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

Funded by the Norwegian Seafood Research Fund

marineharvest LEROY SALMAR Passion for Salmon CERMAQ PHARMAQ Analytiq 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

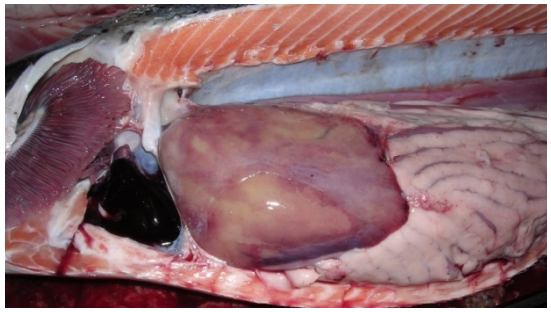
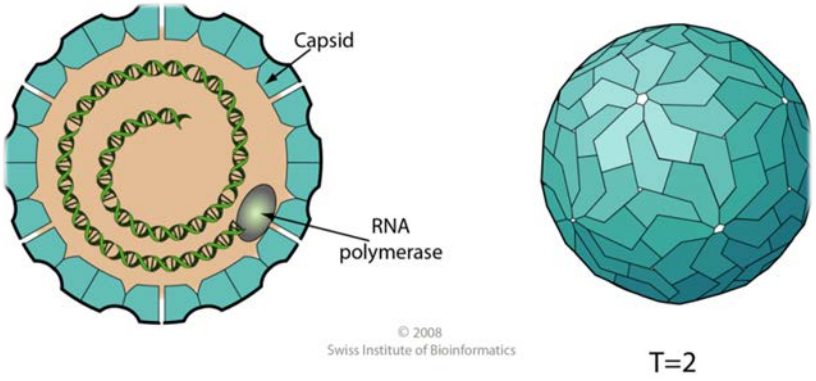


Photo: Brit Tørud, Norwegian Veterinary Institute

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 proporties:
  - Unknown



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

PMCV – genome

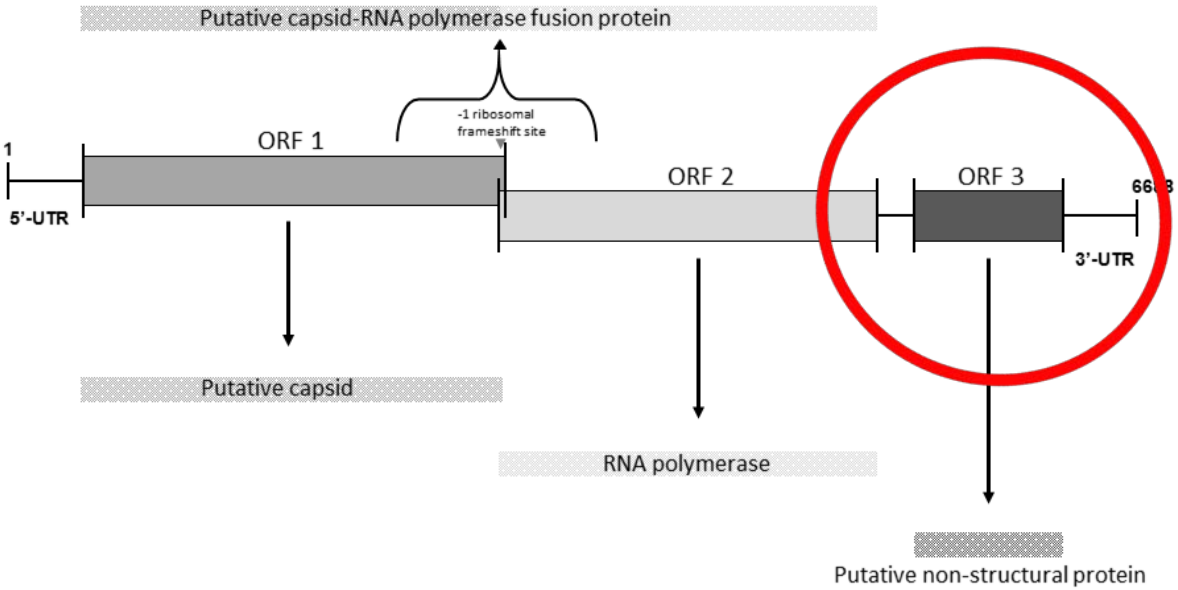


Illustration: Aase B. Mikaelsen NMBU

- 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

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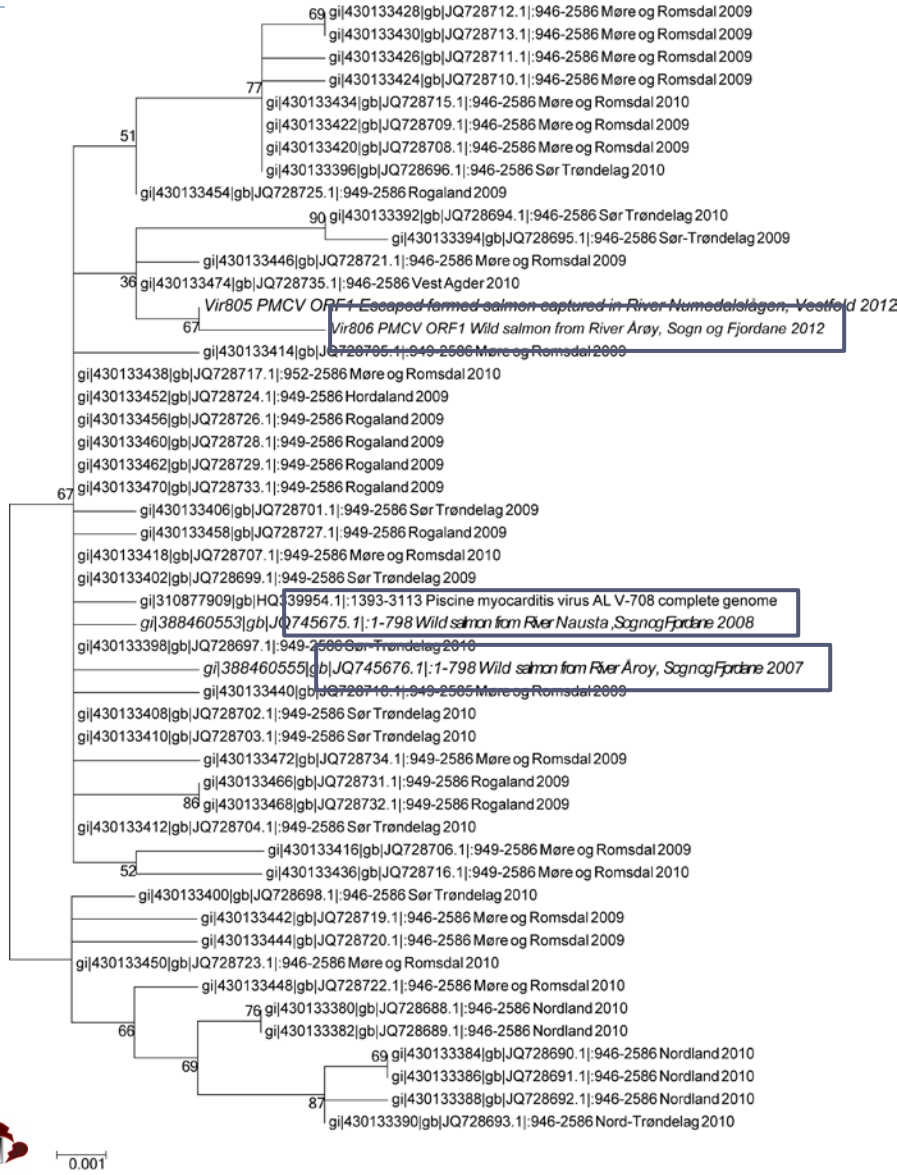


Illustration: Åse Helen Garsethe, NVI

CMS & PMCV – diagnostic tools

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

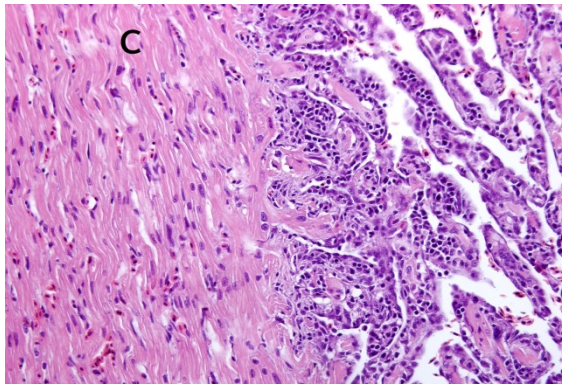


Photo: Trygve Poppe

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

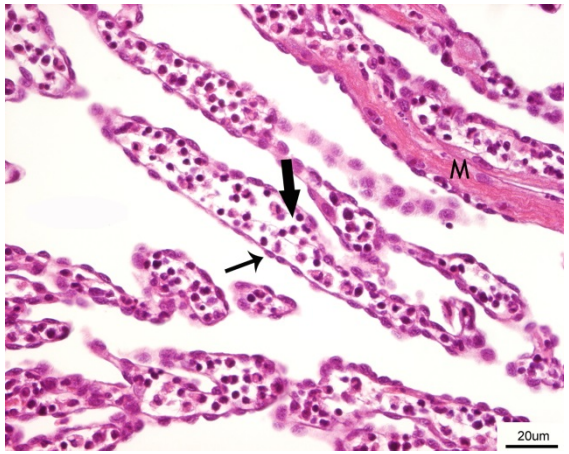
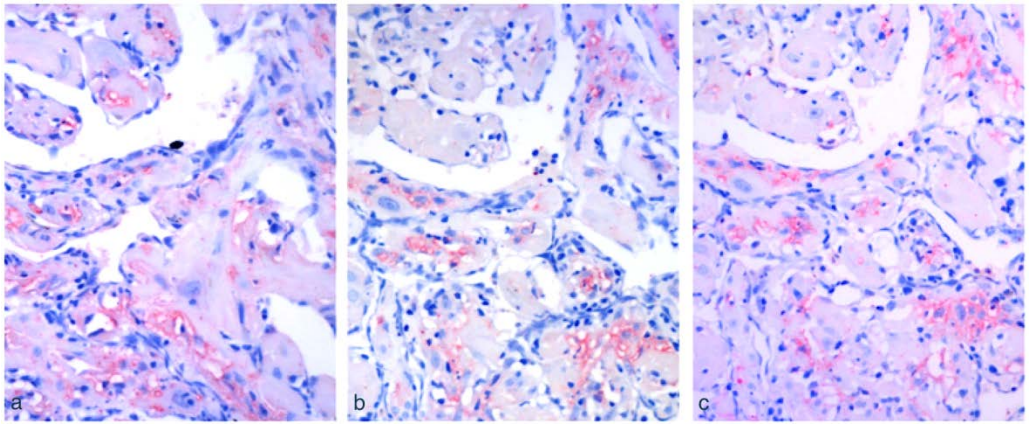


Photo: Camilla Fritsvold, Norwegian Veterinary Institute

CMS & PMCV – diagnostic tools

- In situ hybridization:
  - Detects virus specific nucleic acids in fish tissue with histopathological changes
- Immunhisto 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.



Immunhisto 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

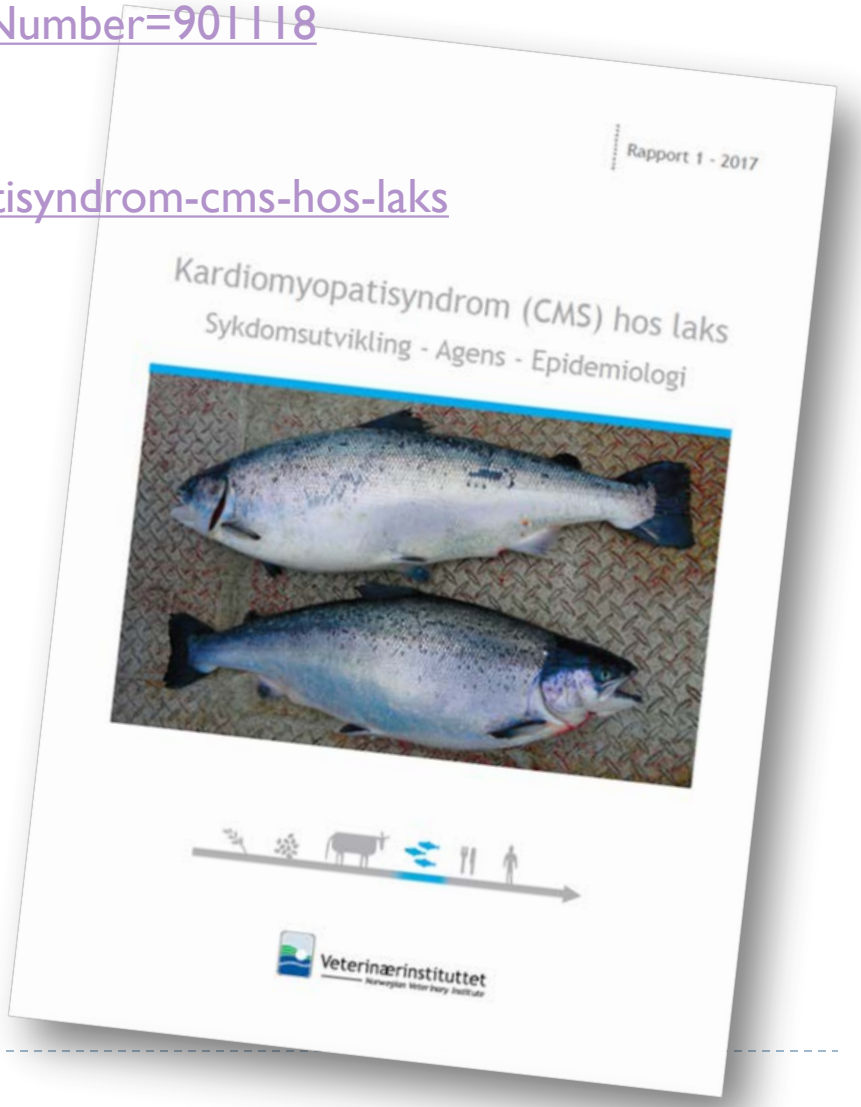
Knowledge gaps

- 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