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Fish Health Report 2015

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Fish Health Report: 2015

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The Norwegian Veterinary Institute's annual review of fish health in Norway

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Good oversight and control of fish health are of decisive importance for Norwegian aquaculture

Recognition of a problem is a prerequisite for being able to deal with it. If Norwegian aquaculture is to continue to develop, good oversight and control of fish health are of decisive importance. The past few years have witnessed a positive climate of greater openness and useful discussions of important questions regarding fish health and welfare.

Unlike our traditional domestic animals, Norwegian farmed fish have a relatively short history. Even though the picture has its nuances and there are wide variations within the industry, aquaculture still faces some major challenges. Towards the end of the 1970s, salmon lice were the cause of important threats to health, which were “solved” by an ever-growing range of chemical products. During the past few years, the development of resistance has been an important reason why salmon lice have posed the greatest challenge to fish health. Paradoxically, some of the means that have been adopted to deal with lice may have given rise to new health problems. Cleaner fish need to be guaranteed good health, and it is important to consider how new operating methods affect fish health and animal welfare.

In 2015, major ambitions for growth were announced at political level on behalf of the Norwegian aquaculture industry. At a difficult time for the petroleum sector, the bioeconomy has been identified as a potential substitute for losses in growth and employment. A five- to sixfold increase in value creation is being promoted as a political aim for the aquaculture industry. Further growth is bound to involve new threats to fish health, which means that it is important for us to possess good systems for monitoring fish health, so that new diseases can be identified at an early stage.

Growth in production will increase our need to monitor fish health, as the consequences can otherwise be serious, due to the spread of infections and diseases, and problems of welfare. This can lead in turn to serious economic and reputational losses for the industry. The assessments of risk discussed in this fish health report will therefore become ever more important.

In any assessment of whether fish health is good or bad, a natural first step is to perform a survey of diseases, production losses and other indicators of welfare. The situation can also be assessed by looking at the consumption of medicines and other chemicals used to fight disease.

For the authorities, it will always be a difficult task to decide which diseases need to be listed as notifiable and thus become the subject of official regulations and countermeasures, as against what the industry itself ought to accept responsibility for. It is therefore essential to determine at an early stage whether or not a disease is infectious. This shows that knowledge regarding the development of disease, infection, reservoirs of diseases and relationships with hosts are important factors in evaluating its significance for both cultivated and wild fish. If a disease is serious, much can be gained by implementing early countermeasures. There will often be major gaps in our knowledge that make it difficult to make good decisions at an early stage. The Veterinary Institute is currently increasing its efforts in aquatic epidemiology and biosecurity, with the aim of contributing to this process.

The Norwegian Veterinary Institute has been issuing its annual report on fish health since 2003. Since the previous edition, we have thoroughly re-evaluated the report. A questionnaire survey indicated that it is in fact read, cited and used by many people. We are also grateful for a good deal of useful input, among the other results of which we are now utilising a web-based questionnaire to gather data from fisheries sector personnel outwith the Veterinary Institute. Risk assessments have also been divided up in order to improve their relationship with the rest of the material.

We realise that it is possible to improve the report yet further. In particular, we will attempt to better integrate data from other laboratories, while we express our gratitude to everyone who has contributed to this edition. Please contact us if you have input or comments relevant to the report or to other aspects of our work, in order to support the industry and the authorities by providing important information about fish health and animal welfare.

Brit Hjeltnes
Editor, Fish Health Report 2015, and director of fish health at the Norwegian Veterinary Institute

Summary

Salmon lice currently present the biggest threat to Norwegian salmon farming, and the development of resistance to drugs is the most difficult problem that needs to be tackled (see chapter on "Changes in risk of infections").

Nowadays, relatively few farmed fish die as a result of salmon lice infections, but this situation could change quite rapidly due to the development of resistance. Paradoxically, there are many example of high mortality caused by treatment for this parasite. Fish that were already weak before treatment are particularly at risk. Alternative treatments for salmon lice that are not based on drugs are being developed, but many of these involve handling the fish, which can also lead to stress and mortality. Every year, salmon lice and their treatment cost the Norwegian aquaculture industry a great deal.

All in all, the situation has changed somewhat since 2014, with a lower incidence of salmon lice in 2015 compared to previous years everywhere in Norway. Estimates of the production of lice larvae by fish farms are displaying marked changes, with significantly lower infection pressure in southern Norway, but significantly higher pressure in mid-Norway than in previous years. The consumption of medicines that target lice is marginally lower than in 2014, but is still high. The resistance situation is serious, with a widespread reduction in responsiveness to drugs all along the coast. It is necessary to find out what has caused the changes in infection pressure in southern and mid-Norway. Pancreas disease (PD) is still the most serious viral disease of salmon in seawater. There are currently two epidemics of Pancreas disease in Norway. The subtype with marine SAV 2 is largely restricted to the counties of Møre og Romsdal and Sør-Trøndelag, while the subtype with SAV 3 occurs only in western Norway. In 2015, a total of 137 new marine sites with Pancreas disease were identified. The situation for Pancreas disease with SAV 3 in the west of the country is stable relative to the previous year, but there is a reduction of 18 percent in the epidemic with SAV 2.

Infectious salmon anaemia (ISA) has been identified at 15 sites in 2015, compared to 10 in 2013 and 2014. Most of these sites were in the county of Nordland, where ISA has characterised the disease situation. Three of the confirmed outbreaks are regarded as primary outbreaks. The others may be due to infections resulting from being in the vicinity of, or sharing a site with, infected sites, or purchases of smolts from a hatchery where ISA has been identified. In northern Norway, ISA-infected fish have been kept in the sea for long periods of time. Late and incomplete fallowing periods of fish farms are among several possible reasons for outbreaks of ISA. In a few cases, the outbreaks have been identified at a relatively late stage. In 2015, the ISA virus has also been registered in rainbow trout. In autumn 2015, a close collaborative effort involving the aquaculture industry, the fish-health services and the Norwegian Food Safety Authority both fallowed and commenced the systematic monitoring of all salmon and rainbow trout sites within defined zones in northern Norway. This is expected to lead to a significant improvement in the infection situation in that part of the country.

Heart and skeletal muscle inflammation (HSMI) is currently one of the most common infectious diseases in Norwegian farmed salmon. In 2015, HSMI was identified at 135 sites, most of which were marin sites. These represent fewer outbreaks than in previous years. Possible reasons for this include the situation that since mid-2014, HSMI is no longer a notifiable disease , that diagnoses of HSMI by private laboratories are not included in the figures, and that there are fewer reports from North Norway due to the fallowing of sites in the wake of the ISA situation. The overall significance of the current state of affairs is not known.

In 2015, Norway produced (figures at harvest) 1 234, 200 tonnes of Atlantic salmon, 71,600 tonnes of rainbow trout, 4000 tonnes (estimated) of Atlantic cod (live storage), 1700 tonnes (estimated) of Atlantic halibut, 2 – 300 tonnes (estimated) of turbot and 5 – 600 tonnes (estimated) of arctic charr. Ten million lumpsucker fish were raised, as were 400,000 to 500,000 (estimated) ballan wrasse. These figures are based on information supplied by Kontali Analyse AS.

Piscine orthoreovirus (PRV) has been linked to HSMI. In 2010, this virus was identified in tissue from HSMI-infected salmon. The virus has been detected in high concentrations in local tissue injuries that are termed "dark spots" in fish fillets. Such dark spots are a major and growing quality problem in farmed salmon. In 2010, the cost of dark spots in fish fillets was estimated to be NOK 500 million.

Cardiomyopathy syndrome (CMS), is a serious disease of the heart that affects farmed fish usually after they are put to sea. In 2015, CMS was diagnosed at 105 sites. This is probably lower than the true figure, because the disease is not notifiable and CMS diagnoses from private laboratories are not included in the total. If we compare our figures with those from other laboratories, there was probably an increase in the number of cases of CMS in 2015.

In 2015, infectious pancreatic necrosis (IPN) was identified at 30 sites where salmonids were being held. This is a significant decrease from 2014, and even greater compared to the peak year of 2009, when it was diagnosed at 223 sites. The use of quantitative trait loci (QTL) roe, together with greater efforts aimed at eliminating "house strains" of the IPN virus are probably the two most important reasons for the reduction we have seen in the number of outbreaks of IPN in the past few years.

Amoebic gill disease (AGD) is caused by the parasitic amoeba *Paramoeba perurans* (formerly *Neoparamoeba perurans*). In 2015, the amoeba was demonstrated all year round at several sites. However, it appears that AGD has not developed into an equally serious disease for Norwegian farmed fish as it was in 2014. Possible reasons for this are that many fish farmers have acquired more experience of dealing with and treating AGD, that late summer last year was characterised by high levels of freshwater runoff and lower salinity in many coastal areas, and that the autumn was not as warm as in the previous year.

Gill diseases appear at all life stages of farmed salmonids. Particularly among salmon held in seawater, chronic gill inflammation is an important, and chronic, problem. Since gill diseases are not notifiable, it is difficult to set a figure on how many farms are affected every year, and thus to say anything about how the situation is evolving from one year to the next. Salmon gill poxvirus, *Paramoeba perurans, Desmozoon lepeophtherii* and *Candidatus Branchiomonas cysticola* are among the agents that lead to gill infections. Diseases of the gills often have complex and multifactorial causes, which means that a number of different micro-organisms may be involved simultaneously and lead to chronic gill inflammation.

Bacterial ulcers continue to cause significant problems, particularly in North Norway. Yersinosis is affecting a growing number of sites.

In 2015, a major increase in the number of submissions of samples of cleaner fish, with what appears to be a trend that the problem of atypical furunculosis, which is caused by the bacterium atypical *Aeromonas salmonicida*, has significantly increased, particularly in lumpsucker fish. One case of typical *Aeromonas salmonicida* has been identified in a lumpsucker in Nord-Trøndelag. This bacterium is the cause of classical furunculosis, which is a notifiable disease. No viral diseases have been diagnosed in the Veterinary Institute's cleaner fish material from 2015.

Introduction to the data utilised to prepare this report

By Britt Bang Jensen

The data used in this Fish Health Report come from three different sources: official data, data from the Veterinary Institute and data from a recent questionnaire survey that replaces the interviews with staff in the fish health services that were used in previous fish health reports.

The individual chapters of the report make a clear distinction between the sources of data and information on which the figures are based, and the authors' assessments of the situation.

Official data

All notifiable diseases must be reported to the Norwegian Food Safety Authority; see "Regulations regarding the sale of aquacultured animals and products thereof, prevention and combatting infectious diseases in aquatic animals." The regulations state that "In cases of an increase in mortality rates, except when such mortality is clearly not due to the disease, a health inspection is to be performed without undue delay in order to determine the causal relationship involved. The health inspection must be performed by a veterinarian or a fish biologist."

The Norwegian Food Safety Authority must be notified immediately in the event of any unexplained sudden increases in mortality in fish farms or mollusc-farming areas, or if there exist any grounds for suspecting the existence of diseases mentioned in lists 1, 2 or 3 in aquacultured animals."

On the basis of monitoring programmes and ongoing diagnostic studies, we know that none of the diseases on list 1 occur in Norway today. An overview of the list 2 and 3 diseases with the number of confirmed outbreaks can be found in Table 1. This table is based on Norwegian Veterinary Institute data, which assists the Norwegian Food Safety Authority by maintaining a permanent overview of listed (notifiable) diseases. This is achieved by the Norwegian Food Safety Authority reporting cases of notifiable diseases to the Norwegian Veterinary Institute that have been reported by external laboratories, so that these can be added to the cases identified by the Norwegian Veterinary Institute itself.

The "official figures" given in this report indicate the number of new sites and new identifications of disease after fallowing. The real number of infected sites may be higher, as these may contain infected fish in the sea from the previous year.

Table 1.1 Overview of list 2 and 3 diseases with number of confirmed outbreaks. Figures are based on Norwegian Veterinary Institute data.

Disease	Liste	2011	2012	2013	2014	2015
Farmed fish (salmonids)						
ISA	2	1	2	10	10	15
VHS	2	0	0	0	0	0
PD	3	89	137	100	142	137
Furunculosis	3	0	0	0	1	
BKD	3	3	2	1	0	
Farmed fish (marine species)						
Francisellosis	3	3	2	1	1	
VNN/VER	3	0	1	1	0	
Wild salmonids (fresh water)						
Infection with Gyrodactylus salaris	3	2	0	1	1	0
Furunculosis	3	1	0	0	0	
Crustaceans						
Crayfish plague (signal crayfish)				1	1	2

Norwegian Veterinary Institute data

The Norwegian Veterinary Institute receives samples for diagnostic purposes from several fish-health services. These are studied by the Veterinary Institute's laboratories in Harstad, Trondheim, Bergen and Oslo. All the information from the submitted fish samples is stored in the Veterinary Institute's Laboratory Information system (PJS).

Data from the PJS are used in the Fish Health Report, for use in tables, graphs, maps and text in individual chapters. The data are sorted, so that only samples submitted for diagnostic purposes are included, but not those submitted for purposes of research, ring tests or monitoring programmes. For each agent or disease, the number of sites at which agents or diseases have been identified in at least one of the submitted samples is counted. We often receive samples from the same site several times in the course of a year, but each site is counted only once for each agent or disease identified. In some cases, the same agent or disease had been demonstrated in the same release in 2014, so it may not be possible to use the overview to draw any conclusions regarding new outbreaks (except for notifiable diseases, as described above).

Where non-notifiable diseases are concerned, the Veterinary Institute's data alone may not provide a complete picture of the national situation. Many private companies also analyses samples and maintain their own databases. We cannot be certain about the extent of such "hidden" figures, but we can say that this year, we have been sent data from a total of 593 salmonid farms, as against 757 last year and 704 in 2013.

Data from the 2015 survey

In previous years, the Veterinary Institute carried out a telephone interview survey of fish health services, in order to obtain their comments regarding the current state of health of fish, and whether there is anything new or interesting that ought to be included in the Fish Health Report. However, it would be desirable to obtain such information in a more efficient and standardised way that would also be testable and transparent. This year, therefore, we drew up a net-based questionnaire that was distributed to fish health services all along the coast, in addition to contact persons and inspectors in the Norwegian Food Safety Authority.

The questionnaire asked respondents, among other things, to rank the five most important diseases in salmon and trout hatcheries and on-growing farms, with the most important disease ranked first, and so on. A number of alternatives could be selected. The questionnaire was sent to a total of 28 fish health services, from which we received 14 responses. In some cases, several persons from the same service completed the questionnaire, so the total number of responses received was 32. We also sent the questionnaire to 35 persons at the Norwegian Food Safety Authority, and received answers from 13. The respondents are listed on page 72 of this report.

The data received have been used in the individual chapters of this report, marked as "Data from the 2015 survey".

Changes in infection risk

By Atle Lillehaug, Helga R. Høgåsen and Brit Hjeltnes

This chapter looks at changes in operating conditions in the aquaculture industry in 2015 that could have implications for fish health and the spread of infectious diseases in farmed fish in Norway, primarily in salmon. In previous years, the evolution of important infectious diseases was discussed in a chapter that covers risk, such as this one. In the future, changes will be described in the context of each individual disease, while the health status of wild salmon will be dealt with in a separate chapter.

Changes in production conditions and the implementation of new technology, as well as development of regulatory framework, also lead to changes in the disease situation. Production volume figures, fish biomass and the number of production units can all contribute to a general picture of the risk of exchanges and spread of infections.

Infection pressure and biomass

If an infection enters a fish population, its spread between individual fish increases in line with fish density and the total number of fish. This is true of both wild populations and in farmed stocks. Where aquaculture is concerned, the number of sites or production units and their physical closeness are also important. The aquaculture situation facilitates spread of infections, because a large number of fish are held within a limited volume of water. The dissemination of infection will depend on how diseases develop, and the number of sick and infected fish within a farm site.

Similarly, the overall potential for spread of infections in a given region will depend on the number of sites, the amount of biomass they hold, the proportion of sick or infected fish, and the distance between sites that are capable of affecting each other via current flow and water contact. Increasing the distance between sites that could affect each other can reduce the risk of spreading infections. This effect can be exploited by introducing aquaculture-free “firebreaks” that consist of a stretch of sea between aquaculture-intensive areas that is large enough to reduce the risk of water-borne spread of infections between zones to a minimum. Hustadvika on the coast of the County of Møre og Romsdal is perhaps the most important fire-break or physical infection barrier for farming salmonids in the sea.

In areas where there are high densities of fish farms, it is important to coordinate the operation of sites that are potential sources of mutual infectious contact. This applies to coordinated releases and harvesting of fish, and in particular to the fallowing of large areas. It is also necessary to plan and systematically monitor health and infection status, as well to be aware of risk factors related to the introduction of infections and their spread.

For several decades, until 2012, salmon production rose by between 10 and 20 percent a year. In the course of the past few years, production has stabilised, a trend that has continued in 2015 (interim production figures, Table 1.2). Reported biomass at the end of 2015, together with interim figures for releases of smolts and fry, suggest that production will continue at the same level next year. The number of hatcheries has fallen slightly in recent years, while on-growing sites have stabilised at just under 1000 for the country as a whole.

Production of rainbow trout has also been stable during the past few years, while cod farming has fallen dramatically. Other marine species, (halibut, turbot, arctic char) are fairly stable in terms of biomass; around 2300 tonnes were reported in 2015 (interim figures from Kontali Analyse), as against 1750 tonnes in 2014. There has been a significant rise in releases of both wild and cultivated cleaner fish from one year to the next. This is an indication that the aquaculture industry is laying great stress on controlling salmon lice by means of non-pharmaceutical based methods. In 2014, almost 25 million individual cleaner fish were released. The production and keeping of these species of fish bring their own health and welfare problems, which will need to be addressed.

Losses are defined as fish that are lost in the course of production from release until harvesting. The concept covers mortality due to disease, handling, losses to predation, escapes, harvesting rejects and unregistered losses. Infectious diseases are among the most important biological and economic loss factors. Total losses for the whole of the salmon farming industry are high. After remaining at more than 20 percent during the marine phase for many years, they displayed a more positive turn in 2012 and 2013, with annual losses of salmon at around 13 – 14 percent (as measured against the number of fish released in the course of the same year). The past two years have unfortunately shown a trend towards higher rates of losses once again. It is believed that mortalities in connection with bath treatments for salmon lice infections and amoebic gill disease have played a significant role in the increase. Rates of losses in aquaculture are an indicator of fish welfare and an indirect indicator of fish health. Mortality in the wake of physical and other types of handling should be regarded as a serious welfare problem. It should be a definite aim to reduce losses to well below current levels.

Spread of disease through transfers of live fish

Transfers of live material, including both smolt and fish for slaughter, are regarded as one of the most serious risk factors for spreading disease. Even though smolts are generally regarded as being free of important agents of infection when they come from the fresh water farm, a population may be infected without this having been noticed. Infections may be introduced at the hatchery; for example, adding seawater may expose the fish to agents that are usually regarded as “marine”. Infections can also be introduced during transport by well-boats. Transferring fish over long distances happens when smolt are produced in one area and set out in another, and when fish for harvesting are being transported to large central slaughtering facilities.

Smolt production figures by individual counties, when compared with the number set out, can act as an indication of the amount of smolt transported across county borders (Table 1.3). Figures for 2015 are not yet available, but in 2014, the total number of smolt released in Northern Norway was 13 million greater than the region’s own production, compared to 14 and 15 million in the two previous years. A gradual increase in self-sufficiency in smolt is therefore taking place in the region, and the need for net imports is falling slowly. In mid-Norway (i.e. the counties of Trøndelag and Møre og Romsdal), the situation

Table 1.2 Production data for farmed fish. Figures supplied by the Directorate of Fisheries

	2011	2012	2013	2014	2015*
Number of sites					
Salmonids, licences, smolt	247	235	230	222	214
Salmonids, licences, ongrowing fish	990	963	959	973	974
Marine fish, number of marine sites	163	122	110	105	79
Biomass at end of year, tonnes					
Salmon	682 000	709 000	726 000	761 000	706 000
Rainbow trout	43 000	43 000	42 000	43 000	47 000
Harvest in tonnes					
Salmon	1 065 000	1 232 000	1 168 000	1 272 900	1 233 952
Rainbow trout	58 000	75 000	71 000	69 000	79 000
Number of fry released, millions					
Salmon	265	252	270	281	287
Rainbow trout	19,1	17,4	18	19,1	15,7
Cleaner fish	10,6	13,9	16,2	24,5	
Losses during marine phase, millions					
Salmon	51	38	41	44	46
Rainbow trout	2,5	3,3	3,1	3,1	3,8
Percentage of losses **					
Salmon	18	14	13	17	16
Rainbow trout	12	17	15	19	24

*Interim figures, Norwegian Directorate of Fisheries, January 2016
**Percentage of fish lost during production, from release into sea until harvesting, as percentage of number released in same year

is reversed, with a figure for smolt production that is 24 million higher than releases in 2014, which itself was an increase from 21 million in 2013. The total excess production of smolt in the other three Western Norwegian counties was less than 2 million.

Well-boats are virtually the only means of transport used for live fish. Infectious agents may be released to the environment on the transport route when a boat sails with its water intake open. Fish being transported may be exposed to infection as a result of intake of untreated water. This is how infections can be spread to distant areas, particularly with long smolt transports. Well-boats should follow their own special routes and avoid areas with farms that contain infected fish. Fish destined for harvesting may also be transported over long distances. In such cases, exposure of farms along the route is a critical factor, due to discharge of potentially infected water from the well-boat. Infections can also be spread at or in the vicinity of harvesting stations, particularly when fish are kept in harvest sea-cages for some time before they are slaughtered.

Developments in wellboat technology include improvements that make it possible to reduce the risk of spread of disease during transport. New boats are designed to enable efficient cleaning and disinfection to be carried out after each transport. They also carry water purification and oxygenation systems that enable the whole or parts of a transport to be carried out with intakes and outlets closed, i.e. without taking in or discharging water. Fish transports are regulated in the "Regulations for transport of aquaculture animals". These regulations have been updated since the turn of the year. Requirements regarding technical equipment for the disinfection of transportation water and to enable boats to be tracked and to register when water intakes have been open are now included. The changes that apply to tracking and registration will come into effect in 2016, and in 2021 for water disinfection, so that the necessary technology can be put in place first. The requirements are likely to have implications for newbuildings and for upgrades in the existing fleet before the new regulations come into effect.

The development of official regulations, in addition to technical innovations that will permit more efficient cleaning and disinfection of boats to take place, and reduce the risk of infection of and by fish during transport, will help to significantly reduce the release and spread of infectious agents from well-boat transports. There also appears to be an ongoing change in attitudes and practice within the industry, in that well-boats are becoming more and more specialised, both with respect to how they are used (smolt as against fish for harvest), and through limits on their geographical area of activity.

Table 1.3 Production and releases of smolt (million individuals) by county, with an estimated index of relative numbers of smolt produced and released at county level. Figures from the Norwegian Directorate of Fisheries.

County	2011	2012			2013			2014			2015*		
	Smolt prod	Smolt set out	Indeks	Smolt prod	Smolt set out	Indeks	Smolt prod	Smolt set out	Indeks	Smolt prod	Smolt set out	Indeks	Smolt set out
Finnmark og Troms	21,3	52,8	0,4	24,6	57,3	0,43	23,9	56,1	0,43	26,5	60,4	0,44	65,9
Nordland	64,2	48,8	1,32	65,6	47,8	1,37	72,8	54,9	1,33	78,7	57,8	1,36	56,5
Nord-Trøndelag	34,8	19,1	1,82	31,9	27,6	1,16	38,1	20,9	1,82	36,2	25,9	1,4	18,6
Sør-Trøndelag	26,7	44	0,61	24,5	23,4	1,05	27,1	53,9	0,5	32,4	16,1	2,01	48,5
Møre og Romsdal	41	25,4	1,61	46	37,8	1,22	44,7	14,1	3,2	44,6	47,2	0,94	12,8
Sogn og Fjordane	23	21,6	1,06	17,3	22,5	0,77	14,5	22,9	0,63	15,1	23,8	0,63	21,1
Hordaland	57,7	47,2	1,21	57,6	40,5	1,42	54,3	46,6	1,17	57,4	41	1,4	41,2
Rogaland	15,6	18	0,87	13,6	19	0,72	15,6	19,1	0,82	13,2	19,1	0,69	22,5
Sum	284,3	276,9		281,1	275,9		291	288,5		304,3	291,3		287,1

* Interim figures, Norwegian Directorate of Fisheries, January 2016

The health situation under new technologies for fish farming

In Norway, salmonids have traditionally been farmed in flow-through freshwater tanks and open net-pens in the sea. During the past few years, a number of recirculation aquaculture systems (RAS) for smolt production have been built. In 2013, there were 23 RAS in Norway. This number rose to 70 in 2015, and several more are being planned. There is every reason to believe that this trend will continue. RAS are a well-known technology, and in the Faeroes they have been the preferred technology for many years. In RAS, the water is cleansed by means of biological filters, and little or no water needs to be replaced. When operated correctly, RAS can provide a more stable aqueous environment than flow-through systems, and in consequence, improved fish health.

Recent production data from large RAS installations have provided evidence of good survival and growth rates of fish after transfer to seawater. Essential prerequisites for this include good technological insight and monitoring of important quality water parameters, such as oxygen content, carbon dioxide concentration and nitrites. Adequate water volume relative to maximum biomass is essential. The most important risk factors for recirculation in freshwater are high nitrite levels, total gas supersaturation, and the addition and insufficient removal of particles from the water. The bio filter can be particularly sensitive during the start up-phase, before the microorganism cultures have stabilised.

In order to cut down production time in traditional open sea-pens, land-based seawater RAS for "large smolts" – up to 1 kg - have been installed, while more are in planning. High carbon dioxide levels can be a greater problem in seawater recirculation systems than they are in fresh-water. One well-known production problem is early sexual maturation.

In all types of RAS, it is important to maintain good control of intakes of biological material and water. Infectious diseases that enter the system may result in high mortalities. In Norway, there have been cases of yersiniosis, caused by *Yersinia ruckeri*, as well as outbreaks of infectious salmon anaemia (ISA) in a RAS installation. Sea transfer of such smolt has led to disease spread to several on-growing fish sites. In Danish salmon farms, outbreaks of classical furunculosis have resulted in serious losses. Since we have only limited experience of seawater recirculation and salmon, we must allow for the possibility that new health problems will arise in connection with this form of operation. It is particularly likely that bacterial ulcer infections could become a problem. Via the questionnaire, the fish health services have identified this as a challenge.

A shorter production period in seawater, resulting from releases of larger fish into traditional open net-pens, could help to reduce the risk of infections during the sea phase, by reducing the length of exposure. This also includes lice infections, and lower emissions of lice and fewer delousing treatments can be expected when larger smolts are released.

In addition to land-based RAS installations, a number of concepts for enclosed and semi-enclosed installations in the sea are under development or testing. What these concepts have in common is that they aim to protect the fish from infections, first and foremost salmon lice, after they have been released into the sea cages. At some sites, exploiting warmer deep water could improve growth. A number of encouraging results concerning salmon lice have been reported, and it has been shown that installations of this type can be operated with low mortality and good growth rates. Experience has been mixed as regards water quality and the stability of this technology. As winter ulcers during smolt production can present a challenge, it will be necessary to have good measurement parameters for fish health and welfare during this development phase.

What developments can we expect?

Salmon lice currently offer the most serious challenge to Norwegian salmon farming, and the development of drug resistance is the most difficult problem we need to deal with. The alternative, non-medicament-based treatments for lice are becoming more and more widely used. Some of these treatments involve relatively frequent handling of the fish, which can lead to stress and death. All other types of development of technology for the marine phase of salmon farming will have to meet the need for better control of salmon lice.

After the region of Nordmøre and Sør-Trøndelag was defined as endemic zone for pancreas disease (PD) SAV2, five cases of PD were identified further north in 2014. These have been dealt with by slaughter or moving of the fish south into the SAV2 zone. These measures appear to have been effective. In 2015 there was only a single case in Nord-Trøndelag, and this trend promises well for the possibility of keeping our four northernmost counties free of PD.

The trend towards a rise in the number of cases of ISA in Lofoten and Vesterålen during the past few years has led to intensified efforts to deal with such outbreaks. We can expect to see better integrated and more effective measures based on more intensive surveillance of infection and rapid slaughter of infected fish in control zones that will be set up in connection with new outbreaks.

International conditions - the threat picture - regulations

Of the notifiable diseases that do not currently occur in Norwegian aquaculture, viral haemorrhagic septicaemia (VHS) and infectious hematopoietic necrosis (IHN) present the most serious threats.

VHS is widespread in continental Europe, and it also occurs in Finland. Denmark has eradicated the disease from its freshwater populations of rainbow trout, and is now regarded as free of VHS. With our disease-free status, and the currently limited import of live material to Norway, the risk of importing VHS to this country is minor. However, the VHS virus is found in wild marine fish off the coast of Norway, and these probably represent a greater threat to farmed salmonids.

IHN is also widespread in continental Europe. The risk of introduction of this disease through imports of live material is about the same as that of VHS. The IHN virus is stable at both chilling and freezing temperatures. Growing global transport and trade of fish products that might carry the virus, increase the likelihood of introducing the virus along with such products.

The status of VHS and IHN in Northern Russia, including that country's border areas with Finland, is unclear.

Changes in the international notifiability of infectious diseases present in Norwegian aquaculture could affect national strategies for controlling and combatting them. PD was declared to be notifiable by the World Organisation for Animal Health (OIE) in 2014. Norway has set up a monitoring programme aimed at confirming the status of our four northernmost counties as being free of PD. This programme has been operating for two years, and Norway may seek status for these counties as PD-free if it is required to do so. Important export markets can make demands of Norwegian aquaculture, particularly regarding the infectious diseases that have been declared notifiable by the OIE. ISA and PD are currently the most important of these diseases. Countries that import products derived from Norwegian aquaculture may, on the basis of their own disease status and evaluations of risk, require documentation that confirms that the country or region of origin of these products is free of such diseases. This is particularly the case for trade in live material (eggs and smolt), but also for products intended for consumption. This emphasises the importance of prioritising efforts to keep the zone that stretches from Nord-Trøndelag to Finnmark free of PD. It is also extremely important that we deal rapidly and effectively with outbreaks of ISA, so that international confidence in the health status of the Norwegian salmon industry is not compromised.

Lack of knowledge and need for research

There is a need to produce new knowledge to provide a better foundation for the management of notifiable and other infectious diseases, and to continue to develop systems of operation and infrastructure for the aquaculture industry, which needs to be made more robust with regard to the introduction and spread of infectious diseases in general.

The following particularly important problems emphasise the need to:

- support technological development by evaluating the effects and consequences of controlling infections, fish health and fish welfare.
- strengthen biosecurity as a discipline, particularly with regard to more effective control of notifiable diseases such as ISA and PD.
- harmonise and improve the efficacy of control strategies in the event of outbreaks of infectious diseases such as ISA.
- develop good alternative strategies and methods for controlling salmon lice.
- map the causes of losses of fish in order to reduce these.
- develop science-based welfare protocols for the entire production chain, so that technology development is based on biological principles.

Fish welfare

By Cecilie Mejdell and Arve Nilsen

Most researchers believe that fish are capable of perceiving sensory stimuli and experiencing feelings such as fright, pain and discomfort. Fish are protected by the Animal Welfare Act along with other vertebrate species, decapods, octopus, squid and honeybees. The Act requires farmed fish, like other production animals, to be kept in an environment that provides good welfare for the whole span of their life, and that they are slaughtered in a way that is responsible in welfare terms. Detailed regulations are described in the Aquaculture Operations Regulations.

Fish health personnel and research institutions have a special responsibility to work for improved fish welfare, and by doing so to influence attitudes to fish in both the aquaculture industry itself and among the general public. Good health is a prerequisite for good welfare, and efforts dedicated to improving fish health are therefore also important for welfare. Diseases affect welfare in various ways, depending on which organs and functions are affected. Both the intensity and duration of pain and discomfort are of important in evaluations of animal welfare. A disease with a lengthy course may affect welfare more than one of short duration that has an identical, or even higher, mortality rate.

Welfare indicators

Since fish have physiological and behavioural needs that not only differ from those of terrestrial animals but also vary greatly between species (for example, salmon, halibut and lumpsuckers), there is a great need for knowledge about the welfare indicators that should be employed to assess the level of welfare in different species. It is important to be aware of the limits of what fish can tolerate of environmental factors such as water temperature and oxygen saturation, biomass density and feed. However, survival in itself is not a guarantee of good welfare. Although mortality is an important parameter of welfare, it needs to be supplemented by other indicators. These may include the incidence of malformations, disease, injuries (to fins, gills, eyes, skin) and the condition factor. Scoring systems that help to ensure that they are assessed consistently have been developed for many of these parameters.

Although a number of indicators of poor welfare are gradually emerging, good welfare is more than the absence of poor welfare. There is therefore a need for indicators of the positive side of the welfare scale. For this, we need better knowledge of the fishes' environmental preferences, rather than merely their tolerance thresholds. Better understanding of fish behaviour will be another central research topic in the future. The development of good methods and technology for monitoring fish behaviour, which could subsequently be incorporated in operational routines, can help to identify deviations earlier and thus enable actions aimed at ensuring fish welfare to be taken before it comes to harm.

Animal welfare describes the condition of the individual, that is, how the animal copes with its physical and social environment. Average values at farm or at sea-cage/tank level therefore need to be treated with caution when describing the welfare levels of a group of fish. We need to take the distribution of the values in the material into account, and keep a close eye on the "worst-off" individuals, the losers in the system.

The testing of new technology and methods for farming and handling fish is currently developing rapidly. Both paragraph 8 of the Animal Welfare Act and the paragraph 20 of the Aquaculture Operations Regulations require that equipment and methods should have been tested and found suitable, taking into account welfare, before they are brought into use. Much of the effort involved has concentrated on new technology (e.g. enclosed sea-cages) and delousing methods. This ought to stimulate a general increase in efforts to identify the most important welfare challenges currently faced by aquaculture, and to find the best methods of dealing with them.

Welfare challenges in production

There are fish welfare challenges to all stages of the production cycle. Mortality in newly released smolts is too high throughout the industry. However, the large differences between individual fish-farms regarding losses show that the potential for reducing such losses is great. Among larger fish, the high mortality caused by repeated handling and salmon lice treatments is a serious concern. At all stages of the life cycle of farmed fish, operational, economic, technological and biological/welfare-oriented factors need to be weighed up against each other. The development of good, science-based welfare protocols that apply to the entire production chain ought to be prioritised.

Welfare challenges related to salmon lice

Preventing high rates of prevalence of lice is an important environmental goal for the aquaculture industry. In some farms, numbers of lice are so high that that they represent a direct welfare challenge to the farmed fish.

In many places, the treatment threshold of 0.5 female lice per fish, in combination with increased resistance to medication, has led to frequent delousing treatments. The treatment threshold has been set so low primarily in order to reduce the infection pressure on wild salmon rather than to prevent lice damage to farmed fish. Low prevalence of lice is only a minor problem as far as salmon welfare is concerned. Treatment, on the other hand, represents a major stress for the fish, not least if it has been affected or weakened by other infections. There have been reports of mortalities of more than 200 tonnes of large salmon in individual farms in connection with treatments of this sort. However, we lack sufficient oversight of the scope of the problem or its associated risk factors. Bath treatment using tarpaulins in sea-cages or on board well-boats involves situations (such as crowding and pumping) that lead to stress, not to mention physical injury and negative changes in water quality such as drops in oxygen saturation.

Due to growing problems of drug-resistant salmon lice, increased drug dosages, longer holding times and in many cases, combinations of different agents have been tried in order to obtain an adequate effect of treatment. Another factor is the significance of sea water temperature on the time of treatment and the health status of the fish. Handling or bath treatment of groups of fish with serious gill diseases such as amoebic gill disease (AGD) or viral diseases such as heart and skeletal muscle inflammation (HSMI) have been reported to result in high mortalities. When hydrogen peroxide is used, the acute mortality is often characterised by burn injuries to the skin, cornea and gills. Many fish subsequently suffer major skin injuries. When fish are overdosed with other agents, or suffer from low oxygen levels or acute stress, there will usually be few histopathological changes or other findings that can provide clear indications regarding the cause of death. Hot-water treatment has been evaluated as justifiable regarding welfare, but here too, injuries that are probably due to the treatment may occur.

Little knowledge is available regarding how the number of delousing treatments and the intervals between them affect fish. Once we add in other operating routines such as changing nets, transferring fish between sea-cages or sites, and moving smolts and harvest-ready fish by well-boats, there are reasons to believe that the tolerance threshold of fish is crossed at many farms.

The use of cleaner fish is a biological method of controlling salmon lice, but this is accompanied by its own welfare challenges. (See section on “Welfare challenges facing new species”.)

Welfare challenges during transport

Salmon are transported as smolt and as harvest-ready fish, while some are also sorted and moved during their growth period in the sea. These operations involve large numbers of individuals, large boats and advanced technology. We currently lack sufficient knowledge about how these operations are carried out and how they affect fish welfare. Carcass findings that lead to product downgrading or customer complaints may be indications that welfare has not been taken sufficiently into account. Generally speaking, it is important to produce robust, healthy smolts, and to develop gentler methods of production and handling. Fish stressed during transport to the slaughter plant reduces product quality.

Labrid fish (wrasse) present a special challenge. These are caught in large numbers by local coastal fishermen in the County of Østfold and in the region of Sørlandet, and sent to fish farms further to the west and north of the country. The handling and transportation conditions can be tough, with up to 40 percent mortality rates being reported. Even fish can become seasick.

Welfare challenges during slaughter

Slaughtering animals always involves a risk of unnecessary suffering, due to the handling (crowding, pumping, possible live chilling in RSW, time spent out of the water and bruises from equipment), effectiveness of stunning and sticking. Some methods of stunning, such as swim-in-tank before a machine delivers the percussive blow to the head, are based on the fishes' own motivation to swim out of the tank towards (before being stunned), and the fish need to be in vigour showing normal behaviour, not being exhausted from prior handling.

Permitted methods of stunning salmonids, i.e. electricity or percussive bolt stunning (or a combination of these) are effective as far as welfare is concerned as long as the systems are used and maintained correctly. Where methods of stunning that only cause a reversible loss of consciousness are employed, it is essential to bleed the fish correctly immediately after anaesthetisation. Cutting the gill arches on only one side results in slower bleeding than if the main artery (or both sides' gill arches) is cut. All automated systems require human control and backup systems.

Fish slaughter is largely automated. Minor improvements and close monitoring of welfare are of great importance for both overall fish welfare and product quality. Requirements regarding training of personnel contribute to awareness of animal welfare. Fish that have been stressed before slaughter enter rigor mortis more rapidly, and develop a stronger rigor, which reduces the potential for pre-rigor filleting, while the final pH of the fillet is higher, reducing its shelf-life.

Welfare challenges regarding feeds and feeding

Correct nutrition is essential for the normal development and growth of all species. Nutritional requirements change in the course of the life-cycle, and there may also be individual differences. Commercial feeds are adapted to the needs of the majority of fish, and seldom have wide safety margins when expensive ingredients are involved. Particularly where new species are concerned, we lack sufficient knowledge of nutritional requirements. Changes in the composition of feeds due to the price of raw materials or environmental considerations, e.g. vegetable-based feeds for salmon, may have side-effects on their health (e.g. digestive tract problems) and welfare, and these must therefore be followed closely in both the short and the long run.

Feeding methods influence fish welfare directly by affecting their behaviour (competitive situations that can lead to aggression). Fish are routinely fasted before transport and before mechanical handling, in order to empty the gut and slow down their metabolism, but our knowledge of how this food deprivation affects fish welfare is limited.

Welfare challenges for new species

The fish welfare field has largely focussed on farmed salmon. However, cleaner fish, i.e. labrids (wrasse) and lumpsuckers, are important components of the fight against sea lice in modern fish farms, and the capture, cultivation and use of cleaner fish also need to take place in a way that ensures good fish welfare. It is far from certain that this is the case in the fish farming industry today. The capture, cultivation and use of cleaner fish very often involves high mortality, and dead fish need to be replaced by new supplies in order to maintain adequate stocks in the sea-cages. Cleaner fish mortality rates are also high in connection with handling and salmon lice treatment. When salmon infected with gill amoebae are being treated with fresh-water, as a rule all the cleaner fish will die.

At the same time, our knowledge of and interest in the welfare and special needs of cleaner fish have greatly increased in the course of the past few years. Monitoring of capture and transport, the use of good shelter for the fish, and not least, feeding, of lumpsuckers in particular, have all helped to improve their welfare, increase survival rates and thus also their efficacy. But the fact that these fish have a limited “working life” in the fish-cages means that they are essentially a consumable resource. This in itself is a major challenge to welfare, and both the authorities and the industry itself need to contribute to finding better solutions. The capture of wild cleaner fish can often lead to injuries, and keeping wild fish in captivity presents a challenge to their welfare. Questions have also been raised regarding the effects of capture of large number of these species on cleaner fish stocks and the potential for transfer of infections. Regional farming of cleaner fish could help to ensure more stable quality, improve fish welfare and reduce the risk of transferring diseases between species and regions. Cleaner fish should also be vaccinated against the most important bacterial diseases (atypical furunculosis and vibriosis), which today are often responsible for high mortality after releases.

Although the general principles of welfare evaluations are similar, it is essential to be aware of the biology and needs of individual species. A lack of such knowledge often presents an important challenge. For example, we have a problem in identifying a good method of stunning halibut at slaughter.

Assessment of fish welfare in 2015

Fish farmers and their organisation take fish welfare seriously, and the interest among the general public in this topic is growing. There are challenges regarding animal welfare in all fields of animal production, not only fish farming, and we need to obtain a better overview of current routines and the scope of the problems to find the best interventions.

We need to work systematically on making improvements, such as on measures to reduce mortality after release into seawater. At the same time, extra efforts need to be made to deal with new challenges as these appear. Today, mortality and injuries in connection with salmon lice treatments present such a challenge, for which the relevance of the regulations also needs to be assessed. Throughout the production cycle, economic, technological and biological/welfare considerations are weighed up against each other. Priority should be given to the development of good science-based welfare protocols for the entire production chain, so that technological development can be based on biological premises.

Viral diseases in farmed salmonids

Table 1.4 provides a brief overview of the status in 2015. Each disease is described in more detail in the following sections. The figures for notifiable diseases are based on Norwegian Veterinary Institute data (see chapter "Introduction to the data…". Diagnoses made by private laboratories are not included in this table.

General evaluation of the status of viral diseases in 2015

Viral diseases characterise the health situation of farmed salmonids. Pancreas disease (PD) remains the most important viral disease of salmon, and the number of infected sites is much the same as in the previous year. Where infectious salmon anaemia (ISA) is concerned, the number of sites identified rose from 10 to 15, and the situation deteriorated into an epidemic in North Norway. A programme of coordinated site fallowing and extended health monitoring has been implemented, and an improvement in the situation is expected in the course of 2016. Where heart and skeletal muscle inflammation (HSMI) is concerned, it is difficult to be sure whether there is a clear change in the situation, but this disease may be growing in importance in hatcheries. For cardiomyopathy syndrome (CMS), figures from the Veterinary Institute and other laboratories indicate that the growth in the number of infected sites is continuing. A more detailed assessment is provided in the discussion of each disease.

Table 1.4 Incidence of viral diseases in farmed salmonids in 2011 – 2015. Figures for non-notifiable diseases are based on data from samples tested by the Norwegian Veterinary Institute.

	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
ISA	21	12	8	16	11	4	7	17	10	7	1	2	10	10	15
PD	15	14	22	43	45	58	98	108	75	88	89	137	99	142	137
HSMI				54	83	94	162	144	139	131	162	142	134	181	135
IPN		174	178	172	208	207	165	158	223	198	154	119	56	48	30
CMS				88	71	80	68	66	62	49	74	89	100	107	105

Pancreas disease (PD)

By Anne Berit Olsen and Torunn Taksdal

About the disease

Pancreas disease (PD) is a serious viral disease of salmonids in the seawater stage of aquaculture, caused by Salmonid alphavirus (SAV). The SAV3 subtype has been widespread in Western Norway for more than a decade, after the virus began to spread out from areas around Bergen in 2003 – 2004. Following an introduction of SAV2 marine, PD has spread rapidly in Mid-Norway since 2010. There are thus two epidemics of SAV. The SAV3 infections are limited to Western Norway, with nearly all cases in recent years occurring south of Stadt, while practically all cases of SAV2 have been registered in the counties of Møre og Romsdal and Sør-Trøndelag.

For more information about PD, go to: http://www.vetinst.no/nor/Faktabank/Pankreassykdom-PD/(language)/nor-NO

Combatting PD

PD is a notifiable disease (National list 3). Since 2014, infections of Salmonid alphavirus (SAV) have also been internationally notifiable to the World Organisation for Animal Health (OIE).

The most important reservoir of infection is already infected farmed fish. Intensified monitoring for early detection of infections, a focus on various conditions associated with transports of smolts and harvest-ready fish, aimed at preventing the spread of infections, and releasing smolts within large fallowed areas, are therefore attracting a great deal of attention. These are important preventive measures. The Norwegian Veterinary Institute is both an international (OIE) and national reference laboratory for PD.

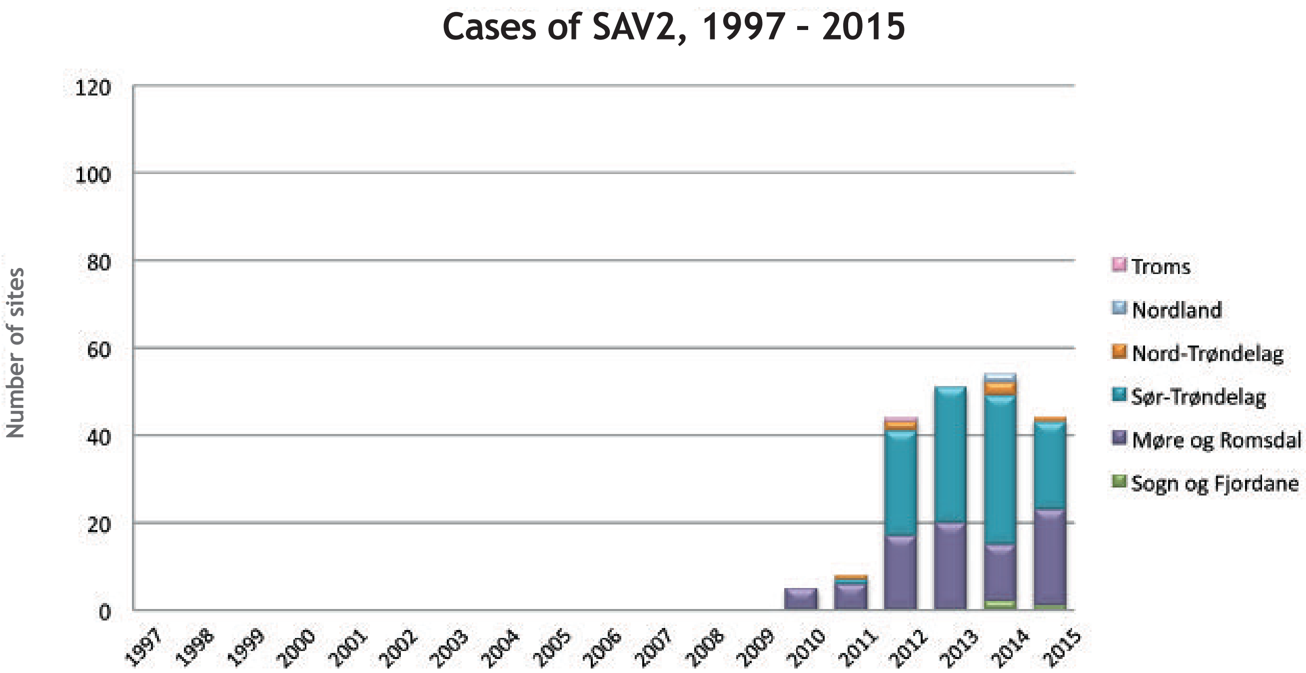
The Veterinary Institute collaborates with the Norwegian Food Safety Authority on daily map updates and monthly reporting of confirmations of PD on www.vetinst.no. Monitoring and countermeasures take place in accordance with regulations, on behalf of the industry itself and through routine health controls and disease diagnoses.

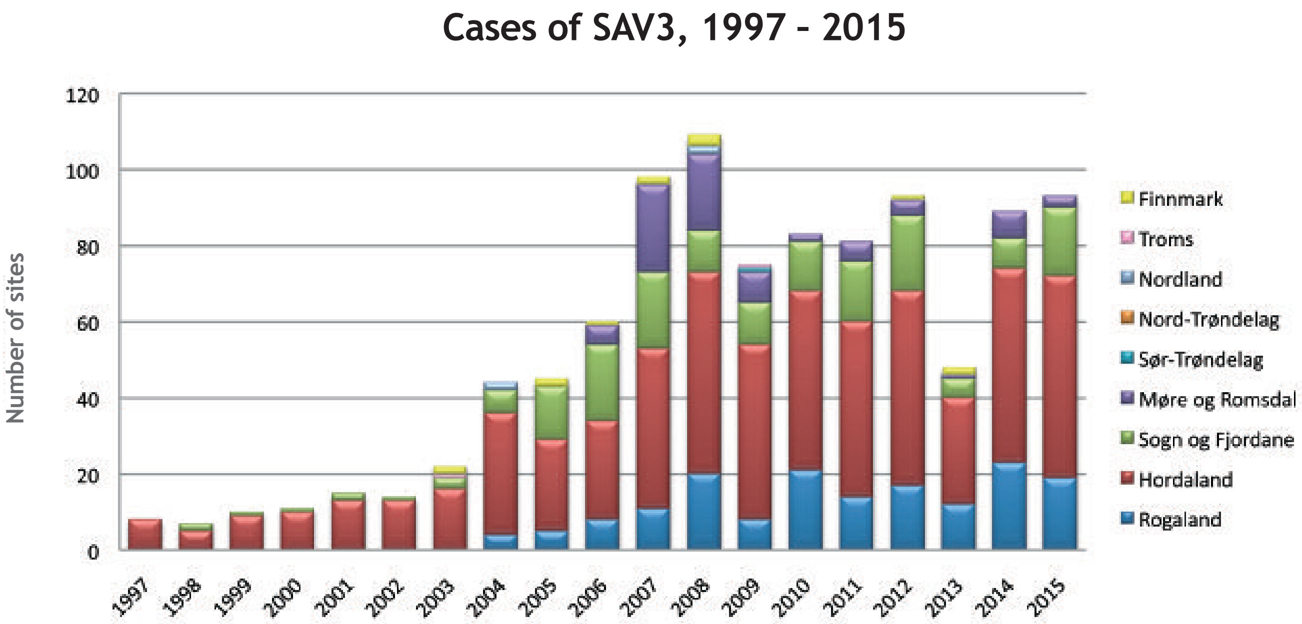
The situation in 2015

Official data

In 2015, a total of 137 new marine sites were identified as being infected by PD. The situation for PD with SAV3 in Western Norway was stable relative to the previous year, with 94 infected sites in 2015 as against 89 in 2014, while there was an 18 percent reduction in the SAV2 epidemic, from 54 sites to 44.

Figure 1.1 Distribution by county of number of new sites with infections of PD subtypes SAV2 and SAV3, 1997 – 2015





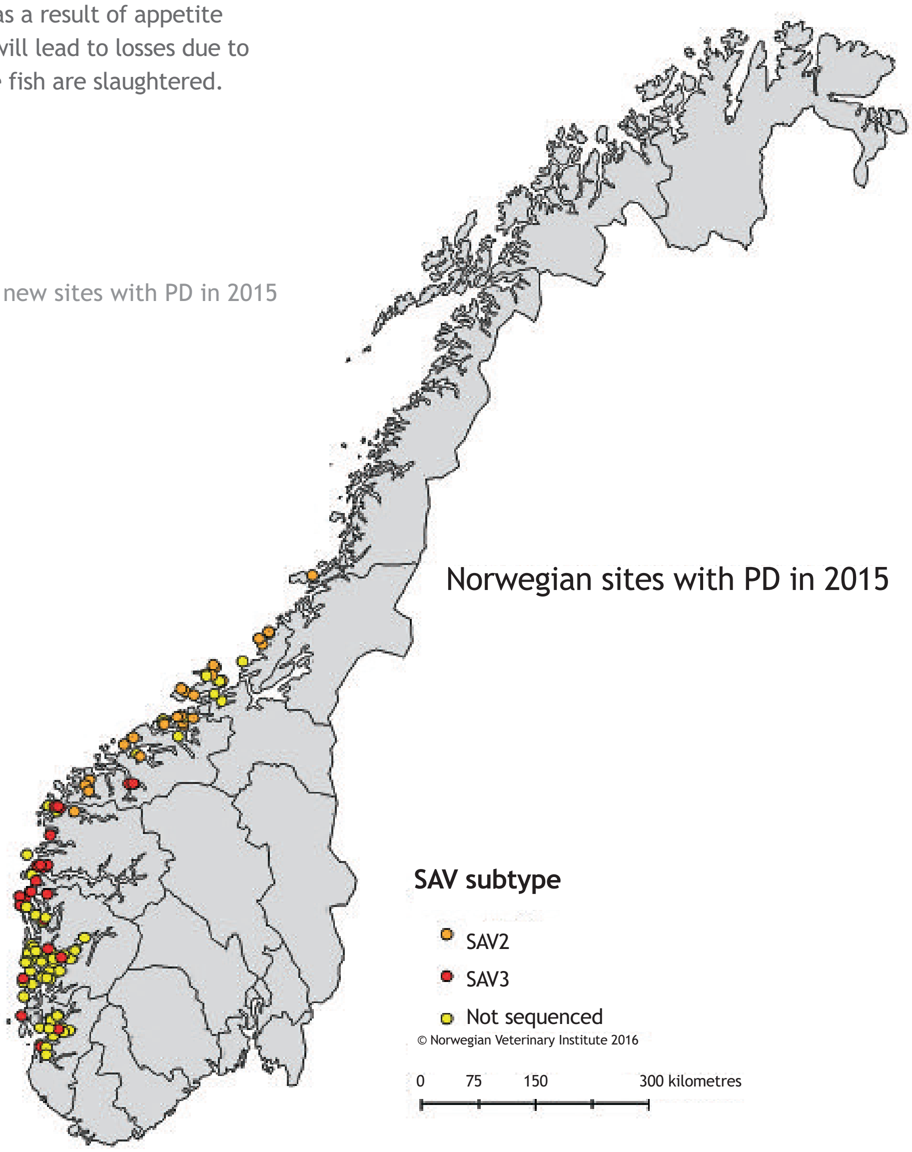
Most new outbreaks of PD in 2015 were in found in salmon. In 13 cases diagnosed by the Norwegian Veterinary Institute, the disease was identified in rainbow trout; all of these were SAV3. The corresponding figure for 2014 was 12; one of these was the first case of PD with SAV2 in rainbow trout.

PD occurs throughout the year. In 2015, cases of SAV3 in Western Norway reached a peak in new confirmations in the summer, as they have done for many years. PD with SAV2 is more frequently diagnosed in the autumn. Mortality due to PD with SAV3 varies, but is now usually moderate to low. Mortality caused by SAV2 infections is generally low, but such infections often lead to an increased feed factor and prolonged production time as a result of appetite failure. Both types of infection will lead to losses due to poorer product quality when the fish are slaughtered.

Data from the 2015 survey

In connection with this report, the Veterinary Institute In connection with this report, the Veterinary Institute carried out a questionnaire study among fish health services and Norwegian Food Safety Authority inspectors. This revealed that in 2015, PD was regarded as the most important disease of salmon in sea-cages by 40 per cent of those who characterised PD as being one of the five most important diseases of salmon. A further 20 per cent of the respondents placed PD in second place. For rainbow trout in sea-cages, the corresponding figures were 30 and 50 per cent respectively.

Figure 1.2 Map of new sites with PD in 2015



Evaluation of the PD situation

The high incidence of cases of PD represents a challenge to the industry, which states that the average direct cost of an outbreak of SAV3 is NOK 55.4 million, based on 2013 prices (outbreak occurring nine months after release into sea-cages at a site with 1 million smolts).

The efficacy of vaccination is still a matter of debate, and vaccination against PD has limited effects in comparison with vaccination against bacterial diseases such as furunculosis. However, vaccination against PD has been shown to have a certain effect, since the number of outbreaks is reduced and vaccinated fish may suffer lower mortality rates. Moreover, vaccination may reduce the transmission of the virus via infected fish.

In order to stimulate more research and spread more rapidly new knowledge about PD, a trinational programme (www.trination.org) has been set up, in which scientists, the aquaculture industry and the authorities in Ireland, Scotland and Norway meet regularly. The secretariat of trination.org is placed at the Norwegian Veterinary Institute.

PD is defined here as the identification of histopathological alterations in tissue that are characteristic of PD, and the demonstration of SAV in the same fish demonstrate PD). In some cases, the diagnostic studies result in a well-founded suspicion of PD. The most frequent reason for suspicion of PD is that the histopathological findings are typical of PD, but there are no samples available for testing for virus. In some SAV2 cases, demonstration of the virus by means of PCR is the only basis for the suspicion of PD. In the statistics, the figures for confirmed and suspected cases (few of the latter) have been combined.

SAV2

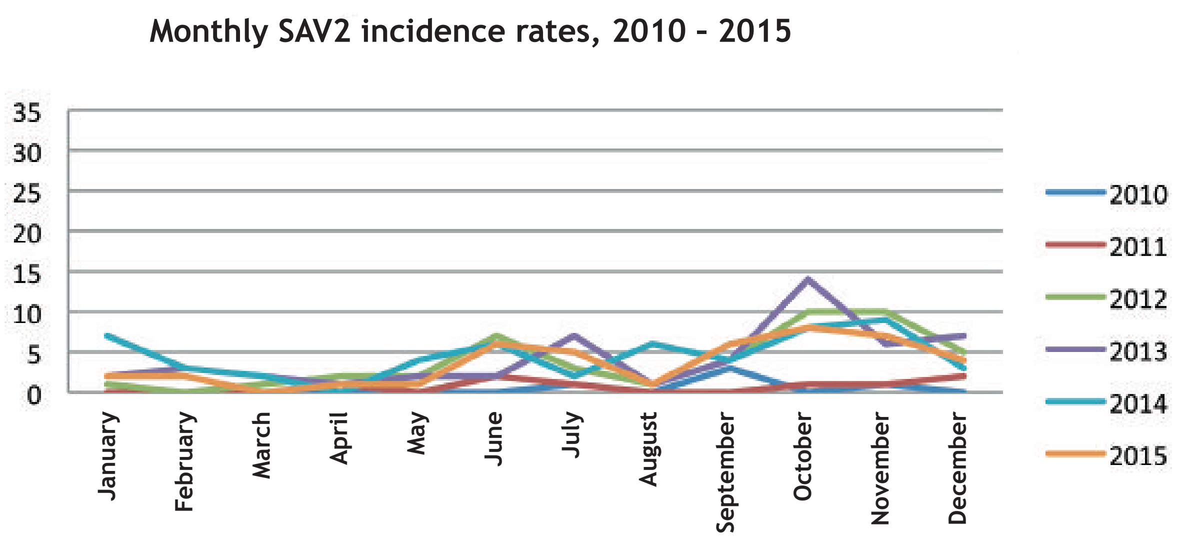
Because of the rapid spread of SAV2 infections north of Hustadvika on the coast of Møre in 2012, a special set of zonal regulations was drawn up (Regulation 2012-11-06, no. 1056). These came into force at the end of 2012. The area between Hustadvika in the County of Møre og Romsdal and the County of Nordland was divided into a control zone (bordering the County of Nord-Trøndelag) and an observation/buffer zone (Nord-Trøndelag to Nordland). Its main aim was to prevent PD from becoming established northwards along the coast.zx

The northernmost PD event in Norway in 2015 was in Nord-Trøndelag, in the municipality of Vikna, which lies outside the control zone but within the observation zone. The disease was confirmed in July, mortality was low and the fish at the farm involved were rapidly destroyed.

The 2012 SAV2 zone regulations had the further aim of controlling infections within the zone involved.

There was a fall in the total number of new SAV2-infected

Figure 1.3 Monthly SAV2 site incidence rates, 2010 – 2015.



sites registered in 2015 (54) compared to 2014 (44). The number of cases in Sør-Trøndelag fell from 34 in 2014 to 20 in 2015, while in Møre og Romsdal there was an increase from 13 to 22 (41 percent).

As in previous years, there was a local epidemic of SAV2 infections just to the south of the boundary of the zone at Hustadvika, when PD was either suspected or confirmed at three sites in Voldsfjorden/Dalsfjorden. In 2014, SAV2 PD was diagnosed for the first time south of Stadt and at two sites in Nordfjord in the County of Sogn og Fjordane. A neighbouring site was infected in early 2015. In May 2015, a separate regulation was promulgated for this area, in order to prevent the further spread of SAV2 and combat SAV2 within the area covered by the regulation. Since then, no further cases of SAV2 have been diagnosed in Nordfjord.

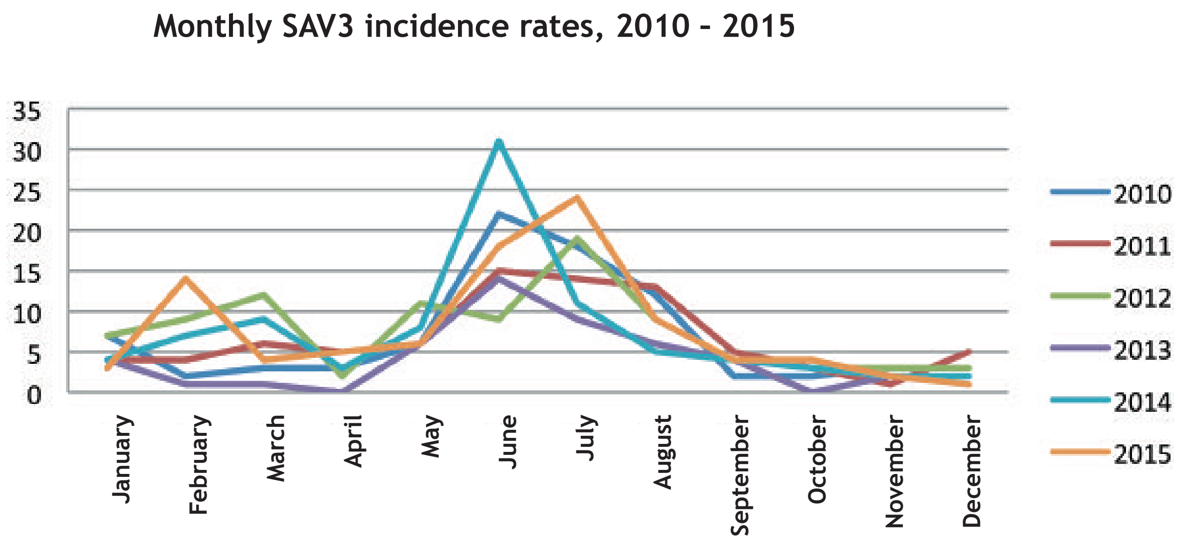
SAV3

As in 2014, virtually all cases of SAV3 infection occurred at sites south of Stadt. In Møre og Romsdal, south of the SAV3 zone boundary at Hustadvika (Regulation 2007-11-20, no. 1315), there remains only a local SAV3 epidemic in rainbow trout in Storfjorden. In Sogn og Fjordane, on the other hand, there were at least twice as many new cases in 2015 as in the two previous years; 18 in 2015 as against eight in 2014 and five in 2013. However, as in previous years, most outbreaks of PD occurred in the counties of Hordaland and Rogaland, making up about 77 percent of all cases of SAV3.

In both counties, the situation was stable in comparison with previous years.

The statistics on which these data are based count the number of new positive sites or new confirmations following a fallowing period. This means that the real number of infected sites in each year is much higher, given that infected fish from the previous year are still in the sea.

Figure 1.4 Monthly SAV3 site incidence rates, 2010 – 2015



Infectious salmon anaemia (ISA)

By Torfinn Moldal and Geir Bornø

About the disease

Infectious salmon anaemia (ISA) is a serious infectious disease of fish that is caused by an orthomyxovirus. In Norway, ISA first and foremost affects Atlantic salmon. The virus primarily attacks the blood vessels, and necropsy usually reveals skin and visceral bleeding. The disease eventually leads to serious blood loss (anaemia).

ISA can be characterised as a "smouldering fire", because a relatively small proportion of the fish in a particular farm are infected and the day to day mortality in sea-cages that contain sick fish is often low; typically, 0.05 – 0.1 percent. We can distinguish between low-virulence ISA (ISAV-HPR0) and high-virulence ISA (ISAV-HPR) on the basis of the composition of the amino acids in the hypervariable region (HPR) of the gene that codes for haemoagglutinin esterase. The presence of ISAV-HPR0 is taken to be a precursor of, and thus to make more likely, the development of ISAV-HPR.

For more information about ISA, go to:

http://www.vetinst.no/nor/Faktabank/Infeksioes-lakseanemi-ILA/(language)/nor-NO

On combatting ISA

ISA is a notifiable disease (National list 2), and has also been declared notifiable by the World Organisation for Animal Health (OIE). Outbreaks of ISA are followed by stringent measures. Usually, a control area that comprises a countermeasures zone and an observation zone surrounding the site of an outbreak is set up.

Control measures depend on whether or not the outbreak occurs within an ISA-free zone. After a period of two years without the occurrence of new cases, the Norwegian Food Safety Authority may cancel the zoning order. In autumn 2015, systematic monitoring was initiated in Salten, Lofoten, Vesterålen and Sør-Troms in order to enable new cases to be identified in their early stages.

The situation in 2015

Official data

In 2015, ISA was confirmed at 15 sites, which are five more than in the two previous years. Nine of these lie in Nordland, two in Troms, two in Møre og Romsdal, one in Finnmark and one in Hordaland. ISA was also identified at two sites which had already been diagnosed in 2014.

Assessment of the ISA situation

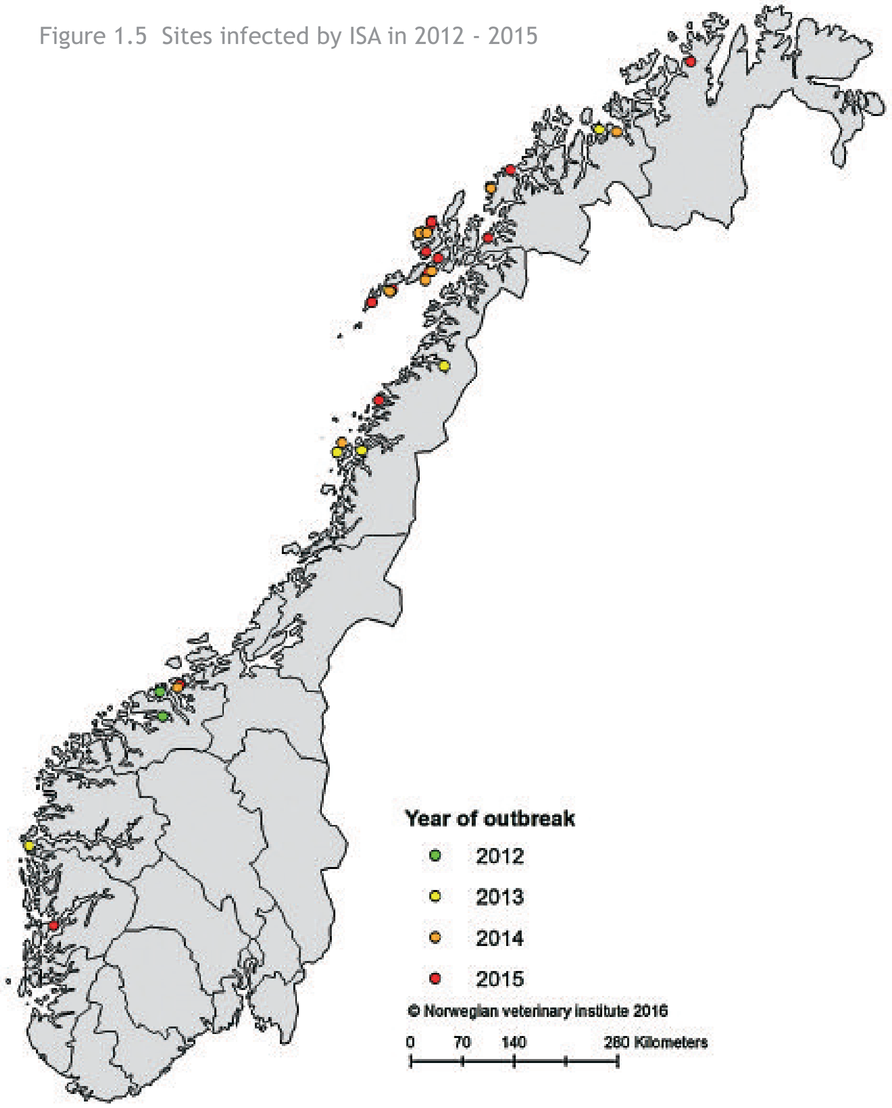
During the past few years there has been a significant increase in the number of outbreaks of ISA. This has continued in 2015, and particularly in Northern Norway, ISA has characterised the disease situation. The outbreak in Hordaland, one of the outbreaks in Vesterålen and an outbreak at a hatchery in Nordland are regarded as primary outbreaks.

One of the outbreaks in Møre og Romsdal is probably related to ISA outbreak at a nearby site in December 2014, while the other in the same county was attributed to its geographical closeness to the site at which ISA had been identified.

Four outbreaks at on-growing farms in Northern Norway could be linked to purchases of smolts from the hatchery where ISA had been identified. The hatchery lies in the shore zone, has a seawater inlet, and HPR0 has been identified. No findings have been made that link the infection to roe suppliers. The other outbreaks in Lofoten and Vesterålen were probably due infections from neighbouring fish farms. Kinship studies support earlier suspicions of unrelated epidemics in Lofoten and Vesterålen since since 2013. The situation has become more complicated in the course of the year, because virus strains that are almost identical to those that had been demonstrated at sites in Lofoten in 2013 and 2014 have also been found at sites in Vesterålen in 2015.

In 2015, the ISA virus was also identified in rainbow trout at two neighbouring sites in Lofoten. One of these sites also contained salmon that were diagnosed with ISA, while the other had contained salmon until just a few months before ISA was detected in the trout. Neither disease nor pathological changes that could be related to ISA in the rainbow trout were reported, but these findings underline the fact that rainbow trout are receptive to ISA and are capable of acting as reservoirs of the virus.

Figure 1.5 Sites infected by ISA in 2012 - 2015



Success in combatting ISA outbreaks and preventing their spread is based on identifying the disease at an early point in time and removing infected fish stocks as quickly as possible. In autumn 2015, a systematic monitoring programme was launched by the industry, the fish health services and the Norwegian Food Safety Authority. The programme covered all sites housing salmon and trout within defined zones surrounding ISA-positive sites in Salten, Lofoten, Vesterålen and Sør-Troms.

Infectious pancreatic necrosis (IPN)

By Torfinn Moldal and Geir Bornø

About the disease

Infectious pancreatic necrosis (IPN) is a viral disease that occurs first and foremost in connection with salmonid farming. The IPN virus belongs to the genus Aquabirnaviridae *in the family* Birnaviridae*, and is extremely widespread in Norwegian salmon and rainbow trout farms. The disease has caused very serious financial losses, and its mortality rates range from negligible to as high as 90 percent. Fry and post-smolts appear to be most vulnerable to the disease. Mortality also varies according to the strains of virus and of fish involved, as well as to environmental and operating conditions. A high proportion of individual fish that become infected by the IPN virus develop a life-long infection.*

For more information about IPN, go to: www.vetinst.no/faktbank/IPN

Combatting IPN

There is no official Norwegian programme for dealing with IPN. As far as the industry is concerned, measure to prevent this infection from entering hatcheries are vital. Fish that are more resistant to IPN are currently being bred. A genetic marker for IPN resistance has been identified, and this has made it possible to produce salmon roe that are extremely resistant to the disease. This type of roe is now widely used in Norway. Systematic extermination of "house strains" of the IPN virus has also had a positive effect. A large percentage of Norwegian salmon are now vaccinated against the IPN virus, but the efficacy of vaccination is still uncertain in comparison with other preventive measures.

The situation in 2015

Norwegian Veterinary Institute data

In 2015, IPN was identified at 30 sites that held salmonids, which is a significant reduction since 2014, when IPN was identified at 48 such sites (Figure 1.6). The drop is wholly due to less identification among salmon, given that the virus was found at 19 salmon farms in 2015, compared to 38 in 2014. The salmon outbreaks occurred at six hatcheries and 13 on-growing farms. IPN was demonstrated at 11 rainbow trout hatcheries in 2015, the same number as in 2014.

Data from the 2015 survey

Of the survey respondents who believe that IPN is among the five most important diseases that occur in hatcheries, only 17 percent regarded IPN as the most important disease in salmon hatcheries. This proportion remained the same, irrespective of whether the hatcheries were of the flow-through or the recirculating type. In rainbow trout hatcheries, the situation was the opposite, in that 86 percent regarded IPN as the most important disease. Ninety-seven percent said that QTL smolts that had a higher resistance to IPN were in widespread use in their area. IPN is not regarded as a serious problem in on-growing farms.

Figure 1.6 Number and type of sites infected by IPN between 1997 and 2015. Data based on samples analysed by the Norwegian Veterinary Institute.

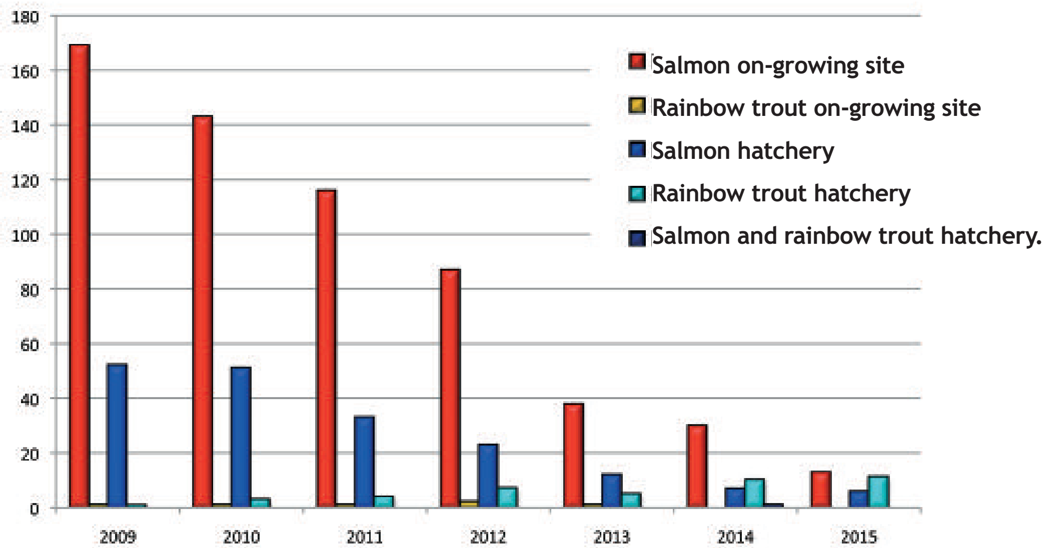
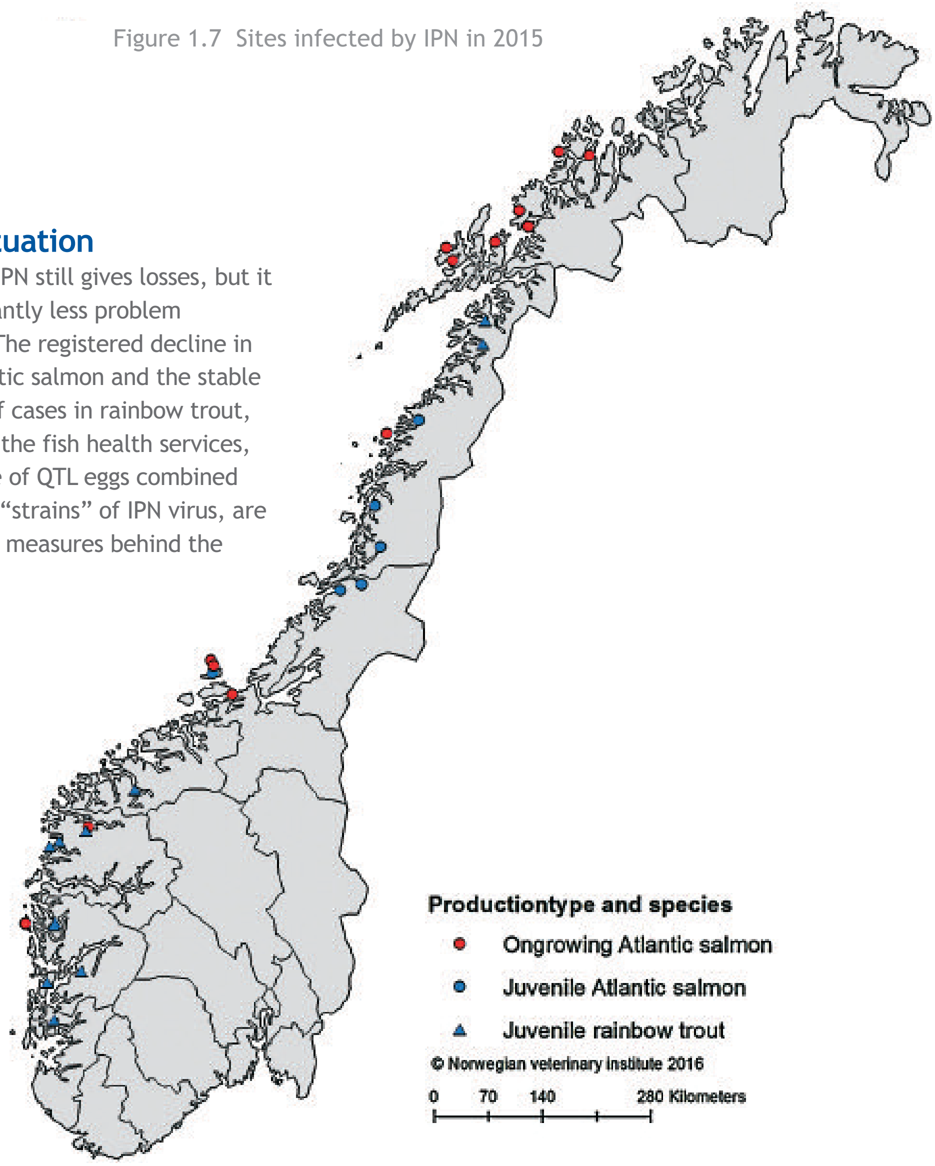


Figure 1.7 Sites infected by IPN in 2015



Assesment of the IPN situation

Fish health services reports that IPN still gives losses, but it is generally considered a significantly less problem nowadays than a few years ago. The registered decline in the number of outbreaks in Atlantic salmon and the stable situation regarding the number of cases in rainbow trout, coincides with the perception by the fish health services, according to the 2015 survey. Use of QTL eggs combined with greater efforts to eradicate "strains" of IPN virus, are probably the two most important measures behind the reduction of registered IPN outbreaks the recent years.

Heart and skeletal muscle inflammation (HSMI)

By Marta Alarcón, Maria Dahle and Torunn Taksdal

About the disease

Heart and skeletal muscle inflammation (HSMI) was identified for the first time at on-growing sites in Møre og Romsdal and Trøndelag in 1999. Today, HSMI is one of the most common infectious diseases of Norwegian farmed salmon. The disease is usually identified in salmon during their first year in seawater, and it can continue for a long time after it has been diagnosed. HSMI mortality rates vary greatly, and losses are often reported in connection with other diseases and when fish are being sorted, transported, treated for lice or during other stressful operations. Salmon that die of HSMI often suffer from significant circulatory problems. The heart is the first organ to be affected, and sparse to gradually more obvious lesions in the heart, and more particularly the epicardium, can be observed microscopically in the months preceding and during the appearance of clinical symptoms, by which time the fish are often suffering from inflammation of the skeletal musculature. Pathological changes in other organs, particularly the liver, may also be observed.

Piscine orthoreovirus (PRV) was identified in 2010 from the tissue of salmon affected with HSMI, and it has since been demonstrated via antibodies in heart and blood samples from infected fish. Controlled infection studies performed during the past five years have significantly reinforced this association. The virus is extremely widespread, and is found in both wild and farmed salmon. High concentrations of PRV in the heart are often related to the clinical disease, though PRV-infected fish do not inevitably develop HSMI. It is not clear whether this is due to genetic variants of PRV, not all of which may be pathogenic, or that other factors are required to trigger the disease in infected fish. Controlled infection experiments have demonstrated that PRV infects the red blood cells in salmon before the virus infects the heart, and a method of laboratory cultivation of PRV in salmon red blood cells has been established. It has been shown that the disease can be transmitted experimentally by injections of either tissue homogenates from HMSI-infected fish or PRV-rich blood cell lysates. It has also been shown that the disease is transmitted by way of water contact between infected and non-infected salmon. In 2015, it was reported that PRV is also associated with dark spots in fillets of farmed salmon (see chapter on "Dark spots on fish fillets").

For more information on HSMI, go to: www.vetinst.no/faktabank/HSMB

Combatting HSMI

There is no official Norwegian programme for dealing with HSMI. There is no treatment for this disease and no vaccines are available on the market, although a vaccine against PRV is under development. Avoiding operating routines that can stress the fish is one of the most important measures available to reduce mortality among fish that are already weakened by HMSI.

The situation in 2015

Norwegian Veterinary Institute data

In 2105, HSMI was demonstrated at 135 sites; 129 on-growing fish farms, three hatcheries, and three broodstock sites. These are fewer cases registered by the Veterinary Institute than in previous years (Figure 1.8).

Data from other laboratories

HSMI was identified at 52 sites by other laboratories in 2015. We do not know whether these observations wholly or partially overlap with those made by the Veterinary Institute.

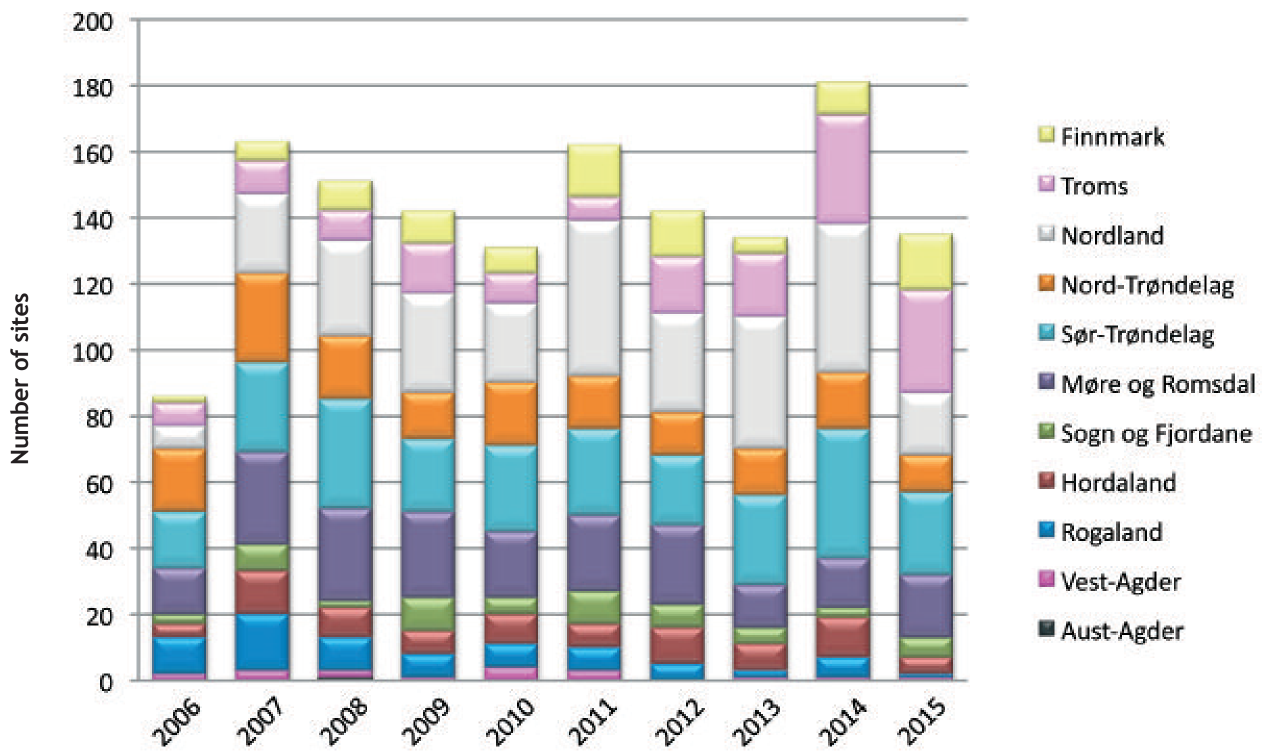
The 2015 survey

The questionnaire survey revealed that fish health service personnel and Norwegian Food Safety Authority inspectors regard HSMI as a significant problem in certain hatcheries. HMSI is ranked as the most important disease in on-growing farms by 20 percent of these respondents.

Assessment of the HSMI situation

The fact that fewer HSMI-positive sites were identified in 2015 than in earlier official statistics does not necessarily means that the situation has improved relative to previous years. One possible reason for the drop in incidence is that since mid-2014, HSMI is no longer a notifiable infectious disease. Diagnoses of HSMI have therefore not been included in the official statistics, which list 52 diagnosed cases. A possible factor here is that fewer samples have been received from North Norway since the fallowing in the wake of the ISA situation. All in all, this suggests that the HSMI situation is at least as serious as in the previous year.

Figure 1.8 County-wise distribution of annually registered sites with HSMI 2006–2015. Data based on samples analysed at the Norwegian Veterinary Institute.



Cardiomyopathy syndrome (CMS)

By Camilla Fritsvold

About the disease

Cardiomyopathy syndrome (CMS), also known as congestive cardiomyopathy, is a serious disease of the heart muscle that usually affects farmed salmon in the sea.

Phase of production

Because large harvest-ready fish are the most frequently affected, financial losses resulting from the disease can be considerable. A new trend in the course of the past few years has been that fish as small as 200 - 300 g die of CMS. In 2010, piscine myocarditis virus (PMCV) of the family Totiviridae *was identified as the cause of CMS. There appears to be a clear connection between the amount of virus and the seriousness of CMS disease. PMCV is a naked, double-stranded RNA virus with a relatively small unsegmented genome, which appears to encode only three or four proteins.*

The virus cannot be cultured in the most commonly availabe cell culture media. CMS transmits infection primarily via water. To date, no reservoirs of the virus other than salmon have been identified, nor are there signs of true vertical transmission as an important route of infection for this virus. Research aimed at elucidating whether transmission of the virus during stripping and fertilisation might play a role in the spread of infection is under way. All the Norwegian PMC virus isolates from salmon that have been investigated are very similar, and probably belong to a single genogroup.

About combatting CMS

Neither Norway nor the OIE list CMS as a notifiable disease, and there is no official Norwegian programme for dealing with CMS. When a fish farm is diagnosed with CMS, all types of handling that might stress the fish should be reduced to a minimum. At present no vaccines against CMS exist, but CMS-QTL smolts are available on the market.

The situation in 2015

Norwegian Veterinary Institute data

Of all the samples from sites received by the Norwegian Veterinary Institute for histopathological diagnosis in 20156, 105 were diagnosed as being infected by CMS (first identification of disease at a given site). This is about the same number as the previous year.

In the formalin-fixed material studied by the Veterinary Institute in 2015, Møre og Romsdal had clearly the most CMS diagnoses (24), followed by Sør-Trøndelag (17), Finnmark (14) and Sogn og Fjordane (13). Troms (8) had the greatest increase in 2015, with an increase of six cases compared to 2014, but the number of cases also increased in Finnmark, Hordaland and Sogn og Fjordane. In Sør-Trøndelag a clear drop in the number of diagnoses could be seen, but also Rogaland (8), Nord-Trøndelag (0) and Nordland (6) registered few cases compared to 2014. The Veterinary Institute found no cases of CMS in Aust-Agder or Nord-Trøndelag in 2015.

Data from other laboratories

In 2015, CMS was identified at 24 sites. We do not know whether these sites are in addition to those identified by the Veterinary Institute, or wholly or partly overlap with sites at which the Institute has identified CMS.

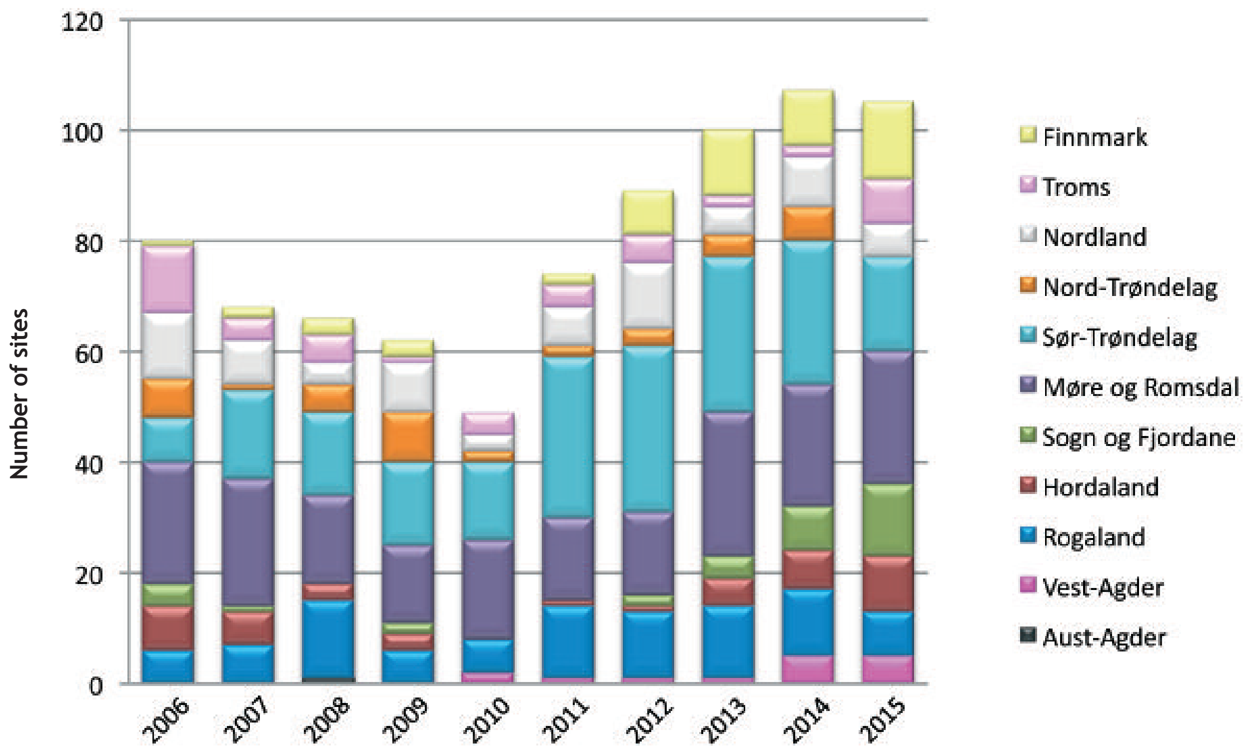
Data from the 2015 survey

Survey respondents regard CMS in salmon as a serious disease problem. Broodfish farms appear to suffer fewer problems with CMS than on-growing farms, although the syndrome does result in mortality and problems at these sites too. Such problems are often complex, in that CMS appears at the same time as, or soon after, one or both of the differential diagnoses HMSI and PD. For this reason, it can be difficult to deduce what proportion of the resulting mortality and reduced production is due to CMS alone.

Assessment of the CMS situation

The Veterinary Institute data show that the number of cases of CMS in 2015 is about the same as in 2014. This is probably lower than the actual number of sites at which CMS was diagnosed in 2015. This is due to the fact this disease in not notifiable, and the diagnosis can also be made by other histopathological laboratories. In 2015, other laboratories diagnosed CMS at 24 sites. The number of CMS cases diagnosed annually by the Veterinary Institute has more than doubled since the lowest figure in 2010.

Figure 1.9 Number of new sites at which CMS has been identified between 2006 and 2015. Data based on samples analysed by the Norwegian Veterinary Institute.



Viral haemorrhagic septicaemia (VHS)

By Torfinn Moldal

About the disease

Viral haemorrhagic septicaemia (VHS) is a viral disease that has been identified in some 80 wild and farmed fish species.The virus belongs to the genus Novirhabdovirus *in the* Rhabdoviridae *family, and outbreaks that lead to high mortality among farmed fish are primarily a problem in rainbow trout. The acute disease is characterised by high mortality, with exophthalmos, distended abdomen, bleeding and anaemia, while an abnormal swimming pattern characterised by corkscrewing and flashing has also been observed.*

For more information on VHS, go to: www.vetinst.no/faktabank/VHS

On combatting VHS

VHS is a notifiable disease in Norway (List 2 for non-exotic diseases). The Norwegian Food Safety Authority runs a risk-based monitoring programme that covers samples that have been submitted for diagnosis. Historical experience has shown that rapid slaughter of all the fish at an infected site (known as "stamping out") is the most effective way of controlling VHS outbreaks.

The situation in 2015

Official data

As in recent years, VHS has not been identified in Norway in 2015. The last case to be identified in the country was in rainbow trout in Storfjorden in 2007 – 2008.

Assessment of the VHS situation

Given the potential consequences of an outbreak of VHS, continuous monitoring of farmed fish in Norway is vital, as this is a prerequisite for the rapid removal of infected fish. The current monitoring programme is risk-based. Species in which the virus is most likely to be found are prioritised for study, in order to improve the likelihood of rapidly identifying the disease.

In 2012, genotype III of the VHS virus (VHSV) was demonstrated i several labrid species in Shetland fish farms, and sequencing analyses showed that that this was genetically very similar to VHSV that had been found in wild fish in the same area. This was also the same genotype as had been found in rainbow trout in Storfjorden in 2007. Kinship studies have revealed certain differences between virus strains that have been demonstrated in Scotland and in Norway. VHSV type Ib has been demonstrated in several wild-living species such as herring and haddock on the Norwegian coast, but the significance of the virus in wild fish is not known. VHSV has not been found in Norwegian waters. Findings of VHSV in labridae are another reason for concern in Norway, as we carry out large-scale transports of labrids from the coast of Southern Norway to as far north as Nordland.

In autumn 2015, VHSV genoetype IV was demonstrated in lumpsuckers (*Cyclopterus lumpus*) in Icelandic waters. At global level, the presence of VHSV type IVb in the Great Lakes in the USA supplies our most serious grounds for anxiety. This strain has resulted in high mortality rates in several species of wild freshwater fish and is gradually spreading to new areas. No other strains of VHSV have previously infected so many different fish species and produced such high mortality rates in wild fish.

VHS is a problem for freshwater farming of rainbow trout throughout Europe, but a Danish extermination programme has been successful. VHS has not been demonstrated in Denmark since 2009. There have been a number of recent outbreaks of VHS at marine rainbow trout sites on Finland's Åland Islands, but no outbreaks have been registered in recent years.

Infectious haematopoietic necrosis (IHN)

By Torfinn Moldal

About the disease

Infectious haematopoietic necrosis (IHN) is a viral disease that primarily affects salmonid species. Like the VHS virus, the IHN virus belongs to the genus Novirhabdovirus *in the* Rhabdoviridae *family. Fry are most liable to become infected, and outbreaks usually occur when temperatures are relatively low. The clinical picture is often characterised by exophthalmos, and necropsy reveals bleeding of internal organs, swollen kidneys, liquid in the abdominal cavity and destruction of haematopoietic tissue.*

For more information about IHN, go to: http://www.vetinst.no/Faktabank/Infeksioes-Hematopoetisk-Nekrose-IHN

On combatting IHN

IHN is a notifiable disease in Norway (List 2), which is dealt with by the slaughter of the entire fish population at sites where the disease has been identified ("stamping out"). Norway has a risk-based monitoring programme that covers samples that have been submitted for diagnosis.

The situation in 2015

Official data

IHN has never been demonstrated in Norway.

Assessment of the IHN situation

IHN was originally isolated from sockeye salmon (*Oncorhynchus nerka*) in Washington State in the USA in the 1950s. It has since been identified in several salmonid species, including Atlantic salmon and rainbow trout. IHN is endemic in the western USA and Canada from Alaska to California, and has spread to Japan, China, Korea and Iran, as well as several European countries, including Russia, Italy, France, Germany, Austria, Switzerland, Poland and The Netherlands.

Infection appears to be due largely to trade in infected eggs and fry of salmonids. However, the virus has also been demonstrated experimentally in marine species and by monitoring wild populations. These species may therefore act as reservoirs of the disease.

Salmon gill poxvirus disease (SGPVD)

By Mona Gjessing

About the disease

Salmon gill poxvirus disease (SGPVD) is a disease of the gills of Atlantic salmon. The specific changes that we observe in cases of SGPVD have been known in Norway since 1995. The disease is caused by a large DNA virus (salmon gill poxvirus) and in evolutionary terms it is the oldest known poxvirus that affects vertebrates. Histological study reveals highly characteristic apoptotic ("suicidal") epithelial cells in the gills, although in the chronic stages these may be difficult to identify. In such cases, the massive epithelial cell proliferation, which hinders respiration, may be dominant. Other manifestations of the disease may also be observed. Particularly during the seawater phase, the picture may be further complicated by the demonstration of other infectious agents. Poxvirus can affect the immune system of fish and thus clear the way for other infections.

For more information about SGPVD, go to:

http://www.vetinst.no/index.php/nor/Faktabank/Laksepox-Salmonid-gill-poxvirus-disease-SGPVD/(language)/nor-NO

On combatting SGPVD

No strategies for combatting SGPVD currently exist.

The situation in 2015

Norwegian Veterinary Institute data

In 2015, the Veterinary Institute confirmed the existence of SGPVD by histology and PCR at a total of 18 sites in several parts of the country (Figure 1.10), showing that this disease is more widespread than was previously believed. The confirmed diagnoses were largely in samples submitted by hatcheries, some of which used seawater circulation systems. SGPVD was also identified in three on-growing sites (Figure 1.10). There are also several sites where the virus is suspected, but it has proved impossible to confirm its presence due to a lack of gill material suitable for PCR. The disease may thus be underdiagnosed, and it is therefore important to include samples of gill material whenever there is a suspicion of SGPVD.

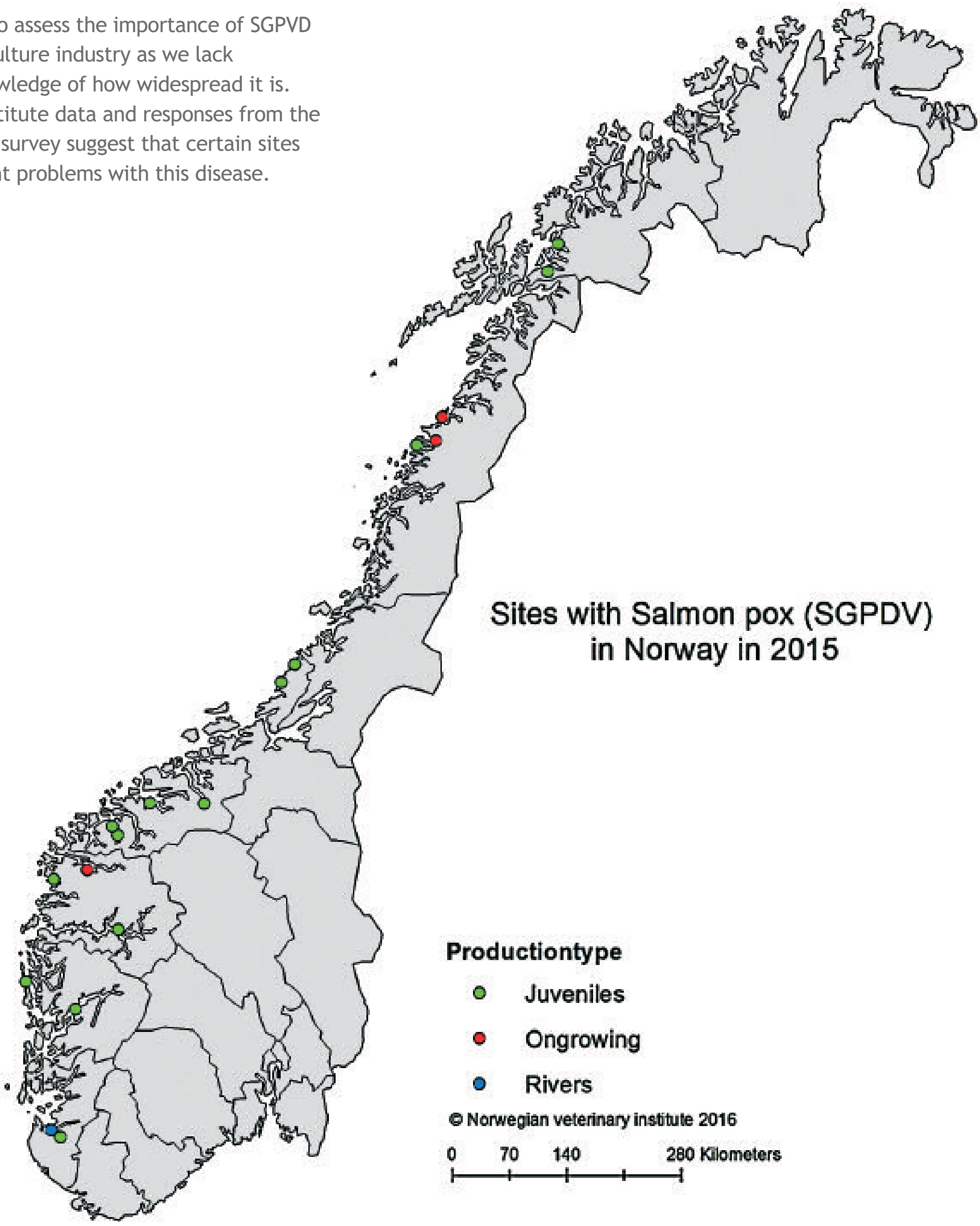
Data from the 2015 survey

Data from the questionnaire survey indicate that the importance of SGPVD is at about the same level as that of IPN.

Assessment of the SGPVD situation

It is difficult to assess the importance of SGPVD for the aquaculture industry as we lack sufficient knowledge of how widespread it is. Veterinary Institute data and responses from the questionnaire survey suggest that certain sites face significant problems with this disease.

Figure 1.10 Sites at which SGPVD has been identified in Norway in 2015.



Diseases of rainbow trout associated with virus Y

By Anne Berit Olsen and Anne-Gerd Gjevre

About the disease

Diseases of rainbow trout in freshwater associated with piscine orthoreo virus-like virus (virus Y) were demonstrated by the Veterinary Institute for the first time in 2013. Symptoms include reduced appetite and signs of circulatory failure, with exophthalmos and bloody fluid in the abdominal cavity. The gills and viscera may be pale as a result of anaemia. Histopathological findings include various degrees of inflammation of the heart and red musculature in addition to liver necrosis. Mortality rates vary, but may be high in individual tanks.

Mortality may also occur among salmon in the sea. The virus Y has been demonstrated within a period of up to 15 months after release into seawater. There are good grounds for believing that the cause of these diseases is a new virus, virus Y, that is closely related to, or is a strain of, piscine orthoreo virus (PRV), which is associated with heart and skeletal muscle inflammation (HSMI) in salmon.

"Virus Y" is a working name that is being used until an official name has been approved.

For more information about the disease and the virus, go to:

http://www.vetinst.no/eng/Factsheets/Virus-associated-disease-in-rainbow-trout-virus-Y

On combatting the disease

In 2016, the Norwegian Veterinary Institute, in collaboration with the Norwegian Food Safety Authority, instituted a monitoring programme to map the incidence of virus Y in rainbow trout and salmon in areas in which the virus had already been demonstrated.

Diagnoses are made by means of light microscopy of tissue samples and demonstrations of the virus using PCR, as developed by the Veterinary Institute. No treatments or vaccines against virus Y are available. General advice is that sick fish should be handled as little as possible.

The situation in 2015

Norwegian Veterinary Institute data

No new cases of virus Y disease were diagnosed in 2015. A national monitoring programme initiated by the Norwegian Food Safety Authority identified virus Y in 2015 at nine out of about 65 sites that held rainbow trout in the sea. The virus had not been previously identified at six of these sites, but all of them lay within areas in which the virus had previously been found (Western Norway and Mid-Norway).

Data from the 2015 survey

Relatively few of the respondents to the questionnaire mentioned virus Y as an important problem. Four of them ranked the importance of the disease or the virus in fourth place for rainbow trout in flow-through sites. For rainbow trout at ongrowing sites, six respondents ranked the disease or the virus between second and fifth in importance.

Assessment of the SGPVD situation

Between autumn 2013 and early 2014, the disease, which is characterised by circulatory failure, cardiac inflammation and anaemia on rainbow trout, was identified at four hatcheries. Virus Y was demonstrated in sick fish in all these hatcheries and in broodfish stocks that had supplied them with roe or fry. The virus was also identified at on-growing sites that stocked fish that had been supplied by infected hatcheries. In two cases, the fish developed the disease, with mortalities during their first four months in seawater of 5.5 and 2.5 percent. These losses also included some unspecified causes of mortality.

Infection studies have not observed clinical symptoms in fish that had been experimentally infected with virus Y, but cardiac inflammation has been observed in infected rainbow trout. Horizontal water-borne infection between water rainbow trout and salmon is known to take place. No experiments that have demonstrated transfer of infection between these species have been performed.

Bacterial diseases in farmed salmonids

The bacterial disease situation in Norwegian salmonid aquaculture varies from year to year. Unlike the cleaner fish situation (see chapter on “The health situation of cleaner fish”, below), the situation here can be generally regarded as relatively stable. The bacterial disease that gives most grounds for concern in salmon aquaculture is yersinosis, which continues to affect a growing number of sites.

Each disease and its causal agents are described in more detail in the following sections. The figures for notifiable diseases are based on official data, while those for non-notifiable diseases come from data gathered by the Veterinary Institute (see chapter on “Introduction to the data …” for more details). Diagnoses made by private laboratories are not included here.

General assessment of the 2015 status of bacterial diseases

Winter ulcers are still the most important bacterial disease problem. Diseases such as furunculosis and vibriosis, which used to be the cause of major losses in Norwegian aquaculture, are still well under control thanks to a large-scale vaccination programme. Coldwater vibriosis is now under control following a slight increase in 2012/2013. The number of cases of yersiniosis appears to be on the increase, particularly in large recirculating-water smolt production facilities. More detailed assessments are provided in the discussion of each agent involved.

Flavobacteriosis

By Hanne K. Nilsen

About the disease

The Flavobacterium psychrophilum *bacterium is the cause of flavobacteriosis in salmonids in fresh- and brackish water, and it has also been reported to be the cause of this disease in other species of fish. Rainbow trout (*Oncorhynchus mykiss*) are regarded as a particularly receptive species.* F. psychrophilum *produces sores and boils in salmonids. A number of different genotypes affect salmon and rainbow trout.*

For more information about the bacterium and the disease, go to www.vetinst.no/nor/Faktabank/Flavobacterium-psychrophilum

Combatting flavobacteriosis

Systemic infection of rainbow trout by F. psychrophilum is a notifiable disease (List 3).

The situation in 2015

Official data

In 2015, *F. psychrophilum* was demonstrated at three sites in Norway. At two of these sites, the disease was registered in adult rainbow trout that displayed sores and boils. Both of the genotypes found in rainbow trout in 2015 displayed reduced susceptibility to quinolone antibiotics.

Assessment of the flavobacteriosis situation

The two sites where *F. psychrophilum* was demonstrated in adult fish in 2015 lie in the same fjord system in which it has been found since 2008. Salinity was 25 – 32 thousandths at the time of these outbreaks, and the genotype identified (ST2) is the same as previously found in that area.

A *F. psychrophilum* infection was also identified in small fish held at an inland site, where a genotype (ST92) that had not previously been found in Norwegian rainbow trout, but which belongs to the same group of closely related strains as ST2, was identified.

Furunculosis

By Duncan Colquohoun

About the bacterium and the disease

Classical furunculosis is an infectious disease that may produce high mortality in salmonids in fresh- and seawater. Aeromonas salmonicida *belongs to the family* Aeromonadaceae. *Five sub-species of this bacterium have been described:* salmonicida, achromogenes, masoucida, pectinolytica *and* smithia. *Strains of* A. salmonicida *subsp.* salmonicida *are often described as typical or classical, while the others are described as atypical. Both A.* salmonicida *subsp.* salmonicida *and atypical strains are rigid rod-like bacteria with rounded ends.* A. salmonicida *subsp.* salmonicida *produces large quantities of a brown water-soluble pigment when it is cultured on media that contain tyrosine or phenylalanine. Atypical strains produce little or no pigment. A few strains of* A. salmonicida *subsp. salmonicida that do not produce pigment have been registered.*

The main route of transmission is believed to be horizontal, i.e. fish to fish. Outbreaks of furunculosis in Norway have largely been related to aquaculture in seawater and hatcheries that use unpurified seawater.

Furunculosis occurs in peracute, subacute and chronic forms. Its most frequent symptom in large fish is the presence of ulcers and boils (furuncles) on the skin. Outbreaks in hatcheries are often characterised by dark spots, extremely high respiration rate and moderate exophthalmos, and the fish may die rapidly without exhibitng any other external signs of disease. Obductions often reveal punctate petechial haemorrhage on the abdominal walls and viscera. Typical histological findings include bacterial microcolonies in gills, heart, adrenal glands and spleen. Cardiac failure would appear to be the most likely cause of death. Diagnosis is based on identification of typical clinical and histopathological findings, immunohistochemistry and bacterial culture.

For more information about classical furunculosis, go to: http://www.vetinst.no/Faktabank/Furunkulose klassisk

On combatting furunculosis

Classical furunculosis, an infection caused by A. salmonicida *subsp.* salmonicida, *is a notifiable disease in Norway (List 3, national diseases.*

The introduction of hygienic measures against infection and of vaccination programmes at the beginning of the 1990s led to the virtual eradication of this disease, which is currently under very good control thanks to vaccination, and only a few outbreaks are now being registered.

The situation in 2015

Official data

Furunculosis was not identified in farmed salmon in 2015, but was observed in wild salmon in two rivers in Nord-Trøndelag (see chapter on “The health situation of wild salmonids”). Infections of *A. salmonicida* subsp. *salmonicida* were also identified for the first time in farmed lumpsuckers in sea-cages (see chapter on “The health situation of cleaner fish”. The salmon with which the cleaner fish shared sea-cages, displayed no sign of the disease.

Bacterial kidney disease (BKD)

By Duncan Colquohoun

About the bacterium and the disease

Bacterial kidney disease (BKD) in salmonids is a serious notifiable disease in Norway (List 3, national diseases), caused by infection by Renibacterium salmoninarum. *The disease affects only salmonids.* R. salmoninarum *is a gram-positive, rigid, slow-growing bacterium that requires a special medium for cultivation (does not grow on blood agar).*

*BKD is a chronic disease, and bacteria can be transmitted across generations via infected roe (vertical transmission). In Norway, BKD was demonstrated for the first time by the Norwegian Veterinary Institute in 1980 among the offspring of wild broodstock salmon. Most outbreaks of BKD have taken place in Western Norway, where several rivers must be regarded as endemically infected. In recent years a number of outbreaks have also occurred in fish farms in Northern Norway, including some among fish imported from Iceland. Species known to be receptive include salmon and brown trout/seatrout (*Salmo *spp.), pacific salmon (*Oncorhynchus *spp.), rainbow trout (*Oncorhynchus *spp.), charr (*Salvelinus *spp.) and European grayling (*Thymallus thymallus*).*

Typical findings at obduction include anaemia and pale whitish nodes in swollen kidneys. These nodes can be quite large and may coalesce, but as the infection spreads to other organs we observe many small white nodes (<2 mm) which are most easily seen in dark organs like the spleen. Histopathological findings in BKD include different degrees of granulomatous inflammation and necroses, and immunohistochemistry can be used to demonstrate the bacterium in the lesions. For a potential first-time identification of BKD, suitable material must be obtained in order to confirm the diagnosis, for example by culturing the bacterium. This is most easily done by freezing tissue from lesions in the kidney and possibly other organs. Soft-textured necroses and nodes often contain large quantities of bacteria, while hard nodes or granulomas have an extremely variable bacterial content. Other tests include biopsies from kidney tissue and scrapes taken from lesions for the serological immunofluorescence antibody test (IFAT) or Gram Periodic acid-Schiff (PAS) assay. Another possibility is formalin-fixed fresh or frozen tissue from lesions in the kidney or other organs.

To identify BKD in broodfish, samples are taken from kidney or from milt or roe fluid, freshly chilled or frozen to check for the presence of the infectious agent by ELISA. Since BKD is a notifiable disease, in which countermeasures may have serious economic implications, the diagnosis must be confirmed by clinical symptoms of BKD and demonstration of infection by R. salmoninarum, *performed by at least two laboratories and based on different biological principles.*

For more information about BKD, go to: http://www.vetinst.no/Faktabank/Bakteriellnyresjuke-BKD

On combatting BKD

Since no effective medicines or vaccines against BKD exist, countermeasures consist in the first instance of avoiding infections and thereafter slaughter or extermination of infected stocks.

BKD was monitored between 2005 and 2011. Some 22,000 samples were analysed, but no positive results were found in the course of the monitoring programme.

The situation in 2015

Official data

BKD is currently found only sporadically in Norway, at a rate of zero to three cases a year. The disease was not diagnosed in Norway in 2015.

Cold-water vibriosis

By Duncan Colquohoun

About the bacterium and the disease

Vibrio salmonicida *(syn.* Allivibrio salmonicida*) is the cause of the disease known as cold-water vibriosis, which only occurs in the sea at low* water temperatures, e.g. 10 oC or less. V. salmonicida *is a facultative anaerobic Gram-negative rod bacterium that grows best at low temperatures (15 oC). It is a purely marine organism that requires the presence of salt in net-pens to grow. No zero-strains of the bacterium have been reported. V. salmonicida can be described as not very virulent, given that relatively high doses are needed for the disease to develop, although different isolates vary in their degree of virulence. The disease primarily affects salmon, but rainbow trout and to a much lesser degree, cod, can also become infected.*

Outbreaks of cold-water vibriosis typically start with a sequence of events in which the fish lose their appetite and appear to faint. Day-to-day mortality is usually low at first, but may increase in the course of time. Total mortality can be high if the outbreak is not dealt with. Typical external signs of the disease include pale gills and punctate skin lesions. The abdominal cavity may contain bloody fluid and bleeding of the swim bladder and fatty tissue. The liver is pale in colour, ranging from greyish brown to yellow.

Findings from obductions that include anaemia and a general tendency to bleed, in conjunction with discolouration of the liver, are indications of cold-water vibriosis, particularly if the outbreak occurs when water temperatures are low. The diagnosis is confirmed by bacterial culture and/or histochemical demonstration of the agent in sections taken from various organs (heart, spleen, kidney, liver).

For more information about cold-water vibriosis, go to: www.vetinst.no/nor/Faktabank/Kvv

Combatting cold-water vibriosis

An outbreak of cold-water vibriosis can be treated with antibiotics. Oxolinic acid, flumequine or florfenicol are currently the types most often used to treat the disease. Cold-water vibriosis is known to develop resistance rapidly, and antibiotics should therefore be administered with caution. Vaccines have been used with good results since the end of the 80s to treat cold-water vibriosis. The Aquaculture Operating Regulations require salmon to be vaccinated against cold-water vibriosis, among other diseases.

The situation in 2015

Norwegian Veterinary Institute data

No cases of cold-water vibriosis were identified in 2015.

For the past 25 years, cold-water vibriosis has been effectively under control thanks to vaccination. After a moderate rise in the number of cases in 2012/13, the situation stabilised again in 2014.

In the 1980s, cold-water vibriosis was regarded as the most serious disease problem for Norwegian aquaculture, and this led to extensive consumption of antibiotics, which peaked in 1987 when 200 outbreaks were registered (figures based on samples submitted to the Veterinary Institute.) At that point in time, vaccines against the disease began to be introduced, and for the past 15 years between zero and a very few cases per year have been identified. Between 2011 and 2013, however, there was an increase in the number of cases before the situation returned to its previous low level in 2014, when no cases were recorded.

The few cases of cold-water vibriosis in salmon during the past few years have mostly occurred among harvest-ready fish. The increase in the number of cases in these years has also affected smaller fish, which supports the notion that conditions related to vaccination status over time have contributed to this situation.

Winter ulcer disease

By Duncan Colquohoun and Anne Berit Olsen

About the disease

Winter ulcer disease is primarily caused by infection by Moritella viscosa *bacteria, although other bacteria such as* Tenacibaculum *spp. and* Allivibrio (Vibrio) wodanis *have been demonstrated in this connection.*

The presence of ulcers during the sea phase is a welfare problem that leads both to elevated mortality and poorer product quality when the fish are slaughtered. Ulcer development is a typical problem of the autumn and winter seasons, although it can occur at any time of the year.

On combatting winter ulcer disease

Winter ulcer disease is not a notifiable disease and no official statistics of its incidence are compiled. Nearly all Norwegian farmed salmon are vaccinated against M. viscosa*. It is important to avoid operating conditions that could encourage the development of ulcers.*

The situation in 2015

Norwegian Veterinary Institute data

Information from the fish health services and the Veterinary Institute's regional laboratories indicates that ulcers continued to be observed at various levels of intensity on farmed fish all along the coast of Norway in 2015. Once again, most of the identifications of M. viscosa were made in North Norway, and are presumably related to low water temperatures.

Assessment of the winter ulcer situation

Feedback from the field indicates that outbreaks of winter ulcer disease often have a connection with delousing treatments. Overall, the situation in the aquaculture appears to have been relatively stable during the past few years.

Ulcer "syndromes" assocated with salmon aquaculture in cold seawater can be divided into two main types, the more usual of which is "classical" winter ulcers, in which ulcers mostly appear on the flanks of the fish affected. Ulcers of this sort are most often caused by *M. viscosa*, which produces ulcers leading to death following experimental infections.

Other bacteria, such as *Tenacibaculum spp*. and *Allivibrio (Vibrio) wodanis*, are often observed together with *M. viscosa*. Almost all Norwegian farmed salmon are vaccinated against M. viscosa, which is relatively easy to identify in petri dish culture due to the typical viscosity of its colonies, and many cases are sufficiently well diagnosed in the field.

"Non-classical" winter ulcers are somewhat less common. This condition often results in high mortality and is particularly characterised by deep ulcers around the jaw ("mouth rot") and head, tail and fins. Cases of this type are primarily associated with *Tenacibaculum spp*. infections.

Salmon are most likely to develop ulcers in seawater, but rainbow trout can also be affected by classical winter ulcer disease. *Tenacibaculum spp*. bacteria can exacerbate small ulcers that were originally caused by physical injury, but are also capable of causing sores under experimental conditions, under high environmental concentrations of

Photo 1.1 Tenacibaculum infection in farmed salmon. Note the large number of erosions around the mouth and jaws. Photo: Trygve Poppe, Norwegian Veterinary Institute

these bacteria. They grow in yellow-coloured colonies on marine media, and are easy to recognise under direct-light microscopy as long thread-like rod bacteria. *Tenacibaculum* is naturally resistant to quinolones (oxolinic acid). *Tenacibaculum* bacteria isolated from ulcers in Norway display a certain range of genetic variation, which suggests that these are opportunistic bacteria from the local marine environment that attack when other conditions are suitable. It is therefore important to avoid operating conditions that favour the development of ulceration.

Yersiniosis

By Duncan Colquohoun

About the disease

Yersiniosis is caused by infection by the Yersinia ruckeri *bacterium. The disease can lead to mortality in several fish species, but internationally is largely known as a salmonid pathogen that primarily affects rainbow trout and Atlantic salmon. In Norway, the infection is exclusively encountered in salmon. Yersiniosis usually occurs during the fry phase; the infection follows the fish and can means losses after release into sea-cages even in fish that appeared to be healthy before release.*

For more information about yersiniosis, go to: www.vetinst.no/faktabank/yersinose

On combatting the disease

Many hatcheries vaccinate against yersiniosis, and in some cases, vaccination appears to be essential for their own survival.

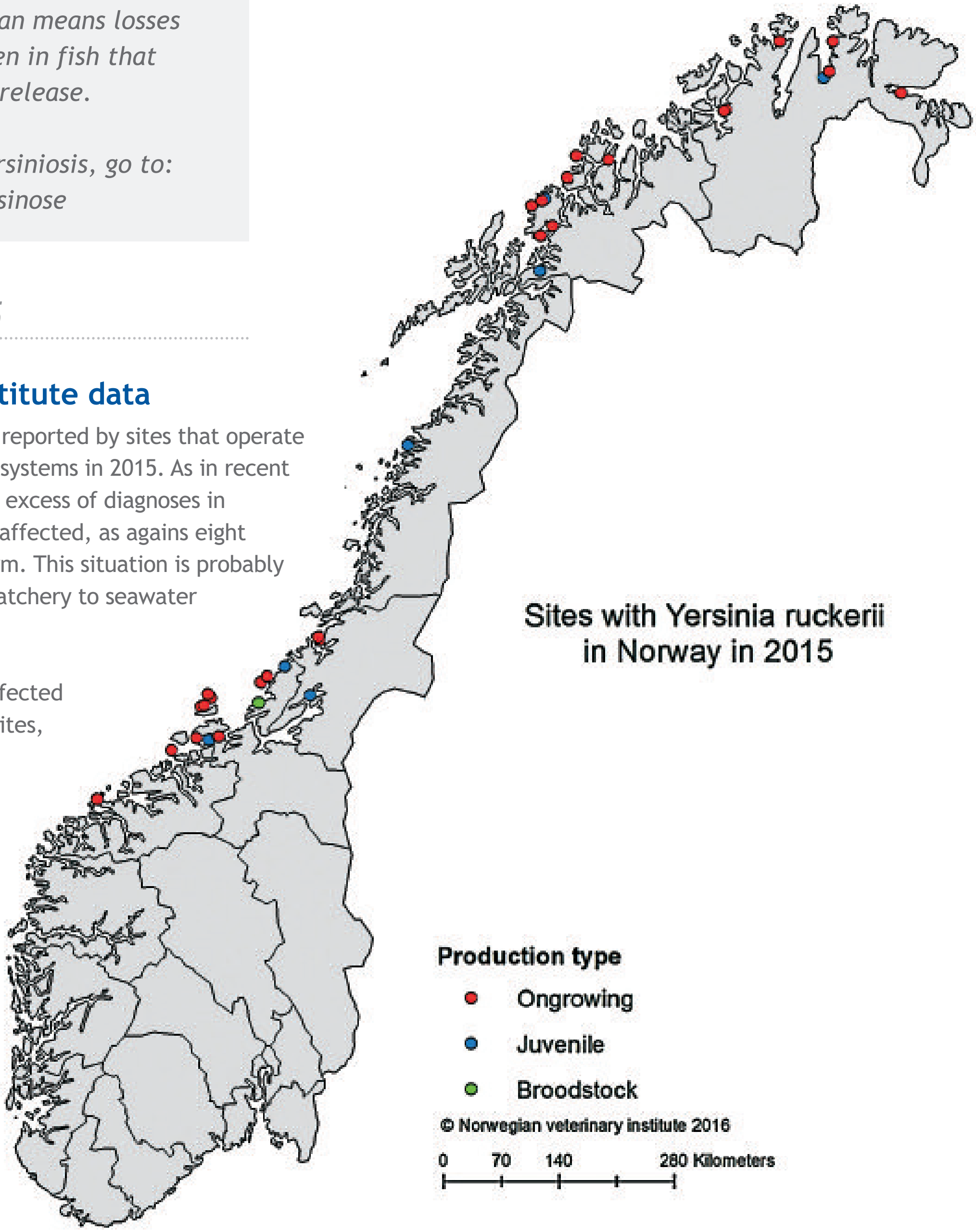
The situation in 2015

Norwegian Veterinary Institute data

Problems with yersiniosis have been reported by sites that operate both flow-through and recirculation systems in 2015. As in recent years, the 2015 situation displays an excess of diagnoses in seawater, with 25 on-growing farms affected, as agains eight hatcheries and a single broodfish farm. This situation is probably an indication of transmission from hatchery to seawater facilities.

With a total of 34 confirmed sites affected (and the suspicion of a further two sites, based on histological and immunohistochemical findings), the 2015 situation is a further deterioration from that in 2014 (27 sites) and 2013 (20) and 2012 (16). In cases where the bacterium has been serotyped, 21 cases of serotype O1 and two of O2 were identified. All of these diagnoses were made on samples from North and mid-Norway.

Figure 1.11 Norwegian sites infected by yersiniosis in 2015



Other bacterial infections in fish

By Duncan Colquohoun

Bacteria belonging to the genera Vibrio, Photobacterium, Alteromonas, Pseudoalteromonas, Psychrobacter, Polaribacter, *etc., are occasionally isolated from clinically sick fish in connection with investigations of disease. Even though these bacteria can occur in large amounts and from several fish in one and the same population, it can be difficult to directly link such findings with a particular disease. These are usually regarded as opportunistic bacteria that invade already weakened fish. This type of bacterial flora is continuously assessed with the aim of early identification of pathogenic strains.*

In 2015, Vibrio anguillarum *serotype O was not diagnosed in salmon, but at two sites holding rainbow trout.*

In 2015, various Pseudomonas *spp. were identified through diagnostic studies of samples from several salmon farms, but none of the identifications could be related to serious cases of disease in the fish population that were investigated.*

Atypical A. salmonicida *(atypical furunculosis) was identified in one salmon on-growing farm in 2015.*

Piscirickettsiosis, which is caused by Piscirickettsia salmonis, *was not identified in Norway in 2015. This bacterium is still an important source of disease and financial losses in Chilean aquaculture.*

Susceptibility to antibacterial drugs in salmonid aquaculture

By Duncan Colquohoun

Very small quantities of antibiotics are still being used in Norwegian salmonid farming. In certain cases, antibiotics have been used to treat Yersinia ruckeri *and* Tenacibaculum *spp. infections in salmon.*

Besides certain types of bacteria that exhibit “natural” reduced susceptibility to certain antibiotics, e.g. *Tenacibaculum* (oxolinic acid) and *Pseudomonas* (most antibiotics), reduced susceptibility to quinolone (oxolinic acid) antibiotics and flumequine has been identified in *Yersinia ruckeri* at one site in the course of the year. Such reduced susceptibility has previously been linked to chromosomal mutations in *Y. ruckeri*, and the risk of transmitting resistance to other bacteria is believed to be small. Reduced susceptibility to quinolone antibiotics is still being found in *Flavobacterium psychrophilum* isolated from sick rainbow trout in Norway.

Reduced susceptibility to quinolone antibiotics has once again been found in *Aeromonas salmonicida subsp. salmonicida* isolated from sick fish in rivers that empty into the Namsen fjord (see chapter on “The health situation of wild salmonids). The strain has been isolated from such fish in the same area for several years. The same bacterium has been identified in sick lumpsuckers kept in sea-cages in the same sea area (see chapter on “The health situation of cleaner fish“).

Fungal diseases in salmonids

By Even Thoen

Since no fungal diseases of salmonids are notifiable, no official statistics are compiled in this area.

The situation in 2015

Norwegian Veterinary Institute data

In 2015 there was a small rise in the number of cases of mycosis diagnosed by the Norwegian Veterinary Institute, compared with previous years. Saprolegniosis in roe, smolt and broodfish in freshwater made up most of the identifications, but isolated cases of systemic mycosis were also diagnosed, with an *Exophiala* sp. having been identified.

Assessment of the situation

As in previous years, feedback from fish health service personnel is often dealt with on the basis of field diagnoses, without samples being submitted for diagnosis in the laboratory. Since formalin was introduced for as a treatment for salmon lice, the Norwegian Food Safety Authority and the Norwegian Medicines Agency have also focussed on its use as a treatment against *Saprolegnia* spp. Both authorities have signalled that stricter regulation of this use of formalin is on its way. This has led to a rise in the number of applications to the Norwegian Veterinary Institute regarding the prevention and alternative treatment of saprolegniosis.

Parasitic diseases in farmed salmonids

Salmon lice were undoubtedly the most important parasitic disease in 2015. Growing resistance to antibiotics and rising mortality in the course of delousing present ever great challenges to the industry. The amoebic gill disease (AGD) situation appears to be better than it was a year ago. A more detailed account is given under each agent.

Salmon lice

By Randi Grøtvedt and Peder A. Jansen

About the parasite

*The salmon louse (*Lepeophtheirus salmonis*) is a natural parasite of salmonids living in saltwater in the Northern Hemisphere. The lice attack the skin and blood of the fish, and can produce extensive ulceration when many lice are present on a single fish. Salmon lice are currently among the most serious problems facing Norwegian aquaculture.*

Salmon lice are one of several species of crustaceans that grow by moulting their exoskeleton. The adult fish mate on their fish hosts. The female louse releases the fertilised eggs down two long sacs that hang from her genital segment. A single female is capable of producing at least 11 pairs of such sacs, each of which contains several hundred eggs.

The eggs hatch and release the first of three free-swimming stages, naupilus I. The naupilus II stage turns into a copepodite that finds and infects the fish. During these stages, which may last for several weeks during periods of low temperature, the lice can spread out over several kilometres.

For more information about salmon lice, go to: www.vetinst.no/faktabank/lakselus

On combatting salmon lice

The regulations set out goals for how many lice are permitted on farmed fish, and the incidence of lice is routinely monitored and reported. Measures against lice are required to be implemented if the threshold for the number of lice permitted is passed. Medication is the main measure involved, but the past few years have seen a rise in resistance to drugs. A new strategy that involves non-medication measures is currently being developed.

The situation in 2015

Official data

In 2015, as in 2014, the mean number of reported salmon lice rose somewhat in the spring. The rise in salmon lice in the course of the summer was weaker, and resulted in a smaller peak number of lice compared to all previous years. This was true of both females and all motile stages (Figure 1.12).

In order to be able to make more than a general assessment of average figures, we have estimated the production of salmon lice larvae in southern, mid- and northern parts of the country from 2012 until January 2016. These estimates show a change in the situation (Figure 1.13), with significantly higher production of lice in mid-Norway in 2105 than in previous years and in the north and south of the country. The development of infections in the south was much lower in 2015 than 2014. Production is estimated on the basis of reported figures, numbers of fish and temperature, besides our knowledge of reproduction, and the development time and survival of the different stages of the salmon louse life cycle (Kristoffersen et al., Epidemics 9:31-39).

Figure 1.12 Mean weekly reported salmon louse numbers at all Norwegian marine fish farms from January 2012 to January 2016, where the upper panel shows number of adult female lice and the lower panel other motile stages (pre-adults and adult males).).

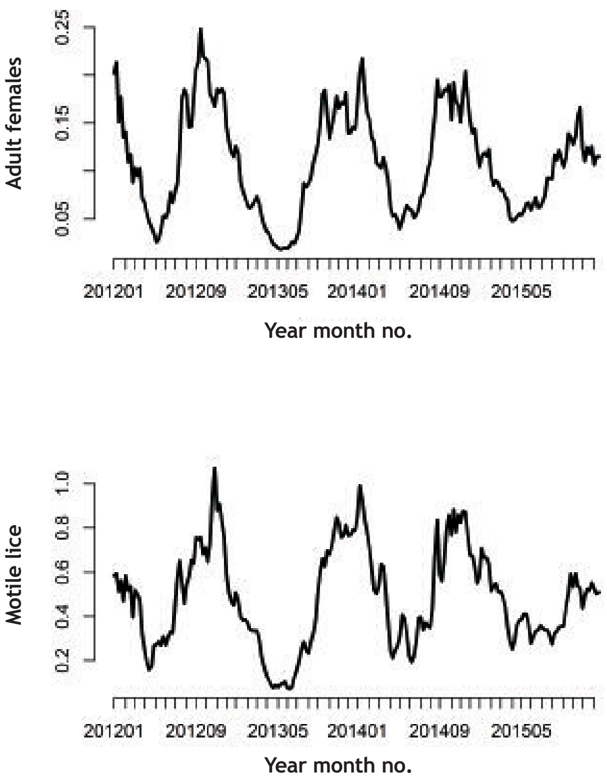


Figure 1.13 Estimated total weekly production of louse larvae at all sites on the southern (red line), mid- (black line) and northern (blue line) coast of Norway between January 2012 and January 2016.

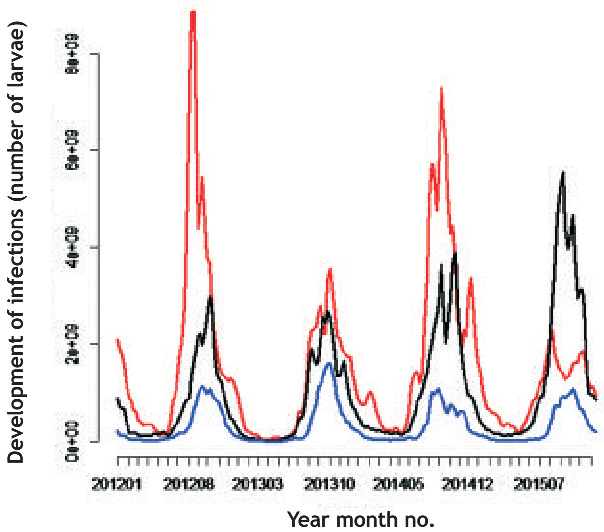
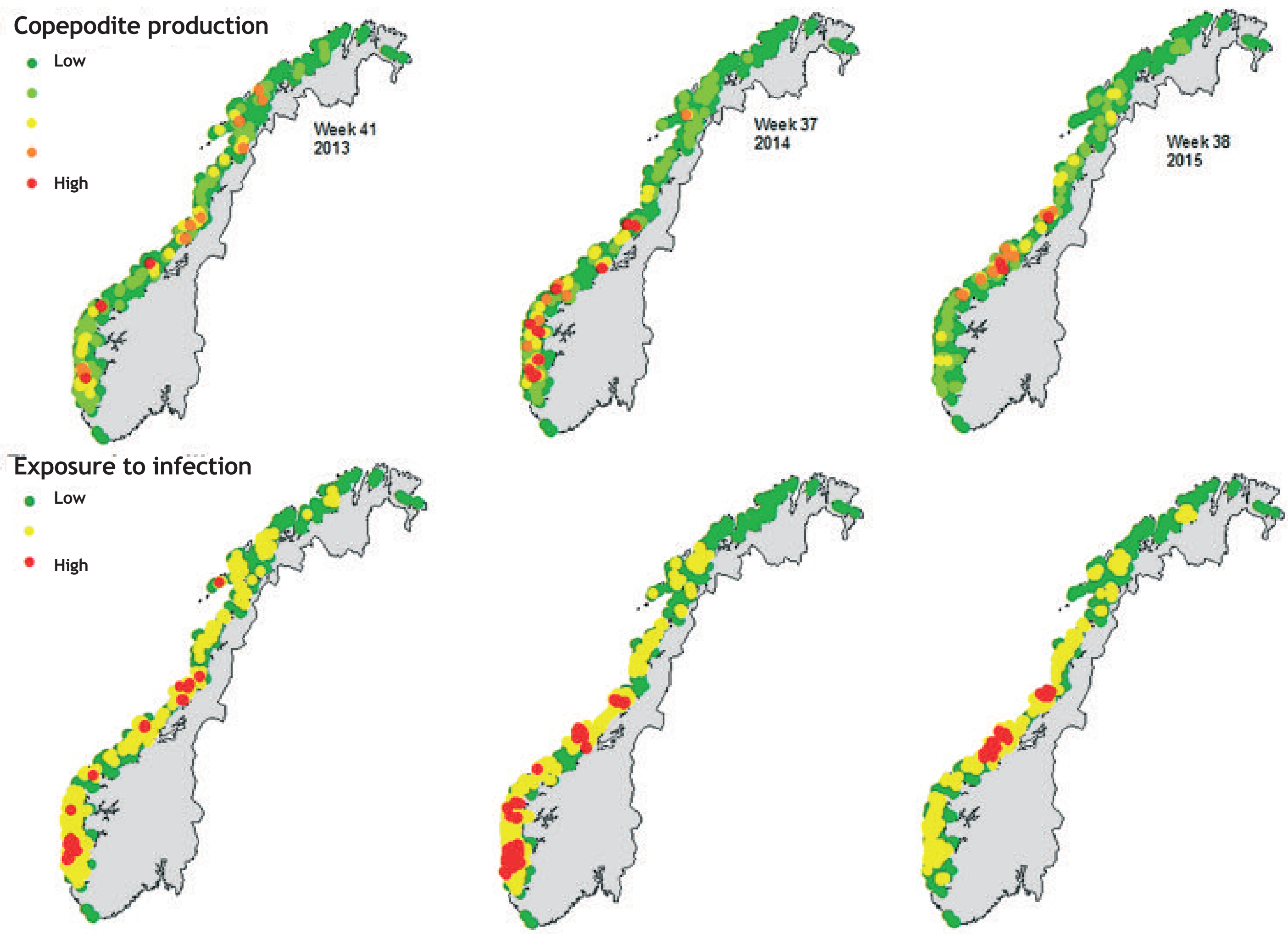


Figure 1.14 Estimated production of infections (upper panel) and infection pressure (lower panel) in weeks with maximum production of infection over the entire country in 2013, 2014 and 2015. Infection pressure is shown as relative density of copepodites, on a colour scale ranging from low density (green) to high density (red).).



The upper panel in Figure 1.14 shows in detail the production of lice larvae along the coast of Norway in the week of the year when the total production of infections was at its highest. The maps show that in 2015, production of infections was highest in mid-Norway. By estimating the likelihood of infectious contact between sites on the basis of their distance from each other by sea, we can estimate the extent to which the production of infections from any given site will lead to infections at any other site. The lower panel shows how sites are exposed to infection pressure. In 2015, it was areas in mid-Norway that were most affected by high infection pressure, while areas in the counties of Hordaland and Sogn og Fjordane that were most affected by high infection pressure in 2014 were less affected in 2015. The counties Rogaland and Agder, as well as large parts of Troms and Finnmark, were exposed to low infection pressure.

Table 1.5 Number of prescriptions for given categories of medicines for treatment of lice in 2011 – 2015

Category of medicine	2011	2012	2013	2014	2015
Azamethiphos	409	691	480	749	616
Pyrethroids	456	1155	1123	1043	660
Emamectin benzoate	288	164	162	481	522
Flubenzurons	23	129	170	195	201
Hydrogen peroxide	172	110	250	1009	1270
Total	1348	2249	2185	3477	3269

The consumption of medicines to control salmon lice is summarised in Table 1.5 in the form of the number of prescriptions in the register of medicines. The table shows that medicine consumption is still high in comparison with previous years, although the number of prescriptions is lower than it was in 2014. At individual drug level, the 2015 figures show that consumption of hydrogen peroxide has greatly increased, while that of pyrethroids and

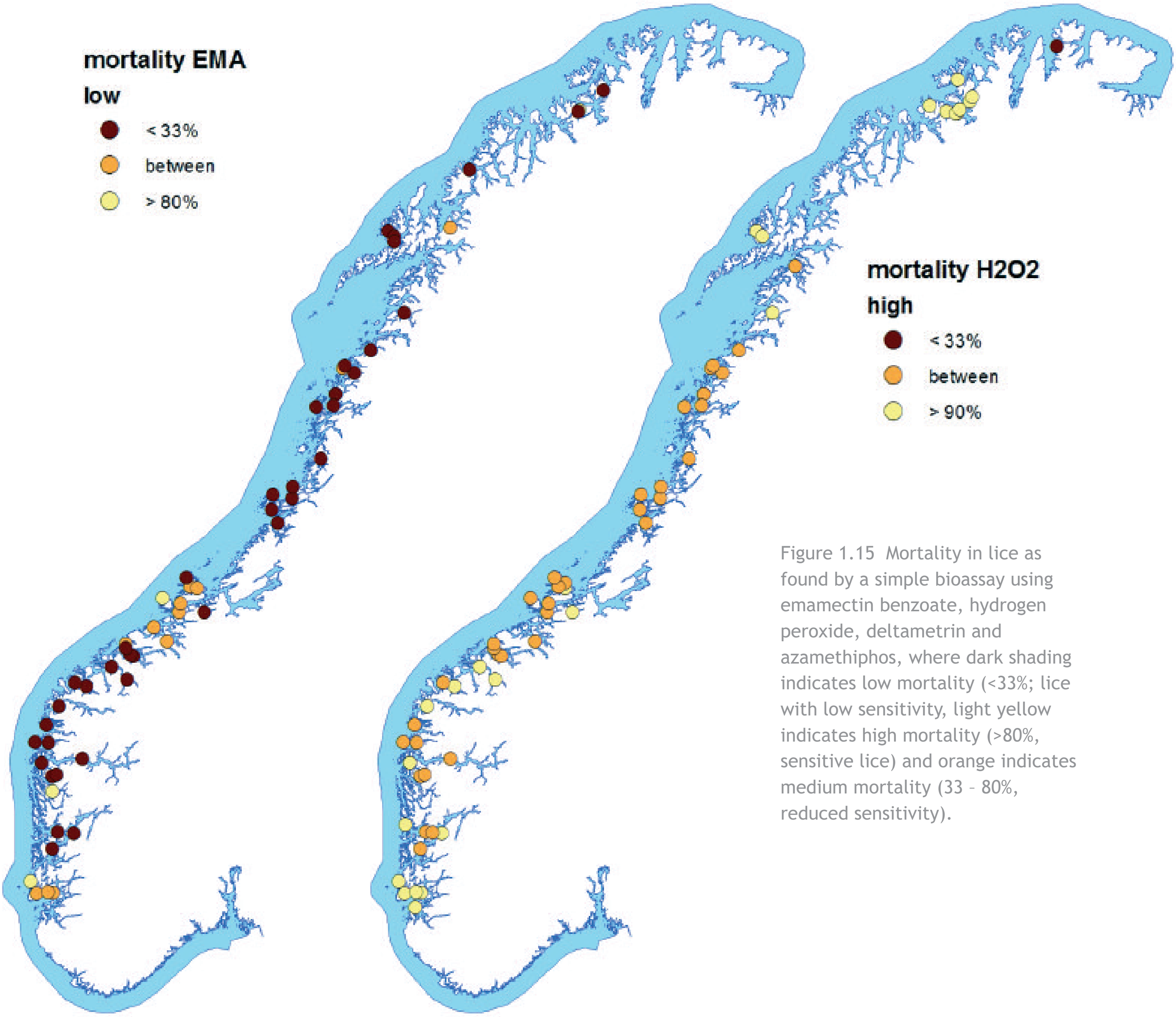


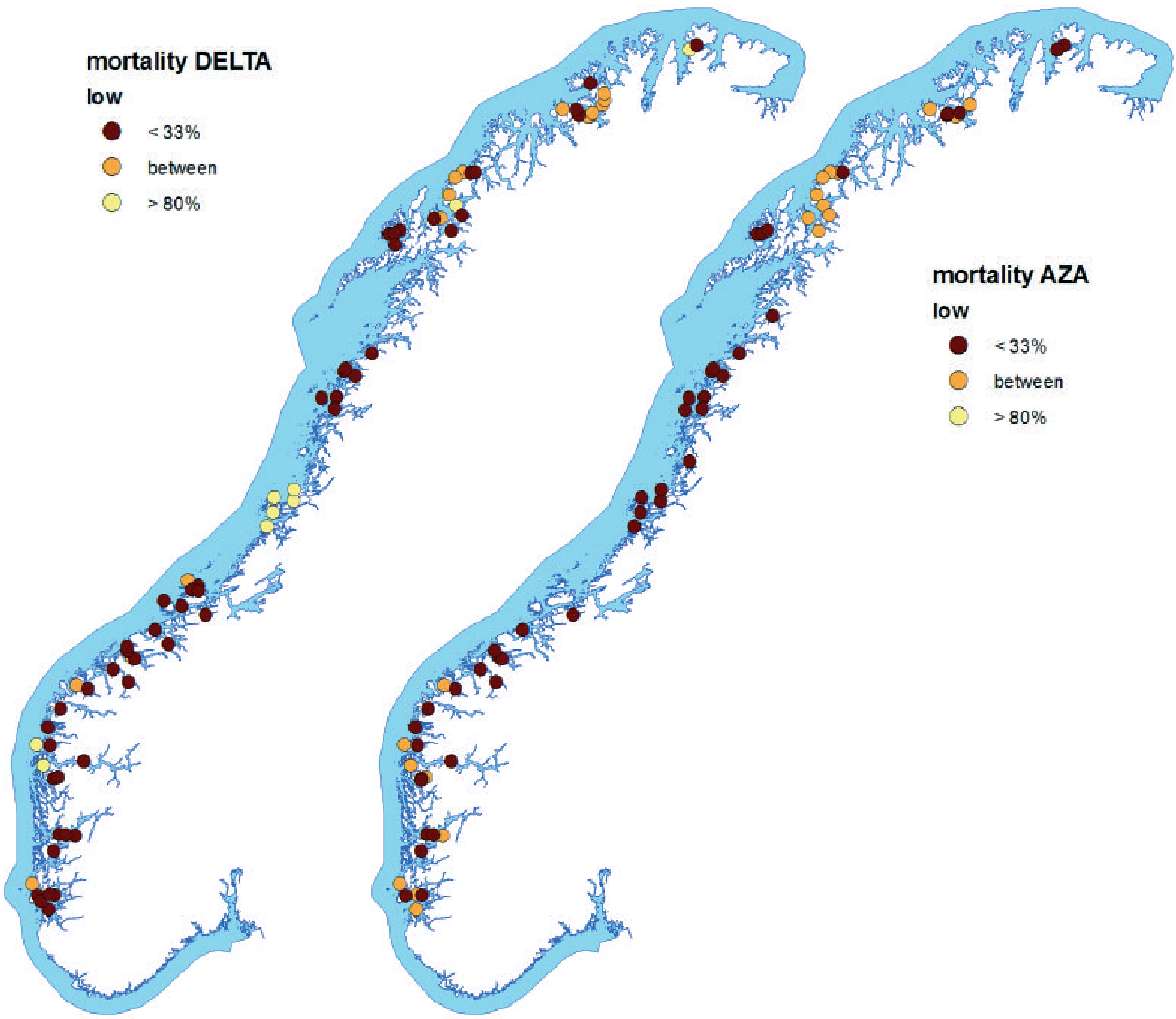
Figure 1.15 Mortality in lice as found by a simple bioassay using emamectin benzoate, hydrogen peroxide, deltametrin and azamethiphos, where dark shading indicates low mortality (<33%; lice with low sensitivity, light yellow indicates high mortality (>80%, sensitive lice) and orange indicates medium mortality (33 – 80%, reduced sensitivity).

azamethiphos has fallen. No distinction has been made between hydrogen peroxide being used against salmon lice and against AGD. The rise in the consumption of emamectin in 2014 and 2015 may be due to its growing use as a inhibitor.

Unfortunately, we lack an overview of the use of other non-medication-based measures against salmon lice, which leaves gaps in the picture of the salmon lice situation and how such measures could affect infection pressure. Good non-medication-based methods, with sufficiently good effects and that do not affect fish welfare, ought to become the main weapon against salmon lice.

Figure 1.15 summarises the results of the monitoring programme for salmon lice resistance that is being carried out on behalf of the Norwegian Food Safety Authority. The programme includes performing simple bioassays at several sites along the coast of Norway, based on pyrethroids, azamethiphos, emamectin benzoate and hydrogen peroxide. The maps show that there is widespread resistance to emamectin benzoate, deltametrin and azamethiphos among salmon sampled at a number of fish farms all along the coast.

The results from Nord-Trøndelag, which indicate high sensitivity to pyrethroids, are not in agreement with the results of genetic analyses of lice from the same area, which indicate a high percentage of resistance. Where hydrogen peroxide is concerned, the maps show that reduced sensitivity is increasingly widespread, while some areas display good sensitivity.



Data from the 2015 survey

A high percentage of questionnaire respondents (66.7) reported that salmon lice are the most important problem at on-growing sites housing salmon and trout, while 69.2 percent said that they are the most important problem at salmon broodfish farms and 71.4 percent rank lice as the worst problem at trout broodfish sites.

Of the respondents, 35.7 percent reported that significant mortality had occurred in the wake of delousing treatments at a few sites, 35.7 percent said that it occurred at several sites, and 16.7 percent that there was significant mortality at many sites as a result of delousing treatments.

Assessment of the situation

The salmon lice situation in 2015 has changed with respect to 2014. The figures for Norway as a whole are rather lower in 2015 than in 2014. Estimates of larvae production at fish farms show a clear change, with significantly lower infection pressure in the south of the country, but significantly higher pressure in mid-Norway compared to previous years. The consumption of medicines is slightly lower, but is still high. The resistance situation is serious, with a widespread reduction in sensitivity to drugs all along the coast.

We need to identify the cause of the change in infection pressure in the south of the country and in mid-Norway, and how we can affect the evolution of the salmon lice situation in 2016 in order to reduce infection pressure in mid-Norway and continue to maintain an improved situation next year.

Amoebic gill disease (AGD)

By Tor Atle Mo

About the disease

Amoebic gill disease (AGD) is caused by the parasitic amoeba Paramoeba perurans *(formerly* Neoparamoeba perurans*). Since the mid-1980s, this disease has been the cause of major annual losses of farmed salmon in Australia, more specifically Tasmania. In the mid-90s, AGD was discovered in the Atlantic, and in the course of the past 20 years it has risen in importance and the amoeba is being found ever further north. In 2011 and 2012, AGD was one of the diseases that caused most losses to Scottish and Irish salmon farms. In 2013,* P. perurans *was demonstrated at several farms in the Faeroes, and in the course of the past three years it has become a serious disease in Norwegian fish farms.*

AGD was diagnosed for the first time in Norwegian farmed salmon in 2006, and since 2102 it has been the cause of serious losses. AGD occurs in farmed fish in saltwater, primarily in Atlantic salmon, although other farmed species such as rainbow trout, lumpsuckers and a number of labrid species can also fall ill. The two most important risk factors for an outbreak of AGD are said to be high salinity and relatively high seawater temperature. Pathological findings occur only in the gills, where we can observe slimy white areas with the naked eye. Amoebae can be identified in freshly taken smears that are studied by light microscopy or PCR. A definitive diagnosis of AGD is made by histological study of the affected tissue.

In 2014, the Scientific Committee for Food Safety (VKM) performed a risk evaluation of AGD:
http://www.vkm.no/dav/931431e420.pdf

For more information about AGD, go to:
www.vetinst.no/faktabank/amoebegjellesykdom-agd

On combatting AGD

AGD is not a notifiable disease.

AGD is treated with either hydrogen peroxide (H2O2) or freshwater, and treatment is most effective if it is given during the early stages of the disease. This is primarily because it reduces relapses, and extends the time it takes for the disease to occur again. No current treatment appears to be 100 percent effective, and several repeat treatments may be required. Where salmonids are concerned, freshwater treatment is both more gentle and more effective than H2O2.

Since treatment early on in the course of the disease appears to be most efficacious, it is important to monitor the presence of amoebae on farmed fish, and this is done by PCR screening. The gills are also inspected visually. A system for classifying macroscopic changes in the gills (gill sores) has been developed. In conjunction with direct-light microscopy of gill smears, this has become an important tool for the fish health services. After repeated treatments, assessment of gill sores may be difficult, and the method requires a good deal of experience. Since a number of other factors and agents can lie behind changes in the gills, it is important to confirm any diagnosis of AGD through histological examination.

The situation in 2015

Norwegian Veterinary Institute data

In 2015, AGD was demonstrated on the coast of Western Norway as far north as Nord-Trøndelag. However, this was no further north than in 2014.

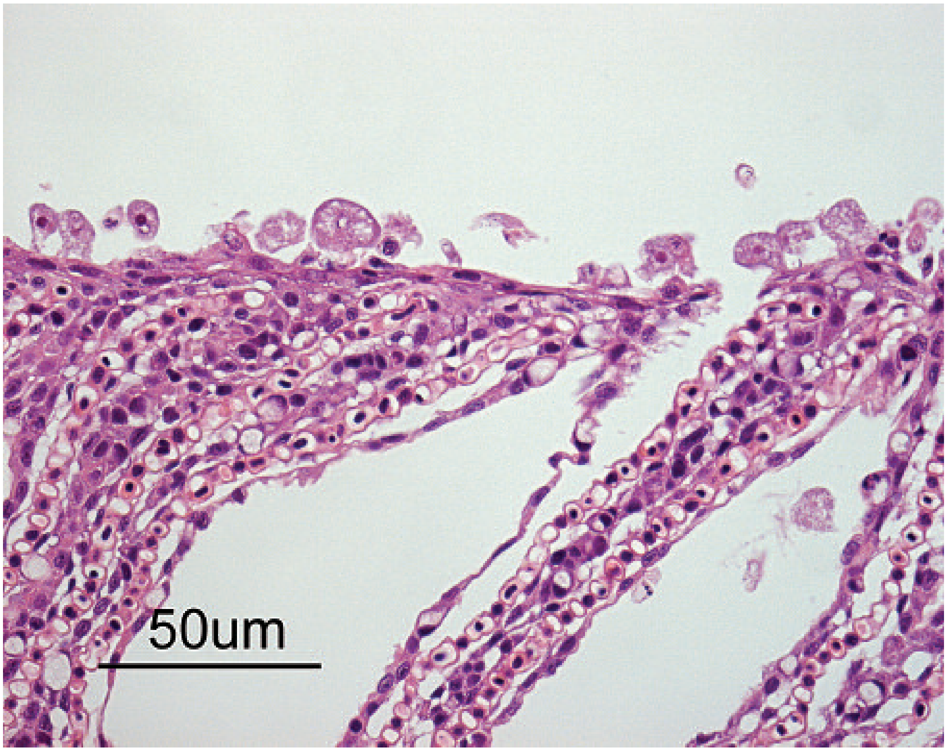
In the winter of 2014 – 2015, the seawater temperature was relatively high, and *P. perurans* was identified at several sites throughout the winter. This may explain why the first outbreak of AGD was registered in July 2015, a month earlier than in 2014, which in turn was a month earlier than in 2013. There are several possible causes of this “trend”; climate change, including a rise in infection pressure, and adaptation in an introduced parasite, but more data and research are needed before we can say anything definite about this.

AGD did not develop into as serious a problem for Norwegian aquaculture in 2015 as it had been in 2014. There are a number of possible explanations for this. It may be that autumn 2015 was not as warm as the previous year, or that fish farmers had gained more experience and had dealt with AGD better than they had in previous years, for example by treating it at an earlier stage in its development.

Data from the 2015 survey

The questionnaire used for the survey asked the question: “At what time of year does AGD lead to mortality in your area?”, where the year was divided into spring, summer, autumn and winter. This identified no clear trends as to when AGD occurs, other than that 15.4 percent of respondents answered that it occurred to a great extent, and 20.5 percent to a certain extent, in the autumn. AGD was mentioned as one of the five most important diseases of salmon and trout, although few respondents ranked it as the most important disease.

Photo 1.2 AGD in Salmon. Note how the gill lamellae adhere to each other, and the large number of amoebae on the surface of the gills. H&E (haematoxylin and eosin) section enlarged 400x. Photo: Trygve Poppe, Norwegian Veterinary Institute



Other parasitic infections

By Haakon Hansen

Desmozoon lepeophtherii (syn. Paranucleospora theridion)

Desmozoon lepeophtherii (syn. *Paranucleospora theridion*) is a *microspiridian* parasite that was first isolated from salmon lice, *Lepeophtheirus salmonis*, but has since been found in farmed salmon in connection with "autumn sickness". The various stages of this organism are extremely small, and for this reason may have been missed in earlier histological sections. This parasite is widespread, but only a minority of our respondents in the questionnaire survey reported it as being important. Its significance therefore remains uncertain.

Ichthyobodo spp. ("Costia")

At least two species of *Ichthybodo* occur in Norwegian farmed salmon: *I. necator* in salmon in freshwater and *I. salmonis* in salmon held in both fresh- and saltwater. This parasite is widespread and can infect both skin and gills. Most identifications have been made by the fish health services.

The Veterinary Institute identified *Ichthyobodo* spp. from 52 Norwegian sites in 2015. Most (45) were identified on salmon, both on adult fish and fry, but the parasite was also found on trout, halibut and *lumpsucker*.

Tapeworm - Eubothrium spp.

In the past few years, a rising incidence of tapeworm in the digestive tract of salmon in the sea has been reported, and once again in 2015 several fish health services have reported problems with this parasite.

Tapeworm infections lead to increase in feed consumption and reduced growth rate in the fish host. Tapeworm infections are treated with Praziquantel, and sales of this medicine have risen in recent years. Several fish health services have reported that treatment has failed and there are worries regarding the development of resistance. Most identifications have been made by the fish health services. The Veterinary Institute found tapeworms at 55 sites in 2015, none of which were north of Nord-Trøndelag.

Parvicapsula pseudobranchicola (parvicapsulosis)

Parvicapsulosis is caused by *Parvicapsula pseudobranchicola*, and the disease can result in high mortality rates in on-growing farms. Parvicapsulosis continues to be reported as a particular problem in Troms and Finnmark. In 2015, the Veterinary Institute detected this parasite (usually via histological analyses) at 36 aquaculture sites. By far the most of the cases come from Norway's three northernmost counties (Nordland, Troms and Finnmark), but the parasite has also been found in Nord-Trøndelag. In 2015, it was only identified in commercial fish farms. *Parvicapsula pseudobranchicola* has a complex life-cycle, likely with a polychaete as its primary host and fish as its secondary host. The primary host of *P. pseudobranchicola* has not yet been identified, but research is ongoing.

Gill diseases in farmed salmonids

By Anne-Gjerd Gjevre

Gill diseases occur at all stages in the life-cycle of farmed salmonids. In some cases, the cause may be one single agent.

Gill poxvirus is one example of a microorganism that can progress rapidly and result in high mortality during the fry stage (see chapter on: "Salmon gill poxvirus disease (SGPVD)"). The amoeba *Paramoeba perurans*, which causes amoebic gill disease (AGD), is a similar example from the seawater phase (see chapter on "Amoebic gill disease (AGD)"). However, gill diseases that occur in seawater have complex causal backgrounds and are often called "multifactorial diseases". In these cases, we can detect various types of microorganisms in the gill tissue, and we often find that fish develop chronic inflammation of the gills (see "Facts about Chronic Gill Inflammation" at: http://www.vetinst.no/Faktabank/Kroniskgjellebetennelse/(language)/nor-NO).

Since none of the gill diseases are notifiable, it is difficult to put a figure to the number of sites that become infected each year. There also appear to be variations from one year to another.

The situation in 2015

Data from the 2015 survey

In the questionnaire survey respondents were asked to rank the five most important diseases found in hatcheries and on-growing salmon and rainbow trout farms. The most important disease was ranked no. 1, and so on down. It was possible to select a number of alternatives. Below, we summarise the respondents' ranking of gill diseases.

Fry to smolt

Non-specific gill problems: Ten out of 12 respondents ranked non-specific gill problems at RAS sites as either first or second in importance, while a further eight out of ten answered that problems of gill health are common in RAS systems. In flow-through system hatcheries, 11 of 12 respondents ranked such problems in first or second place.

Poxvirus: Seven out of 16 ranked poxvirus in first or second place in flow-through system hatcheries. In RAS systems, two of seven ranked this disease as either first or second in importance.

Desmozoon lepeophtherii: This microsporidian affects the gill tissue and produces systemic infections. It was ranked by a few respondents as the most important cause of health problems in both types of hatchery.

On-growing fish

Gill problems: 22 out of 36 respondents ranked gill problems as the first or second most important concern among salmon living in seawater. In adult rainbow trout, a corresponding ranking was made by three of six respondents. To the question about the status of gill diseases (apart from AGD) in adult fish in the sea in 2015 compared to 2014, 17 of 40 respondents answered that it lied at the same level. Twelve thought that the incidence of gill diseases was higher in 2015..

Assessment of the gill disease situation

Fry to smolt

The questionnaire survey indicates that non-specific gill diseases are more of a problem in RAS than in flow-through hatcheries. Poxvirus is regarded as a greater problem in flow-through than in RAS hatcheries. It was surprising that *D. lepeophtherii* was regarded as a major problem for some hatcheries. It's not documented that this microsporidian causes disease in freshwater, so it is likely that the organism enters along with seawater, and this needs to be studied in more detail. It was also noted that Ca. *Branchiomonas cysticola* is a growing problem in RAS systems.

On-growing fish

Chronic gill diseases are a major and growing problem of farmed salmon in seawater. These diseases are often associated with algal blooms. It has been stated that mechanical delousing after a period of high algal concentrations exacerbates the situation. Rainbow trout appear to be more resistant to gill diseases during the seawater phase than Atlantic salmon.

Poor smolt quality and the runt syndrome

By Hanne Skjelstad and Jinni Gu

The runt syndrome is a condition in which fish become emaciated or do not grow normally after releases into seawater and develop into thin "losers" or "runts".

A typical histological picture in emaciated fish is a partial or total lack of perivisceral fatty tissue and high melanin concentration in the kidney, but with the pancreas intact. Bacteriological and virus investigations are often negative. Runts are also found during the fry stage.

The causes of runt syndrome are still unknown, and they are probably complex. Some of them may arise during the freshwater phase, and it is thought that the syndrome may be caused by problems during or in connection with smoltification. Optimal smoltification and timely release into seawater are important for the normal development, growth and health of salmonids. Fish that have survived infectious pancreatic necrosis (IPN) may become extremely emaciated during the seawater phase. Tapeworms are also frequently found in runt fish. Many fish that develop this syndrome live for a very long time, and clearly represent a significant challenge to fish welfare. We can expect such individuals to attract more parasites and diseases than normal fish in sea-cages. It is therefore important to remove them, as weakened fish can be a source of infection for other fish.

The situation in 2015

Norwegian Veterinary Institute data

In 2015, the Norwegian Veterinary Institute diagnosed emaciation in salmonids in the seawater phase at 41 sites, a slight drop since 2014, when emaciation was registered at 50 sites. A partial or complete lack of fatty tissue in the abdominal cavity was found in these cases, frequently in adddiion to parasitic infections.

Data from the 2015 survey

Reports from the field state that many sites still have to deal with runt syndrome, which several report as a serious health problem that affects both production and fish welfare. The survey also showed that the syndrome affects rainbow trout more than salmon. Both fish farms and the fish health services find it unsatisfactory that the cause of the syndrome has not yet been identified. Other respondents reported a lower percentage of runts this year. For those, it is possible that keeping fish for longer in the hatchery before transport has unfortunate consequences. Meanwhile, a more gentle form of transport, during which the fish are sedated, has been introduced.

Some respondents report that producing ever larger smolt in hatcheries brings problems of early smoltification, followed by desmoltification that is followed in turn by a further smoltification. Others report that smolt quality is often poor; the fish are too small and of different sizes, and then they often have fin injuries. Furthermore, with large groups of fish it can be difficult to synchronise smoltification. However, other respondents have had few problems of smoltification and release into seawater this year.

Several sites and groups of fish display poor smolt quality. This may increase the risk of poor development, growth and health in some fish in such groups, which may contribute to the development of losers and the loser syndrome.

Dark spots on fillets

By Cecilie S. Walde and Marta Alarcón

Dark spots on fillets have become a major problem for salmon farms, a problem that has grown significantly in extent from 13 to 19 percent country-wide between 2011 and 2015.

The incidence of such spots is currently higher in Southern and mid-Norway than in North Norway, with every fifth salmon fillet displaying one or more dark spots. This usually leads to lower quality at slaughter, and in 2010 the cost of dark spots was estimated to be NOK 500 million. In order to investigate the significance, incidence and origin of dark spots, FHF launched a research project: (http://www.fhf.no/prosjektdetaljer/?projectNumber=900824).

Dark spots may be anything from small grey or reddish, almost invisible shadows to large dark-pigmented areas. They are mostly found at the front of the abdominal part of the fillet, but can also be found on the back. No differences in incidence have been found between the right and left sides.

It has been suggested that red spots are the precursors of dark or melanised spots. Both types are believed to be a reaction to local tissue damage. Histological study of red spots shows an acute haemorrhagic necrotising myocyte, while similar studies of dark spots reveal chronic degenerative inflammation with obvious fibrosis and several well-organised granuloma. The dark spots contain abnormally high concentrations of iron and zinc. Blood-rich macrophages may be a sign of previous bleeding.

Identification of the origin of local tissue damage is essential to our ability to prevent the occurrence of red and dark/melanised spots. What these have in common is that high levels of piscine orthoreovirus (PRB) antigen have been found in both conditions. It is presumed that a focal PRV infection is a prerequisite for the transition from red to dark spots, in which an inability to get eliminate the PRV antigen drives the process. It has not been ascertained whether a PRV infection is the source of the red spots. Environmental and operating conditions could also be contributory factors.

A connection has been found between the development and incidence of dark spots and certain farming conditions, including:

- Vaccination method (injection failure)
- Feed composition (the addition of vitamins E and C, plus selenium, hinders the development of spots
- Water quality (low oxygen saturation raises incidence)
- Physical injury
- State of health (strong correlation between high incidence and outbreaks of HSMI and PD).

Genetic background, vaccine and handling during slaughter are not regarded as relevant. The vaccine as such is not believed to be an important cause of the occurrence of these spots, but injection failure is of relevance. It has been noted that mechanical vaccination results in a higher incidence of spots than manual vaccination.

It has also been found that crush injuries may result in long-term tissue damage in the shape of elevated melanin deposition, although it is not known how long it take for haematomas to develop into dark spots. On the other hand, experimental studies of poor water quality in the form of low oxygen concentration have been shown to double the incidence of spots. Feed composition is also important, as the addition of extra antioxidants, such as vitamins C and E, the trace elements selenium and, to a certain extent, zinc, can inhibit their development. A possible correlation exists between higher incidence of spots on fillets and outbreaks of HSMI and PD. Although we appear to be well on the way to an answer, much remains to be done in order to understand the causal relationship between farming conditions and the incidence of dark spots.

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Injuries caused by vaccines

By Cecilie S. Walde

A statutory requirement (Aquaculture Regulations §63) that Atlantic salmon should be vaccinated against the following three diseases is currently in force: furunculosis (which is caused by Aeromonas salmonicida *subsp.* salmonicida*), vibriosis (caused by* Vibrio anguillarum serotypes *O1 and O2a) and* coldwater vibriosis *(caused by* Vibrio salmonicida*).*

It is also usual to vaccinate against winter ulcer disease (Moritella viscosa) and infectious pancreatic necrosis (IPN). Vaccines against yersiniosis (*Yersinia ruckeri*), pancreas disease (PD), infectious salmon anaemia (ISA) and flavobacteriosis (*Flavobacterium psychrophilum*) are also available, as they also are for cod and cleaner fish. Several agents are usually combined into a single multicomponent vaccine, although this is not always the case. Double vaccination is a further possibility.

Fish may receive their vaccines intraperitoneally, this being the most frequently used method for salmonids, orally or by dip and bath vaccination. Oral vaccination via feed is not usually employed in Norway, while dip and bath is frequently used where fish need to be vaccinated when they are still too small to be vaccinated by injection, for example vaccination against Enteric Redmouth Disease (ERM).

Vaccine damage can be a result of side-effects of the vaccine itself, failed injections or infections acquired during vaccination due to poor hygienic conditions.

Thanks to the introduction of more gentle vaccines, and primarily to lower doses of injections, vaccine injuries that are serious enough to represent a health or welfare threat to fish are now rare. However, side-effects do occur to a certain extent in the form of melanisation, adherences of internal organs to the abdominal wall and narrowing of the throat or digestive tract, all of which can lead in turn to discomfort or pain for the fish.

Reduced growth may also be a result of the side-effects of vaccination because energy is lost through inflammation and due to body repair being prioritised over growth.

The most common method of ranking vaccine side-effects uses the Speilberg Scale (1 – 6). This ranks side-effects as 1 – 2 if they have no serious effects on the growth and welfare of the fish, and between 3 and 6 if they do have serious effects on growth and welfare.

The situation in 2015

Data from the 2015 survey

In 2015, 60.9 percent of respondents reported that injuries due to vaccines are a minor health problem for fish, while 58.7 percent answered that only a few such injuries are ranked above grade 3 on the Speilberg Scale.

82.2 percent said that nearly all fish are vaccinated against VPN and 26.1 that they almost all are vaccinated against PD, while 39.1 percent answered that no fish are vaccinated against PD. There are therefore wide differences in reports as to whether or not fish are vaccinated against PD. Where yersiniosis is concerned, 4.5 percent reported that around half or nearly all fish are vaccinated, which suggested that in Norway as a whole, only a small percentage of fish are vaccinated against yersiniosis.

Heart diseases other than PD, HSSI and CMS

By Cecilie S. Walde

Besides the virus diseases PD, HSMI and CMS, all of which affect the heart, a number of different deviations and abnormalities that affect the heart are regularly identified in farmed fish. Both the size and shape of the heart frequently differ from the normal pyramidal ventricle form that is important for normal functioning. The most frequent deviations are minor, and consist of more or less rounded or bean-shaped hearts.

Subepicardial hypercellularity or epicarditis is a common finding in connection with PD, HMSI and CMS, but it also occurs as an apparently independent condition that cannot be linked to other diseases. The significance of this type of inflammation is not known, but in general, we are aware that such changes negatively affect cardiac function. This syndrome may therefore act as a component that contributes to more complex ”inexplicable mortality” and to mortality related to delousing treatments.

The situation in 2015

Norway does not compile official statistics regarding cardiac problems of this type.

Several fish health services report that a large number of apparently health fish die. Many of these are fish that have been released into seawater in the autumn and die in the course of their first winter there. Besides congestion, ascites (accumulation of internal fluids) and cardiac tamponade (accumulation of body fluids in the pericardium), there are few or no specific obduction findings apart from a few cases of inflammation in these hearts.

The health situation of wild salmonids

By Åse Helen Garseth, Sigurd Hytterød, Asle Moen and Trygve Poppe

Increasing salmon lice infection pressure

The national salmon lice monitoring programme reports a general rise in infection pressure on wild salmonids (salmon, sea-trout and charr) in 2015 compared to 2014. At several of the monitoring sites, the number of lice on individual sea-trout was at a level that could have reduced the local populations.

It has also been reported that migrating salmon smolt from Hordaland (Hardanger and Nordhordland), Sogn og Fjordane (outer Sognefjord), Møre og Romsdal (Storfjord) and Nordland (Nordfolda) probably have been negatively affected by salmon lice in 2015. The monitoring programme is led by the Institute of Marine Research on behalf of the Norwegian Food Safety Authority, and in collaboration with the Norwegian Institute for Nature Research (NINA) and UNI Research Environment. You can read more about The National Salmon Lice Monitoring Programme here: http://www.imr.no/nyhetsarkiv/2016/januar/mye_lakselus_i_2015/nb-no

Furunculosis in wild salmon in rivers around the Namsen fjord

Between August and October 2015, mortality was observed among returning wild salmon in the River Namsen and its tributaries Sanddøla and Bogna, which also lie close to the Namsen fjord. Furunculosis is virtually an annual occurrence in wild salmon in the rivers that feed this fjord system, and it was also confirmed on this occasion. What was special about this year was that *Aeromonas salmonicida* subsp. *salmonicida* was also identified in lumpsuckers in a fish farm in the fjord system.

Bacterial isolates from the infected salmon and lumpsuckers were identical. Resistance testing demonstrated reduced sensitivity to oxolinic acid. For several years the Veterinary Institute has been observing reduced sensitivity to oxolinic acid in *A. salmonicida subsp. salmonicida* from the Namsen area. (See chapter on "The health situation of cleaner fish" in this report.

Fish mortality and algal blooms in freshwater

In August, dead fish of various sizes were observed in the River Søa in Hemne Municipality in Sør-Trøndelag. Around the same time, an algal bloom was observed in the shape of a belt of scum and mats of algae across part of Lake Rovatnet, which lies upstream of Søa.

Post mortem examinations performed by the Norwegian Veterinary Institute provided no answers regarding the cause of death. However, water samples analysed by NIVA revealed the presence of algal toxins (microcystines), golden algae (*Chrysophysae*) and cyanobacteria (*Dolichospermum lemmernannii*).

A number of blue-green algal species are toxic to livestock and fish. Golden algae have also been linked to fish deaths. Besides their direct toxic effects, algae can also lead to mortality in fish due to oxygen deficit (www.miljolare.no). In this case, the coincidence in timing suggests that there may have been a connection between the algal bloom and the deaths of these fish.

Mapping SAV2 and several other agents in wild-caught salmonids in Trøndelag

Between 2013 and 2015, the Fish Health Group at the University of Bergen mapped SAV and a number of other agents in wild-caught salmonids in Trøndelag. The material consisted of salmon and trout from NINA's salmon netting station at Agdenes and salmon from the Rivers Gaula, Orkla, Stjørdal and Namsen. In 2013 and 2014, SAV2 was not found in this material, which comprised almost 900 fish. In 2014, the incidence of the other agents differed from one site to another. IPNV was identified only in Orkla, while ILAV, PRV, *Ichthyobodo salmonis, Parvicapsula pseudobranchicola* and *Desmozoon lepeophtherii* were found at all these sites. The 2015 results have yet to be reported.

Ulcerative dermal necrosis in neighbouring countries

During summer 2015, high rates of mortality were registered in returning salmon in several rivers in Sweden, Finland and Russia. These deaths could be attributed to ulcerative dermal necrosis (UDN), a disease of the skin that occurs in wild salmon and sea-trout during freshwater migration.

The Veterinary Institute analysed the material from the North of Sweden and Russia. The North-Swedish material was diagnosed as having UDN. The Russian material was more limited, but here too it was concluded that the alterations could be attributed to the same disease of the skin.

Photo 1.3 Dead salmonid fry from River Søa, downstream of Lake Rovatnet. Photo: Jo Vaagam, Hemne Hunting and Fishing Club

Photo 1.4 Algal bloom in Lake Rovatnet, Sør-Trøndelag. Photo: Hemne Municipality

In Norway, most cases of UDN are found in rivers that flows into the Oslo Fjord (Numedalslågen, Drammenselva, Lierselva and Sandvikselva). The disease typically occurs in cycles, at intervals of several years. In Norway, cycles are typically seven to eight years long.

Diagnoses of UDN are based on macroscopic observations, behaviour and histopathological alterations. Early-phase findings are characterised by light, sunken areas of skin on scale-free parts of the body (head and neck, and near the adipose fin). The cause of UDN is still unknown, and attempts to identify the agent by means of traditional methods are often compromised by the fact that secondary fungal and bacterial infections rapidly emerge.

However, virus particles have been identified in connection with injuries of this type. The possibility of outbreaks of disease in neighbouring countries spreading to Norway is a source of some concern, but so far, no reports of mortality from UDN in Norwegian rivers have been received.

Monitoring the health of wild salmonids

The Norwegian Veterinary Institute and the Institute of Marine Research monitor the health of wild anadrome fish on behalf of the Norwegian Food Safety Authority. The Veterinary Institute is responsible for the freshwater phase, while the Institute of Marine Research is responsible for the marine phase (migrating smolt).

In 2012 – 2014, the Norwegian Veterinary Institute's health monitoring contribution was based on extended testing of broodfish that had been caught for use in stock enhancement hatcheries and the gene bank for wild salmon. As Table 1.6 shows, the PRV virus was found in around 24 percent of wild-caught salmon and about 3 percent of sea-trout. The other viruses (IPNV, SAV, ISAV and PMCV) have been found in only a small percentage of wild salmon.

This large difference in incidence could be due to many factors. It may be related to the infectivity of the agent, or to differences in virulence (ability to cause disease). A low-virulence virus is more likely to spread through low-density populations, such as wild salmon. High virulence leads to populations becoming more easily weakened, so that they either die directly of the disease or become more liable to be taken by a predator, whether piscine, avian or mammalian.

For more information go to:
http://www.vetinst.no/Publikasjoner/Rapportserie/Rapportserie-2015/Annual-report-on-health-monitoring-ofwild-anadromous-salmonids-in-Norway

The 2015 health-monitoring programme had two objectives: first, freshwater reservoirs were surveyed for the presence of piscine orthoreovirus (PRV) by screening non-anadrome salmonids. The other sub-goal was to follow up previous identifications of viruses, first and foremost with the aim of performing phylogenetic analyses that might tell us something about exchanges of infectious agents between wild and farmed populations. The programme also investigated whether previously virus-positive hosts were more likely to be a product of inbreeding with farmed fish than virus-negative hosts.

Gyrodactylus salaris

Gyrodactylus salaris is a parasite that does not naturally occur in Norwegian fauna, and it is regarded as a threat to all Norwegian stocks of wild salmon. The parasite attaches itself to the fish skin, where it multiplies to large numbers. Attachment to- and feeding on the salmon skin from thousands of *G. salaris* specimens lead to mortality in the Atlantic salmon juveniles. Under international environmental agreements, Norway is required to eradicate this parasite from all infected watersheds.

The Veterinary Institute has been responsible for all measures that have been taken to eradicate *G. salaris* in Norwegian rivers. Most of these have involved the use of Rotenone, but trials and research on other methods are also being performed by the Institute. So far, Rotenone treatment has been the only effective way of removing the parasite from entire river systems.

On behalf of the Norwegian Food Safety Authority, the Veterinary Institute is carrying out two *G. salaris*

Table 1.6: Summary of results from health monitoring of wild catched anadromous salmonids in the period 2012-2014.

	Salmon		Sea-trout		Artic char	
2012-2014	Number tested	Number positive	Number tested	Number positive	Number tested	Number positive
IPNV	1134	1	296	0	200	0
SAV	1157	1	120	0	-	-
ISAV	1137	1	120	0	-	-
PMCV	453	2*	100	0	-	-
PRV	532	130	100	3	-	-

surveillance programmes: The surveillance programme for *Gyrodactylus salaris* in Atlantic salmon and rainbow trout (the OK programme), and The post-treatment control programme to ascertain freedom from infection with *Gyrodactylus salaris* in Atlantic salmon (the FM programme).

Go to: http://www.vetinst.no/Helseovervaaking/FiskGyrodactylus/(language)/nor-NO, for more detailed descriptions of these programmes.

Also on behalf of the Norwegian Food Safety Authority, the Veterinary Institute is performing a study to map the occurrence of *G. salaris* in the Drammenselva catchment. In 2014 and 2015, the project has focussed on the surveillance for *G. salaris* on Arctic charr (*Salvelinus alpinus*) in Lake Tyrifjorden, where the Arctic charr is regarded as the only potential long-term host to this parasite. The study will continue in 2016, focusing on the Begna River system. The results are expected to play a decisive role in the further planning of countermeasures against *G. salaris* in the Drammenselva region.

The situation in 2015

In 2015, the OK programme analysed around 3300 salmon and rainbow trout from about 100 fish farms and about 2300 salmon from 69 rivers. *Gyrodactylus salaris* was not detected in any of the rivers or farms included in the OK programme in 2015.

In 2015, altogether, 1385 salmon juveniles from 12 rivers in the infection regions Vefsna (10 river systems), Rauma (one), and Lærdal (one) were examined for *Gyrodactylus salaris*. in the FM programme. *Gyrodactylus salaris* was not detected in any of the rivers included in the programme in 2015.

In 2014 – 2015, a total of 388 charr from eight sites in the Lake Tyrifjorden were caught and examined for *G. salaris*. The parasite was not detected. This study provides sufficient results to conclude that *G. salaris* is not present on Arctic charr in Lake Tyrifjorden.

Gyrodactylus salaris countermeasures in 2015

On behalf of the Norwegian Environment Agency and the County Governor, the Veterinary Institute has been responsible for all major Rotenone treatments for *G. salaris* in Norway. After several years of struggle, with a number of victories and some defeats, this campaign now appears to be successful. In 2015, the first treatment for *G. salaris* in the Skibotn region in Troms County, and the final treatment of the River Rana in Nordland were carried out. Current efforts to discover the source of infection in Rana will tell us whether further treatments in this region will be needed.

The rivers in the Skibotn region were treated in August/September last year. The measure covered the infected Skibotn and Signaldal Rivers, plus the River Balsfjord. Smaller rivers that are closely connected to these infected rivers were also treated. On the basis of their closeness to infected rivers, their size and the possibility of monitoring them, every river that drains into Storfjorden was individually assessed for potential treatment. In the process, the parasite was identified for the first time in the River Kitdalselva.

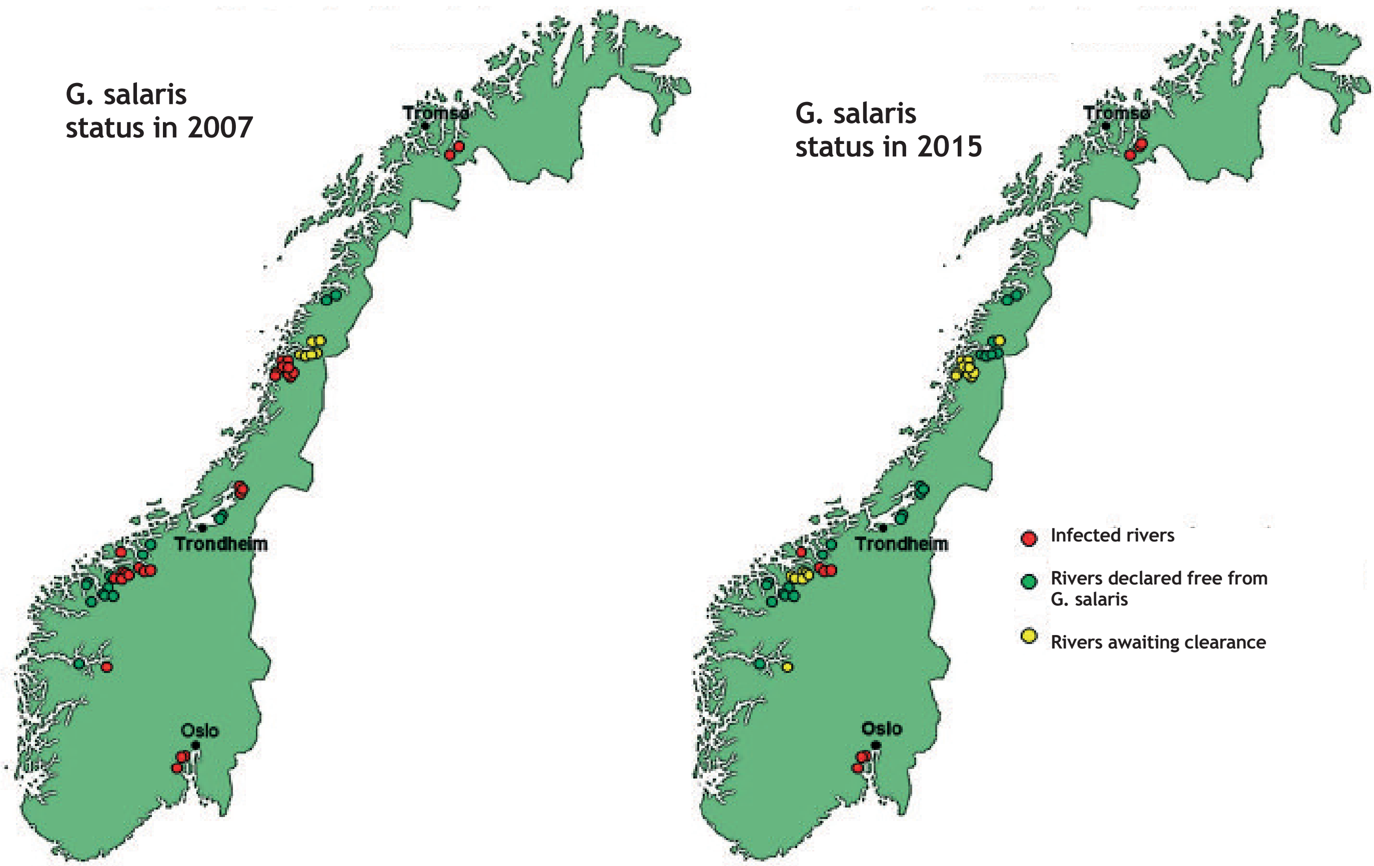
Treatment has now been completed in the Lærdal region in Sogn og Fjordane, Vesfn in Nordland and Rauma in Møre og Romsdal. All three are in the post-treatment control programme to ascertain freedom from infection with *Gyrodactylus salaris*, which requires the rivers to be free from the parasite for five consecutive years after treatment. The infected regions in which treatment not yet has been conducted are the Driva region in Møre og Romsdal and the Drammen region in Oppland, Buskerud and Vestfold. The Norwegian Environment Agency has commenced the construction of fish barriers in Driva. A consortium has been established to investigate the feasibility of implementing measures against *G. salaris* in the Drammen Region. Treatment of these regions will not be implemented for some years yet, and few preparations to that end have been started

Assessment of the *G. salaris* situation

In the course of the past few years, the status of *G. salaris* in Norwegian rivers has changed significantly. Successful treatment measures and subsequent declaration of freedom from *G. salaris* in entire infected regions have reduced the distribution of this parasite in Norway. Infection pressure has been reduced in all rivers that border regions in which treatment measures have been implemented.

Between 2007 and 2015, the treatment of rivers in four infected regions has been completed (Steinkjer, Vefsna, Lærdal and Rauma). Rivers in the Rana region (with the exception of the River Rana, where *G. salaris* was detected in 2014) and the Steinkjer region have been declared free from *G. salaris*. During the same period of time, very few new rivers have become infected. In 2007, 24 rivers had the status of being infected, while six were in the process of being cleared (Rana region). On January 1, 2016, 10 rivers were infected, and six were in the process of obtaining clearance (Figure 1.12).

Figure 1.12 Status of distribution of G. salaris in Norway in 2007 and 2015



The health situation in the gene bank for wild Atlantic salmon

By Åse Helen Garseth

Norwegian salmon stocks possess genetic traits that have enabled them to adapt to local environmental conditions. A number of threats, including the G. salaris *parasite, acid precipitation and escapes of farmed salmon, have led to many local stocks being defined as extinct or threatened. Consequently the Norwegian environmental authorities established a national gene bank programme for wild salmon in 1986, in order to conserve genetic material from threatened stocks. Recently, national gene bank activity has been extended to cover several stocks of sea trout and Arctic charr.*

The live gene bank is a temporary measure that is implemented to protect the most endangered fish stocks until a defined threat has been eliminated. The gene bank supplies roe of local origin for release directly into rivers or to local hatcheries that produce fish for release. There currently exist four gene banks for live fish; Haukvika in Sør-Trøndelag, Hamre and Herje in Møre og Romsdal, and Bjerka in Nordland.

A fifth live gene bank is in the process of being established at Ims in Rogaland. Freezing of milt is another aspect of gene-bank activity. Such material is stored at GENO in Hallsteingård Semen Station in Trondheim. The existing four gene banks house 17 salmon stocks, eight stocks of sea trout and two of charr. When the Ims station opens, a further 20 or so stocks will be brought into the gene bank programme. The gene bank station at Ims is established partly because of aquaculture-related challenges for anadromous wild salmonids in the Hardanger region.

The Norwegian Veterinary Institute is the national centre of expertise for Norway's gene banks and for the restoration of wild salmon stocks, and coordinates their activities on behalf of the Norwegian Environment Agency. The Veterinary Institute has authority to issue instructions regarding the operation of the gene banks and their associated infrastructure. This includes the acquisition of broodfish, releases of different stages of fish, and the collection of data and samples for documentation of the effect of the different measures. These activities are performed in collaboration with central and local authorities, regulators, landowner associations, relevant interest associations and local and central service suppliers.

Health control of wild-caught broodfish

An important aim of the gene banks is to prevent pathogenic organisms entering, multiply and spreading through releases of roe and fish. Of particular importance in this respect are diseases that are transmitted vertically from parent fish to their offspring. Wild-caught broodfish are subjected to health control routines that include post mortem examinations and PCR analyses for the IPN virus and *Renibacterium salmorinarum*, which causes bacterial kidney disease (BKD). Most of the banks have been exempted from the requirement to test for the furunculosis bacterium *A. salmonicida subsp. salmonicida*.

Detection of IPNV or BKD leads to destruction of the spawning products of the infected fish. It is only fertilised roe from broodfish that are free of IPNV and BKD, and without signs of infectious disease, that are accepted by the gene banks. Table 1.7 shows the results of the 2015 broodfish health monitoring programme. This year, IPN virus was identified in a single Arctic charr from Troms County.

In some rivers from which it has been difficult to obtain broodfish for some time, the concept of a "dirty gene bank" can be employed. This involves capturing young fish and bringing them up in a hatchery until they can be used as broodfish. Like fish that are caught as adults, these are subjected to a health control before they are used.

Control of the origin of wild-caught broodfish

All wild-caught salmon broodfish pass through a control of origin routine designed to identify escaped farmed fish. The first step in the control routine involves inspection of the scales, which is performed by the Veterinary Institute. This is followed by a test of the genetic integrity of the fish, carried out by the Norwegian Institute for Nature Research (NINA). The genetic test reveals if the fish have ancestors of farmed origin in their pedigree. Kinship between different fish are also established in order to avoid breeding between closely related individuals.

Table 1.7 Number of wild salmon, sea-trout and charr tested for IPNV and BKD in the broodfish health monitoring programme. The figures are shown by county, and also include results from two ordinary stock enhancement hatcheries. In 2015, IPNV was identified in an Arctic charr from Troms County.

County	Salmon	Sea-trout	Arctic charr	Remarks
Troms	11	80	57	1 PNV-positive charr
Nordland	-	30	-	
Nord-Trøndelag	29	-	-	Of which, 6 relict salmon
Sør -Trøndelag	31	-	-	30 salmon also tested for A. sal.
Møre og Romsdal	-	17	-	“Dirty gene bank”
Hordaland	108	83	-	34 salmon also tested for SAV and A.sal.
Totalt	179	210	57	

The health situation of cleaner fish

By Geir Bornø and Snorre Gulla

*It is increasingly usual in Norwegian aquaculture to use cleaner fish (labrids and lumpsuckers) to rid fish of salmon lice. The most widely used species are the labrids goldsinny wrasse (*Ctenolabrus rupestris*), corkwing wrasse (*Symphodus melops*) and ballan wrasse (*Labrus bergylta*). Lumpsuckers (*Cyclopterus lumpus*) are also widely used, as these remain active at lower water temperatures than labrid fish.*

In recent years, a number of aquaculture facilities for cleaner fish, most of them for lumpsuckers, have been established. Some labrids are still taken in pots or traps during the summer months, and are tranported in deck tanks, on board well-boats or in road tankers, to the fish farms where they are to be used. The longest transports can run from the west coast of Sweden or the Baltic all the way up to Nordland. While most labrids used as cleaner fish are wild-caught (a small proportion of the ballan wrasse are farmed), all the lumpsuckers come from fish farms.

Common diseases and agents in cleaner fish.

Viruses

Previous investigations of wild-caught Norwegian cleaner fish have not detected viral haemorrhagic septicaemia (VHS), infectious pancreatic necrosis virus (IPNV) or nodavirus. Salmonid alphavirus (SAV) has been reported in farms where labrids have shared sea-cages with salmon during an outbreak of pancreatic disease (PD). It has been demonstrated experimentally that lumpsuckers can be infected with IPNV.

Bacteria

Atypical furunculosis, which is caused by the bacterium atypical Aeromonas salmonicida, is one of the most important bacterial diseases of cleaner fish. The bacterium usually causes a syndrone of chronic infection, with granulomas in internal organs (Image 1.5), boils and ulcers. Two genetic strains of the bacterium (A-layer types V and VI) are almost completely dominant in Norwegian cleaner fish.

Image 1.5 Lumpsucker with white granulomas in the kidney due to infection with atypical A. salmonicida (here, A-layer type VI). Photo: Karoline Skaar Amthor, LetSea.

Many species of Vibrio are normal members of the bacterial flora of the marine environment. The bacteria most often isolated from cleaner fish include *Vibrio tapetis, V. logei, V. wodanis* and *V. splendidus*, but the importance of these species as causes of health problems is not yet known. Some strains of *V. tapetis* and *V. splendidus* have been described as being pathogenic in labrids, but more recent research has not convincingly confirmed this claim. It has been speculated that the effects of transportation and living in sea-cages make these fish more sensitive to bacteria that do not normally give rise to disease.

Vibrio anguillarum can cause disease in all species of cleaner fish, while *V. Ordalii*, *Pseudomonas anguilliseptica* and a *Pasteurella* sp. (the last-mentioned being a newly discovered species) have been shown to be pathogenic for lumpsuckers.

In cultivated ballan wrasse, fin-rot is a recurring problem. Tenacibaculum spp. is often found in outbreaks of this disease, as both pure and mixed cultures, while *V. splendidus* is often also found. *Tenacibaculum* spp. has also been identified in other labris species and lumpsuckers.

Cleaner fish are vaccinated against bacterial diseases only to a imited extent.

Parasites

AGD, which is caused by the amoeba *Paramoeba perurans*, has been identified in lumpsuckers, corkwing wrasse, ballan wrasse and other labrids that have shared sea-cages with salmon, as well as in lumpsuckers housed in tanks on dry land. The pathological finding of organs adhering to each other in the gills appears to be similar to that found in salmon.

Gyrodactylus spp. can be found on both the skin and gills of lunmpsuckers. The incidence of *Gyrodactylus* and of the gill damage that these parasites cause has not been mapped. Infections of this sort could turn out to be a problem for fish farming. The state of health of cleaner fish in 2015 is described below, while the welfare of cleaner fish is discussed in the section on fish welfare.

The situation in 2015

Norwegian Veterinary Institute data

In 2015, the Veterinary Institute received 225 samples of material from 166 sites that used cleaner fish. This was a major increase from 2014, when 170 samples from 92 sites were investigated. The main findings, as well as those from previous years, are summarised in Table 1.8. The figures cover both cultivated and wild-caught cleaner fish. In some cases, there was some uncertainty as regards labrid species

Table 1.8 Incidence (number of sites with identified cases) of selected diseases or agents in cleaner fish, studied by the Norwegian Veterinary Institute between 2012 and 2015.

Species	Disease or agent	Number of samples studied (positive sites)			
		2012	2013	2014	2015
Lumpsucker	AGD	0	0	2	2
	Vibrio anguillarum	7	6	8	12
	Atypisk *Aeromonas salmonicida*	1	8	5	51*
	Aeromonas salmonicida subsp. *salmonicida*	-	-	-	1
	Vibrio ordalii	3	4	1	3
	Pasturella sp.	1	16	8	14
	Pseudomonas anguilliseptica	0	0	1	4
Labrids	AGD	0	5	2	2
	Vibrio anguillarum	6	6	6	2
	Aeromonas salmonicida (atypisk)	12	13	16	32*

identification in the field, and some of the material received is therefore identified simply as “labrid” in the summary.

Bacteria

2015 saw a significant rise in the incidence of atypical furunculosis (Table 1.7), particularly in lumpsuckers, where A-layer type VI was identified in 93 percent of the cases of A. salmonicida identified in this species.

In December 2015, *A. salmonicida subsp. salmonicida* (A-layer type I) was also isolated from lumpsuckers, causing elevated mortality in a single diagnosed case in Nord-Trøndelag. The bacterium and clinical changes due to the disease were identified in a number of lumpsuckers in several sea-cages at the same site, but no signs of disease were found in salmon at the same site. Further study of the bacterial isolate may provide evidence that the agent belongs to a strain of typical *A. salmonicida* that occasionally causes disease in wild salmon in nearby rivers (see section on resistance to antibiotics, below, and the chapter: “The health situation of wild salmonids”). Typical *A. salmonicida* causes furunculosis, which is a notifiable disease. This finding makes it clear that lumpsuckers can be receptive to this type of bacteria. The lack of symptoms in the salmon in the same sea-cage, which were undoubtedly highly exposed to the same bacterium, shows that the protection provided by the vaccine is probably good.

Vibrio anguillarum was identified in sick lumpsuckers, ballan wrasse and other incompletely identified labrids. The O1 serovariants were dominant in the lumpsuckers, while O2a and O2a biotype II were also found in a few individual cases. Serotype O1 was identified among the labrids (at a site where lumpsuckers were also infected with serotype O1), and serotype O2 was also found in a number of cases, as were some other isolates that could not be serotyped. A wide range of *Vibrio* species (*Vibrio tapetis, V. logei, V. wodanis* and *V. splendidus*, and another Vibrio species), as well as *Tenacibaculum* spp. were frequently isolated from cleaner fish, although usually in the form of a mixed flora on the basis of which it was difficult to make reliable diagnoses.

A Pasteurella sp. was diagnosed in lumpsuckers from 14 different sites, *V. ordalii* from three sites and *Pseudomonas anguilliseptica* from four sites in 2015.

Sensitivity to antibacterial medicaments in cleaner fish aquaculture

Antibiotic treatments, for example with oxolinic acid and florfenicol, may be necessary when we are dealing with cleaner fish. To date, relatively few concrete signs of the development of resistance among clearer fish pathogens have been found. Many bacteria have different degrees of “natural” resistance to one or more types of antibiotic. Even closely related bacteria may display different degrees of sensitivity, without this necessarily being the result of natural selection through treatment with antibiotics.

In 2015, we registered a number of isolates of *V. anguillarum* serotype O1, particularly in lumpsuckers (from several different regions). These appeared to be less sensitive to quinolone antibiotics than other *V. anguillarum* serotypes that we have investigated recently. Our interpretation of our findings is that they probably represent “natural” reduced sensitivity in these strains, and the effects of any treatment with quinolones in such cases cannot be predicted.

Reduced sensitivity to quinolone antibiotics has been demonstrated in *A. salmonicida subsp. salmonicida* in sick lumpsuckers that had been kept together with salmon in the Namsenfjord area. The salmon with which the lumpsuckers had been held displayed no signs of disease. It can therefore be assumed that the infection originated from wild salmon in the same area. This strain of bacteria (with its reduced sensitivity to quinolone antibiotics), has been isolated from wild salmon in the same area of a period of several years. The reduced sensitivity has not recently been linked to antibiotic treatment (see chapter: “The health situation of wild salmonids”.

Viruses

No virus infections were identified in the Veterinary Institute's cleaner fish material in 2015.

Parasites

AGD, which is caused by the parasitic amoeba *Paramoeba perurans*, was found in ballan wrasse, corkwing wrasse and lumpsuckers in 2015, when alterations compatible with a diagnosis of microsporidia were also identified in lumpsuckers.

Sporadic occurrences of ectoparasites (*Trichodina* sp. and other ciliates on gills) were identified, but these were not linked to major health problems. Infestations of nematodes (probably *Hysterothylacium aduncum*) in the abdominal cavity and internal organs are also normal findings in wild-caught goldsinny wrasse. Histopathological alterations were also found in 2015 that give rise to a suspicion of other parasite problems in cleaner fish.

Fungi

A suspicion of infections caused by *Ichthyophonus hoferi* on lumpsuckers with damaged gills, musculature and spleen was reported on a single occasion in material sent to the Veterinary Institute in 2014. In 2015, an Exophiala sp. fungus was identified on a single lumpsucker sample.

Data from the 2015 survey

The questionnaire survey revealed that nodavirus is regarded as the most feared disease of farmed labrids and lumpsuckers. In labrid hatcheries, infections of various *Vibrio* bacteria (vibriosis) and fin rot are relatively serious problems. Atypical furunculosis and pasteurellosis are regarded as problems of various degrees of seriousness. We can observe a similar trend in lumpsucker hatcheries.

Mortality in cleaner fish

Mixed feedback has been received regarding mortality in cleaner fish in general, but there is general agreement that lumpsucker mortality figures were significantly higher in the second half of 2015 than in previous years. Bacterial problems appear to present the greatest challenge as regards mortality in lumpsuckers and other cleaner fish, but vaccinations and vaccination routines, shelter and feeding routines also appear to be of significance.

Assessment of the cleaner fish situation

Cleaner fish are growing in importance, and in recent years there has been an enormous rise in the production of labrids, and even more so of lumpsuckers. The number of samples of material submitted to the Norwegian Veterinary Institute has significantly increased, particularly where lumpsuckers are concerned, as these doubled between 2014 and 2015.

This trend may reflect both the increasing use of lumpsuckers in aquaculture, and that we face distinct challenges regarding the health of these species. These are particularly serious where bacterial diseases are concerned, although parasite diseases also appear to have effects on the health of cleaner fish. Virus infections do not appear at present to play a significant role in the health of cleaner fish. In 2015, VHSV was identified in lumpsuckers at an Icelandic onshore site that had used wild broodfish, which shows that this practice brings its own risks.

Irrespective of which infectious agent is involved, good cleaner fish health and welfare (for example via good feeding regimes, provision of shelter and minimal and gentle handling) probably contribute to a certain extent to reducing the problem of infectious diseases. The vaccination of farmed cleaner fish against certain bacteria is a relatively recent measure, so we currently lack sufficient information to draw any conclusions regarding its effects.

Many unsolved problems regarding cleaner fish remain, both during the fry phase and after they have been released into sea-cages, and there is a need to build up better knowledge about the health and welfare of these new aquaculture species

The health situation among farmed marine species

By Hanne K. Nilsen

This chapter provides an overview of the health situation of other marine species in aquaculture.

Cod

Cod farming is significantly reduced in scope, and fewer companies remain active in Norway in 2015. Many facilities that were originally set up to produce cod are now used for cleaner fish production. Most of the registered volume of production actually consists of wild-caught cod kept in live storage.

Halibut

Production of halibut for the table takes place in both shore-based facilities and sea-cages. Halibut require deep sea-cages with shelves that provide large areas on which the fish can lie. Shore-based RAS facilities now exist, in which halibut can spend their entire life-cycle until they are ready for harvesting.

The situation in 2015

Norwegian Veterinary Institute data

Cod

In 2015, we received five submissions of material from three sites that held cod, the same number as in 2014. In the 2009 peak year, the corresponding figure was above 350, from more than 85 different sites. Typical findings in such material have been inflammations of the gills caused by *Trichodina* spp., and a number of gill-cysts.

Francisellosis, which is caused by *Francisella noatunensis, subsp. noatunensis,* was not found in 2015.

Halibut

In 2015, we received 34 submissions of material from 11 halibut farms, which was rather more than in 2014. Typical findings included infections of atypical *A. salmonicida* in early life stages. Other results included gill problems of various degrees of seriousness, with findings of "costia" and *Trichodina* spp. Infectious pancreatic necrosis (IPN) was identified in small fish at two sites during the summer. Various Vibrio species, such as *V. logei* and *V. splendidus* are frequently found in samples of halibut. At one site, myxosporidians were found in connection with high mortality. Nodavirus was not found in 2015.

Data from the 2015 survey

Cod

The questionnaire survey revealed that vibriosis and francisellosis are regarded as the most serious diseases of cod. Atypical furunculosis and *Tenibaculum* sp. infections were ranked third and fourth respectively in seriousness.

Halibut

The questionnaire survey reported that in general, few health problems have been observed, and mortality was at about the same level as in the previous year. Vibriosis, IPN and atypical furunculosis were the three most important diseases, but eye-snapping and ulcers/finrot were also mentioned as problems of health.

Sensitivity to antibacterial medicines in the aquaculture of marine species

Antibiotic treatments using, for example, oxolinic acid or florfenicol, are occasionally necessary in the aquaculture of marine species. Findings of reduced sensitivity of *V. splendidus*-like bacteria to quinolones are common, and can be explained in terms of natural resistance in this group of bacteria.

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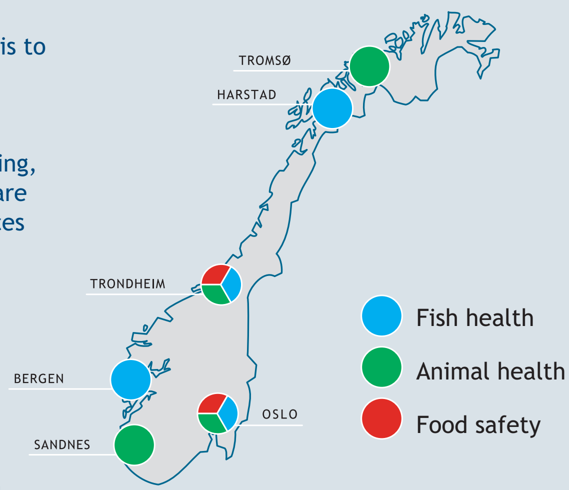

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