Fish Farmageddon:

The Infectious Salmon Aquacalypse

[Graphic courtesy of Markus Fenz: http://morxn.com]

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Introduction:

The New York Times hit the nail on the coffin when it stated "Salmon farming is a problem everywhere" in an Editorial published earlier this month. The Editorial - "About That Salmon" - was a follow up to an article – "Norwegians Concede a Role in Chilean Salmon Virus" - in July which reported that the deadly disease Infectious Salmon Anaemia (ISA) had been spread to Chile from Norway. Without a shadow of doubt, salmon farming is spreading disease all over the world.

This report – "Fish Farmageddon: The Infectious Salmon Aquacalypse" - focuses on the wave of infectious diseases, pathogens, viruses, bacteria and parasites sweeping salmon feedlots like the Black Death. Farmed salmon are affected by fish versions of bubonic plague (Yersinia), rabies (IHN and VHS), Tuberculosis, a retrovirus called salmon leukemia, the clap (Piscichlamydia), Parasitic Meningitis, a flesh eating parasite which leaves farmed salmon like 'milk jelly' as well as the more commonly known Listeria, botulism and sea lice.

A tsunami of Salmon Transmitted Diseases (STDs) is spearheaded by the 'Seven Horsemen of the Aquacalypse'; namely: Infectious Salmon Anaemia (ISA), Sea Lice (Lepeophtheirus salmonis), Salmon Rickettsial Syndrome/Septicaemia (Piscirickettsiosis), Listeria monocytogenes (Listeriosis), Kudoa (Soft-Flesh Syndrome), Infectious Pancreatic Necrosis (IPN) and Pancreas Disease (Salmon Pancreas Disease Virus/Salmonid Alphavirus Disease/Sleeping Disease).

The use of ever more powerful chemical weapons in the salmon 'pharming' industry's war on disease has served only to create chemical resistance and 'Salmon Superbugs'. In many ways this report is a follow up to 'Silent Spring of the Sea' in that the use of medicines, pesticides, antibiotics, disinfectants and other 'chemotherapeutants' are merely symptomatic of disease problems.

The 'Salmon Superbugs' and Salmon Transmitted Diseases (STDs) detailed in this report include: Gill Disease (Proliferative Gill Inflammation, Epitheliocysts/Chlamydia & Amoebic Gill Disease), Paranucleospora theridion, Parvicapsulosis (Parvicapsula pseudobranchicola/ Paranucleospora theridion), Gyrodactylus ('Salmon Killer'), Furunculosis (Aeromonas salmonicida), Infectious Hematopoietic Necrosis (IHN), Viral Haemorrhagic Septicaemia (VHS), Cardiomyopathy Syndrome (CMS), Heart and Skeletal Muscle Inflammation (HMSI), Plasmacytoid Leukemia (Marine Anemia), Bacteria Kidney Disease (BKD) Myxobacterial Infection (Piscine Tuberculosis), Spironucleosis (Spironucleus salmonicida) Francisella (Francisellosis), Yersinia ruckeri (Yersiniosis/Enteric Redmouth/ERM), Flavobacterium psychrophilum (Bacterial Cold Water Disease/Rainbow Trout Fry Syndrome), Vibriosis (Cold Water Vibriosis/Hitra Disease), Moritella Vicosa (Winter Ulcer) Hemorrhagic smolt syndrome (HSS), Mad Fish Disease, Botulism (Clostridium botulinum) Parasitic Meningitis, Costia (Ichthyobodo species), Tapeworm (Diphyllobothriasis), Microsporidian encephalitis, Nephrocalcinosis (urolithiasis), Malignant Intestinal Tumours, Desmozoon lepeophtherii (Paranucleospora theridion) & Autumn Disease and Salmonella.

Infectious salmon diseases and chemical resistance could spell the end of the line for salmon farming. Unless the global salmon farming industry drastically changes course, the end is nigh for the salmon farming industry in Norway, Chile, Canada, Scotland, Faroe Islands, Ireland, Australia, New Zealand, Japan and other areas of the world. Judgment Day is approaching in British Columbia where a salmon inquiry is opening up a can of worms.

Contents

Chapter 1:

Fish Farmageddon

A plague of Biblical and bubonic proportions is salmon farming's very own 'Farmageddon'. For decades, salmon farming has left a trail of disease-ridden farmed salmon and death in its wake all over the world.


Photos: Maggot-infested disease-ridden farmed salmon in Scotland


Photos: Dead farmed salmon known as 'morts' in Chile and Canada

Salmon feedlots are seen as 'A Stain Upon the Sea' and weeping sores on the face of the blue planet. Or as *Scientific American* reported in 2010: "Farm-raised salmon has long been the poster child of unsustainable aquaculture practice".

Research on the environmental and public health impacts of salmon farming has quite literally been done to death with reports including: 'Industrial Disease', 'Nightmare in New Brunswick', 'Containing Disaster', 'Farmed & Dangerous', 'Net Loss', 'Super Un-Natural', 'In Too Deep', 'A Big Fish in a Small Pond' and 'Salmon Piranha Style'. As Salmon Are Sacred says, "the science is in on salmon farms". However you cut it, the unsavory side of farmed salmon leaves a bad taste in the mouth.

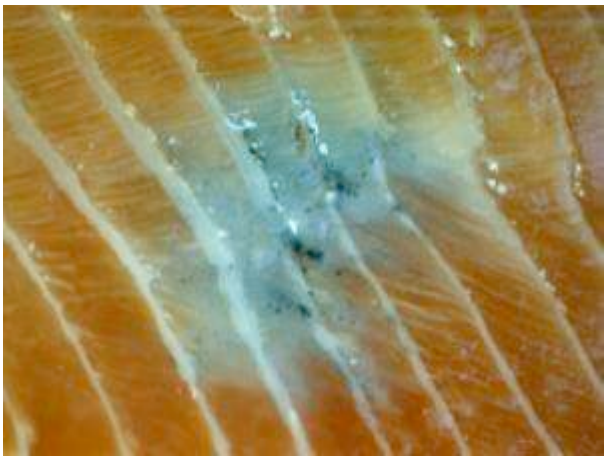
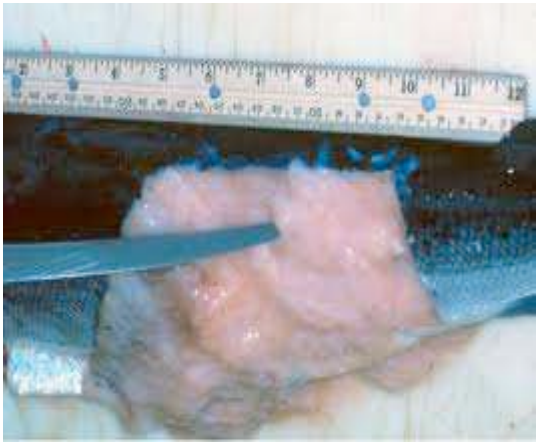
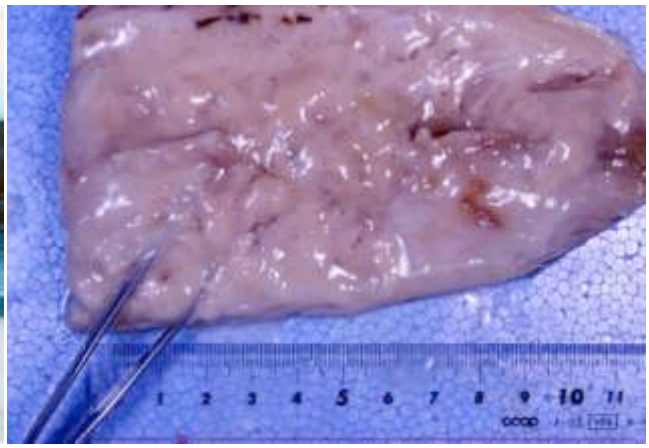



Photo: Sea Lice Damage and Mouldy Farmed Salmon

The sickly salmon smorgasbord laid out in this report (read in full via Chapters 2 & 3) includes:

- Listeria monocytogenes (Listeriosis): contaminating smoked farmed salmon and considered by the US Food and Drug Administration (FDA) as "a poisonous or deleterious substance" and one which may be "injurious to health".

- Kudoa thyristes ('Soft-Flesh Syndrome'): a parasite which develops as white cysts in the flesh of farmed salmon and causes softening (myoliquefaction) into a jelly-like consistency like salmon flavoured blancmange or 'milk jelly'.

- Tapeworms (Diphyllobothriasis): parasites which are “on the attack” and can cause a nasty surprise for lovers of raw fish like sushi and ceviche.

- Botulism (Clostridium botulinum): “the most poisonous substance known” which can cause life-threatening illness and a fatal form of food poisoning.

Deadly diseases, viruses, bacteria, pathogens and other infections afflicting factory farmed salmon also include:

- Sea Lice (Lepeophtheirus salmonis): a blood-sucking parasite which literally eats baby wild salmon alive and leaves the victim with ‘death crown’ scars (think of the Death-Eaters and Lord Voldemort in Harry Potter and you get the picture).

- Infectious Salmon Anaemia (ISA) and Infectious Pancreatic Necrosis (IPN) which have been dubbed “The hoof and mouth disease of the salmon farming industry” and “Salmon farming’s foot-and-mouth”.

- Pancreas Disease: described as a “sleeping monster” caused by an alphavirus known as salmon pancreas disease virus (SPDV).

- Paranucleospora theridion: a microsporidian parasite whose rounded spores are causing mass mortalities on Norwegian salmon farms.

- Yersinia (Yersinosis): The Black Death or bubonic plague was caused by the bacteria *Yersinia pestis*: in salmon farming it is the pathogen *Yersinia ruckeri* which results in septicaemia, blood spots in the eye and a slow lingering death.

- Piscichlamydia (also known as Ephitheliocystis or Prolferative Gill Inflammation): Fish Chlamydia (or Fish Clap) leads to haemorrhage and tissue necrosis in the gills.

- Moritella vicosa (Winter Ulcer): the plague of boils and ulcers can be chronic with wounds covering large parts of the skin of the fish including swelling and necrosis.

- Flavobacterium psychrophilum (Bacterial Cold Water Disease): causes ulcers, fin-rot and systemic infection.

- Cardiomyopathy syndrome (CMS): farmed salmon's version of the heart attack which causes blood clots and is also referred to as "acute cardiac mortality" and "heart rupture".

- Heart and skeletal muscle inflammation (HSMI): this lethal disease sounds like a salmon smoker's condition destroying heart and muscle tissue wasting away the victims.

Other skeletons lurking in the salmon closet include:

- Gyrodactylus salaris: a parasitic flatworm which has a hook more lethal than Captain Hook and is often called 'Salmon Killer'.

- Mycobacterium marinus: a form of 'piscine Tuberculosis' which can be transmitted to humans causing 'fish-tank granuloma' or 'swimming pool granuloma'.

- Plasmacytoid leukemia (marine anemia): this retrovirus dubbed "dead fish swimming" is also known as Salmon Leukemia Virus and could be associated with pre-spawning mortality of up to 95% of Fraser sockeye (salmon are supposed to spawn and die not die before they spawn).

- Infectious Hematopoetic Necrosis (IHN) and Viral Haemorrhagic Septicaemia (VHS) are 'Salmonid Rhabdoviruses' and "resemble closely that of rabies virus".

- Parasitic meningitis: a microscopic parasite which has been found in the brain vault of farmed salmon.

In view of such deadly diseases, 'Salmon Superbugs' and STDs, it is little wonder then that there has been a global backlash against the impending 'Fish Farmageddon'. In Chile, salmon farming is seen by many environmental groups as a ticking time bomb and 'Poison of the Sea'.


LA PRIVATIZACIÓN DEL MAR AUSTRAL CHILENO

BOMBA DE TIEMPO

Photo: The Ticking Time Bomb of Salmon Pharming

Photo: ‘Salmon for the World, Poison for the Sea’

In Norway, the horrors of the industry makes people want to scream and cry in equal measure.

And in Scotland, the horrors of salmon farming have appeared in the Edinburgh Dungeon.

A new documentary - 'Farmageddon – The Unseen War on American Family Farms' opened in the United States in July. 'Farmageddon' is described by Salon as an "informal sequel to the hit documentary 'Food Inc.,' and exposes how the "Americans' right to access fresh, healthy foods of their choice is under attack".

If 'Farmageddon' is a sequel to 'Food Inc.,' then this report is an informal sequel to an article by Kim Petersen in *Dissident Voice* in 2003. His article - "Farmageddon and the Spin Doctors" - looked at a public relations campaign launched by the salmon farming industry in British Columbia (which is 92% owned by Norwegian corporations).

Nearly a decade later, the public relations 'battle' escalated further in January with the launch of a $1.5 million advertising campaign by the BC Salmon Farmers Association. The global salmon farming industry may be more adept and have more money to muddy the waters with expensive PR campaigns than a decade ago but the bottom line is that this dirty industry is still a Salmon 'Stinkbomb' (as one Norwegian newspaper reported in August following a protest where rotten farmed salmon and fish wastes were dumped outside a trade show as a present for the King of Norway). 'Cut the Crap' was the simple message delivered to Norwegian companies in Canada in April and June.

Photo: 'Cut the Crap' campaign from Salmon Are Sacred in Canada

Super Sized Salmon Pharming

In the film "Super Size Me", Morgan Spurlock stuffed his face on junk food from McDonalds. A sequel - 'Super Sized Salmonbugs' - should involve factory farmed salmon. On World Oceans Day in June, McDonald's unveiled a new 'sustainable' whitefish sandwich with the world's media falling hook line and sinker for this whopper of a fish story. Less well known is the unsavoury story of McDonald's failed attempts to promote farmed salmon.

In 1997, McDonald's were sued when "four people, including two McDonald's employees, were hospitalized after eating tainted McLaks salmon burgers at a restaurant in Lorenskog, located in the outskirts of Oslo". McDonald's Norway confirmed that the food poisoning materialized from a 'corrupted' consignment of salmon fillets. "At first the McLaks tasted very good, but after some minutes my mouth and throat became numb, and I experienced internal spasms," said Geir Sundberg, one of the four filing suit against McDonald's.

A*dvertising Age* reported under '1997 Ad Follies': "In Norway, McDonald's pulled the McLaks salmon burger off the market after four customers were treated for food poisoning. McLaks had been a hit with health-conscious Norwegians, and McDonald's had been considering expanding the product to Sweden and Denmark".

Not learning their lesson, McDonald's teamed up with the world's largest salmon farming company Marine Harvest a decade later in 2007 and launched a farmed salmon wrap with an ad campaign showing a 'Laksewrap' (Salmon wrap) leaping out of the water with a M shape and the Marine Harvest logo underneath.

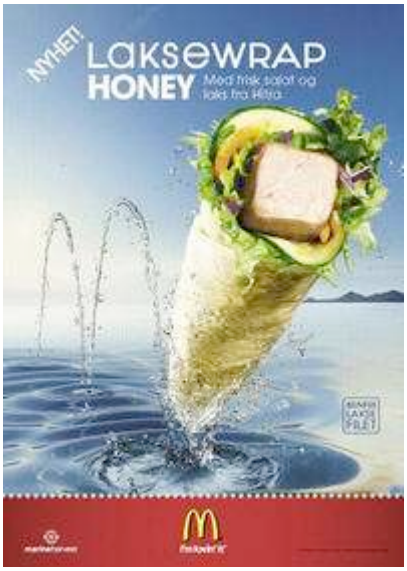


Photo: The McDonald's 'Laksewrap' which flopped like a flaccid farm salmon

Marine Harvest Canada blogged about it via 'Marine Harvest teams up with McDonalds' and even the Norwegian Embassy in the United States blogged "McSalmon, Please!" (Read more via 'Eco-Washing McFarmed Fish'). Marine Harvest's masterplan was to have a trial in Norway and then conquer the world supplying McDonald's over 30,000 outlets. Suffice to say that McDonald's quietly dropped the salmon wrap sometime in 2009 and appear not to be

lovin' the idea of a farmed salmon burger. It could be a wrap for farmed salmon as far as McDonald's is concerned.

No amount of advertising and 'Salmon Propaganda' can alter the fact that salmon farming has a super-sized PR problem. 'Toxic' farmed salmon made global headlines in 2004 when a paper – "Global Assessment of Organic Contaminants in Farmed Salmon" – published in the journal *Science* detailed a cocktail of cancer-causing contaminants and chemicals in pharmed salmon. It turned out that the only truly 'organic' thing about farmed salmon were the cancer-causing organic contaminants. Farmed salmon tested around the world were found to contain PCBs, dioxins, chlordane, dieldrin, toxaphene and other contaminants "associated with serious health risks from neurological effects to cancer". The Guardian newspaper in UK reported via "Cancer warning over Scottish farmed salmon" that: "Levels of cancer-causing toxins in Scottish farmed salmon are so high that consumers are being advised not to eat more than one portion every two months to safeguard their health".

The multi-billion dollar salmon farming industry went into apoplectic shock and then mounted a full out PR assault spearheaded by spinmeisters Hill & Knowlton (for an in-depth review read 'Spinning Farmed Salmon'). Hill & Knowlton – the 'Red Adair' of the PR world – is adept at dousing the fires of a public relations disaster and have hawked their snakeoil salesmen services to Big Tobacco to brand cigarettes safe and to the oil industry. They've even been sent in like 'The Cleaner' (played by actor Harvey Keitel in the film 'The Assassin') to clean up the aftermath of disasters like the gulf war and nuclear fallouts like Three Mile Island.

Kim Petersen writes in 'Farmageddon and the Spin Doctors' that: "Hill & Knowlton is the spinmeister for, among others, corporate polluters, heinous dictatorships, and scandalized elites. It seeks to maneuver and ameliorate the public perceptions through, according to the H&K Canada website, traditional methodologies as well as cutting-edge technologies. Translated from corporate euphemism this means mendacity and appeal to the venality of officials. Hill & Knowlton has attempted to manipulate the public perception of miscreants and a slew of debacles, among them the massacre at Tiananmen Square, Exxon Valdes, the establishment of the Tobacco Institute to bolster cigarette smoking, the Lays of Enron infamy, Iran Contra, the near disaster at Three Mile Island, the Moonies, and improving the public face of regimes in flagrant breach of human rights."

In their review of the murky world of Hill & Knowlton, Corporate Watch quotes an adage that is apt for the salmon farming industry too: "Managing the outrage is more important than managing the hazard".

Hazards to Health

Salmon farming is clearly a hazard to health: a hazard to the health of the public; a hazard to the health of wild salmon; and a hazard to the health of our global ocean. Dead workers as well as dead farmed salmon is a skeleton the salmon farming industry wants to keep shut firmly in the closet. Sadly, mortalities on salmon farms are not limited to farmed salmon but also divers and other workers.

In Chile, in particular, poor health and safety has contributed to dozens of dead salmon farm workers. A report – "X-Ray of the Chilean Salmon Industry" – published in 2007 calculated that over 50 workers had died since 2005. In 2009, the Norwegian newspaper *Dagbladet*

reported that the death toll had risen to 63 and they published a list of over dozen workers killed by two Norwegian companies.

Photo: A graveyard of dead workers in Chile

In 2010, *Dagbladet* reported that a secret deal had been made with one of the widows of the dead divers. The global salmon farming giants may be able to buy people's silence but they cannot shake the smell of blood on their hands.

DØMT
til rekord-
erstatning

- Vi føler ansvar for dødsfallet

Stratos Dobbel

Mmm... Luftig hvit sjokolade
dekket med deilig melkesjokolade

Photo: Norwegian newspaper report in *Dagbladet* in 2010

The death of divers is not just a problem in Chile. In Canada, Marine Harvest was fined $75,000 in March following the death of a diver in British Columbia. In Scotland, STV reported that two companies were fined a total of £640,000 following the death of two fish farm workers on a barge in Argyll and Bute.

Photo: Maarten Den Heijer (left) and Robert MacDonald died in 2009

Next time you are tempted to buy cheap farmed salmon, please spare a thought for Robert MacDonald, Maarten Den Heijer, Valentin Ordenes, Juan Miranda, Claudio Torres, Roque Álvarez, Franklin Delgado, Héctor Millalonco, Javier Velasquez, Francisco Bernabé Vera, Pedro Alvarado, Samuel Arturo, Cristian Campos, Nilo Rafael, Raul Villegas and all their families left behind. Cheap farmed salmon comes at a high price.

In addition to the health hazards due to dioxin and PCB contamination of farmed salmon (not to mention Listeria), there are artificial colourings such as Canthaxanthin which has been linked to eye defects (for an in-depth review read 'Silent Spring of the Sea'). "It all started innocently with a delicious salmon dinner after a day's sightseeing in the Canadian Maritimes," wrote Linda Forristal in an article in *The World & I* in 2000 describing her experience eating farmed salmon. Suffice to say that Linda does not eat farmed salmon anymore and recommends that educated consumers eat wild salmon.

The list of chemicals used on salmon farms and detected in farmed salmon reads like a who's who of the chemical industry (for reviews read 'Chemical Use in Salmon Aquaculture' and 'Silent Spring of the Sea'). In Chile, in particular, the issue of chemical contamination of farmed salmon has caused controversy and negative media coverage The New York Times (for a review read 'Chilean Farmed Salmon: Chronology of Chemical Contamination'). In the UK, *The Daily Mail* reported on a "New salmon cancer scare" following the detection of the carcinogen malachite green in farmed salmon in 2004. In 2008, German health authorities detected "Carcinogenic Crystal Violet in Chilean Salmon".

Antibiotic resistance in aquaculture could also be spilling out from feedlots and having impacts on human health. Antibiotic resistance has already been detected in fish farms in Japan, Denmark and Norway. The issue is alive and kicking. Dan Rather – the American news anchor behind CBS Evening News for many years - talked about drug resistance and Norwegian fish farms in a radio show earlier this year. And article in *Wired* magazine by

Maryn McKenna (author of 'Superbug' and 'Beating Back the Devil') in August raised the spectre drug resistance in food coming from aquaculture.

Sea lice infestation of wild salmon from salmon feedlots, with mortality rates of up to 95%, is also a turn off for many TV viewers and has put an end to many a farmed salmon TV dinner. "As the aquaculture industry grows and diversifies, there is concern about the potential effects of pathogens spreading from farmed fish to wild populations," stated a scientific paper – "Disease interaction and pathogens exchange between wild and farmed fish populations with special reference to Norway" – published in the journal *Aquaculture* in May.

Others are shocked to learn that salmon farming drains the oceans of wild fish to feed farmed salmon – the so-called 'Tigers of the Sea'. Even if people do not care about the state of the oceans, the moral and ethical issues thrown up by stealing fish from the mouths of starving people presents a dilemma for many. "This is akin to robbing Pedro to pay Paul," writes Dr. Daniel Pauly in a 2009 article – "Fish As Food: A Love Affair, Issues Included" - in The Huffington Post.

Moreover, the only 'green' thing about farmed salmon may turn out to be radioactive contamination that leaves people feeling green behind the gills like the sick salmon described in Chapters 2 and 3. "Radioactive waste from Sellafield [a nucelar power plant] has been found in Scottish farmed salmon sold in major British supermarkets," reported Greenpeace in 2003. Tests conducted independently by Southampton University's oceanography centre found Technetium-99 (Tc-99 - a byproduct of the nuclear industry) in farmed Scottish salmon sold in supermarkets across the UK.

More recently, Greenpeace reported in August that radioactive cesium had been found in fish caught near the crippled Fukushima Daiichi nuclear power plant. Whether we will soon be seeing glow-in-the-dark Japansese farmed salmon remains to be seen. Whatever the case, there should be a bright flashing red light on all farmed salmon – thankfully farmed Atlantic salmon worldwide is given a 'red' (avoid) rating by the Monterey Bay Aquarium.

Factory Fish Farming

The advance of modern aquaculture has ushered in a new era of factory fish farming which should carry a global health warning. The latest data from the Food & Agriculture Organization shows that global production from aquaculture is now on a par with wild capture fisheries. The latest report (published in January but based on 2010 data) states that "Aquaculture accounted for 46 percent of total food fish supply". This is a staggering increase - in 1984 aquaculture accounted for only 8 per cent – and salmon farming is in the vanguard.

The march of mariculture has brought fish farming into conflict with other coastal users such as First Nations and fishermen. In ancient times, the Biblical battle between the farmer and the hunter was played out between Cain and Abel. In the modern era we are witnessing the same clash of cultures between fishing and aquaculture. In the Bible, there was a fatal end as Cain (the farmer) killed his own brother Abel (the hunter gatherer). In the sea it seems that wild salmon will go the way of the buffalo on land as the salmon farming industry pushes wild salmon to the brink of extinction.

Salmon feedlots are "happy hunting grounds for diseases and parasites" as Douglas Gantenbein puts it in an article – "The Perils of Aquaculture" - published in *Slate* magazine in 2004. Put simply - salmon are 'Farmed & Dangerous'. Salmon feedlots are 'The Killing Farms'.

The intensive monoculture of salmon – the so-called 'Hogs of the Sea' – is led by Atlantic salmon but Pacific species of salmon are also farmed. The truth behind salmon feedlots is all too gruesome to go into ALL the gory details here (for a review read 'The Five Fundamental Flaws of Sea Cage Fish Farming' and 'A Big Fish in a Small Pond'). Suffice to say that salmon farms are disease-ridden feedlots similar to their terrestrial counterparts. Think battery chickens, pigs and cows crammed in crates and you're getting there. For a true picture of the factory salmon feedlot then watch the film 'The Meatrix'. As Moopheus says: "Take the red pill and I'll show you the truth". Friends of Clayoquot Sound in Canada clearly get the message:

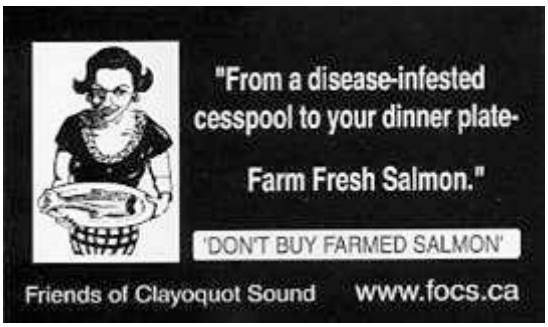


Photo: 'From a disease-infested cesspool to your dinner plate – Farm Fresh Salmon'

Photo: Friends Don't Let Friends Eat Pharm Salmon

Infectious Salmon Anaemia (ISA), sea lice, Infectious Pancreatic Necrosis (IPN) and other deadly diseases are aquaculture's equivalents of Bird Flu, Foot-and-Mouth Disease, Tuberculosis, Swine Flu, Rabies, Ebola, Mad Cow Disease (BSE) and other animal diseases. ISA, for example, was described as "the hoof and mouth disease of salmon farming" in a scientific paper published in *Marine Biotechnology* in 2011. An Editorial - "The hoof and mouth disease of the salmon farming industry" - in *The Vancouver Sun* in 2008 stated:

"There's no evidence that ISA is transmissible from fish to mammals or that it affects humans in any way, but reassuring customers still twitchy in the aftermath of concerns about mad cow disease is likely to pose a significant marketing challenge....Like the "flu" virus, what's most alarming about ISA is what the U.S. government's veterinarian service says is its ability

to mutate rapidly by recombining genetic elements within its hosts. For example, researchers have found significant molecular differences between strains of the virus in Norway, Scotland and New Brunswick. These outbreaks in the 1990s caused more than $50 million in estimated damage. So consider ISA the hoof and mouth disease of the global salmon farming industry."

In Scotland, Infectious Pancreatic Necrosis was also given the moniker "Salmon farming's foot-and-mouth" in 2004 due to the rampant spread of the virus.

There are a host of public health risks associated with eating farmed salmon – ranging from the potential to the proven. In a scientific paper – "Bovine Spongiform Encephalopathy and Aquaculture" – published in 2009 in the *Journal of Alzheimer's Disease* researchers were "concerned that consumption of farmed fish may provide a means of transmission of infectious prions from cows with bovine spongiform encephalopathy to humans, causing variant Creutzfeldt Jakob disease".

According to Compassion in World Farming, farmed salmon "often swim in constant circles like caged zoo animals" and "wave after wave of serious disease outbreaks have caused the deaths of millions". In Compassion in World Farming's 2001 report – 'In Too Deep: the welfare of intensively farmed fish' – farmed salmon were calculated to have the equivalent of a bath-tub of water to swim around. "Often suffering blinding cataracts, fin and tail injuries, body deformities, alarmingly high mortality, and infested with parasitic sea lice that are treated with strong chemical nerve toxins, the welfare of the 'king of fish' needs urgent reform" (read more details via 'In Too Deep').

This is the 'Frankenfish' farming nightmare that has nothing to do with genetic engineering and everything to do with conventional factory fish farming. Even without the dangers and risks posed by GE salmon, 'The Horrors of Intensive Salmon Farming' are already here in salmon farming's very own version of Apocalypse Now.

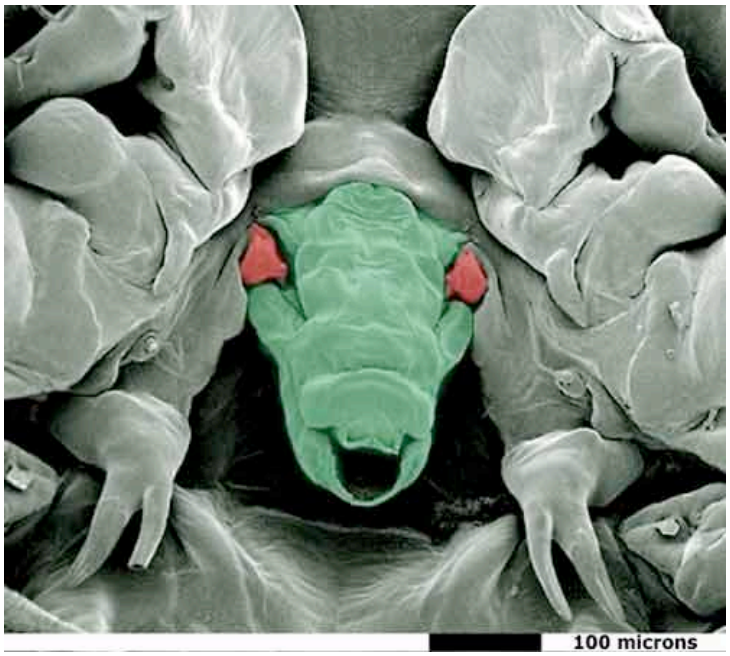


Photo: Sea Lice (Under a Microscope)

Aquacalypse Now: The End of the Line for Salmon Farming

Welcome to the 'Infectious Salmon Aquacalypse'. Aquacalypse was a term coined by Dr. Daniel Pauly of the University of British Columbia in his essay 'Aquacalypse Now: The End of Fish' published by *The New Republic* in 2009.

Photo: 'Aquacalypse Now' article in The New Republic

In the film 'The End of the Line', Dr. Daniel Pauly warned that: "We're fighting a war against fish." Dr. Pauly also warned of the threats posed by salmon feedlots in the documentary 'Farmed Salmon Exposed: The Global Reach of the Norwegian Salmon Farming Industry'. The disease-ridden state of salmon feedlots around the world may well spell the 'The End of Farmed Fish'.

In Biblical times, the 'Ten Plagues' of Egypt included frogs, locusts, pestilence, boils, darkness, hail, flies, a river of blood, sores and lice. Now add to that Sea Lice and Farmed Salmon.

Photo: The image illustrates the text which says that God will send evil angels to punish the Egyptians. The evil angels are depicted as demons whose breath emits one of the 10 plagues. For example, one of the demons crouches by the shore of the Nile while breathing on it and causing the water to turn to blood. Another emits lice from his mouth and a third locust.

The 'Plague of Lice' is described in the Bible in the book of Exodus:

"Then the LORD said […] "Stretch out thy rod, and smite the dust of the land, that it may become lice throughout all the land of Egypt." […] When Aaron stretched out his hand with the staff and struck the dust of the ground, gnats came upon men and animals. All the dust throughout the land of Egypt became lice." Exodus 8:20–21

Other plagues included 'The Plague of Pestilence', 'The Plague of Boils' and 'The Plague of Blood' (sometimes referred to as 'The Plague Upon the River'). In the latter, the Bible states that the River Nile "will be changed into blood" and "the fish in the Nile will die, and the river will stink." What a perfect description of a modern day salmon feedlot!

The Plague upon The River

The Plague of Frogs

The Plague of Lice

The Plague of Flies

The Plague upon The Cattle

The Plague of Sores

The Plague of Hail and Fire

The Plague of Locusts

The Plague of Darkness

The Plague upon The First-Born

Photo: The Ten Plagues

A 'Plague of Sea Lice' is certainly now rampant within the global salmon farming industry and is threatening a mass exodus of wild salmon.

In addition to the 'Ten Plagues', the Bible's book of Revelation describes the 'Four Horsemen of the Apocalypse' who represent Death, Famine, Conquest and War.

Photo: Four Horsemen of the Apocalypse, an 1887 painting by Victor Vasnetsov.

On land, the 'Four Horsemen of the Agricalypse' could be viewed as Avian Influenza (Bird Flu/H5N1), Foot-and-Mouth Disease (Hoof and Mouth Disease/Aphtae epizooticae), Mad Cow Disease (BSE) and Swine Flu (H1N1). Indeed, the mass mortalities of flocks of birds due to the spread of Avian Influenza was recently dubbed the 'Aflockalypse' with Google Maps tracking mass bird deaths. In terms of deadly diseases affecting humans and animals, HIV (AIDS), SARS, MRSA, Smallpox, E. Coli, Tuberculosis, Rabies, Ebola and the Black Death (Bubonic) have all plagued the planet since Biblical times.

Photos: The Four Horsemen of the Apocalypse

Similarly, the blue revolution and rapid expansion of intensive aquaculture on the seven seas has inevitably been accompanied by deadly diseases, infections, pathogens, viruses, parasites and other harbingers of death.

Photos: 'Four (Sea) Horsemen of the Aquacalypse'

The Grim Reaper is a regular visitor to salmon feedlots. Mass mortalities on salmon farms (so-called 'morts') are indicative of the scale of the disease problem. Deadly diseases such as ISA, IHN and IPN can scythe through a salmon feedlots quicker than you can say 'The End is Nigh'.

In Scotland, for example, there were nearly 10 million dead farmed salmon or 'morts' reported to the Scottish Environment Protection Agency in 2004. Following an ISA outbreak in 2009 over 100,000 farmed salmon died on one farm in Shetland. In Canada, 1.3 million 'morts' were reported in the Clayoquot Sound UNESCON Biosphere Reserve from a dozen salmon feedlots in 2003. According to data supplied by the New Brunswick Department of Agriculture Fisheries and Aquaculture, 9.6 million farmed salmon were culled due to ISA between 2000 and 2006. The OIE's 'World Animal Health Information Database' reported three new ISA outbreaks in Norway between June and December 2009 with over 1 million fish 'slaughtered'. The OIE's 'World Animal Health Information Database' also reported almost 3 million 'destroyed' farmed salmon following twenty new outbreaks of ISA in Los Lagos Region in 2008 (January to June).

Prioritising which disease issues are the most significant is fiendishly difficult. In attempting to choose between the 'Four Horsemen of the Apocalypse' and the 'Ten Plagues' it is a case of caught between the devil and the deep blue sea. Hence, the 'Seven Seahorsemen of the Aquacalypse' leaping out of the raging ocean like 'Neptune's Horses' are: Infectious Salmon Anaemia, Sea Lice, Salmon Rickettsial Syndrome, Listeria, Kudoa, Infectious Pancreatic Necrosis and Pancreas Disease.

Photos: 'Neptune's Horses' and 'King Neptune's Horses'

Hot on their heels are a legion of 'Salmon Superbugs' and Salmon Transmitted Diseases (STDs) which haut the industry like the Ringwraiths in the Lord of the Rings.

Photos: Ringwraiths from the Lord of the Rings; Seven Seahorsemen of the Aquacalypse (Graphic courtesy of Markus Fenz: http://morxn.com)

Judgment Day in British Columbia

"If you shut up truth and bury it under the ground, it will but grow, and gather to itself such explosive power that the day it bursts through it will blow up everything in its way" (Émile Zola, 1840-1902)

The acrimonious battle against salmon farming is no more apparent than in British Columbia, Canada. "Judgment Day may be fast approaching for the three Norwegian multinationals – Marine Harvest, Cermaq and Grieg – which control 92% of the BC salmon farming industry," reported *The Common Sense Canadian* in August via 'Farmed Salmon Confidential'. "If and when compelling new evidence comes to bear – on the public record, there for media to freely report – connecting BC's declining salmon populations with diseases related to the salmon farming industry, the fall-out for the industry could indeed be as severe as it fears. Those flashy TV ads professing the industry's utter innocence would certainly come back to haunt it, as would all the years of obstructing the communication of

important science to the public whose wild salmon and marine environment are at stake. After all, as Watergate taught us, "it's not the crime, it's the cover-up." Is the Norwegian salmon farming industry in line for a Nixonian fall?"

This multi-billion dollar question will hopefully be answered via a judicial inquiry set up by Canadian Prime Minister Stephen Harper to investigate the declines of sockeye salmon in the Fraser River. The 'Cohen Commission' will tackle the issue of 'Diseases' and 'Aquaculture' via evidentiary hearings in Vancouver during August and September.

Two years ago, the film 'Farmed Salmon Exposed' lifted the lid on the can of worms that is the global reach of the Norwegian salmon farming industry. The documentary portrayed an industry in crisis, especially in Chile where the deadly disease Infectious Salmon Anaemia (ISA) wiped out three-quarters of farmed salmon production and caused millions of dollars in financial losses.

Two years later the Norwegian-owned salmon farming industry in British Columbia is still desperately trying to prevent the truth about infectious diseases being released in the public domain. However, the Cohen Commission will open up the disease-ridden can of worms whether the Norwegian-owned industry likes it or not. The sordid salmon secrets of the industry will be publicly revealed for the first time.

The Book of Revelation will be opened starting on August 22 when the Cohen Commission, led by Justice Bruce Cohen, investigates 'Diseases' and 'Aquaculture'. Ten years of disease data for 120 salmon farms in B.C. will finally be published and made available as exhibits at the inquiry. A decade of disease data represents B.C.'s very own D-Day in the battle against salmon farming.

If the industry is to be believed, the mere publication of disease records will cause 'irreparable' and 'irrevocable' financial damage. Moreover, if a report in *The Globe & Mail* in May is true, the Norwegian-owned industry has been secretly hiding ISA for years. Shamefully, the industry has also been concealing the implications of a scientific paper showing the spread of ISA from Norway via infected eggs – and continues to import eggs despite the science showing 'vertical transmission'.

A technical report on "Diseases and Parasites" will be published before the end of the evidentiary hearings in September. The report, authored by Professor Michael Kent of Oregon State University, will "take a broad view of sockeye diseases and parasites that span the life cycle from egg to adult, and will evaluate the full spectrum of diseases that occur at all life history stages".

Another technical report will address the issue of "Impacts of salmon farms on Fraser River sockeye salmon". According to the Cohen Commission: "The researchers will evaluate the linkage between salmon farm operations and Fraser sockeye spawning returns, if any. This research will consider the impact on Fraser sockeye of sea lice exposure, farm wastes that affect benthic and pelagic habitat quality, Atlantic salmon escapees, and disease".

The damning revelations on Judgement Day could blow the industry out of the water and back home to Norway where infectious diseases and parasites such as sea lice ravage the Norwegian industry.

The salmon farming industry are desperately trying to keep a lid on the industry's dirty big secrets. "The salmon feedlot owners are now refusing to allow the provincial government of British Columbia to test the fish in their pens for disease as of April 1 2010, they will not even permit access to their dead fish," wrote Alexandra Morton in August 2010. "I don't know how these feedlots are getting away with this, but they must have reasons for such extreme secrecy".

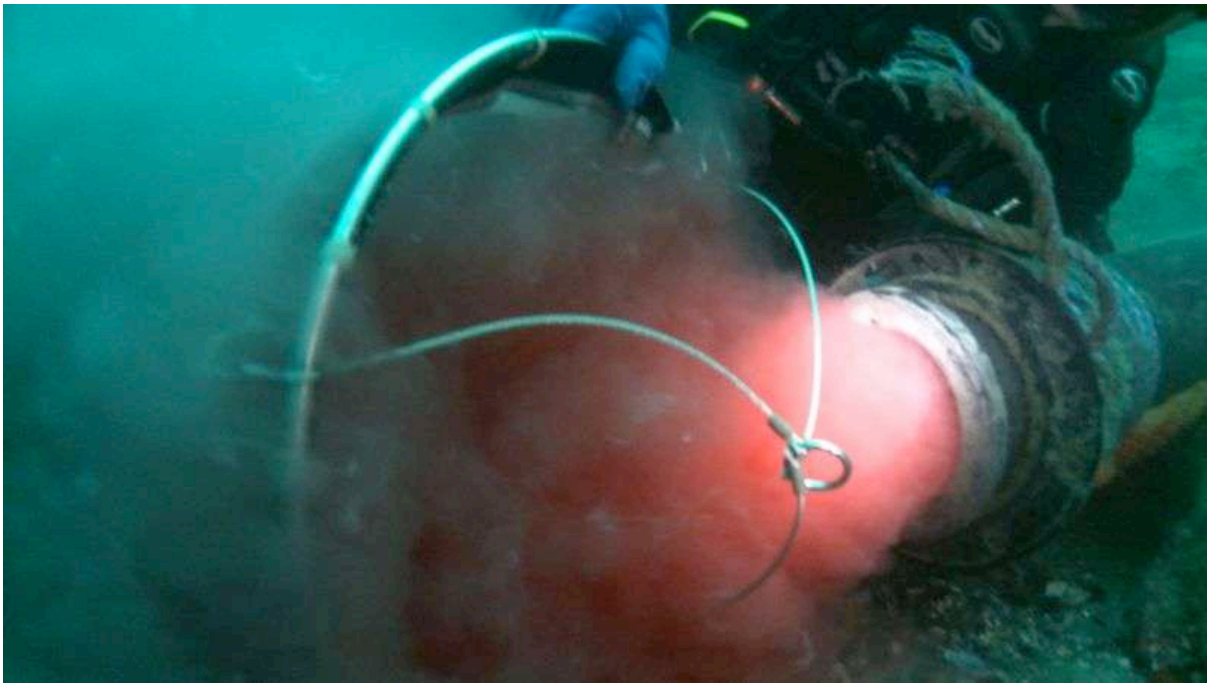


Photo: Blood and sea-lice infested effluent being discharged into the 'Wild Salmon Narrows'

Documents reveal that the Norwegian-owned companies Marine Harvest and Cermaq (who together control three-quarters of B.C.'s salmon farms) have been lobbying behind the scenes since at least 2008 for the Government not to release disease information. The BC Salmon

Farmers Association (BCSFA) also successfully argued against the disclosure of disease data during the Cohen Commission with Justice Cohen ruling last month that information must be kept confidential until the evidentiary hearings on aquaculture.

In documents recently obtained by *The Common Sense Canadian*, Marine Harvest admitted in a submission to the Office of the Information & Privacy Commissioner in 2008 that release of disease information "would cause significant commercial harm", "undue financial loss" and that "Marine Harvest Canada's reputation could be tarnished and sales volume reduced". It further stated that: "Marine Harvest is a publicly traded company on the Oslo Stock Exchange and as such, corporate reputation is very important in maintaining share price and shareholder loyalty". Marine Harvest is owned by Norway's richest man, John Fredriksen, who is worth over $10 billion and 72nd richest person in the world according to *Forbes*.

Cermaq (who operate in Canada as Mainstream) claimed in another submission in 2008 to the Office of the Information & Privacy Commissioner that "disclosure would result in 'undue financial loss' to Mainstream", "damage Mainstream's business" and referred to "the harm which such information in the wrong hands can do".

Similar statements were made by the BC Salmon Farmers Association (BCSFA) in submissions to the Cohen Commission in May this year. The BCSFA conceded that should disease data be disclosed publicly there would be a "likelihood of misuse and irrevocable damage to the economic interests and reputations of participants and individuals". In another submission to the Cohen Commission in May, the BCSFA admitted that "irreparable damage will occur to the reputations and economic interests of the BCSFA's member companies and their shareholders".

Whilst the BCSFA – whose members include the Norwegian companies Marine Harvest, Cermaq and Grieg – has been privately lobbying for the non-disclosure of disease data they have issued public statements claiming "good health" and "healthy fish" on B.C. salmon feedlots. This is despite the fact that in April 2010, the BCSFA refused access to government inspectors to carry out disease monitoring and data which reveals a host of deadly diseases,

viruses, pathogens and bacteria since 2003 (published online via the 'BCSFA Fish Health Database' – see Appendix).

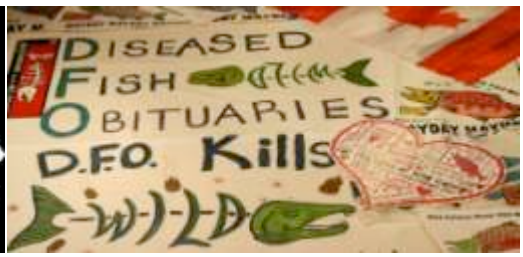
The silencing of scientist Dr. Kristi Miller from the Canadian Government's Department of Oceans is surely symptomatic of the damaging information being kept secret. Nevertheless, a policy of suppressing science and 'muzzling' legitimate scientific research (however damaging to vested and business interests) contrasts markedly with the open nature of salmon feedlots in the ocean.

The Vancouver Sun reported in July (26th) in an article – "Ottawa silences scientist over West coast salmon study" - that: "Top bureaucrats in Ottawa have muzzled a leading fisheries scientist whose discovery could help explain why salmon stocks have been crashing off Canada's West Coast, according to documents obtained by Postmedia News. The documents show the Privy Council Office, which supports the Prime Minister's Office, stopped Kristi Miller from talking about one of the most significant discoveries to come out of a federal fisheries lab in years."

"Never Heard of Salmon Leukemia? Chances are you won't… for a while," reported 'Silencing Science' in March: "DFO has banned Dr. Miller from giving any media interviews about the subject. In a time when the information is of significant importance and the idea is still fresh in the minds of the scientific community, the spokesperson is barred from reaching her audience. Likely, the issue will again gain some momentum once Dr. Miller is forced to testify in front the Cohen Commission into the response of Fraser River Salmon depletion, in the coming months."

Allowing dirty secrets to fester in a climate of apathy and denial has a nasty habit of coming back to bite you. As any marathon runner will know, starving anything of oxygen is a recipe for a bad smell at the end of the day.

In Canada, the Department of Fisheries and Oceans (DFO) is held in such contempt for presiding over the collapse of wild Atlantic cod on the East coast and now wild Pacific salmon on the West coast that it is known by the monikers 'Department of Fish Obituaries', 'Dead Fish Organization' and 'Diseased Fish Obituaries'.



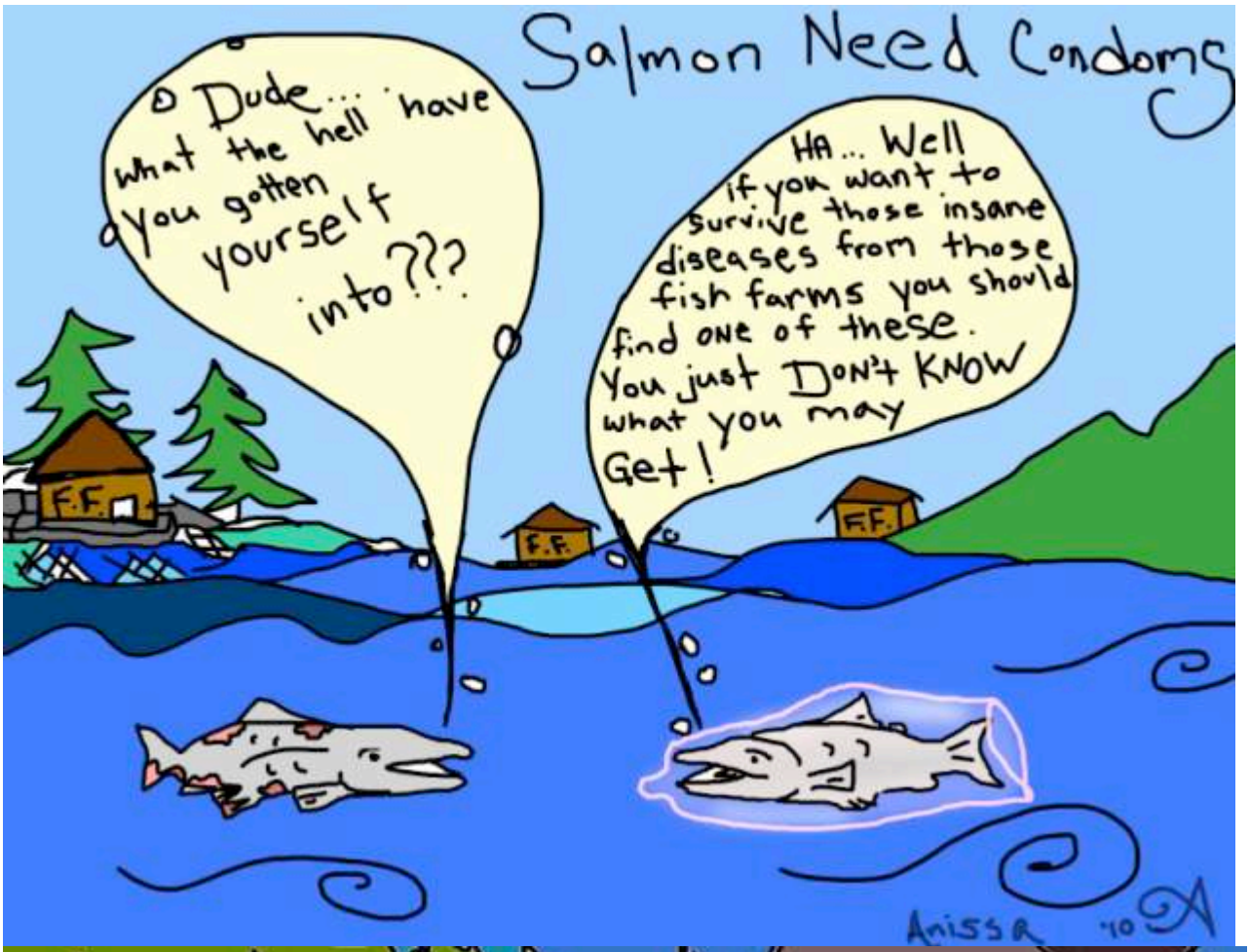
Canadian Prime Minister Stephen Harper, who set up the Cohen Commission, and the BC Salmon Farmers Association (BCSFA) are viewed as salmon killers not salmon protectors.

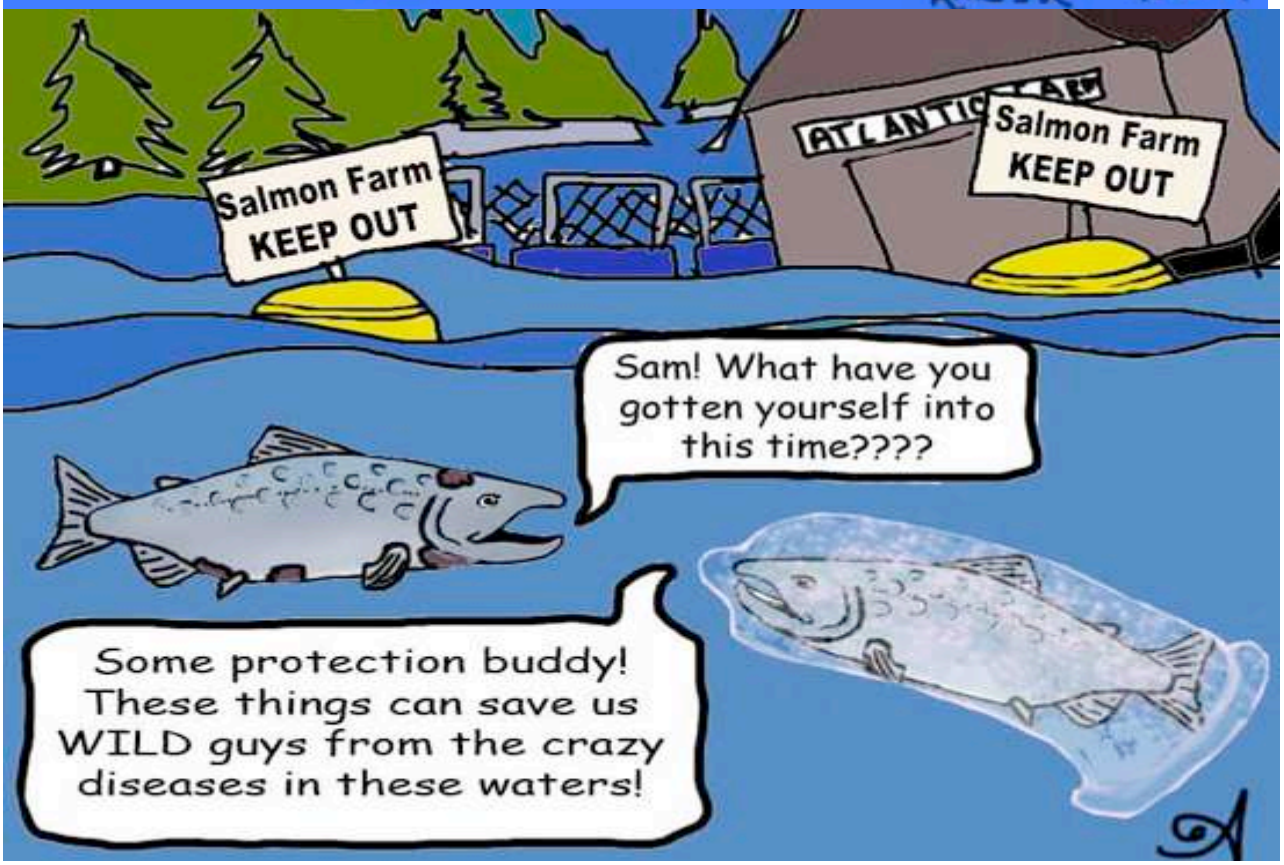
DFO staff on the witness stand at the Cohen Commission for 'Diseases' (August 22-25) include Dr. Stewart Johnson (Head, Aquatic Animal Health), Dr. Kristi Miller (Head, Molecular Genetics), Dr. Christine MacWilliams (Fish Health Veterinarian – Salmonid Enhancement Program) and Dr. Kyle Garver (Research Scientist). DFO staff appearing in the 'Aquaculture' evidentiary hearing (August 25 – September 8) include Andrew Thomson (Director, Aquaculture Management Directorate), Trevor Swerdfager (formerly Director General, Aquaculture Management Directorate, DFO (NHQ)), Brian Atagi (Area Chief Aquaculture, Conservation & Protection), Kerra Hoyseth (Senior Aquaculture Biologist, Aquaculture Environmental Operations) and Dr. Simon Jones (Research Scientist).

In British Columbia, Captain Condom is coming to the rescue of wild salmon in. This caped crusader is fighting to stop the spread of STDs and is asking that disease-ridden salmon feedlots take protection.

Photo: Captain Condon promotes safe salmon farming

The 'Safe Salmon Farming' campaign is no laughing matter.


Salmon Need Condoms
Dude... what the hell have you gotten yourself into???
HA... Well if you want to survive those insane diseases from those fish farms you should find one of these. You just DON'T KNOW what you may Get!
F.F.
F.F.
F.F.
Anissa '10


Salmon Farm KEEP OUT
ATLANTIC
Salmon Farm KEEP OUT
Sam! What have you gotten yourself into this time????
Some protection buddy! These things can save us WILD guys from the crazy diseases in these waters!

Cartoons: Salmon Need Condoms to Stop the Spread of STDs

Even the Pope is standing firm in the fight to prevent the spread of infectious diseases.

Photo: The Pope and Captain Condom

Feedlots as '**Pathogen Culture** Facilities'

"Salmon farms differ fundamentally from terrestrial farms because their effluent flows directly, untreated into contact with wild species," pointed out biologist Alexandra Morton of the Raincoast Research Society back in 2003.

Speaking to PBS for their 2004 film 'Farming the Seas', Alexandra Morton said: "If they want to avoid these diseases they should put their farms on land. We almost never see sick wild fish because they're grabbed. The seals, the whales, the birds, and the sharks get them. So that pathogen is at the end of its role. But, in the farm situation, they're coddled, they're drugged, they're protected. In the words of a Norwegian scientist, the salmon farms are pathogen-culturing facilities. They get it from the wild, but then they amplify it. And this is the real problem we're seeing here. If you stand on a football field with a person with a cold, you're less likely to get that cold than if you stand in an elevator for 4 hours with 10 other people who are very sick with the same cold. That's the principle. When the wild fish go by it passes the pathogen to the farm, it multiplies, and the nets prevent any predators from taking these sick fish out."

The Norwegian scientist cited above was Professor Tor Bakke from the University of Oslo in Norway. His scientific paper – "Diseases and parasites in wild Atlantic salmon (*Salmo salar*) populations" - published in 1998 stated: "Finally we would stress again the position of marine rearing pens as pathogen culture facilities at the crossroads for migrating salmonids moving between fresh and saltwater. We know nothing of the epidemiology of disease of

marine salmon, beyond the fact that highly pathogenic organisms such as ISA are unlikely to have a wide distribution in nature because they would kill salmon before they had dispersed. The possibility of organisms such as this colonizing smolts on migration and then having a significant impact on marine salmon stocks should be treated very seriously."

Sadly, those planning the location of salmon farms on migration routes did not heed this warning. Over a decade later, the same warnings are being repeated by Norwegian scientists. A scientific paper – "Disease interaction and pathogens exchange between wild and farmed fish populations with special reference to Norway" – published in the journal *Aquaculture* in May reported: "In fish farms the density of susceptible hosts is unnaturally high. Once a pathogen is introduced to a farm, the probability of an encounter between an infected and a susceptible host is increased compared to natural systems. The probability of transmission per contact may also increase since farmed populations consists of homogenous groups of fish (Ebert, 1998), or since the fish may be stressed by crowding or confinement to stressing environmental conditions (Sniezko, 1974). In the theory of evolution of virulence, high densities of susceptible hosts will promote increased virulence since rapid propagation of a pathogen within an infected host will affect infectivity of this host and lead to higher rates of transmission in dense host populations."

Moreover:

"Artificially high population densities have also been suggested to be the underlying cause of recurrent emergences of new infectious diseases in aquaculture (Murray and Peeler, 2005). Circumstantial evidence suggests increased virulence of pathogens causing VHS (Einer-Jensen et al., 2004) and ISA (Nylund et al., 2003) in fish farms compared to wild fish. Whether this is due to pathogen evolution or the artificial farm conditions, however, is not clear. Long term studies from Finland on the evolution of *Flavobacterium columnare*, causing columnaris disease, suggest that this bacterium has evolved towards increased virulence (Pulkkinen et al., 2010). It is argued that aquaculture conditions have enabled virulent strains of *F. columnare* to spread and cause outbreaks. Among many correlating arguments to support this, it is shown that dead fish stay infectious and greatly enhances transmission of the pathogen. Hence, virulent strains of the pathogen are less compromised by killing their host in terms of transmission (Pulkkinen et al., 2010)."

Furthermore:

"Risks of acquiring and spreading diseases are always present in food production, regardless of the foods that are produced or systems that are used for production. However, fish-farming has some unique characteristics worth considering, as well as some characteristics that are common to farming of livestock. Unique to fish farming is, naturally, that it is conducted in water and often in open net-pens that have no barriers to pathogen exchange with the environment. Water flows freely through the cages and potential pathogens may come in contact both with wild fish and other farmed fish populations. These open systems are also vulnerable to escape of farmed fish. The likelihood of pathogen exchange between wild and farmed fish is enhanced by the attraction of persistent shoals of wild fish to fish farming cages due to feed being available or due to shelter (Dempster et al., 2009). Furthermore, the fish farming industry is commonly divided into juvenile and grow-out production. Producers of juvenile fish typically serve many grow-out farm sites. Hence fish, and potentially pathogens, are moved over large distances (Lyngstad et al., 2008). In common with other livestock production, fish are farmed in large, dense populations. The scale of production of

farmed fish may vastly exceed that of natural production of the same species. This may have implications for the quantities of pathogens produced, and hence the infection pressure to which both farmed and wild fish are exposed (Krkôsek, 2010). Dense and large farmed populations may also promote selection towards increased virulence in pathogens (Pulkkinen et al., 2010)."

Moreover, the open nature of salmon feedlots (often called 'cages' or 'pens') is an open invitation to the spread of disease:

"Net pens allow pathogen exchange with the surrounding environment. This is a recognised and widely debated problem for sea lice in salmon farming, where planktonic larval stages produced on fish in the pens drift passively into the surroundings with the water current. The spread of other pathogens by passive drift in the water current has also been suggested in a number of studies. Most of these studies rely on the tendency for disease outbreaks to cluster in space and time. This is well documented for ISA in Norway (Jarp and Karlsen, 1997; Scheel et al., 2007; Vågsholm et al., 1994), Canada and USA (McClure et al., 2005) and Chile (Mardones et al., 2009) and for PD in Norway (Kristoffersen et al., 2009)."

Aquaculture, especially factory salmon farming, spreads diseases. As a 'Disease Report' published in 2009 via the Salmon Aquaculture Dialogue stated: "Aquaculture activities in themselves can contribute to the spread of pathogens. There are many cases where the movement of fish for public or commercial salmon farming or even the movement of fish products has been clearly linked to the movement of pathogens into new locations, even crossing ecological boundaries. Whirling diseases in the Unites States, Gyrodactylus in Europe, and IHN in BC are all examples of diseases that have been moved by the movement of fish, water or equipment tied to public or private aquaculture."

A report - "Review of fish disease interactions and pathogen exchange between farmed and wild finfish and shellfish in Europe" – published in 2007 by the European Union examined the evidence for the transmission of pathogens between farmed and wild fish populations. The report stated that:

"Diseases in farmed fish may affect wild populations. Outbreaks of disease in farmed populations could change the disease status in the wild population through elevated pathogen levels."

You don't need to be a rocket scientist to work out that increasing the number of farmed salmon and expanding production inevitably exacerbates the spread of infectious diseases and parasites. Just ask any parent who's had to deal with hair lice in their children due to growing class sizes at school or anyone who keeps chickens or fish in a tank or aquarium.

As DIPNET (Disease Interactions and Pathogen Exchange Network) – a European Unioon-funded project - put it: "Farming creates a favourable environment for the transmission and expression of disease through high stocking densities and other stressors."

ISA and sea lice may be the most well known ills lurking on salmon feedlots but there are a host of other deadly diseases, pathogens, viruses, bacteria and parasites. The disease-ridden global salmon farming industry supports a legion of scientists, pathologists, virologists, bacteriologists and veterinarians.

Parasites in particular are a growing threat to salmon – both wild and farmed. Science Daily reported in August that: "Research at Oregon State University suggests that parasites are a more significant threat to salmon that has previously been assumed, making them weaker, smaller and more vulnerable to predators. The study will be published soon in the journals *Aquaculture, Journal of Parasitology*, and *International Journal of Parasitology*."

The Global Spread of Infectious Salmon

'Salmon Superbugs' have spread around the globe since the inception of salmon farming in Norway and Scotland in the 1960s. The disease-ridden nature of salmon farming has spawned a host of academic books, scientific journals and a legion of veterinarians, parisitologists, pathologists and microbiologists devoted to preventing the impending 'Aquacalypse'. Useful books include: 'Diseases and Disorders of Finfish Cage Culture' (2002), 'Pathogens of Wild and Farmed Fish' (1993) and the recently published 'Salmon Lice' (2011). A 'Disease Report' published in 2009 via the Salmon Aquaculture Dialogue also provides a global review on farmed salmon diseases and their effects on wild fish and helpfully notes that: "The term 'disease' captures a wide array of physical, physiological and population abnormalities."

The prevalence of diseases in farmed fish in Europe, for example, led to the formation of DIPNET (Disease Interaction and Pathogen exchange Network) by the European Union in 2004. DIPNET published various documents and reports including "Review of fish disease interactions and pathogen exchange between farmed and wild finfish and shellfish in Europe" in 2007. PANDA (Permanent Advisory Network for Diseases in Aquaculture) was another network funded by the European Union from 2004 to 2007.

However, the industry is expanding so quickly and new diseases are being diagnosed all the time that scientific journals such as the *Journal of Fish Diseases* and *Diseases of Aquatic Organisms* are an invaluable resource. The World Animal Health Organization (OIE) also publishes weekly 'Disease Information' online.

According to the Food and Agriculture Organization of the United Nations:

"The major disease problems affecting Atlantic salmon vary with geographic location. Some of the more important are included in the table below. In some cases antibiotics and other pharmaceuticals have been used in treatment but their inclusion in this table does not imply an FAO recommendation:

DISEASE	AGENT	TYPE	SYNDROME	MEASURES
ISA (Infectious salmon anaemia)	Orthomyxovirus	Virus	Lethargy; appetite loss; gasping at water surface; pale gills & heart; fluid in body cavity; dark liver; haemorrhages in internal organs	No treatment; statutory controls; biosecurity; bloodwater treatment

VHS (Viral Haemorrhagic Septicaemia)	Rhabdovirus	Virus	Bulging eyes and, in some cases, bleeding eyes; pale gills; swollen abdomen; lethargy	No treatment; statutory controls; vaccines being developed
IPN (Infectious Pancreatic necrosis)	Birnavirus	Virus	Erratic swimming, eventually to bottom of tank where death occurs	No treatment; statutory controls; biosecurity; broodstock screening; vaccines being developed
SPDV (Salmon Pancreas Disease virus)	Togavirus	Virus	Weight loss; emaciation; mortalities	No treatment; withholding feed; vaccination
Furunculosis	*Aeromonas salmonicida*	Bacterium	Inflammation of intestine; reddening of fins; boils on body; pectoral fins infected; tissues die back	Antibiotics; vaccination
BKD (Bacterial Kidney Disease)	*Renibacterium salmoninarum*	Bacterium	Whitish lesions in the kidney; bleeding from kidneys and liver; some fish may lose appetite and swim close to surface; appear dark in colour	Statutory controls; biosecurity; broodstock screening
Winter sores	*Moritella viscose* (multifactorial)	Bacterium	Ulcers	Antibiotics; vaccination
ERM (Enteric Redmouth)	*Yersinia ruckeri*	Bacterium	Black, lethargic fish 'hanging' in areas of low flow; bilateral exophthalmia; abdominal distension as result of fluid accumulation; haemorrhages of mouth and gills	Antibiotics; vaccination in freshwater
SRS (Salmon	*Piscirickettsia*	Bacterium	Increased	Antibiotics

Rickettsial Disease)	*salmonis*	(rickettsia)	mortality; anorexia; pale gills and lowered haematocrits; swollen abdomens; affected fish appear dark and lethargic, swimming at the sides of enclosures	
Saprolegniasis	*Saprolegnia*	Fungus	White or grey patches of filamentous threads on surface; cotton-like appearance radiating in circular, crescent-shaped or whorled pattern; usually begins on head or fins	Bronopol/formalin bath
Sea lice	*Lepeophtheirus salmonis*; *Caligus elongatus*	Ectoparasites	Reduced growth; loss of scales; haemorrhaging of eyes and fins	Paraciticides (bath e.g. Azamethiphos, Cypermethrin, Hydrogen peroxide); in feed (e.g. Emamectin, teflubenzuron)
Gill amoeba	*Paramoeba pemaquidensis*	Ectoparasite	Gill infestation	Freshwater baths
Tapeworms	*Eubothrium* spp.; *Diphillobothrium* spp.	Endoparasites	Reduced growth; reduced condition factor; aesthetically unacceptable to consumers	Fenbendazole/praziquantel in feed for *Eubothrium*; avoidance of early hosts
Freshwater protozoa	*Ichthyobodo*; *Trichodina*; *Ichthyophthirius*	Ectoparasites	Irritation response; heavy and laboured operculum movements; flashing and rubbing; skin cloudiness caused by excess mucus; focal	Formalin baths

			redness; lethargy	
Algal/Jellyfish blooms	Various	Various	Various	Avoidance; airlift systems; skirts
Production diseases	Various (congenital, nutritional, environmental)	Various	Various	Improved management

[For country specific information see Table 1 – 'Disease distribution in selected production areas of the world' – in the 'Disease Report' published in 2009 via the Salmon Aquaculture Dialogue]

The World Organization for Animal Health (OIE) also publishes disease data via the 'World Animal Health Information Database' (WAHID) and other disease occurrence databases. Diseases of fish affecting salmon listed by the OIE under their 'Aquatic Animal Health Code' include: Epizootic haematopoietic necrosis, Infectious haematopoietic necrosis, Viral haemorrhagic septicaemia, Infectious salmon anaemia and Gyrodactylosis (*Gyrodactylus salaris*).

According to the OIE: "The standards published in the *Aquatic Code* are the result of consensus among the veterinary authorities of OIE Members and are references for World Trade Organization (WTO) Members under the Agreement on the Application of Sanitary and Phytosanitary Measures, in regard to which the OIE provides the health standards for safe international trade in aquatic animals and their products". In other words, the presence of certain fish diseases can be a barrier to international trade.

Disease data can still be difficult to access (e.g. Chile, Japan and the Faroe Islands) but information is available for the most of the major salmon farming producing regions of the world. Norway, as one might expect from the world's #1 salmon farming nation, leads the world in diseases (as well as the export of diseases).

- Norway:

In Norway, ISA is just the tip of the infectious salmon iceberg: Pancreas Disease, Infectious Pancreatic Necrosis, Furunculosis, Heart and Skeletal Muscle Inflammation, Bacterial Kidney Disease, Cardiomyopathy Syndrome, sea lice and emerging diseases such as Francisella spell doom and gloom for the birthplace of salmon farming.

A scientific paper – "Diseases of farmed Atlantic salmon Salmo salar associated with infections by the microsporidian Paranucleospora theridion" – published in the journal *Diseases of Aquatic Organisms* in March 2011 reported:

"Production of Atlantic salmon *Salmo salar* in Norway has for many years suffered from several diseases associated with inflammation of various tissues such as gills, heart and skeletal muscle. These diseases have been named proliferative gill inflammation (PGI) or proliferative gill disease (PGD), pancreas disease (PD) or salmonid alphavirus disease (SAV-disease), heart and skeletal muscle inflammation (HSMI), and cardiomyopathy syndrome..... Gill diseases in the production of farmed Atlantic salmon have been an increasing problem in Norway."

Another scientific paper – "Disease interaction and pathogens exchange between wild and farmed fish populations with special reference to Norway" – published in the journal *Aquaculture* in May 2011 reported: "In 2009, the largest disease-related losses in the seawater phase of salmonid culture were virus-associated. The highest number of outbreaks were due to infectious pancreatic necrosis (IPN), pancreas disease (PD) and heart and skeletal muscle inflammation (HSMI) with both PD and HMSI apparently spreading to new areas."

Specific diseases may wax and wane over the years but new diseases are always emerging. Here's a snapshot from 1998 to 1997.

	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
ILA (ISA)	13	14	23	21	12	8	16	11	4	7
IPN					174	178	172	208	207	165
PD*	7	10	11	15	14	22	43	45	58	98
HSMB (HMSI)							54	83	94	162
Piscirickettsiose	0	6	0	1	17	5	0	0	1	1
Furunkulose	1	2	6	3	0	2	3	1	3**	5***
BKD	0	3	3	3	1	1	1	2	0	0

Table 1: Diseases in Norwegian Aquaculture (1998-2007) as reported by the Norwegian Veterinary Institute

However, in 2008 the number of cases of ISA more than doubled to 17 and in 2009 the number of cases of IPN increased to 223 (up from 165 in 2007).

Data on diseases in Norway has been reported in English by the Norwegian Veterinary Institute since 2006. A 'Farmed Fish Health Report 2005' published in 2006 stated that: "The viral diseases infectious salmon anaemia (ISA), pancreas disease (PD), heart and skeletal muscle inflammation (HSMI), and infectious pancreatic necrosis (IPN) appear to be the main problems in the industry.... Cardiomyopathy syndrome (CMS) and proliferative gill inflammation (PGI) caused high losses in 2005 and were seen in association with viral diseases. The most important bacterial disease seems to be *Moritella viscosa* infection, which causes winter ulcers."

A 'Farmed Fish Health Report 2008' published in 2009 stated that "Pancreas Disease gives grounds for concern" and "there is an increasing problem with salmon-lice resistance to various therapeutant treatments". According to the report:

"Infectious pancreas necrosis (IPN) and gill-associated disease continue to account for the largest losses during the fresh water phase of culture. Of new trends for 2008, there has been a slight but marked increase in the number of registered infections caused by *Yersinia ruckeri* in salmon and *Flavobacterium psychrophilum* in rainbow trout. The largest disease related losses during the seawater phase of culture were registered following outbreaks of pancreas disease (PD) and heart and skeletal muscle inflammation (HSMI), with both of these diseases apparently spreading to new areas....Infectious salmon anaemia (ISA) has been particularly problematical in an area of south- and mid-Troms during 2008, and special measures

including vaccination have been introduced in this area in an effort to control the disease. The unique isolate of viral haemorrhagic necrosis virus (VHSV) which was detected for the first time in Norway in 2007, has now been detected in several farms within the same fjord system".

The report also detailed a new disease: "The fact that a large number of cases of a new disease of as yet unknown aetiology, in seawater reared salmon, were registered towards the end of 2008, give grounds for concern. Based on the clinical presentation, several fish health services conclude that this must be new and previously unregistered. The histopathological findings are varied, and the disease is currently being described and the causes investigated."

- Chile:

In Chile, disease data is more difficult to access. An article – "Salmonid Rickettsial Septicaemia" – by Intervet published in 2006 stated that: "SRS (a.k.a. Salmon Rickettsial Syndrome or Piscirickettsiosis or Coho salmon septicaemia or Huito disease) is considered to be the most important disease problem in the Chilean salmon farming industry, with economic losses of over US$100 million in some years."

Since 2007, Chile has been fighting a losing battle to stem the tide of ISA which recent scientific evidence shows was imported from Norway and cost the industry an estimated $2 billion between 2007 and 2009. Other issues include Endohelminth parasites (tapeworms).

- Scotland:

In Scotland, disease data obtained this year by the Salmon & Trout Association revealed an industry infested with sea lice and battling disease problems. "The devil is in the detail – now we have seen at least some of that detail and it is not pretty," said solicitor Guy Linley-Adams in March. The disease dossier revealed "alarming results" of Government inspections of salmon farms based on Fish Health inspectorate reports from 2009 and 2010.

Scottish salmon farms have been riddled with infectious diseases since the 1980s when Furunculosis became a particular problem and continued throughout the 1990s when ISA was first reported. Diseases reported on Scottish salmon farms during 2006 and 2007 (data obtained from the Scottish Government via Freedom of Information), for example, included: Adhesions, Gill Pathology, Vibrio species, Bacterial Kidney Disease, Infectious Pancreatic Necrosis, Capriniana, Dermocystidium species, Yersinia ruckeri (ERM), Pseudomonas species, Nephrocalcinosis, Haemorrhagic smolt syndrome, Moritella viscosa, Aeromonas hydrophila, Epitheliocystis, Myxosporean species, Salmon pancreas disease, Cardiomyopathy syndrome, Cataract, Exophiala, Gyrodactylus derjavini, Eubothrium species, Ichthyobodo species, Proliferative kidney disease, Aeromonas salmonicida (furunculosis), Flavobacterium psychrophila (RTFS), Bacterial gill disease and Piscirickettsia salmonis (SRS).

A review of disease data for Scotland between 1980 and 2006 (the latest data set available) shows an inexorable increase in the number of different diseases reported – with a peak of nearly 40 in 2006 (increasing from 20 in 1998 and less than 10 in 1989).

In 2009, a second wave of ISA swept through the Shetland Islands in Scotland. A report published in March (based upon data from 2009 and 2010) revealed ongoing problems with

Cardiomyopathy syndrome, Infectious Pancreatic Necrosis, Pancreas Disease, ISA and sea lice.

- Canada:

In Canada, ISA has been a recurring problem in New Brunswick since it was first diagnosed in 1996. According to data obtained in August from the Ministry of Agriculture, Aquaculture and Fisheries in New Brunswick, there were 10 cases of 'ISA Virus' and 9 cases of 'ISA Virus (H0) in 2007. Bacterial Kidney Disease, Enteric Redmouth, Skin Lesions and Sea Lice were also reported problems in New Brunswick between 2007 and 2011.

The long 'List of Veterinary Biologics Licensed in Canada' is indicative of the disease problem in Canada. Licensed products include: 'Aeromonas Salmonicida-Vibrio Anguillarum Serotypes 01 & 02 Bacterin; Arthrobacter Sp. Nov., Live Culture, Bacterial Kidney Disease Vaccine'; 'Enteric Redmouth Bacterin (Yersinia Ruckeri Bacterin)'; 'Flavobacterium Columnare Bacterin; Infectious Salmon Anaemia Virus Vaccine, Killed Virus - For Export Only'; 'Infectious Pancreatic Necrosis Virus Vaccine, Killed Virus, Recombinant Piscirickettsia Salmonis Bacterial Extract, Aeromonas Salmonicida, Vibrio Ordalii Bacterin - For Export Only'; and 'Piscirickettsia Salmonis Subunit Vaccine - For Export Only'.

In British Columbia, the BCSFA 'Fish Health Database' reported the following between 2003 and 2010: Aeromonas hydrophilia Infection, Aeromonas salmonicida Infection, Caligus Infection, Caprellid infection, Costia Infection, Fusiform Bacteria Infection, Infectious Hematopoetic Necrosis Virus Infection, Large Spleen Syndrome, Lepeophtheirus Infection, Loma infection, Mycobacterium marinus Infection, Myxobacterial Infection, Net Pen Liver Disease, Nucleopsora (Enterocytozoan) salmonis Infection, Phoma herbarum Infection, Piscirickettsia salmonis Infection, Pseudomonas Infection, Renibacterium salmoninarum Infection, Saprolegnia Infection, Trichodina Infection, Vibrio (Listonella) angullarum Infection, Viral Haemorrhagic Septicemia Virus Infection, Virus Infection and Yersinia ruckeri Infection (see Appendix for more details).

A 'Fish Health Report 2006' published by the Ministry of Agriculture and Lands in B.C. also detailed Bacterial Kidney Disease, Enteric Red Mouth, Carnobacterium Gallinarum, Mouth Myxobacteriosis, Photobacterium leiognathi, Vibrio tasmaniensis, Shewanella putrefaciens, Rickettsiosis, Bacillus psychrosaccharolyticus, Rahnella aquatalis and VHS (North American Strain, genotype IV). The 'Fish Health Report 2007' detailed particular problems with Mouth Myxobacteriosis and Bacterial Kidney Disease and also reported Loma, Enteric Red Mouth, VHS (North American strain genotype IVa), Rickettsiosis, Pseudoalteromonas sp, Psychrobacter sp, Vibrio splendidus, Carnobacterium maltaromaticum, Vibrio tubiashii and Vibrio wodanis. It also reported:

"Two marine parasites found in the brains of a limited number of Atlantic salmon carcasses in 2007 are of scientific interest and contribute to the information derived from surveillance efforts. These parasites may represent the emergence of an indigenous pathogen worthy of close monitoring and further investigation however there is no evidence that they are exotic to British Columbia."

The 'Fish Health Report 2008' reported that: "Of the infectious disease cases (for Atlantic salmon), the main diagnoses were mouth myxobacteriosis (11%) and bacterial kidney disease

(4%). For farmed Pacific salmon, 50% of the audits cases found 'no infectious disease' (at the farm-level), and the main disease diagnoses were bacterial kidney disease (45%) and vibriosis (5%)." 'Pathogens of concern' also included Infectious Salmon Anemia Virus (ISAV) and Infectious Pancreatic Necrosis Virus (IPNV).

The 'Fish Health Report 2009' also detailed cases of Parasitic meningitis, Skin Ulcers (filamentous myxobacteriosis) and Jaundice syndrome. It reported that: "Two microscopic parasites have appeared sporadically in the brains of a limited number of Atlantic salmon carcasses since 2007, and these micro-parasites continue to be of scientific interest....There is no evidence that these parasites are moving beyond the brain vault of their Atlantic salmon host. In 2009, BCMAL's routine histological assessments revealed eighteen Atlantic salmon carcasses, over four coastal sub-zones, afflicted by the brain parasite." These cases were all listed as 'Parasitic meningitis'.

- Ireland:

In Ireland, a battle is being waged against the spread of IPN (linked to imported eggs from Scotland), sea lice (due to chemical resistance) and Pancreas Disease (PD). PD is a "serious issue for the salmon farming industry in Ireland" and is considered by the Marine Institute in Ireland as "the most significant infectious disease of Irish farmed salmon".

Disease data supplied by the Irish Government in 2007 reported the following 'Infectious Diseases':

Viral Diseases: Infectious salmon anaemia (caused by ISAV), Infectious pancreatic necrosis (caused by IPNV), Pancreas Disease (caused by SPDV)

Bacterial Diseases: Typical Furunculosis (caused by *Aeromonas salmonicida ssp salmonicida);* Atypical Furunculosis (caused by *Aeromonas salmonicida ssp. Achromogenes),* Vibriosis (caused by several species of *Vibrio*), Piscirickettsiosis (caused by *Piscirickettsia salmonis*), Myxobacteriosis (caused by *Flexibacter sp*), Bacterial Septicaemia (caused by *Aeromonas sp* and *Pseudomonas sp*)

Parasitic Diseases: Sea lice (mainly *Lepeophtheirus),* Costia, Ichthyopthirius, Trichodina Complex, Childonella, Kudoa, Hexamita, PKD agent, Paramoeba, Schyphidia Complex, Myxosporea, Gyrodactylus (*derjavini and truttae)*

Fungal Diseases: Saprolegnia

'Non-Infectious Diseases'Disorders' reported were: Cataracts, Skeletal deformities, Gill pathology caused by phytoplankton and /or zooplankton events.

- Australia:

In Australia, the Government admitted in 2007 that the salmon farming industry is "under attack" from Amoebic Gill Disease (AGD). Diseases reported on Australian salmon farms between 2004 and 2007 included: Amoebic gill disease (*Neoparamoeba sp.)*, Vibriosis, Marine aeromonas disease of salmonids (Aeromonas salmonicida: acheron), Marine yersiniosis (Yersinia rucheri: non-Haggerman strain), Tasmanian richettsial disease, Cutaneous erosive disease/mouth rot (Tenachibacteria maritimum), gill necrosis, Moon

jellyfish toxicosis (Aurelia aurita), Marine algal toxicosis, BSKD (Ichthiophonus sp.) and Irritable GUT syndrome (the true aetiology is yet to be determined).

- Iceland:

In Iceland, bacterial infections are an issue according to a scientific report published in 2011: "Bacterial infections have caused the major infectious diseases in Icelandic aquaculture. The bacterium *Aeromonas salmonicida* subsp. *achromogenes* (atypical furunculosis) has affected all species of fish cultured in Iceland and together with *Renibacterium salmoninarum* (bacterial kidney disease), *Moritella viscosa* (winter ulcer disease), *Yersinia ruckeri* (enteric redmouth disease) and *Vibrio anguillarum* (vibriosis) have been the cause of most bacterial disease problems in the last decade. Parasitic infections in Icelandic aquaculture due to Costia (*Ichtyobodo necator*) are a common problem, mainly in salmon farming. Ciliates of *Trichodina* spp. and fish lice, mainly *Caligus elongatus*, are frequently diagnosed in fish farms, among other parasites."

Chapter 2:

The Seven Seahorsemen of the Aquacalypse

[Graphic courtesy of Markus Fenz: http://morxn.com]

The 'Four Horsemen of the Apocalypse' and 'Ten Plagues' simply do not do the disease-ridden and parasite-infested salmon pharming industry justice. It is impossible to cram all the major disease issues into just four categories and even seven is difficult. Such is the speed of

the science on emerging issues and the problems of diagnosis that some diseases, bacteria and viruses defy simple categorization.

A scientific paper – "Diseases of farmed Atlantic salmon Salmo salar associated with infections by the microsporidian Paranucleospora theridion" – published in the journal *Diseases of Aquatic Organisms* in 2011 pointed out that:

"Most diseases that occur in the production of salmonids are a result of a combination of factors. These could be environmental changes (changes in factors like temperature, oxygen, algal blooms and fish shoals), human activities (e.g. transport of fish, sorting of fish, delousing) and pathogens (e.g. *Lepeophtheirus salmonis, Nucleospora salmonis)* weakening the immune defence of the host, increasing susceptibility or permitting proliferation of pathogens already present in the fish".

Hence, there are often a number of pathogens, gremlins and nasty critters at work at the same time. In searching the seven seas it is difficult to narrow down the field and there may be different 'horses for courses' in different countries (e.g. SRS in Chile and Kudoa in British Columbia). That being said, here's an attempt to define the seven most significant problems associated with salmon: the so-called 'Seven Seahorsemen of the Aquacalypse':

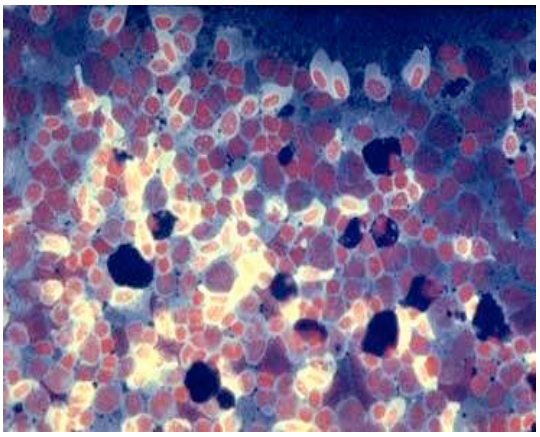
Infectious Salmon Anaemia (ISA)
Sea Lice (Lepeophtheirus salmonis)
Salmon Rickettsial Syndrome/Septicaemia (Piscirickettsiosis)
Listeria monocytogenes (Listeriosis)
Kudoa (Soft-Flesh Syndrome)
Infectious Pancreatic Necrosis (IPN)
Pancreas Disease (Salmon Pancreas Disease Virus/Salmonid Alphavirus Disease/Sleeping Disease)

These deadly demons are followed by a tsunami of other infectious diseases, viruses, bacteria, pathogens, parasites and 'Salmon Superbugs'. Many more may be out there lurking in the murky waters like Martin Sheen's character Captain Willard in the film classic 'Apocalypse Now'.

Photo: Captain Willard in 'Apocalypse Now'

Infectious Salmon Anaemia (ISA)

The global spread of ISA from Norway in 1984 is a critical case study in everything that is wrong with salmon farming. According to the Norwegian Veterinary Institute: "ISA is caused by a virus which infects and damages blood cells and cells lining the wall of blood vessels. This often results in haemorrhage in inner organs and the fish develops anaemia."



Photos: ISA symptoms and virus

A scientific paper in the *Virology Journal* in 2007 reported that: "Infectious salmon anemia (ISA) virus (ISAV) is a fish orthomyxovirus that has recently been assigned to the new genus *Isavirus* within the family *Orthomyxoviridae*. The virus causes a fatal clinical disease in Atlantic salmon with signs of exophthalmia, pale gills, ascites, congestion of gut, enlargement of liver and spleen, petechial hemorrhages in the visceral organs, and severe anemia."

"Consider ISA the hoof and mouth disease of the global salmon farming industry," reported Stephen Hume in *The Vancouver Sun* in 2008. "According to an information leaflet from the U.S. government's National Fish Health Research Laboratory, infected blood, feces, urine

and mucus, animal wastes, contaminated slaughter facilities, transport vessels and workers all easily transmit it from fish to fish and from site to site. As with hoof and mouth, the standard treatment is to kill all infected or exposed stocks within designated containment zones, disinfect all equipment and facilities and then keep fingers crossed."

As one might expect, a strategy based on keeping your fingers crossed is not particularly effective. Since first being reported in Norway in 1984, ISA has spread to every major salmon farming producing region in the world except British Columbia: including New Brunswick in Canada (1996), Scotland (1998), Faroe Islands (2000), United States (2001), Ireland (2002) and Chile (2001 for Coho salmon; 2007 for Atlantic salmon). Such was the devastating impact of ISA that: "The Faroe Islands paid the price of their entire industry when the virus hit in 2000." [For a review see 'ISA Diary of Disease Disaster'].

According to Professor Are Nylund of the University of Bergen in Norway, it's only a matter of time before ISA is reported in British Columbia. Professor Nylund – co-author of "ISA virus in Chile: evidence of vertical transmission" stated in 2009: "Based on 20 years of experience, I can guarantee that if British Columbia continues to import salmon eggs from the eastern Atlantic infectious salmon diseases, such as ISA, will arrive in Western Canada".

Even Marine Harvest admitted in 2009 that they cannot guarantee ISA will not appear in British Columbia. An article - "Are our fish safe from ISA?" – in Marine Harvest Canada's newsletter claimed that: "The specific virus that causes ISA has never been detected in farmed Atlantic salmon on the West Coast of Canada". The article concluded: "Can we guarantee that Marine Harvest Canada will never see ISA? Realistically no, but Marine Harvest Canada will continue to do everything within its power to minimize its likelihood of occurring and mitigate its impact should it ever be found".
An article – "How long can B.C. avoid ISA?" – in *Intrafish* in January 2009 reported: "British Columbia is the only major salmon growing area in the world that hasn't been impacted by ISA. How long will that last?"

Country	Date	Species	Comments
Norway	1984	Atlantic salmon	Demonstrated to be infectious in 1987
Canada	1996	Atlantic salmon	Initially identified as HKS*
Scotland	1998	Atlantic salmon	
Faeroe Islands	2000	Atlantic salmon	
Chile	2001	Coho salmon	Complex aetiology
United States of America	2001	Atlantic salmon	
Ireland	2002	Rainbow trout	Virus isolation

* HKS Haemorrhagic Kidney Syndrome

Table: Global Spread of ISA (courtesy of Professor Ron Stagg of the Marine Laboratory in Scotland)

In Norway, ISA is an ongoing problem nearly thirty years after the first reported outbreak in 1984. A report in 2007 by the Norwegian Veterinary Institute stated that: "A total of 438 outbreaks have been reported in Norway during the time period 1984 and 2005. The yearly number of outbreaks peaked in 1990 with a total of 80 cases." A report – "The Health

Situation in Norwegian Aquaculture 2009" – published by the Norwegian Veterinary Institute in 2010 stated that: "Infectious salmon anaemia (ISA) has also been particularly problematical in the South- and mid-Troms area during 2009." Cases of ISA in Norway in 2009 were 10 – down from 17 in 2008 and 23 in 2000 but up from 8 in 2003 and 4 in 2006.

The OIE's 'World Animal Health Information Database' reported three new ISA outbreaks in Norway between June and December 2009 with 1,397,056 'susceptible' fish and 1,087,927 'slaughtered'. In July 2010, there were two new outbreaks reported in Nordland with 987,806 'susceptible' fish and 904,557 'slaughtered'. In June 2011, one new outbreak in Finnmark was reported with 535,921 'susceptible' fish and 19,050 'slaughtered'.

The ISA problem is morphing as new variants of the virus appear. A 'Farmed Fish Health Report 2008' published by the Norwegian Veterinary Institute stated that: "A variant of ISA virus known as HPR0, which is considered to be of low virulence, has been detected in several salmon producing countries."

A scientific paper published in 2011 in the *Journal of General Virology* also detailed a "low-pathogenic variant of infectious salmon anemia virus (ISAV-HPR0)" in the Faroe Islands. The researchers reported that: "ISAV-HPR0 causes a subclinical respiratory infection more like seasonal influenza, as opposed to the systemic infection and serious disease caused by highly pathogenic ISAV" and that "ISAV-HPR0 might represent an ancestor of pathogenic variants and thus be a potential risk factor in the emergence of new strains of disease-causing ISAV".

In Canada, ISA is also still a problem 15 years after the first recorded case in 1996 in New Brunswick. According to a report by the Conservation Council of New Brunswick: "Between 1997 and 1999 nearly 4.5 million fish were slaughtered on 65 sites". The cost to the industry was $50 million.

According to data supplied by the New Brunswick Department of Agriculture Fisheries and Aquaculture, 9.6 million farmed salmon were culled due to ISA between 2000 and 2006: In 2000, nine fish farms were infected and 222,000 fish destroyed. Over the next two years, the numbers increased to 15 sites with 1.1 million fish destroyed in 2001. In 2002, 16 sites were infected with a record 2.4 million fish destroyed. In 2003, 10 sites destroyed 406,000 fish and in 2004 only one infected site was reported. From September 2005 to July 2006, 14 sites were positive for ISA and 950,000 fish were destroyed.

The World Organization for Animal Health's World Animal Health Information Database, also reported 13 cases of ISA in Canada between January 2005 (when records were made available) and December 2010. Only 4 out of the 13 cases listed a location: two in New Brunswick in 2007 and 2008 and two in Prince Edward Island in 2009.

According to data obtained in August from the Ministry of Agriculture, Aquaculture and Fisheries in New Brunswick, there were 10 cases of 'ISA Virus' and Virus' and 9 cases of 'ISA Virus (H0) in 2007 with 528,000 fish 'depopulated due to ISA'. In 2009, there were no cases of 'ISA Virus' but 9 cases of 'ISA Virus (H0)' and 4 cases of 'ISA Virus (H0) in 2010 and 2 cases in 2011 (data up to May).

According to the New Brunswick Salmon Growers' Association: "Ever since the disease was first diagnosed in the Bay of Fundy net cages in 1996, New Brunswick salmon farmers have

worked tirelessly to control it. Since an effective vaccine did not exist, salmon farmers initially sacrificed millions of valuable salmon in order to prevent the spread of the disease. As the disease's mode of transmission became better understood, the industry developed and successfully implemented the Fish Health Surveillance Program - which reduced the incidence of ISA by 33% within 3 years. While the program still requires culling of infected fish (and healthy fish as a preventative measure), it relies more upon proactive management practices that prevent the spread of the disease."

The Aquaculture Association of Canada reported in July that ISA: "has remained a recurrent problem in Eastern Canada and Maine since the initial epizootics of 1996".

In British Columbia, there are fears that ISA is already present on salmon feedlots. *The Globe & Mail* reported (in data submitted to the Cohen Commission) that: "There are approximately 35 indications of the existence of ISA identified in these records to date". In July, *The Courier-Islander* reported: "The Infectious Salmon Anemia virus (ISAv) is a ticking time bomb that could explode under BC's salmon farming industry and their open net-pens. If this industry has imported such a disease into the ecology of the Pacific Northwest via infected Atlantic salmon material, the results could be an ecological catastrophe". *The Common Sense Canadian* reported via "Farmed Salmon Confidential: ISA and the Cohen Commission" in August: "ISA could already be here in BC - and may already be mutating to affect wild salmon."

In Chile, ISA was first officially reported in Atlantic farmed salmon in July 2007 with Norwegian-owned Marine Harvest identified as the first company infected. In January 2008, *Fisheries Information Service* reported that 79% of ISA virus outbreaks reported by the Chilean Government and 80% of suspected cases solely involved Norwegian salmon farming company Marine Harvest. In February 2008, Marine Harvest's Q4 2007 financial results reported "a huge write-down of NOK 466 million (EUR 58.8 million)" with *Fisheries Information Service* reporting "A Half Billion Written Off".

In March 2008, *The New York Times* reported: "The new virus is spreading, but it has primarily affected the fish of Marine Harvest, a Norwegian company that is the world's biggest producer of farm-raised salmon...Since discovering the virus in Chile last July, Marine Harvest has closed 14 of its 60 centers and announced it would lay off 1,200 workers, or one-quarter of its Chilean operation." In April 2008, a report – "ISA in Chile" – by SalmonChile concluded: "ISA is an agent the industry will have to keep living with".

In June 2008, an article – "El gran secreto del salmon" (The Big Secret of Salmon) – in the Chilean newspaper *La Nacion* reported that a presentation by Professor Are Nylund from the University of Bergen identified a Norwegian company who brought ISA to Chile from Norway via infected eggs. "It is said that the ISA virus started with the company that imported eggs," said Ricardo Casas. "It is no coincidence that 60% of infected sites are from them". *NRK* in Norway reported in an article – "Sjuk Norsk Rogn til Chile?" ('Sick Norwegian Eggs to Chile') - that: "Norwegian salmon is the origin of sick salmon in Chile, says professor of fish health". Professor Are Nylund of the University of Bergen said: "There is no doubt. Norwegian roe is sold to Chile, and it has been the ISA virus. We have seen a number of ISA virus in Chile. When we go in and characterize the genetic material in them, according to the Norwegian author".

In November 2008, a scientific paper – "ISA virus in Chile: evidence of vertical transmission" - published in the *Archives of Virology* reported that: "Norway exports large amounts of Atlantic salmon embryos every year to Chile; hence, the best explanation for the Norwegian ISA virus in Chile is transmission via these embryos, i.e. vertical or transgenerational transmission.....The brood stock population belongs to a Norwegian brood stock company exporting large numbers of Atlantic salmon embryos to Chile".

A scientific paper – "Epidemiologic investigation of the re-emergence of infectious salmon anemia virus in Chile" - published in 2009 in the journal *Diseases of Aquatic Organisms* reported: "During the 64 wk study period, 76 ISAV-infected salmon farms, representing 17 companies, were reported in 65% of the management geographic zones of the 10th region in southern Chile. Approximately 20% of the farms at risk became infected, with the incidence rate increasing slightly over time. Results from epidemic analyses and observed spatial and spatiotemporal patterns suggested an initial dispersal and subsequent clustering of cases around the index case (IC) in a propagated epidemic mode."

In May 2009, Marine Harvest's 'Annual Report 2008' reported that: "In 2008 the market value of our equity decreased by 70 percent, and Marine Harvest delivered a net deficit of almost NOK 2.9 billion. This is for the most part the consequence of serious biological problems accumulated in Chile over several years. We very much regret the large number of employees that had to leave the company as a result of the downsizing. We had to reduce the workforce in Chile by almost 1 800 employees (37 percent) in 2008....The consequences of ISA is not only an economic crisis for the industry but also very serious crisis for those employees we had to lay off and for the Chilean society. These numbers illustrate the economic effects of ISA, and the consequences of biological and fish health problems accumulating over time".

In January 2010, a report – "The Salmon Disease Crisis in Chile" – stated that: "compared to the production level in 2007, production will be reduced cumulatively by at least 700,000 tonnes during the period 2009–11, and production value will be reduced by more than 2 billion USD". *Infosur Hoy* reported in November 2010 that: "The virus, which first appeared in Chile in July 2007, caused the overall production of salmon to plummet 50% and 15,000 employees to lose their jobs, according to the country's National Fisheries Service".

ISA is still a huge problem with suspected cases of ISA rising in July to 23 cases. In November 2010, the Chilean Government announced an ISA outbreak in Magallanes (Region XII) and in March 2011 the National Fisheries Service (Sernapesca) filed a complaint with a salmon farming company for violation of health regulations.

The OIE's 'World Animal Health Information Database' reported one new outbreak of ISA in 'AISÉN GRAL. CARLOS IBANEZ DEL CAMPO' (July - December 2010) with 79,520 'susceptible' fish. Another new outbreak of ISA was reported in 'MAGALLANES' (July - December 2010) with 797,567 'susceptible' fish. And two more outbreaks were reported in 'AISÉN GRAL. CARLOS IBANEZ DEL CAMPO' (January - June 2010) with 804,570 'susceptible' fish. In 2008, there were 20 new outbreaks in 'LOS LAGOS' (January – June) with 14,097,446 'susceptible' fish, 1,159,198 'deaths' and 2,901,057 'destroyed'.

In July, *The New York Times* reported that infected eggs from Norway were the source of the spread of ISA to Chile. Earlier this year in April, the Norwegian Government-owned company Cermaq gave a presentation acknowledging that ISA was spread to Chile from

Norway – publicly endorsing the paper "ISA virus in Chile: evidence of vertical transmission".

Photo: The ISA crisis in Chile

In Scotland, ISA returned like a nightmare in 2009 a decade after the first recorded cases in 1998-9. "ISA back to haunt fish farmers" reported *The Shetland Times* in January 2009. *The Fish Site* reported that: "According to figures from the World Animal Health Information Database, over the course of 2008 the ISA virus claimed an outbreak in Canada, 20 outbreaks in Chile and 14 outbreaks across Norway. Now, with the inclusion of Scotland, all the big salmon farming countries have recently suffered".

Intrafish reported in an article – "Scottish Sea Farms confirms it owns ISA-infected site" - that Norwegian-owned company "Scottish Sea Farms confirmed it owns the salmon farm site in Scotland where ISA was discovered". Norwegian-owned Grieg Seafood reported the presence of ISA at one of their sites in Scotland and admitted that: "There was always a high risk that the ISAV would spread to neighbouring sites". In May 2009, *The Shetland Times* reported that: "The problems with infectious salmon anaemia (ISA) in Shetland cost the Norwegian multinational Grieg Seafoods over £810,000 in the first three months of the year".

The OIE's 'World Animal Health Information Database' reported in May 2009, for example, two new outbreaks of ISA (5 in total) with 179,008 fish listed as 'susceptible' and 6,658 'deaths' and 169,501 'slaughtered'. In January 2009, one new ISA outbreak was reported with 491,829 'susceptible' fish.

A Scottish report published in March, detailed the following in 2009 for a salmon farm at Langa Isle East in Shetland: "Infectious salmon anaemia. Total number removed from site since confirmation 174,480. Site had an unaccountable loss of 109,289."

ISA was reported in the Faroe Islands (one case) with 5 outbreaks in 2001 and 2002; 10 in 2003; 11 in 2004 and 1 in 2005. The Scottish Government reported that "The Faroe Islands' salmon farming industry was destroyed by ISA in 2000".

According to the Marine Institute in Ireland: "Ireland had its first case of Infectious Salmon Anaemia (ISA) in a trout farm in Mayo". The 2002 annual report stated that ISA Virus was "isolated from sub-clinically infected rainbow trout located on two sites in the west of Ireland".

ISA was first reported in the United States in Maine in 2001. In December 2001, the US Government's Department of Agriculture announced a "Declaration of Emergency Because of Infectious Salmon Anaemia" and estimated losses at $11 million. According to the Conservation Council for New Brunswick all 17 salmon farms in Cobscook Bay were either infected or exposed to the disease and one farm in Passamaquoddy Bay was infected. Two million farmed salmon were slaughtered. Two sites were infected in 2003 and six in 2004.

In Norway and Scotland, escaped farmed salmon infected with ISA have been reported. The Norwegian Veterinary Institute reported in their 'Farmed Fish Health Report 2008':

"Escaped farmed salmon are caught in several rivers in the region of south- and mid–Troms, and ISA-virus has been detected in some of these fish. This is an extremely unfortunate situation which has resulted in a significant degree of media attention. In addition to the risk of transmission of ISA to wild salmon, escaped salmon pose a risk of infection to salmon farms over an area larger than that possible by water-borne infection".

A scientific paper – "Disease interaction and pathogens exchange between wild and farmed fish populations with special reference to Norway" – published in the journal *Aquaculture* in May reported: "Recently, there were two instances of reported escapes of Atlantic salmon from two different sites with ISA in Troms County, North Norway. Escaped salmon were later caught in two different local rivers, and ISAV was isolated from these fish (Johansen et al., 2009b). These instances clearly demonstrate the potential for pathogen exchange from escaped farmed fish to wild fish."

Sea Lice (*Lepeophtheirus salmonis*)

Photo: Global spread of Sea Lice

The sea louse or 'salmon louse' (Lepeophtheirus salmonis) is farmed salmon's equivalent of the tick in sheep and cattle; fleas in cats and dogs and head lice in humans. The parasite attaches to the head or under the fins of the fish sucking the life out of the victim – literally eating the fish alive and leaving so-called 'Death Crowns'.


Photos: Sea Lice Damage

The sea lice found on salmon farms are not to be confused with other 'Sea Lice' (jellyfish larvae) which plague beaches and have been subject to recent health warnings in Florida and Cancun.

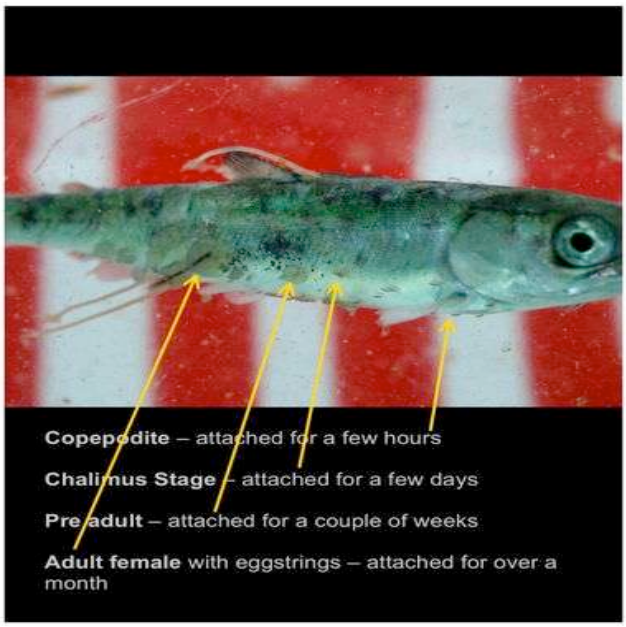


Photo: Sea Lice infestation

Lepeophtheirus salmonis is "the main parasite" on farmed Atlantic salmon in Norway – as well as in Scotland, Ireland and Canada. In addition to the 'salmon louse' there is the 'herring louse' (Caligus elongatus) and in Chile the biggest sea lice problem is Caligus rogercresseyi.

Photo: Juvenile wild salmon with sea lice

Sea lice have been the scourge of salmon farming since its inception in Norway and Scotland in the 1970s. Sea lice infestations also swept through Atlantic salmon farms in British Columbia prompting concerns of local extinctions of native wild salmon and media coverage in *The New York Times* as well as the prestigious journal *Science*. In 2011 a scientific paper reported that sea lice were potentially affecting Fraser River sockeye.

Photo: Sea lice on wild salmon in British Columbia, Canada

"Salmon feedlots break the natural laws unleashing bacteria, viruses and sea lice," wrote biologist Alexandra Morton in April.

A report by the European Union in 2007 stated that: "In Norway, heavily infected wild sea trout post-smolts have been captured in areas where salmon are farmed (Birkeland and Jacobsen 1997; Schram et al. 1998). Bjorn and Finstad (2002) concluded from a study on charr and sea trout in Norway that fish farming contributed to the elevated sea lice levels found on wild fish. Higher infestation rates of sea lice were also found on juvenile pink and chum salmon in British Columbia near fish farms than on those sampled in areas not exposed to fish farming (Morton et al. 2004). In Ireland, Tully et al. (1999) found significantly higher

infestations of sea lice occurring on wild fish in bays that contained lice infested farmed salmon."

In 2007, a 'plague' of sea lice swept through Chile. The Chilean newspaper *La Nación* published an alarming exposé entitled 'The Plague of Salmon', warning that Region X – where some 84 percent of the nation's 2.2 billion US dollars salmon industry is concentrated – is on its way to becoming "more lice-infested than a homeless shelter".

Scientific research has shown that sea lice may be an important vector for the ISA agent in the epidemic and endemic phase. The Furunculosis bacterium has also been found on the bodies of sea lice, making it likely that sea lice spread this disease as well.

In Norway, Scotland, Ireland and Eastern Canada, sea lice have developed resistance to the toxic chemicals designed to kill them (for more background read 'Silent Spring of the Sea').

According to the Irish Government: "Sea lice are regarded as having the most commercially damaging effect on cultured salmon in the world with major economic losses to the fish farming community resulting each year. They inflict damage to their hosts through their feeding activity on the host's body. Sea lice affect salmon in a variety of ways; mainly by reducing fish growth; loss of scales which leaves the fish open to secondary infections; and damaging of fish which reduces marketability."

According to a Norwegian report published in 2008: "The salmon louse (*L. salmonis*) is an ectoparasitic copepod feeding on skin, mucous and blood from salmonid hosts. Recently it was shown that *L. salmonis* infections in farmed fish induce epizootics in wild fish. The life cycle of *L.salmonis* consists of 10 developmental stages separated by ecdysis and after the final molt, females develop into mature adults that continuously produce eggs for life. The first free-living larvae (naupli I) hatch directly from egg-strings attached to adult females and all three larval stages (naupli I, naupli II and the infectious copepidid stage) can be transported by the ocean currents over large distances depending on hydrographical conditions. After host settlement the infectious copepodids stage molt into chalimus. The four chalimus stages, all separated by molting, are anchored to the host by a frontal filament, which restricts the feeding area. However, in the succeeding pre-ad I and -II and adult stages the salmon louse can move unrestricted on the host surface resulting in increased virulence."

A report – "The Health Situation in Norwegian Aquaculture 2009" – published by the Norwegian Veterinary Institute in 2010 stated that: "The major fish health challenge during 2009 was that of salmon lice infestation. Problems of reduced sensitivity and development of resistance to treatment have increased and as a consequence large numbers of lice were recorded throughout the autumn....Registered lice levels in Norwegian farms, especially towards the end of the year, were the highest recorded in several years."

Sea lice data is available online in Norway via Lusedata and published annually in Ireland. In British Columbia, Marine Harvest and Cermaq both publish sea lice data online in addition to annual data reported by the Government sea lice data (the latest data is available via the 'Fish Health Report 2009'). In Scotland (where sea lice data is not publicly available), a report published by the Salmon & Trout Association in March (based upon data for 2009 and 2010 obtained from the Scottish Government via Freedom of Information regulations) revealed that:

• 68 instances of fish-farms recorded as having sea-lice levels above the thresholds recommended in the industry's own Code of Good Practice during the period for which records were inspected;

• 52 instances of fish-farms recorded as having other sea-lice related issues, such as damage or mortality caused by sea-lice, or high lice loads on sampled fish;

• 48 instances of fish-farms reported as not recording farm sea-lice numbers in accordance with industry standards;
• 21 instances concerning evidence of a lack of efficacy of, or tolerance to, or potential resistance to available sea-lice treatments, including unexpectedly low sea-lice clearance rates using licensed treatments and failure to control sea-lice numbers.

A data entry for 2009, for example, for a salmon farm in Shetland (operated by Westside Salmon) included:

"Site experiencing increased mortality. This is expected to be due to high sea lice burdens. Latest lice numbers c 50 per fish (total). Skim of heavily burdened fish and moribunds done during week prior to visit. Many fish were observed to have white heads due to lice. Site treated with Slice in July and previously on other site (fish recently moved onto site in May from Crossroads)". 6 fish sampled all have head damage from lice and lice burden of over 100 lice per fish."

Another salmon farm in Shetland (operated by Hoganess Salmon) reported in 2009: "Severe sea lice problems reported during August 2009. Now sea lice reported to be 'under control'. 7 treatments since Feb 2009 (Slice, Salmosan, Alphamax, Alphamax, Slice, Salmosan and Salmosan).... several lethargic dark fish with lice damage and/or physical damage to the eyes were observed."

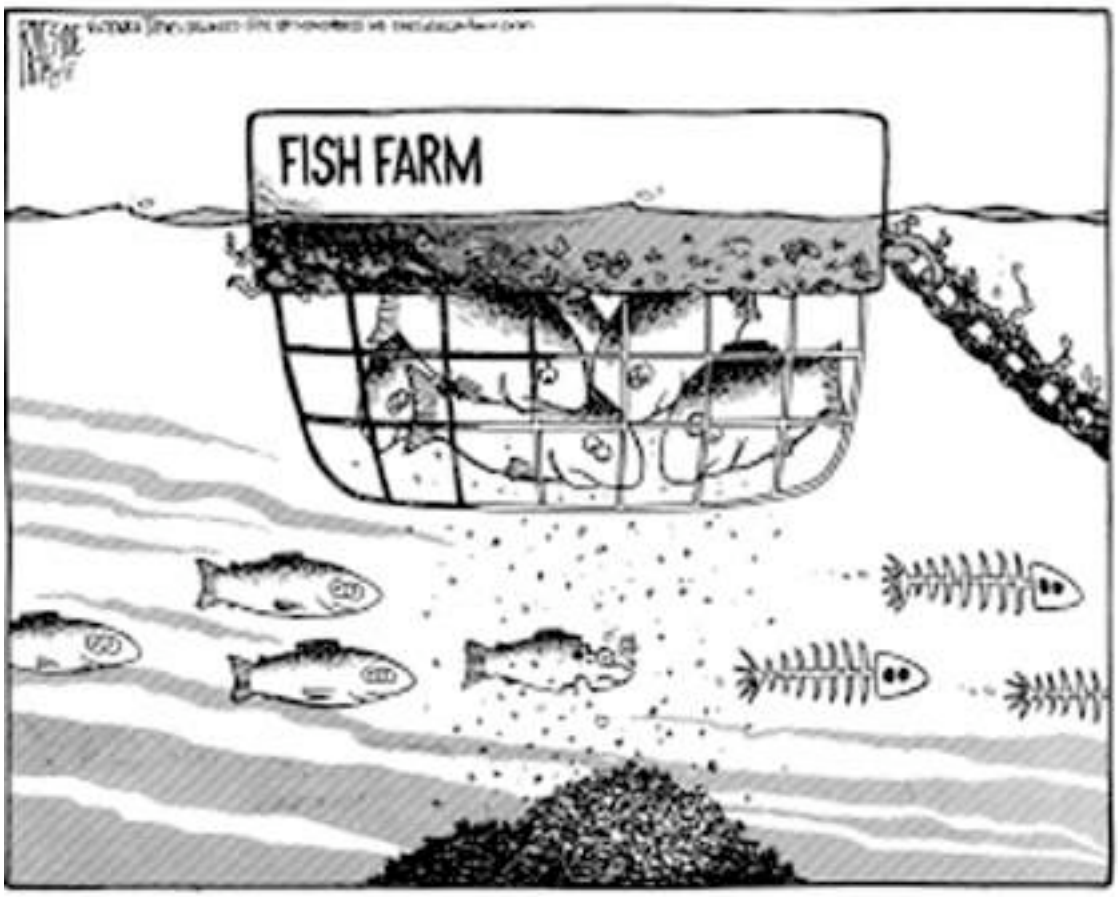


Photo: Cartoon by Adrian Raeside

Ireland is also experiencing problems with sea lice – a report published in November 2010 by the Department of Agriculture, Fisheries & Food identified "persistent and serious failures in controlling sea lice". Moreover, "increases in infestation were not isolated incidences as lice levels breached sea lice protocol levels on ten of twelve inspections in one particular area". The report "records that of the inspections carried out on farms in the Galway/Mayo area during the critical spring period in 2010 (when junior salmon and sea trout are migrating to sea) it was found that in 61% of cases sea lice levels exceeded those that trigger a requirement for treatment and over the year as a whole 53% of inspections detected excessive sea lice levels."

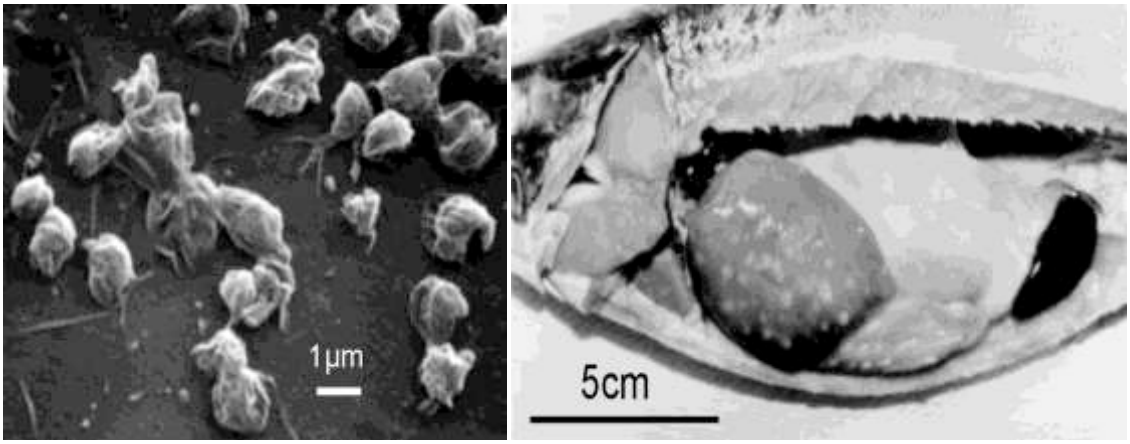
Another Irish Government report published in May 2008 stated that: "In 2005 and 2006 levels increased and this trend continued in 2007. The mean ovigerous lice level for one sea winter salmon in 2007 is the second highest since monitoring commenced. Only 1992 is higher. Mean mobile levels increased from 2001 to 2002 and again from 2002 to 2003 but show a reduction in the 2004 figure. Levels increased in 2005 and again in 2006 and 2007. Mean mobile lice levels for one sea winter salmon in 2007 are the highest recorded to date."

Norway too is having problems controlling sea lice infestation levels due to chemical resistance. The latest fish health report published by the Norwegian Veterinary Institute in 2010 reported that: "From April until September 37% of all sites had exceeded the threshold limit at least once, while 14% exceeded the limit on at least two consecutive occasions and 6% on three or more consecutive occasions. Destruction/slaughter of fish in such localities may be necessary."

In Canada, too, sea lice infestation is a growing problem. According to data obtained in August from the Ministry of Agriculture, Aquaculture and Fisheries in New Brunswick, cases of sea lice increased from zero in 2007 to 3 in 2008, 37 in 2009 and 42 in 2010. In British Columbia, sea lice is the #1 issue. Farmed & Dangerous reports that: "Sea lice from salmon farms are one of the most significant threats facing wild salmon in British Columbia."

Photo: Advert from the Coastal Alliance for Aquaculture Reform

Salmon Rickettsial Syndrome/Septicaemia (Piscirickettsiosis)



Photos: Piscirickettsia salmonis in Coho farmed salmon

Salmon Rickettsial Syndrome or Salmon Rickettsial Septicaemia (SRS) is also known as or Piscirickettsiosis or Huito disease and is the #1 disease problem in Chile. Outbreaks of SRS in other countries have not reached the levels of the Chilean outbreaks (where mortalities have reached 90%). According to MSD Animal Health, variable and inconsistent mortality of 0.6 - 15% has been reported in Canada and Norway.

SRS is an example of what can go wrong when farming an alien species (Atlantic salmon) in the Pacific. A scientific paper – "*Piscirickettsia salmonis*, a major pathogen of salmonid fish in Chile" – published in *Fisheries Research* in 1993 stated: "Annual importation of eggs into Chile from salmonid-growing regions in the Northern Hemisphere provides a supply of fish for culture, but one which may have limited natural resistance to fish pathogens unique to Chilean waters. The epizootics of piscirickettsiosis amply demonstrate one unfortunate consequence of the interaction of native species with non-indigenous fish species introduced for aquaculture."

A report – "Fish Egg Trade: Pathogen survival outside the host, and susceptibility to disinfection" – published in 2005 by the European Commission stated that: "The conclusion was that vertical transmission of P. Salmonis including so-called "true vertical transmission" should now be considered scientifically established."

According to a report by the European Union in 2007, the problem is 'ubitiquous': "Piscirickettsiosis was initially confined to coho salmon in sea water. However, all marine cultured salmonids in southern Chile, including Atlantic, chinook and masou salmon and rainbow trout are reported susceptible (Fryer et al. 1990; Lannan and Fryer 1993). In Norway *P. salmonis* has been detected in farmed Atlantic salmon (Olsen et al. 1997). Morphologically and serologically similar pathogenic rickettsial organisms have also been reported in British Columbia in farmed chinook, coho, pink and Atlantic salmon in seawater (Brocklebank et al. 1992; Kent 1992; Jones et al. 1998), in Ireland and Scotland from Atlantic salmon (Rodger and Drinan 1993; Grant et al. 1996; Birrell et al. 2003). The geographical distribution of *P. salmonis* and related organisms is ubiquitous."

A 'Farmed Fish Health Report 2008' published by the Norwegian Veterinary Institute in 2009 reported that: "Piscirickettsiosis is caused by infection with the bacterium *Piscirickettsia salmonis* and this disease is one of the most important diseases in Chilean aquaculture. Although this disease has also been identified in Norwegian aquaculture in recent years, the Norwegian isolates award much lower mortalities than those isolated in Chile. Only a single detection was made in Norway during 2008, and this constituted a "miscellaneous" finding in a fish under investigation from a PD outbreak. It does however confirm that the bacterium can still be found in Norwegian waters."

In Canada, 'Piscirickettsia salmonis Infection' was reported every year between 2003 and 2010 via the BCSFA 'Fish Health Database'. In Scotland, 'Piscirickettsia salmonis (SRS) (PCR)' was reported in 2006.

A scientific paper – "Salmonid rickettsial septicemia caused by *Piscirickettsia salmonis* : a review" – published in 1997 reported: "Rickettsial infections in finfish have been reported in several salmonid and non-salmonid fish in fresh water and salt water since 1939. However, rickettsia were not considered of economical importance until a massive outbreak was reported in Chile. In 1989, a new disease of unknown aetiology killed approximately 1.5 million market-sized (2 kg) coho salmon *Oncorhynchus kisutch* cultured in the area of

Calbuco, southern Chile. The disease was later described as affecting Atlantic salmon *Salmo salar,* rainbow trout *Oncorhynchus mykiss,* and Chinook salmon *Oncorhynchus tshawytscha*. In Chile, the losses were extensive and, on certain farms, mortalities of up to 90% were reported."

A scientific paper published in 1999 in the journal *Diseases of Aquatic Organisms* reported that: "Piscirickettsia salmonis was first recognized as the cause of mortality among pen-reared coho salmon Oncorhynchus kisutch in Chile. Since the initial isolation of this intracellular Gram-negative bacterium in 1989, similar organisms have been described from several areas of the world, but the associated outbreaks were not reported to be as serious as those that occurred in Chile."

An article – "Salmonid Rickettsial Septicaemia" – by Intervet published in 2006 stated that: "SRS (a.k.a. Salmon Rickettsial Syndrome or Piscirickettsiosis or Coho salmon septicaemia or Huito disease) is considered to be the most important disease problem in the Chilean salmon farming industry, with economic losses of over US$100 million in some years. SRS was first reported, from Chile, in 1989, but (Pisci)rickettsia-like organisms (RLO) are now frequently associated with disease syndromes in both salmonid and non-salmonid fish from both fresh and saltwater worldwide. During 1989, this disease was considered to be the cause of death of an estimated 1.5 million Coho salmon, many near market-size. A year later, the disease was also found to occur in Atlantic salmon and up to 90% mortality was seen on some farms. Outbreaks of SRS in other countries have not reached the levels of the Chilean outbreaks. For example, variable and inconsistent mortality of 0.6 - 15% has been reported in Canada and Norway."

A report by the European Union in 2007 stated that: "The clinical signs and gross lesions reported for piscirickettsiosis from natural and experimentally infected fish from Chile include anorexia, darkening of the skin, lethargy, swimming near the water surface and respiratory distress (Branson and Nieto Diaz Muñoz 1991; Cvitanich et al. 1991). Skin lesions include perianal and periocular haemorrhage, abdominal petechiae and shallow haemorrhagic ulcers, varying between 0.5 and 1.5 cm in diameter. Characteristic ring-shaped, yellow / cream-coloured subcapsular nodules can be observed throughout the liver of chronically infected fish (Cvitanich et al. 1991). The abdomen is frequently distended; splenomegaly is common with white spots occurring in the skin. Petechiae on the serosa surfaces of the intestine, pyloric caeca and swim bladder have been observed in Atlantic salmon. In other organs macroscopic changes include ascites, diffuse swelling, general pallor and multifocal pale areas in the kidney and spleen. Additionally, bilateral exophthalmia and an ulcerative inflammatory reaction around the mouth have been described. In Canada and Ireland a similar gross pathology is reported from rickettsia-like organisms among farmed Atlantic salmon (Brocklebank et al. 1992; Rodger and Drinan 1993)."

In Australia, 'Tasmanian richettsial disease' (Rickettsial-like organism specific to Tasmania) was reported in 2006. The Government reported: "Significant and widespread disease event occurred during summer of 2006 in south-eastern Tasmania resulting in significant mortalities. Affected companies treated large volumes of stock using OTC."

Listeria monocytogenes (Listeriosis)

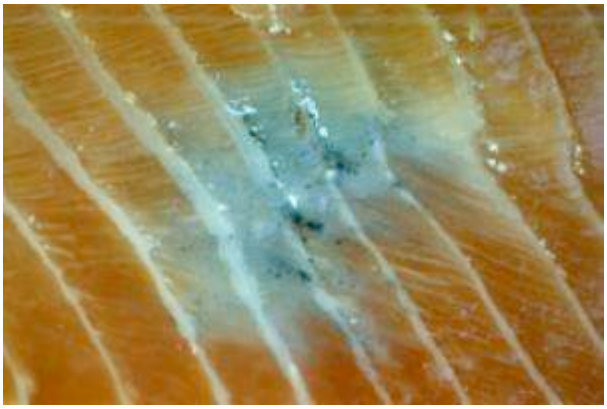


Photo: Mouldy farmed salmon

Listeria monocytogenes is considered by the US Food and Drug Administration (FDA) as "a poisonous or deleterious substance" and one which may be "injurious to health". An FDA health warning for 'Norwegian style' smoked salmon issued in 2009, for example, stated: "Listeriosis, the illness caused by L. monocytogenes, can be serious and sometimes cause fatal infections in young children, frail, or older people, and others with weakened immune systems. Although healthy individuals may experience only short-term symptoms such as high fever, severe headache, stiffness, nausea, abdominal pain and diarrhea, Listeria infection can cause miscarriages and stillbirths."

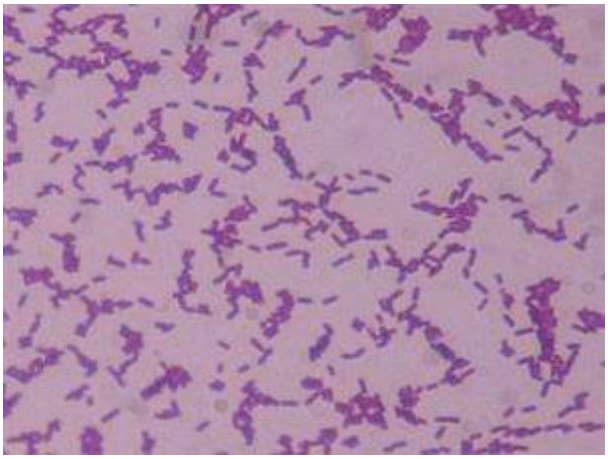


Photo: Listeria in farmed Norwegian salmon

In 2011, the FDA reported that: "St James Smokehouse Inc, is conducting a voluntary recall of Scotch Reserve Whiskey & Honey Smoked Scottish Salmon....due to potential contamination with Listeria Monocytogenes". The recall affected 20 states in the US including: Alabama, Arkansas, Connecticut, Florida, Georgia, Illinois, Indiana, Kentucky, Louisiana, Maryland, Massachusetts, Mississippi, New York, North Carolina, Ohio, Pennsylvania, South Carolina, Tennessee, Virginia and Wisconsin.

FDA safety alerts and recalls for listeria in farmed salmon are sadly all too routine – 26 cases were reported in 2003 alone along with 'insanitary' and 'filthy' farmed salmon. *The Salmon Farm Monitor* reported in 2003: "The problem of listeria in salmon is an escalating one. The FDA and the Norwegian Government attempted to tackle the issue of listeria contamination in 1996 via a 'Memorandum of Understanding' which included: "The Norwegian Directorate

of Fisheries will assure that the product does not contain detectable Listeria monocytogenes through verification sampling and by evaluating processor verification results".

However, dozens of 'Import Alerts' for listeria contamination of farmed salmon from Norway have been issued by the FDA since 1996 – with dozens of cases also from Canada, Chile and Scotland. An FDA import alert in 2009, for example, involved 'Kosher' salmon and another recall in 2011 involved 'Norwegian smoked salmon'.

Photo: Listeria monocytogenes

Listeria contamination is not just an issue in the United States but also in Europe, South America, Asia and Oceania. In 2008, the EU Fish Processors Association (AIPCE) issued a warning that Norwegian farmed salmon was not meeting quality standards in relation to listeria. *Intrafish* reported on concerns expressed by Peter Bamberger, AIPCE board member and chairman of the Association of Danish Fish Processing Industries and Exporters:

"There are several things that worry us. Among others, listeria has been detected in much of the salmon from Norway. The other thing is the quality of the salmon fillets. The salmon meat is softer and more fatty than was the case earlier," Bamberger said. Bamberger said the listeria problem will be tackled by AIPCE's salmon group at the earliest opportunity. "Our aim is first to find out which salmon processing plants in Norway the 'listeria salmon' is coming from. We are looking for a dialogue with the Norwegians about this because we are in the same boat. It all concerns the reputation of the salmon. It's not all pleasant for any of us when supermarkets in the European Union reject salmon because the listeria bacteria content is too high," Bamberger said. Bamberger said AIPCE believes the Norwegians are not taking the problems with listeria seriously"..... Bamberger says the problem with Norwegian salmon is much bigger than the Norwegians believe themselves. "The Norwegian Seafood Federation (FHL) is not taking this seriously," he said. FHL's director for health and quality, Henrik Stenwig said the FHL is "highly concerned" with the listeria problem."

In Australia, for example, a safety recall was issued in 2011 by salmon farming company Huon Aquaculture. *The Mercury* newspaper reported: "Listeria may cause illness in pregnant women, the very young, the elderly and people with low immune systems. The company says consumers concerned about their health should seek medical advice."

An investigation by *The Sunday Times* in the United Kingdom in 2004 revealed that: "Almost a fifth of smoked salmon samples bought from supermarkets and food suppliers last week contained traces of the bug, dealing another damaging blow to the industry".

The article – "Listeria Found in Smoked Salmon" - reported that: "The level of contamination was high enough to mean that the fish would be banned from America, Australia and New Zealand as well as a number of European countries, all of which have a "zero tolerance" of food contaminated with listeria. America has already blocked dozens of consignments of Scottish smoked salmon amid fears that they may be contaminated with listeria. In 2001, the European Commission recommended each member state carry out a study of listeria contamination in smoked fish products. Of the 15 member states, only six participated including France, Belgium, Finland, Germany, Ireland and Spain. The Sunday Times investigation is therefore the first confirmation that the bacteria is present in some Scottish-reared fish."

An article – "Safety of Cold Smoked Salmon" - published by the SafeFood Rapid Response Network in 2008 warned: "Approximately 50% of farm reared Atlantic salmon reaches the consumer as a cold-smoked product.... Like other ready-to-eat meats, the organism of concern for cold smoked salmon is *Listeria monocytogenes*. Listeriosis is a severe but uncommon infection caused by *Listeria monocytogenes* and has been a nationally notifiable disease since 2000. Listeriosis is primarily foodborne and occurs most frequently among persons who are older, pregnant, or immunocompromised..... Cold smoked salmon is considered safe for healthy, non-immune compromised persons; however, as with other raw or semi-raw meat products, it is risky for pregnant women, the frail elderly and others with compromised immune systems due to disease or medical therapy. Many countries, including the U.S., recommend these groups avoid cold smoked fish. The shelf life of smoked salmon is very short, one to two weeks in the refrigerator and about one month in the freezer. Storage time is another critical factor in the proliferation of *L. monocytogenes*."

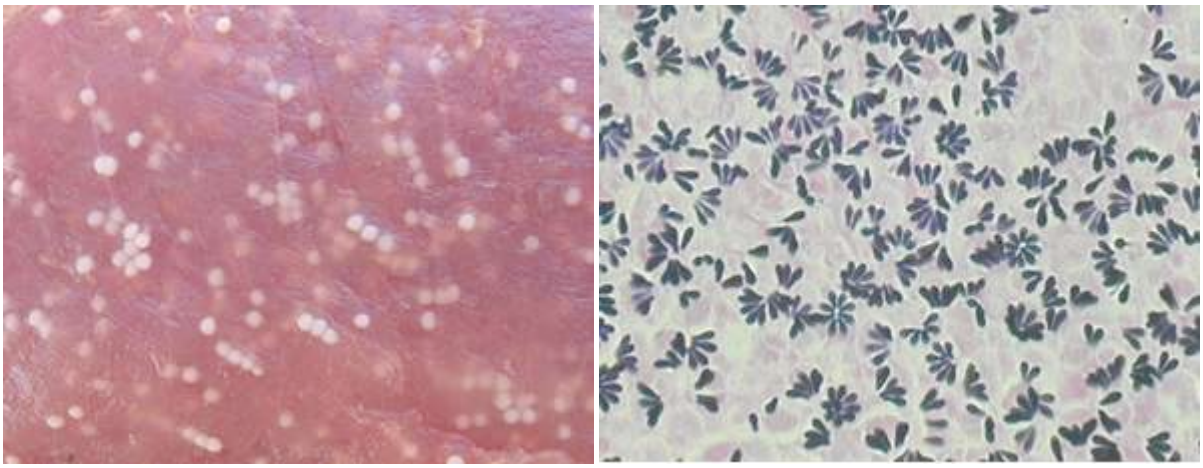
According to the FDA: "Given the ubiquitous nature of *L. monocytogenes*, the lack of listericidal steps in the cold-smoking procedure, and the ability of the organism to become established in the processing environment and re-contaminate products, it is not possible to produce cold-smoked fish consistently free of *L. Monocytogenes.*"

A report published in 2008, showed listeria contamination of Chilean farmed salmon in a processing plant in Brazil: "*L. monocytogenes* was confirmed in salmon samples (41%), food contact surfaces (32%), non-food contact surfaces (43%) and of food handlers' samples (34%)". CBC News in Canada reported in 2010 that an unreleased study by the B.C. Centre for Disease Control "found potentially toxic Listeria bacteria in 18 per cent of ready-to-eat fish products tested in B.C." All of the contaminated fish was smoked salmon, the study found. It also concluded fish processing facilities need more scrutiny.

A study from China in 2008 also "showed that rates of Norway salmon contamination by Listeria monocytogenes were form 1.2% to 6.2%" (although "contamination rates decreased from 2003 to 2006"). The study concluded that: "About 97% of Listeria monocytogenes isolates from salmon imported could cause the Listeriosis in human".

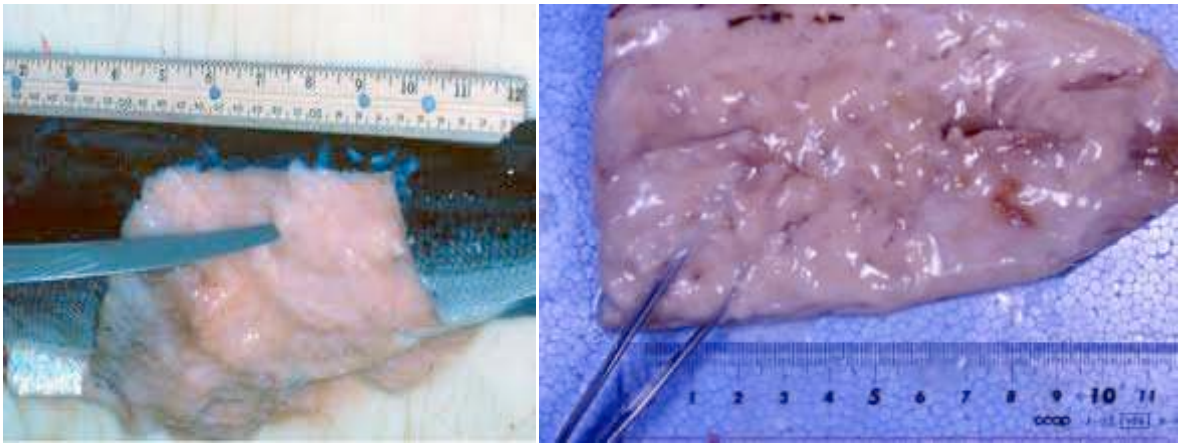
Kudoa (Soft-Flesh Syndrome)

Kudoa thyristes is a parasite which has affected farmed salmon in British Columbia since the 1990s. Kudoa causes the flesh of farmed salmon to soften into a jelly-like consistency – hence the name 'Soft-Flesh Syndrome'.



Photos: Fish filet with obvious white cysts, in this case a sign of infection with the parasite Kudoa; Stained histological section of fish muscle showing numerous Kudoa parasites.

"Beware milk jelly" warned *Fishing News* in 2002. "When the fish dies post mortem changes and release of enzymes by the parasite result in massive liquefaction of the muscles to produce a milky white mush or jelly... Kudoa is an emerging problem. Most of us would hope that it emerges very slowly, as it is a threat that could wipe out the salmon farming industry if it took a real hold on salmon stocks. Salmon flavoured blancmange or milk jelly is all that even the most gifted chef could make from the mush left by a Kudoa outbreak. I am sure that would never catch on as an alternative product."



Photos: Myoliquefaction (soft-flesh syndrome) in farmed salmon due to Kudoa thyristes; liquefaction of Atlantic mackerel due to Kudoa thyristes

According to *IntraFish*, the kudoa parasite affects 20-50% of all salmon farmed in British Columbia, costing the industry there at least $30 to $40 million annually. Marine Harvest alone reported losses of NOK 13 million in the Fourth Quarter of 2010 as "achieved prices for Marine Harvest Canada were negatively impacted by discards and claims from Kudoa (soft flesh)." *Intrafish* reported in 2003 that: "one major company has infection rates of up to

50 percent of its stocks and brokers of the product say that the BC industry is giving farmed salmon a bad reputation by selling infected fish."

In 2003, *Intrafish* reported that British Columbia "appears to suffer the highest infection rates in the world and chalked up an estimated CA $30 to $80 million in losses last year from the disease." Kudoa has also been reported in farmed Atlantic salmon from Tasmania in Australia. Disease data supplied by the Irish Government in 2007 also reported Kudoa.

In 2008, the Centre for Aquatic Animal Health Sciences described Kudoa as an "ongoing challenge". A paper – "Managing soft-flesh syndrome among British Columbia farmed Atlantic salmon (Salmo salar)" – presented at the APICS conference in 2011 reported that:

"Soft-flesh disease, caused by Kudoa thyrsites, costs the BC industry about $50M annually. The disease cannot be treated, but can be managed. Prevalence of soft-flesh disease varies along coastal Vancouver Island, being low in part of north and severe in Campbell River area. Temporary rearing of smolts at a northern site with low infection pressure ('low risk') results."

Marine Harvest Canada reported in 2010: "Kudoa thyrsites is a common fish parasite found in many species of fish in the Pacific and Atlantic Oceans. It poses no human or fish health risks but instead, affects product quality by causing pitting and softening of the fish muscle tissue. The effects of infection are not seen until after the fish has been delivered to the customer, therefore, the economic impact of Kudoa thyrsites can be substantial. Kudoa thyrsites was discovered in British Columbia farmed Atlantic salmon in the early 1990's yet, to date, little is known of its life cycle and how and when fish become infected."

The Aquaculture Association of Canada reported in 2011 via "*Kudoa thyrsites* – increasing our knowledge" that: "*Kudoa thyrsites* is an intramuscular parasite that has a world wide distribution and can infect several species of fish. This parasite imposes no fish health risks, but instead affects product quality by causing pitting and softening of the fish muscle tissue after harvest. At low levels of infection the pathology of *Kudoa thyrsites* infection can go unnoticed, but at higher levels it produces extensive myoliquefaction and the fish meat is no longer commercially viable. Marine Harvest Canada and the BC Centre for Aquatic Health Sciences (BC CAHS) have embarked upon a 3 year joint research and development project to increase our understanding of *Kudoa thyrsites.* During the first year, two saltwater farm sites will be monitored to determine when the fish become infected and how the infection develops throughout the production cycle."

Another report – "Control of post-harvest myoliquefaction in farmed Atlantic Salmon" (funded by DFO and Marine Harvest Canada) – published by the Aquaculture Association of Canada in 2011 stated that: "Soft-flesh syndrome presents a significant challenge to the fish farming industry by compromising product quality and lending to a negative consumer stigma of farmed fish products. In farm reared Atlantic Salmon *(Salmo salar)* the most common cause of soft-flesh is a parasitic infection by *Kudoa thyrsites.* At the moment, there are no available treatments to control *K. Thyrsites* infection. Alternative technologies, such as high hydrostatic pressure (HHP) have been successful at controlling parasite infestation in other meat processing industries. In this project an industrial trial using HHP technology was tested as a means to control the manifestation of myoliquefaction caused by *K. thyrsites* infection. Whole fish and fillets were subjected to several pressure intensities, which were applied for different times. Myoliquefaction manifestation (presence and number of pits

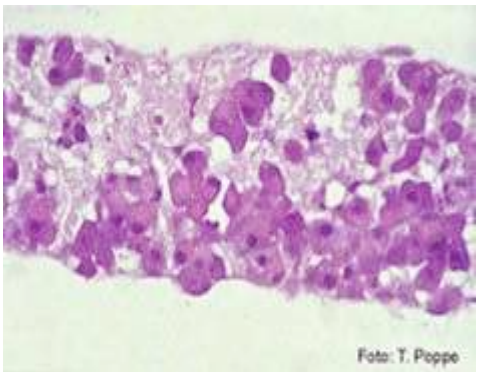
formation) was monitored daily for 5 consecutive days. Fish fillet quality parameters such as colour, texture, flesh integrity (gaping), and smell were evaluated in pressure treated and untreated fillet portions using standard operation procedures for quality control. The results demonstrated that the HHP technology was not effective at suppressing myoliquefaction, and it adversely affected product quality, including colour and texture."

Photo: Muscle liquefaction of mackerel due to Kudoa thyristes

Infectious Pancreatic Necrosis (IPN)

IPN is a "serious problem for Norwegian and Scottish salmon aquaculture" and has also caused problem on Irish and Chilean salmon farms. The *Virology Journal* reported in 2011 that: "Infectious pancreatic necrosis virus (IPNV) is an aquatic member of the Birnaviridae family that causes widespread disease in salmonids. IPNV is represented by multiple strains with markedly different virulence."

According to the Scottish Government: "IPNV is a very robust virus". Clinical disease "may be characterised by a swollen abdomen and faecal casts trailing from the vent". Internally there may be pancreatic necrosis and "catarrhal exudates in the intestine."



Photos: IPN in farmed Atlantic salmon from Norway and Chile

The OIE's 'disease card' on IPN reports that: "The disease has a wide geographical distribution, occurring in most, if not all, major salmonid farming countries of North and South America, Europe and Asia, and has been reported from South Africa."

A report - "Review of fish disease interactions and pathogen exchange between farmed and wild finfish and shellfish in Europe" – published in 2007 by the European Union reported that: "A significant characteristic of the disease is that high proportions of fish develop a lifelong persistent infection i.e., a carrier state."

Moreover: "Farmed fish may be the most important reservoir of IPNV in the aquatic environment. During an epizootic of IPN, virus is shed with faeces and urine and from dead and moribund fish into the waters around the farm (Billi and Wolf 1969; Wolf et al. 1968). There is increasing evidence that IPNV is transferred from farmed to wild fish through contact with discharges and products from IPNV-contaminated farms (Sonstegard et al. 1972; Munro et al. 1976; Bucke et al. 1979; Hastein and Lindstad 1991; McVicar et al. 1993; Mortensen et al. 1993; McAllister and Bebak 1997; Wallace et al. 2005b). Recently, IPNV has been found at significantly higher prevalence in wild marine fish in the vicinity of salmon farms undergoing clinical IPN than at sites greater than 5 km from aquaculture (Wallace et al. 2005b) further supporting a transfer from farmed to wild fish."

IPN was reported in Chile for the first time in 1985. According to Intervet: "IPN has become a serious problem for salmon producers not only in Chile, but also in Scotland, Ireland and Norway, he says. In Chile, average losses in fry from IPN are about 15%, but in many cases, mortality has reached 70%."


Photos: IPN in Atlantic farmed salmon from Chile (Marcos Godoy)

A report by the Norwegian Seafood Federation published in 2003 admitted that:

"The IPN virus has a history as one of the most important loss factors in salmonid aquaculture....No other fish pathogenic virus has been more extensively examined, yet it is still an unsolved problem for the industry."

A report – "The Health Situation in Norwegian Aquaculture 2009" – published by the Norwegian Veterinary Institute in 2010 stated that: "The number of recorded IPN cases in 2009 was a record high with confirmed diagnoses registered from 223 sites compared to 158 in 2008. Local fish health services also report IPN to have been more problematical in 2009 compared to 2008."

"IPN has been described as the biggest health problem for the Norwegian aquaculture industry and a real possibility exists that cases of clinical IPN outbreaks have been under reported," stated a report published in 2007. "Statistics released by the National Veterinary Institute of Norway showed that in 2005 there were 208 cases of clinical IPN, compared to 35 cases of pancreas disease."

A report published by the European Union in 2007 stated that: "In Norway, data from several national surveys (reviewed in Brun 2003) revealed 40-70 % of all seawater sites and 30-40 % of hatcheries experienced IPN outbreaks between 1994 and 2000 (Brun 2003). The average accumulated crude mortality related to IPN outbreaks in Norway varies between 10 and 20 % with a range of a few percent to over ninety percent (Brun 2003)."

In Scotland, 82% of marine salmon farms were affected by IPN in 2002 (an increase from less than 30% in 1997 and 45% in 2000) compared to 26% of freshwater salmon farms. The Salmon Farm Protest Group reported in June 2004: "Since July 2001, the Scottish Executive has issued an estimated 446 Designated Area Orders (DAO) for IPN, Bacterial Kidney Disease (BKD) and Furunculosis under the Diseases of Fish Act. An estimated 90% of all DAOs issued involve IPN with BKD and Furunculosis making up the remainder."

The Herald newspaper reported in an article – "Killer Infection Ravaging UK Salmon Farms" – published in June 2004 that: "Shetland is the worst affected area, with more than 90% of sites affected. Ron Stagg, vice-chairman of the working group, said: 'In sea water farms, the virus is pretty much ubiquitous.'"

IPN continues to cause problems in Scotland. A report published in March, for example, detailed the following for a salmon farm in Shetland in 2009: "Total mortality since input 22%, put down to IPN and recently PD." Another data entry for a salmon farm at Ardgadden in 2009 read: "Peak in morts post input - IPN... c10k per month."

According to disease data presented by the European Union in 2007: "In Scotland, mean prevalence of IPNV was 49.6 % at seawater sites and 10.6 % at freshwater sites between 1996 and 2001 with an annual increase over this period of 10 % at seawater sites and 2-3 % in freshwater sites (Murray et al. 2003). In terms of clinical IPN in Scotland, the mean number of outbreaks over this period was 4.9 % which represented an increase from 0.6 % in 1996 to 12.5 % in 2002 (Bruno 2004)."

In Ireland, IPN first hit the industry in 2003 causing significant problems in 2006. A report – "Infectious Pancreatic Necrosis Virus and its impact on the Irish Salmon Aquaculture and Wild Fish sectors" - published in 2007 by the Marine Institute in Ireland stated: "The first reported clinical outbreak of IPN in Atlantic salmon occurred in 2003. However in 2006 severe outbreaks in a number of freshwater salmon hatcheries occurred which were all linked to imports from a specific single source. To date, clinical outbreaks of IPN in Ireland have been associated with imports of infected ova and their subsequent movement within the country."

The report pinpointed Scotland as the source of IPN infection: "In 2006, clinical outbreaks of IPN occurred in five salmon hatcheries. All five hatcheries had imported ova from a single source in Scotland."

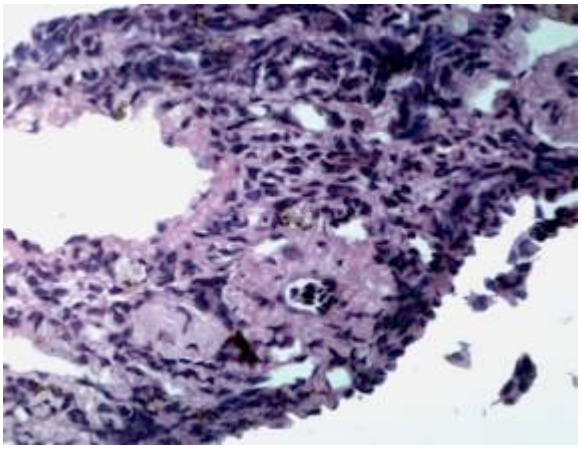
Escaped farmed salmon have also acted as vectors in the spread of IPN. In 2003, for example, escapes occurred from several IPN-infected salmon farms in Scotland.

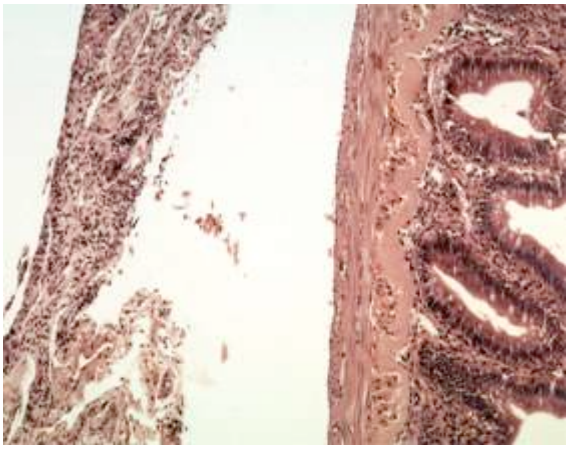
A scientific paper – "Disease interaction and pathogens exchange between wild and farmed fish populations with special reference to Norway" – published in the journal *Aquaculture* in May 2011 reported that: "Out of 8 Atlantic salmon positive for IPNV in 2008, 7 were escaped farmed fish" and that "There is increasing evidence that IPNV may be transferred from farmed to wild fish through contact with discharges and products from IPNV-contaminated farms." The paper reported that: "High proportions of the farmed fish undergoing an IPNV infection develop a lifelong persistent infection. Thus, farmed fish may be the most important reservoir of IPNV in the aquatic environment."

IPN can also be spread via infected eggs- so-called 'vertical transmission'. A report – "Fish Egg Trade: Pathogen survival outside the host, and susceptibility to disinfection" – published in 2005 by the European Commission stated: "there is clear evidence in the scientific literature for vertical transmission of IPNV via the fertilised egg of trout species and that disinfection of the eggs does not prevent this suggesting the virus is within the fertilised egg."

A report - "Review of fish disease interactions and pathogen exchange between farmed and wild finfish and shellfish in Europe" – published in 2007 by the European Union stated that: "The disease has spread throughout the world (OIE 2006) largely through the movement of live fish and eggs (Reno 1999)."

Pancreas Disease (Salmon Pancreas Disease Virus/Salmonid Alphavirus Disease/Sleeping Disease)





Photos: Pancreas Disease in farmed Atlantic salmon

PD is called a "sleeping monster" and is caused by an alphavirus known as salmon pancreas disease virus (SPDV) – also referred to as salmonid alphavirus disease (SAV-disease). Pancreas Disease (PD) is a "significant" disease problem in Norway and causes problems in Scotland and Ireland. So serious is the PD problem that a 'Tri-Nation Consortium' involving Norway, Scotland and Ireland was set up in 2005.

According to a scientific paper – "Molecular epidemiology of salmonid alphavirus (SAV) subtype 3 in Norway" – published in *Virology Journal* in 2010: "Pancreas disease (PD) is a viral fish disease which in recent years has significantly affected Norwegian salmonid aquaculture."

A scientific paper – "Disease interaction and pathogens exchange between wild and farmed fish populations with special reference to Norway" – published in the journal *Aquaculture* in May 2011 reported that: "PD has been a continuous problem in Irish salmon production and is an increasing problem in marine salmonids in Scottish and Norwegian aquaculture."

Salmon Pancreas Disease Virus, Sleeping Disease Virus and Salmonid Alphavirus are "closely related". According to a scientific paper – "Alphavirus infections in salmonids--a review" – published in the Journal of Fish Diseases in 2007: "The first alphavirus to be isolated from fish was recorded in 1995 with the isolation of salmon pancreas disease virus from Atlantic salmon, Salmo salar L., in Ireland. Subsequently, the closely related sleeping disease virus was isolated from rainbow trout, Oncorhynchus mykiss (Walbaum), in France. More recently Norwegian salmonid alphavirus (SAV) has been isolated from marine phase production of Atlantic salmon and rainbow trout in Norway. These three viruses are closely related and are now considered to represent three subtypes of SAV, a new member of the genus Alphavirus within the family Togaviridae. SAVs are recognized as serious pathogens of farmed Atlantic salmon and rainbow trout in Europe."

Intervet reported in 2006: "In Norway, PD is an important economic disease of Atlantic salmon particularly around the Bergen area. It has also recently been described in sea-reared rainbow trout. It can cause significant losses due to morbidity, mortality, reduced production and downgrading. While the name suggests that the primary organ damaged is the pancreas, severe cardiac and skeletal myopathies are also key features of this disease. One form of chronic PD has also been known as 'sudden death syndrome' (SDS), due to deaths in well conditioned feeding fish."

A report – "The Health Situation in Norwegian Aquaculture 2009" – published by the Norwegian Veterinary Institute in 2010 stated that: "Pancreas Disease (PD) has been the dominant disease in salmon farming in recent years." Reported cases of PD have risen steadily since the late 1990s – from 7 cases in 1998 to 98 in 2007.

	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
ILA (ISA)	13	14	23	21	12	8	16	11	4	7
IPN					174	178	172	208	207	165
PD*	7	10	11	15	14	22	43	45	58	98
HSMB (HMSI)							54	83	94	162
Piscirickettsiose	0	6	0	1	17	5	0	0	1	1
Furunkulose	1	2	6	3	0	2	3	1	3**	5***
BKD	0	3	3	3	1	1	1	2	0	0

Diseases in Norwegian Aquaculture (1998-2007) as reported by the Norwegian Veterinary Institute

A scientific paper – "Salmonid alphavirus (SAV) and pancreas disease (PD) in Atlantic salmon, *Salmo salar* L., in freshwater and seawater sites in Norway from 2006 to 2008" – published in the *Journal of Fish Diseases* in 2010 reported: "In the seawater phase, SAV was detected in samples from 23 of 36 (63.9%) studied sites located within the endemic region. No SAV subtype 3 was detected in samples from seawater sites located outside the endemic region. The cumulative incidence of PD during the production cycle amongst sites with SAV detected was 87% (20 of 23 sites)."

PD is also a major problem in Scottish and Irish salmon farming. A report published in March, for example, detailed the following in 2009 at a farm at Shuna Castle in Scotland: "Problems with Pancreatic Disease so delayed sea lice treatments on advice of vets. 20,000 morts over last 4 weeks to PD." Other reports from salmon farms in Scotland included: "Site experiencing problems with PD/sleeping disease and sea lice. Lost approx 33% since input" and "3 - 5,000 morts/site/week for last 6 weeks - sea lice/ PD / CMS. 17,083 mortalities /site / week 47 - sealice / PD / CMS." Another data entry for a salmon farm at Ardgadden in 2009 read: "Peak in morts post input - IPN... c10k per month....Grumbling suspect PD also".

In Ireland, a report – "Pancreas Disease in Farmed Salmon – Health Management and Investigations at Irish Farm Sites, 2005 – 2008" – published by the Marine Institute in 2008 stated that.

"Pancreas disease emerged as a significant disease of farmed salmon in Ireland in the mid-1980's with 73% of marine sites affected by the disease in 1987. The disease is now considered endemic in Ireland, occurring on the majority of marine salmon sites each year and is the most significant infectious disease of Irish farmed salmon at present."

The report stated that:

"In 2003, 62% of sites were affected with an average pancreas disease associated mortality of 18.8% (range 2 – 35%) which increased in 2004 to 86% of sites affected and 14.8% average mortality (range 4 – 35%). Over the next two years, the number of sites affected by pancreas disease remained high in Ireland (80% in 2005; 69% in 2006) but the average mortality associated with the disease was reduced to just below 10% in both years. The prevalence of the disease increased again in 2007 to > 90% of marine sites with an associated mortality of 23%."

A report published by the European Union in 2007 stated that: "PD was a significant problem in the Irish salmon industry in the 1980s and into the 1990s, when mortalities in severe outbreaks exceeded 50% (Crockford et al. 1999). Thereafter infection continued to occur, although the associated levels of mortality declined to low levels for a period. However, since 2002 PD has re-emerged as the cause of significant losses in the Irish industry (McLoughlin et al. 2003). In parallel with this, PD is also considered to be an emerging problem in the salmon industries of Scotland and in Norway, where outbreaks remain concentrated in the Bergen area (Olsen 2004; Hodneland et al. 2005). Overall, mortality levels in outbreaks of SD tend to be low but can vary even on a single site, on occasion exceeding 40% (Graham et al. 2003b, 2006a)."

According to the Marine Institute in Ireland, clinical signs associated with PD include a loss of appetite, lethargy, an increased number of faecal casts in the cages and increased mortality. Affected fish are often unable to maintain their position in the water column due to muscle damage and are sensitive to any handling procedures.

A paper published in the *Journal of Virology* in 2006 reported that: "Sleeping disease in salmon was first observed in France in 1985. In the rainbow trout (*Oncorhynchus mykiss*), the disease is characterized by an abnormal behavior of the fish, staying on their sides at the bottom of the tanks, reminiscent of a "sleeping state" that has provided the name of the disease . A related disease in farmed Atlantic salmon (*Salmo salar* L.) has also been reported."

A report published by the European Union in 2007 stated: "Both PD and SD are associated with characteristic sequential histopathological changes that include pancreatic and cardiomyocytic necrosis and skeletal myopathy (Boucher and Baudin Laurencin 1996; McLoughlin et al. 1996, 2002). Clinical signs include inappetence, lethargy and an increased number of white faecal casts. Affected salmon in cages tend to "hang" on the nets. Affected trout tend to settle to the bottom of raceways or ponds, only moving when disturbed."

Chapter 3:

'Salmon Superbugs' and Salmon Transmitted Diseases (STDs)

In addition to the seven major problems identified above, there are a host of other deadly diseases, infections, pathogens, viruses, parasites, bacteria and other issues which pathologists, veterinarians and microbiologists struggling to keep track of. The following list is by no means exhaustive:

Gill Disease (Proliferative Gill Inflammation, Epitheliocysts/Chlamydia & Amoebic Gill Disease)

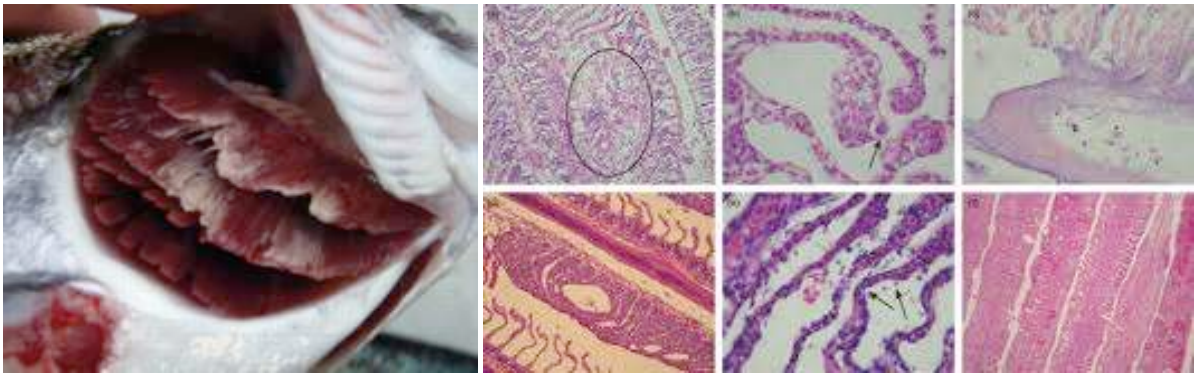
Paranucleospora theridion
Gyrodactylus ('Salmon Killer')
Furunculosis (Aeromonas salmonicida)
Infectious Hematopoietic Necrosis (IHN)
Viral Haemorrhagic Septicaemia (VHS)
Cardiomyopathy Syndrome (CMS)
Heart and Skeletal Muscle Inflammation (HMSI)
Plasmacytoid Leukemia (Marine Anemia)
Parvicapsulosis (Parvicapsula pseudobranchicola/ Paranucleospora theridion)
Bacteria Kidney Disease (BKD)
Myxobacterial Infection (Piscine Tuberculosis)
Spironucleosis (Spironucleus salmonicida)
Francisella (Francisellosis)
Yersinia ruckeri (Yersiniosis/Enteric Redmouth/ERM)
Flavobacterium psychrophilum (Bacterial Cold Water Disease/Rainbow Trout Fry Syndrome)
Vibriosis (Cold Water Vibriosis/Hitra Disease)
Moritella Vicosa (Winter Ulcer)
Hemorrhagic smolt syndrome (HSS)
Mad Fish Disease
Botulism (Clostridium botulinum)
Parasitic Meningitis
Costia (Ichthyobodo species)
Tapeworm (Diphyllobothriasis)
Microsporidian encephalitis
Nephrocalcinosis (urolithiasis)
Malignant Intestinal Tumours
Desmozoon lepeophtherii (Paranucleospora theridion) & Autumn Disease
Salmonella

Following this section, the report concludes by asking if there are other skeletons lurking in the closet. Finally, in the Appendix there are details of the diseases officially reported in British Columbia.

Laid out below like a smorgasbord are specific details on 'Salmon Superbugs' and Salmon Transmitted Diseases:

Gill Disease (Proliferative Gill Inflammation, Epitheliocysts/Chlamydia & Amoebic Gill Disease)

Gill diseases are apparent in all major salmon farming regions yet diagnostic criteria are different – with conditions ranging from Piscichlamydia (more widely known in humans as Chlamydia - a sexually transmitted disease), Ephitheliocystis, Prolferative Gill Inflammation and Amoebic Gill Disease.



Photos: Gill Disease in Atlantic farmed salmon in Ireland

In Scotland, 'Epitheliocystis' and 'Gill Pathology' were reported in 2006 and 2007 and 'Bacterial Gill Disease' in 2004. In Norway, 'Proliferative Gill Inflammation' (PGI) is the common term and in Australia 'Amoebic Gill Disease' (AGD) is the #1 disease problem. AGD is also an issue in Chile.

In 2010, a scientific paper – "Epitheliocystis in Atlantic salmon, Salmo salar L., farmed in fresh water in Ireland is associated with 'Candidatus Clavochlamydia salmonicola' infection" – published in the *Journal of Fish Diseases* reported that: "Intracellular inclusions containing chlamydia-like organisms are frequently observed in the gill epithelial cells of Atlantic salmon, Salmo salar L., cultured in fresh water in Ireland."

Another scientific paper – "Microfauna associated with amoebic gill disease in sea-farmed Atlantic salmon, Salmo salar L., smolts" – published in 2006 in the *Journal of Fish Diseases* reported: "A diverse polyphyletic protozoan community was observed colonizing the gills, including Neoparamoeba sp., other amoebae, scuticociliates, Ichthyobodo-like flagellates, trichodinid ciliates and prostomatean ciliates. The earlier gill tissue changes in the gill were not always associated with the presence of these microorganisms, whereas amoebae (other than Neoparamoeba sp.), Ichthyobodo-like flagellates and trichodinid ciliates correlated with augmenting gill lesions. Neoparamoeba sp. was present, but its abundance did not correlate with the disease. This study suggests that a diversity of protozoans including Ichthyobodo-like flagellates, trichodinid ciliates and amoebae other than Neoparamoeba sp. are involved in the aetiology of amoebic gill disease in the Irish situation."

In 2004, scientists reported on 'Candidatus piscichlamydia salmonis' (order Chlamydiales), a chlamydia-like bacterium associated with epitheliocystis in the *Journal of Clinical Microbiology*. The paper stated that: "Epitheliocystis has been associated with heavy mortality and reduced growth of survivors in farmed Atlantic salmon (*Salmo salar*)".

Moreover:

"Morphological data from epitheliocystis inclusions investigated in this study identified ultrastructural differences between developmental stages of year 2000 Norwegian inclusions and year 1995 Irish inclusions that suggest that two different chlamydia-like developmental cycles representing two different species exist in farmed Atlantic salmon, one occurring in proliferative gill lesions and one occurring in nonproliferative gill samples."

A 'Farmed Fish Health Report 2008' published by the Norwegian Veterinary Institute reported that: "Proliferative gill inflammation (PGI) is a term used to describe a condition which has been diagnosed in sea-farmed salmon in Norway since the 1980's. Most diagnoses occur in the autumn, between August and December, in salmon transferred to sea the previous spring. In the course of the autumn affected fish may develop serious gill injury characterised by moderate to extreme proliferation of gill tissues. Commonly associated findings include haemorrhage and tissue necrosis in the gills, while liver necrosis is not uncommon. Epitheliocysts (*Piscichlamydia salmonis* inclusions) are also commonly associated with this condition."

Moreover:

"Information received from field fish health services indicate that many farmers do not distinguish losses related to PGI from other inflammatory gill conditions. PGI is therefore considered only one of many different types of gill problem which when taken together, result in considerable losses in many farms in many parts of the country. The direct losses related to gill disease, both in relation to increased mortality and reduced growth etc. are significant and appear to be an increasing problem in 2008.

Farmed salmon in Scotland and Ireland are also affected by serious gill related problems. Researchers from these countries are currently in discussion with Norwegian researchers regarding development of a strategic joint research programme on this theme. One important initial aim will be to reach a consensus regarding diagnostic criteria for the various types of gill complaints. As further knowledge regarding PGI has accumulated, the diagnostic criteria have changed, making compiling of comparable statistics relating to outbreaks over time difficult."

In Australia, CSIRO reported in 2007 that "the fish are under attack from amoebic gill disease". Amoebic Gill Disease is "a health problem that costs the Tasmanian industry some A$20 million a year in treatment and lost productivity, and is a major constraint to industry expansion." Government data reported for 2004-2007 in relation to AGD detailed: "Major disease cost to industry. Restricted mainly to farms located in the south-east of the state. Primary control treatment is freshwater bathing. Work on developing a vaccine and disease resistant breeding programs are currently under way."

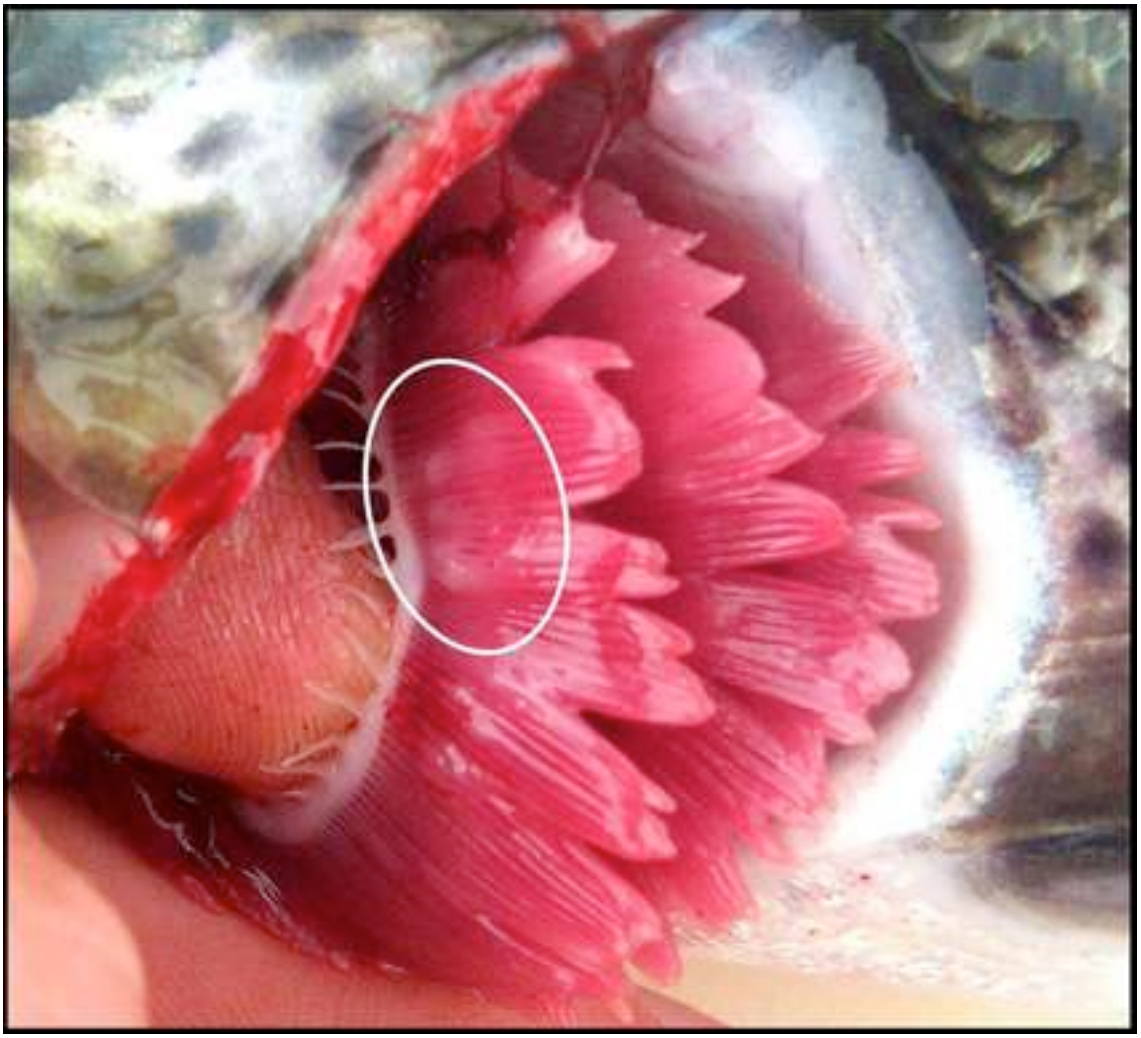


Photo: AGD in farmed Atlantic salmon in Tasmania (white patches on gills)

AGD also causes problems in Chile. *Fish Farming Xpert* reported in 2007 that: "In October of 2006 the Chilean salmon industry registered its first clinical diagnosis of AGD, which was found closely linked to problems incurred by sea lice (caligus sp.). Further investigation revealed that the AGD present in Chile is the Neoparamoeba perurans, the same type found in Scotland, Ireland, the United States, and New Zealand for example, and affects specifically Atlantic salmon."

A scientific paper – "Amoebic gill disease (AGD) in Atlantic salmon (*Salmo salar*) farmed in Chile" – published in *Aquaculture* in 2011 reported that: "Between May and November 2007, three marine Atlantic salmon farms around Chiloé Island, Chile, reported mortalities in which affected fish presented with *Caligus rogercresseyi* infections and gross gill lesions characteristic of amoebic gill disease (AGD)". The causal agent of AGD in Chile was identified as the trophozoite *Neoparamoeba perurans.*

Paranucleospora theridion

A scientific paper – "Diseases of farmed Atlantic salmon Salmo salar associated with infections by the microsporidian Paranucleospora theridion" – published in the journal

Diseases of Aquatic Organisms in 2011 reports a link between *Paranucleospora theridion* and PGI:

"The microsporidian Paranucleospora theridion was discovered in Atlantic salmon Salmo salar suffering from proliferative gill disease in a marine farm in western Norway in 2008. The parasite develops in cells of the reticuloendothelial system, cells important for normal immune function. The aim of this study was to see if P. theridion could play a part in some of the diseases with unclear causes in salmon production in Norway, i.e. proliferative gill disease (PGI), pancreas disease (PD), heart and skeletal muscle inflammation (HSMI) and cardiomyopathy syndrome (CMS). P. theridion was present in all areas with salmon farming in Norway, but high prevalence and densities of the parasite in salmon and salmon lice were only seen in southern Norway. This region is also the main area for PGI and PD in Norway. Quantification of pathogens associated with PGI, PD, HSMI and CMS diagnoses showed that P. theridion levels are high in southern Norway, and may therefore play a role in susceptibility and disease development. However, among the different diagnoses, fish with PGI are particularly heavily infected with P. theridion. Therefore, P. theridion appears as a possible primary agent in cases with high mortality in connection with PGI in western Norway."

The paper concluded:

"PGI is associated with a range of different pathogens, viruses, bacteria and parasites, but in western Norway, *Paranucleospora theridion* seems to be the most important agent in association with PGI and high mortalities. No evidence was found for elevated *P. theridion* densities in fish from farms with diagnoses of PD, HSMI and CMS in western Norway, and these diseases occurred in the absence of the parasite. However, our findings do not exclude a role for this parasite in affecting host susceptibility or disease severity in connection with PD, HSMI and CMS."

Patogen also reports that: "The parasite *Paranucleospora theridion* is a microsporidium and a new phenomenon in the Norwegian aquaculture industry. Much remains unknown about this parasite and its importance."

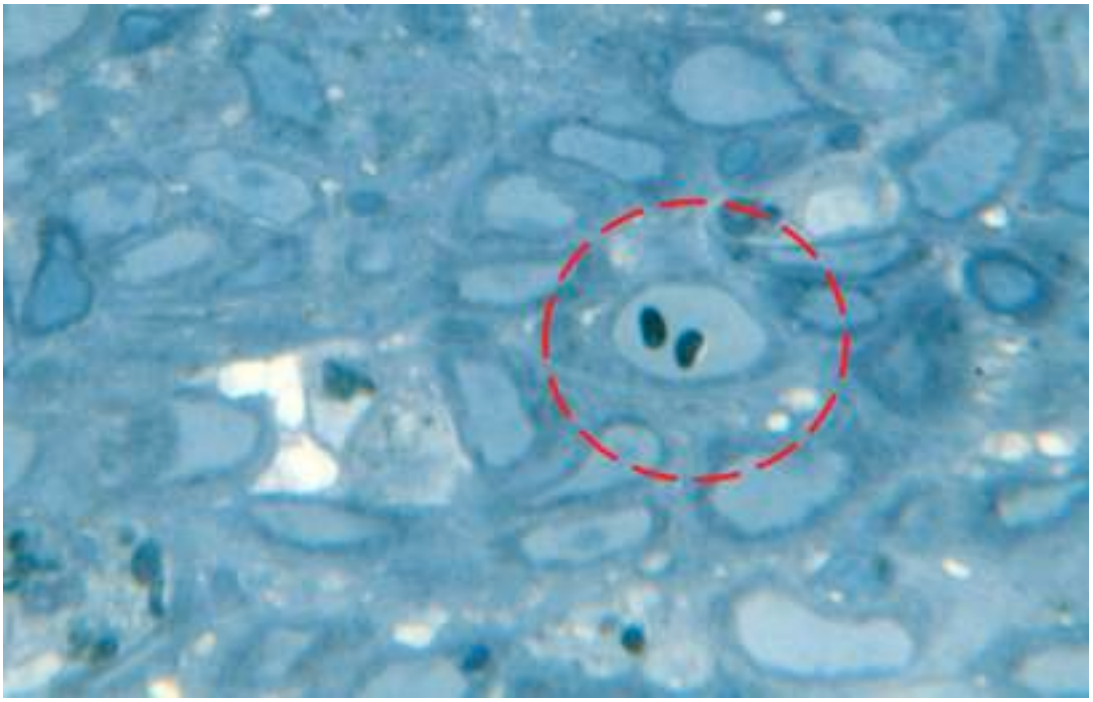


Photo: Paranucleospora theridon

Patogen reported in 2011: "The parasite was detected for the first time in Norway this year and has aroused considerable attention as a potential problem both for the aquaculture industry and for wild fish. The parasite appears to occur frequently in connection with PD, HSMB, PGI and/or CMS, but it remains unclear whether it is the primary or secondary cause of the diseases observed. Infection experiments with *P. theridion* conducted at the University of Bergen have produced over 50% mortality in some groups and according to Prof. Are Nylund the pathology has had clear similarities to HSMB and CMS in salmon. *P. theridion* is most widespread in the area from Rogaland to Nord Trøndelag but has been detected throughout Norway."

Parvicapsulosis (Parvicapsula pseudobranchicola)

According to the Research Council of Norway: "The myxozoan parasite Parvicapsula pseudobranchicola were first reported from seawater reared Atlantic salmon in Norway in 2002 as the cause of severe disease and economical losses and has since then been an increasing problem in the Norwegian aquaculture industry. Individual farms experience economical losses in the range of 10 million NOK annually."

A scientific paper published in 2011 stated that: "*Parvicapsula pseudobranchicola* infections were first reported from seawater-reared Atlantic salmon, *Salmo salar,* in Norway in 2002 and have since then been an increasing problem." Patogen reports that "Fish often go blind as a result of the disease" and that "Parvicapsulosis is probably underdiagnosed in Norway".

A scientific paper – "Epidemiology of parvicapsulosis in Norwegian farmed salmon (Salmo salar)" - published in 2003 reported that: "In March 2002 a myxosporean parasite - *Parvicapsula pseudobranchicola* - Karlsbakk, Saether, Hostlund, Fjellsoy and Nylund, 2002 - was detected in the pseudobranchs of diseased fish in five seawater farms in Northern Norway. The mortality varied between 2-35% in affected farms. This was the first

observation of the parasite, but it is suspected that *P. pseudobranchicola* may account for some of the annual mortality of unknown aetiology registered in salmon farming in Norway".

The paper concluded that: "Parvicapsulosis has puzzled fish farmers and researchers since the first diagnosis in March 2002....many questions remain to be answered."

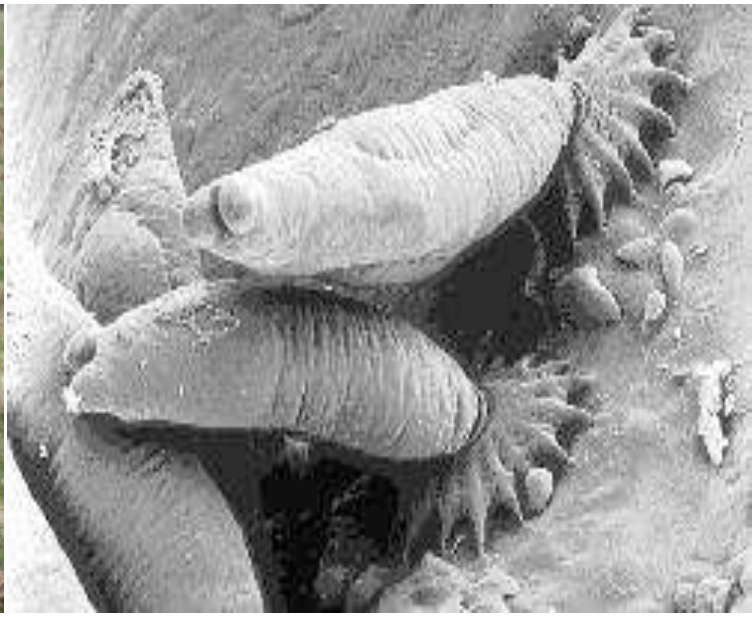
A 'Farmed Fish Health Report 2008' published by the Norwegian Veterinary Institute in 2009 stated that: "*Parvicapsula pseudobranchicola* is a myxozoan first described from Norwegian farmed salmon in 2002. The number of affected farms increased slightly between 2007 and 2008. Several farms experienced outbreaks of parvicapsulosis in both spring and autumn sea-transferred salmon, in some cases with significant losses. Parvicapsulosis is often registered concomitantly with other diseases, therefore the proportion of the losses attributable to this parasite is debatable. Fish are intermediate hosts, and work continues to identify the final host organism."

A report by the European Union in 2007 stated that: "Individuals developing parvicapsulosis, surface, swim disorganised or appear lethargic, may be unresponsive to visual challenge as when blind. The eyes usually show crescent shaped bleedings, cataracts and exophthalmia may also occur. The fish do not feed, tend to be slim and anaemic (Karlsbakk et al. 2002; Sterud et al. 2003). Affected pseudobranchs may be swollen or papillate, in severe cases they may show a whitish "cheesy" covering occasionally with bleeding. In some fish the pseudobranchs may be more or less replaced by ulcers. Histologically, sporogonic stages occur intracellularly in the pseudobranch cells, but eventually appear free and fill the space between the secondary lamellae. It is believed that the pseudobranch infections may interfere with the blood supply to the eyes, causing blindness."

Gyrodactylus ('Salmon Killer')

Gyrodactylus salaris is a parasitic flatworm which is lethal to salmon – hence it is often called 'Salmon Killer'. According to the OIE's 'disease card' on 'Gyrodactylus of Atlantic salmon' (Gyrodactylus salaris):

"When the parasite is introduced to a new river, up to 98% of the native Atlantic salmon parr population dies within a few years. The existence of the salmon population is threatened in many of these rivers (mortality of salmon parr in original endemic rivers is unknown)...Up to 100% mortality in farmed Atlantic salmon parr (if not chemically treated)."



Photos: Gyrodactylus salaris – 'Salmon Killer'

According to the 'NOBANIS – Invasive Alien Species Fact Sheet':

"The parasite was described by Malmberg (1957) from Atlantic salmon parr in a hatchery situated at the river Indalsälven in Sweden. Since then, there have been a growing number of observations of *G. salaris* from several countries both on wild fish and on fish in hatcheries and freshwater fish farms. Three clades of *G.salaris* have been described; clade 1 was most abundant and only found on salmon, clade 2 was isolated from the river Göta älv in Sweden and clade 3 was observed on Norwegian salmon in three rivers and on rainbow trout in fish farms in Sweden, Denmark and Finland."

Moreover:

"In Norway, *G. salaris* has caused epidemics that have devastated stocks of Atlantic salmon in many rivers. The density of salmon parr in infected rivers has been reduced on an average of 86% and the catch of salmon in infected rivers are reduced on an average of 87 %."

Photo: The deadly Gyrodactylus salaris parasite

A report by the European Union in 2007 states that: "Within Norway, *G. salaris* is an alien parasite fauna and the main goal of Norwegian authorities is to eradicate the parasite from infected sites. Until recently, rotenone has been used to eradicate the parasite from rivers. This is a controversial method as this biocide first of all kills the fish in the rivers and other aquatic animals."

So serious is the threat posed by the spread of Gyrodactylus that there is a 'Code of Practice to Avoid the Introduction of Gyrodactylus salaris into Great Britain". The Scottish Government also has a "Contingency Plan for Gyrodactylus salaris" which states:

"Unlike many aquatic animal disease agents, which are often most pathogenic to farmed populations, *G. salaris* causing gyrodactylosis, is most detrimental to wild fish. Surveillance on fish farms and from wild fisheries has been conducted in Scotland over the past 15 years suggesting the absence of *G. salaris*. Scottish Atlantic salmon strains have been identified as being susceptible to the pathogen (MacKenzie & Bakke, 1994), and it is probable that its introduction would have catastrophic effects to wild fisheries in Scotland which are valued at over £100 million to the Scottish economy."

Gyrodactylus derjavini was reported on Scottish salmon farms in 2006 and 2007 and in Norway. Disease data supplied by the Irish Government in 2007 also reported Gyrodactylus (*derjavini and truttae*). Both Gyrodactylus salaris and Gyrodactylus derjavini have been reported on Atlantic salmon in Norway and both mainly infest the fins on their host.

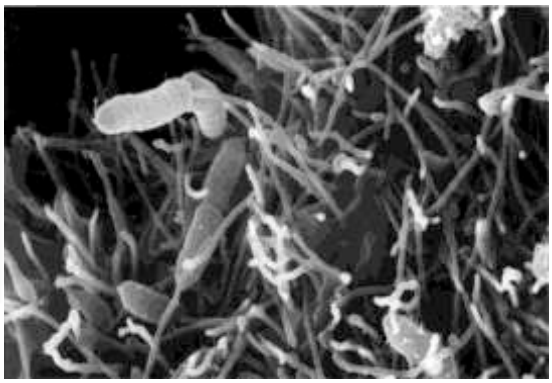
A report by the European Union in 2007 stated that: "In fish farms the mortality in affected tanks can be as high as 100 % if not treated in time. Usually clinical signs such as flashing

can be observed a long time before the fish become diseased and it is relatively easy to keep the number of parasites to an insignificant level by treatment. *G. salaris* cause at least two types of damage to the epidermis of the host. The 16 marginal hooks and two anchors in the opisthaptor attach the parasite to the host. The wounds in the epidermis caused by the hooks are probably too small to affect the host badly. However, the wounds caused by parasite feeding are much larger. The numerous wounds due to many hundreds of parasites are likely to be the main cause of gyrodactylosis and host mortality."

The report states that: "In Norwegian fish farms, stamping out of fish have mostly been used to eradicate this introduced parasite. Currently (2006) there is no known presence of *G. salaris* in any of the 39 farms where *G. salaris* previously was observed (Mo and Norheim 2005). Several compounds can be used for treatment against gyrodactylosis (Schmahl 1993). Many compounds are effective against the disease but very few are effective enough to eradicate the parasite from a tank or farm."

Furunculosis (Aeromonas salmonicida)

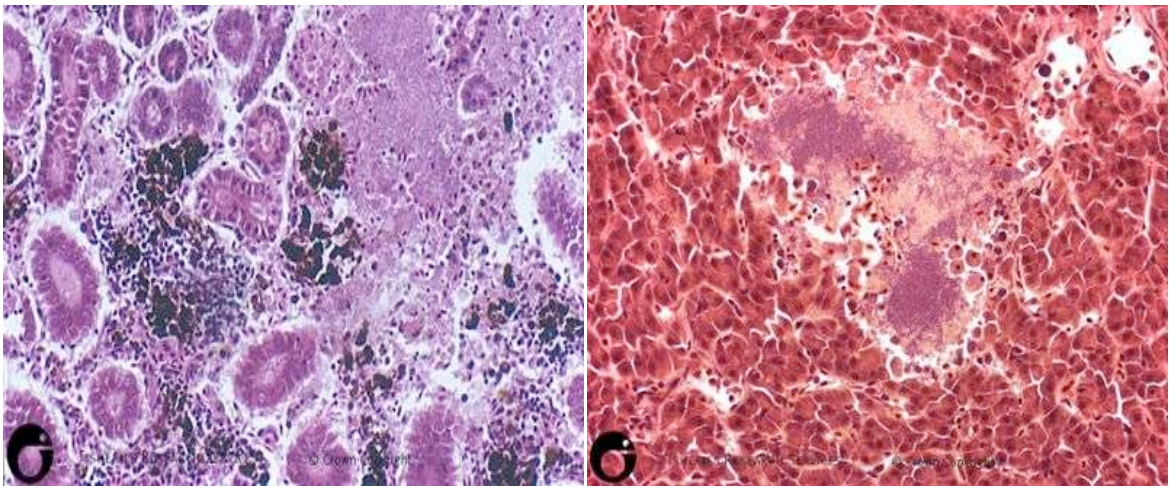
Furunculosis is caused by Aeromonas salmonicida. Classical furunculosis derives its name from the boil-like lesions (furuncules), appearing on the skin and in the musculature of infected fish. Furunculosis has been reported in salmon farms in Scotland, Norway, Canada, Ireland and the United States.



Photos: Furunculosis and *Aeromonas salmonicida* bacteria

A report published by the European Union in 2007 stated: "The name of the disease "furunculosis" refers to lesions in the dermis seen as characteristic umbonate ulcers. The organism penetrates into the underlying tissues and organs. Munro and Hastings (1993) describes the epizootiology and gross pathology as follows: In a population, a continuum of pathologies may be presented from the most acute to chronic. Acutely dying fish most often show few external signs, whereas in chronic cases one or more of the following may be present: darkening, lethargy, inappetence, petechiation at fin bases and sometimes gross swellings. The gills are very pale. Internally the blood vessels surrounding the lower intestine are inflamed and often those of the pyloric caeca as well. The intestine is devoid of food and may have exudates of blood, mucus and cellular debris. The spleen is swollen and cherry red, whereas the liver is grey to greenish. Petechiae are common on all serosal surfaces. The swim bladder may be swollen and cloudy. The kidney is swollen. Haematocrit measurements often show severely depressed red cell numbers."

Like ISA, Furunculosis has been spread around the northern hemisphere by the global salmon farming industry. The bacterium can be very long-lived in water, where it is easily transmitted among fish. Researchers have shown that Furunculosis can be spread between unrelated salmon farms up to 24 kilometres (15 miles) apart, even though no farmed fish were exchanged between them. This bacterium also persists in high concentrations in sediment under salmon pens.



Photos: Furunculosis in farmed Atlantic from Scotland

The spread of Furunculosis from Scotland to Canada is described by biologist Alexandra Morton of Raincoast Research Society: "In 1991, IBEC brought Atlantic salmon eggs into Canada from the Landcatch hatchery in Scotland. This hatchery had experienced trouble with furunculosis, shipping stock to Norway that triggered an outbreak of the disease which spread into 70 Norwegian Rivers (Johnsen and Jensen 1994). When IBEC put their Atlantic salmon into the Broughton Archipelago - the wild coho returned to a local enhancement hatchery with furnuculosis. Over 28% of the adult coho died in this hatchery disease-free for the previous ten years.....In 1993, Scanmar put furunculosis infected Atlantic salmon into the archipelago again. But this time it was a highly antibiotic resistant strain. It spread in days to infect the B.C. Packer fish farms." (For more details view Alexandra Morton's 2006 presentation 'Disease Epidemics: 1991-Present').

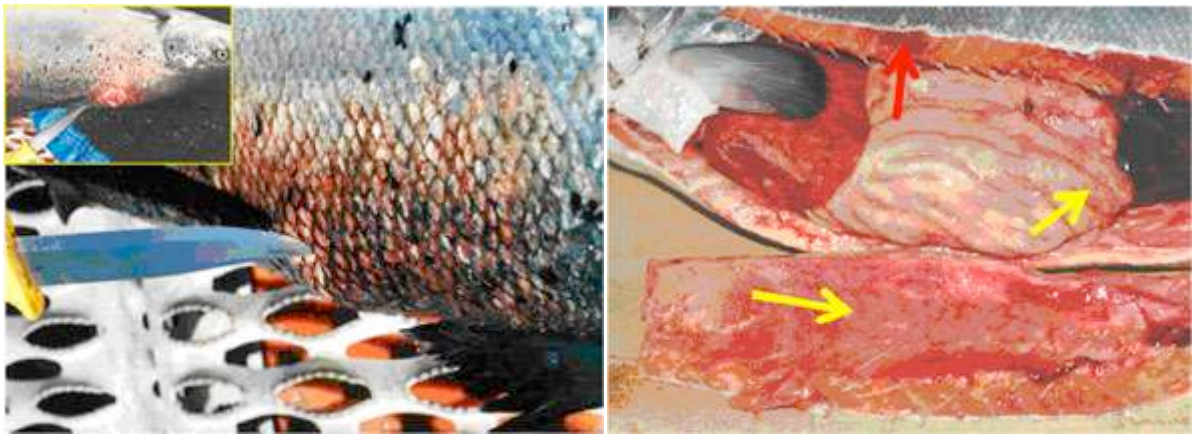
A scientific paper – "The spread of furunculosis in salmonids in Norwegian rivers" – published in the *Journal of Fish Biology* in 1994 reported that: "In 1985, furunculosis was discovered in marine fish farms in Nord-Trøndelag, following importation of salmon smolts from Scotland. The disease reached Møre og Romsdal in 1988, by which time 32 fish farms were infected in the two counties. By the end of 1992, 550 farms were infected. The disease spread concurrently in natural watercourses, from 22 in 1989, to 74 by the end of 1992. Rapid spread of the disease was associated with several factors including escapes from fish farms." In an attempt to eradicate Furunculosis, 20 Norwegian salmon farmers slaughtered all of their fish, an estimated economic loss of more than $100 million.

In Scotland, 'Furunculosis (histology)' was reported in 2006 and 2007 and 'Furunculosis' every year between 1998 and 2004. In Canada, 'Aeromonas salmonicida Infection' was reported every year between 2003 and 2010 via the BCSFA 'Fish Health Database'. And 'Aeromonas salmonicida (Atypical) Infection' was reported in 2008 and 2009. In Norway, no cases of Furunculosis were reported in 2009.

Furunculosis has also caused problems in Ireland where Aeromonas salmonicida was detected in the tank effluent of hatchery-reared Atlantic salmon smolts in 1995.

A report published by the European Union in 2007 stated that: "The bacterium has been demonstrated to persist in the surroundings of aquaculture farms for a certain period and its hydrophobic nature causes it to accumulate at surface layers or associated with organic wastes and fish feed (Enger 1997). To combat infections the fish farmers used orally administrated antibacterial agents, the organic waste constituted a pathway for the drugs into the marine environment resulting in accumulation and high concentrations in the sediments (Jacobsen and Berglind 1988; Samuelsen et al. 1992). As explained elsewhere in this article, residues of the antibacterial agents were also found in the wild fauna in the vicinity of the medicated fish farms, the bacteria in the sediments developed high frequencies of resistance against the drugs (Lunestad 1992). Additional environmental problems emerged when organic enriched sediments proved to be a refuge in which bacteria pathogenic to fish could survive for at least 18 months (Husevåg 1994)."

Iceland has also suffered problems with Furunculosis. A scientific report published in 2011 stated: "Bacterial infections have caused the major infectious diseases in Icelandic aquaculture. The bacterium *Aeromonas salmonicida* subsp. *achromogenes* (atypical furunculosis) has affected all species of fish cultured in Iceland".



Photos: External appearance of a large 'furuncle' under the skin of an Atlantic salmon with furunculosis; inset shows open furuncle; Opened peritoneal cavity of an Atlantic salmon with furunculosis showing extensive haemorrhage in peritoneal fat and wall (yellow arrows) and within musculature (red arrow); this salmon presented with no external clinical signs.

In Australia, 'Marine aeromonas disease of salmonids' (Aeromonas salmonicida: acheron) was reported from 2004 to 2007 (the last date data was available). In 2005, the Government reported: "The "Atypical *A. salmonicidia* strain affecting Atlantic salmon located within Macquarie Harbour. Pathogen originally identified during 2000 and increased in impact on production again during 2005. Resulted in an increase in the use of OTC (Oxytetracycline) during this year. Work on vaccine development currently under way.

As with other infectious diseases, the spread of Furunculosis has been linked to escapes from salmon farms. A Norwegian study reported in 1991, for example, that escaped fish are believed to be the source of Furunculosis in 20 Norwegian rivers.

Infectious Hematopoietic Necrosis (IHN)

The Journal of Virology reported in 1977 that Infectious Hematopoetic Necrosis (and VHS) is a 'Salmonid Rhabdovirus' and has been "found to resemble closely that of rabies virus".

IHN has been a major problem in British Columbia including an "epidemic" in 2001-2003. IHN is also known as 'Sockeye Disease' although it now affects farmed Atlantic salmon in the Pacific.

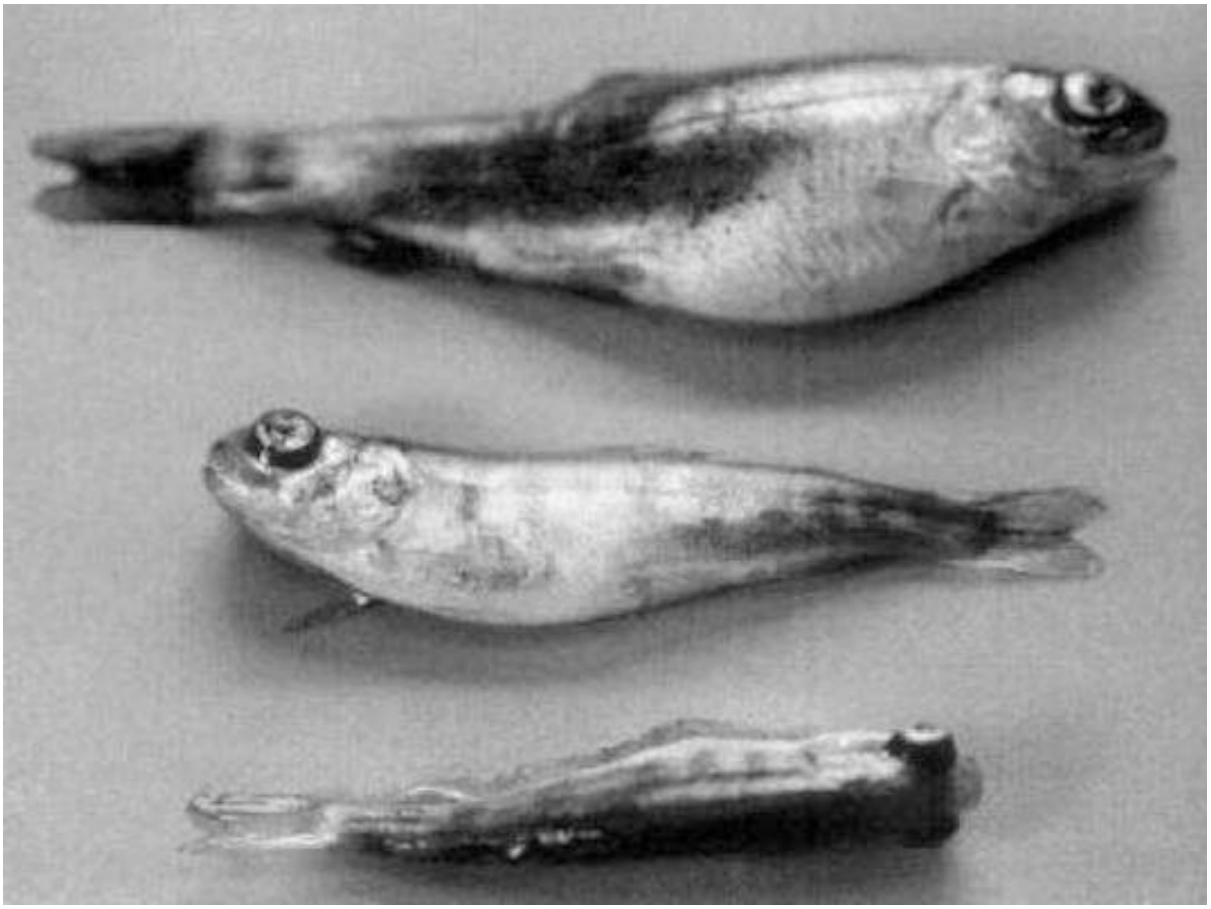


Photo: Clinical signs of IHN infection: the diseased fish show darkening of the dorsal body with petechial haemorrhaging on the body near the operculum and at the vent (diseased fish at top). Exophthalmia is common (diseased fish in middle) and scoliosis is seen in some of the fish (diseased fish at bottom).

A 'Fish Health Report' for 2006 from the Ministry of Agriculture and Lands in B.C. describes IHN as: "A viral septicaemia caused by a rhabdovirus. Atlantic salmon have no natural immunity to IHNv and it is diagnosed on a farm by a positive PCR for the pathogen and confirmation by cell culture. High level losses are evident within 7 to 10 days post initial infection. Farmed Chinook and Coho salmon are refractory to infection."

'Infectious Hematopoetic Necrosis Virus Infection' was reported in 2003 via the BCSFA 'Fish Health Database'. The Pacific Biological Station reported in 2004: "In British Columbia, infectious hematopoietic necrosis virus is usually associated with sockeye salmon

(*Oncorhynchus nerka*) in freshwater; it is often detected at the fry and spawning adult life stages. In Pacific salmon the virus is rarely detected when fish are in the marine environment. However, the virus has been reported in a few marine species and is a serious pathogen for farmed Atlantic salmon (*Salmo salar*) in marine netpens."

IHN was reported as far back as 1993 in a scientific paper published in the *Canadian Veterinary Journal*. The paper - "Infectious hematopoietic necrosis in Atlantic salmon in British Columbia" – reported that: "In the summer of 1992, an outbreak of infectious hematopoietic necrosis (IPN) developed in farmed Atlantic salmon in British Columbia..... Increasing mortality was observed in a group of farmed Atlantic salmon smolts (about 1 year old), approximately six weeks following transport from fresh to salt water. Affected fish were dark, lethargic, and swam slowly near the surface. Gills were pale brown. Fish opened for postmortem had pinpoint hemorrhages on peritoneal surfaces, in pyloric cecal fat, and in the lateral line and dorsal sinus area of skeletal musculature. Patchy hemorrhage in the kidney was a frequent finding. Histopathological changes consisted of endothelial cell necrosis in multiple tissues, leading to petechial and ecchymotic haemorrhages throughout the body."

Alexandra Morton reported in an article – "Fish Disease not public" - published in 2010 that: "In July 1992, IHN virus broke out in Atlantic salmon smolts as they were put in salmon farm in Okisollo Channel. Okisollo is within the Fraser sockeye migration route. Even though the Fraser sockeye were migrating through the area, no one called for the IHN infected farm salmon to be culled. The Ministry of Agriculture, Fisheries and Food (MAFF) kept this epidemic secret from the Ministry of Environment, Lands and Parks (MELP) even though there was a disease sharing protocol in place. When MELP heard "rumors" of this IHN outbreak three months later, MAFF still refused to give them the details of the outbreak" (more details via '1992 memos - a trail of secrets and disregard for wild salmon health').

A scientific paper – "Epidemiological investigation of infectious hematopoietic necrosis virus in salt water net-pen reared Atlantic salmon in British Columbia, Canada" – published in the journal *Aquaculture* in 2002 reported on 18 IHN outbreaks on farms between 1992 and 1996. The paper reported that: "The crude cumulative mortality associated with IHNV in Atlantic salmon was high (average 47%), and outbreaks lasted 5.8 months on average. On the two farms where the virus was detected during the surveillance program, IHNV was confirmed in all pens within 1 month. On two of three sites where fish were kept on farms after the initial disease outbreak subsided, IHN reoccurred within 30 weeks."

"When a salmon farm in the Broughton Archipelago tried to dispose of 1.6 million IHN infected farm salmon in 2002, BC Supreme Court granted the Musqueam First Nations an injunction to prevent delivery of these fish to a processing plant in the Fraser River because these fish threatened the Fraser River's wild salmon with IHN," wrote Alexandra Morton in an article – "Fish Disease not public" - published in 2010. "What about the other 10 million left in net pens on the marine migratory routes used by the Fraser all south coast, and Clayoquot wild salmon and steelhead?" (For more details view Alexandra Morton's 2006 presentation 'Disease Epidemics: 1991-Present').

IHN caused significant problems in the Clayoquot Sound UNESCO Biosphere Reserve. According to Friends of Clayoquot Sound: "As of March 2003, Infectious Hematopoietic Necrosis (IHN) virus had swept through at least five of Cermaq's salmon farms within Clayoquot Sound. Cermaq only started re-stocking its salmon sites in Clayoquot Sound again in early 2004, after more than a year of inactivity because of disease problems."

According to a report – "Implications of Holding Diseased Fish in Open Net-Pen Fish Farms and the Potential Impacts on Wild Fish and Adjacent, Disease-Free Farms, with Particular Reference to *Infectious Hematopoietic Necrosis* (IHN)" – by John Werring of the Sierra Legal Defense Fund published in 2003 in *Bioline*:

"There is a substantial risk that both adults and juvenile salmon migrating past fish farms where IHNV epizootics are occurring could come into contact with the virus when passing by the infected farms and can, themselves, become infected or infective. In the case of out-migrating wild juvenile salmon that have not been previously exposed to IHN, infection could lead to massive mortality (upwards of 50-90%) should an infection become an outbreak."

A scientific paper – "Infectious haematopoietic necrosis epidemic (2001 to 2003) in farmed Atlantic salmon *Salmo salar* in British Columbia" - published in 2006 in the journal *Diseases of Aquatic Organisms* reported that: "Over 12 million Atlantic salmon on infected farms died or were culled during the epidemic with cumulative mortality on the farms averaging 58%. The first reported case of IHN occurred in August 2001 and the last outbreak in June 2003. Outbreaks on the farms lasted between 20 and 22 wk."

In 2005, the *Ha-Shilth-Sa* newspaper reported that 1.8 million Atlantic salmon smolts died at the Grieg Seafoods smolts hatchery after an outbreak of furunculosis.

The spread of IHN via infected eggs – so-called 'vertical transmission' - is a possibility. A report – "Fish Egg Trade: Pathogen survival outside the host, and susceptibility to disinfection" – published in 2005 by the European Commission stated: ""Hazard identification for vertical transfer of fish disease agents", indicated that infectious haematopoietic necrosis (IHN) outbreaks had occurred in areas previously thought to be IHN-free following shipments of salmonid eggs from areas where the disease was known to occur. Additionally, in a small number of cases, progeny that originated from eggs from IHN virus-positive parents that had been iodophor disinfected prior to incubation and rearing in virus-free water were found to be infected, indicating the possibility for true vertical transmission of the virus. Infectious haematopoietic necrosis virus (IHNV) can be detected in milt and reproductive fluids, and was found to adsorb to sperm. However, there is evidence for significant antiviral activity in yolk components prior to the eyed-egg stage. Although more than a billion eggs have been imported into Chile, no outbreaks of IHN or VHS have been reported, suggesting that both viruses are not or are rarely transmitted vertically when eggs are disinfected in iodine.... In conclusion, there is some evidence that the virus may be truly vertically transmitted, but if at all possible, this appears to be a very rare and infrequent event".

Viral Haemorrhagic Septicaemia (VHS)

The Journal of Virology reported in 1977 that Viral Haemorrhagic Septicaemia (and IHN) is a 'Salmonid Rhabdovirus' and has been "found to resemble closely that of rabies virus".

According to the Norwegian Veterinary Institute, the acute stage of the disease is commonly associated with haemorrhage in the skin, musculature and inner organs. The fish display pale gills (anaemia), exophthalmia and distended abdomen. Abnormal swimming behaviour e.g.

spiral swimming and flashing are registered, either as sole symptoms (nervous form) or in combination with haemorrhage (haemorrhagic form).

Photo: Viral haemorrhagic septicaemia in rainbow trout (Note swollen stomach and 'pop eye')

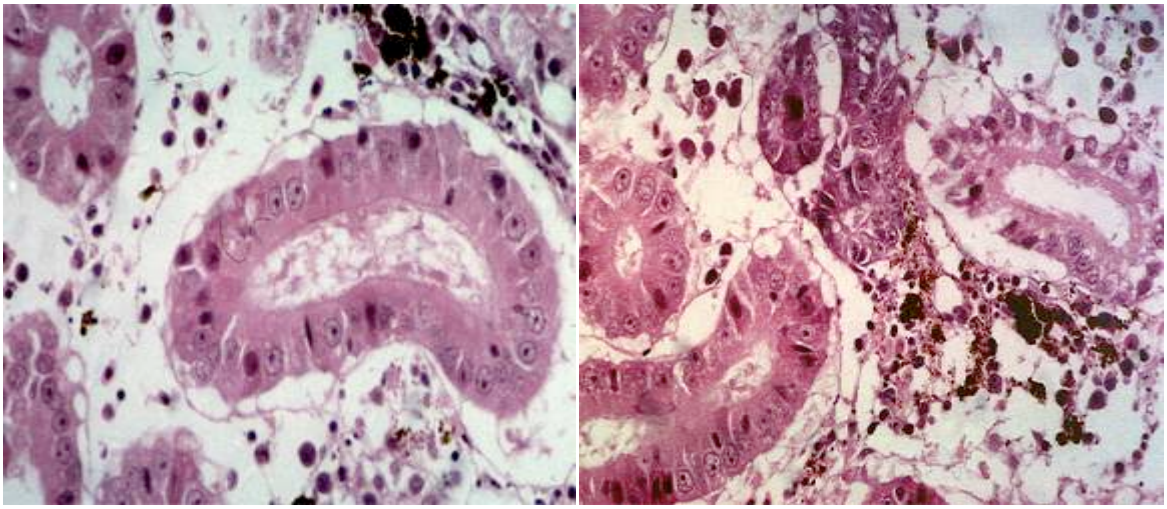
VHS-virus belongs to the novirhabdovirus family, and has a single-segment RNA genome. VHS-virus can be split into four genotypes, I-IV (and at least seven sub-groups), of which genotypes I-III have been detected in Europe. Genotype III has only previously been detected in marine species, and the Norwegian isolate is the first detection of this genotype in rainbow trout.

A scientific paper – "Disease interaction and pathogens exchange between wild and farmed fish populations with special reference to Norway" – published in the journal *Aquaculture* in May 2011 reported that: "Virulent virus is shed with urine and ovarian fluids, and once the virus is established in a farmed stock the disease becomes enzootic because of the latent carrier fish."

A 'Farmed Fish Health Report 2008' published by the Norwegian Veterinary Institute reported that: "The first detection of VHS-virus in Norwegian aquaculture since 1974 was made in a rainbow trout farm in Storfjorden in Møre og Romsdal in November 2007. The disease was also diagnosed in two other farms in the same fjord system in 2007 and in a further two farms in 2008. The latest detection was in December 2008."

According to the Norwegian Veterinary Institute: "Identification of disease in salmonid fish caused by virus of this genotype is unique on a world basis. Infection trials have confirmed that the new Norwegian virus isolate can result in significant mortality in rainbow trout and that the situation is serious. Most RNA-viruses have the capability for adaption to new hosts and environments, therefore rapid stamping out of infected populations is considered important to reduce spread of the virus. The fact that this unique virus continues to be detected with spread to new sites gives grounds for concern."

A scientific paper by Scottish scientists published in 2001 stated: "The risk of VHS to the Atlantic salmon culture industry in Europe appears to be low. Indeed, after many years of rigorous testing, no VHSV has ever been isolated from Atlantic salmon in Scotland. However, the North American strain of VHSV has been isolated from farmed Atlantic salmon in Canada (Traxler et al. 1995). Hence, the evidence does not preclude the potential for a VHSV strain that is virulent for Atlantic salmon to emerge in Europe, but our data together with other published reports lead to the conclusion that Atlantic salmon are not at direct risk from VHSV."



Photos: VHS affecting kidney of farmed rainbow trout.

An outbreak of VHS was reported on an Atlantic salmon farm in British Columbia for the first time in 1995. 'Viral Haemorrhagic Septicemia Virus Infection' was reported in 2003, 2005, 2006, 2007, 2008, 2009 and 2010 via the BCSFA 'Fish Health Database'.

A disease report published by the European Union in 2007 stated that: "VHSV has been isolated from Atlantic salmon in Spain (Jimenez de la Fuente et al. 1988; López-Vázquez et al. 2003) and in Canada (Traxler et al. 1995). VHSV has also been isolated from a single farmed Atlantic salmon from a marine net pen in Puget Sound, Washington. The fish had ceased feeding and clinical signs in some moribund individuals suggested an infectious agent. Abnormal mortality levels were not observed (Amos and Thomas 2002)..... In Canada VHSV has been isolated from 1995, 1998, 1999 and 2002 in British Columbia, (G.S. Traxler, Pacific Biological Station, Nanaimo, Canada, personal communication)."

The spread of IHN via infected eggs – so-called 'vertical transmission' - is a possibility. A report – "Fish Egg Trade: Pathogen survival outside the host, and susceptibility to disinfection" – published in 2005 by the European Commission stated: ""Hazard identification for vertical transfer of fish disease agents", indicated no evidence of true vertical transmission of viral haemorrhagic septicaemia (VHS) virus. This is in contrast to IHNV where few reports suspected cases of true vertical transmission. For many years eggs were exported from Denmark to UK also from VHS infected farms without any outbreak of the disease in UK. In addition, more than a billion of salmon and rainbow trout eggs have been imported into Chile, and no outbreaks of VHS have been reported, suggesting that VHSV is not or extremely rarely transmitted vertically when the eggs are iodine disinfected. In conclusion, there is no evidence that the virus is truly vertically transmitted."

Cardiomyopathy Syndrome (CMS)

Cardiomyopathy Syndome (CMS) is a problem in Scotland and Norway. According to the Scottish Government: "Affected fish may go off feed and swim sluggishly; developing skin haemorrhage and oedema, raised scales, exophthalmia and ascites. Typical findings at necropsy are fibrinous peritonitis, ascitic fluid, and blood clots on the dorsocranial surface of the liver and surrounding the heart, or within the heart with subsequent cardiac tamponade"

Photo: CMS in Scotland

"Characteristic lesions are found in the atrium myocardium and ventricle spongiosum, and comprise epicarditis, muscular degeneration, proliferation of the endocardial cells with macrophage infiltration and lymphocytes subendocardially and moderate to marked thickening of myofibres with loss of striation within the sarcolemma. Focal necrosis in the hepatic parenchyma may also occur with hyalinization and occasional nuclear enlargement, extending from the outer compact layer of the myocardium moderately deeply into the spongy layer. Within some sections of liver, a mild, fibrosis of the central vein can be observed."

A 'Farmed Fish Health Report 2009' published in 2010 by the Norwegian Veterinary Institute reported that: "Cardiomyopathy syndrome (CMS) is a very serious and economically important disease of farmed salmon, first described in the mid-eighties. The condition is also referred to as "acute cardiac mortality" and "heart rupture". While daily mortalities are in many cases low, accumulated mortalities may reach 2-30%".

Photo: CMS in Norway

A report – "The aetiology and epidemiology of PD, HMSI and CMS in Scotland" - by the Institute of Aquaculture, University of Stirling, published in 2007 admitted that: "More than 20 years have passed since the first outbreaks of Cardiomyopathy Syndrome (CMS) were described (Ferguson *et al.* 1990). We still know little about this disease and the question 'Is it an infectious disease or not?' remains unanswered."

The report stated that:

"The lack of any significant level of disease in the post-smolt salmon suggests that CMS is a non-infectious disease. It has been suggested that CMS may be a production problem, resulting from fish growing too fast resulting in the heart not being able to support such a rapid growth. This opinion is supported by farmers' data showing that CMS affects fast growers, fish with best performances/conversion ratio during the life cycle, which usually have never been affected by any other disease, and is usually observed when the fish are ready for slaughter."

The Norwegian Veterinary Institute reported in 2010: "During 2007, the transmissible nature of CMS was demonstrated in laboratory trials. A viral aetiology is suspected, but this is as yet not confirmed."

Another paper in the journal *Diseases of Aquatic Organisms* in 2009 describes CMS as "an enigmatic syndrome" which "accounts for significant losses through disease in terms of tonnage." The paper stated that: "The first presumptive reports of CMS occurred in the mid-1980s for farmed salmon at coastal aquaculture sites in western Norway but CMS has now been reported to occur in most of the salmon farming areas in Norway."

In Norway, a 'Farmed Fish Health Report 2008' published in 2009 stated that: "A total of 75 sites with varying CMS-associated mortality were registered by the National Veterinary

Institute during 2008. As the disease primarily affects large salmon in the second year of sea culture, the economic losses are often large". CMS cases in Norway in 2010 rose slightly to 76. In Scotland, CMS was reported on salmon farms in 2001, 2004, 2005 and 2006 and 2007 (the latest data available).

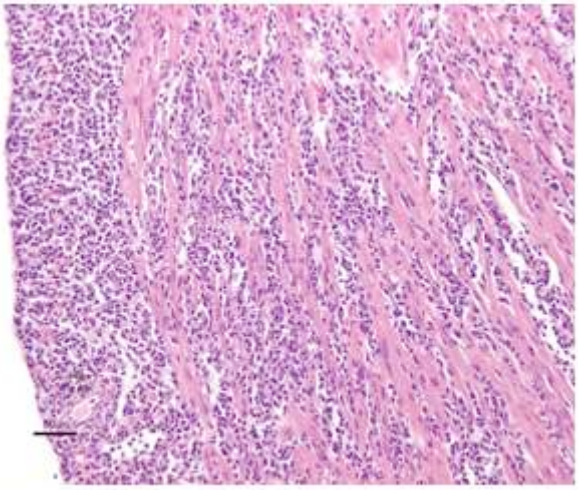
Heart and Skeletal Muscle Inflammation

Heart and Skeletal Muscle Inflammation (HMSI) is a particular problem in Norwegian salmon farming with reported cases increasing from zero in 2003 to 162 in 2007. The latest data available for 2010 reports 143 cases of HMSI in Norway.

	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
ILA (ISA)	13	14	23	21	12	8	16	11	4	7
IPN					174	178	172	208	207	165
PD*	7	10	11	15	14	22	43	45	58	98
HSMB (HMSI)							54	83	94	162
Piscirickettsiose	0	6	0	1	17	5	0	0	1	1
Furunkulose	1	2	6	3	0	2	3	1	3**	5***
BKD	0	3	3	3	1	1	1	2	0	0

Table: Diseases in Norwegian Aquaculture (1998-2007) as reported by the Norwegian Veterinary Institute

Science Daily reported in 2009 that: "A new disease called heart and skeletal muscle inflammation (HSMI) is a serious infectious disease of farmed Atlantic salmon, with a high potential for transmission. The increasing number of outbreaks of this disease in recent years indicates that it poses a significant threat to Norwegian salmon farming. HMSI was discovered in 1999, and has since been found in disease outbreaks at many fish farms along the entire Norwegian coastline."



HSMI: Heart muscle inflammation in Atlantic salmon
Photo: Ruth Torill Kongtorp

Photo: HMSI in Norwegian farmed salmon

Science Daily reported in 2010 that: "Heart and skeletal muscle inflammation (HSMI), an often fatal disease, was first detected in salmon on a farm in Norway in 1999, and has now been reported in 417 fish farms in Norway as well as in the United Kingdom. The disease destroys heart and muscle tissue and kills up to 20 percent of infected fish. Although studies have indicated an infectious basis, recent efforts to identify the pathogen causing the disease have been unsuccessful."

According to Norwegian research, HMSI produces heart changes in nearly 100% of affected fish. Inflammation and cell death spread to the red skeletal muscles, cell death to the liver, and oedema (swelling) and disturbed blood circulation to multiple organs of many fish. HMSI was reported in Scotland in 2005 in a scientific paper – "An outbreak of disease resembling heart and skeletal muscle inflammation in Scottish farmed salmon, *Salmo salar* L., with observations on myocardial regeneration" – published in the Journal of Fish Disease. This was "the first time the condition has been described outside Norway."

Photo: HMSI in Norwegian farmed salmon

A 2010 scientific paper – "Heart and Skeletal Muscle Inflammation of Farmed Salmon Is Associated with Infection with a Novel Reovirus" – published in PloS ONE reported that: "HMSI is associated with infection with piscine reovirus." One of the study's authors, W. Ian Lipkin, MD, the John Snow Professor of Epidemiology and director of the Center for Infection and Immunity at Columbia University's Mailman School of Public Health, told *Science Daily*: "While there is no evidence that this could spread to humans, it is a threat to aquaculture and it has the potential to spread to wild salmon."

Wired Science reported in an article "Salmon Killer Disease Mystery Solved" (July 2010): "Related reoviruses have been found on poultry farms and cause muscle and heart disease in

chickens. “Analogies between commercial poultry production and Atlantic salmon aquaculture may be informative,” wrote the researchers. “Both poultry production and aquaculture confine animals at high density in conditions that are conducive to transmission of infectious agents.”

In 2010 (the latest information available), the Norwegian Veterinary Institute reported that: “The heart disease heart and skeletal muscle inflammation (HSMI) continues to represent a large problem for the aquaculture industry.”

Plasmacytoid Leukemia (Marine Anemia)

Plasmacytoid leukemia or marine anemia has affected farmed salmon in British Columbia since the 1980s. It is also referred to as Salmon Leukemia Virus – a so-called ‘retrovirus’.

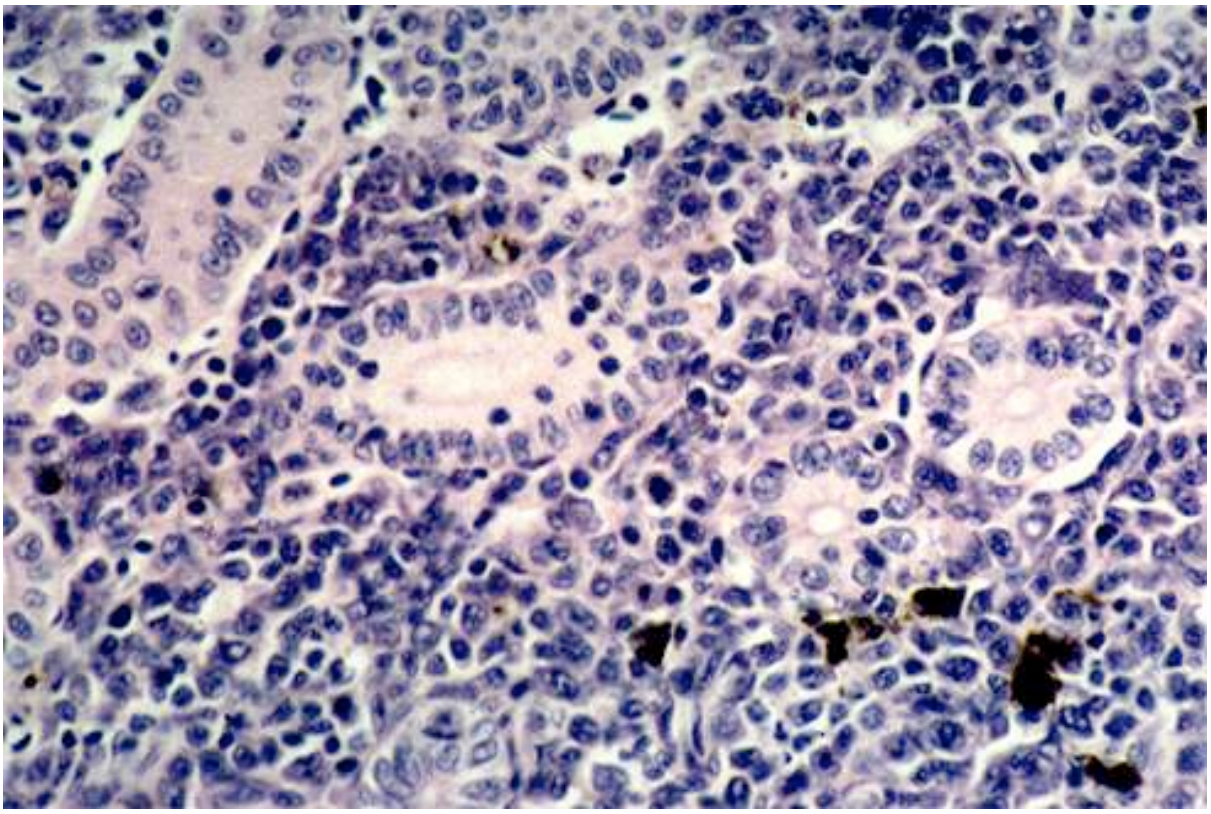


Photo: Plasmacytoid leukaemia in chinook salmon

A scientific paper – “Descriptive epidemiology of marine anemia in seapen-reared salmon in southern British Columbia” - published in 1996 in the *Canadian Veterinary Journal* reported that: “Marine anemia, also known as plasmacytoid leukemia, is a recently described disease of farmed Pacific salmon in British Columbia..... The results showed marine anemia to be widely distributed throughout the major salmon farming regions in British Columbia”.

Another paper – “A retrovirus in chinook salmon (Oncorhynchus tshawytscha) with plasmacytoid leukemia and evidence for the etiology of the disease” – published in the journal *Cancer Research* in 1992 reported: “A plasmacytoid leukemia (PL) has caused mortalities in chinook salmon (Oncorhynchus tshawytscha) reared in seawater netpens in western British Columbia, Canada, since 1988.... The evidence in this study shows the

presence of a retrovirus in chinook salmon with PL and further suggests a retroviral etiology of the disease. We are tentatively calling this virus salmon leukemia virus."

A 'Fish Health Report' for 2006 from the Ministry of Agriculture and Lands in B.C. described Marine Anaemia as: "An endemic disease of farmed Pacific salmon characterized by marked gill pallor, renosplenomegaly, ascites and exophthalmia. The cause of this disease is uncertain but it is thought to be associated with a retroviral infection. Marked hemoblast proliferation is the histopathological hallmark of the disease. Atlantic salmon are unaffected by marine anaemia."

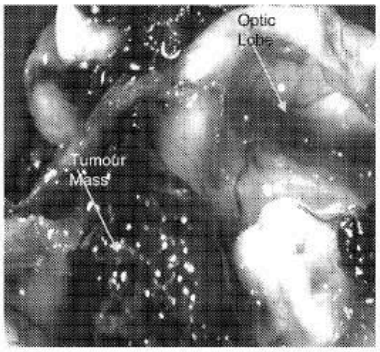
The salmon farming industry in British Columbia argue that salmon leukemia is not a problem currently: "Salmon leukemia is not "known to plague salmon fish farms," wrote Mainstream Canada's Grant Warkentin in May 2011 in reply to an article in *Scientific American*. "The last time any farms in B.C. had a problem with salmon leukemia, also known as marine anemia or plasmacytoid leukemia, was nearly 20 years ago when B.C. salmon farms farmed almost exclusively Chinook salmon. The disease is of particular concern for Chinook salmon. Since then most farms have switched to farm mostly Atlantic salmon, and all are continually improving farming practices. Since the early 1990s the disease has not been a problem for B.C. salmon farms which farm Atlantic as well as Chinook salmon..... farms test regularly for marine anemia and have reported to the province if any cases have been found. From 2003-2009, only three cases were found."

The issue of salmon leukemia made headlines in Canada during 2011 following the publication of a paper – "Genomic Signatures Predict Migration and Spawning Failure in Wild Canadian Salmon" – in *Science* in January by Dr. Kristi Miller. According to the study, ocean-tagged salmon that had the gene signature associated with the viral infection (a leukemia-type virus) were 13.5 times more likely to die before spawning. Scientists thought that the salmon became infected at sea, before making their runs upriver and likened it to "dead fish swimming". Pre-spawn mortality may be killing up to 95% of some Fraser sockeye stocks.

Dr. Miller is scheduled to testify to the Cohen Commission in British Columbia on August 24.

In March at the Cohen Commission evidentiary hearing in Vancouver, a presentation by Dr. Miller was made publicly available.

Epidemic of a novel, cancer-causing viral disease may be associated with wild salmon declines in BC



Kristi Miller
Molecular Genetics Lab
Karia Kaukinen, Shaorong Li, Tobi Ming, Norma Ginther, Angela Schulze

David Patterson, Jayme Hillis, and others….

- Genomic Evidence
- Tumour Evidence
- Adults
- Smolts
- Sockeye, Coho and Chinook salmon

Sept 27, 2008

CAN185457_0001

Photo: Presentation by Dr. Kristi Miller

However, Dr. Miller was "muzzled" and not permitted to speak to the media. The Globe & Mail reported in March in an article – "Researcher suggests 'salmon leukemia' is to blame for decline of Fraser sockeye" - that: "Of all the theories heard so far by the Cohen Commission, the most intriguing involves new research by a molecular scientist who is pointing to the possibility of an epidemic of salmon leukemia. Kristi Miller hasn't been called to testify on her research yet, but her work is already causing a buzz at the inquiry, in part because it seems an effort has been made to keep it under wraps."

In July, *Postmedia News* reported that: "Top bureaucrats in Ottawa have muzzled a leading fisheries scientist whose discovery could help explain why salmon stocks have been crashing off Canada's West Coast."

In August, *The Common Sense Canadian* reported: "Dr. Miller was barred from speaking to the media about her findings by the Privy Council, which supports the Prime Minister's Office. This isn't surprising when you view a powerpoint of hers released already as an exhibit by the Cohen Inquiry on March 17, which suggests Salmon Leukemia is causing brain tumors in our sockeye and relates the virus to salmon farms. To what extent this disease is related to salmon farms on BC's coast and/or collapsing Fraser River sockeye stocks remains to be seen, but Dr. Miller will finally have her chance to answer questions when she's on the stand and under oath during the Cohen Commission's "Diseases" hearing on August 24. This will be one of the big questions to be answered at the Judicial Inquiry: "To what extent is Salmon Leukemia affecting Fraser River salmon stocks?"

Another witness at the Cohen Commission will be Dr, Craig Stephen who will be testifying during the 'Diseases' evidentiary hearing on August 22 and 23. His report – "A Field Investigation of Marine Anemia in Farmed Salmon in British Columbia" – published in 1995 stated:

"The potential for epidemics of infectious cancer in Pacific salmon populations raised the interest of scientists and the public. In December 1991, marine anemia became the subject of mass media attention. Concerns over public health and food safety, coupled with a perceived threat to wild salmon stocks, emphasized the need to understand the nature of marine anemia and to develop management strategies for the disease."

Dr. Stephen is currently studying whether salmon from public hatcheries are potentially spreading disease to sockeye salmon in B.C.'s Fraser River, contributing to their decline.

Bacterial Kidney Disease (BKD)

Photo: Bacterial Kidney Disease

Bacterial Kidney Disease (BKD) is caused by Renibacterium salmoninarum. BKD has caused problems in Norway, Scotland, Canada and Japan. The first appearance of BKD in Japan was reported from Hokkaido in 1973, and it "spread rapidly among Japanese salmonid fish farms". The OIE's 'disease card' on BKD reports that BKD:

"Occurs in feral and farmed populations of salmonids in almost all areas where they are naturally distributed or have been acclimatised. No conclusive evidence has been reported for the presence of *R. salmoninarum* in the salmonid population of Australia, New Zealand, Russia, or some Mediterranean, countries."

In British Columbia, 'Renibacterium salmoninarum Infection' has been reported every year on salmon farms since 2003 (when data was available via the BCSFA 'Fish Health Database'). A 'Fish Health Report' for 2006 from the Ministry of Agriculture and Lands in B.C. detailed Bacterial Kidney Disease at several salmon farms and described BKD as: "A chronic granulomatous disease; the causative agent is *Renibacterium salmoninarum*. BKD is diagnosed in an Atlantic salmon population when the population is undergoing treatment for the disease or if the fish sampled show gross clinical signs of the disease and population level mortalities. BKD is almost always found in Pacific Salmon Populations at some level. A Pacific salmon farm is diagnosed as positive for BKD if the farm is under treatment for the

disease or the fish sampled have gross clinical signs of BKD, histopathological lesions of BKD and the farm is experiencing population level losses to the disease."

BKD has caused problems in B.C. since the 1990s. A scientific paper published in the *Diseases of Aquatic Organisms* in 1996 stated that: "BKD causes mortality in salmonids reared in fresh water and in seawater, resulting in a significant economic loss to the salmon farming industry in British Columbia (B.C.), Canada."

BKD is an ongoing problem in Eastern Canada. According to data obtained in August from the Ministry of Agriculture, Aquaculture and Fisheries in New Brunswick, reported cases of BKD increased from zero in 2007 to 17 in 2008, 22 in 2009 and 15 in 2010 (with 13 cases already in 2011 – data available to May).

In Norway, there were three cases of BKD reported in 2000 but none in 2007 (according to data from the Norwegian Veterinary Institute). BKD continues to cause problems in Scotland since first being reported in 1976 on a raindow trout farm – with reported cases rising to 37 in 1985 and a case being reported in 2006. According to the Scottish Government, the causative agent of BKD is a small, non-motile, Gram positive rod shaped bacterium Renibacterium salmoninarum that usually occurs in pairs referred to as diplobacilli.

Photo: http://www.thefishsite.com/diseaseinfo/2/bacterial-kidney-disease-bkd

The gross external pathology of BKD is variable and ranges from a complete lack of clinical signs to fish exhibiting protruding eyes (exophthalmia), darkening of the skin and haemorrhage at the base of the fins. The gills may appear pale and anaemic and internally there may be fluid accumulation in the abdominal cavity and enlargement of the kidney.

The spread of BKD via infected eggs – so-called 'vertical transmission' – is proven beyond doubt. A report – "Fish Egg Trade: Pathogen survival outside the host, and susceptibility to disinfection" – published in 2005 by the European Commission stated: "Vertical transmission of Renibacterium salmoninarum was no longer a matter of discussion. All sources of information, field observations, experimental approaches, direct microscopy and, as a practical confirmation, the striking results obtained after control and managing provisions had been introduced are clearly indicative of in ovo contamination of fry, and let little doubt about the reality of intra-ovum infection."

Myxobacterial Infection (Piscine Tuberculosis)

Myxobacterial Infection can give rise to a form of 'piscine Tuberculosis' and is a disease which can be passed onto humans. Mycobacterium marinus can cause 'fish-tank granuloma' in aquaria or 'swimming pool granuloma'. The risks are all too real. In June, it was reported that a teenage girl was facing a hand amputation after a scratch in a fish tank became infected. In another case in reported in 2008, a 48-year old man with an aquarium developed Mycobacterium marinum infection.

Photo: Mycobacterium marinum Infection

According to Aquarium.Net: "it is VERY IMPORTANT for the Hobbyist to be aware, that this is one of the few forms of fish disease, that is communicable to humans. This transmission, when it takes place, usually manifests itself with large melanomas on the arms of the fish-keeper. They can spread, and are very difficult if not impossible to eradicate. Any Hobbyist suspecting therefore that they may have encountered this disease, is strongly advised to were surgical type gloves, when handling any fish, to sterilize all nets & other items that may come in contact with the fish, and notwithstanding all these precautions, to "scrub up" after handling them. These melanomas usually take some 3-4 weeks after exposure before manifesting themselves, so it is essential that the Hobbyist be aware of the danger, and take precautions, as the writer is aware of a few cases, in which the unfortunate Hobbyist has got these disfigurements for life."

Myxobacterial infection has been reported in farmed salmon in Canada and the United States. The BCSFA 'Fish Health Database' reported 'Mycobacterium marinus Infection' in 2005 and 'Myxobacterial Infection' every year between 2003 and 2010. A scientific paper – "An outbreak of myxobacterial disease in coho salmon (Oncorhynchus kisutch) reared in a Maine estuary" – published in 1976 reported that:

Photo: Miliary lesions (abscesses) on internal organs due to Mycobacterium fortuitum in adult chinook salmon

"An epizootic of a myxobacterial infection in coho salmon (Oncorhynchus kisutch) was responsible for the death of 50,000 fish, 30% of the population. Cartiage in the nose, mouth and lower jaw was eroded, and yellow sheets of bacterial growth were observed in the mouth, pharynx and pneumatic duct. The severity of the disease increased with increasing water temperature. Pathogenicity trials were inconclusive; only two of 18 experimentally infected fish succumbed to the disease. However, the lesions, and the absence of other known pathogens suggests the myxobacterium was responsible."

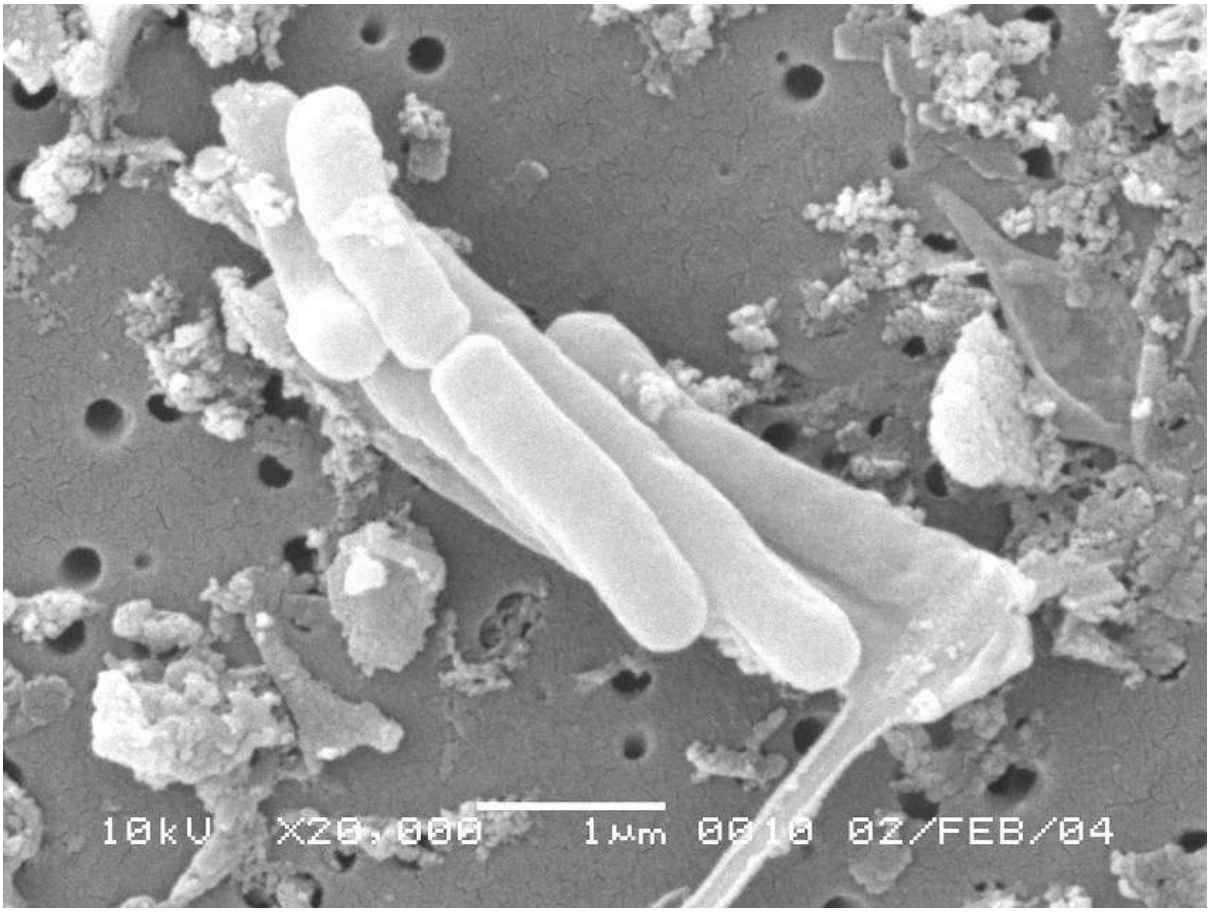


Photo: Mycobacterium marinus

Spironucleosis (Spironucleus salmonicida)

Spironculeus salmonicida is a parasite which quite literally leaves a bad smell. *Science Daily* reported in an article – "New Fish Parasite Species Described" - published in 2008: "Single-celled parasites of the genus Spironucleus are known to produce serious illness in farmed and aquarium fish. In farmed salmon, these parasites create foul-smelling, puss-filled abscesses in muscles and internal organs."

Photo: Abscesses in the kidney of farmed salmon caused by Spironucleus Salmonicida

According to the Norwegian Veterinary Institute's 'Farmed Fish Health Report 2008': "This single celled parasitic flagellate, *Spironucleus salmonicida* (previously *S. barkhanus*), can cause systemic spironucleosis in famed salmonids. This parasite was diagnosed in one farmed salmon site in Finnmark in 2008, and infected fish appear to be limited to a single smolt producer.....*S. salmonicida* may have an extensive range, which is supported by previous outbreaks in both Norway and Canada."

According to Professor Patrick Woo at the University of Guelph in Canada: "Systemic spironucleosis is caused by *Spironucleus* - the parasite is in the blood and internal organs of salmonids. The parasite causes morbidity and mortality in fishes and there have been outbreaks of the disease in salmon cultured in sea cages - in chinook salmon on the west coast of Canada and in Atlantic salmon in Norway. Fish mortality was high and some infected chinook salmon had abdominal distensions and were anemic while infected Atlantic salmon were significantly smaller than healthy fish and they behaved 'abnormally' prior to death. Little is known about the biology of the pathogen nor factors that precipitated the outbreaks, and there are at present no preventive nor control strategies against the parasite and the disease".

Francisella (Francisellosis)

According to Patogen: "Francisellosis primarily affects cod (*Gadus morhua* L.), but is also known in tilapia farming and in smolt in Chile." Francisella was identified in farmed Atlantic salmon in Chile in 2007.

Photo: Atlantic salmon (Salmo salar) francicellosis, gross pathology (Marcus Godoy)

A scientific paper – "Francisella infections in farmed and wild aquatic organisms"- published in 2011 in *Veterinary Research* reported that:

"Over the last 10 years or so, infections caused by bacteria belonging to a particular branch of the genus Francisella have become increasingly recognised in farmed fish and molluscs worldwide..... A number of fish species are affected including Atlantic cod, Gadus morhua; tilapia, Oreochromis sp.; Atlantic salmon, Salmo salar; hybrid striped bass, Morone chrysops × M. saxatilis and three-lined grunt, Parapristipoma trilinineatum. The disease is highly infectious and often prevalent in affected stocks."

A scientific paper – "Francisella species causing mortality in Norwegian cod farming" – published in April 2006 in *Archives of Microbiology*, stated that: "*Francisella* species constitutes a future threat, not only to cod production in Norway, but to all fish farming in the marine environment including salmonids."

Yersinia ruckeri (Yersiniosis/Enteric Redmouth/ERM)

The Black Death or bubonic plague was caused by the bacteria *Yersinia pestis*. In aquaculture, it is the bacterial pathogen *Yersinia ruckeri* which causes Yersinosis or Enteric Redmouth Disease (ERM). While the first instances of the disease were reported in Rainbow trout (*Oncorhynchus mykiss*) in the USA in the 1950s, it has also become "a very significant pathogen of farmed salmon" and causes "significant economic losses in salmonid aquaculture worldwide".

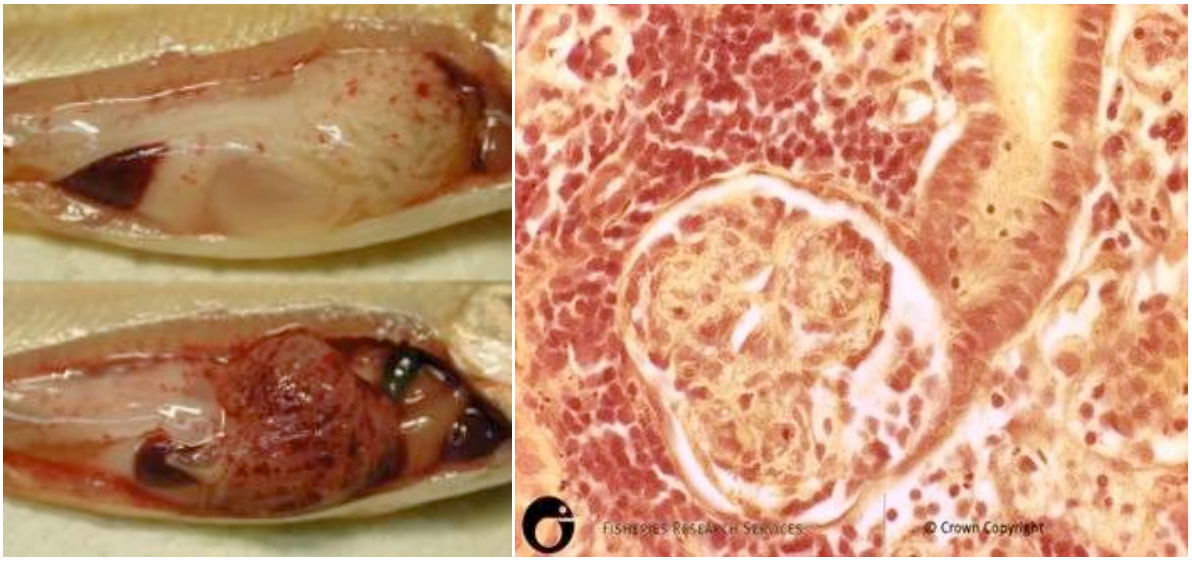


Photo: Yersinosis or Enteric Redmouth Disease

In 2009, scientists in Australia reported that: "The number of countries in which *Yersinia ruckeri* has been isolated is increasing". Y*ersinia ruckeri* was recorded in fish in Australia, Bulgaria, Canada, Chile, Denmark, Finland, France, Germany, Greece, Iran, Italy, New Zealand, Norway, South Africa, Portugal, Spain, Sweden, Switzerland, Turkey, United Kingdom, United States of America and Venezuela. Infection with *Yersinia ruckeri* results in a bacterial septicaemia without disease specific signs but is most commonly detected due to exophthalmos and blood spots in the eye. The severity of the disease is dependant upon the biotype of the bacterium involved. Acute infections in trout with the 'Hagerman' strain are usually florid and the disease is referred to as enteric red mouth. A milder form of the disease occurring in Atlanitic salmon is termed Yersiniosis.

A 'Farmed Fish Health Report 2008' published by the Norwegian Veterinary Institute in 2009 reported that: "Yersiniosis is caused by infection with the bacterium *Yersinia ruckeri* and may result in increased mortality during the whole juvenile phase of culture. Infected fish transferred to sea may also suffer losses after sea transfer. In 2008, yersiniosis was detected in 16 sites, which constitutes an increase from the 7 sites affected in 2007".

In Canada, 'Yersinia ruckeri Infection' was also reported in 2003, 2006, and 2007 by the BCFSA via the 'Fish Health Database'. According to data obtained in August from the Ministry of Agriculture, Aquaculture and Fisheries in New Brunswick, there was one case of 'Enteric Redmouth' in both 2009 and 2010.

Marine yersiniosis (Yersinia rucheri: non-Haggerman strain) was reported on Australian salmon farms from 2004 to 2007. The Government reported: "Results in clinical expression of yersiniosis post transfer to marine sites. Level of subclinical carriage in stock within hatcheries affects level of disease expression post-transfer. Occasional problem requiring treatment with chlortetracycline or trimethoprim."

According to the Centre for Environment, Fisheries & Aquaculture Science (CEFAS) in the UK: "Of particular concern are new and emerging diseases. Emerging diseases can include established pathogens that can change their host range or develop resistance to available treatments. One such example is *Yersinia ruckeri*, causative agent of Enteric Redmouth

(ERM) in rainbow trout (*Oncoryhnchus mykiss*). The disease is also causing increased problems in Atlantic salmon (*Salmo salar* L.)."

Flavobacterium psychrophilum (Bacterial Cold Water Disease/Rainbow Trout Fry Syndrome)

According to a report published in 2010 by the Norwegian Veterinary Institute: "Flavobacterium psychrophilum causes large losses in aquaculture throughout the world. The bacterium is associated with ulcers, fin-rot and systemic infection in several species of fish."

Photo: Flavobacterium in rainbow trout

A 'Farmed Fish Health Report 2008' published by the Norwegian Veterinary Institute in 2009 reported that: "There was a dramatic increase in the number of outbreaks of systemic infection with *Flavobacterium psychrophilum* in rainbow trout in 2008. Previously in Norway, this bacterium has been mainly linked with surface complaints such as ulceration and fin rot. A total of 10 hatcheries/juvenile production sites were affected in 2008, for the most part in Hordaland and Sogn and Fjordane.... Towards the end of the year, an outbreak of disease associated with *F. psychrophilum* was diagnosed in salmon in a juvenile production facility. The fish appeared apathetic and displayed extensive haemorrhage in the musculature. Bacteria were detected in both the affected musculature and inner organs."

Photo: Deep ulcerative lesion of the caudal peduncle provoked by *Flaviobacterium psychrophilum* in a rainbow trout (Skin and muscle tissues have been destroyed, exposing the spinal cord. In the course of 'cold-water disease' of adult salmonid fish, such necrotic lesions typically occur around the adipose ('peduncle disease') or dorsal ('saddleback disease') fins, on the gills and on the flank. Scale is in centimeters).

According to the Norwegian Veterinary Institute: "Systemic infection with *F. Psychrophilum* is referred to as bacterial cold water disease (BCWD) in large fish or rainbow trout fry syndrome (RTFS) in juvenile rainbow trout..... Until the mid-eighties BCWD had only been reported in salmonids in North America. By the end of the eighties it had been diagnosed in rainbow trout in Germany, France and Japan. Since then the disease has been reported from all areas of the world in which culture of salmonid fish is practised. The bacterium has also been detected in several other types of fish. Clinically, *F. psychrophilum* infections in rainbow trout are often associated with spiral swimming, morbidity and reduced appetite. Juveniles may display a short "cramp" phase prior to death. In larger fish, skin infection and fin rot appear more common. Fish often display a distended abdomen, and may appear dark, later changing to a paler colour due to anaemia and/or oedema. A large blood filled, possibly semi-liquefied spleen is often characteristic."

In 2010 (the latest information available), the Norwegian Veterinary Institute reported that: "Flavobacterium psychrophilum continues to cause problems."

The spread of Flavobacterium psychrophilum via infected eggs – so-called 'vertical transmission' – is viewed as "very likely". A report – "Fish Egg Trade: Pathogen survival outside the host, and susceptibility to disinfection" – published in 2005 by the European Commission stated: "Vertical transmission of Flavobacterium psychrophilum is generally accepted as a very likely mode of contamination."

Vibriosis (Cold Water Vibriosis/Hitra Disease)

Vibriosis is a bacterial disease of salt-water and migratory fish caused by the bacterium *Vibrio anguillarum*. Affecting primarily salt and brackish water environments although found in fresh water as well, the disease has been recorded in nearly all farmed fish. The disease causes significant losses in cultured Pacific salmon and Atlantic salmon. Vibriosis has been reported in Chinook farmed salmon in British Columbia causing mortalities of 8%.

Photo: Fish exhibiting infection with vibriosis. Note the frayed tail fins and red abdomen caused by hemorrhaging from the bacterial infection. Both are signs of Vibrio infection.

According to Oregon State University: "One of the most important types of vibriosis bacteria of concern to salmon farming in British Columbia is *Listonella (Vibrio) anguillarum*; a key method of transmission from this pathogen is through the feces of infected fish. The accumulation and dispersal of salmon farm sewage is, therefore, of concern with respect to possible transmission of the disease to wild fish."

Vibrio salmonicida, known as a cold water vibriosis, affects Atlantic salmon (*Salmo salar*). In Norway, it is known at 'Hitra disease'. The pathogen is characterized as a facultative anaerobic, motile rod. Characteristics of this disease, also known as hemorrhagic syndrome, are anemia and hemorrhages with a generalized septicemia, presenting large amounts of bacterial cells in the blood of sick or recently dead fish.

A report by the European Union in 2007 stated that: "The so-called Hitra disease first appeared in 1977 and occurred for the first time on a large scale in 1979 in fish farms on the island of Hitra in central Norway. Since then the disease has spread along the coast of Norway, in Scotland (Bruno et al. 1986), the Faeroe Islands, Canada (referred in Actis et al. 1999) and Iceland (unpublished data from the Fish Disease Laboratory (FDL) at the Institute for Experimental Pathology at Keldur, University of Iceland). However, the mechanisms of how the disease was spread were not investigated, any potential interactions between farmed and wild populations of fish not known."

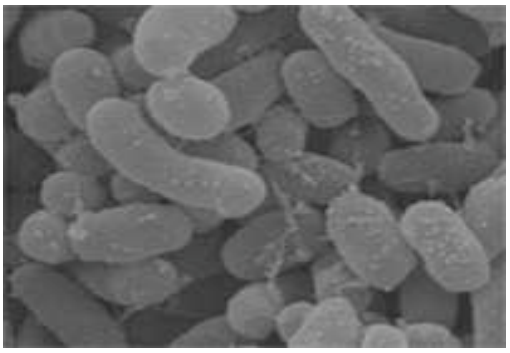
In 2010 (the latest information available), the Norwegian Veterinary Institute reported that: "Vibriosis, caused by Vibrio anguillarum serotype O1 was registered in unvaccinated salmon juveniles following intake of sea water in a freshwater hatchery and in a further eight sea water rainbow trout farms."

In Canada, 'Vibrio (Listonella) angullarum Infection' was reported in 2003, 2004, 2008, 2009 and 2010 via the BCSFA 'Fish Health Database'. In Scotland, 'Vibrio salmonicida' was reported in 2002 and 'Vibrio anguillarum' in 2003. 'Vibrio Species' were reported in 2006 and 2007 (the latest data publicly available). In 1998, Vibrio viscosus was reported in Scottish farmed salmon for the first time. Internally prominent dark-brown petechiae or ecchymotic haemorrhage was observed. Splenomegaly was associated with congestion and widespread necrosis.

A report by the European Union in 2007 stated that: "Vibriosis results from systemic infections caused by *Listonella* (*Vibrio*) *anguillarum* and notably *Vibrio salmonicida* and caused major problems to the Atlantic salmon industry during the 1980s (Bruno et al. 1986; Egidius 1987). *Vibrio salmonicida,* isolated from salmon and described as a species by Egidius et al. (1986) caused a major epizootic culminating in 1987, associated with the use of approximately 50 tonnes of antibacterial agents in salmon aquaculture that year."

Moritella Vicosa (Winter Ulcer)

Moritella viscosa is considered the main aetiological agent of 'winter ulcer' disease in farmed salmonid fish and is a problem in Norway and Scotland – and has also been reported in farmed Atlantic salmon from the Faroe Islands and Canada. 'Winter ulcer' or 'cold-water ulcer' has been reported on salmon farms "since the early 1980s" and "causes great losses in the farming industry".



Photos: Atlantic salmon suffering from Winter ulcer; Bacterial cells

The disease is initially characterised by localised swelling of the skin followed by development of lesions and primarily affects salmonid fish in sea water during cold periods. Ulceration of surfaces exposed to *Moritella viscosa* in parallel with occurrence of septicaemia suggests that both skin and gills may act as possible initiation sites for *Moritella viscosa* infections. Research in Norway reports that the disease can be acute, with a high level of mortality, or it can demonstrate more chronic characteristics with wounds covering large parts of the skin of the fish. If an individual fish survives the outbreak, it develops scars and is given a poor quality assessment when sent to the market.

According to a report by the European Union in 2007: "In Norway, the disease has been associated with use of seawater in smolt production, and is considered to be a major animal welfare problem. Pathogenesis of winter ulcer is related to development of lateral skin lesions, and affected fish are usually easy to recognize. The size of the lesions might range from barely visible to large, confluent lesions covering the body surface, with degenerative changes in underlying muscle. Changes may also occur in gill pallor and fin rot. The disease

is also characterized by diffuse or petechial haemorrhages in the liver, pyloric ceaca and perivisceral fat, necrosis in the spleen and kidney."

According to a 2009 report – "Norwegian Researcher Sheds Light on Winter Ulcer" – published by *The Fish Site*:

"For fish farming in Norway, the disease annually causes a financial loss of approximately NOK 100 million. In addition to this loss, there is the ethical problem of fish suffering from large ulcers after an outbreak. A vaccine against the disease exists, but until recently has not been optimal. Enhanced knowledge of the bacterium, *Moritella viscosa*, which causes the disease can reduce the financial loss in the farming industry and save the fish from suffering."

The *Journal of Fish Diseases* reported in 2011 that "Knowledge of its pathogenicity is limited". A scientific report also published in 2011 stated that: "The disease has had significant economic effects on the salmon aquaculture industry in the North Atlantic, and continues to cause problems despite the availability of commercial vaccines."

A 'Farmed Fish Health Report 2008' published by the Norwegian Veterinary Institute in 2009 reported that: "The bacterium *Moritella viscosa* is considered an important causal agent in development of winter-ulcer, although other bacteria may also be isolated from such cases. The total aetiology of winter-ulcer is therefore not completely clear and much research continues into this disease.... The National Veterinary Institute has registered isolation of *M. viscosa* from a total of 51 sites in 2008, 44 salmon and 7 rainbow trout."

Moritella viscosa was reported for the first time on Scottish salmon farms in 1997 and throughout the period 1998 to 2005 and again in 2006 and 2007 (data since 2007 is unavailable).

Hemorrhagic smolt syndrome (HSS)

A 'Farmed Fish Health Report 2008' published by the Norwegian Veterinary Institute in 2009 reported that: "Hemorrhagic smolt syndrome (HSS), also called hemorrhagic diathesis (HD), results in mortality in large, good quality smolts during the freshwater phase..... Histopathologically, extensive haemorrhage in several organs and blood in kidney tubules may be observed. Quantification of losses attributable to HSS is difficult as this disease is not commonly reported. From interviews with fish health services, it is clear that this disease causes limited but noticeable losses in many juvenile production sites. The cause(s) of the disease are unknown, but is/are clearly associated with the smoltification process and affects particularly the largest and best fish. Mortality declines and disappears following sea transfer. Macroscopically, the disease (as with VHS) results in serious circulatory disturbances."

HSS was reported in Scotland in 2006.

Mad Fish Disease

A scientific paper – "Bovine Spongiform Encephalopathy and Aquaculture" – published in 2009 in the *Journal of Alzheimer's Disease* stated that: "We are concerned that consumption of farmed fish may provide a means of transmission of infectious prions from cows with bovine spongiform encephalopathy to humans, causing variant Creutzfeldt Jakob disease."

Photo: Mad Fish Disease?

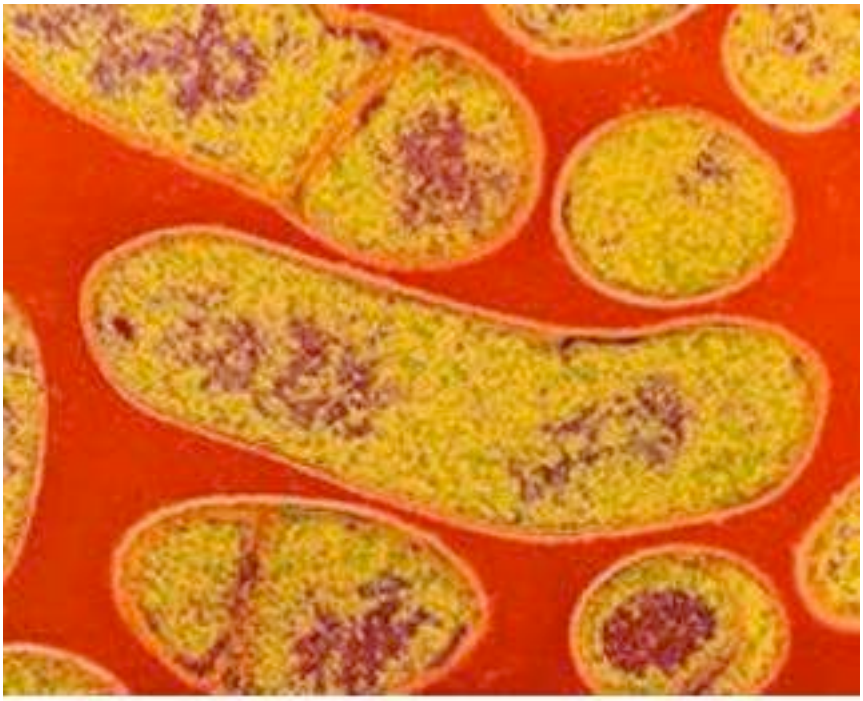
The paper, authored by scientists at the Department of Neurology, University of Louisville School of Medicine and Departments of Pathology and Neuroscience, Case Western Reserve University School of Medicine pointed out that: "Prion protein (PrP) homologies have been demonstrated in zebrafish, salmon, pufferfish, trout, and other fish species." It stated that:

"Thus, there are two underlying concerns: first, farmed fish eating material from a BSE infected cow may undergo pathological transformation of the endogenous fish prion and subsequently transmit the agent to people. Secondly, a farmed fish eating material from a BSE-infected cow may act as a vehicle to transmit the agent to people without involvement of the fish prion, because the infectious agent of prion diseases is extraordinarily stable and resistant to inactivation by heat, chemical agents, or time."

It concluded that: "Enhanced safeguards need to be put in place to protect the public from possible transmission of BSE through fish farming or other possibly hazardous practices."

http://www.tgdaily.com/general-sciences-features/42888-beware-of-catching-mad-fish-disease-say-scientists

Botulism (Clostridium botulinum)



Clostridium botulinum

Photo: Clostridium botulinum

In July 2003, the US Food and Drug Administration recalled 170 cases of smoked farmed Atlantic salmon and issued the following "Recall" notice:

"Pesquera Trans Antarctic Ltda. of Puerto Montt, Chile is recalling its Robinson Crusoe Canned Smoked Atlantic Salmon because it has the potential to be contaminated with Clostridium botulinum, a bacterium that can cause life-threatening illness or death. Botulism, a potentially fatal form of food poisoning, can cause the following symptoms: general weakness, dizziness, double-vision and trouble with speaking or swallowing. Difficulty in breathing, weakness of other muscles, abdominal distention and constipation may also be common symptoms. People experiencing these problems should seek immediate medical attention. The canned smoked Atlantic salmon was distributed in Miami, Florida and San Juan, Puerto Rico by local distributors through retail outlets".

Ecoceanos News reported: "This episode raises questions about the current government health and safety controls and the production methods of this industry. It alters consumers and public opinion to the current health and environmental standards of the Chilean salmon industry". The botulism bacterium is "the most poisonous substance known," said Dr Stephan Arnon, director of the 'Infant Botulism Prevention Program' at the Department of Health in California.

In August 2003, the FDA sent a warning letter to Marine Harvest in Chile including:

"Your firm's HACCP plan for frozen, vacuum-packed, brine injected salmon portions does not list the food safety hazard of Clostridium botulinum. Although you are brining and freezing the vacuum packed fish that you process, your labels do not provide sufficient handling instructions. In addition to thawing under refrigeration, you should inform the consumer that it is important to open the individual vacuum packs immediately upon thawing. If you correctly label your retail packages, the hazard of Clostridium botulinum will

not be considered reasonably likely to occur and would not need to be addressed in your HACCP plan. If the labeling for your packages is not corrected, you must control the hazard of Clostridium botulinum. For additional information regarding control strategies for Clostridium botulinum growth and toxin formation, please refer to the Fish and Fishery Products Hazards and Controls Guidance: Third Edition, Chapter 13 (Clostridium botulinum Toxin Formation), found at www.cfsan.fda.gov/`comm/haccp4.html".

Botulism has been a problem for decades. In 1982 *The New York Times* reported that "A 27-year-old Belgian, Eric Mathay, died of botulism on Feb. 7 after eating a pate made by his wife from a can of salmon imported from the United States." In another case, a 68-year old woman was left "almost completely paralyzed" after eating canned salmon. The incidents led to the FDA initiating eight separate recalls in the United States involving 55 million cans of salmon.

Parasitic Meningitis

A 'Fish Health Report 2009' published by the Ministry of Agriculture and Lands in B.C. reported that: "Two microscopic parasites have appeared sporadically in the brains of a limited number of Atlantic salmon carcasses since 2007, and these micro-parasites continue to be of scientific interest....There is no evidence that these parasites are moving beyond the brain vault of their Atlantic salmon host. In 2009, BCMAL's routine histological assessments revealed eighteen Atlantic salmon carcasses, over four coastal sub-zones, afflicted by the brain parasite." These cases were all listed as 'Parasitic meningitis'.

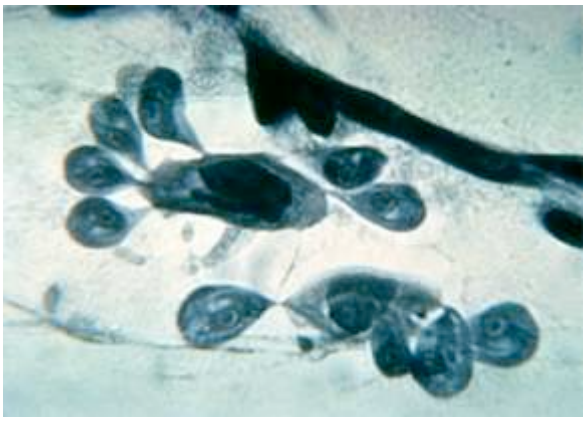
Costia (Ichthyobodo species)

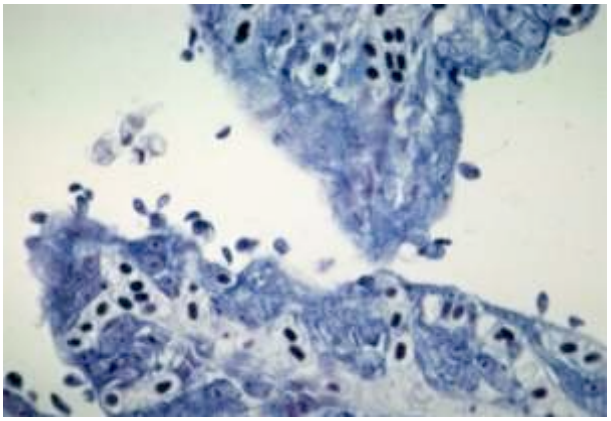
In the aquarium trade, Costiasis or Costia is known as a freshwater ciliated protozoa parasite species called *Ichthyobodo necatrix* or *Ichtyobodo pyriformis*. These are stalked or Flagella (hairs) protozoa which attach to the skin or gills of fish to feed and can swim and attach to other fish and then reproduce to infect other fish.

According to the European Union: "*Ichthyobodo* spp. are ectoparasitic flagellates infecting fish, tadpoles and some invertebrates. *Ichthyobodo* spp. occur as a biflagellate free swimming form and an attached parasitic stage. The latter is secured to a host cell through an attachment disc, which contain a protruding cytostome that extends into the host-cell when feeding. The flagellates reproduce by binary fission."

A scientific paper – "Disease interaction and pathogens exchange between wild and farmed fish populations with special reference to Norway" – published in the journal *Aquaculture* in May 2011 reported that: "The euglenozoan flagellate *Ichthyobodo necator* is reported to infect fish worldwide and causes massive losses to aquaculture. Evidence suggests that *Ichthyobodo* is a species complex with several species preferring different hosts (Callahan et al., 2005). *Ichthyobodo* spp. are reported from salmonids, cod and halibut (Isaksen et al., 2007; Karlsbakk et al., 2009; Rintamaki Kinnunen and Valtonen, 1997) and pose a major threat to both wild and farmed fish populations. The parasite is found on the skin of juvenile salmon in freshwater, and if left untreated can lead to mass mortalities (Poppe, 1999; Rintamaki Kinnunen and Valtonen, 1997). Salmon in sea cages usually show infection of *I. necator* on the gills where the parasite is attached to the secondary lamellae (Poppe, 1999)."

According to the Norwegian Veterinary Institute's 'Farmed Fish Health Report 2008': "Both fish gills and fish skin can be infested by this group of parasites, both in fresh- and seawater. There are several different species of costia, inhabiting different species of fish. If the parasite is found to cause problems in freshwater, formalin treatment of the fish can be carried out effectively. However, treatment of fish in seawater meets practical problems."





Photos: Ichthyobodo necator attached to loose epidermal cells of a fingerling rainbow trout, Oncorhynchus mykiss; Ichthyobodo (Costia) necator attached to the gill lamellae of a yearling sockeye salmon, Oncorhynchus nerka.

In Canada, 'Costia Infection' was reported in 2003, 2004 and 2006 via the BCSFA 'Fish Health Database'.

In Scotland, 'Ichthyobodo species' was reported on salmon farms in 2006.

A report by the European Union in 2007 stated: "Massive infections with *Ichthyobodo. necator* (*sensu lato*) are associated with extensive epidermal hyperplasia, necrosis and goblet cell exhaustion. The epithelium looses its integrity leading to inflow of water, oedema and eventually sloughing of hyperplastic epithelium (Robertson 1985). Mortalities from severe skin infections are attributed to osmoregulatory breakdown. Gill infections may be associated with extensive hyperplasia and increased mucus secretion, mortalities are likely due to asphyxiation.... Epizootics due to *Ichthyobodo* infections are generally a problem in juvenile fish and are only known in aquaculture, especially among salmonids in freshwater. *Ichthyobodo necator* (*sensu stricto*) infections in farmed salmonids tend to occur at first feeding (winter/spring) and during autumn."

Tapeworm (Diphyllobothriasis)

Science Daily reported in August that "parasites are a more significant threat to salmon that has previously been assumed" (the research "will be published soon in the journals *Aquaculture, Journal of Parasitology*, and *International Journal of Parasitology*"). One parasite which needs no introduction is the Tapeworm which can be ingested via uncooked food and have already reared their ugly heads in salmon farming.

A scientific paper – "Salmon Aquaculture and Transmission of the Fish Tapeworm" - published in 2007 in the journal of *Emerging Infectious Diseases* reported that: "Several recent publications report outbreaks of human cases of infection by the fish tapeworm Diphyllobothrium latum in Brazil. These infections have been epidemiologically linked to

consumption of raw salmon produced by the aquaculture industry in southern Chile, thousands of miles away.... The link that closes the epidemiologic chain between the Brazilian outbreak of fish tapeworm infections and the aquaculture of salmon in southern Chile is that some of the freshwater lakes where D. latum and D. dendriticum are endemic are used to grow the freshwater stages of juvenile salmon, or smolt, in cages."

Photo: Infection of humans results from eating raw fish containing plerocercoid larvae of Diphyllobothrium latum. With new food habits in many parts of the world ("sushi" restaurants), the fish tapeworm is once more "on the attack".

The paper by Professor Felipe Cabello from New York Medical College concluded: "The expansion of diphyllobothriasis-endemic areas in Chile may, in turn, facilitate the appearance of future outbreaks of this disease as the aquaculture industry expands to these new infested areas and the market for Chilean salmon enlarges worldwide. The increased popularity of eating uncooked fish in sushi and ceviche will also be a factor in the emergence of future outbreaks of this disease. As has been the case with other human infectious diseases disseminated by the industrialization of animal husbandry, this outbreak of diphyllobothriasis could have been prevented by use of existing information, including that concerning the endemic nature of diphyllobothriasis in the lakes of southern Chile and its transmission by raw fish."

A scientific paper – "Endohelminth parasites from salmonids in intensive culture from southern Chile" – published in the *Journal of Parisitology* in 2010 stated that: "The occurrences of Diphyllobothrium sp. in a lake and a tetraphyllidean plerocercoid from marine cultured salmonid in Chiloé are reported for first time....Three endohelminth species have been recorded in the Chilean salmon farming industry, i.e., larvae and adults of Hysterothylacium aduncum in Oncorhynchus kisutch, Oncorhynchus mykiss, Salmo salar,

and Oncorhynchus tshawytscha from net pen farms in the Chiloe´ Archipelago and in S. Salar from localities close to Puerto Montt."

The paper reported that:

"Between 2004 and 2005, about 30 cases of human diphyllobothriosis occurred in different cities in Brazil and were attributed, in part, to the consumption of salmonids imported from Chile. This resulted in the suspension of such imports for several months, as well as the industry's economic distress. Since 2006, the Chilean National Fishing Service has required that plants processing salmon exports perform further parasitological tests to complement routine organoleptic and microbiological examination."

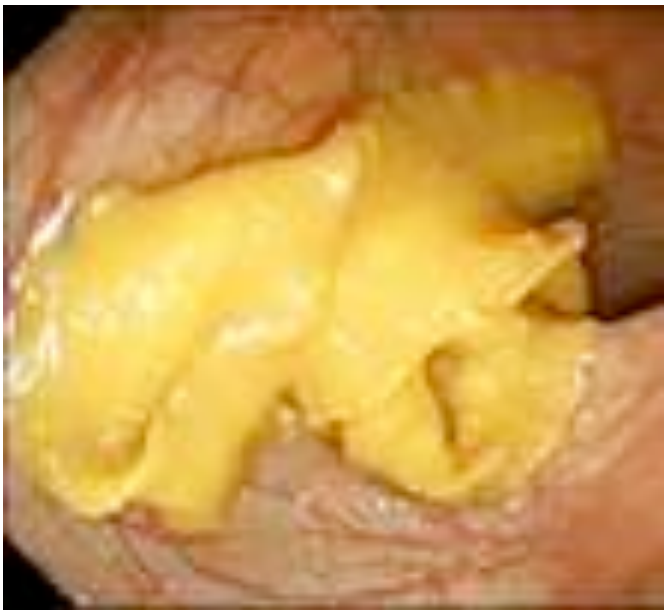


Photo: A Long, Moving Tapeworm is Located in the Terminal Ileum and Extends to the Sigmoid Colon.

Microsporidian encephalitis

A scientific paper – "Microsporidian encephalitis of farmed Atlantic salmon (Salino salar) in British Columbia" – published in the Canadian Veterinary Journal in 1995 described "the clinical signs and pathology associated with an outbreak of a previously unrecognized microsporidian encephalitis in farmed Atlantic salmon (Salmo salar) in British Columbia". This disease was initially diagnosed in December 1993 at 2 separate netpen sites in the coastal waters of Vancouver Island and continued through January to June 1994.

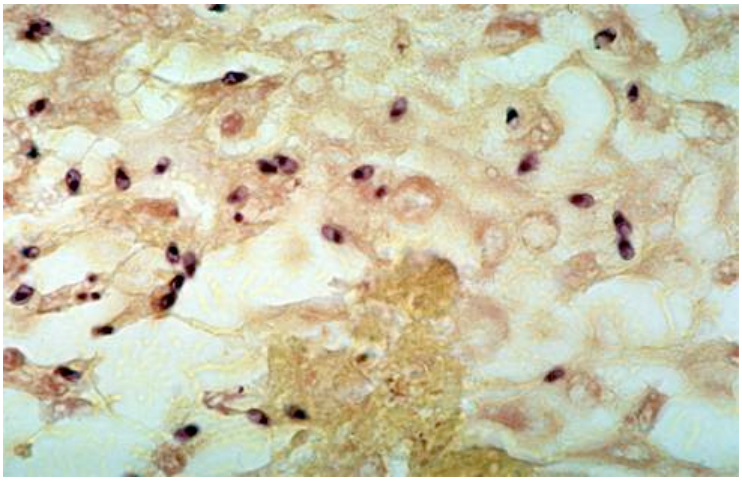


Photo: *Loma salmonae* spores dispersed in a granulomatous lesion in the ventricle of a juvenile coho salmon, *Oncorhynchus kisutch*

The paper stated that: "Microsporidians are important pathogens of cultured fish. Two microsporidians infect seawater-reared salmonids in the Pacific Northwest: Loma salmonae infects the gills and, to a lesser extent, the visceral organs of coho (Oncorhynchus kisutch) and Chinook salmon (Oncorhynchus tshawytscha); and Enterocytozoan salmonis infects the nuclei of blood-forming cells in chinook salmon."

'Loma Infection' was reported in 2005 and 2006 via the BCSFA 'Fish Health Database'.

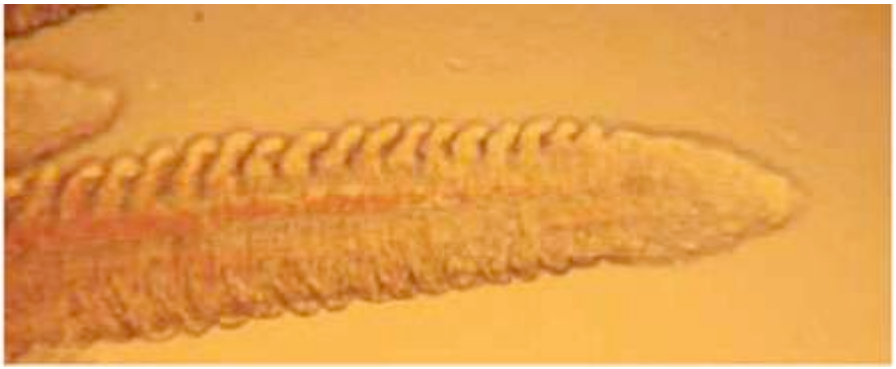


Photo: Loma salmonae

Encephalitis was also reported in 1996 in Ireland in farmed salmon in a paper – "Encephalitis and mass mortality of farmed salmon smolts in an isolated sea bay in Ireland" – published in *The Veterinary Record*. The journal *Diseases of Aquatic Organisms* reported further via the 1999 paper "Molecular characterization of the myxosporean associated with parasitic encephalitis of farmed Atlantic salmon *Salmo salar* in Ireland".

The paper reported: "During seasonal epizootics of neurologic disease and mass mortality in the summers of 1992, 1993 and 1994 on a sea-farm in Ireland, Atlantic salmon *Salmo salar* smolts suffered from encephalitis associated with infection by a neurotropic parasite. Based on ultrastructural studies, this neurotropic parasite was identified as an intercellular presporogonic multicellular developmental stage of a histozolc myxosporean, possibly a *Myxobolus* species."

Nephrocalcinosis (urolithiasis)

Nephrocalcinosis is granular deposits composed mainly of calcium phosphate in the kidney tubules and ducts and can be caused by long-term exposure to carbon dioxide which is pumped into salmon farms and hatcheries.

Nephrocalcinosis (or urolithiasis) was reported in Norway in 1999 and Scotland in 1996 and was again on salmon farms in Shetland and Highland in 2004. The Norwegian Veterinary Institute reported in 2008 that: "Every year a degree of nephrocalcinosis is registered in hatchery rainbow trout and salmon. Calcium deposits are observed in the tubuli of the kidney, with lesser or major changes in kidney tissues surrounding the tubuli. The condition is related to the level of dissolved CO2 in the water."

Malignant Intestinal Tumours

"Malignant intestinal tumours were diagnosed for the first time in 2005 in brood stock of both salmon and rainbow trout," reported the Norwegian Veterinary Institute in 2009 in their 'Farmed Fish Health Report 2008'. "In subsequent generations up to and including 2007, very high prevalence's of macroscopically visible intestinal tumours were registered in certain groups of brood stock."

The Norwegian Veterinary Institute reported in 2010 that: "The common factor in all severely affected groups was that all had been fed a particular type of feed. The results of a study relating to the prevalence of- and pathological changes associated with- such tumours have been published. During the spawning season of 2008 the frequency of detection of this type of tumour was very much reduced, probably due to the discontinued use of the suspected feed type. During 2009, the same type of tumour (adenocarcinoma) was identified in approximately 0.5% of a large broodfish population. This demonstrates that although the feed shift may have reduced the prevalence or delayed tumour development, such tumours remain a significant problem. Closer studies of the causes are difficult as the lists of ingredients for commercial feeds are not available.

No detectable carcinogens have been identified which could explain the tumour development. During
2009 only a few malignant tumours (malignant lymphoma, hepatocarcinoma) have been identified. This strongly indicates a production related cause."

Desmozoon lepeophtherii (Paranucleospora theridion) & Autumn Disease

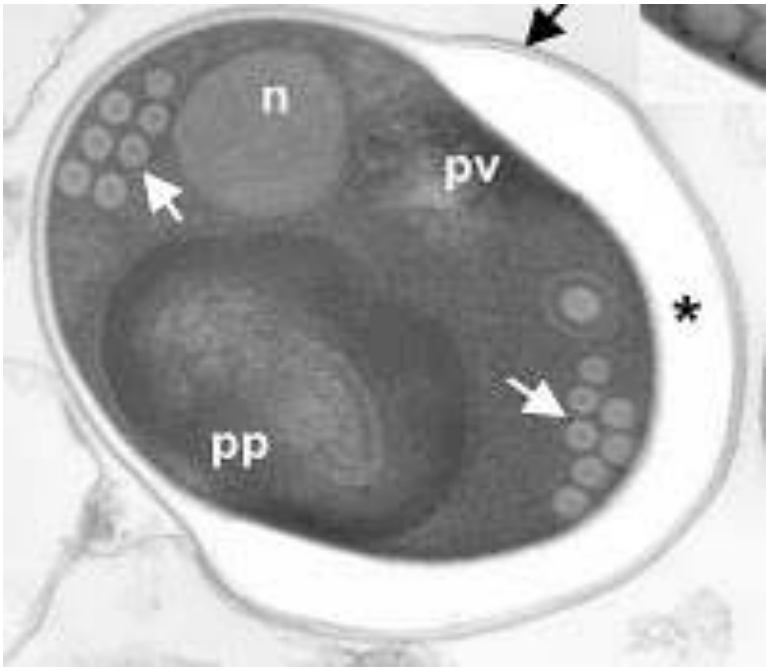


Photo: Desmozoon lepeophtherii

The Norwegian Veterinary Institute reported in 2010 via their 'Farmed Fish Health Report 2009' that: "Speculations have been made during 2009 on a possible relationship between so-called "autumn disease" and the microsporidian parasite Desmozoon lepeophtherii. This microsporidian was first identified in 2003 in salmon-lice Lepeophtheirus salmonis in Scotland, but was not formally described and named until 2009. Early in 2010, a description of a microsporidian from salmon and salmon-lice was published and named Paranucleospora theridion. Although there are some small differences in the DNA sequences used to describe these two variants, they are considered to represent the same species..... The National Veterinary Institute has in the course of 2009 investigated (molecular investigations) 15 cases in relation to D. lepeophtherii, based on indications following histopathological investigation. The microsporidean was detected in 12 of these cases."

The Norwegian Veterinary Institute also detailed a new disease called 'Autumn Disease':

"During the autumn of 2008 several cases of disease, with similar clinical and histological findings were detected in farmed salmon. Mortality was variable with losses of up to 20% registered, in addition to reduced growth. Clinically, respiratory problems were common, with swollen pale gills, yellow-brown liver, ascites and congested and swollen spleen and kidney. The intestine in affected fish was normally empty. Microscopic investigations of tissue sections revealed necrotic and later proliferative changes in the gill. In serious cases, changes were also observed in the kidney. Inflammation of the peritoneum and inner organs with signs of increased degradation of blood cells were normal observations. Bacteriological and virological investigations gave negative results. Due to the occurrence of the disease in the autumn and lack of identification of a presumptive aetiological agent/s, the condition was termed "autumn disease". The timepoint of the first diagnosis in 2009 was almost exactly the same as that of 2008, although the number of cases reported during 2009 was lower and the pathology less severe. The cause of the disease remains unknown. The microsporidian Desmozoon lepeophtherii has been proposed to be the causal agent. It would appear that this parasite is transmitted to salmon via salmon-lice."

Salmonella

Photo: Salmonella

The issue of Salmonella in salmon farming may not be a serious issue right now but salmonella contamination has already been reported in Norwegian fish feed factories and the spectre of Salmonella problems in aquaculture looms on the horizon.

An article – "Drug Resistance in Food — Coming from Aquaculture?" published in August in *Wired* by Maryn Mckenna (also known as 'Scary Disease Girl' – and author of 'Superbug' and 'Beating Back the Devil') reported on an outbreak of Salmonella in turkey meat in the United States and warned of a possible link with aquaculture. "The association between the resistance DNA and the waterborne bacterium *V. cholerae* suggests that fish farming played a role too, either through medicated fish feed, or because the cycling of chicken byproducts into the ponds and fish and then out again as aquaculture waste may have spread that DNA much more broadly," she wrote (for more background read a paper in the *Journal of Infectious Diseases*).

In 2005, Birdlife International also reported that "Bird flu may be spread by using chicken dung as food in fish farms". Salmonella may be spread in the same way: a paper – "Detection of *Salmonella* Spp in Aquatic Insects, Fish and Water by MPN-PCR" – published in 2011 reported that: "*Salmonella* spp. may reach aquatic environments through faecal contamination and it has been isolated from freshwater fish culture ponds in many countries. This accounts for the occasional detection of *Salmonella* from fish and fishery products."

In a letter – "Aquaculture and Florfenicol Resistance in Salmonella enterica Serovar Typhimurium DT104" – published in 2009 in the journal *Infectious Diseases* Professor Felipe Cabello from New York Medical College points to "direct or indirect horizontal gene transfer between bacteria in the aquaculture environment and *Salmonella enterica* serovar Typhimurium DT104".

A scientific paper by Norwegian researchers – "Molecular Analyses of *Salmonella enterica* Isolates from Fish Feed Factories and Fish Feed Ingredients" – published in 2003 in *Applied and Environmental Microbiology* reported that: "From 1998 to 2000, nine different serovars of *Salmonella enterica* were identified in four fish feed factories by using the internal control systems of the factories, and 14 different serovars were identified in samples of fish feed ingredients by using official and private control systems. In the fish feed factories, 90% of the

isolates belonged to *S. enterica* serovar Agona, *S. enterica* serovar Montevideo, *S. enterica* serovar Senftenberg, and *S. Enteric* serovar Kentucky."

The paper stated that:

"In all four factories, one or two serovars were repeatedly isolated over a period of up to 10 years. It was not known whether the presence of these bacteria was due to a few long-lasting contaminants or to several successive contamination events. We suggest that if long-lasting contaminants are present, the routines for decontamination have been inadequate and that if several succeeding contamination events have occurred, improving the routines to prevent bacteria from entering the factories is probably more important."

The paper concluded that:

"Several investigations have shown that fish meal, as well as raw material of vegetable origin, can be contaminated by *Salmonella* spp..... our results support the presumption that fish feed ingredients may represent a risk of introducing salmonella into fish feed factories.... In conclusion, this study revealed the long-lasting persistence of certain salmonella clones in fish feed factories."

The Norwegian Government's Ministry of Fisheries and Coastal Affairs reported in 2010 that: "One sample is taken for every 100 tonnes of fish feed produced. The feed samples are analysed for prohibited feedstuff materials such as bone meal, blood meal and ARG-GMO modified material, in addition to microbiological parameters such as Salmonella sp., Enterobacteriaceae and mould."

In 2006, a report – "Assessment of the risk from *Salmonella* occurring in feedingstuffs and the feed production process" – by the Norwegian Scientific Committee for Food Safety reported that: "Experiments have shown that under current conditions for farmed Atlantic salmon in Norway, and with the low occurrences of *Salmonella* observed in the feed, the risk of *Salmonella* in fish feed being transmitted via fish to humans is negligible.... Experiments have shown that even after administration of very high doses of *Salmonella*, Atlantic salmon did not exhibit any signs of disease (Nesse *et al*., 2005). Nevertheless fish may be exposed to *Salmonella* spp. through consumption of contaminated feed or by residing in contaminated water."

The report stated that:

"Only one publication describes the fate of orally-administered *Salmonella* in marine fish (Nesse *et al.* 2005a). In this study, farmed Norwegian Atlantic salmon were experimentally fed *Salmonella*-contaminated feed. Two *Salmonella* serovars were used, both strains originating from Norwegian fish feed factories. The results showed that both the persistence and the dissemination of the bacteria in the fish were highly dependent on the dose administered. No clinical signs were observed..... We therefore conclude that, given the low concentrations of *Salmonella* in fish feed, under the usual conditions for farmed Atlantic salmon in Norway, the risk of *Salmonella* in fish feed being passed on to the consumer via the fish should be considered negligible."

A scientific paper – "*Salmonella* in fish feed; occurrence and implications for fish and human health in Norway" - published in 2007 in the journal *Aquaculture* reported that:

"During the years from 2000 to 2004, the prevalence of *Salmonella* in samples of feed materials varied from 0.14 to 0.33%. Of environmental samples obtained at Norwegian fish feed production facilities, 3.78% of the examined samples were positive. During the same period, the prevalence of *Salmonella* in Norwegian ready to use compound fish feed were shown to be 0.3%. The predominant serovars found in fish meal were *S.* Senftenberg and *S.* Montevideo. The same serovars were dominating in isolates from the production environment, and could in these cases be considered "house strains". In ready to use compound fish feed, the most common serovars were found to be *S.* Senftenberg, *S.* Agona, *S.* Montevideo and *S.* Kentucky. Under natural rearing conditions for farmed Atlantic salmon in Norway, and with low concentrations of *Salmonella* in the feed, the risk of transmission to humans via fish products is minimal. Epidemiological data on salmonellosis from the Norwegian Surveillance System for Communicable Diseases, show that the most common serovars in fish feed ingredients, fish feed and fish feed factories accounts for approximately 2 % of clinical *Salmonella* isolates from domestically acquired cases in Norway. There is no evidence for transmission of *Salmonella* from fish feed to humans. However, there is little information on the risk of *Salmonella* cross-contamination from fish feed, the ingredients and the factories to other parts of society, including wildlife. A probable cross-contamination between fish feed factories and seagulls have been described. The prevalence of antimicrobial resistant *Salmonella* strains isolated from fish feed, its ingredients and the production environment have so far been very low."

Testing by the US FDA has also found Salmonella in seafood. A paper – "Incidence of Salmonella in fish and seafood" - published in 2000 stated: "Field laboratories of the U.S. Food and Drug Administration collected and tested 11,312 import and 768 domestic seafood samples over a 9-year period (1990 to 1998) for the presence of Salmonella. The overall incidence of Salmonella was 7.2% for import and 1.3% for domestic seafood. Nearly 10% of import and 2.8% of domestic raw seafood were positive for Salmonella."

In an article – "Salmonella outbreak linked to raw fish consumption" – published in 2008, *Reuters* also reported: "nine electrophoresis-matched cases of Salmonella infection were reported in mainland US, eight of which involved consumption of raw tuna prior to disease onset."

Even if the risks from Salmonella in raw farmed salmon are low, the risks of listeria contamination are surely too high.

Aquacalypse Tomorrow: Salmon Skeletons in the Closet?

There's nothing more certain in life than death – and in the realm of salmon farming there's nothing more certain than deadly diseases. It is inevitable that more diseases will rear their ugly heads in the future as the industry expands further. When tomorrow comes, the dawning of new diseases, bacteria, pathogens and viruses is a dead cert.

As a 'Disease Report' published in 2009 via the Salmon Aquaculture Dialogue stated: "Salmon farming is a relatively young activity. With each passing year since its inception, more diseases have been discovered and/or studied, yielding new insights into how diseases affect salmon.... As the industry evolves, it can be expected that disease patterns will change

with some diseases disappear and others emerging. Disease-free salmon farming will remain an elusive and impractical goal for the foreseeable future."

A report – "The Health Situation in Norwegian Aquaculture 2009" – published by the Norwegian Veterinary Institute in 2010 stated that: "'New' diseases will always present a challenge. In some cases, established diseases may change and present in new form."

A scientific paper published in 2011 in *Veterinary Research* also warned that the Aquacalypse will spawn more 'Salmon Superbugs' and Salmon Transferrable Diseases: "As the aquaculture industry worldwide intensifies and diversifies, it is natural that domestication of new aquaculture species results in recognition of "new" infectious agents and diseases."

In a decade's time keep an eye out for Fish Farmageddon II. For the time being, keep track of the Cohen Commission in Canada where damning disease data is due to be published in August and September during the evidentiary hearings on 'Diseases' and 'Aquaculture'.

Appendix: BCSFA 'Fish Health Database'

Diseases reported in British Columbia (2003 – 2010):

Aeromonas hydrophilia Infection (2006)
Aeromonas salmonicida Infection (2003, 2004, 2005, 2006, 2007, 2008, 2009, 2010)
Aeromonas salmonicida (Atypical) Infection (2008, 2009)
Caligus Infection (2004)
Caprellid infection (2004)
Costia Infection (2003, 2004, 2006)
Fusiform Bacteria Infection (2003, 2006)
Infectious Hematopoetic Necrosis Virus Infection (2003)
Large Spleen Syndrome (2004)
Lepeophtheirus Infection (2003, 2004, 2005, 2006, 2007, 2008, 2009, 2010)
Loma infection (2005, 2006)
Mycobacterium marinus Infection (2005)
Myxobacterial Infection (2003, 2004, 2005, 2006, 2007, 2008, 2009, 2010)
Net Pen Liver Disease (2004, 2007)
Nucleopsora (Enterocytozoan) salmonis Infection (2004)
Phoma herbarum Infection (2003)
Piscirickettsia salmonis Infection (2003, 2004, 2005, 2006, 2007, 2008, 2009, 2010)
Pseudomonas Infection (2007)
Renibacterium salmoninarum Infection (2003, 2004, 2005, 2006, 2007, 2008, 2009, 2010)
Saprolegnia Infection (2003, 2004, 2005, 2006, 2010)
Trichodina Infection (2003, 2010)
Vibrio (Listonella) angullarum Infection (2003, 2004, 2008, 2009, 2010)
Viral Haemorrhagic Septicemia Virus Infection (2003, 2005, 2006, 2007, 2008, 2009, 2010)
Virus Infection (2007)
Yersinia ruckeri Infection (2003, 2006, 2007)

2010:

Aeromonas salmonicida Infection
Lepeophtheirus Infection
Myxobacterial Infection
Piscirickettsia salmonis Infection
Renibacterium salmoninarum Infection
Saprolegnia
Trichodina Infection
Vibrio (Listonella) Infection
Viral Haemorrhagic Septicemia Virus Infection

2009:

Aeromonas salmonicida (Atypical) Infection
Aeromonas salmonicida Infection
Lepeophtheirus Infection
Myxobacterial Infection
Piscirickettsia salmonis Infection
Renibacterium salmoninarum Infection
Vibrio (Listonella) Infection
Viral Haemorrhagic Septicemia Virus Infection

2008:

Aeromonas salmonicida Infection
Aeromonas salmonicida (Atypical) Infection
Lepeophtheirus Infection
Myxobacterial Infection
Piscirickettsia salmonis Infection
Renibacterium salmoninarum Infection
Vibrio (Listonella) Infection
Viral Haemorrhagic Septicemia Virus Infection

2007:

Aeromonas salmonicida Infection
Lepeophtheirus Infection
Myxobacterial Infection
Net Pen Liver Disease
Piscirickettsia salmonis Infection
Pseudomonas Infection
Renibacterium salmoninarum Infection
Viral Haemorrhagic Septicemia Virus Infection
Virus Infection
Yersinia ruckeri Infection

2006:

Aeromonas hydrophilia Infection
Aeromonas salmonicida Infection
Costia Infection

Fusiform Bacteria Infection
Lepeophtheirus Infection
Loma infection
Myxobacterial Infection
Renibacterium salmoninarum Infection
Piscirickettsia salmonis Infection
Saprolegnia Infection
Viral Haemorrhagic Septicemia Virus Infection
Yersinia ruckeri Infection

2005:

Aeromonas salmonicida Infection
Lepeophtheirus Infection
Loma Infection
Mycobacterium marinus Infection
Myxobacterial Infection
Piscirickettsia salmonis Infection
Renibacterium salmoninarum Infection
Saprolegnia Infection
Viral Haemorrhagic Septicemia Virus Infection

2004:

Aeromonas salmonicida Infection
Caligus Infection
Caprellid infection
Costia Infection
Large Spleen Syndrome
Lepeophtheirus Infection
Myxobacterial Infection
Net Pen Liver Disease
Nucleopsora (Enterocytozoan) salmonis Infection
Piscirickettsia salmonis Infection
Renibacterium salmoninarum Infection
Saprolegnia Infection
Vibrio (Listonella) angullarum Infection
Yersinia ruckeri Infection

2003:

Aeromonas salmonicida Infection
Costia Infection
Fusiform Bacteria Infection
Infectious Hematopoetic Necrosis Virus Infection
Lepeophtheirus Infection
Myxobacterial Infection
Phoma herbarum Infection
Piscirickettsia salmonis Infection
Renibacterium salmoninarum Infection

Saprolegnia Infection
Trichodina Infection
Vibrio (Listonella) angullarum Infection
Viral Haemorrhagic Septicemia Virus Infection
Yersinia ruckeri Infection

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[i] Don Staniford is an award-winning campaigner and author. In 2005, he won the Roderick Haig-Brown Regional Prize at the BC Book Prizes for co-authoring the book "A Stain Upon the Sea: West Coast Salmon Farming" (read his chapter "Silent Spring of the Sea"). In 2002, he won the Andrew Lees Memorial Award at the British Environment & Media Awards.

He is also author of 'Cage Rage' in The Ecologist (2001); 'Marine Salmon Farming in Scotland: The One That Got Away' (2001), 'A Big Fish in a Small Pond' (2002), 'The Five Fundamental Flaws of Sea Cage Fish Farming' (2002), 'Closing the Net on Sea Cage Fish Farming' (2003), various factsheets for the Pure Salmon Campaign and 'Global Statistics' compiled by Farmed Salmon Exposed.

Don has investigated salmon farming issues since 1993 and has worked for Friends of the Earth Scotland, the Salmon Farm Protest Group, Friends of Clayoquot Sound, the Pure Salmon Campaign and currently works for the Global Alliance Against Industrial Aquaculture (GAAIA).