Prevention, Detection and Control of Diseases in Closed Containment Systems: Results from Projects in CtrlAQUA SFI

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sfi Senter for forskningsdrevet innovasjon
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Dept. Preventive Fish Health

- **Inventions to prevent, detect and control disease in closed containment systems (CCS)**
  - Strengthen fish robustness and disease resistance with focus on barrier functions and cardiovascular capacity.
  - Strengthen pathogen control and handling of disease outbreaks in CCS.
  - Develop new or refined vaccines and protocols for pathogens representing a special threat in CCS.

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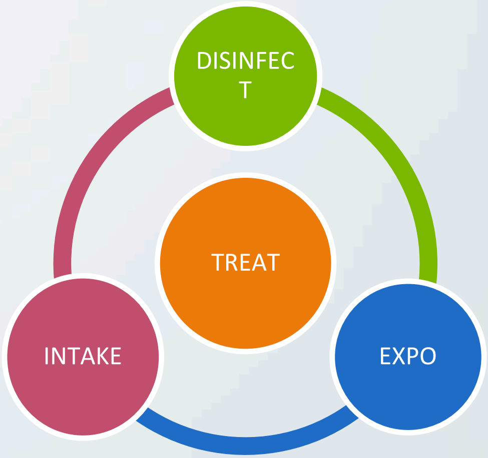
TREAT: Treatment strategies in CCS/RAS: Impacts on system performance, water quality, biosecurity and fish health (PL Carlo Lazado, Nofima)

- Collates all tasks related to water/system treatment

- Main objective:

Generate an integrative understanding on how different water/system treatment strategies affect CCS/RAS and the fish reared in the systems

- Tasks:
  - INTAKE
  - EXPO (Presentation by J Davidson)
  - **DISINFECT**



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Task DISINFECT: Disinfection strategies in RAS (TL Carlo Lazado)

- No standard procedures available for disinfection in land-based production systems
- Efficacy of strategies used not fully documented.

Goal: Develop knowledge based standard protocols for efficient disinfection

A. Collation of current knowledge – comparison Norway and USA

B. Survey in two parts (Norway):

- Part A: Materials and Equipment
- Part B: Water and Biofilter

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Cont DISINFECT

Findings survey A and B:

- Majority of RAS facilities have in-house protocols
    - Disinfection efficacy not verified

Desinfection of materials and equipment:

- Peroxide-based disinfectants (mainly peracetic acid) most often used

Cont DISINFECT

Activities 2019:

- Standardization of disinfection protocols for materials and equipment

- Experiments to document the effect of different water disinfection protocols on:

  - biofilter performance
  - water quality
  - fish health

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PREVENTIVE: Improved disease prevention, pathogen detection and immune prophylaxis in CCS (PL Lill-Heidi Johansen, Nofima)

- Hypothesis: optimal water velocity in CCS/RAS is a rational strategy for enhancing fish growth and health and robustness traits through aerobic exercise effects.

- Trial 2018:
  - Test effects of low to very high water velocities on Atlantic salmon smolts in RAS
    - Evaluation of growth, muscle development, schooling behavior and welfare

Task CARDIO: Identify optimal water velocity for post-smolts in RAS (TL Gerrit Timmerhaus)

- Setup
  - RAS facility, Nofima Sunndalsøra
  - 12 x 3.2 m^3 tanks, 3 repl/ treatment group
  - 200 fish/ tank (total 2400 fish)
  - Density 5 kg/m^3 at beginning of trial
  - Constant 12° C, 12 ppt salinity

- Four constant water velocities:

-Low (L):	0.5 body length (BL)/ second (s)
-Medium (M):	1.0 BL/s
-High (H):	1.8 BL/s
-Very high (VH):	2.5 BL/s

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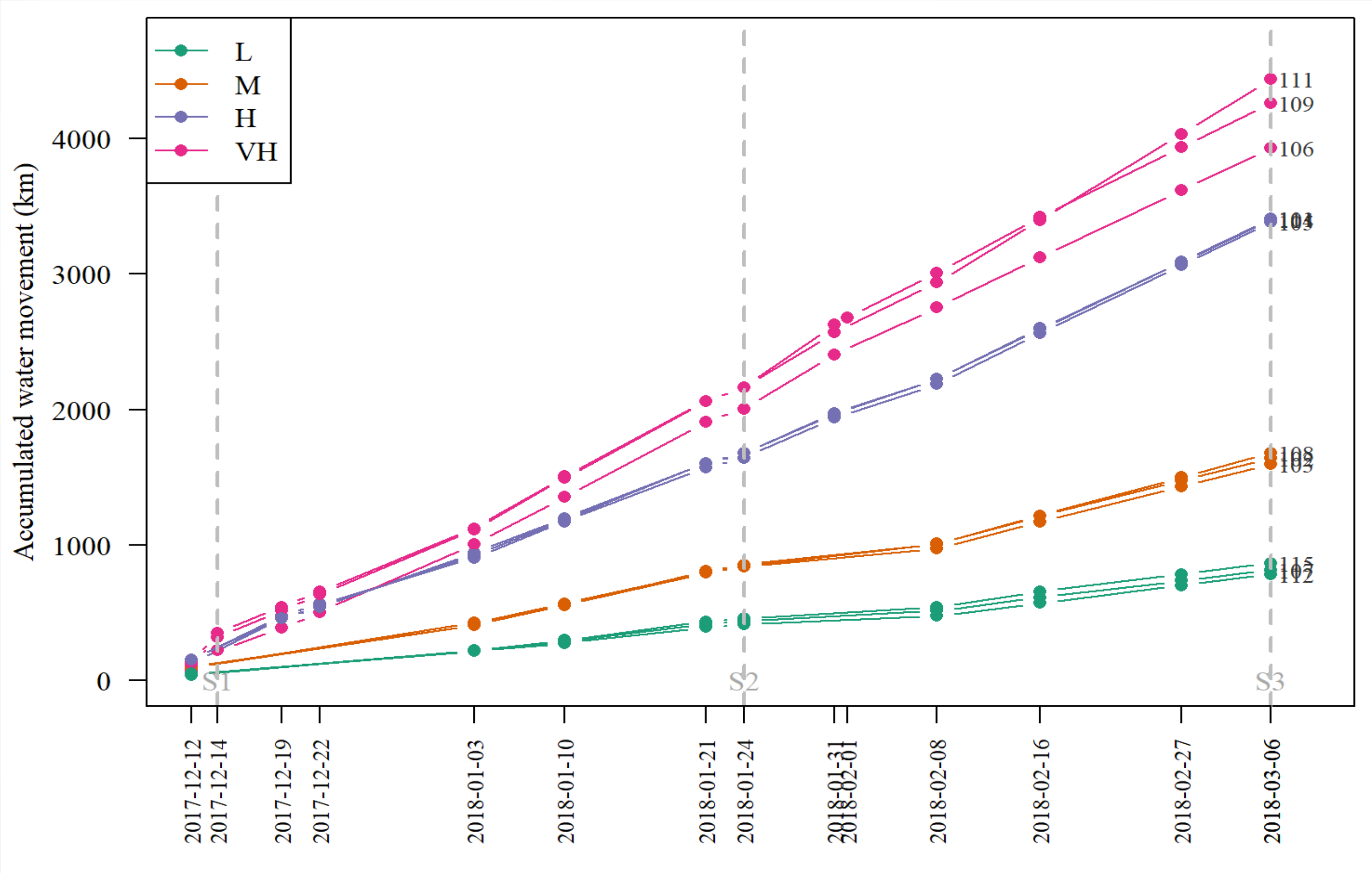
Water movement in the tanks

- Adjustments to keep constant velocity in tanks throughout experiment
    - Accumulated movement throughout the 3 months trial period



Swimming distance in 3 months:

VH group **~4000 km**

L group ~700 km

Growth: correlated to velocity

- Sampling after 3 months
- Close to linear growth rate increase with higher water velocities
- Length increase of **L group**:

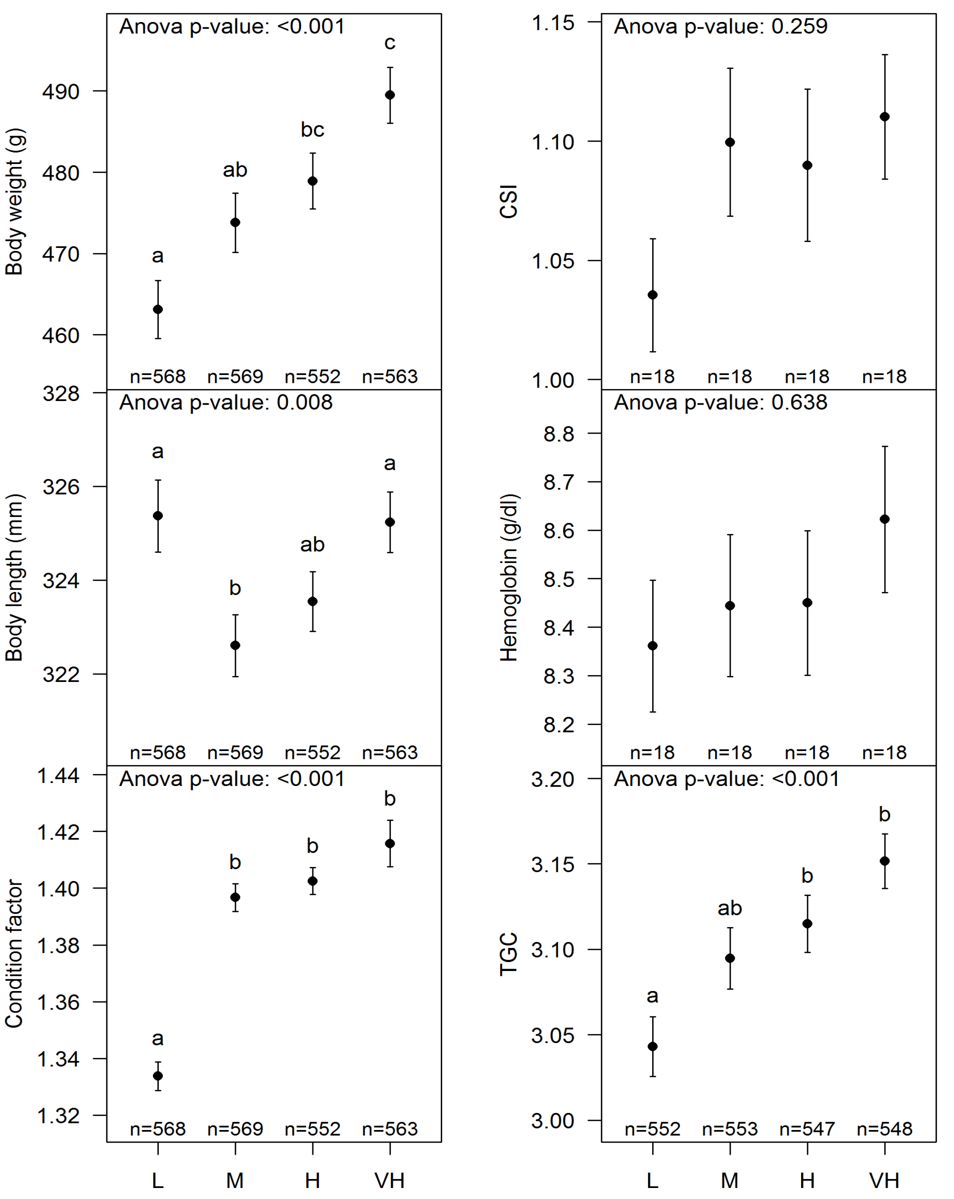
  - increase in length but not in body weight

- Condition factors:

  - fish grew more “massy” in H and VH groups
    - remained relatively slim in L group

- Hemogobin and CSI:

  - trend to higher values in higher velocities



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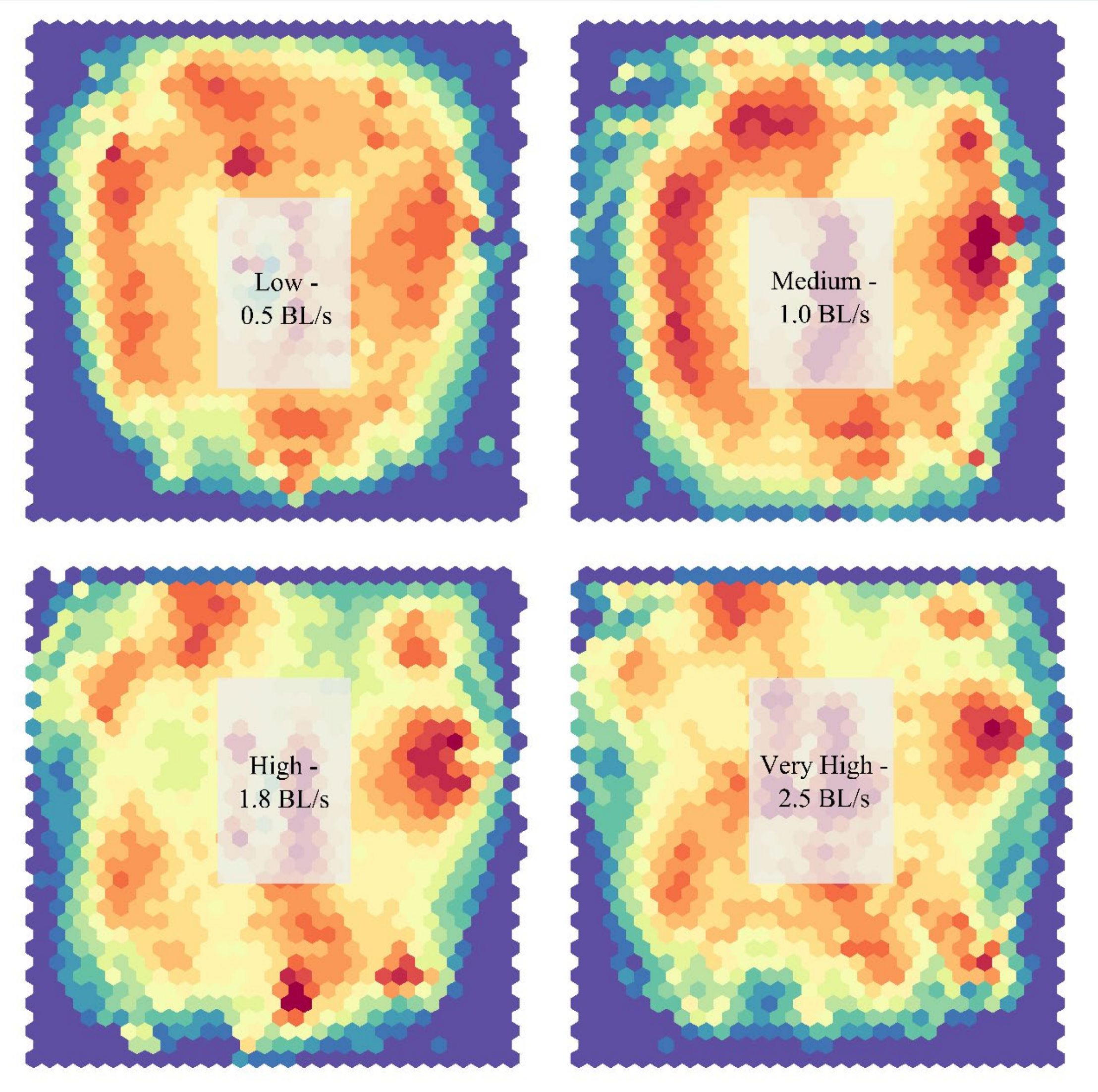
Fish positioning in the tanks at different velocities

- Counted fish positions in the triplicate tanks:
  - Fish distributed relatively evenly in the tanks at L and M velocities
  - Locally higher densities of fish at higher speeds (H and VH)

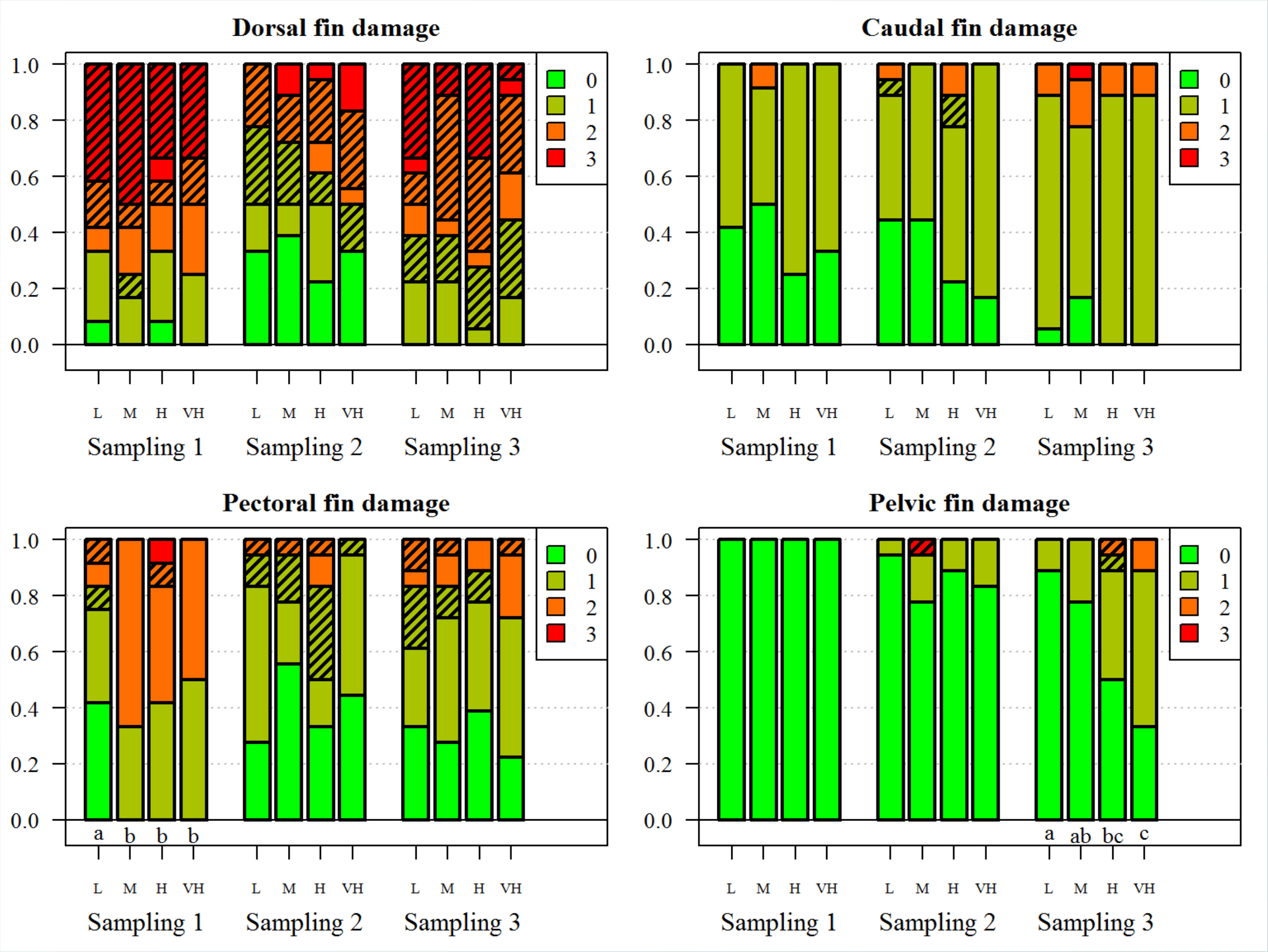
    → schooling

      – possible increase of territorial tension/interaction?



Welfare score: Minor differences between groups

- No/minor differences for dorsal and caudal fins
- L had lowest pectoral fin damage S1, 6 days post transfer
  - No difference S3, after 3 months
- More pelvic fin damage in higher speeds, but not severe
  - Effects of schooling?



Shaded: healed, unshaded: active

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Cardio: summary

- Close to linear correlation in fish growth and water velocity;
  - **Fish in higher velocities grew bigger (weight and K)**
- Highest tested water speed so far;
  - optimum velocity remains unclear –
    - may not have reached the highest beneficial velocity
- Fish form denser groups in higher velocities
  - → increase in social interaction/territorial concurrency?
- Pay-off in pelvic fin damages vs. higher growth, however low score damages

MICROPARASITES in semi-closed containment systems (S-CCS)

(PL Are Nylund, University of Bergen)

Project objectives:

To identify and characterize the most important known and emerging microparasites in CCS and S-CCS.

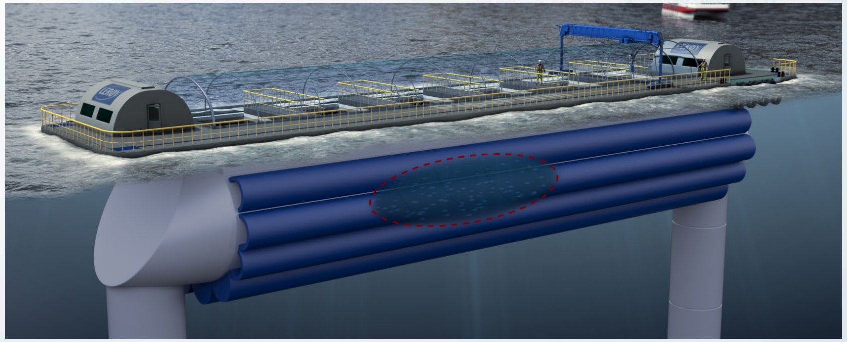
a) mapping of diversity, prevalence and load

b) mapping of transmission routes (introduction into CCS and S-CCS)

c) identification & characterization of emerging pathogens

Pathogens in S-CCS

- *Hypothesis:* Use of S-CCS will not affect the diversity, prevalence and load of parasites compared to open production systems at the sea.
- Focus on viruses that can be present in smolt before sea transfer.
- Four different productions followed in Preline and Neptun S-CCS and reference: open net pens.



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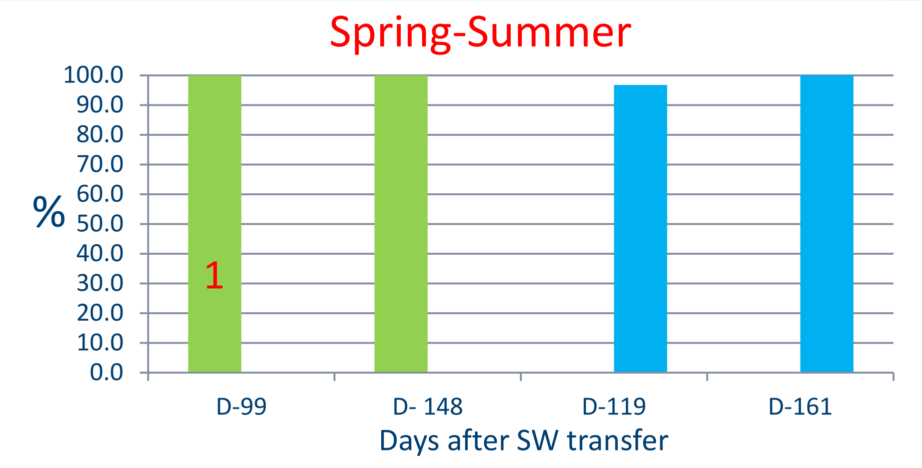
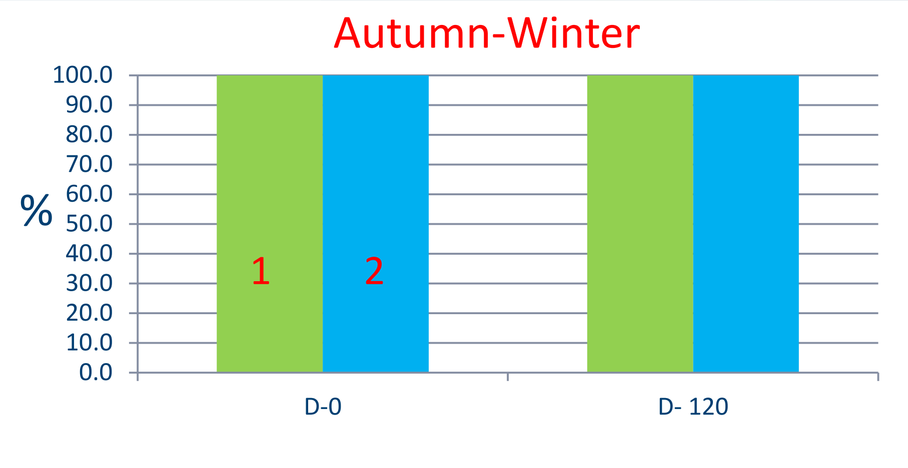
PRV (Piscine orthoreovirus/HSMI) Prevalence

S-CCS (green) **Control** (blue)

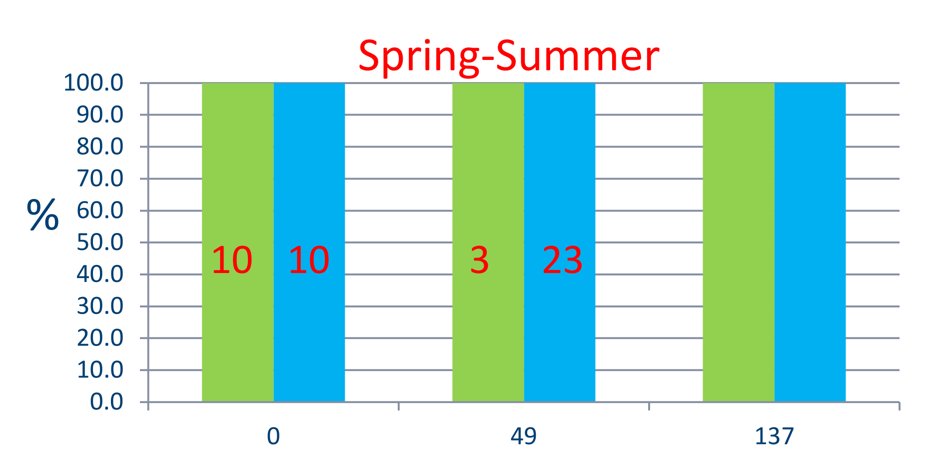


Production - 1

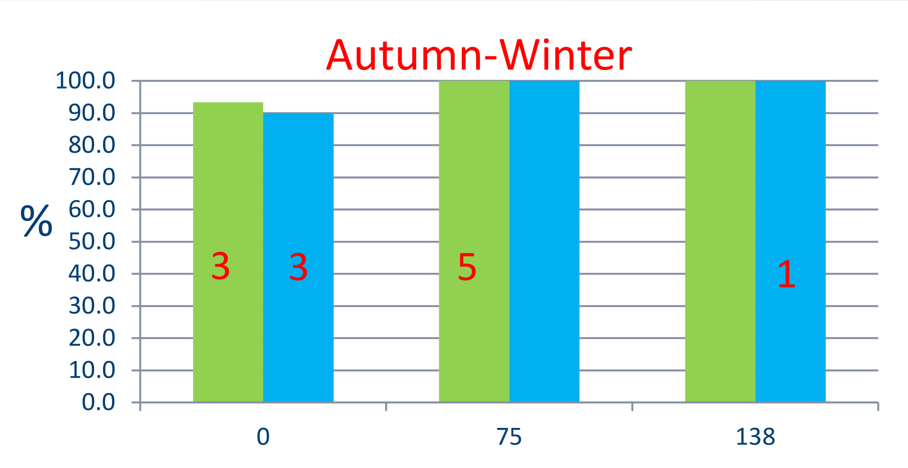


Production - 2

D-0 = smolt before SW transfer
N=30



Production - 3



Production - 4

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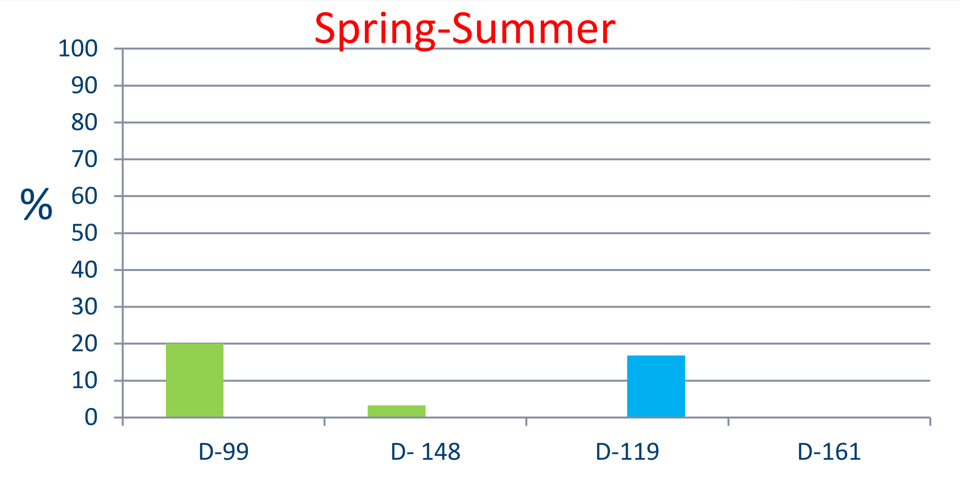
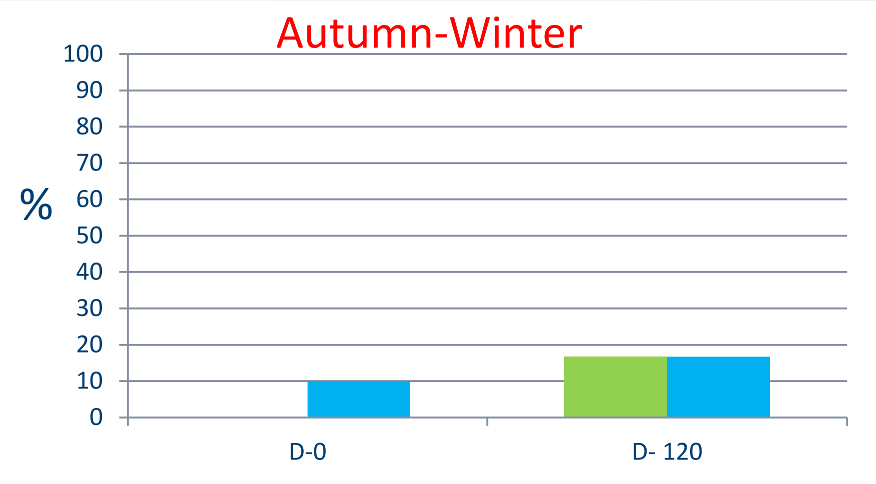
IPNV (Infectious pancreas necrosis virus/IPN) Prevalence

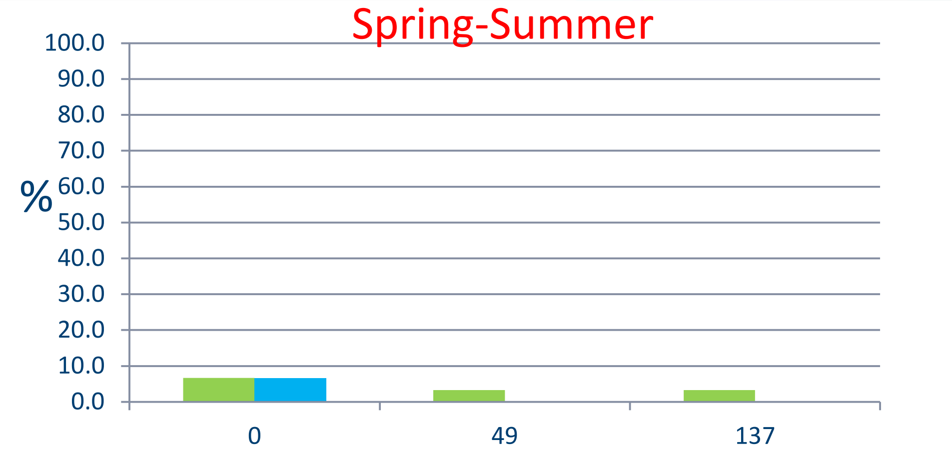
S-CCS ■ Control ■



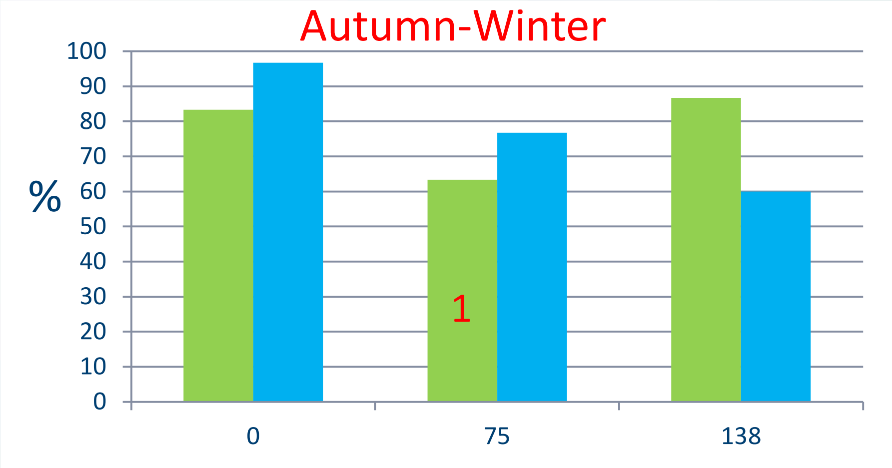
Production - 1



Production - 2



Production - 3



Production - 4

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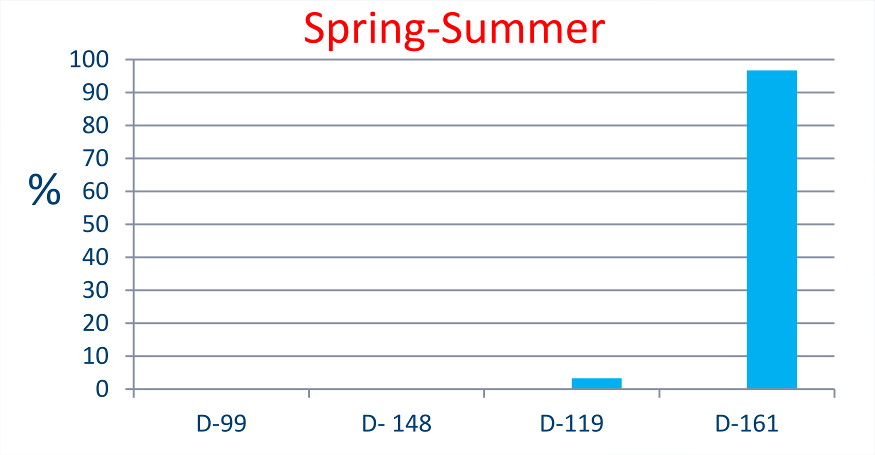
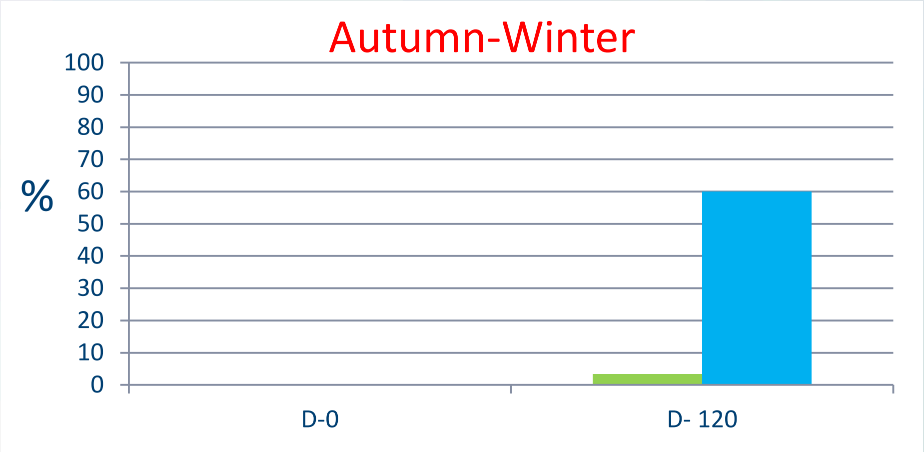
ISAV (Infectious salmon anaemia virus/ISA) Prevalence

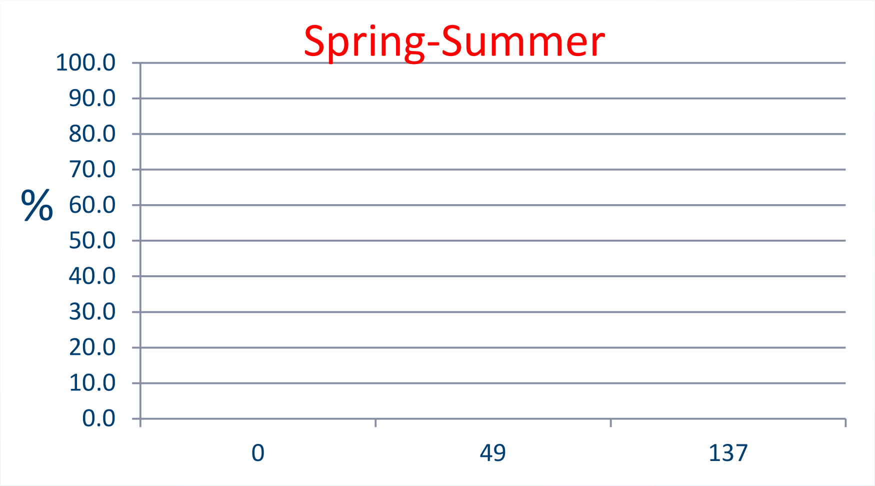
S-CCS **Control**



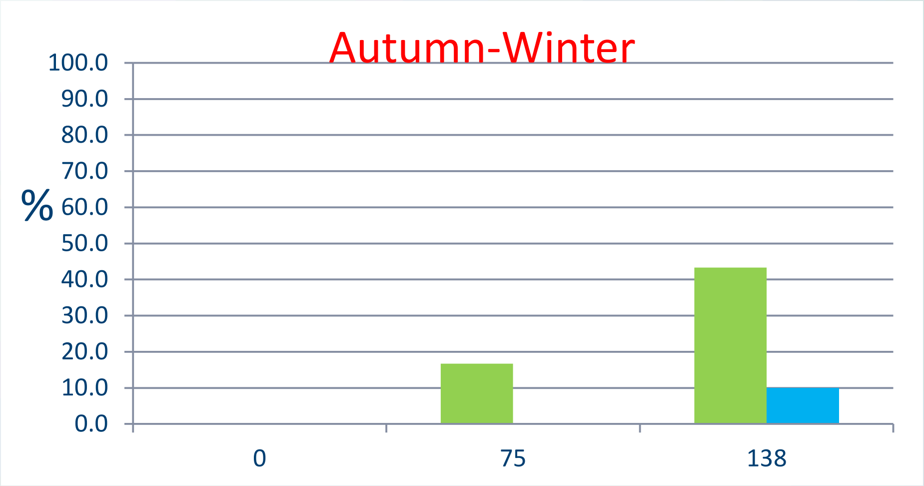
Production - 1



Production - 2



Production - 3



Production - 4

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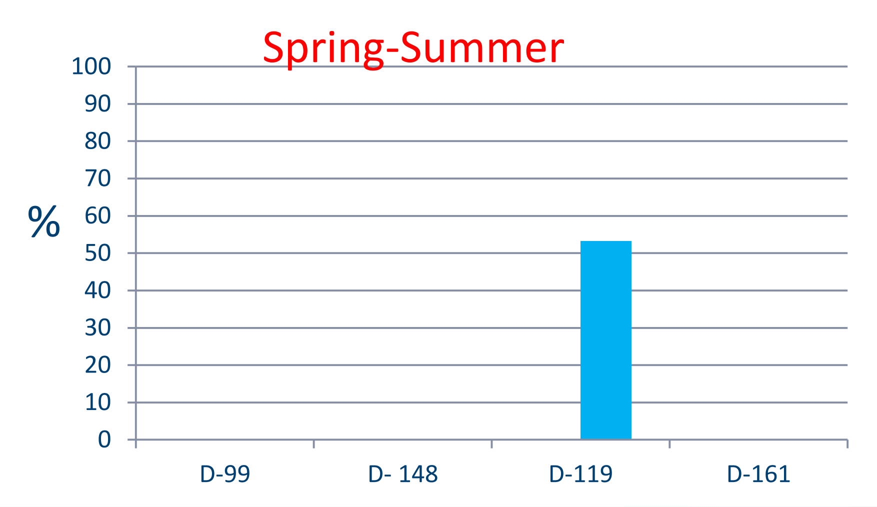
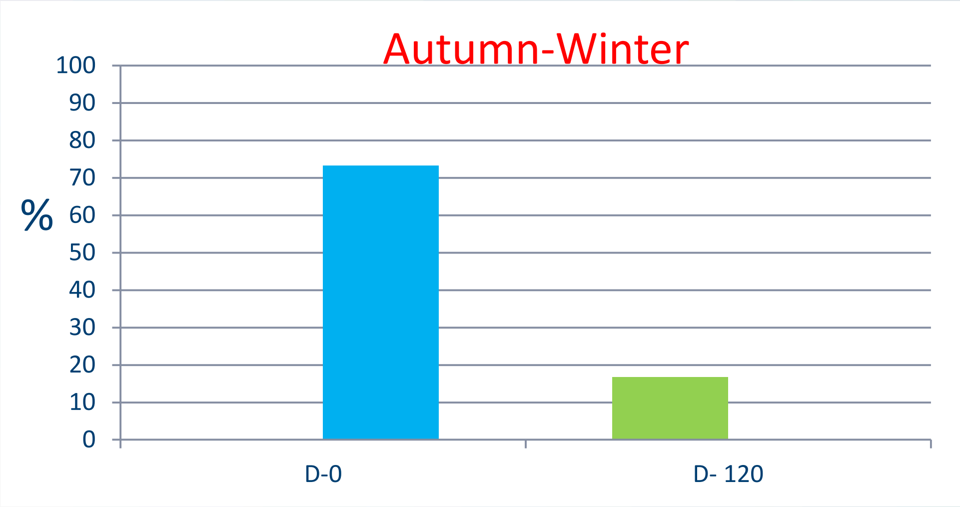
SGPV (Salmon gillpoxvirus/Gillpox) Prevalence

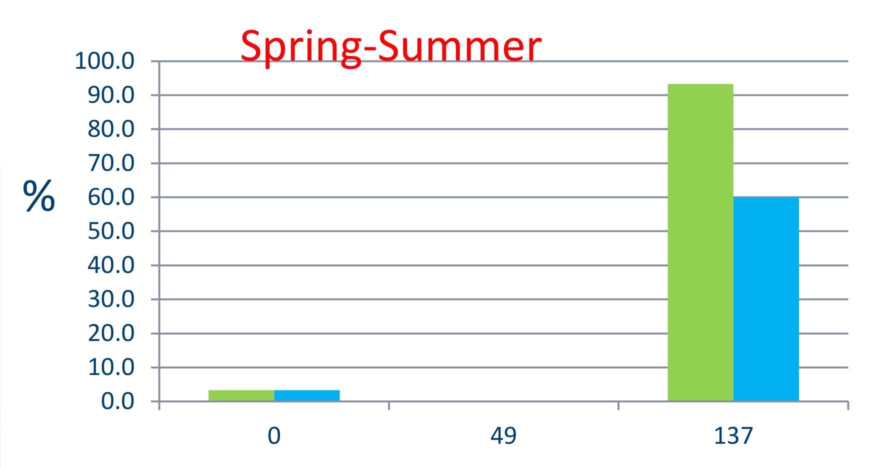
S-CCS **Control**



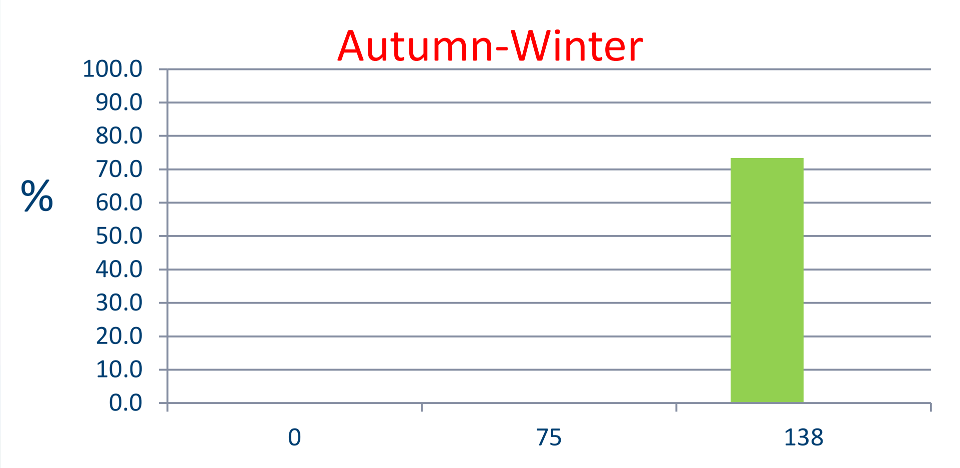
Production - 1



Production - 2



Production - 3



Production - 4

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Viruses & CCS

- **Few pure marine salmon viruses**
  - Vertical transmission (IPNV, PRV, ISAV ++?)
  - Introduction from smolt in fresh water
  - Direct transmission in sea water
  - Introduction through water intake

- **Important**
  - Horizontal transmission within the cage will be dependent on the water exchange rate

Preliminary conclusions

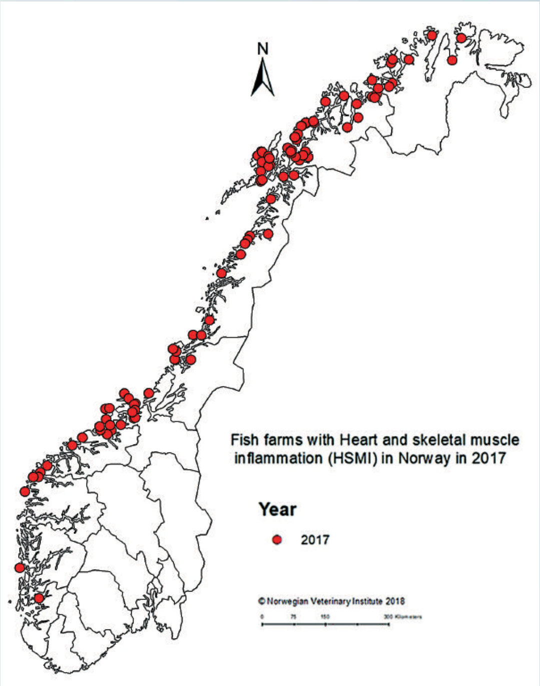
- Use of S-CCS do not seem to have a negative effect on the prevalence of microparasites compared to open production systems.
- Use of S-CCS may prevent introduction of microparasites transmitted horizontally in the sea.
  - Microparasites follow with the fish into the system

PRV (Heart and sceletal muscle inflammation)

- Found in farmed salmon and wild salmonid - and non-salmonid fish species in several countries, including Canada and USA

- Until recently: only connected to disease in farmed fish (mainly in sea)
- in Norway.
  - could be due to genetic differences in virus and fish

  - Di Cicco et al. 2017: first farm-level diagnosis of HSMI in BC (also documented in Chile)



- In Norway;
  - HSMI develop if the fish is stressed due to handling procedures etc.
  - Limited success in attempts to remove PRV from land-based facilities
    - disinfection strategy unknown

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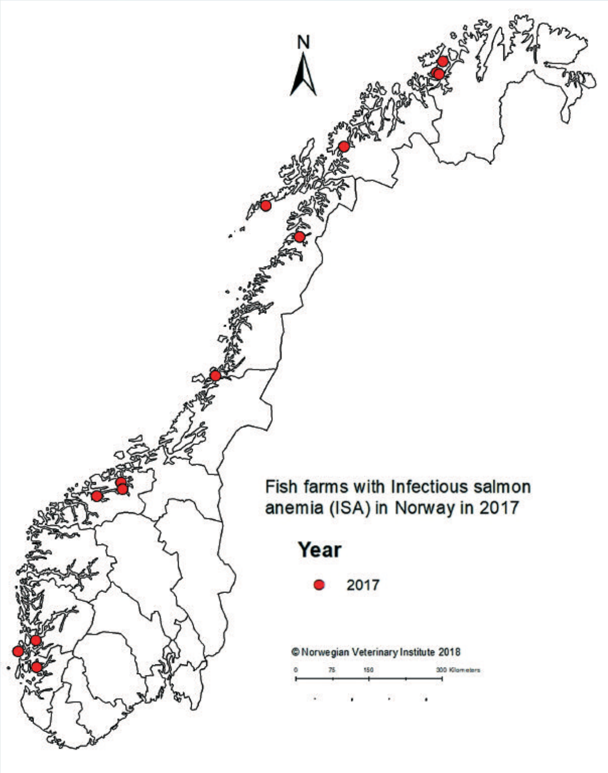
ISAV (Infectious salmon anaemia)

May be present in land-based facilities

-not detected in the screenings performed by Are Nylund and co-workers.

- Outbreaks are rare in land-based facilities
  - A few incidents in Norway (related to intake of seawater?)
  - The avirulent virus type is most prevalent
    - may mutate to the virulent type, causing ISA



Vertical transmission

- Strongly suspected that ISAV, IPNV and PRV are vertically transferred,
    - the direct evidence in A. salmon is lacking.

- The transfer may still happen indirectly from parents to offspring
    - The viruses are very difficult to remove completely from the surface of the eggs
        - Offspring may then be infected at hatching.

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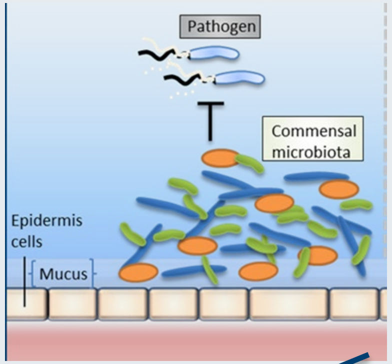
BARRIER: Primary epithelial function and health – changes in immune competence and susceptibility to diseases. (PL Christan Renè Karlsen, Nofima)

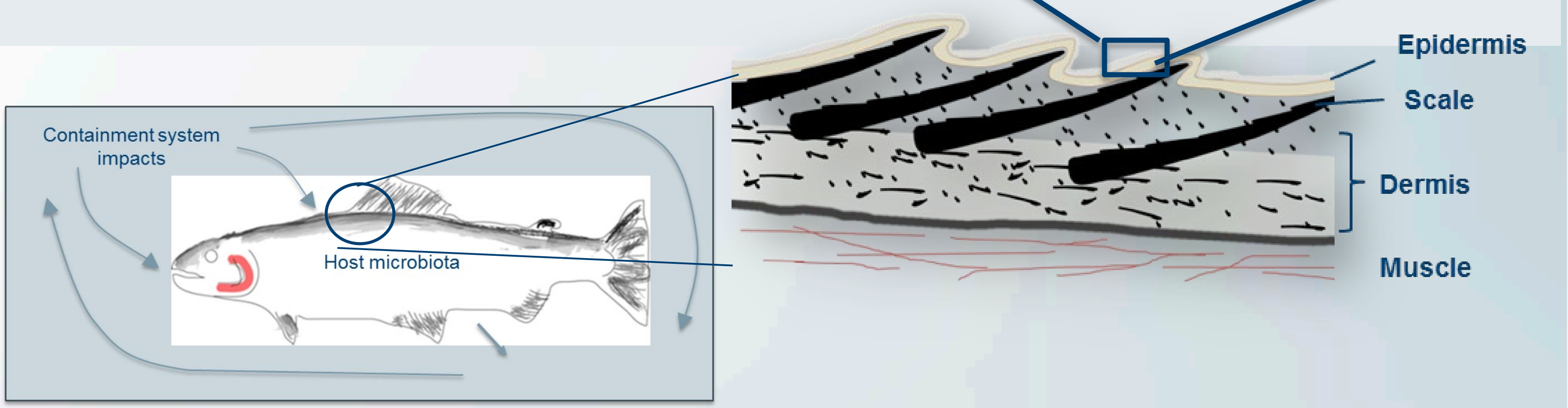
Main objective:

- Understand mechanisms that enhance fish robustness and resilience against microparasites to optimize health and welfare of post smolts in CCS



Focus on:

- Mucus barrier
- Skin integrity
- Gene regulation
- Immune activity
- Microbial interactions



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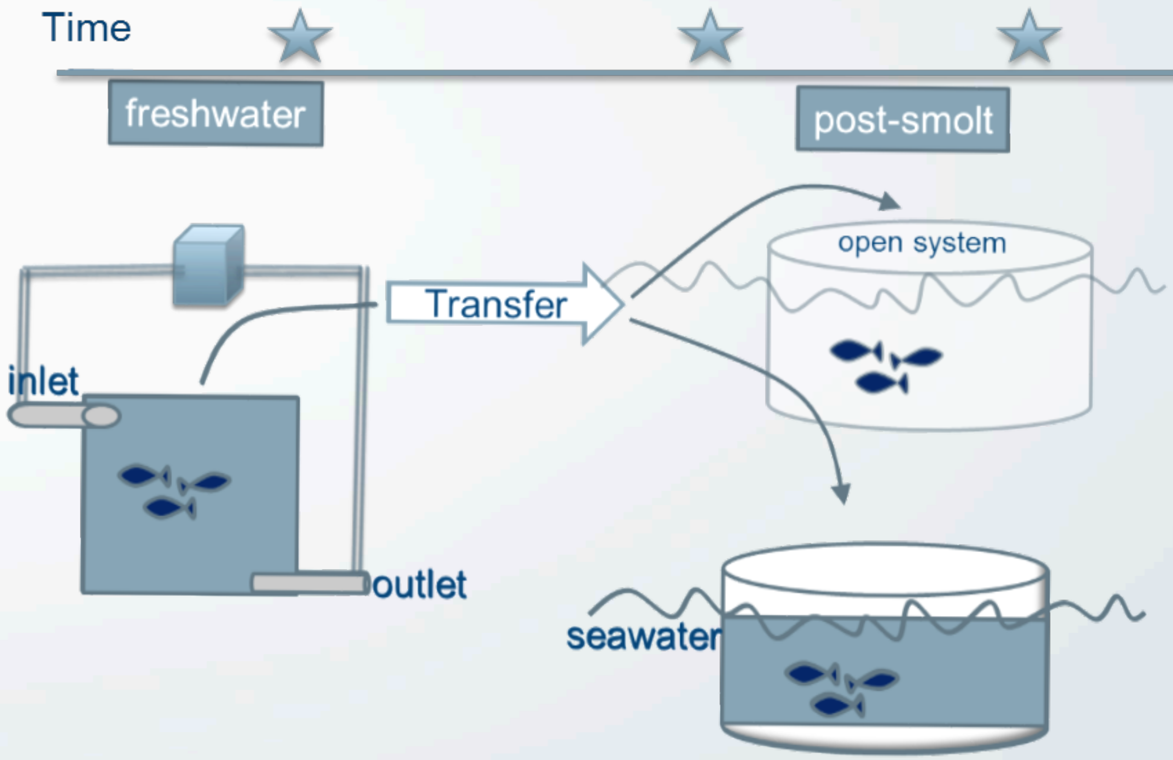
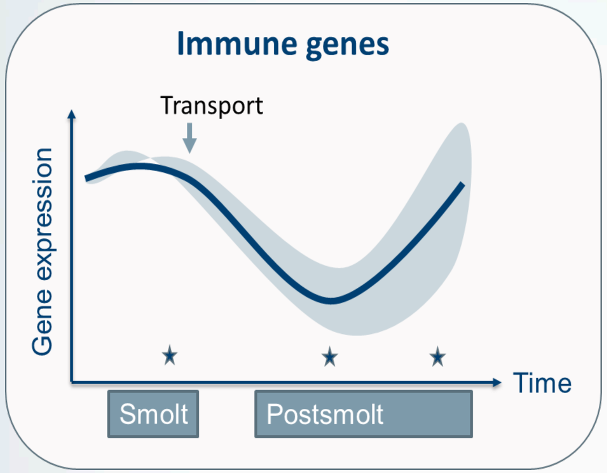
Study intrinsic and extrinsic barrier functions around transfer to sea water

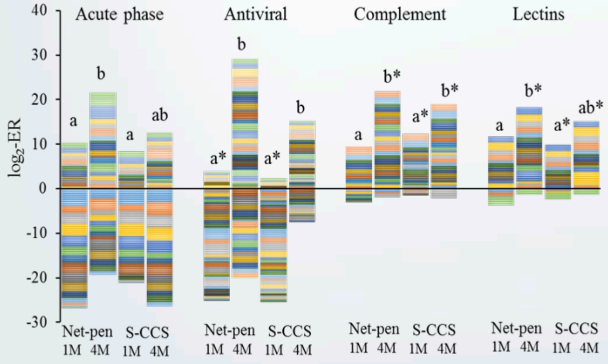
- Freshwater smolt compared to post-smolt 1 and 4 months after transfer to open net pens or S-CCS (Preline)

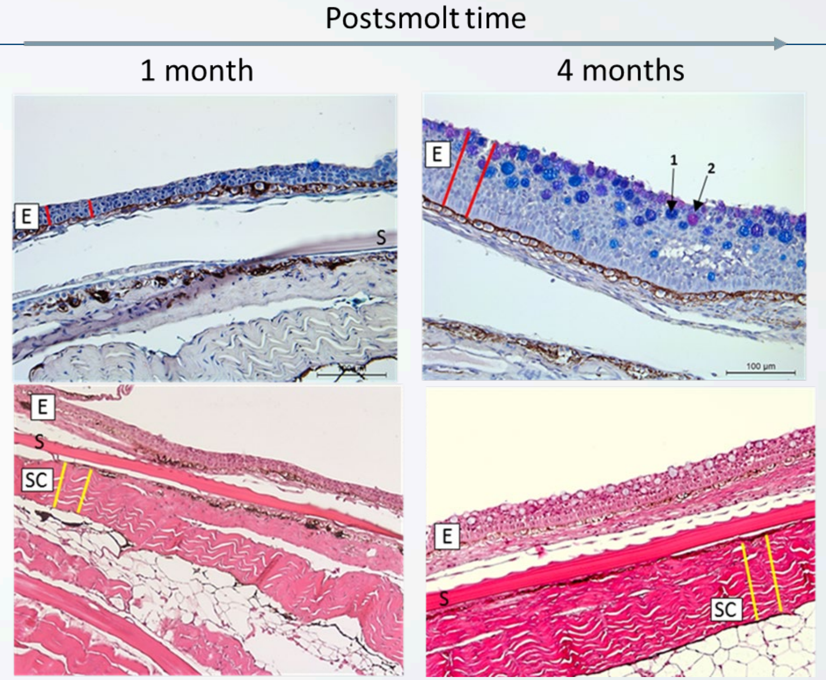


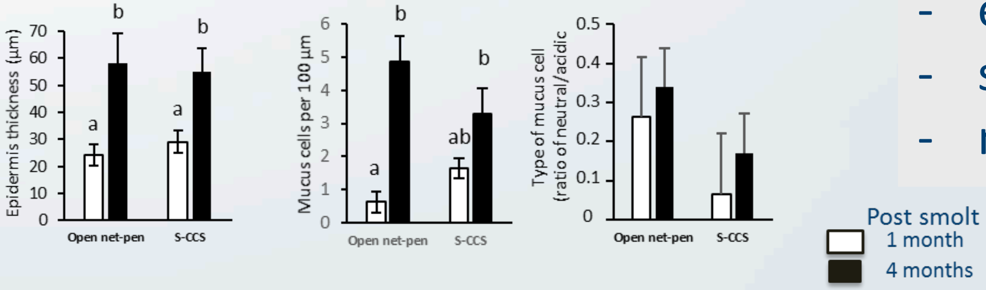
Semi-closed containment systems

Immune competence and structural integrity in posts-molt skin develops after sea water transfer









Immune gene expression

- **reduced** 1 month post SW transfer
- increased after 4 months

Skin structure

- increase in epidermis/dermis thickness
- increase in no. mucus cells

Correlate to **increased gene expression in skin**

- connective tissue
- extracellular matrix
- secretion
- mucus

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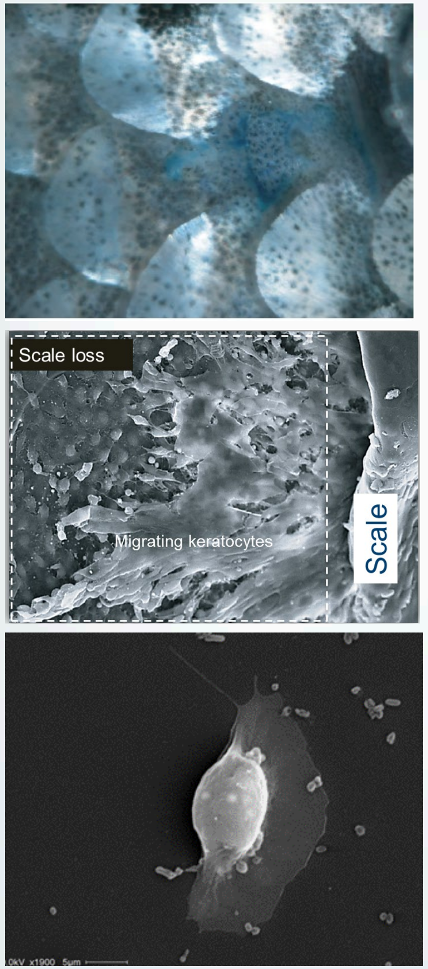
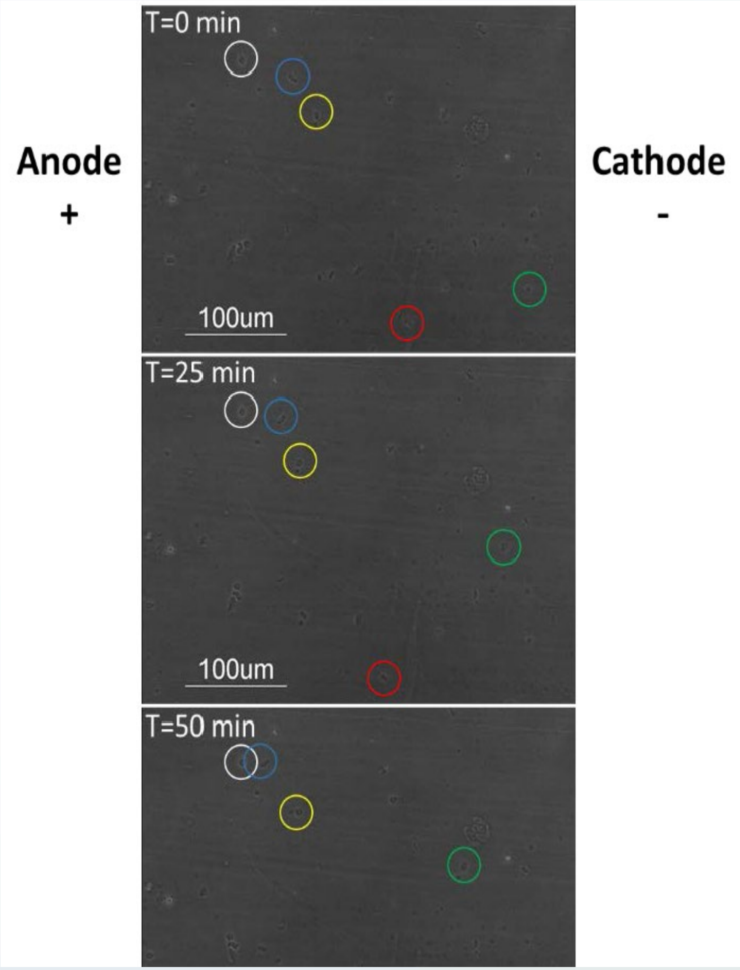
Model study: Galvanotaxis is part of the wound healing process

Scale loss and migrating keratocyte cells





- Directional migration of keratocytes in response to electrical fields
  - galvanotaxis important cue behind wound healing in fish
- The model aim to characterize how galvanotaxis is influenced by biotic and abiotic factors

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Thanks for your attention!