. The consumption of antibiotics in Norwegian farming is generally very low given the quantity of fish that is produced.

Other bacterial diseases

Piscirickettsiosis has not been demonstrated in Norway in the last two years.

Coldwater vibriosis (infection by *Vibrio salmonicida*) was demonstrated at one site with rainbow trout. Classic furunculosis (infection by *Aeromonas salmonicida sp salmonicida*) was demonstrated at one site with salmon and classic vibriosis (infection by *Vibrio* (*Listonella*) *anguillarum*) was demonstrated at four sites with rainbow trout. One must now be able to say that these classic bacterial diseases, which previously threatened the Norwegian farming industry, are under control due to vaccination.

Outbreaks of yersinosis were demonstrated at two sites in Trøndelag, and there were also some problems with disease due to infection by atypical *Aeromonas salmonicida* and by *Flavobacterium* in salmonids in 2005.

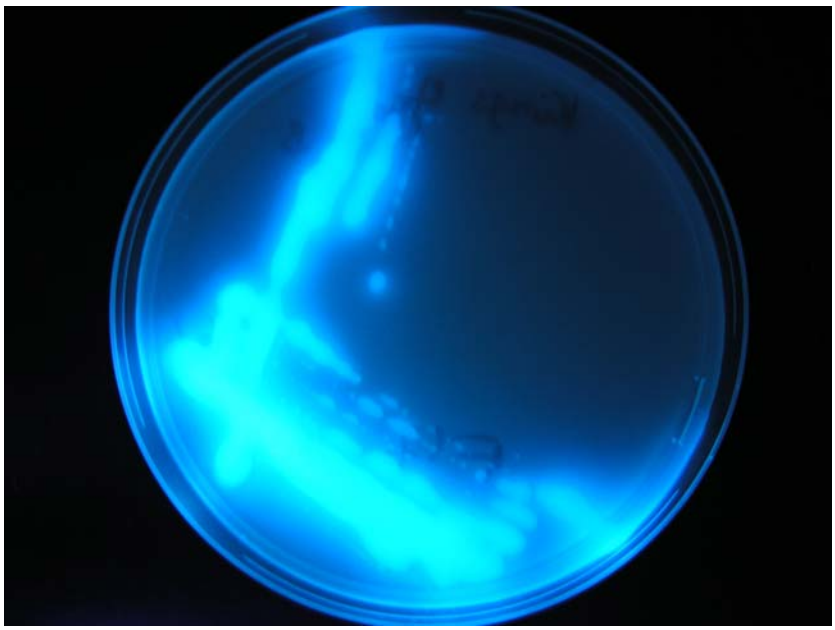


Figure 6. The figure shows *Pseudomonas fluorescens*, a bacterium that is often considered a secondary pathogen. The bacterium can, among other things, cause problems in facilities with a high density and generally poor environmental conditions.

Bacterial kidney disease (BKD)

In 2005, bacterial kidney disease (BKD) was diagnosed in two sea sites. One case was detected in a parent fish population, but in good time prior to maturity such that the quality of the fish flesh was good. Since only a handful of fish had developed the disease they could be slaughtered with minimal loss and alternative parent fish put into spawn production. This shows the benefit of continuously investigating deaths in stocks of parent fish. In the second BKD outbreak the presence of furunculosis was also demonstrated. BKD was a major problem in salmonids, especially between 1987-1993, in both commercial farming facilities and hatchery facilities for wild fish. From and including 1999, there has only been from one to three outbreaks of BKD per year. From 2006, the Norwegian Food Safety Authority and the National Veterinary Institute will implement a monitoring programme for BKD in order to facilitate the EU documentation work.

Fungi

No particular problems with respect to attacks of fungi in Norwegian salmon farming were reported in 2005.

Parasite diseases

Salmon lice – *Lepeophtheirus salmonis*

Salmon lice now seldom occur in large numbers per salmon in farming facilities.

A national action plan to combat salmon lice has been implemented for eight years and appears to have had a good effect. On average there were a lower number of mature female lice in 2005 than in both 2003 and 2004. The proportion of facilities that have treated against salmon lice increased somewhat from 2004, and during the same period the use of wrasse has fallen somewhat.

In general, the trend in the last three years has been moving in the direction of a lower number of mature female lice and mobile lice per fish. The large increase in the number of farmed salmon (potential growth organisms) mean that there are still a substantial number of salmon lice in Norwegian farming, with the problems this entails. They primarily represent a problem for wild salmon stocks. Large amounts are spent on medications to treat salmon lice today. A vaccine is being worked on which, if successful, may be important in limiting the problems with salmon lice in the Norwegian farming industry. If successful in reducing the general incidence of infections, this will also benefit wild salmon.

Parvicapsula pseudobranchicola

The parasite *Parvicapsula pseudobranchicola* was demonstrated at 20 sites in 2005, from Mid Norway and northwards. It is still a problem in Norwegian salmon farming, and the problems appear to be greatest in Northern Norway. It is likely that this is an underdiagnosed parasite since it is somewhat more difficult to find the parasite in organs, which in many cases are not routinely submitted for examination, other than the pseudobranchs.

Pseudobranchs are normally the same healthy colour as gills but with the presence of the disease they gradually become more bloody before they change to become more greyish and slimy due to the dead tissue. Finally they disappear and are replaced by scar tissue. Fish are often blinded by the disease. It is also thought that the pseudobranchs play an important function in a fish's osmoregulation.

Infection with this parasite sometimes results in serious problems and increased mortality. In other cases, and in these instances probably in association with a low infection rate, it only results in minor problems.

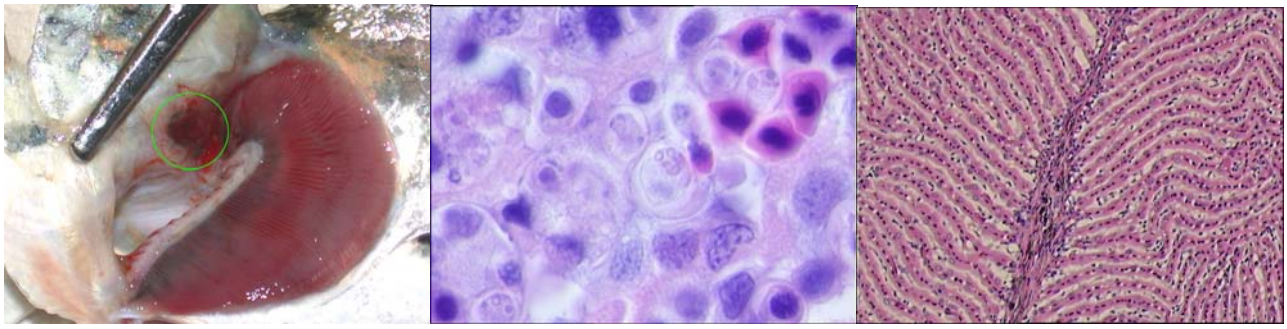


Figure 7. The parasite *Parvicapsula pseudobranchicola* can most easily be found in a fish's pseudobranchs (yellow ring), which are located on the inside of a fish's gill cover. Pseudobranchs are normally the same healthy red colour as healthy gills but with the presence of the disease they gradually become more bloody before they change to become more greyish and slimy due to tissue death. Finally they disappear and are replaced by scar tissue. In the middle is a histological section showing *Parvicapsula pseudobranchicola* in a pseudobranch, and to the right is a normal pseudobranch.

Tapeworm – *Eubothrium crassum*

This tapeworm occurs in the intestines of salmon and rainbow trout. It is a large and broad worm that in adult fish can grow to more than a metre long. Tapeworms often result in increased feed consumption and, since feed is the single largest expense in farming, the problem of tapeworms constitutes a financial burden. Tapeworm infected salmon have reduced lengths and weights compared with uninfected fish.

Eubothrium crassum was still a problem in 2005 and some fish health services reported poorer effects than previously from treatment with Praziquantel, which is the most widely used agent against the parasite.

Gyrodactylus salaris

In 2005, the parasite was not demonstrated in any river that had not previously been reported as being infected, but on the other hand in the autumn of 2005 it was reported in the Steinkjerelva and Figgja rivers. These rivers were treated with rotenone in 2002 and were in the process of being taken off the so-called "infected" list.

The entire stretch of the Lærdalselva river in which salmon migrate was treated in the spring and autumn of 2005 with an acidic aluminium solution. The spring treatment was primarily intended to limit infection, while the aim of the autumn treatment was to eradicate the parasite. No mortality of young salmon and trout as result of the treatments was demonstrated, but a few hundred adult salmon and sea trout did die as they proved to be more sensitive to aluminium than previously assumed. Since the autumn treatment, several hundred salmon smolt have been examined without the presence of *G. salaris* being demonstrated. The Lærdalselva river will probably also be treated in the spring of 2006 as a further guarantee that the total eradication of the parasite has been achieved.

No *Gyrodactylus salaris* were recorded in farmed salmonids in 2005.

Pursuant to a new EU directive it will become illegal to use rotenone in Norwegian waterways from 1st September 2006. The Ministry of the Environment is currently considering whether or not Norway should apply for an exemption.

Other parasites

Ichthyobodo necator (*Costia necatrix*) and similar parasites and trichodines have caused some problems in some facilities, often in connection with proliferative gill inflammation.

Other health problems

Cardiomyopathy syndrome – CMS

CMS is widespread along the entire coast, but occurs especially in Mid Norway, and in 2005 continued to be an important cause of losses to the Norwegian farming industry. The disease primarily affects larger fish and mortality rates are reported to vary. Some facilities have lost several tens of tonnes of fish per week.

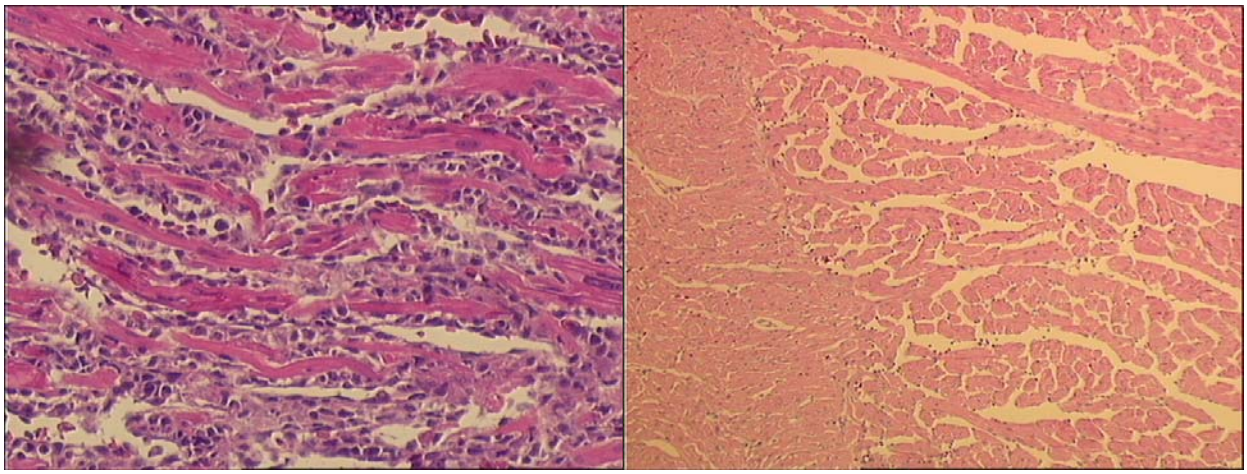


Figure 8. Cardiomyopathy syndrome is a major problem in Norwegian salmon farming. It often affects large fish that are ready for slaughtering and this results in significant financial losses for the industry every year. To the left is a normal salmon heart and to the right a heart with changes due to cardiomyopathy.

Proliferative gill inflammation- PGI

This disease occurs in salmon in the sea and in 2004 was – according to submissions to the National Veterinary Institute – demonstrated in more than 100 sites from Agder to Finnmark. This is about the same as in 2003. However, in 2005 fewer than 40 sites reported the disease. Reports from fish health services also indicate a lower rate of incidence in 2005. The disease must still be regarded as a serious problem in Norwegian fish farming and results in significant losses.

The problem often occurs in the autumn in salmon that were transferred to sea in the spring. The course of the disease can stretch over several weeks, with somewhat variable mortality rates. Some facilities have reported major losses. Its cause it not fully understood, but it is thought to involve bacteria (epitheliocystis, *Piscichlamydia salmonis*) and Atlantic salmon paramyxovirus. Epitheliocystis is demonstrated through histology, while methods for demonstrating viruses are still under development. Research on this problem continues.

Hemorrhagic smolt syndrome – HSS (hemorrhagic diathesis)

HSS occurs in salmon in freshwater. Sporadic cases are reported, though the number of cases has apparently not changed notably in recent years. The cause of this disorder is still unknown. HSS often only results in minor problems in facilities, and the mortality associated with this disorder is generally low. The disease often disappears upon transfer to seawater.

During autopsies HSS can be mistaken for viral hemorrhagic septicaemia (VHS) and infectious haematopoietic necrosis (IHN), which are two serious viral diseases. However, one can differentiate between these diseases with histological and virological examinations.

Cataracts

The fish health services reported a low rate of incidence of cataract in 2005, and the disorder does not appear to be as large a problem as before. A better quality of feed with a different composition for farmed fish is thought to have been a factor in this improvement. Low water temperatures in 2004 and 2005 may also have been beneficial in avoiding cataracts.

Vaccine side effects

Some problems involving vaccine side effects in fish were reported. One type of vaccine in particular appears to produce more damage than other vaccines according to actors in the industry. Some groups of fish still undergo unacceptably large changes due to vaccines. Vaccination is a desirable and effective disease prevention measure, but the extent of side effects is a cause of concern with respect to welfare, reduced growth, and the downgrading of slaughtered fish.

Deformities

Problems with deformities are still being reported, primarily in vertebrae (like short tails) and heart. It may appear that the problem is less widespread than before, probably due to better temperature control in hatcheries, and possibly stricter sorting in young fish facilities.

Jellyfish and algae damage – high temperatures

There appear to have been few problems with mortality among salmonids in 2005 due to jellyfish and algae. Water temperatures were lower on average in 2005 than in 2004, and has in itself not produced any notable problems in connection with the farming of salmonids in 2005.

Tumours in salmon

In general, tumours are very rare in farmed salmonids in Norway. In 2005, however, malignant intestinal tumours with spreading to other organs were demonstrated in salmon and rainbow trout in a few sites. The changes are not easy to see at an early stage, but by feeling the intestines one can find clear nodules, and at a later stage the tumours are relatively easy to see, especially when they spread to the liver.

Gill problems due to unknown causes

Some facilities with salmon in freshwater experienced high mortality due to gill problems with peculiar changes to tissue. The cause is unknown, but possible ‘parasitic gill amoebas’ are considered likely contributory factors.

Problems in the farming of char

No particular problems were reported in association with the farming of sea char, and no incidences of disease due to the *Spironucleus sp.* parasite have been demonstrated. Nor have there been particular problems associated with high temperatures, which can result in some problems in the farming of sea char.

Problems in the production of inland char are primarily the result of parasites, *Ichthyobodo necator* and tapeworms.

Diseases of juveniles

In 2005, there were some problems in some facilities with somewhat high mortality rates for salmon smolt. No causal relationship has been established. In addition, at a couple of sites there were suspicions concerning a nervous disorder in salmon smolt, but it is hard to make a diagnosis since so far one does not know the specific histopathological changes caused by this disease.

Animal welfare – ethically and environmentally sound production

The welfare of fish was the subject of much attention in 2005, and will also be an extremely important topic in the future. Fish have traditionally been regarded as different to warm-blooded animals in relation to animal welfare. One does not see the same empathy for fish as one does for warm-blooded animals. This is probably due to both old attitudes and the fact that compared to warm-blooded animals fish are less able to 'communicate' with people.

Now, however, we are seeing a steadily stronger focus on animal welfare for farmed fish. Recently it was experienced that animal welfare boards have ordered farmers to improve the conditions for fish in farming facilities. The prevention and treatment of ulcers and vaccine side effects in fish are examples of key challenges for the industry.

The Act concerning the Welfare of Animals also applies to farmed fish and new operating regulations have in recent years tightened the requirements concerning the welfare of farmed fish. Norway has a special responsibility for developing good farming systems from a welfare perspective, and to be a pioneering country within animal welfare for fish.

Consumers are making steadily increasing demands concerning welfare, and ethically and environmentally sound production. It is therefore important that Norway is able to document that it operates ethically sound systems for the production of farmed fish, in which good health conditions and welfare for fish are in focus.

Surveillance programmes

Annual surveillance programmes are carried out for *Gyrodactylus salaris* and the viral diseases infectious haematopoietic necrosis (IHN) and viral hemorrhagic septicaemia (VHS). These two viral diseases have not been demonstrated in Norway in 2005 or previously, with the one exception of VHS which was demonstrated in 1974. From 2006, a monitoring programme will be introduced for bacterial kidney disease (BKD).

Health situation for wild salmonids

The situation for outwardly migrating smolt vis-à-vis salmon lice appears to be better now than before. This is primarily due to the better control of salmon lice in farming facilities.

Sea trout are still much plagued by lice, which results in them migrating back to rivers earlier than normal.

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Health situation of marine fish 2005

Summary

Samples from cod constituted the majority of the materials submitted for disease investigation at the National Veterinary Institute in 2005. Vibriosis, caused by the bacterium *Vibrio (Listonella) anguillarum*, was the most common problem. Serotype O2β was isolated from most cases of vibriosis in cod, but in one disease outbreak serotype O2α was detected. Isolates are routinely tested for antimicrobial sensitivity. This monitoring has generated research projects, one of which investigates the molecular basis of cases of quinolone resistance in *Vibrio (Listonella) anguillarum*. In 2005, a 'new' disease was detected in cod, which causes granulomas in internal organs. A Francisella-like bacterium has been identified in the lesions. Except for an outbreak of IPN in halibut fry, the notifiable viral diseases infectious pancreatic necrosis (IPN) and viral nervous necrosis/viral encephalopathy and retinopathy (VNN/VER) were not reported in farmed marine fish species in 2005.

Cod

Bacterial diseases

Vibriosis or infection with *Vibrio (Listonella) anguillarum* is still a major problem in cod. Vibriosis has also been demonstrated in coalfish. The symptoms can vary with the degree of seriousness of the outbreak, but sick fish often display ulcers and skin haemorrhages, especially in the region of the head. One also sees haemorrhages at the bases of the fins and fin deterioration. In chronic cases one may also see bloody, protruding eyes (Figure 1). In 2005, the bacterium was isolated in instances of increased mortality in juvenile fish, on-growing fish and broodstock along the coast up to and including Trøndelag, but not further north. There is much to indicate that there have been fewer outbreaks of vibriosis in 2005 than in previous years. This may be related to lower water temperatures and the testing of oil-based vibriosis vaccines in some areas.

Figure 1. Vibriosis in cod.

Vibrio (Listonella) anguillarum occurs in several serotypes (including O1, O2α, O2β, O3, O5). Serotype O1 is often isolated in instances of vibriosis in salmonids, while the samples submitted from marine fish are primarily serotype O2. Both O2α and O2β were isolated from outbreaks in cod. In 2003 and 2004, the proportions of O2α in O2 cultures that were submitted to the National Veterinary Institute, Section for Fish Health, for further characterisation were 18 % (of the total 26 submissions) and 35 % (of the total 37 submissions) respectively. This material did not cover the entire country, but nonetheless indicates a trend in the development of the disease. One can see similar tendencies in 2005 in which the proportion of O2α amounts to only 6% (of the total 18 submissions on a countrywide basis). In other words there are indications that the number of vibriosis outbreaks have fallen, and that the serotype O2α has played less of a role in 2005 than the two previous years. *Vibrio (Listonella) anguillarum* isolates are routinely resistance tested. In addition to the fact that this information is used during treatment, one at the same time achieves the continuous monitoring of any resistance problems. Reduced sensitivity to quinolones was also recorded in 2005. This gives cause for concern, and in general one should be restrictive regarding the use of antibiotics/chemotherapeutics. The effect of treatment in the event of outbreaks of vibriosis has varied somewhat, also because cod eat poorly in high water temperatures.

The most important finding in 2005 was the identification of a 'new' bacteria disease in several sites in Rogaland and Hordaland (Figures 2 and 3). Several finds of granulomas (chronically inflamed nodules) have been made in cod. Granulomas may have a number of different causes, and the problem has varied in scope. In the most serious cases however abundant occurrences have been recorded of granulomas in musculature and inner organs, and high mortality over time. In addition there are large losses due to destruction and downgrading. In several of these cases one has now identified an intracellular bacteria in the lesions. The bacteria have been identified by two independent research institutions as *Francisella sp.* with the aid of, among other techniques, molecular biology. Further work on the epidemiology and pathology, development of diagnostic media, and characterisation of the bacteria are high priorities. A similar bacterium has been found in connection with disease in tilapia in Taiwan and in marine fish in Japan. For further information about *Francisella sp.* in cod please refer to the National Veterinary Institute's website: www.vetinst.no, Journal of Fish Diseases, 2006 ("A novel systemic granulomatous

inflammatory disease in farmed Atlantic cod, Gadus morhua L., associated with a bacterium belonging to the genus Francisella" by A. B. Olsen, J. Mikalsen, M. Rode, A. Alfjorden, E. Hoel, K. Straume-Lie, R. Haldorsen and D. J. Colquhoun) and *Norsk Fiskeoppdrett* no. 12, 2005 ("*Ny torskesykdom forårsaket av bakterien Francisella n. sp.*" by A. Nylund, K. F. Ottem and K. Watanabe).

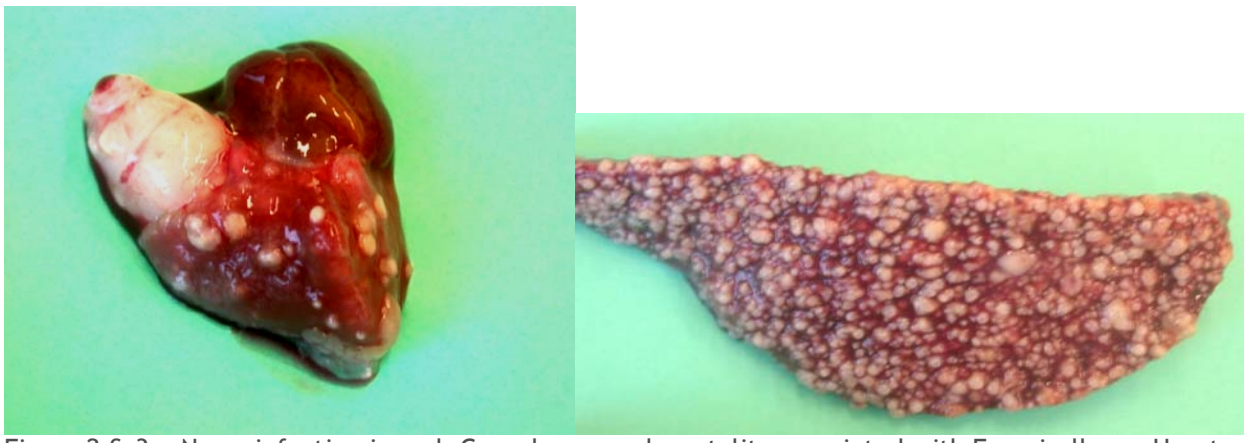

Figure 2 & 3. «New» infection in cod. Granulomas and mortality associated with Francisella sp. Heart and spleen

Another important finding in 2005 was the first demonstration of *Vibrio ordalii* in Norway. The bacterium was isolated from 5-8g cod fry. Outbreaks of the disease resulted in high mortality and the fish in the facility were treated with oxolinic acid. Further follow-up was not possible since the fish were lost due to flooding. Infection with *Vibrio salmonicida* (coldwater vibriosis) was demonstrated in cod fry (6g) and larger fish (300g).

The fish had a sepsis picture and there was some mortality. Atypical furunculosis (infection by atypical *Aeromonas salmonicida*) has been demonstrated in cod.

Reports are constantly received concerning high mortality in cod fry. In many cases no other findings are made other than large quantities of bacteria in the intestinal tract, so-called bacterial overgrowth in the intestines. Harmful bacteria can establish itself in the intestinal tract and multiply in large numbers, which results in various kinds of injuries: inflammation of the intestines, systemic infection or the absorption of toxins produced by the bacteria. Various causes may lie behind this problem, however poor nutritional and environmental conditions probably play a role in that the fish's resistance is weakened and a harmful bacterial flora is established. In one case of high mortality a bacterial swim bladder infection in 11-day-old cod fry was identified (Figure 4). Initially a red/brown fleck in the swim bladder was observed, this increased in size and finally the entire swim bladder was covered. Direct microscopy of swim bladders demonstrated large quantities of motile rod-shaped bacteria. The multiplying of opportunistic pathogenic bacteria in live feed was suspected as the source of the infection.

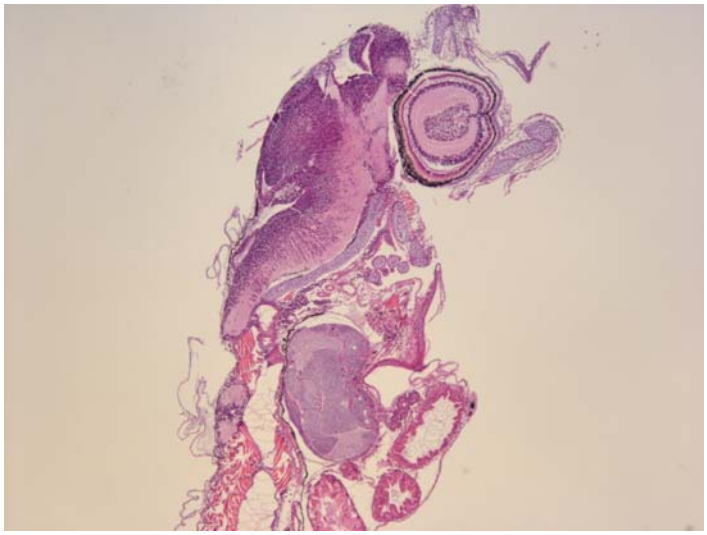

Figure 4. Cod fry (11 days post hatching) with bacterial swim bladder infection.

In addition to the continuous collation and characterisation of bacteria from the diagnostic work on cases of disease in marine farmed fish, special research is being carried out into the characterisation of various genera including *Vibrio salmonicida* and *Aeromonas salmonicida* and resistance to antibiotics in *Vibrio (Listonella) anguillarum*. Work is also being done to analyse the virulence (i.e. how great an ability the microbes have to cause disease) of *Vibrio ordalii*, which has recently been isolated from cod in Norway. This bacterium has also been genetically compared with *V. ordalii* isolated from other species of fish in other countries. Diagnostics, characterisation and analysis of *Mycobacterium spp.* in cod and other marine species of fish is another relevant area of research.

Parasite diseases

Parasitic gill inflammation is well known in cod. *Ichthyobodo* (Costia) and *Trichodina* are the most common, however haptor worms (*Gyrodactylus marinus*) and epitheliocystis have been demonstrated. Skin infections involving *Trichodina* and *Cryptocotyle* (black spot disease) are also often seen.

Viral diseases

No serious viral infections in cod were reported in 2005. The notifiable viral diseases infectious pancreatic necrosis (IPN) and viral nervous necrosis (VNN or VER) have so far not been demonstrated in cod in Norway. Both of these diseases can cause high mortality in young and juvenile fish. High loss percentages and high 'natural mortality' are to some degree expected and accepted in the production of young marine fish species. Very few cases of high 'natural mortality' are examined for the presence of infectious diseases. It is therefore uncertain if the absence of recorded and reported incidences of disease is due to a genuine absence of the disease in the industry or simply reflects a lack of investigation into the existing mortality.

Other

Several fish health services reported mortality in female fish that were ready to spawn. The fish becomes apparently ready to spawn, but does not release her eggs. The female fish becomes swollen and reddish in colour around the area of the anus and develops ulcers (Figure 5). Fin rot is also common. Bacteriological examinations of the ulcers demonstrate the presence of ordinary ulcer bacteria such as *Moritella viscosa* and *Vibrio sp*. No systematic bacterial infection has been demonstrated from kidney samples. It may appear that the problem starts with the fact that the fish does not manage to spawn and becomes overdue, and that ulcer problems are secondary to this 'need to spawn'. Mortality increases the longer fish 'go over their time' and the total losses can be large.

Figur 5. Broodfish of cod. Females failing to spawn develop ulcers and die.

One case of appetite failure and mortality in cod was reported following treatment with oxolinic acid. During the autopsy the fish health service found light flecks on the heart, a distended stomach and a similarly distended, almost transparent fluid filled intestine. Light microscopy examinations of organs demonstrated haemorrhages in parts of the heart (bulbus arteriosus), fluid retention in the intestinal mucous membrane, and indications of circulation failure. The case is being examined for possible oxoline acid poisoning. The surviving fish are being followed up with further examinations.

Transport injuries during pumping occur. In addition to mechanical injuries, it has been emphatically demonstrated how sensitive cod are to rapid pressure changes. One facility lost 93.5 tonnes of large fish during transfer to a wellboat from 40m deep enclosures. During the slaughtering of the next enclosure a couple of weeks later the enclosure was raised in stages over seven days from 40 to 10m without mortality. However, fish began to die when the enclosure was raised from 10 to 5m, and the mortality increased during further raising, even though this was carried out very carefully and slowly. Autopsies of the fish demonstrated very distended or burst swim bladders.

Deformities such as 'broken neck' were a smaller problem than in previous years. The incidence rate of 'floaters' (young fish with overfilled swim bladders) also fell. More rigorous sorting is contributing to a better quality of fish being sent out from hatchery facilities. In previous years various forms of 'volvulus' or colic were reported in cod in food fish facilities, and this problem still exists. Other types of intestinal problems in cod have also been reported, but the causal relationships are still unclear.

Halibut

Halibut larvae are not very developed when they hatch and high mortality rates during the young fish phase have previously been a limiting factor in its production. Infection with nodavirus, also called viral nervous necrosis (VNN) or viral encephalopathy and retinopathy (VER), contributed to the high mortality. No outbreaks of VNN were reported in 2005, but one clinical outbreak of infectious pancreatic necrosis (IPN) was diagnosed in halibut fry. The special thing about this case is that 60 randomly selected fish from this facility were checked for nodavirus and IPN virus (screening) a few weeks prior to the outbreak of the disease. The examinations were conducted with aid of the PCR method and the result was negative. Despite the apparent absence of IPN virus in the population a few weeks later it experienced an outbreak of IPN. Environmental conditions may have contributed to the outbreak of the disease. The screening of randomly selected fish for specific diseases can provide an indicator of what exists in the facility/population, but will always represent a snapshot and provides no guarantees for the future. A wide-ranging disease and environmental investigation into episodes of increased mortality will help to clear up the causes of losses and provide a basis for preventative measures.

Over time technical solutions have been developed that make it possible to hold halibut in enclosures in the sea, but much of the food fish are farmed in land-based facilities. One can see a correlation between poor water quality and the occurrence of gill problems. Recirculation systems are especially susceptible and require good technical and infection prevention routines to avoid disease causing organisms to multiply in these systems. Bacterial and parasitical gill inflammations (*Ichthyobodo* (Costia) and *Trichodina*) were demonstrated in halibut on several occasions in 2005. Problems due to chronic gas supersaturation were also reported.

The bacterial disease atypical furunculosis (infection by atypical *Aeromonas salmonicida*) is a recurring problem in larger halibut. Atypical *A. salmonicida* is often isolated in connection with increased mortality in halibut. Vaccination against atypical furunculosis in marine fish has so far not produced as good an effect as vaccination against furunculosis in salmonids. The bacterium is often present in the water or in the fish, and excessively poor environmental conditions can weaken the fish's resistance and cause outbreaks of the disease. Bacterial skin inflammations also occur: *Flexibacter sp*. and *Tenacibaculum maritimum* have been isolated from these cases. In addition infection by *Vibrio sp.* has been demonstrated. One also sees problems with so-called bacterial overgrowth in the intestines of young halibut.

Wolffish

Few facilities produce wolffish, and the fish is in general regarded as pretty robust (Figure 6). The bacterial disease atypical furunculosis (infection by atypical *Aeromonas salmonicida*) is however a recurring problem in wolffish. Wolffish are a coldwater fish and in several instances one has seen a clear correlation between increased water temperatures and outbreaks of disease. Wolffish farming takes place in tanks on land, and the use of recirculation systems makes great demands concerning the monitoring of the fish's environment. A number of gill problems have been observed in wolffish. This may be associated with poor water quality and the presence of the ectoparasites *Trichodina* and *Ichthyobodo* (Costia). The microsporid *Pleistophora ehrenbaumi* has previously caused major injuries to the musculature of wolffish, but there were no reports of major losses due to this parasite in 2005.

Other species

Increased mortality has been recorded in turbot associated with ulcers/injuries in the jaw region. With histopathological examinations of the fish one finds long, thin *Flexibacter/Tenacibaculum* like bacteria in the affected areas. It has proven to be very difficult to cultivate these bacteria, which hinders reliable identification. A collaboration with Spanish research institutions has been initiated in this area.

Figure 6. Farmed spotted wolf-fi sh (Anarhichas minor).

Transmission between species

Many pathogens (disease causing agents) can be transmitted between species. Some have a narrow register of hosts and will only be transmitted between closely related species, while others are not particularly host specific and can be transmitted between many species. This applies to viruses, bacteria and parasites. A long-lasting, high level of exposure can also result in a pathogen with a narrow register of hosts adapting to a new species over time and causing diseases where this previously would not have happened. Aquaculture is especially susceptible, both because the total biomass is very large and because it is very difficult to achieve full anti-infection hygienic differentiation between facilities in the sea and between farmed fish and wild fish. Norwegian veterinary authorities have therefore been reticent when it comes to permitting the collocation of species in aquaculture facilities. Bearing in mind Norway's large production of salmonids, one is especially on guard against diseases one can envisage being transmitted between marine fish and salmonids.

There are several pathogens that can cause problems in both salmonids and relevant farmed marine species in Norway. *Vibrio (Listonella) anguillarum* and *Caligus elongatus* (Scottish lice) are two examples. It has also been demonstrated that IPN virus is capable of causing disease in several species, both in natural outbreaks and in transmission experiments. In this context one would however like to particularly highlight three serious viral diseases, namely VNN/VER, infectious salmon anaemia and viral hemorrhagic septicaemia.

VNN/VER (infection by nodavirus)

Nodavirus causes diseases in many marine fish species and can be transmitted between species, though so far outbreaks of disease have not been demonstrated in salmonids. Recently conducted transmission experiments at the Norwegian Institute of Marine Research and the University of Bergen however show that nodavirus from halibut fry can cause diseases and mortality in Atlantic salmon under laboratory conditions. VNN/VER is one of the largest disease problems in the farming of marine species on a global basis, and the disease has been demonstrated in both turbot and halibut in Norway.

Infectious salmon anaemia (ISA)

ISA is a very serious viral disease in Atlantic salmon. The ISA virus has been demonstrated through molecular biological methods in wild individuals in a few marine fish species, but no disease has been recorded in marine fish. In transmission experiments with the ISA virus at the National Veterinary Institute it was not possible to cause disease in cod.

Viral hemorrhagic septicaemia (VHS)

VHS, also known as Egtvedt Disease, is an infectious disease that causes major losses in the farming of rainbow trout. The disease has also been observed in other salmonids, Japanese flounder, Pacific herring, and turbot. VHS is a class A disease which is notifiable to the Norwegian authorities, the European Union (EU), and the World Organisation for Animal Health (OIE). Demonstration of its occurrence results in the destruction of infected fish and extremely strict restrictions. In addition to this, its demonstration could have major trade related consequences, since Norway has a VHS free zone status. Several varieties of the VHS virus exist, but the legislation does not differentiate between these, meaning that its demonstration in farmed marine species will result in the destruction of the fish and the establishment of control zones. The VHS virus is found in a number of marine species, including in Norwegian waters. The virus is transmitted horizontally, i.e. from fish to fish, and infection has been linked to feed containing fresh or frozen fish.

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These reports are also included as chapters in the Norwegian Institute of Marine Research's report: "*Kyst og havbruk 2006*".

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