



An Epidemiological study of CMS:
Transmission, risk factors and disease development
in Norwegian salmon farming

Funded by the Norwegian Seafood Research Fund



Veterinærinstituttet
Norwegian Veterinary Institute

Project goal

- ▶ To increase knowledge on spread of PMCV and factors influencing development of CMS
- ▶ Specific aims:
 - ▶ Is PMCV transmitted from broodstock to ongrowing fish under normal production?
 - ▶ Map the course of PMCV infection in the sea
 - ▶ Identify risk factors for infection with PMCV
 - ▶ Identify risk factors for development of CMS
 - ▶ Literature review
 - ▶ Advise farmers on best practise for prevention and control



Cardiomyopathy Syndrome (CMS)
in Atlantic salmon

Litterature review

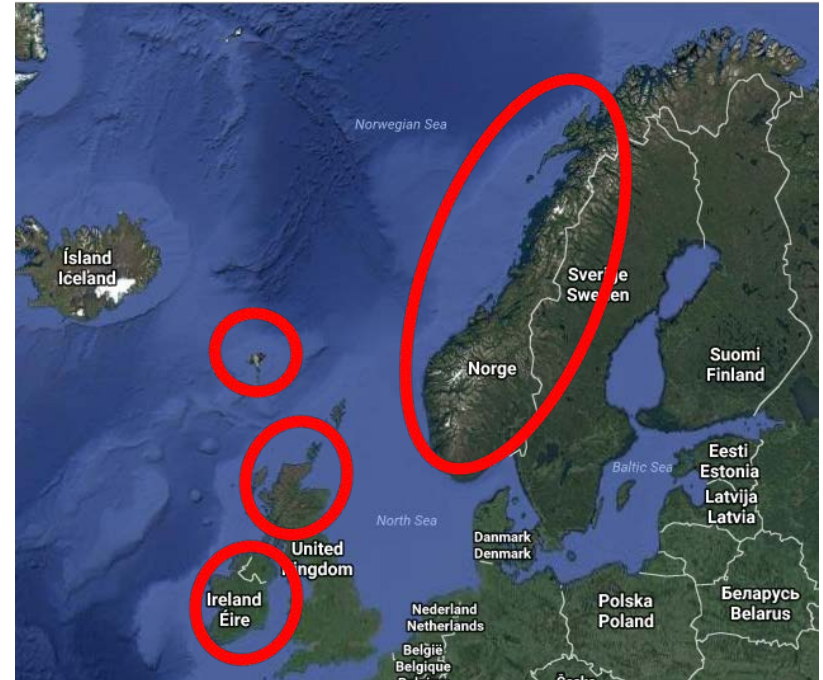
Overview of presentation

- ▶ The CMS-Epi project
- ▶ CMS - Cardiomyopathy syndrome
- ▶ PMCV – piscine myocarditisvirus
- ▶ Epidemiology
 - ▶ Occurrence
 - ▶ Reservoirs
 - ▶ Transmission
 - ▶ Risk factors
- ▶ Prevention and control
- ▶ Economy
- ▶ Knowledge gaps



CMS - cardiomyopathy syndrome

- ▶ Disease in Atlantic salmon
- ▶ Occurrence
 - ▶ Norway (100 + cases/year)
 - ▶ Scotland
 - ▶ Ireland
 - ▶ Faroe Islands
- ▶ Onset and course of disease:
 - ▶ Typically second year in sea, but also earlier
 - ▶ Sudden high mortality or prolonged period of raised mortality
- ▶ Considerable welfare issue
- ▶ Significant economic impact



CMS – clinical signs

- ▶ None or signs of lethargy
- ▶ Signs of circulatory failure
 - ▶ Protruding eyes (Exophthalmia)
 - ▶ Ventral skin bleedings
 - ▶ Raised scales
- ▶ Internal findings
 - ▶ Ascites
 - ▶ Blood clots in the pericardial cavity.
 - ▶ Enlarged or ruptured atrium and/or sinus venosus = «Hjertesprekk»
 - ▶ Discoloured liver with fibrinous casts



Photo: Per Anton Sæther,
MarinHelse AS

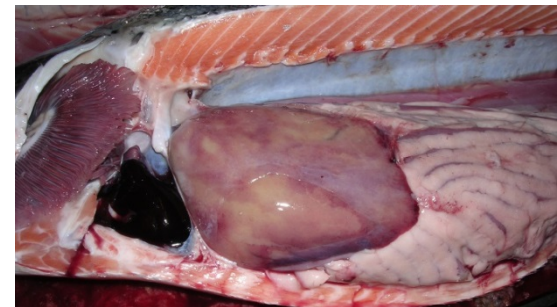
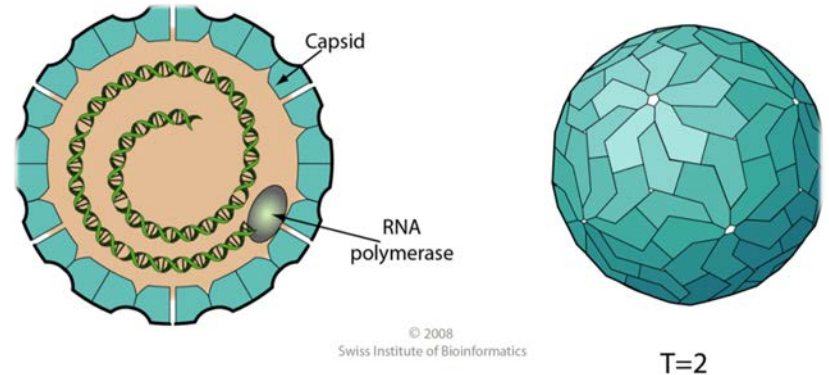


Photo: Brit Tørud,
Norwegian Veterinary Institute

PMCV – piscine myocarditis virus

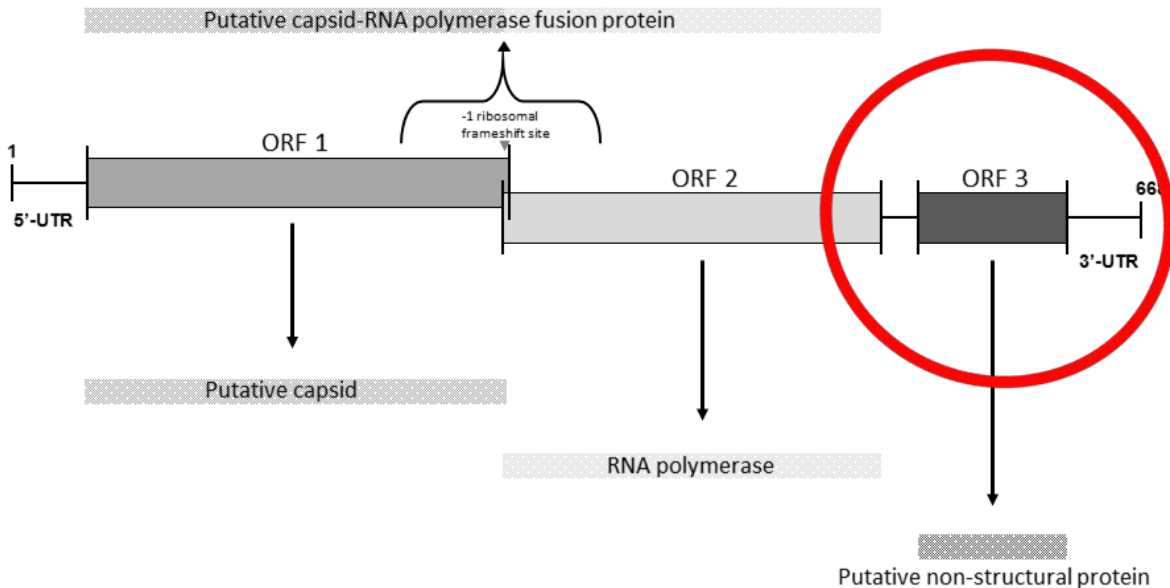
- ▶ RNA-virus
- ▶ Similarities with *Totiviridae* family
 - ▶ A family that:
 - ▶ Infects protozoan parasites and fungi
 - ▶ Are transmitted with cell division, sporogenesis or cell fusion
- ▶ Size: ~50nm
- ▶ Structure:
 - ▶ Non-enveloped («naked»)
→ likely very resistant
 - ▶ Spherical
- ▶ Biophysical properties:
 - ▶ Unknown



Totiviridae

*Illustration: Swiss Institute of Bioinformatics (SIB)
used with permission*

PMCV – genome



*Illustration: Aase B. Mikaelson
NMBU*

- ▶ 6.688bp
- ▶ Three open reading frames (ORF1, ORF2 and ORF3)
- ▶ ORF3: Exclusive for viruses infecting vertebrate hosts
 - ▶ Research is focused on the ORF3

PMCV – genetic variation

- ▶ Homogenous population in Norway (one genogroup)
- ▶ Most divergent:
98.6% nucleotide identity
- ▶ PMCV from Atlantic argentine had 86% nucleotide identity
- ▶ Virulence factors:
 - ▶ Three positions on the ORF3 has been suggested

*Illustration: Åse Helen Garseth
Norwegian Veterinary Institute*



PMCV – genetic variation

- ▶ Homogenous population in Norway (one genogroup)
- ▶ Most divergent: 98.6% nucleotide identity
- ▶ PMCV from Atlantic argentine had 86% nucleotide identity
- ▶ Virulence factors:
 - ▶ Three positions on the ORF3 has been suggested

Illustration: Åse Helen Garsethe, NVI



CMS & PMCV – diagnostic tools

- ▶ The CMS diagnosis is based on:
 - ▶ Clinical observations and autopsy
 - ▶ Histopathology
 - ▶ Differential diagnosis: PD and HSMI

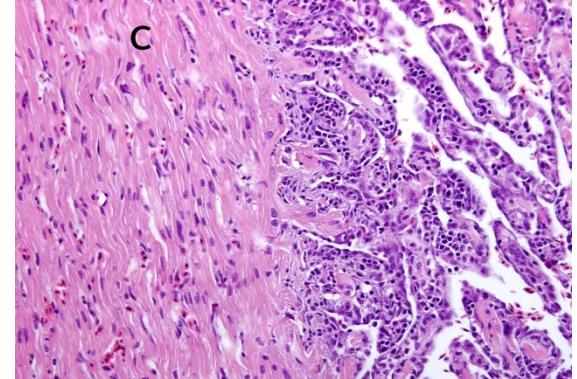


Photo: Trygve Poppe

- ▶ PMCV specific real-time PCR:
 - ▶ High correlation between virus load and pathological changes
 - ▶ Widely used for screening
 - ▶ Patent by Pharmaq Analytiq

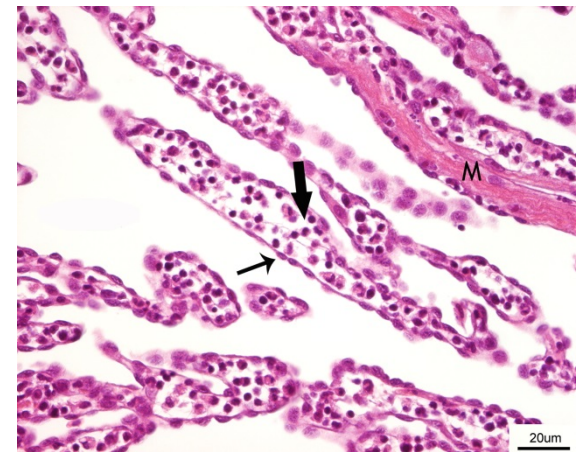


Photo: Camilla Fritsvold,
Norwegian Veterinary Institute

CMS & PMCV – diagnostic tools

▶ In situ hybridization:

- ▶ Detects virus specific nucleic acids in fish tissue with histopathological changes

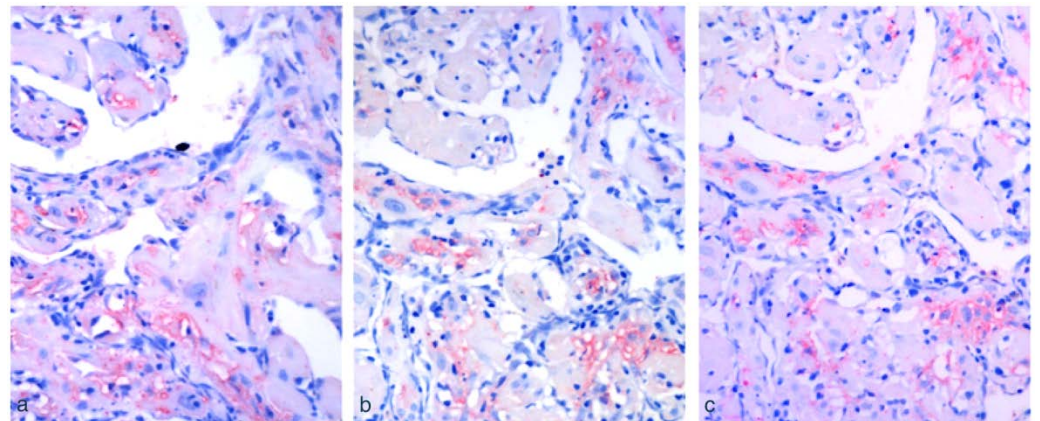
▶ Immunohisto chemistry (IHC):

- ▶ Detects PMCV specific proteins
- ▶ Not available for routine use due to lack of antibodies

▶ Cell culture:

- ▶ PMCV replicates in fish cell lines, but at too low levels, and too weak CPE.

Immunohisto chemistry detects PMCV specific proteins by the use of labelled antibodies
Photo: Gulla *et al.* 2012



CMS & PMCV - epidemiology

▶ Reservoir:

- ▶ Farmed Atlantic salmon
- ▶ Diagnosed in a few wild salmon
- ▶ Found in escapees
- ▶ Recently found in cleaner fish in Ireland
- ▶ Not found in environmental samples, but in mucus, faeces and salmon lice in infected cage

▶ Transmission routes:

- ▶ Horizontal transmission
- ▶ Vertical transmission is under investigation

▶ Risk factors:

- ▶ Time in sea
- ▶ Size of population
- ▶ Infection pressure (CMS in neighbouring farms and distance)
- ▶ CMS in previous cohorts
- ▶ HSMI



*A virus sharing 86 % nucleotide identity with PMCV has been found in Atlantic Argentine
Photo:Wikipedia*

CMS - prevention and control



- ▶ **Biosecurity**

- ▶ All-in all-out, disease free stock, cleaning and disinfection

- ▶ **Screening**

- ▶ For early detection, before movement of fish

- ▶ **Husbandry**

- ▶ Reduce stress, early slaughter

- ▶ **Vaccination**

- ▶ Pharmaq is working on a vaccine

- ▶ **Breeding**

- ▶ High heritability for resistance. QTL-selected eggs are available

- ▶ **Feed**

- ▶ Lower lipid content and higher Ω -3/ Ω -6 ratio (PUFAs)
- ▶ Effect demonstrated in trials



CMS - economic impact

- ▶ > 100 cases per year
- ▶ Direct loss ~4.5-8.8 million € in 2002
- ▶ Estimated loss in 2007: ~25 million €

(Not including costs for prevention and extra labour)



Photo: Trygve Poppe



Photo: Per Anton Sæther, MarinHelse

Knowledge gaps

▶ PMCV:

- ▶ Characterize proteins that are coded for by the virus RNA
- ▶ Understand mechanisms for infection and replication in the host
- ▶ Develop cell culture technique

▶ CMS:

- ▶ Pathogenesis
- ▶ Factors that trigger disease development in infected fish
- ▶ Can infected fish get rid of virus?

▶ Transmission, prevention and control

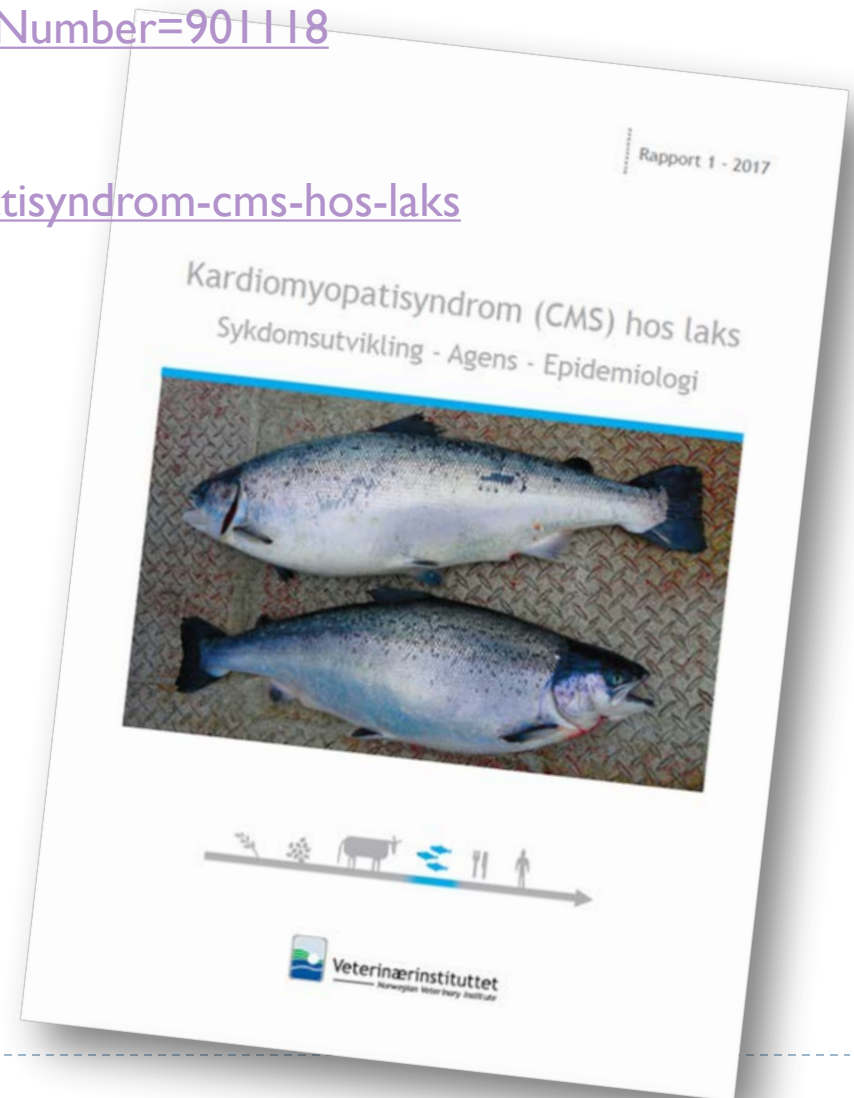
- ▶ Can PMCV be transmitted vertically?
- ▶ Virus reservoir (beyond the farmed salmon)
- ▶ Does transmission with smolt from freshwater phase have any importance?



Read more about CMS and the project

<http://www.fhf.no/prosjektdetaljer/?projectNumber=901118>

<https://www.vetinst.no/rapporter-og-publikasjoner/rapporter/2017/kardiomyopatisyndrom-cms-hos-laks>



Thank you for the attention!



Britt Bang Jensen, NVI
Julie Christine Svendsen, NVI
Åse Helen Garseth, NVI
Aase B. Mikalsen, NMBU
Camilla Fritsvold, NVI