Healthy fish and sustainability

Aquatic research- and development projects at the Norwegian Veterinary Institute

Veterinærinstituttet
Norwegian Veterinary Institute

Photo: Ccolourbox

No health – no growth!

Norwegian aquaculture remains a young industry, with unparalleled development and growth. The rapid implementation of new knowledge and technology within the industry has been dependent on a solid research- and competence-infrastructure. Further sustainable expansion will require continued high-level research.

As the world-leading nation in salmon farming, Norway must acknowledge its responsibility in the field of research involving farming of Atlantic salmon. Fish health and welfare challenges are probably the most important limiting factors for continued expansion. It will be necessary for the industry and the authorities to work together to meet these challenges.

The Norwegian Veterinary Institute remains one of the most important sources of research relating to identification of the causal-relationships and control and prevention of fish diseases. This research has been, and remains crucial for further secure growth of the aquaculture industry. The Norwegian Veterinary Institute also makes vital contributions in the field of wild fish disease. Research on salmon lice and *Gyrodactylus salaris* are two good examples of work equally valuable to both farmed and wild fish populations.

Halvor Hektoen: Locum Director, Department for Fish Health. Photo: Bryndis Holm

The following presentation of central aquaculture-related areas of research at the Norwegian Veterinary Institute illustrates the high degree of relevance our institute has for both the public authorities and for the aquaculture industry itself. Our aim is to ensure that we remain a central actor in the work towards a sustainable bio-economy, good fish-health and good fish-welfare. We also aim to continue to be an institute that actively seeks cooperative research with industry, the authorities and other research institutions.

Satisfactory control of the salmon louse is critical for sustainable growth. The Norwegian Veterinary Institute approaches this problem from many angles including studies relating to development of resistance, vaccine development, various non-medicinal treatments and testing of farming technologies designed to reduce infection. A solid epidemiological of infection dynamics and infection model development is critical for management and control of lice infections. Both medicinal and non-medicinal treatments have considerable physical and physiological effects on the salmon treated and thus represent considerable welfare challenges. Fundamental knowledge of fish welfare and fish health is a vital components in evaluation (and eventual success) of new farming technologies whether it be gigantic offshore farms or land-based farms based on recycling technology.

Vaccination has proven to be one of the most important preventative measures against fish disease. The Norwegian Veterinary Institute is currently participating in a series of research projects in cooperation with other leading research institutions and industry partners towards development of new and more effective vaccines against infectious fish diseases. Through a better understanding of the fish immune system and interactions between pathogen and host, the aim is to control several of the most serious and economically significant virus infections through development of new and effective vaccines.

Due to our societal role in identification and control of disease, the Norwegian Veterinary Institute prioritises identification of new infectious diseases of fish, so-called *emerging diseases*. Rapid identification, development of diagnostic methodology, eradication and control of such infections are all priority areas of research. This presentation describes several research projects aimed at creating fundamental knowledge of emerging diseases and agents. Continued, sustainable development of both salmon and novel species aquaculture industries will depend on continued 'basal' research into emerging diseases.

At the Norwegian Veterinary Institute we value being able to contribute to increasing knowledge of concrete societal challenges. When we succeed we know that the work and the results have a value for both the farmed animals and for mankind. This forms the basis for sustainable growth, good disease management and healthy fish...

Halvor Hektoen
Locum Director, Department for Fish Health

Photo: Davis Stland

Salmon Louse. Photo: Trygve Poppe

Salmon louse- mouth and teeth. Photo Jannicke Wiik-Nielsen –>

The salmon louse

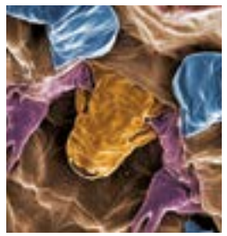
The Norwegian Veterinary Institute has performed research on the salmon louse for many years. Central research themes include the biology of the louse, resistance to chemical treatments and the potential for spread of lice from aquaculture facilities to wild salmon and other farms. We also perform research into the salmon's immune response to the parasite. Other important topics for research include transmission of lice between wild and captive fish populations and evaluation of the environmental conditions that may affect transmission of lice. The Institute is also currently working towards development of a vaccine against salmon lice and we have broad experience of testing new technologies for salmon lice control.

Prediction of future louse infection pressure

The Norwegian Veterinary Institute has a particular research focus on the epidemiology of salmon lice infestation and has a team of researchers devoted to development of knowledge and tools for control of salmon lice within the aquaculture industry. This research group has several projects financed by the aquaculture industry and the public authorities, in addition to internal institute financed projects. In collaboration with several other institutions, the Norwegian Veterinary Institute has developed models for prediction of spread of salmon lice. We recently released two models, a 'louse map' and a 'louse calculator' capable of calculating future infestation pressure at the cage-, locality- and area- levels. These models enable the industry to initiate measures to mitigate future infestation pressure in particular sites and represent useful planning and support tools for use by the authorities in the so-called 'traffic light system' for further development of the aquaculture industry.

Testing of enclosed aquaculture- and salmon lice treatment- technologies

There is a need for new treatments for control of salmon lice. The Norwegian Veterinary Institute is involved in several projects aimed at development and testing of new technologies that may contribute to control and prevention of infestation e.g. cage technologies and new treatment technologies. We focus on documentation of fish health, preventative effects, de-licing effect and animal welfare aspects. More information is available in the *Welfare and New Technology* section.



Current projects related to salmon lice*

Project: Development of a standarised method for manual salmon lice counts and calculation of the occurrence of lice

- Goal: Establish a standarised method for manual salmon lice counts, a more accurate method for calculation the occurrence of lice on a farm, and a method for handling the remaining insecurity in the lice counts
- Expected value: More accurate lice counts and increased understanding of lice counts as estimates of the true lice numbers, can give both fish farmers and authorities a better basis for their lice-related decisions
- Period: 2017–2018
- Project leader: Bengt Finstad, Norwegian Institute for Nature Research (NINA)
- Responsible person at the Norwegian Veterinary Institute: Kari Olli Helgesen
- Other collaborating partners: SINTEF Ocean, University of Prince Edward Island
- Finance: The Norwegian Seafood Research Fund (FHF)

Project: Salmon-louse strategy 2017: United lice-strategy for Rogaland

- Goal: Make use of new tools to control salmon louse infestations in real time through integrated pest management in the Rogaland production area.
- Expected value: Advance preventive tools to control lice infestations and document experiences regarding effective control measures that are coordinated through the use of new warning systems for the whole production system.
- Period: 2017–2018.
- Project leader: Trine Danielsen, Blue Planet
- Responsible at the Norwegian Veterinary Institute: Peder Jansen
- Other collaborative partners: Proactima AS, Norsk Regnesentral
- Funding: The Norwegian Seafood Research Fund (FHF)

Project: Host density and transmission in salmon farming: the effect of increased production and changes in spatial distribution

- Goal: Development of site-specific models to study how host density and spatial distribution affects spread of salmon lice, PD and ISA. Further, the economic importance of different growth- or spatial production models will be investigated.
- Expected value: Contribute to and provide a knowledge base for decision making relating to further expansion of the aquaculture industry.
- Period: 2016–2019
- Project leader: Peder Jansen, Norwegian Veterinary Institute
- Collaborating partners: Norwegian computing Centre, Norwegian University of Life Sciences (NMBU), Norwegian Institute for Nature Research (NINA), Penn State University and University of Prince Edward Island
- Finance: Research Council of Norway (RCN)

*see also *Welfare and New Technology*, and *Fish Vaccine* themes

Project: Economic incentives for disease control and zoning strategies for reduction of salmon lice and pancreas disease (PD) in salmonid fish

- Goal: To identify economic incentives within the industry which will act as drivers for disease control strategies in salmon farming. The project will also evaluate the cost effectiveness of treatment- and control- alternatives in salmon production, where production is divided into geographic zones.
- Expected value: Increase knowledge on factors driving establishment of effective and pragmatic management measures.
- Period: 2016–2018
- Collaborating partners: Karl Rich, Lincoln University, New Zealand; Barbara Haesler, Royal veterinary College, London
- Project leader: Mona Dverdal Jansen, Norwegian Veterinary Institute
- Finance: Research Council of Norway (RCN)

Project: Strategic Institute Program – The Salmon Louse Research Group

- Goal: Development of tools and new knowledge for control of salmon lice in aquaculture
- Expected value: Improve coordination and quality of epidemiology-based salmon louse related research.
- Period: Continual from 2014
- Project leader: Kari Olli Helgesen, Norwegian Veterinary Institute
- Finance: Internal program

Counting lice: Norwegian Veterinary Institute researcher Arve Nilsen can happily declare that not a single louse can be found on salmon sampled from an enclosed cage on the Akvafuture farm in Velfjorden outside Brønnøysund. Photo: Asle Haukaas, Norwegian Veterinary Institute

Recently terminated projects related to salmon lice:

Project: A population model for salmon lice at the cage and locality level- further development of management tools for control of the salmon louse in aquaculture

- Goal: Development of a demographic population model for salmon lice at the cage level, giving greater precision than individual lice counts, for estimation of the prevalence of all developmental stages of lice on the farming site.
- Expected value: Prediction of lice population development under given conditions, for use in planning of treatment strategies at the site and regional level.
- Period: 2014–2017
- Project leader: Randi Grøntvedt/Edgar Brun, Norwegian Veterinary Institute
- Collaborative partners; Norwegian computing Centre, Norwegian Institute for Nature research, Penn State University
- Finance: The Norwegian Seafood Research Fund (FHF)

Fish welfare and new technologies. Fish welfare is a research focus at the Norwegian Veterinary Institute. Photo: Stine Gismervik

Fish welfare and new technology

As fish health, infection prevention, biosecurity and welfare are closely interwoven, the Norwegian Veterinary Institute has a holistic approach to fish welfare. This is a priority area of research for us and we cooperate closely with Fish Health Services, farmers, equipment producers and other research institutions. Mortality remains a significant problem to the aquaculture industry and new technologies can at times represent a significant threat to fish welfare. If we are to take fish welfare seriously, we must work actively towards both a reduction in overall mortality and a change in attitude towards fish welfare within the industry.

Welfare testing of new technologies

The Norwegian Veterinary Institute provides scientific expertise during field-testing of new technologies, including non-medicinal de-licing methodologies and enclosed cage technologies. As there is a considerable need for development of tools for evaluation of fish welfare we focus on development of better welfare indicators for fish. A solid base of experience and a common terminology is important when considering scientific and ethical questions relating to acceptable levels of mortality and injury to farmed fish.

New farming technologies

There are many projects aimed at development and testing of new farming technologies, both planned and already in use. While many relate to prevention or reduction of salmon lice damage, others are aimed at e.g. collection/recycling of waste or avoidance of escape. Enclosed or semi-enclosed aquaculture systems on land or at sea provide many opportunities, but also result in new biological challenges. The Norwegian Veterinary Institute intends to develop further models for documentation of fish health and welfare in such novel aquaculture systems.

Non-medicinal methods

Non-medicinal methods for de-licing and AGD treatment of fish have arrived in numbers. Lice flushing, or a combination of brushing and lice flushing and warm- or fresh- water treatments are among the methods currently used for physical removal of lice. As these are new technologies, constant refinement has been necessary to safeguard fish welfare. Reduction of louse settlement is a central element in avoidance of the welfare risk that handling of fish represents. We have therefore also become involved in the study of technologies directed at prevention of lice settlement. As welfare is often affected by the sum of several factors, we work actively to fill welfare related knowledge gaps to ensure the needs of the fish are met.

Current projects related to fish welfare and new technologies:

Project: Status review of the welfare of farmed salmon and rainbow trout (FISHWELL)

- Goal: To identify operational welfare indicators based on evaluation of existing knowledge- and compile species-specific guidelines that allow the farmer to evaluate, ensure or optimise the welfare of farmed salmon or rainbow trout.
- Expected value: An updated knowledge base relating to the welfare requirements of Atlantic salmon and rainbow trout will provide the industry with adequate and easily understandable operational welfare indicators that are both species- and developmental stage specific.
- Period: 2015–2018
- Project leader: Chris Noble, Nofima AS
- Responsible person within the Norwegian Veterinary Institute: Kristine Gismervik
- Collaborative partners: Institute for Marine Research, North University, University of Stirling, UK.
- Finance: The Norwegian Seafood Research Fund (FHF)

Project: Effects of legislation on fish welfare and health (REGFISHWELH)

- Goal: Review current public management and legislation and identify areas for improvement
- Expected value: Identify conflicts involving fish health and welfare within current legislation, analyse how and why such conflicts occur
- Period: 2017–2018
- Project leader: Lars H. Stien, Institute for Marine Research
- Responsible person within the Norwegian Veterinary Institute: Kristine Gismervik
- Other collaborative partners: NTNU and the University of Oslo
- Finance: Research Council of Norway (RCN)

Field studies near Haugesund. Photo: David Stand

Photo: Rudolf Svendsen, UW photo

Project: Development of models for production capacity, environmental influences and fish welfare incompact, enclosed cage farms (KOMPAKT)

- Goal: The project will help solve two important problems related to development and use of enclosed cage technology: (1) Identify the realistic production potential in such systems and (2) Identify realistic levels of waste emission reduction. In all activities involving fish, their health and welfare will be monitored.
- Expected value: The project will develop and document a new and commercially viable enclosed cage concept. The goal is to develop a dynamic and automated system that ensures good production and fish welfare whilst maintaining minimal environmental impact compared to current open cage systems.
- Period: 2017–2020
- Project leader: Eirik Biering, Norwegian Veterinary Institute
- Collaborative partners: NMBU, Bergen University College, International Research Institute of Stavanger (IRIS), University of Gothenburg, Akvadesign AS, Previwo AS, Akvadesign systems AS
- Finance: Research Council of Norway (RCN)

Project: Fish health and the environment in enclosed cages

- Goal: Surveillance of fish health, fish welfare and production in novel, enclosed cage systems
- Expected value: Document the effect of new farming technology on fish health and fish welfare. Identify important knowledge gaps and thereby form a foundation for development of new research projects.
- Period: Continual
- Project leader: Arve Nilsen, Norwegian Veterinary Institute
- Finance: Industry

Project: Salmon farming in enclosed cages – technology and sustainability

- Goal: Investigate how different water flow rates in enclosed production of salmon affects fish health, growth and muscle development
- Expected value: Provide knowledge allowing optimisation of water flow in enclosed cages, investigate the effect of swimming training on growth, digestion and muscle physiology
- Period: 2014–2018
- Project leader: Marit Bjørnevik, North University
- Project contact at Norwegian Veterinary Institute: Arve Nilsen
- Finance: Regional Research Fund, Northern-Norway

Project: Sensors and surveillance systems for farmed fish (FarmDoctor)

- Goal: Develop new technology for surveillance of fish health status using two different technology platforms a) a sensory probe travelling through the salmons digestive tract and b) analysis of salmon blood
- Expected value: Provide knowledge and systems for continual surveillance of health status in farmed fish allowing intervention and reduction of losses.
- Period: 2017–2018
- Project leader: Kjetil Korsnes, BioVivo Technologies AS
- Project contact at Norwegian Veterinary Institute: Lars Qviller
- Other collaborating partners: FMC Kongsberg Subsea AS, Sintef Digital and Sintef Ocean
- Finance: Research Council of Norway (RCN)

Recently terminated projects related to fish welfare and new technologies:

Project: Helixir – Documentation of welfare and effect on lice

- Goal: Document fish welfare and effect on lice of the Helixir treatment system.
- Expected value: Provision of a novel welfare tested technological solution for bath treatment in a controlled and enclosed system (treatment barge).
- Period: 2015–2017
- Project leader: Kristine Gismervik, Norwegian Veterinary Institute
- Collaborative partners: Åkerblå AS, Måsøval Aquaculture AS, Salmar ASA, BDO AS, Aquamedic AS, Stranda Prolog AS.
- Finance: The Norwegian Seafood Research Fund (FHF)

Project: Best practices for drug-free lice control (MEDFRI)

- Goal: Describe and evaluate current non-medicinal treatments for control and prevention of salmon lice infestations and recommend best practice for each method.
- Expected value: «A step down the road» towards non-medicinal prevention and control of salmon lice infestations. Contribute to identification of operational parameters to ensure optimal performance of individual methods.
- Period: 2015–2017
- Project leader: Astrid Buran Holan, Nofima
- Responsible person within the Norwegian Veterinary Institute: Kristine Gismervik
- Collaborative partners: University of Stirling, Bremnes Seashore AS, Sjømat Norge, Marine Harvest ASA, SalMar ASA, Nordlaks
- Finance: The Norwegian Seafood Research Fund (FHF)

Project: AGD – Treatment strategies/dose-response studies in farmed salmon

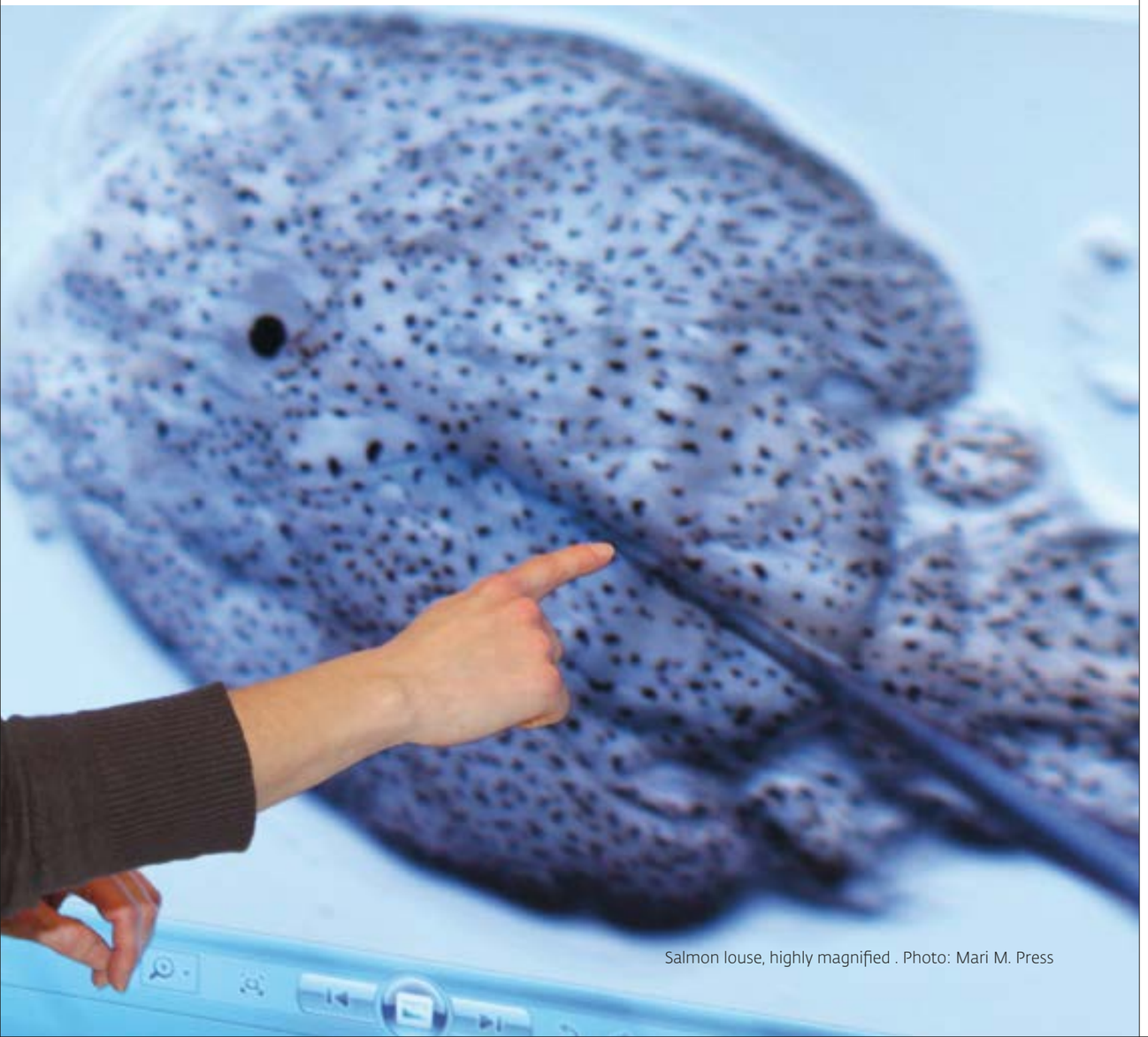
- Goal: Optimise fresh water and hydrogen peroxide (H_2O_2) treatment methods against amoebic gill disease (AGD) under conditions relevant for Norwegian aquaculture and investigate whether the amoeba *Neoparamoeba perurans* develops reduced sensitivity and/or resistance to H_2O_2 and fresh water following repeated treatment.
- Expected value: Increased knowledge of the effects, and eventual resistance to fresh water and H_2O_2 treatment of *N. perurans* under Norwegian conditions. This will provide the aquaculture industry with a better knowledge base on which to plan anti-AGD strategies and selection of treatment type when repeated treatments are necessary.
- Period: 2015–2017
- Project leader: Sigurd Hytterød, Norwegian Veterinary Institute
- Collaborative partners: Stiftelsen Industrilaboratoriet (ILAB) AS
- Finance: The Norwegian Seafood Research Fund (FHF)

Project: Lice flushing – Full scale documentation of the effect on salmon lice and fish welfare

- Goal: Documentation of fish welfare and mechanical removal of salmon lice using seawater flushing (FLS-de-licing system).
- Expected value: The project will contribute to testing of fish welfare associated with new non-medicinal de-licing technologies. The project expects to identify important parameters for successful mechanical de-licing whilst identifying indicators valuable for evaluation of fish welfare.
- Period: 2015–2017
- Project leader: Kristine Gismervik, Norwegian Veterinary Institute
- Collaborative partners: Havet Fish Health Service AS, Marine Harvest ASA, Lerøy Midt AS, Flatsetsund Engineering AS.
- Finance: The Norwegian Seafood Research Fund (FHF)

Researcher David Strand conducting field studies on amoebic gill disease (AGD). Photo: Sigurd Hytterød

Fish vaccines and immune responses



Salmon louse, highly magnified . Photo: Mari M. Press

Outbreak of disease represents one of the most significant threats against further expansion of the aquaculture industry. Development of new fish vaccines and new vaccine concepts are therefore an important part of fish health related research at the Norwegian Veterinary Institute.

Vaccination is a prophylactic measure which should activate the immune defences such that the vaccinated organism is capable of defending itself against various bacteria, virus and parasites. Effective vaccines are not available for a number of important diseases of fish. Through vaccination, the immune defences of the fish are stimulated t o provide a long lasting and protective immune response. The immune system is complicated and many current vaccines are unable to stimulate a fully protective response.

Development of targeted vaccines

The Norwegian Veterinary Institute, together with collaborative partner institutes has worked on development of a flexible vaccine platform (TarGet) to ensure a strong and effective immune response, in combination with vaccine components tailored towards different diseases and fish species. This project aims to increase protection against present and future disease challenges via stimulation of particular immune cells.

Research on new salmon louse vaccines

The salmon louse quickly develops resistance against chemical treatments and new alternative treatments are often associated with fish welfare concerns. An effective salmon louse vaccine could contribute to alleviation of the salmon louse problem and considerably increase fish welfare. Norwegian Veterinary Institute research in vaccinology includes two innovation projects involving cooperation with industry collaborators e.g. Pharmaq, in which the main goal is development and effect studies of anti-salmon louse vaccines.

Participation in the national vaccine platform

The Norwegian Veterinary Institute participates in the national platform for vaccines against viral diseases (ViVaFish), where our task is development of analyses to document the duration of antibody and cellular-immunity based protection. The Norwegian Veterinary Institute has focused research on vaccines against HSMI and CMS. Another vaccine platform project focuses on culture of virus for production of HSMI and CMS vaccines. A novel follow-up to the vaccine platform is the ViVaAct project that compares long term effects and immune responses of attenuated and inactivated vaccines against PD and HSMI.

Synthetic biology contributes to development of optimal protective immune responses

The Norwegian Veterinary Institute is utilising synthetic biology and reverse genetics to construct a PD-virus with a defined genetic structure. This will allow study of 1) how the virus adapts and changes and 2) how the salmon immune system may be optimally stimulated. The second parameter may prove valuable in optimisation of future PD-vaccines.

Current projects related to fish vaccines and immune responses:

Project: Changing our view of Major histocompatibility Complex (MHC) class I in vertebrates

- Goal: Test hypothesis that the MHC class I molecules have a much more complex role than previously assumed similar to what has recently been found in humans and chickens
- Expected value: Assuming the hypothesis is verified this will have a serious impact on how we design vaccines as well as breeding and conservation of both fish as well as other vertebrates
- Period: 2018–2021
- Project leader: Unni Grimholt, Norwegian Veterinary Institute
- Collaborative partners: Cambridge University, University of Southern Denmark
- Finance: Research Council of Norway (RCN)

Project: ISA resistance in Atlantic salmon: Defining new phenotypes for accurate breeding (iSABreed)

- Goal: identify new phenotypes for efficient selection against ISAV infection and to implement these phenotypes in breeding programs
- Expected value: Production of salmon with increased resistance to ISA
- Period: 2018–2021
- Project leader: Marie Lillehammer, Nofima
- Project owner: Borghild Hillestad, SalmoBreed
- Responsible person at Norwegian Veterinary Institute: Søren Grove.
- Collaborative partners: Nofima, The Roslin Institute/University of Edinburgh
- Finance: Research Council of Norway (RCN)

Project: Comparing the protection of attenuated and inactivated virus vaccines against pancreas disease and heart and skeletal muscle inflammation (ViVaAct)

- Goal: Compare the protective mechanisms and vaccine potential of immunization with attenuated and inactivated viruses, mapping humoral- and cellular responses and long term effects against Pancreas disease and Heart and skeletal muscle inflammation.
- Expected value: Effective vaccines against Pancreas disease and Heart and skeletal muscle inflammation are needed, as these diseases are among the most challenging in Norwegian salmonid aquaculture
- Period: 2018–2021
- Project leader: Espen Rimstad, Norwegian University of Life Sciences (NMBU)
- Project contact at Norwegian Veterinary Institute: Maria Dahle
- Collaborative partners: The Arctic University of Norway – UiT, Marine Laboratories Scotland, Denmark Technical University, Friedrich-Loeffler Institute, Germany
- Finance: Research Council of Norway (RCN)

Project: Epigenetic regulation by Atlantic salmon miRNAs in disease and osmotic stress

- Goal: To characterize miRNA genes responding to bacteria and parasite infections and osmotid stress in salmon, and to use this knowledge in development of functional feed
- Expected value: The project will contribute important new knowledge on epigenetic regulation by miRNAs in host-pathogen interactions, about miRNAs as participants and key regulators of the immune system, and help disclose molecular details of disease mechanisms

Photo: Anne Mette Kirkemo

- Period: 2018–2021
- Project leader: Rune Andreassen, Oslo and Akershus University College
- Project contact at Norwegian Veterinary Institute: Hilde Sindre
- Collaborative partners: NMBU, UiO, Nofima, Memorial University of Newfoundland Canada, University of Stirling UK, Roslin Institute UK
- Finance: Research Council of Norway (RCN)

Project: Robust salmon skin – genetics, vaccination and nutrition

- Goal: Improve skin health, wound healing and resistance to *Moritella viscosa* in Atlantic salmon by a combined effort of genetics, vaccination and diets
- Expected value: reduced wound related losses in the Norwegian and international salmon industry
- Period: 2018–2021
- Project leader: Jacob Seilø Torgersen, AquaGen
- Project contact at Norwegian Veterinary Institute: Duncan John Colquhoun
- Collaborative partners: Vaxxinova Norway AS, Skretting AS
- Finance: Research Council of Norway (RCN)

Project: A cost-effective salmon louse vaccine – development and optimisation (Louse-off 2)

- Goal: Further development of a commercial vaccine against the salmon louse. Optimisation of protection and reduction of production costs.
- Expected value: Development of an effective salmon louse vaccine at a commercially acceptable cost.
- Period: 2017–2020
- Project leader: Bjørn Brudeseth, Pharmaq AS
- Responsible person at Norwegian Veterinary Institute: Søren Grove.
- Collaborative partners: Pharmaq AS, Sintef
- Finance: Pharmaq AS and Research Council of Norway (RCN)

Researchers Unni Grimholt (left) and Helene Haug are working on development and testing of a universal fish vaccine in the TarGet project. Photo: Mari M. Press

Project: Synthetic biology and rational virus attenuation – a study on Salmonid pancreas disease virus (SYBIATT)

- Goal: design and produce attenuated variants of Salmonid pancreas disease virus and to employ these for experimental studies of virus-host interactions and development of protective immunity after live-virus vaccination
- Expected value: An understanding of the genetic characteristics implicated in the evolution and adaptation of Salmonid pancreas disease virus to its host, Atlantic salmon. This will help us understand what genetic characteristics the virus is dependent upon in order to successfully infect salmon
- Period: 2017–2019
- Project leader: Aderito Monjane, Veterinærinstituttet
- Collaboratice partners: INRA (Paris)
- Finance: Research Council of Norway

Project: Proteomics and metabolomics in aquaculture: Epidermal mucus and the *Gyrodactylus* mystery (PROMOfish)

- Goal: Establish and test modern 'targeted' and 'non-targeted' '-omics' methods for use in aquaculture, focusing on a comparison of the proteome and metabolome of mucus from Atlantic and Baltic salmon infected with *Gyrodactylus salaris*.
- Expected value: Increased knowledge on resistance against *G. salaris* in the Baltic salmon population. Identification of biomarkers in the mucus of fish skin will allow monitoring of stress and health status in living fish. Development of methods for analysis of proteins and metabolites in fish mucus has potential use in several areas of aquaculture and biomedicine research
- Period: 2017–2018
- Project leader: Silvio Uhlig, Norwegian Veterinary Institute
- Collaborative partner: University of Oslo
- Finance: Ministry of Industry and Fisheries (NFD)

Project: miRNA and its role in viral disease and immune response in Atlantic salmon

- Goal: Characterise miRNA-genes important in host-pathogen interactions following infection with salmonid alphavirus (SAV) and infectious pancreatic necrosis virus (IPNV).
- Expected value: The project will contribute new knowledge relating to the role of miRNA in the immune system, and its specific role during viral infections. Further, the project will elucidate molecular mechanisms behind disease processes important for development of new vaccines.
- Period: 2016–2019
- Project leader: Rune Andreassen, Oslo and Akershus University College
- Project contact at Norwegian Veterinary Institute: Hilde Sindre
- Collaborative partners: Oslo University Hospital, Norwegian University of Life Sciences, Ocean Sciences Centre Memorial University of New Foundland, Canada, University of Stirling, UK
- Finance: Research Council of Norway (RCN)

Photo: Colourbox

Project: New directed vaccines for sustainable aquaculture (TarGet)

- Goal: Develop a flexible fish vaccine platform allowing tailoring of vaccines to different virus and fish species
- Expected value: Targeted and effective vaccines will contribute to a significant reduction in virus-associated disease in fish farming, which will again contribute to increased production, sustainable bio-economy and improved fish welfare.
- Period: 2015–2018
- Project leader: Helena Hauge, Norwegian Veterinary Institute
- Collaborative partners: Pharmaq AS, Vaccibody AS, Kongla AS, Kjeller Innovasjon
- Finance: Research Council of Norway (RCN)

Project: Development of a vaccine against the salmon louse (Louse-off 1)

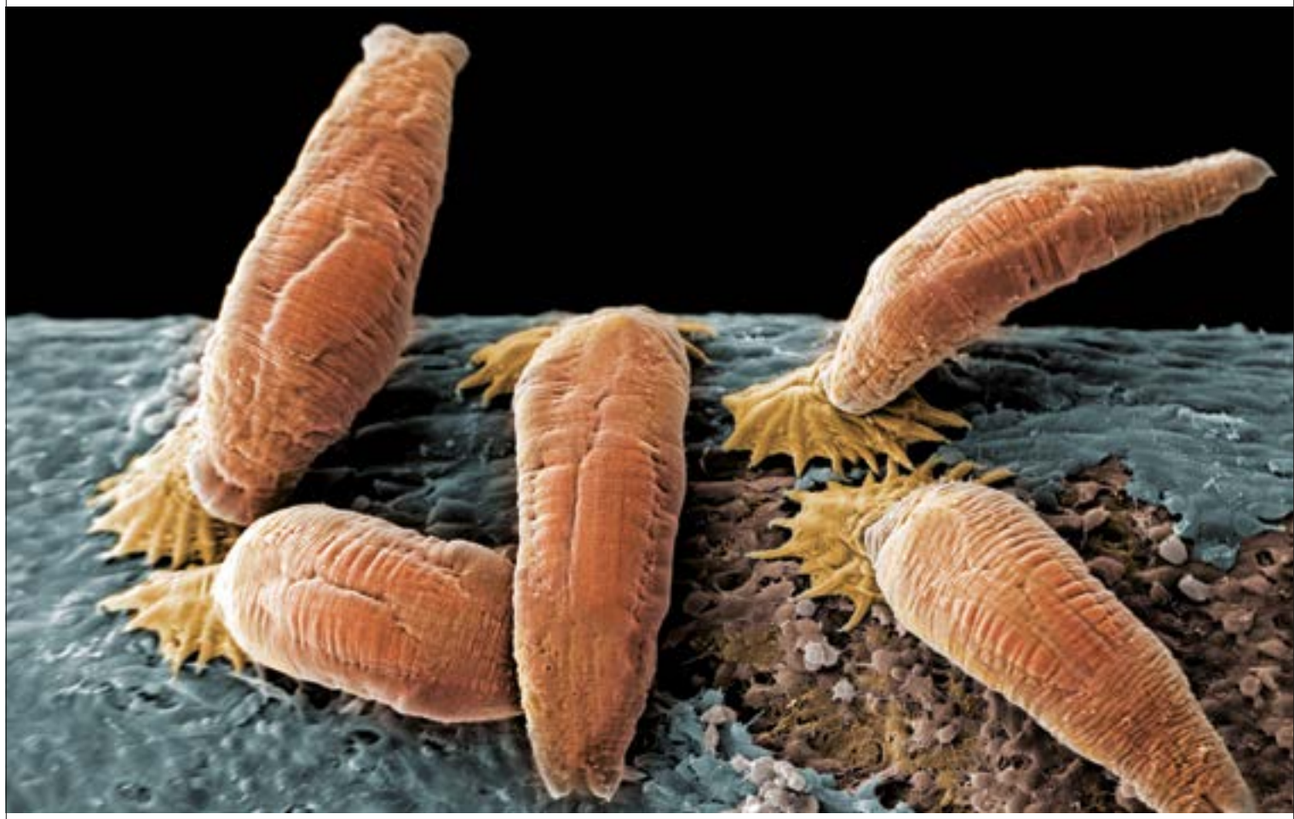
- Goal: Identification and evaluation of putatively protective antigens.
- Expected value: A first step on the road to development of a salmon louse vaccine, which could ultimately contribute to reduction or elimination of the salmon louse problem in Norwegian aquaculture.
- Period: 2014–2018
- Project leader: Bjørn Brudeseth, Pharmaq AS
- Responsible person at Norwegian Veterinary Institute: Søren Grove.
- Collaborative partners: Pharmaq AS, Institute of Marine Research, University of Castilla-La Mancha
- Finance: Pharmaq AS and Research Council of Norway (RCN)

Project: Development of vaccines against HSMI and CMS in Atlantic salmon

- Goal: Develop methods for production of Piscine orthoreovirus (PRV) and Piscine myocarditis virus (PMCV) and virus-like particles in cell culture for use in vaccine development. Perform vaccination trials with inactivated whole-virus based vaccines.
- Expected value: No vaccines exist against these economically important viral diseases, but the need is great.
- Period: 2015–2018
- Project leader: Pharmaq (Innovation project)
- Project contact Norwegian Veterinary Institute: Maria Dahle
- Other collaborative partners: Norwegian University for Life Science
- Finance: Research Council of Norway (RCN)

Project: Platform for viral vaccines in fish (VivaFish)

- Goal: Generate knowledge, tools and methods for development of improved vaccines against viral diseases in farmed fish. Focus is directed on Pancreas disease (PD), heart and skeletal muscle inflammation (HSMI) and infectious salmon anaemia (ISA)
- Expected value: No vaccines exist today against several important viral diseases within the aquaculture industry. One aim of the platform is to increase the number of doctoral and masters theses in this field.
- Period: 2014–2018
- Project leader: Espen Rimstad, Norwegian University of Life Sciences (NMBU)
- Project contact at Norwegian Veterinary Institute: Maria Dahle
- Other collaborative partners: Institute for Marine Research, University of Tromsø, Nofima.
- Finance: Research Council of Norway (RCN)



The parasite *Gyrodactylus salaris*, which is currently under eradication from Norwegian rivers, seen highly magnified through an electron microscope. Photo: Jannicke Wiik-Nielsen

Recently terminated projects related to fish vaccines and immune responses:

Project: Strategic Institute Program – Mucosal pathogenesis and pathogens (MucoPath-SIS)

- Goal: To study the interaction between host and infectious agent (pathogen) on mucosal surfaces of salmon.
- Expected value: Increased knowledge on how salmon immune defences respond to different infections and elucidate the role of the mucosal defences.
- Period: 2012–2017
- Project leader: Søren Grove, Norwegian Veterinary Institute
- Finance: Internal project

Aquatic biosecurity and epidemiology

Well-boats can spread disease.
Photo: Colourbox

The Norwegian Veterinary Institute works with research and development of methods and concepts for improved biosecurity in aquaculture and the aquatic environment. The institute has a large portfolio of projects in this area, financed through strategic internal financing and external agencies.

The term *biosecurity* in fish farming relates primarily to control of infectious diseases through prevention of the introduction and spread of diseases, together with surveillance and eradication measures following outbreak of disease. Biosecurity also relates to tracing infection routes, tracing escaped farmed fish and invading species. Epidemiology is one of several important disciplines in biosecurity and the Norwegian Veterinary Institute has a large number of biosecurity projects utilising an epidemiological approach. Improved biosecurity improves health and welfare, two factors critical for expansion and sustainability of the aquatic bioeconomy.

Working towards a reduction in the risk and transmission of disease in aquaculture

To reduce the risk of transmission and outbreak of infectious diseases between farms and regions, effective health control and environmentally friendly barriers of infection are necessary. Well-boats are used to transport live fish and the risk of disease transmission by well-boats may be reduced by screening transported fish for disease prior to transport, combined with good disinfection procedures. The Norwegian Veterinary Institute leads a project aimed at identification of optimal measures for reduction of the risk of infection in aquaculture. Any measure must satisfy regulatory requirements regarding removal/destruction of infective particles from effluent water such that local ecosystems and local fish farms are not affected. We shall also further develop environmentally friendly technologies based on ultraviolet light treatment for disinfection of aquaculture effluents which will meet new legal requirements.

New concepts for tracing and surveillance of infection and alien species

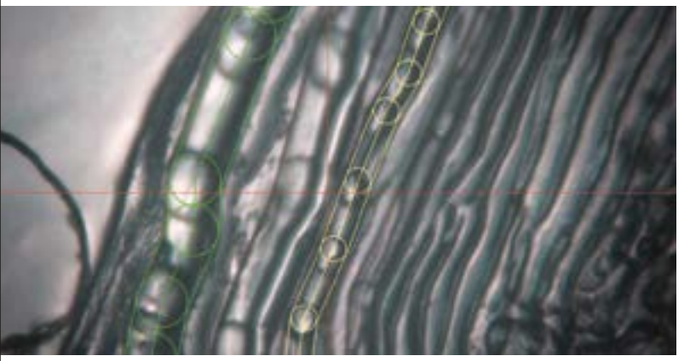
Hereditary material present in water, so-called environmental DNA/RNA (eDNA and eRNA), has been found to provide a good indicator of the presence of both alien species and pathogenic agents in water bodies. eDNA/eRNA detection may form the basis for development of effective surveillance and tracing methodologies which do not disturb the ecosystem and do not require capture, destruction or other treatments which may stress aquatic species. The Norwegian Veterinary Institute initially developed an eDNA-based surveillance system for detection of crayfish plague and is now conducting several eDNA/eRNA projects directed at development of effective identification of and surveillance for various infectious agents and aquatic species of relevance for aquaculture and environmental monitoring i.e. see the projects Biosecurity in aquaculture, SAFEGUARD, ISMOTOOL, TARGET, eDNAqua-Fresh, DNAqua-NET and MONITOR.

Current projects related to Biosecurity and Epidemiology:

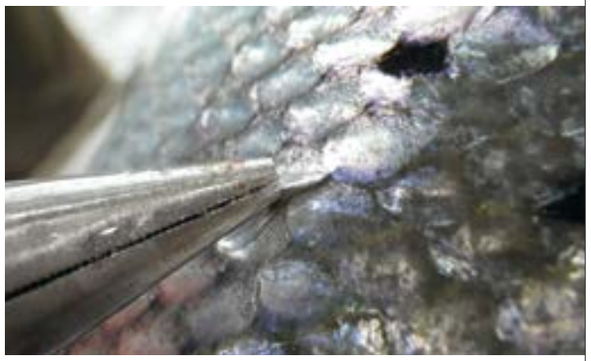
Project: Tracing farmed fish
- Goal: Tracing escaped farmed salmon back to the location and fish farm of origin using element analyses of fish shells. The procedure under establishment is combined with DNA analyses.
- Expected value: tracing escaped salmon back to its site of origin with high precision and without using resources on fish marking
- Period: 2018–2022
- Project leader: Ketil Skår, Veterinary Institute
- Collaborative partners: Under clarification
- Funding source: Seafood Norway or the one they appoint

Project: Biosecurity in aquaculture
- Goal: Strengthen biosecurity in aquaculture, primarily control of specific, infectious diseases through prevention of introduction and spread of pathogenic agents.
- Expected value: Development of effective counter measures and biosecurity plans for better control of infectious diseases at the farm level and in larger zones/areas
- Period: 2015–2019
- Project leader: Atle Lillehaug, Norwegian Veterinary Institute
- Finance: Department of Industry and Fisheries (NFD)

Project: Protection of Atlantic salmon – A non-invasive approach to the study of viral disease dynamics, surveillance methods and effect of control measures (SAFEGUARD)
- Goal: Establish and test methods for direct detection of fish pathogenic agents in water.
- Expected value: Improved methods for surveillance of infectious diseases in farmed fish, evaluation of control measures and development of improved spread of infection models.
- Period: 2017–2020



Laser analysis of fish scales reveals a chemical 'fingerprint'. This method was developed to track escaped fish back to the farm from which they escaped.



Tracking of escaped farmed fish. A single fish scale is enough to identify the farm of origin. Photo: Ketil Skår

- Project leader: Simon Weli, Norwegian Veterinary Institute
- Collaborative partners: Norwegian University of Life Sciences (NMBU), Fisheries and Oceans Canada, Pacific Biological Station BC, Canada, University of the Fraser Valley (UFV), Canada, University of Waterloo, Ontario, Canada
- Finance: Research Council of Norway (RCN)

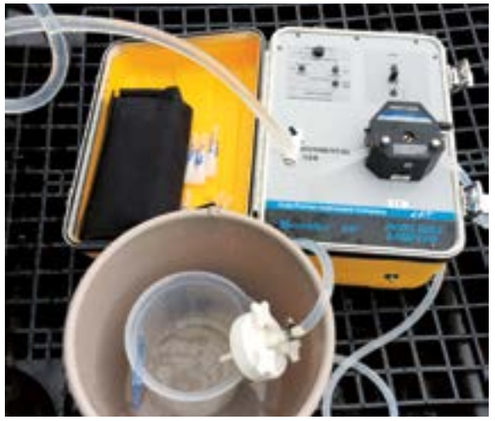
Project: In-situ molecular surveillance: a tool to tackle the operative and environmental challenges in aquaculture (ISMOTOOL)
- Goal: Utilise an automated unit for operational surveillance of fish pathogenic organisms (the salmon louse and *Paramoeba perurans)* present in the water column. The project will also target escaped farmed salmon.
- Expected value: Real-time surveillance of infectious agents and parasites will allow early instigation of counter measures and thus reduce losses, improve fish health and welfare. Detection of escaped farmed fish will allow rapid response, thereby reducing negative impacts to the environment and wild fish populations.
- Period: 2017–2020
- Project leader: Thierry Baussant, International Research Institute of Stavanger (IRIS)
- Project contact Norwegian Veterinary Institute: Trude Vrålstad
- Other collaborative partners: Technical University of Denmark (DTU)
- Finance: Research Council of Norway (RCN)

Project: PRV infection: a model of how salmon farming have an impact on wild salmon
- Goal: investigate whether 1) piscint orthoreovirus (PRV) affect the life history of wild salmon and 2) if whether genetic introgression is associated with PRV carrier state.
- Expected value: Results from part 1 may be used in monitoring of the impacts of farming on wild salmon stocks. The results from part 2 may illuminate and document a health-related effect of genetic introgression in Norwegian salmon stocks.
- Period: 2018
- Project leader: Åse Helen Garseth, Norwegian Veterinary Institute
- Collaborative partners: Norwegian Institute for Nature Research (NINA)
- Finansieringskilde: The Norwegian Environment Agency

Project: Environmental DNA surveillance of fresh water host-pathogen models (eDNAqua-Fresh)
- Goal: Demonstrate the potential for directed eDNA-detection as a surveillance and biosecurity tool in natural, aquaculture and aquarium environments, with focus on lowly prevalent agents and early post-introduction detection.
- Expected value: Rapid and precise surveillance tools provide the public authorities and industry the opportunity to initiate necessary measures on detection of a target organism. Surveillance of eDNA in water is a non-destructive method.
- Period: 2016–2019
- Project leader: Trude Vrålstad, Norwegian Veterinary Institute
- Collaborative partners: Norwegian Institute for Water Research, University of Oslo
- Finance: Department of Industry and Fisheries (NFD)

Project: Directed strategies for protection of European crayfish against non-native, invasive threats (TARGET)

- Goal: Develop cost-effective and environmentally friendly surveillance tools and control strategies for better protection of the European crayfish
- Expected value: Rapid eDNA surveillance methods can provide population estimates for European crayfish and parallel warning of introduction of threatening species or pathogenic agents. This may increase the opportunity for early introduction of effective counter measures.
- Period: 2015–2018
- Project leader: Trude Vrålstad, Norwegian Veterinary Institute
- Collaborative partners: Norwegian Institute for water Research (NIVA), Norwegian Institute for Nature Research (NINA), University of Oslo, Charles University Prague Czech Republic, Food Safety Authority EVIRA, Finland, Swedish Agricultural University (SLU), University of Copenhagen, Denmark, LG SOUND Netherlands.
- Finance: Research Council of Norway (RCN)



This photograph shows sampling and filtering of water from farms and the environment for analysis of environmental DNA (eDNA). Environmental DNA based methods are used for surveillance of both micro- and macro-organisms and provide a 'snap-shot' of organisms present in the water body. The concept may be used to identify specific infectious agents and species directly from water samples. Photo: David Strand

Project: Development of new genetic methodologies for biological mapping of aquatic ecosystems in Europe (DNAqua-NET, COST Action CA15219)

- Goal: Unite researchers in a cross-disciplinary project aimed at identification of a genetic 'gold standard' method and novel eco-genomic indexes and database models for routine use in estimation of biological diversity and bio-surveillance of European water systems.
- Expected value: Current methodologies and strategies for surveillance of biological diversity are time consuming, based on morpho-taxonomy and invasive techniques. Novel genomic tools can avoid these problems and complement or replace traditional surveillance strategies.
- Period: 2016–2020
- Project leader: Florian Leese, University of Duisburg-Essen, Germany
- Project contact Norwegian Veterinary Institute: Trude Vrålstad
- Collaborative partners: More than 50 institutions and companies in > 30 countries
- Finance: EU, COST

Project: Transmission of infection between farmed and wild fish – status of knowledge and risk evaluation

- Goal: Review published literature relating to the risk of transmission of pathogenic bacteria, virus and parasites between farmed and wild fish, both salmonid and marine in the marine environment and evaluate the risk for future transmission of infection and importance of transmission of infection between wild fish and farmed fish.
- Expected value: Prevent and reduce the risk of transmission of infection between wild and farmed fish
- Period: 2017–2018
- Project leaders: Roar Gudding and Atle Lillehaug, Norwegian Veterinary Institute
- Finance: The Norwegian Seafood Research Fund (FHF)

Project: Development and optimisation of environmentally friendly water treatment systems in aquaculture organism transport based on UV-technology, to meet new Norwegian legislation

- Goal: The main aim of the project is further development and optimisation of environmentally friendly water treatment systems based on ultraviolet radiation such that they may be approved under new Norwegian legislation.
- Expected value: Purification technology shall inactivate fish pathogens to prevent disease transmission and control outbreaks of disease to satisfy the new Transport act, but also to maintain good fish welfare during transport.
- Period: 2015–2018
- Project leader: Semir Loncarevic, Norwegian Veterinary Institute
- Finance: Research Council of Norway (RCN)

Project: Low concentrations of chlorine as an anti-*Gyrodactylus salaris* treatment

- Goal: Find out whether chlorine-based compounds may eradicate *Gyrodactylus salaris* in natural river systems without damaging fish and other aquatic organisms to a significant degree.
- Expected value: Should chlorine treatment work, it will represent a more benign eradication method than today's standard which is rotenone treatment.
- Period: 2017–2018
- Project leader: Anders Gjørwad Hagen, Norwegian Institute for Water Research (NIVA)
- Project responsible at Norwegian Veterinary Institute: Sigurd Hytterød
- Other collaborative partners: Norwegian Institute for Nature Research (NINA)
- Finance: The Norwegian Environment Agency

Project: Adaption of surveillance tools for estimation of bacterial load in enclosed marine fish farms – for improved fish health and reduced mortality (MONITOR)

- Goal: Adapt modern technologies developed for ecological studies to map the microbial population in enclosed marine farms.
- Period: 2017–2020
- Project leader: Heidrun Wergeland, University of Bergen
- Project contact Norwegian Veterinary Institute: Hanne Nilsen
- Finance: Research Council of Norway (RCN)

Project: Strategies to limit spread of PD between marine salmonid farms
- Goal: Identify factors influencing disease and spread of SAV-infection, identify cost-effective preventative measures and increase general knowledge and motivation for use of preventative measures.
- Expected value: Reduce disease problems related to PD/SAV
- Period: 2014–2018
- Project leader: Mona Dverdal Jansen, Norwegian Veterinary Institute
- Collaborative partners: SINTEF, PatoGen AS, Salmar, Lingalaks, Marine Harvest
- Finance: The Norwegian Seafood Research Fund (FHF)

Project: Evaluation of multi-source data and integrated research tools for real-time analysis of infections affecting sustainability in aquaculture (MERITS)
- Goal: Establish an international platform for network analyses.
- Expected value: International cooperation with focus on network analyses
- Period: 2017–2018
- Project leader: Saraya Tavornpanich, Norwegian Veterinary Institute
- Collaborative partners: Nordlaks, Lerøy, Marine Scotland Science, UK, University of Stirling, UK, The Centre for Environment, Fisheries and Aquaculture Science (Cefas), UK, Universidad Andrés Bello, Chile, University of California (UC) Davis, USA
- Finance: Research Council of Norway (RCN)

Project: Epidemiological study of cardiomyopathy syndrome (CMS) – Spread, risk factors and course of disease in Norwegian salmon farming (CMS-Epi)
- Goal: Increase knowledge of PMCV spread and factors influencing development of clinical CMS
- Expected value: Identification of routes of infection and mapping of the course of disease in the field will be decisive in gaining control of the disease. The project will summarise available possibilities for limiting spread of PMCV and clinical outbreak of CMS at the individual farm level and within the industry as a whole.
- Period: 2015–2018
- Project leader: Britt Bang Jensen, Norwegian Veterinary Institute
- Collaborative partners: Salmar, Lerøy, Marine Harvest, Cermaq and Pharmaq Analytiq
- Finance: The Norwegian Seafood Research Fund (FHF) and private companies

Project: Integrated development of Mediterranean aquaculture (MedAID)
- Goal: Contribute to development of aquaculture activity in the Mediterranean (seabass and seabream)
- Expected value: Sustainable expansion of Mediterranean aquaculture
- Period: 2017–2020
- Project coordinator: Bernardo Basurco IAMZ-CIHEAM, Spania
- Project contact Norwegian Veterinary Institute: Edgar Brun
- Collaborative partners: Ca 35 partners from Europe and North Africa
- Finance: EU Horizon 2020

Recently terminated projects related to Biosecurity and Epidemiology:

Project: Tracing escaped farmed salmon (FARMSALMTRACK)
- Goal: develop methodologies and systems for tracing of escaped farmed salmon to the marine cage and hatchery level.
- Expected value: the ability to trace unmarked fish back to the marine farm or hatchery of origin.
- Period: 2014–2017
- Project leader: Ketil Skår, Norwegian Veterinary Institute
- Collaborative partners: Geological Survey of Norway, Seafood Norway, SalMar, Marine Harvest, Lerøy
- Finance: Seafood Norway, SalMar, Marine Harvest, Lerøy, The Environmental Fund and The Norwegian Seafood Research Fund (FHF), together with all farms involved in the project

Photo: Erling Svendsen, UW photo

Technician Saima Nasrin Mohammad of the Norwegian Veterinary Institute examines an AGD culture in the microscope. Photo. Mari M. Press

Fish Diseases

The Norwegian Veterinary Institute has many years of experience in disease diagnosis in farmed and wild fish. Research activity is particularly directed at economically important diseases and those which may threaten fish health in the future. As is usual in fish species newly introduced to aquaculture, both recognised and novel diseases have been identified in wrasse and lumpsucker (cleaner fish) used for biological salmon louse control, and mortality in these species is commonly high.

Norway is the world's largest producer of farmed salmon. Aquaculture concentrates a large number of individuals in tanks or cages and prevention of spread of infectious agents in water is challenging. Effective measures for control of disease are, therefore, extremely important in maintaining the sustainability of Norwegian aquaculture. To control disease we must also build our knowledge base of disease processes and the pathogenic organisms involved.

We carry out research on viral diseases including infectious salmon anaemia (ISA), pancreas disease (PD), heart and skeletal muscle inflammation (HSMI), cardiomyopathy syndrome (CMS) and salmon pox (SGPVD). In addition, we perform research in the fields of intestinal health, multi-factorial gill disease and parasitic infections such as amoebic gill disease (AGD) and parvicapsulosis. While vaccination has dramatically improved control of bacterial infections in farmed salmon, bacterial diseases such as winter ulcer and yersiniosis continue to cause problems.

Working towards increased control of HSMI

Heart and skeletal muscle inflammation (HSMI) is an infectious viral disease of farmed salmon which results in inflammation and necrosis in the heart. A variant of this disease is also found in rainbow trout. The disease is caused by *Piscine orthoreovirus* (PRV). The Norwegian Veterinary Institute's research activity on PRV includes studies relating to genetic variation and virulence differences between PRV-variants, effective disinfection methods, measures to reduce spread of infection and vaccine development.

Increasing knowledge of Salmon pox

Salmon pox is a pox virus which causes gill disease in salmon. Salmon gill pox (SGPV) was characterised by the Norwegian Veterinary Institute in 2015. The disease often has a drastic course in hatcheries with high associated mortalities. Salmon held in the sea may also be affected. The Norwegian Veterinary Institute is currently leading two research projects on salmon pox, one of which focuses on increasing our understanding of the disease and development of infection models, while the second generates knowledge on tracing and control of salmon pox in practical aquaculture.

Atypical winter ulcer in farmed salmon

Tenacibaculosis, or atypical winter ulcer caused by *Tenacibaculum*, has recently emerged as a serious disease in Norwegian salmonid aquaculture. The epidemiology of tenacibaculosis may, however, be complicated, and the relative contribution of environmental, management and bacterial factors remains unknown. The Norwegian Veterinary Institute leads a project aimed at identification of risk factors for outbreak of tenacibaculosis, identify and characterize toxins that cause the clinical symptoms, and test whether anti-toxin antibodies can protect against the disease.

Diseases of cleaner fish

Aeromonas salmonicida is a well-known bacterial fish pathogen, and very effective vaccines are available for farmed salmon. However, *A. salmonicida* is one of the primary causes of mortality in cleaner fish today.

In a current post-doc project (2016–2019), we now investigate the basis of the host-specificity displayed by various genetic types of *A. salmonicida*. In lumpsucker, the single-celled parasite *Nucleospora cyclopteri* is associated with severe histopathological changes, and there are indications that the parasite may transmit from the parent generation to the offspring. In a newly established project (FHF 2017–2018) the Norwegian Veterinary Institute will, in collaboration with industry partners, establish more knowledge of this parasite and its significance as a pathogen of farmed lumpsucker.

Corkwing wrasse.
Photo: Snorre Gulla

Current Projects related to diseases of fish:

Project: *Tenacibaculum* spp. as a cause of atypical winter ulcer on Norwegian farmed salmon

- Goal: To increase the knowledge of tenacibaculosis in Norwegian farmed salmon.
- Expected value: Identification of risk factors for the development of tenacibaculosis, which may enable initiation of measures to avoid outbreaks. Toxin characterization and vaccination experiments based on cell cultures will provide a basis for further vaccine development
- Period: 2017–2019
- Project leader: Duncan John Colquhoun, Norwegian Veterinary Institute
- Collaborative partners: Norwegian Reseach Centre AS (NORCE; previously IRIS)
- Finance: The Norwegian Seafood Research Fund (FHF)

Project: Infections with the tapeworm *Eubothrium* sp. in fish farms in Norway: resistance, propagation and impact on fish health

- Goal: Increase the knowledge of tapeworm infestations in Norwegian aquaculture, and create a knowledge base for further research that can contribute to better combating such infestations
- Expected value: 1) New knowledge of a parasite that is an increasing problem in Norwegian aquaculture, but has not been the subject of studies for many years. 2) Detailed basis for further development of new treatment methods and medications against the parasite
- Period: 2017–2019
- Project leader: Haakon Hansen, Norwegian Veterinary Institute
- Collaborative partners: Marine Harvest, VESO, University of Bergen, Norway, Skretting AS, Lerøy AS:
- Finance: The Norwegian Seafood Research Fund (FHF)

Project: Characterisation of PRV – Inactivation and virulence

- Goal: To generate knowledge which may reduce the impact of PRV in the aquaculture industry.
- Expected value: The project aims to identify whether different strains of PRV vary in virulence and ability to cause HSMI, to identify disinfection routines against PRV and find out whether current egg disinfection routines sufficiently inactive PRV.
- Period: 2017–2020
- Project leader: Øystein Wessel, Norwegian University of Life Sciences
- Project contact at Norwegian Veterinary Institute: Maria Dahle
- Other collaborative partners:
- Finance: The Norwegian Seafood Research Fund (FHF)

Project: Cardiomyopathy syndrome (CMS) in Atlantic salmon

- Goal: Study of the pathology, pathogenesis and epidemiology of cardiomyopathy syndrome in salmon
- Expected value: Knowledge of disease development with the aim of prevention of this disease.
- Period: 2016–2018
- Project leader: Camilla Fritsvold, Norwegian Veterinary Institute
- Finance: Ministry of Food and Fisheries (NFD)

Project: Geographic range and importance of ISA-virus to the Norwegian farmed salmon population

- Goal: Map the presence of low virulent/HPRO-variants of ISA-virus in salmon and rainbow trout in Norwegian aquaculture with a particular focus on harvest ready fish.
- Expected value: Investigate a non-lethal method for sampling of mucus from gills and skin surfaces for screening of low virulent HPRO ISA-virus and establish a standardised infection model for virulence evaluation.
- Period: 2016–2019
- Project leader: Knut Falk, Norwegian Veterinary Institute
- Collaborative partners: University of Valparaiso, Chile, CEFAS, UK, Food and Veterinary Agency, Faroe Islands, Technical University of Denmark (DTU), Marine Scotland-Science
- Finance: The Norwegian Seafood Research Fund (FHF) and private companies

Project: Infectious salmon anaemia virus (ISAV) – uptake and early infection

- Goal: Investigate the site of infection for ISAV and characterise uptake and spread of the virus in salmon as well as the immune responses related to early stages of infection
- Expected value: Increase knowledge of the pathogenesis of ISA.
- Period: 2016–2019
- Project leader: Maria Aamelfot, Norwegian Veterinary Institute
- Finance: Research Council of Norway (RCN)

Project: ISAV vs RBCs – Interactions between infectious salmon anaemia virus and red blood cells in salmon and their role in pathogenesis of infectious salmon anaemia

- Goal: Characterise and document the interactions between ISAV and RBC in salmon, characterise virus-RBC-complexes in vitro and the immune responses related to these interactions.
- Expected value: Increase knowledge of the pathogenesis of ISA
- Period: 2017–2020
- Project leader: Knut Falk, Norwegian Veterinary Institute
- Finance: Research Council of Norway (RCN)

Project: Pan-genome analysis of the fish pathogen *Aeromonas salmonicida* with focus on genetic determinants for host specificity

- Goal: To survey the pan-genome and populations structure of *A. salmonicida*, particularly in relation to the observed association between A-layer type and host fish species.
- Expected value: *A. salmonicida* is an extremely important fish pathogenic bacteria on a worldwide basis and for several farmed species effective vaccines have not yet been developed. Findings generated during the current project should provide a better knowledge base for improved control of this disease and allow development of improved vaccines for e.g. cleaner fish.
- Period: 2016–2019
- Project leader: Snorre Gulla, Norwegian Veterinary Institute
- Finance: Research Council of Norway (RCN)

Project: Parasitic infection of lumpsucker: *Nucleospora cyclopteri*

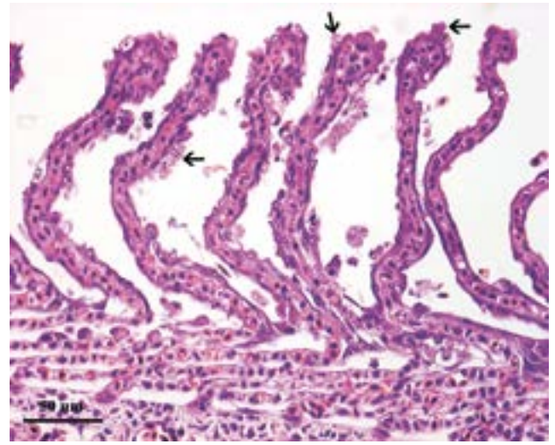
- Goal: Generate new knowledge on a little known parasitic infection of lumpsucker including mapping the geographical range, importance of different modes of transmission and establishment of infection models and improved diagnostics.
- Expected value: Improved diagnostics will benefit the industry in general. Establishment of infection models is important for studies involving infection, immunology and development of treatment regimes and vaccines. Identification of infection routes is important for development of procedures for disinfection of eggs.
- Period: 2017–2018
- Project leader: Haakon Hansen, Norwegian Veterinary Institute
- Collaborative partners: Institute of Marine Research, PatoGen Analyse AS
- Finance: The Norwegian Seafood Research Fund (FHF)

Project: Understanding salmon pox virus disease; an emerging threat for Atlantic salmon farming (SALPOX)

- Goal: Establish tools necessary to understand salmon pox disease
- Expected value: Create a basic knowledge base for control of salmon pox disease
- Period: 2017–2018
- Project leader: Mona Gjessing, Norwegian Veterinary Institute
- Collaborative partners: Marine Harvest, Sisomar, National Institutes of Health USA, USGS (USA)
- Finance: Research Council of Norway (RCN)

Project: Salmon pox – tracing infection in fish and environmental samples, disinfection of farms and possible vertical transmission

- Goal: To establish knowledge necessary to allow control of salmon pox virus in juvenile salmon production until and including the post-smolt phase in seawater
- Expected value: To reduce the impact of salmon pox in affected groups and increase knowledge around sea-transfer of infected smolt populations, as this infection may have a negative effect on smoltification and display negative synergies with other established infectious agents during the sea phase of culture. Taken together this will provide better fish welfare and more predictable and profitable production.
- Period: 2016–2018
- Project leader: Britt Tørud, Norwegian Veterinary Institute
- Collaborative partners: Pharmaq Analytic, Marine Harvest, SalMar, Åkerblå, Sisomar, Trøndersmolt
- Finance: The Norwegian Seafood Research Fund (FHF)



Stained gill tissues from wild Norwegian salmon infected with salmon gill pox virus. The arrows indicate dead and sloughing respiratory cells. Photo: Mona Gjessing

Project: Standardisation of AGD-gill scoring – Unified gill-scoring based on experimental and field data

- Goal: Develop further and adapt the current AGD-scoring system to Norwegian conditions, whilst making the system more objective and fit for purpose as a tool for 1) evaluation of treatment effect and 2) distinguishing AGD-related injuries from non-AGD related injuries.
- Expected value: An improved gill scoring system will provide a better basis for evaluation of AGD-outbreak management, whether outbreaks should in fact, be treated and when treatments should be performed. This will reduce the risk of unnecessary treatment against AGD. A unified gill-scoring will also increase the 'portability' of practical experiences between farms and regions.
- Period: 2017–2018
- Project leader: Sigurd Hytterød, Norwegian Veterinary Institute
- Collaborative partners: Industrilaboratoriet (ILAB) AS og FoMAS – Fiskehelse og Miljø AS
- Finance: The Norwegian Seafood Research Fund (FHF)

Project: Triploid salmon: Susceptibility to infectious diseases

- Goal: To identify whether triploid salmon have the same susceptibility as diploid salmon to diseases of relevance for Norwegian aquaculture.
- Expected value: If triploid salmon are more susceptible to infectious diseases this will result in increased mortality and possibly increased spread of infectious agents from farm to farm. The welfare and economic consequences for the industry can therefore be significant. The results generated in this project will enable the industry and the authorities to make qualified decisions regarding use of triploid salmon in Norwegian aquaculture.
- Period: 2015–2018
- Project leader: Hilde Sindre, Norwegian Veterinary Institute
- Collaborative partners: Institute for Marine Research
- Finance: The Norwegian Seafood Research Fund (FHF)

Project: Testing of salmon feed at Nordfjord Research Station

- Goal: Establish histology-morphology based methods for evaluation of intestinal health
- Expected value: The ability to identify and quantify the effects of feed components on intestinal health will allow systematic improvement of feeds and evaluation of new feed components.
- Period: 2017–2020
- Project leader: Ole Bendik Dale, Norwegian Veterinary Institute
- Finance: Nordfjord Research Station

Recently termimated projects related to diseases of fish

Project: Proliferative Gill Disease in Atlantic salmon

- Goal: Study of the pathology and pathogenesis of proliferative gill disease in salmon
- Expected value: Knowledge of disease development with the aim of prevention of this disease.
- Period: 2016–2017
- Project leader: Mona Gjessing, Norwegian Veterinary Institute
- Finance: Research Council of Norway (RCN)

Project: The importance of HPR0-variant of ISA-virus for outbreaks of ISA

- Goal: To describe the mechanisms related to transition of HPRO/low virulent HPR-deletions to highly virulent HPR-deleted ISA-virus.
- Expected value: Identify genetic markers which describe and allow identification of the developmental stages between HPRO and highly virulent HPR deleted ISAV.
- Period: 2015–2017
- Project leader: Edgar Brun, Norwegian Veterinary Institute
- Collaborative partners: University of Valparaiso, Chile, CEFAS, UK, Food and Veterinary Agency, Faroe Islands, Technical University of Denmark (DTU), Marine Scotland-Science
- Finance: The Norwegian Seafood Research Fund (FHF) and private companies

Project: Yersiniosis in recirculation farms for salmon: Tracing infection, biofilm studies and disinfection

- Goal: To establish knowledge on *Yersinia ruckeri* related to problems in recirculation based farms.
- Expected value: Identify infection routes and identify critical factors in recycling based farms related to spread/development of disease combined with increasing knowledge related to eradication of infection. The project should provide a basis for increased profitability in the industry.
- Period: 2015–2017
- Project leader: Duncan John Colquhoun, Norwegian Veterinary Institute
- Finance: The Norwegian Seafood Research Fund (FHF)

Project: PRV-PROTect – Studies of piscine orthoreovirus (PRV)-infection in Norwegian salmon farming

- Goal: To prevent HSMI and identify the effectiveness of measures introduced to reduce transmission of infection of PRV and development of HSMI.
- Expected value: Development of tools and strategies for mapping of PRV-infection, origin of infection and effect on fish health. This will contribute to a more robust and sustainable aquaculture industry.
- Period: 2014–2017
- Project leader: Vidar Aspehaug, PatoGen
- Project contact at Norwegian Veterinary Institute: Maria Dahle
- Other collaborative partners: Norwegian University of Life Sciences (NMBU)
- Finance: Research Council of Norway (RCN)

Project: Gill disease in Atlantic salmon- study of multiple factors in infection models (MultifacGillhealth)

- Goal: Establish infection models for different agents which may be of importance for development of gill disease and to study multi-factorial interactions
- Expected value: Knowledge of disease development relating to gill inflammation and prevention of disease.
- Period: 2014–2017
- Project leader: Anne-Gerd Gjevre, Norwegian Veterinary Institute
- Finance: Research Council of Norway (RCN)

Project: Parvicapsula pseudobranchicola: Increase knowledge and reduce losses

- Goal: To increase knowledge about the parasite and to take measures to reduce losses related to disease outbreak of *P. pseudobranchicola*
- Expected value: Identification of the primary host of *P. pseudobranchicola* will be the key to prophylactic measures against the parasite, as well as the development and testing of pharmaceuticals
- Period: 2013–2017
- Project leader: Øyvind Jakobsen Brevik, Cermaq
- Contact person at the Norwegian Veterinary Institute: Haakon Hansen
- Collaborative partners: University of Bergen, Institute of Marine Research, Lerøy AS, Grieg Seafood Finnmark AS
- Funding source: The Norwegian Seafood Research Fund (FHF)

The amoeba *Paramoeba perurans* which causes amoebic gill disease (AGD) changes shape following treatment with hydrogen peroxide (H_2O_2) and fresh water. The ability to change shape is probably important in enabling the amoeba to attack gill tissues. Photo: Jannicke Wiik-Nielsen

‘Blue Food’ – Safety and production

There is an increasing worldwide demand for aquaculture food products. This increasing demand creates pressure on existing production systems, which may lead to problems with disease, hygiene, food-safety and biosecurity. Norway, as a leading aquaculture nation, must continue to maintain the highest production standards whilst helping other countries with developing aquaculture industries to produce healthy fish and safe food.

The Norwegian Veterinary Institute has for many years focused on the food-safety aspect of aquaculture products. The risks associated with seafood safety may be associated with contamination by zoonotic pathogens such as *Salmonella*, *Escherichia coli* and *Listeria monocytogenes*. Expansion of Norwegian aquaculture is dependent on exploitation of new, sustainable protein resources for fish feeds, as marine resources are limited. This has also risks involved for seafood safety as plant ingredients may contribute to contamination of fish feeds.

Rapid identification and control of *Listeria*

Listeria monocytogenes can multiply in high salt concentrations, even at refrigerator temperatures with or without oxygen. It is an extremely resilient bacterium and can survive in industrial facilities for many years independent of disinfection routines. Listeriosis in humans is uncommon but serious for those infected as many infections are often serious, lead to hospital admission and may be fatal. At the Norwegian Veterinary Institute we are working towards development of rapid detection of *L. monocytogenes* at lower concentrations than standard methodologies. In cooperation with the industry we are also developing new tools and products which will allow identification, reduction or elimination of *Listeria* from work surfaces, instruments and biofilm.

Are feedstuffs of relevance for seafood safety?

The Scientific Committee for Food-Safety (VKM) has recently indicated, in a recent report, that plant-based fish feed may contain contaminants which could be carried over into the consumable portion of the fish, and thus represents a risk for consumer safety. The Norwegian Veterinary Institute leads a project on this topic. The project studies the potential effects on fish physiology and transmission of substances from feed to fish. The project focuses on transmission of three typical plant components with potential implications for consumer safety i.e. plant peptides, fungal toxins and hormone like molecules.

Photo: Colourbox

Current projects related to food-safety and food production in the blue sector:

Project: Advancing global strategies and understanding on the origin of ciguatera fish poisoning in tropical oceans (PIRE)

- Goal: Contribute to 1) increased understanding of the chemistry behind ciguatera fish poisoning and 2) improved management strategies through characterisation of the metabolome of *Gambierdiscus species*, structural studies of ciguatoxins (CTXs) and immunological methods for the detection of CTXs.
- Expected value: Increased knowledge of, and new analysis tools for, ciguatoxins and their metabolites in ciguatera poisoning provides the foundation for better management strategies.
- Period: 2018–2022
- Project leader: Alison Robertson, University of South Alabama & Dauphin Island Sea Lab, USA
- Project contact at Norwegian Veterinary Institute: Silvio Uhlig
- Collaborative partners: National Research Council (NRC, Canada), Florida Gulf Coast University (USA), Woods Hole Oceanographic Institute (USA), University of the Virgin Islands (USA), University of Texas Marine Sciences Institute (USA), Center for Environmental Studies of Cienfuegos (Cuba), City University of Hong Kong (China), Heriot-Watt University (Scotland) and Center for Marine Ecosystems Research (Australia)
- Finance: Research Council of Norway (RCN-BILAT) and National Science Foundation (NSF), USA

Prosjekt: Enhanced biorefining methods for the production of marine biotoxins and microalgae fish feed (MARBioFEED)

- Goal: Develop biorefining methods for the preparation of reference materials of marine algal toxins to make them available, as we as the production of microalgal supplements as fish feed.
- Expected value: The project will contribute with enhanced biorefining methods and prepare standards for EU-regulated marine algal toxins biotoxins requiring statutory monitoring in shellfish for the European market. In addition will a fish feed supplement be produced.
- Period: 2016–2019
- Project leader: Jane Kilcoyne, Marine Institute in Ireland
- Project contact at Norwegian Veterinary Institute: Ingunn A. Samdal
- Collaborative partners: Instituto Espanol de Oceanografia (IEO), Neoalgae Microseaweed products, Spain and National Research Council (NRC) in Canada
- Finance: Research Council of Norway (RCN; Marine Biotech (ERA-MBT))

Project: The first rapid and precise method for detection of *Listeria monocytogenes* (SensiList)

- Goal: Develop a rapid method/kit for precise detection and/or quantification of *Listeria monocytogenes*
- Expected value: SensiList is approximately 100 times more sensitive than today's standard detection method. This opens for possible recall of products from the market on detection of *Listeria* in the production facility. This will result in less wastage and increased food safety. Both production companies and their customers will gain rapid and better information as the analysis starts as soon as samples are taken. The method will also give more precise data for surveillance programmes and a better basis for risk analysis.
- Period: 2016–2018
- Project leader: Kjeller Innovasjon
- Project owner: Norwegian Veterinary Institute og Kjeller Innovasjon
- Contact person at Norwegian Veterinary Institute: Taran Skjerdal
- Finance: Research Council of Norway (RCN), Forny 2020

Photo: Colourbox

Project: Implications of green fish feed for consumer safety – transmission of plant peptides, natural toxins and bioactive molecules (SafeFish)

- Goal: Transmission of components (mycotoxins, isoflavons, peptides) from plant based fish feeds to the edible parts of the fish
- Expected value: Risk evaluation of plant based fish feeds for consumers
- Period: 2016–2019
- Project leader: Christiane Kruse Fæste, Norwegian Veterinary Institute
- Collaborative partners: North University (UiN), Nofima, University of Oslo (UiO), Haukeland University Hospital, Bergen, University of Colorado, Denver, USA (UoD)
- Finance: Research Council of Norway (RCN)

Project: PRV and melanin in salmon fillets

- Goal: Analyse existing production data for identification of any relationship between PRV and melanin spots in salmon fillets.
- Expected value: Melanin deposition in salmon fillets is one of the most significant quality related problems in salmon production. Identification of the causative factors will save the industry large sums.
- Period: 2017–2018
- Project leader: Edgar Brun, Norwegian Veterinary Institute
- Collaborative partners: Marine Harvest, Bremnes Seashore, NOFIMA
- Finance: The Norwegian Seafood Research Fund (FHF)

Project: Bacterial load and risk assessment related to *Listeria monocytogenes* in specific foodstuffs

- Goal: Perform studies to determine the growth potential and growth rate of *L. monocytogenes* in specific foodstuffs
- Expected value: The data forms the basis for industry risk assessment and adaptation of internal control to ensure food safety for its own products
- Period: Continual from 2014
- Project leader: Taran Skjerdal, Norwegian Veterinary Institute
- Finance: National and international industry

Recently terminated projects related to food-safety and food production in the marine sector:

Project: New sustainable products for control of *Listeria monocytogenes* in the aquaculture industry (InhibioList)

- Goal: Develop new, sustainable products for control of *Listeria monocytogenes* in biofilm in the aquaculture industry
- Expected value: In addition to development of new products, the project will identify and characterise persistent Listeria strains in fish harvest facilities. The project will also test the effect of different, currently used disinfectants on Listeria in biofilm.
- Period: 2015–2017
- Project leader: Live Nesse, Norwegian Veterinary Institute
- Collaborative partners: Inhibio AS (Project owner)
- Finance: Research Council of Norway (RCN) and industry

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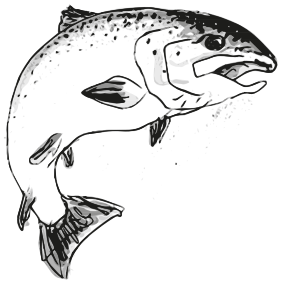

NO HEALTH - NO GROWTH!

We take fish health to a new level

Medlem i NCE AQUATECH CLUSTER

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