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Best Practice for Diagnosis and Management of Piscirickettsiosis

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Best Practice for Diagnosis and Management of Piscirickettsiosis

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Introduction

Piscirickettsiosis, also known as salmonid rickettsial septicaemia (SRS), is a systemic infection caused by the facultatively intracellular Gram-negative, gamma-proteobacterium *Piscirickettsia salmonis.* This bacterium can survive/persist for at least 50 days under suitable marine environmental conditions and is capable of forming viable and mucus-tolerant biofilms on non-living surfaces (Marshall et al. 2012, Rozas & Enríquez 2013). Although primarily infecting salmonid species farmed in the sea*,* infections and clinical disease caused by *P. salmonis* (or possibly *P. salmonis*-like bacteria), have been reported in other marine fish species including lumpfish (Marcos-López et al. 2017), sea-bass species in both the Atlantic and Pacific Oceans (Comps et al. 1996, Chen et al. 2000) and turbot (Nilsen et al. 2026), with bacterial detections in other wild fish species recorded (Schober et al. 2023). While piscirickettsiosis has been detected in Atlantic- and Pacific- salmon species in most salmon-producing countries including New Zealand (Brosnahan et al. 2017), Australia (Corbiel et al. 2005) Canada (Brocklebank et al. 1992), Ireland (Rodger & Drinan 1993), Scotland (Grant et al. 1996) and Norway (Olsen et al. 1993, Olsen et al. 1997), the severity of the infection experienced varies significantly across different geographic regions. In Chile, piscirickettsiosis is considered the most important infectious disease in salmon farming, responsible for approximately half of all infection-related mortality and over 90% of antibiotic use in seawater salmon farming (Sernapesca 2026). Its clinical significance has been lower in the Northern Hemisphere, but it is considered a major threat in Irish salmon farming and, to a lesser but increasing extent, in Scottish farming (Rodger et al. 2025). The disease was detected at many sites in Norway in the late 1980s and again in 2002 (Fig. 1). Over the past 20 years in Norway, with the exception of 2024 when at least seven outbreaks were experienced, piscirickettsiosis has only been detected sporadically.

An element of the PisciNor project, funded by the Norwegian Seafood Research Fund (FHF project no. 910068), was to investigate the status of piscirickettsiosis in the North-East Atlantic area and review the state of the art and current practices regarding prevention, diagnosis and management of piscirickettsiosis in the region. Further, the study was to cover commonalities and contrast with the situation in Chile where the industry and research infrastructure has many years' experience of working with piscirickettsiosis. The findings in this report are based on information gathered from available scientific and grey literature, publicly available data, diagnostic laboratory data, interviews and surveys with farming staff, fish health workers, diagnosticians and government agencies in Norway, Ireland and Scotland and incorporated findings from a Chilean survey on the same topic carried out by Bustos et al. (2025). The study was undertaken during February to May 2026. The farmed fish populations from which data was collected included fish at sea during 2024 and 2025 in Ireland, Norway and Scotland. Within Norway the farming companies contacted were those who experienced detections in 2024. Additional details were also provided for the Australian situation through communications and meetings with farming companies, veterinarians and government bodies.

Genetic diversity amongst *Piscirickettsia* spp.

Although an early study of Irish, Scottish and Norwegian SRS cases indicated geographical differences between the organisms involved (Reid et al. 2004) there has as-yet been no unifying whole-genome based comparison of *P. salmonis* representatives from North Atlantic countries. There has, however, been a gradual increase in evidence indicating considerable diversity within isolates pathogenic for fish belonging to or closely related to this bacterial species worldwide (Isla et al. 2019; Schober et al. 2023). While the Chilean situation is dominated by two genomovariants i.e. LF-89 and EM-90 (Table 1), Schober et al. (2023) identified significant genetic differences between these strains and isolates from Norway and the Pacific northwest coast of Canada, which grouped together into the 'NC' cluster. While *Piscirickettsia* isolates from Australia and New Zealand (Jauregui et al. 2025) have been whole-genome sequenced, they do not yet appear to have been placed in a phylogeographical context.

Although yet to be strictly confirmed, a new *Piscirickettsia* variant, putatively representing a new species, related to, but genetically different from *P. salmonis*, has been identified (Rodger et al. 2025) in Ireland and Scotland. This bacterium, involved in recent Irish and Scottish outbreaks has not been officially named but is currently referred to as '*Piscirickettsia nova'* (Teigene et al. 2025). Although only recently discovered, this bacterium has been found to be widely present amongst Irish and Scottish farmed salmon sampled between 2020 and 2025, and is associated with a disease highly similar, if not identical, to piscirickettsiosis caused by *P. salmonis*. This bacterium is currently the most frequently detected species from clinical SRS cases in Ireland and Scotland, although *P. salmonis* is also present in Scotland (Teigene et al. 2025). It is not yet known whether '*P. nova*' is present in Norway.

Table 1. *Piscirickettsia* spp. (& genotype where known) by country

***Piscirickettsia* spp. (& genotype)**	**Country**				
	Chile	**Ireland**	**Norway**	**Scotland**	**Australia**
P. salmonis	Yes (EM90 & LF89)	Yes	Yes (NC)	Yes	Yes
P. nova	No	Yes	No	Yes	unknown
Piscirickettsia sp. (TRLOs)#			No		Yes (3 serovars)

Tasmanian Rickettsia-like Organisms

Prevention & history

Methods to limit the impact of piscirickettsiosis include improved biosecurity, use of vaccines, genetic-based selection for tolerance or resistance, regulatory measures and improved fish husbandry. A brief history and the application, or otherwise, of preventative methods is reported from surveys for Ireland, Norway and Scotland and compared to status in Chile.

Norway

History

A new disease, with particularly characteristic liver pathology, was diagnosed for the first time in Norway in the autumn of 1988. The disease was then called necrotic hepatitis in salmon (NHL) and was observed along the coast of Western and Mid-Norway with 36 cases, all in Atlantic salmon, diagnosed that year. Most cases were in post-smolts (between 80 to 600g size) between August and December following transfer to sea in the spring. Some cases registered the following spring were also considered likely to have started the previous year. The disease was also seen in adult salmon of approximately 3 kg, and a few cases were identified in fry or parr after the introduction of undisinfected seawater to hatcheries. The associated mortality was usually low. Some farms experienced moderate to high cumulative mortalities with a few farms experiencing very high mortalities (30 to 40 %) in the most affected pen. In the cases of higher mortality, usually other diseases or harmful events

contributed, such as IPN, furunculosis, gill disease, organophosphate-based sea lice treatment etc. Disease was occasionally detected at water temperatures of 8 to 9 °C or lower. In 1988, a harmful algal bloom of *Gyrodinium aureolum,* now reclassified as *Karenia mikimotoi,* and/or *Ceratium furca* may have contributed to or been an indication of favourable conditions in the marine environment for the bacterium that year (Dahl & Tangen 1990). Of note were the large numbers of amoebae e.g. *Oscillosignum* sp. (now *Vexillifera* sp.) observed feeding on the algae. Overproduction of smolts in 1988 may also have been a contributing factor to the outbreak as many producers held elevated stocking densities in marine pump-ashore facilities or utilised temporary marine sites. As a result, many fish were reported to be feeding on marine copepods. Following 1988 the disease was only sporadically seen until 2002, when a relatively large number of farms (17) on the West coast were affected (Fig. 1). The record warm dry summer that year, with water temperatures of 18 to 20°C, is considered likely to have contributed to the 2002 outbreak.

Until 2024, all cases of piscirickettsiosis in Norway occurred along the coast of West and Mid-Norway (Rogaland-Trøndelag). However, the situation in 2024 involved a number of salmon farms in the North of the country (Holm et al. 2025). This, combined with the recent identification of piscirickettsiosis in farmed turbot (Nilsen et al. 2026) in the South of the country, gives cause for concern, particularly in light of the worsening situation and the probable presence of a novel species of *Piscirickettsia* in neighbouring countries, combined with generally increasing water temperatures.

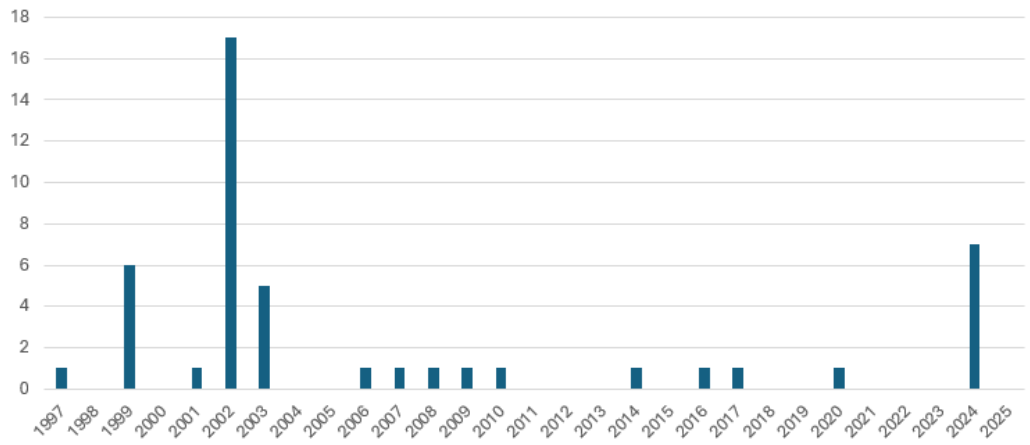

Figure 1. Confirmed piscirickettsiosis diagnoses in Norwegian salmon farming 1997 to 2025.

Biosecurity & improved fish husbandry

Reports from farms and fish health professionals indicate that movement of infected fish and transmission involving suboptimally cleaned and disinfected well-boats were suspected. Transmission via water currents could not be excluded as clusters of farms were affected, but a more widespread marine reservoir was also suspected. Intake of undisinfected or suboptimally disinfected seawater to hatcheries was not uncommon in 1988 and would have been a biosecurity weakness which was addressed when regulations were introduced in 1989 relating to disinfection of seawater intake.

Risk factors for piscirickettsiosis in Norway have been considered to include the following:

- Smolts/fish in poor condition
- High fish densities
- Underfeeding
- Other diseases

- Stressful events
- Poor water flow through the farm
- High water temperature
- Algal blooms
- Time of year (autumn)
- Infected fry/parr/smolt from a hatchery/smolt producer with suboptimal disinfection of sea water
- Having had a history of piscirickettsiosis on the site or in the area

Vaccination

Piscirickettsiosis is not currently vaccinated against in Norwegian aquaculture.

Genetics

There has been no focused genetic selection program for piscirickettsiosis in Norway.

Regulatory legislation

Piscirickettsiosis was a listed disease (Group B) in Norway between 1992 and 2007. Suspicion or confirmation of piscirickettsiosis on a farm qualified for imposition of operational restrictions during that period.
Restrictions placed on affected farms by the authorities during this period included:

- Movement of fish to other locations was not permitted
- It was not permitted to increase the population on the farm
- Affected hatcheries: Stamping out of affected tanks, not allowed to transfer fish to sea
- Cage sites: Rarely/in case of significant mortalities- stamping out of positive cages or whole farm
- Sanitary slaughter
- Not allowed to keep the fish in sea cages at the processing plant awaiting slaughter
- Prolonged fallowing
- Not allowed to use affected populations as brood fish
- Compulsory disinfection of seawater to hatcheries (by law since 1989)

Piscirickettsiosis was officially relisted as a Category G notifiable disease in June 2025, and three suspected cases were reported that year but not confirmed (in Northern production areas 8 and 9). The overall aims of Category G listing are 1) surveillance of infectious diseases that have potential for serious negative consequences for fish health and 2) surveillance of established serious infectious diseases. There are no operational restrictions related to notification of Category G diseases.

Ireland

History

The salmon aquaculture industry in Ireland is comparatively small with between 20 to 22 marine salmon sites operating per annum (five farming companies in the Republic and one in Northern Ireland). Piscirickettsiosis was first described in one farm in 1991, which presented with low level (<3 % cumulative losses) SRS-related mortalities (Rodger & Drinan 1993). Until 2021/2022, SRS remained a sporadic disease affecting only two to three sites every two to three years with typically low-level mortalities. Since 2021/2022 the situation has, however, deteriorated significantly to the current situation where 95% of the marine sites (including North-West, West and South-West regions) have been affected. During 2024 and 2025 cumulative SRS-related mortalities ranged from <5 % to >25 % per annum (Rodger et al. 2025). The high-risk period for disease is from June to October. Clinical signs vary, with some mortalities exhibiting few or no external signs while internally displaying signs consistent with a bacterial septicaemia (see Diagnosis section). Oral antibiotic treatments with either florfenicol or oxytetracycline may be required for all fish on an affected site, and treatments have been extended in time or require a second treatment (in such a case with the alternate active ingredient). Withdrawal times for

residues after treatment can however be lengthy, especially with oxytetracyclines and will determine whether treatment is an option.

Biosecurity & improved fish husbandry

Biosecurity risk factors that have been previously identified by fish health professionals and vets include the physical proximity of different fish generations, detection by PCR of *P. salmonis* in farm equipment (some cleaned and disinfected), vessels, clothing and planktonic organisms e.g. *Apolemia*. Farmed lumpfish (to be used as cleaner fish) were affected by piscirickettsiosis in one land-based site in 2015, prior to any contact with farmed salmon (Marcos-Lopez et al. 2017), but there have been no further detections of the pathogen or the disease in cleaner fish in Ireland. There was concern on several sites that reuse of uncleaned tarpaulins for bath treatments represented a biosecurity risk. In addition, the use of older well-boats or treatment vessels, which can be more challenging to access for cleaning and disinfection, are considered of higher risk for pathogen transfer. One farm noted the observation that they experienced SRS for the first time the year they first used wild cleaner fish (Ballan wrasse). The wrasse were not, however, screened for the bacterium. All sites utilise a fallow period, normally 2 to 3 months, although not all water bodies e.g. bays, lochs or fjords, had all sites fallowed synchronously. There were concerns that under-pen sediments in the shallow sites may hold reservoirs of *P. salmonis* following an outbreak, but this remains to be tested. One company had instituted PCR screening of recent mortalities or moribund fish for *Piscirickettsia* spp. every two weeks during the warmer months and were pursuing the use of functional feeds and minimising handling during the high-risk periods. Bath treatments (medical delousing or freshwater for AGD) were seen as risk factors for triggering SRS outbreaks. Improving mortality classification into stricter categories is one aim in the industry to more accurately give results on cause/s of livestock losses, timing for treatment, efficacy of treatments, vaccinations, etc.

Vaccination

Vaccination was performed (inactivated bacterial cells, autogenous) in a low number of sites and stocks in 2024, and in 2025 all autumn smolts (S0s) transferred to sea were administered with autogenous vaccine. In terms of efficacy, veterinarians in Ireland consider this vaccine to score between a 1 and 2 (score range 0 to 4, with 0 being no effect and 4 being very effective). While vaccination does not prevent disease, it does appear to prolong the period between first detection of *Piscirickettsia* spp. and a clinical outbreak on a site by several weeks.

Genetics

There has been no focused genetic selection program for piscirickettsiosis in Ireland.

Regulatory legislation

Piscirickettsiosis is not a notifiable disease in Ireland. In instances of elevated or unexplained mortality, the first step is to contact the company's designated private veterinary practitioner for assessment. If the cause of mortality remains undetermined following veterinary evaluation, the Fish Health Unit of the Marine Institute should be notified via email at notification@marine.ie .

Scotland

History

The first cases of piscirickettsiosis in Scotland in farmed salmon were observed in two sites on the west of mainland Scotland in 1995 (Grant et al. 1996) and presented with low level mortality (including splenomegaly and encephalitis). Similarly to the early Irish situation, only sporadic cases were observed with very low-level clinical impacts and this only every two to three years (Birrell et al. 2003). Historically, cases were reported on the West coast of mainland Scotland and Northern Isles (Orkney). However, since 2019 there has been a significant increase in the number of sites in which *Piscirickettsia* spp. have been detected. These cases have been associated with increased mortality and antibiotic treatment has frequently been considered necessary.

One farming company attributed 71% of mortalities at sea in 2024 to SRS. Between 2023 and 2025, *Piscirickettsia* spp. were detected in >25 marine sites, with the majority exhibiting clinical signs of SRS. Most of the clinically affected sites were located on the West coast of mainland Scotland and the Outer Hebrides. The most severe outbreaks occurred in southerly locations and were associated with relatively high sea temperatures in the late summer/early autumn. There have been detections in the Northern Isles, but clinical disease has not been reported in recent years. The peak season for clinical SRS is from August to December. *P. salmonis* was detected in marine farmed rainbow trout in Scotland in 2023, but no clinical signs of SRS were observed. There were no detections in this rainbow trout site in subsequent years, despite the close presence (1 to 2km) of SRS affected salmon sites. *P. salmonis* has also been detected by PCR and culture in ballan wrasse (cleaner fish) in a small number of salmon farm sites. Affected wrasse exhibited clinical signs (and histopathology) of general septicaemia (no other pathogenic bacteria were detected by PCR or culture). It is not established whether infected wrasse act as a transmission vector to salmon. In salmon, oral antibiotic treatments have been used when clinical signs are present, and mortalities are elevated above selected trigger levels (where established). Bath treatments (medical delousing or freshwater for AGD) as well as mechanical and thermal delousing procedures were considered a risk for triggering SRS outbreaks with increased reuse of freshwater of most concern.

Biosecurity & improved fish husbandry

Biosecurity risk factors identified in the survey include use of contract divers, reuse of bath water for immersion treatments in well-boats, lack of management options regarding gill disease and environmental stressors, in particular hydrozoan swarms (*Muggiaea* spp., *Apolemia* spp.) and harmful algal blooms. Several farms consider SRS secondary to primary gill disease or plankton damage. Movement of infected fish and vessels between sites has been identified as a risk.

Recommendations for fish farmers in Scotland to minimise risks of piscirickettsiosis include:

- Smolts should be in good condition
- Optimal fish densities
- Do not underfeed to avoid the fish grazing on algae and copepods
- Remove sick fish
- Increase frequency of removal of dead fish to twice daily
- Avoid stressful events
- Avoid other diseases
- Localities with good water flow
- Awareness of direction of currents within and between the farms
- Antibiotic treatments when required
- Continuous health monitoring, including routine autopsy of ‘normal’ mortalities

Vaccination

There has been very limited use of vaccine (live attenuated) in salmon under special import permit in 2025, however, there are no details on efficacy, although there are reports that efficacy is reduced when this vaccine is administered when water temperatures are lower than 9°C (Olsen et al. 2024).

Genetics

There is funded research (SalmoStrong, https://www.ukri.org/news/new-bbsrc-prosperity-partnerships-set-to-boost-uk-bioinnovation/) to improving the genetics of tolerance to diseases such as piscirickettsiosis in farmed salmon in Scotland which is on-going and will continue until 2029.

Regulatory legislation

Piscirickettsiosis and *P. salmonis* are not notifiable in Scotland and there are no restrictions regarding movement of affected fish.

Australia

History

The first cases of piscirickettsiosis-like disease in farmed Australian salmon were observed in Tasmania in 2001 (Corbeil et al. 2005) and appeared as a chronic condition with low level impacts for many years. These rickettsial-like organisms (RLO) were confirmed to be related to *P. salmonis* but were not identical and three genomovars have been highlighted associated with specific geographical areas in Tasmania (Morrison et al. 2016). However, in 2024 and 2025 elevated mortalities and an increased need for antibiotic treatments due to piscirickettsiosis were widely reported. Treatment, primarily with oral oxytetracycline, and more recently florfenicol, has assisted with disease control, although treatment failures are also observed.

Biosecurity & improved fish husbandry

Biosecurity controls outlined in the Biosecurity Program: Tasmanian Salmon Industry (2023) https://nre.tas.gov.au/Documents/Biosecurity%20Program%20Tasmanian%20Salmonid%20Industry.pdf prevent movement of salmonids from marine to freshwater environments and between marine sites.

Vaccination

A vaccine has been developed for the Tasmanian industry which includes the Tasmanian RLO and is widely used. Efficacy of the vaccine is reported as providing average to moderate protection (scoring 2 to 3, score range 0 to 4, with 0 being no effect and 4 being very effective).

Genetics

Genetic selection for resistance to piscirickettsiosis is being actively assessed for salmon in Tasmania.

Regulatory legislation

The presence of *P. salmonis* is confirmed in Tasmania and piscirickettsiosis is not presently notifiable as it is considered endemic as historical investigations indicate the bacteria may have been present since at least 2021 https://nre.tas.gov.au/Documents/Piscirickettsia%20salmonis%20Information%20Sheet.pdf .

Chile

SRS outbreaks in Chile are often reported following fluctuating sea temperature, an algal bloom, or other environmental stressor such as a delousing bath. SRS mortality has a strong seasonal component, with mortalities significantly higher in warmer months and in the presence of lice infestations (Arriagada et al. 2019, Diethelm-Varela et al. 2025). In Chile, piscirickettsiosis is mitigated through improved biosecurity and fish husbandry, regulation, surveillance, mandatory vaccination, selective breeding, and antibiotic use. It remains, however, a significant challenge for salmon farming with estimates of costs attributed to the disease of over $700 million per annum, associated with quality downgrades, loss of market, loss of growth, mortalities, costs of treatment, vaccines, mortality disposal, etc. (Aquabench 2025). It is considered that SRS is the main driver of antibiotic use in aquaculture in Chile. Treatment failure is reported, possibly due to the development of antibiotic resistance, although other factors may be involved. Resistance to two of the main antibiotics used to treat SRS in Chile (oxytetracycline and florfenicol) was not identified in a recent comprehensive analysis (Schober et al. 2023). As the bacteria survive inside salmon cells, antibiotic treatment is often ineffective, making early diagnosis essential for effective operational management. Piscirickettsiosis affects Atlantic salmon and rainbow trout most severely, while coho salmon are more resistant in the (warmer) regions of Los Lagos and Aysén. The disease is rare or sporadic in the southerly (colder) Magallanes region. The main route of transmission is horizontal, and the agent can enter through skin and gills (Smith et al. 1999) and coinfections with different genogroups can

occur at a single sea-sites, although this is of very low frequency. Currently, coinfection with *P. salmonis* and *Tenacibaculum* spp. is common, which has some impact on the control of one or both diseases.

Biosecurity & improved fish husbandry

The strongest determinants of piscirickettsiosis prevalence in Chile have been shown to be the proximity to infected sites (Rees et al. 2014), the number of infected farms in upstream waters and the severity of disease (total mortality) in these, followed by seawater salinity and temperature (Bravo et al. 2020), with higher prevalence above 9 °C at week 36 post-transfer or above 15 °C at week 41. In addition to vaccination, genetics and legislatory regulation (see below), good farming practices and improved biosecurity have proven vital to reduce impacts of SRS with maintenance of net-pen cleanliness, reduced ongrowing period at sea, daily mortality/moribund removal, effective lice control, accurate mortality classification, effective predator (sea lion) control and high standards of smolt quality all priority areas (Bustos & Mancilla 2025). Metaphylaxis, or treatment of the whole site when diagnosed in a single pen, and use of functional feeds have also been applied with some success to the management of SRS in Chile. Early treatment has proven critical, due probably to declining appetite associated with late initiation of antimicrobial therapy (i.e. at weekly mortality $\geq$0.03 % compared to $\leq$0.01 %). The latter is identified as a risk factor for a negative outcome (Gaete-Carrasco et al. 2026). Further, salmon transferred to sea in the autumn in Chile are at higher risk of early SRS (Gaete-Carrasco et al. 2026). Disinfection with peracetic acid, peroxides and chlorine dioxides demonstrated good efficacy in inactivating *P. salmonis* in a laboratory comparison of 36 disinfectant types (Muniesa et al. 2019).

Vaccination

Vaccines have been in use for SRS for over 20 years in Chile but have less than adequate long-term efficacy. Inactivated antigen, recombinant and live attenuated injectable oil-based forms are in commercial use with experimental oral and immersion forms also developed (Figueroa et al. 2022, Rozas-Serri 2022). Genotyping has been an important issue related to vaccine development, genetic resistance programs, and antibiotic treatment. While the majority of commercial vaccines are based on the EM-90 genogroup, LF-89 has been the predominant genogroup in Chile in recent years.

Genetics

Genetic and genomic selection has been applied for resistance to piscirickettsiosis in Chile and a significant heritability ($h^2 = 0.43$) has been demonstrated (Correa et al. 2015, Moraledo et al. 2021). In addition, coinfections with *Caligus* sealice (*C. rogercresseyi*) and *P. salmonis* have shown salmon are more susceptible during coinfections but that resistance to coinfections is also a heritable trait (Lhorente et al. 2014).

Regulatory legislation

Vaccination against piscirickettsiosis is mandatory in Chile. It is also now mandatory that samples relating to the first detection of *P. salmonis* in a farm site population should be forwarded to the appointed national reference laboratory to establish the genogroup/s involved in each case (Sernapesca 2026). Routine surveillance by PCR (30 fish) is required to be undertaken no more than 30 days before transfer of fish to sea and must be carried out by a laboratory registered with Sernapesca. When 30 days have lapsed after the last fish have been transferred to sea another 30 fish must be tested, and this is repeated every 30 days if tested negative (with reduced sampling requirements for colder regions (Magallanes). Farm sites and diagnostic laboratories must notify the authorities of positive piscirickettsiosis diagnoses. Sites with confirmed detection of *P. salmonis* are categorized according to mortality level with different control measures applied i.e. if a site has 50 % or more of its pens with a weekly piscirickettsiosis associated mortality rate >0.35 % it is classified as a high dissemination center (CAD) and following 6 weeks if this situation remains in more than 25 % of pens then early harvest will be required (Sernapesca 2026). Farms can be permitted to split pens once only during the production cycle. Further measures include implementation of a voluntary management plan, utilising defined sanitary management

practices in farming sites with confirmed piscirickettsiosis and/or associated mortality. Rigorous verification and certification ensure these procedures do not affect mortality statistics or the regulatory implications entailed.

Survey of farms in Ireland, Norway & Scotland 2026

A questionnaire-based survey was undertaken of farms and companies through interviews and direct questionnaire with farming staff, fish health workers, farm company veterinarians, fish vet service providers and diagnosticians in Norway, Ireland and Scotland. The study was undertaken February to May 2026. The farmed fish populations from which data was collected included fish at sea during 2024 and 2025 in Ireland, Norway and Scotland.

Data and information were compiled from 14 farming companies, covering 223 marine sites of Atlantic salmon (or rainbow trout) during 2024 and 2025 in Ireland (12), Norway (105) and Scotland (106), including both SRS -positive and -negative farms. In addition, monthly mortality data for farm sites in Scotland was obtained from the publicly available Salmon Scotland website https://www.salmonscotland.co.uk/. PCR cycle threshold (Ct) values for *Piscirickettsia* spp. detections for the Scottish sites were obtained from the PatoGen AS database for 2024 and 2025.

Salmon sites in all three countries had experienced *Piscirickettsia* spp. detections in 2024 and 2025. No detections were made in rainbow trout sites during the study period. In positive farms (Scotland, where data available), no correlation (r = -0.15) could be identified between *Piscirickettsia* spp. PCR Ct value and percentage mortality. This was in contrast to experiences from Chile (Bustos, personal communication). This may reflect lack of detail in mortality data in Scotland. Mortalities were not significant in any site with *P. salmonis* infection in Norway during the study period and site level mortality data was not available for Ireland. In clinical cases (including all three countries) the mean size of salmon affected was 1.1 kg (range 0.2 to 2.2 kg) at a stocking density of 5.1 kg/m^3 (range 1.8 to 10 kg/m^3) and water temperature of 13.9 °C (range 9.5 to 17 °C). The mean duration of a clinical outbreak was 13 weeks (range 4 to 26 weeks) including antibiotic treated and untreated fish. SRS outbreaks (including some co-infections with other diseases) were often reported as closely following delousing or amoebic gill disease bath treatments or after exposure to harmful cnidarians (hydrozoans).

Diagnosis

Presumptive diagnosis of piscirickettsiosis is undertaken by fish health professionals or veterinarians in all regions and is based on a combination of clinical signs, history and post mortem findings (which can include cytology or microscopy of stained tissue or blood smears for intracellular bacteria), with laboratory tests for confirmation which can include qPCR, histopathology (including immunohistochemistry) and bacterial culture. ELISA, IFAT and cell culture have also been used in the past but are not now routinely used in any country. Loop-mediated isothermal amplification (LAMP) assays for *P. salmonis* have also been developed.

Clinical signs and post-mortem findings

In Ireland and Scotland, the clinical signs in salmon can include lethargy, anorexia, exophthalmia, nervous signs (spiral or abnormal swimming), skin colour change (increased melanisation), as well as skin lesions which initially may appear as haemorrhagic or pale patches, later becoming ulcerated (Fig. 2). Haemorrhagic lesions in the skeletal muscle, partly visible as skin blisters (cranial in many cases), and large ulcerative lesions on the peduncle are examples of less common presentations. External signs may be absent in some fish and, internally, gross pathological findings can include ascites, splenomegaly, cream-coloured patches (which in some may be ring-shaped) on occasionally yellowish livers, pale swollen kidneys, mucoid gastrointestinal contents as well as haemorrhage in visceral organs, peritoneum, brain and skeletal muscle. In more chronic cases a diphtheritic membrane may be apparent on the spleen and liver. Gills can appear pale with packed red blood cell (PCV) levels of 2 to 20 % in moribund fish indicating a significant anaemia. Meningeal haemorrhages have also been observed.

Figure 2. External ulceration commonly associated with *Piscirickettsia* infection (photo: H. Rodger)

In Norway, clinical behavior has included sluggish swimming near the surface combined with poor appetite, and symptoms indicating nervous disturbance (spiral swimming etc.). Otherwise, two differing main gross pathological manifestations have been observed:

1) Often no external signs. The fish had a liver of normal colour with well-circumscribed, white, circular foci of varying size up to 5-6 mm in diameter. The centre of the foci was typically raised above the surface of the liver and contained either central or peripheral haemorrhaging. A dark and enlarged congested spleen was also observed.
2) The fish had pale gills due to anaemia (haematocrit of diseased fish 6 to 30 %) and haemorrhages were scattered throughout the skeletal musculature, perivisceral fat, stomach wall and swimbladder. The liver was typically yellow-green and 'crispy' with white, occasionally haemorrhaged spots. Clear or haemorrhagic fluid in peritoneal and heart cavities was present and spleen and kidney were swollen. Small, white foci could be seen in internal organs and skeletal musculature in both groups. Scaleless white spots in the skin or haemorrhaged, round to oval skin lesions were sometimes the only gross findings. In Chile, exophthalmus is not usually associated with *P. salmonis* infection alone, but may be observed in the case of co-infections.

PCR

Real-time PCR (qPCR) assays are an essential tool for early detection and surveillance for *Piscirickettsia* spp. Variation between laboratories in testing methods and results have been reported and routine ring-tests are recommended (Peña et al. 2025). Targeted sampling via PCR of 10 dead or moribund fish from 2 to 3 pens, at least every two months has been shown to be cost-effective for surveillance in Chile (Delphino et al. 2021). Tissues including liver, kidney and spleen are frequently used for PCR assays with liver samples appearing optimal for both PCR and bacterial isolation (Bustos & Mancilla 2025). Gill and skin mucus swabs can also be utilised for non-lethal pathogen screening. Water samples and inanimate objects/surfaces have also been screened for *P. salmonis* by PCR and this technique can be helpful in assessing efficacy of cleaning protocols.
As closely related *Piscirickettsia* taxa may produce clinically indistinguishable disease, diagnostic workflows should avoid assuming that all positive qPCR results represent *P. salmonis sensu stricto* unless species-discriminating assays or sequencing data are available. While PCR assays have been developed to distinguish *P. salmonis* from '*P. nova*', they remain as yet unpublished.

Histopathology

Histopathology reveals a range of pathologies and cases may include multifocal ulcerative, haemorrhagic, and commonly densely cellular dermatitis and multifocal myositis, epi- and myocarditis, multifocal branchitis, random multifocal necrosis and inflammation in liver (Figure 3a), spleen and kidney, as well as meningitis and ocular

retrobulbar inflammation. Basophilic intracellular microorganisms, with occasional cytoplasmic vacuolation, may also be observed in many organs and within leucocytes on blood smears (Fig. 3b). The acute to subacute stages are characterized by focal to multifocal necrosis and inflammation. In chronic cases a granulomatous inflammatory reaction with granuloma formation may dominate. A reparative reaction with connective or fibrous tissue proliferation is seen in late stages.
In Norway, immunohistochemistry using polyclonal antisera (rabbit) raised against a Norwegian isolate cultured from an outbreak of piscirickettsiosis in Western Norway in 2006, is commonly used as a confirmatory test on formalin fixed, paraffin embedded tissues (Fig. 3a). This test has been particularly useful in confirming diagnoses in cases in which suitable media for culture of *P. salmonis* has not been available in the field at the time of sampling.

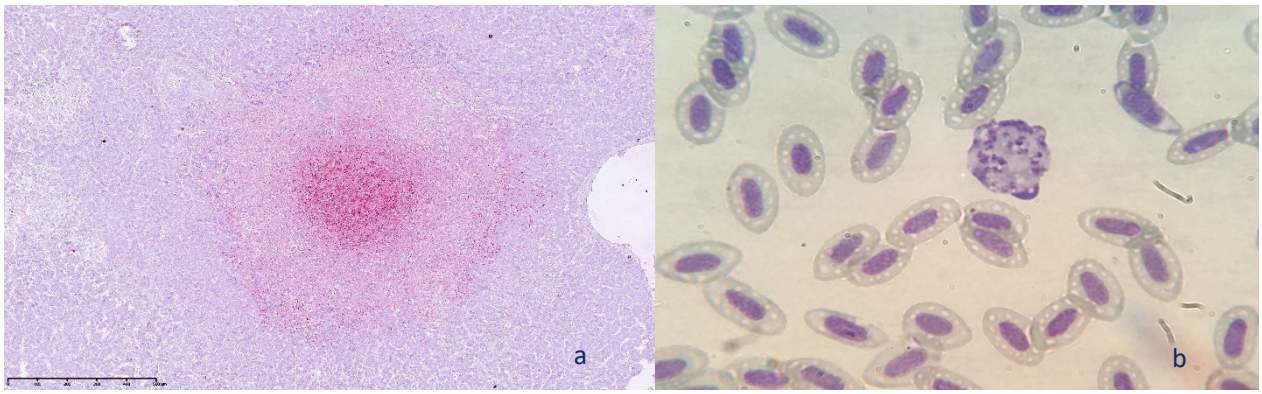

Figure 3. a) immunohistochemical staining of *P. salmonis* in the liver of an Atlantic salmon with SRS (photo A.B. Olsen). b) blood smear with intracellular Giemsa positive microorganisms (*Piscirickettsia* sp.) in a leucocyte of Atlantic salmon with SRS (photo H. Rodger).

Bacterial isolation

The bacteria can be cultured on cysteine-enriched cell-free media with a variety of published recipes, including those with blood, such as CHAB (Mikalsen et al. 2008) and those without, such as Austral-TSHem (Yañez et al. 2013). The genogroups and subgroups differ in media preference and/or temperature for growth and isolation (Otterlei et al. 2016, Makrinos & Bowden 2017, Saavedra et al. 2017).

Management

There are many management options and practices influencing the likelihood and outcome of *Piscirickettsia* infections, the most important of which are listed in the following 'Summary and Conclusions' section below. Important practices include fallowing of marine sites before restocking. As it has been shown that *P. salmonis* remains viable in seawater, declining to non-detection levels only 50 days after fish are removed (Olivares & Marshall 2010), this practice is important (and mandatory in most farming regions) and will also assist with general benthic recovery. While the main reservoir for *P. salmonis,* in regions where SRS is endemic, is now likely to be farmed salmon, the bacterium has been detected in bacterioplankton (Mauel & Fryer 2001) and a recent publication has confirmed the ability of *P. salmonis* to survive and multiply within free living amoebae (Gomez et al. 2026). Other 'original' marine reservoirs therefore, undoubtedly exist, making totally biosecure farming of salmon in open net cages in the sea difficult if not impossible in many areas.

Table 2. Prevention-specific diagnostic methods and management application for piscirickettsiosis in different countries.

Parameter (specific for SRS)	Country				
	Chile	**Ireland**	**Norway**	**Scotland**	**Australia**
SRS specific biosecurity	Yes	No	No	No	Yes
Vaccination	Yes (mandatory)	Yes	No	Low level	Yes
Genetic selection	Yes	No	No	Yes	Yes
Notifiable disease	Yes	No	Yes	No	No[1]
Diagnosis	Clinical signs, PCR, histopathology, culture	Clinical signs, PCR, histopathology, culture	Clinical signs, PCR, histopathology culture	Clinical signs, PCR, histopathology, culture	Clinical signs, histopathology, PCR, culture, serology
Mandatory surveillance	Yes	No	No	No	No

[1] Weekly mortalities and percentage attributed to SRS to be reported to Tasmanian authorities.

In Chile, bacterial isolation and Minimal Inhibitory Concentration (MIC) to OTC and FFC is mandatory.

Summary & Conclusions

Piscirickettsiosis has emerged in Ireland and Scotland (and Australia) to become a priority health issue in marine salmon farms. The disease continues to be detected in Norway but remains a low impact disease of sporadic occurrence. Risk factors identified in countries impacted severely include higher marine water temperatures, seasonal fluctuations in sea temperature, skin and gill damage from harmful plankton (phyto- and zooplankton) or another environmental stressor, and proximity to other farm case outbreaks.

Why has this disease emerged to significance in regions which previously only experienced low-level sporadic issues in the past? The common factors between regions include changes in farming methods with increased use of well-boats for bath treatments, increased frequency of periods of elevated sea temperatures and frequent harmful plankton challenges, increased gill disease and resulting compromised gill function. Possible reduced levels of biosecurity remain a concern. Whether increased virulence in existing bacterial strains or emergence of new strains is related to the increased impact of the disease, particularly in the Northern hemisphere needs further study.

Several traits/characteristics complicate mitigation of the impact of piscirickettsiosis; the organism is difficult to treat and can survive in the environment (and on fish) for many weeks. The organism can enter the fish easily through skin and gills, particularly when these organs are compromised. Existing vaccines are only partially effective and while marine reservoirs are known to exist, they remain obscure.

To mitigate the impact of piscirickettsiosis the following are recommended:

- Use of Robust, seaworthy smolts
- Good husbandry practices.
- Daily removal of mortalities and moribund fish.
- Synchronise fallowing of all marine sites in a water body.
- Disinfection of seawater taken into land-based sites, where not already mandatory
- Fallowing periods should be a minimum of seven weeks, ideally 3 months.
- Biosecurity relating to service vessels between sites, regions and countries should be of a high level (especially cleaning and disinfection protocols) and regularly audited.
- Post harvest cleaning and disinfection of nets, ensure biofilms are physically removed before disinfection is applied.
- Fish from an infected site should not be moved.
- Surveillance (via targeted PCR) should be undertaken in endemic areas on a regular (at least monthly) basis and any detections or isolations sequenced for confirmation of genotype/s. Isolates should also be obtained in culture to assess antibiotic sensitivity and for potential vaccine development.
- Genetic or genomic selection for piscirickettsiosis resistance should be pursued for regions with endemic disease.
- Improvement of skin and gill health will reduce risk of opportunistic infections.
- Control sea lice burden with minimal physical trauma.

Vaccination should be available and utilised where the disease is endemic. Further requirements include genetic surveillance of *Piscirickettsia* spp. and improved rapid diagnostics. Research into alternative therapies and effective vaccines (and utilisation of lab challenge models using single or multiple genotype combinations) should be supported.

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