	Council ***Parasites and diseases associated with pink salmon***	**CNL(24)53** **Agenda item: 7a)**

Parasites and diseases associated with pink salmon

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Abstract

The objective of this abstract is to present a concise overview of parasite and diseases potentially associated with pink salmon and the potential risks for Atlantic salmon. What does monitoring show so far, what are potential future risks, and what are the knowledge needs?

What does monitoring show so far?

Parasites

Several Russian researchers have conducted systematic studies of the parasite fauna in pink salmon in the White Sea and Barents Region and some of these have compared with the fauna of pink salmon in the Pacific region (Ninburg 1963 (Reviewed in Rullestad 2021), Grozdilova 1974, Barskaya *et al*., 2005, Ieshko *et al*., 2016). In Norway, two comprehensive studies of parasite fauna have been conducted from pink salmon caught in rivers on the west coast in 2017 (Fjær 2019) and from pink salmon caught in the Norwegian Sea during the period 2013-2019 (Rullestad 2021). Table 1 presents an overview of parasites found in pink salmon in the White Sea/Barents Sea area and Northern Atlantic Ocean. In 2023, the Institute of Marine Research in Norway (IMR) included pink salmon in the national surveillance program for salmon lice. The results are presented here:

https://hi.no/hi/nyheter/2023/november/fant-lus-ogsa-pa-pukkellaks.

The studies show that the parasite fauna of pink salmon is dominated by marine parasites, corresponding to pink salmon spending the majority of their life in the marine environment. The parasite fauna indicate that pink salmon in the North Atlantic and the Barents Sea/White Sea occupy the same niche in the ecosystem as they do in their native habitats (Sokolov et al., 2024).

Risk for Atlantic salmon: Parasites may have a simple direct life cycle or a complex life cycle involving several hosts. For parasites that have a direct life cycle, susceptible pink salmon will increase the number of susceptible hosts and thus contribute directly to the infection dynamics by increasing the reproduction rate R, increase the risk of transmission to wild Atlantic salmon, bridge the gap between farmed and wild populations or between geographical areas. The impact of this contribution is highly dependent on the number of pink salmon present.

Human health risk: Rullestad (2021) found the zoonotic nematode *Anisakis simplex* in the muscle of 23 % of examined pink salmon. Sokolov and co-workers also recorded an increase in *A. simplex* abundance in 2021 compared to earlier years. Although freezing kills the parasite, and eliminates the risk of human anisakidosis, it should be noted that allergic reactions may occur in humans.

Microparasites, virus and bacteria

PCR- based screening has so far been focused on a very limited number of pathogens, notably those that are relevant for the aquaculture industry. Table 2 presents an overview of results from PCR based studies of micro parasites in pink salmon in Norway and Ireland.

Culture based screenings for bacteria and virus are rare, but was conducted by the Norwegian Veterinary Institute (NVI) in 2023. Cultures from the kidney of pink salmon on suitable agars for bacteria did not detect *R. salmoninarum* or *Aeromonas salmonicida* subsp. *salmonicida* (listed as category F infections in Norway), but there was growth of other bacteria commonly found in the environment. Several of which can be opportunistic pathogens in fish. Culture for viruses was only conducted from nine pink salmon and were without any findings (Sommerset et al., 2024).

In summary, listed virus or bacterial infections have not been detected so far. However, the virus PRV-1 has been detected in several cases. PRV-1 is a common virus in farmed and wild Atlantic salmon in Norway, and has also previously been detected in pink salmon in the Pacific Ocean (Purcell et al., 2018).

Risk-based Health Monitoring

The health monitoring efforts described so far have been conducted in randomly selected, apparently healthy pink salmon, while examination of fish showing signs of disease may be more informative.

In 2021, a pink salmon with symptoms resembling typical furunculosis (*Aeromonas salmonicida* subsp. *salmonicida* infection) was found in the River Gjersjøelva near Oslo, Norway. Culturing from internal organs and muscle yielded significant growth of the bacterium *Aeromonas hydrophila*, an ubiquitous opportunistic pathogen, meaning it can cause disease in fish, humans, and a wide range of other animal species when conditions are favourable (Sommerset et al 2020). This finding may be an example of how susceptible pink salmon either are covert carriers of an infection that is activated during spawning or get infected by an opportunistic pathogen that is present in the freshwater environment. Either way, such pink salmon will shed bacteria to the environment and increase the infection pressure for native fish in affected rivers.

In 2022, the parasite *Ichthyophonus* sp. was detected in a moribund pink salmon from the River Lakselva in Norway. *Ichthyophonus* sp. occur in a wide range of fish species in freshwater and marine environments, and has caused mass mortality of herring. In Chinook salmon in the Yukon River, the parasite has caused significant challenges affecting survival, spawning success, and fillet quality (for consumption) (Kocan *et al.,* 2004, 2006). In the specific pink salmon from Lakselva, there was little evidence that tissue reactions with white nodules affected fillet quality. However, the examination only involved one fish (Sommerset *et al.,* 2023, Erkinharju *et al.,* submitted 2024). The pink salmon was most likely infected by ingesting infected prey (Kocan *et al.,* 2019). The prevalence of this parasite in pink salmon is currently unknown, and the impact on Atlantic salmon is also unknown due to lack of knowledge regarding the parasites potential for horizontal transmission between these species.

Potential risks for Atlantic salmon

Introduction of an alien invasive species is associated with a risk of introducing new pathogens or alternatively a risk of expanding the range or impact of pathogens that already exist in the particular geographical area or environment.

Pink salmon were translocated from the Pacific Ocean to the White Sea area as fertilised eggs. The risk of introducing new pathogens is therefore primarily associated with pathogens that can either be present within the fertilised egg (true vertical transmission), as contamination on the surface of fertilised eggs, or in the transport water. This reduces the probability of introducing for instance larger parasites. The biosecurity measures during the translocation operations are of interest in this context. Were the broodfish healthy? Were the eggs disinfected before translocation or upon arrival at the hatchery? The translocations ended in 1999, which means that this particular threat is not active today. But we cannot rule out the possibility that pathogens were introduced and established in the new environment.

Long distance marine migrations and straying into new rivers and regions may create a connection between geographical areas that may lead to movement of pathogens between areas. Pink salmon may for instance be exposed to pathogens from aquaculture sites in one geographical area and carry it to new regions (Hindar *et al.,* 2020).

The significant increase in population and spread of the pink salmon in recent years suggests that they are well adapted to the new environment. During health checks, pink salmon may appearing “healthier” than for instance wild Atlantic salmon. Several pathogens may persist in fish after infection and potentially be activated later in life. Accordingly, the prevalence of certain pathogens increases with age. The short life cycle of pink salmon can thus result in less time to be exposed to and accumulate pathogens, both in the freshwater phase and the marine phase. It has also been suggested that introduced species may have fewer enemies in the new environment (Paterson 2023). According to the "enemy release hypothesis," introduced species are released from their "old" enemies - competitors, predators, and disease-causing organisms - when transferred to a new area. This release should provide a basis for growth and success in the new area. Thus, the pink salmon now spreading in Europe are conquering new areas without encountering the same challenges that native species in established ecosystems face (Paterson 2023).

There is still a lack of knowledge about the susceptibility of pink salmon to virus, bacteria and parasites that are present in wild and farmed fish in the North Atlantic and Barents region. There are already enemies present, either as pathogens that are native to the North Atlantic region and more pathogenic to Pacific salmonids, or already established by previous introductions of other pacific salmonids (Infectious hematopoietic necrosis virus (IHNV).

Potential future risks

The most essential factor pertaining to the risk of pathogen interactions and disease caused by the presence of pink salmon is the number present on a local scale. Accordingly, all factors contributing to an increase of the number of pink salmon constitute a risk. This includes changing climate (melting of the ice cap), proliferation of even year pink salmon or unhindered spread of the species.

Knowledge needs

The reservoir of many of the pathogens reside in farmed salmonids in open net pens along the coast. Accordingly, knowing how pink salmon interact with marine aquaculture sites is essential for understanding their role in pathogens transmission and disease interaction between pink salmon, and farmed and wild native populations.

Detection of pathogens in samples from pink salmon does not provide sufficient information about the host-pathogen interaction. Meaning that pathogen presence is not evidence of infection, and furthermore not evidence of proliferation and shedding of the pathogen. Experimental transmission trials and cohabitation trials makes it possible to study host-pathogen interactions, for instance how susceptible pink salmon are to some of the important pathogens that are present either in European salmon farming or in wild salmonid populations (for instance common bacteria, virus, *G. salaris*).

After spawning, the pink salmon carcasses provide nutrients to both the freshwater and the terrestrial ecosystems. Bacteria, oomycetes and fungi that establish and proliferate in the moribund fish and contribute to the decomposition of the carcasses are released into the aquatic environment and influence the microbial community. Some of these microorganisms are opportunistic pathogens - we need more information about the impact of altered microbiota on Atlantic salmon.

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Table 1. Comparative overview of parasites found in pink salmon in North Atlantic (Norway, Ireland) and the White Sea/Barents Sea region.

	Norway, Ireland	**White Sea and Barents Sea**
Fungi, Microsporidia	*Desmozoon lepeophtherii* (syn. *Paranucleospora theridion)*	
Animalia, Protozoa	*Ichthyophonus* sp., *Ichthybodo* sp	*Ichthybodo* sp
Animalia, Gnidaria, Myxozoa	*Parvicapsula pseudobranchicola*	
Animalia, Plathyhelminthes, Trematoda	*Apatemon gracilis (Diplostomata), Brachyphallus crenatus, Cryptocotyle lingua, Derogenes varicus, Hemiurus communis, Hemiurus levinseni, Hemiurus luehei, Lecithaster gibbosus,*	*Brachyphallus crenatus, Derogenes varicus, Digenea gen sp., Diplostomum sp. Ichthyocotylurus erraticus Lecithaster gibbosus, Podocotyle atomon, Podocotyle reflexa*
Animalia, Plathyhelminthes, Monogenea		*Gyrodactyloides bychowskii, Discocotyle sagittata*
Animalia, Plathyhelminthes, Cestoda	*Bothriocephalidea gen.* sp, *Clistobothrium* sp., *Diphyllobothrium* sp., *Eubothrium crassum, Scolex Bothriosimplex*[1], *Scolex pleuronectis*[2]	*Bothriocephalidea gen.* sp, Cyathocephalus truncatus, *Diphyllobothrium* sp., *Eubothrium crassum, Diplocotyle olrikii, Scolex pleuronectis*[2]
Animalia, Acantocephala		*Echinorhynchus gadi*
Animalia, Nematodea	*Anisakis simplex* (kveis), *Hysterothylacium aduncum,*	*Anisakis simplex* (kveis), *Hysterothylacium aduncum, Pseudoterranova decipiens*
Animalia, Crustacea	*Caligus elongatus, Lepeophtheirus salmonis, Salmincola salmoneus*	*Lepeophtheirus salmonis, Salmincola salmoneus*
Animalia, Mollusca (glochidia)		*Unionidae* gen. sp. (glochidia)
Reference	Fjær 2019, Garseth et al., 2020, Rullestad 2021, Sommerset et. al., 2023	Ninburg 1963, Grozdilova 1974, Barskaya et al., 2005, Ieshko et al., 2016

Table 2. Overview of results from PCR analyses for microparasites, virus and bacteria from North Atlantic pink salmon.

Year	2007	2017		2019	2013-2019	2021	2023
Location (number tested)	Tana (38), Neiden (36)	Etne, Ekso, Norway	Ireland, several rivers	Karpelv, Norway (60)	Norwegian Sea (86)	Several rivers in Norway (181)	Six rivers in Finnmark
Pathogens							
IHNV (Infectious haematopoietic necrosis v.)	0	0/40	-	0	0	0	0
VHSV (Viral hemorrhagic septicemia v.)	-	-	0/13	0	-	0	0
ISAV (Infectious salmon anaemia virus)	0	0/40	-	0	0	0	0
SAV (Salmonid alphavirus)	-	0/40	0/15	0	0	-	-
IPNV (Infectious pancreatic necrosis v.)	0	0/40	-	-	0	-	-
SGPV (Salmon gill poxvirus)	-	-	-	0	-	-	-
ASCV (Atlantic salmon calicivirus)	-	-	-	0	-	-	-
PRV-1 (Piscine orthoreovirus-1)	-	-	-	4	2	8/181	0
PRV-3 (Piscine orthoreovirus-3)	-	-	-	0	-	-	-
PMCV (Piscine myocarditis virus)	-	0/40	-	0	0	-	-
Renibacterium salmoninarum	-	-	0/13	0	-	0	0
Ca. Branchiomonas cysticola	-	1/43	-	0	-	-	-
Desmozoon lepeophtherii	-	26/43	-	2	-	-	-

Spironucleus spp.	-	0/43	-	-	-	-	-
Parvicapsula pseudobranchicola	-	4/30	-	0	0	-	-
Paramoeba perurans	-	-	-	0	-	-	-
Ichthyobodo sp.	-	39/43	-	-	0	-	-
References	Skjåvik H. 2008	Fjær 2019	Millane et al. 2019	Garseth et al. 2020/ Sommerset et al., 2020	Rullestad 2021	Sommerset et al., 2022	Sommerset et al., 2023