

FitSmolt:

Utvikling av seleksjonstester, treningsregimer og markører for å styrke smoltens robusthet og redusere tap i sjø

NFR/FHF prosjekt #900870; 2013-2016

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FitSmolt

WP1: Novel screening tests for robustness selection in juvenile salmon (completed)*

WP2: Optimisation of exercise protocols for improved smolt robustness (completed)

WP3: Phenotypic and genomic analysis of cardiac & physiological robustness (finalizing data)

Project consortium:

- Nofima (Harald Takle, Sven Martin Jørgensen, Gerrit Timmerhaus, Aleksei Krasnov, Matthew Baranski, Nicholas Robinson, Øivind Andersen)
- University of Brest, France (Guy Claireaux, Florian Mauduit)
- University of British Columbia, Canada (Tony Farrell, Yangfan Zhang)
- Universitetet i Nordland (Torstein Kristensen)
- Turku University, Finland (Katja Anttila)

*Anttila/Jørgensen et al. Frontiers Marine Science 2014, 1:76

WP2: Optimization of exercise protocols for improved smolt robustness

Objective:

- Evaluate the impact of swimming exercise regimes in juvenile salmon in order to establish optimal exercise protocols for improving inherent robustness traits of salmon during the freshwater production cycle

Motivation:

- No knowledge of optimal exercise regimes from start-feeding
- Both too low and high water current may affect survival, growth and performance
- Will exercise already from fry stage allow higher exercise intensity during parr – smolt stage?

Exercise training regimes fry – smolt

Fry – parr:

Parr – smolt:

PD challenge:

1.8 g

20 g

80 g

Low

0.3 BL/s

0.2 BL/s

Medium

1 BL/s

0.8/0.6 BL/s

High

1.5 BL/s

2/1.5 BL/s

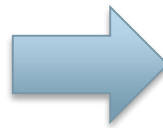
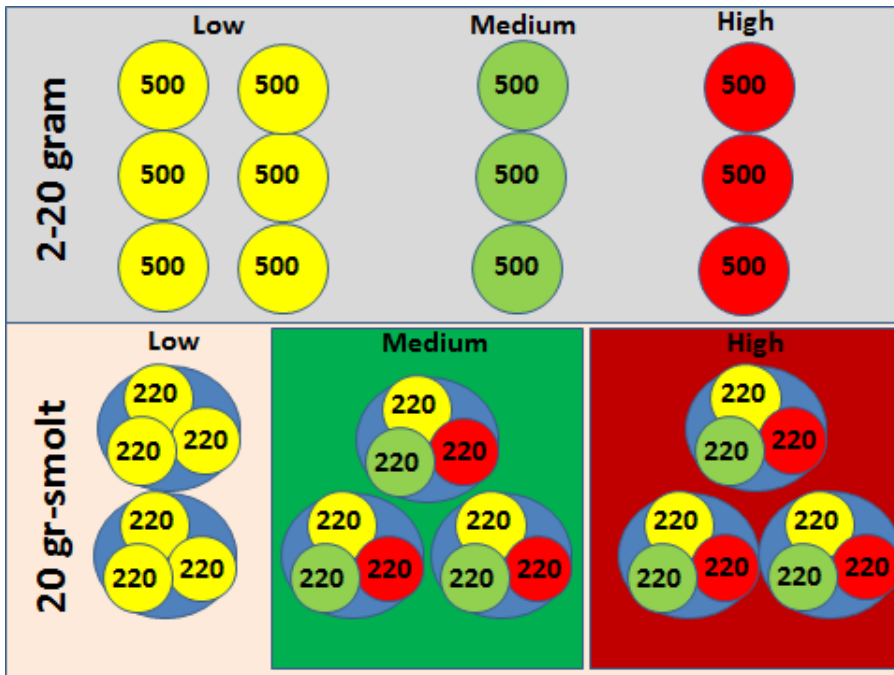
- Growth
- Heart physiology
- Swimming endurance
- Morfometry
- Gene/protein expression

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- Mortality
- Histopath.
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- Gene exp.

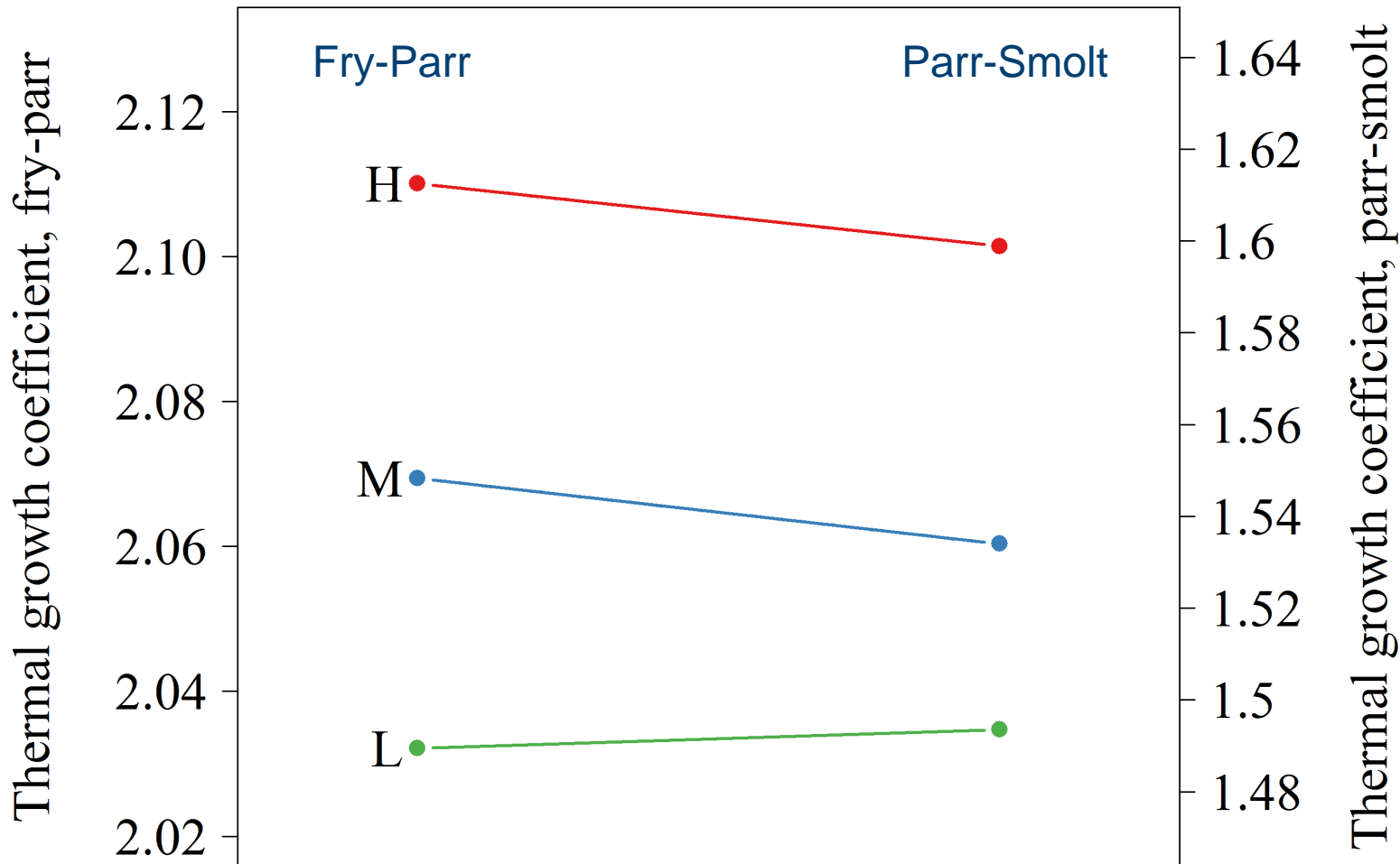
Experimental design

- Number of fish and training groups:



1st period, parr stage	2nd period, smolt stage	Group name
Low	Low	LL
Low	Medium	LM
Low	High	LH
Medium	Medium	MM
Medium	High	MH
High	Medium	HM
High	Low	HL

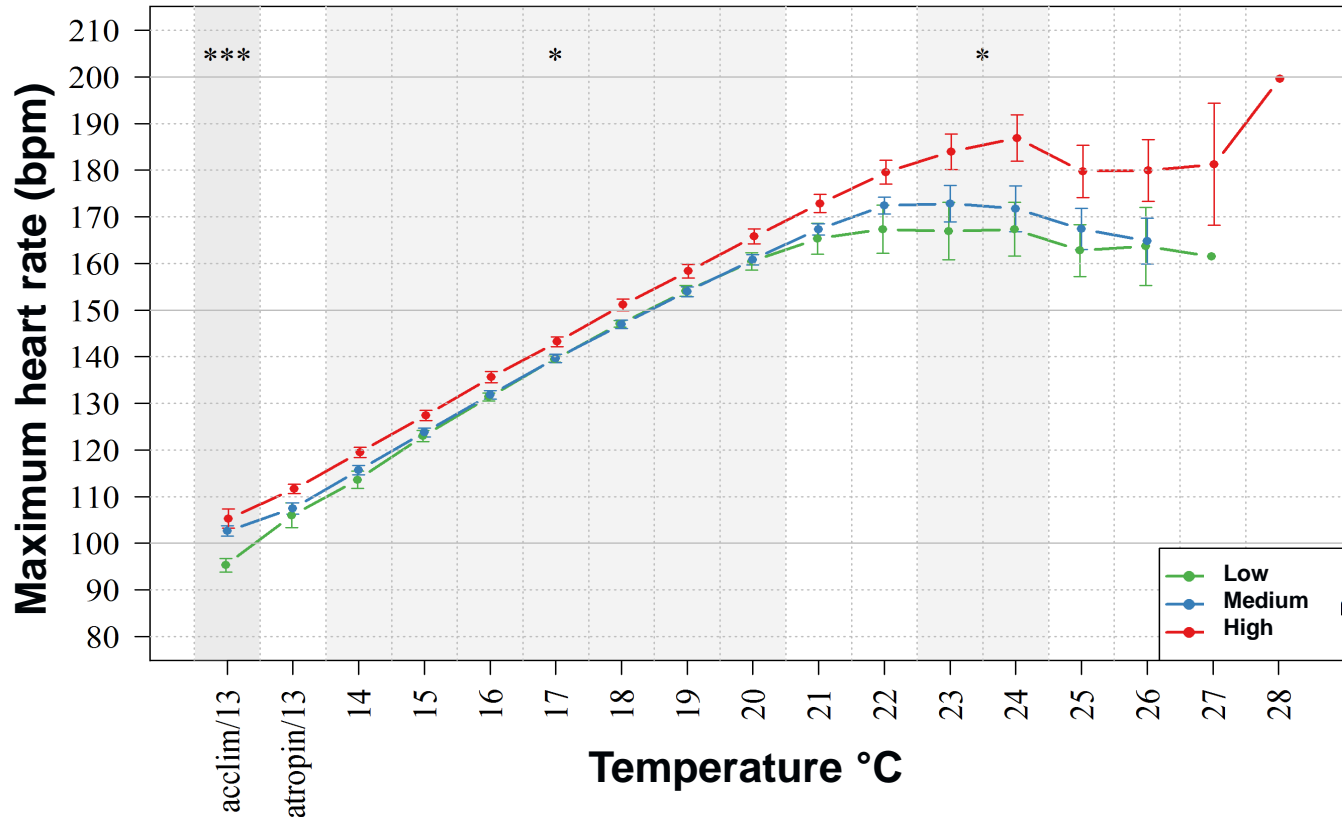
Training stimulates growth



- Non-trained smolts had significant larger CF than Medium & High training
 - N = 300

Training increases heart rate in parr

Temperature dependent heart rate

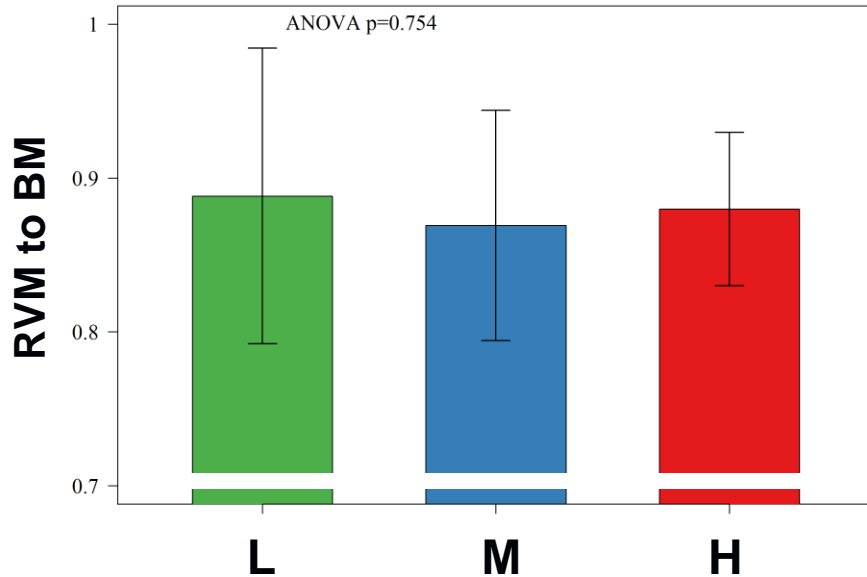


High training (1.5 BL/s from 2-12 g) resulted in a:

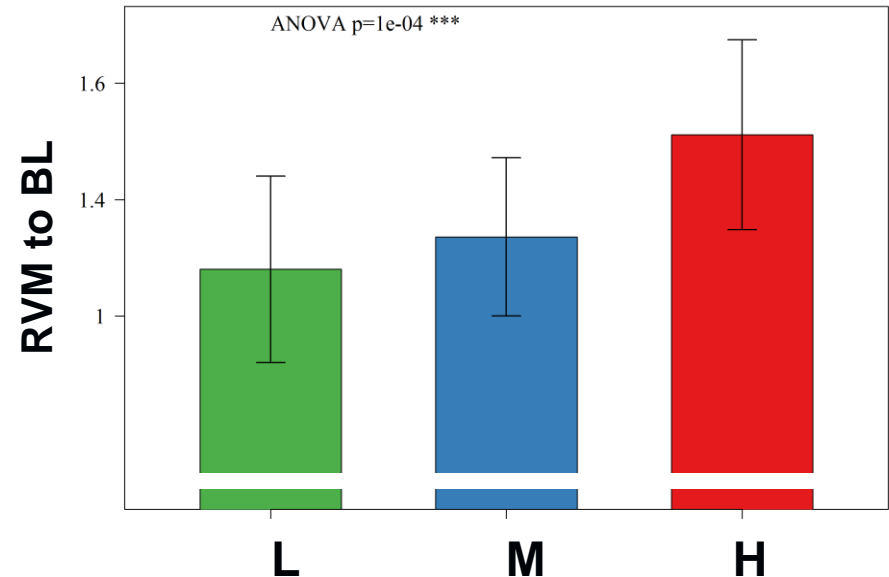
- Higher maximum heart rate over the entire temperature challenge
- A greater peak for maximum heart rate
- A higher upper temperature tolerance

Trained parr have bigger hearts

Ventricle mass/ body mass

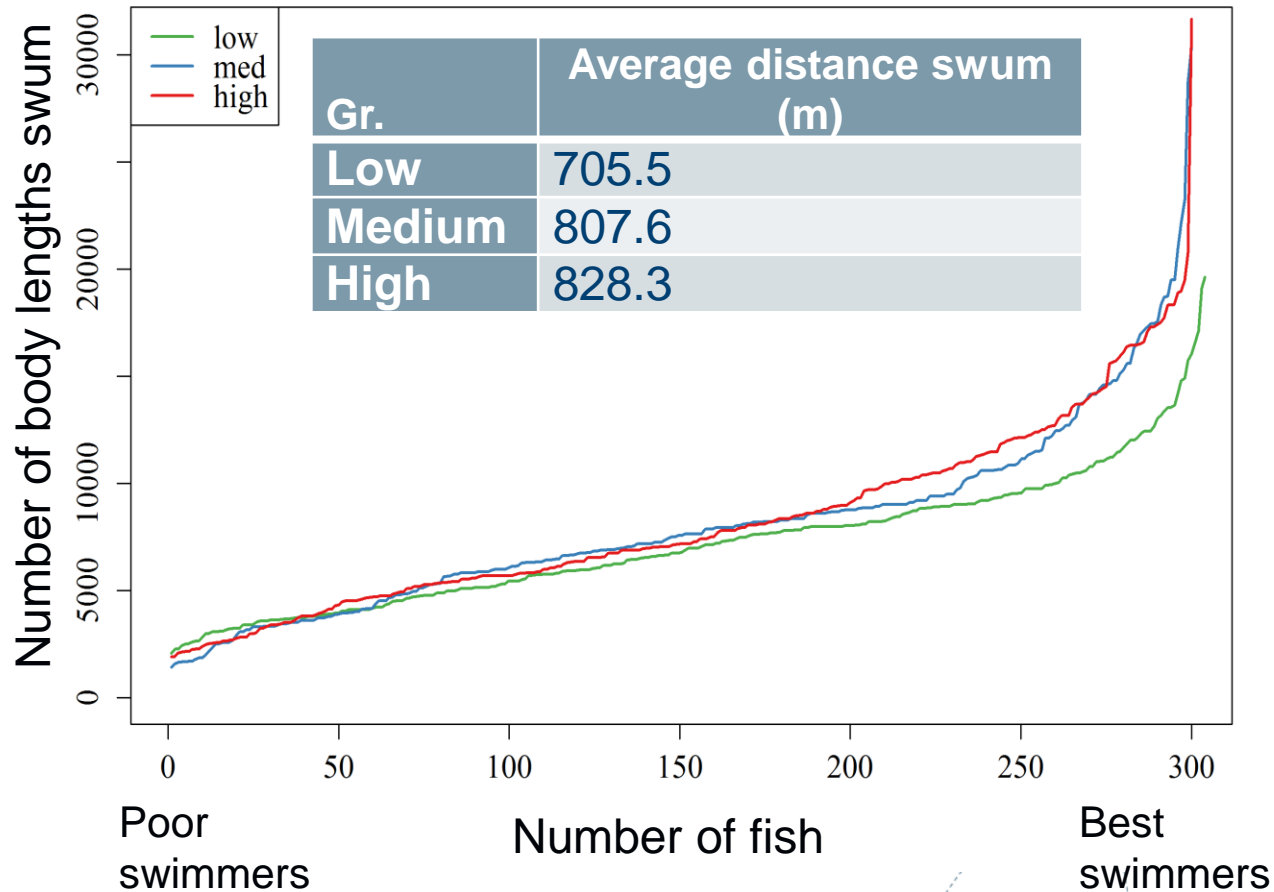


Ventricle mass/ body length



- Training increased ventricular mass relative to body length but not relative to body mass
- Same effects on liver mass relative to length
- No effects on hematocrit

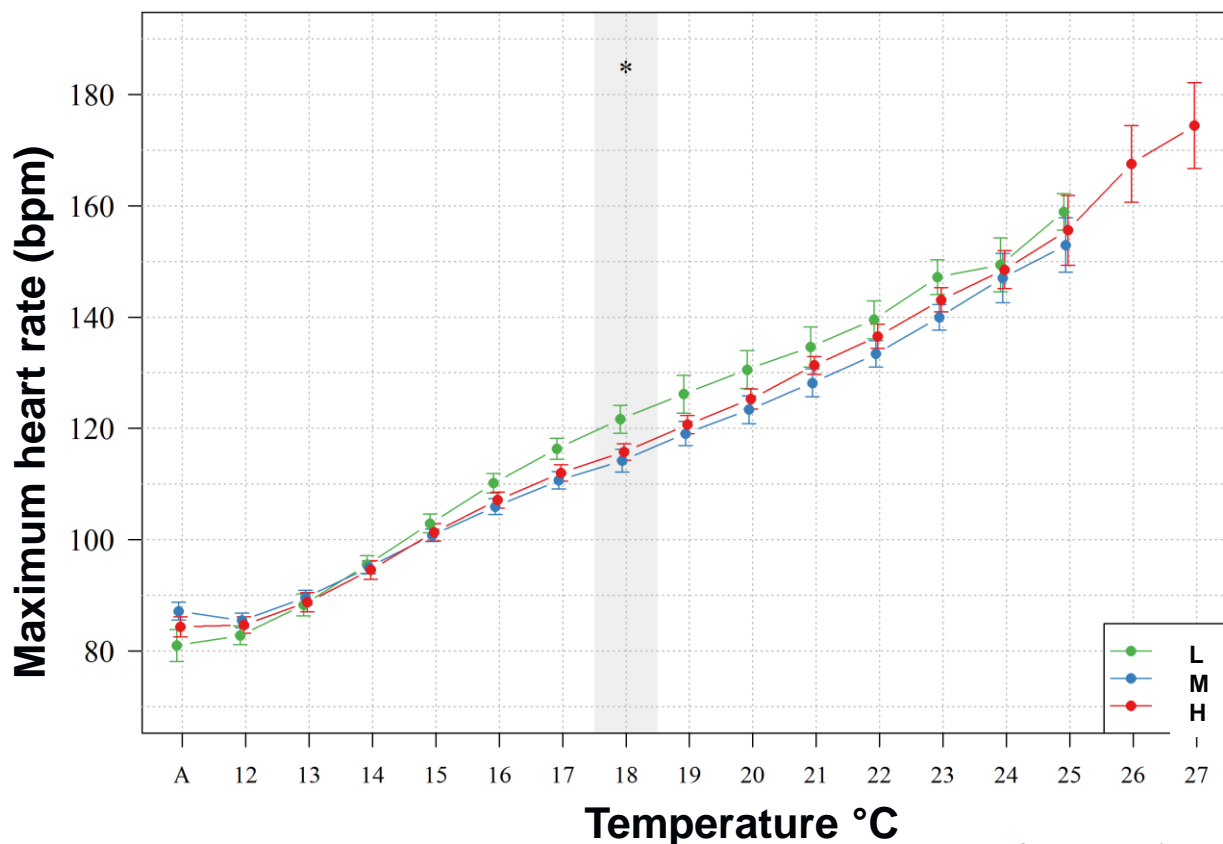
Trained parr have better swimming endurance



- Poorer swimming performance of untrained parr
- Higher heart rate and larger ventricle mass results in better swimming capacity

Effect of training on heart rate of smolts

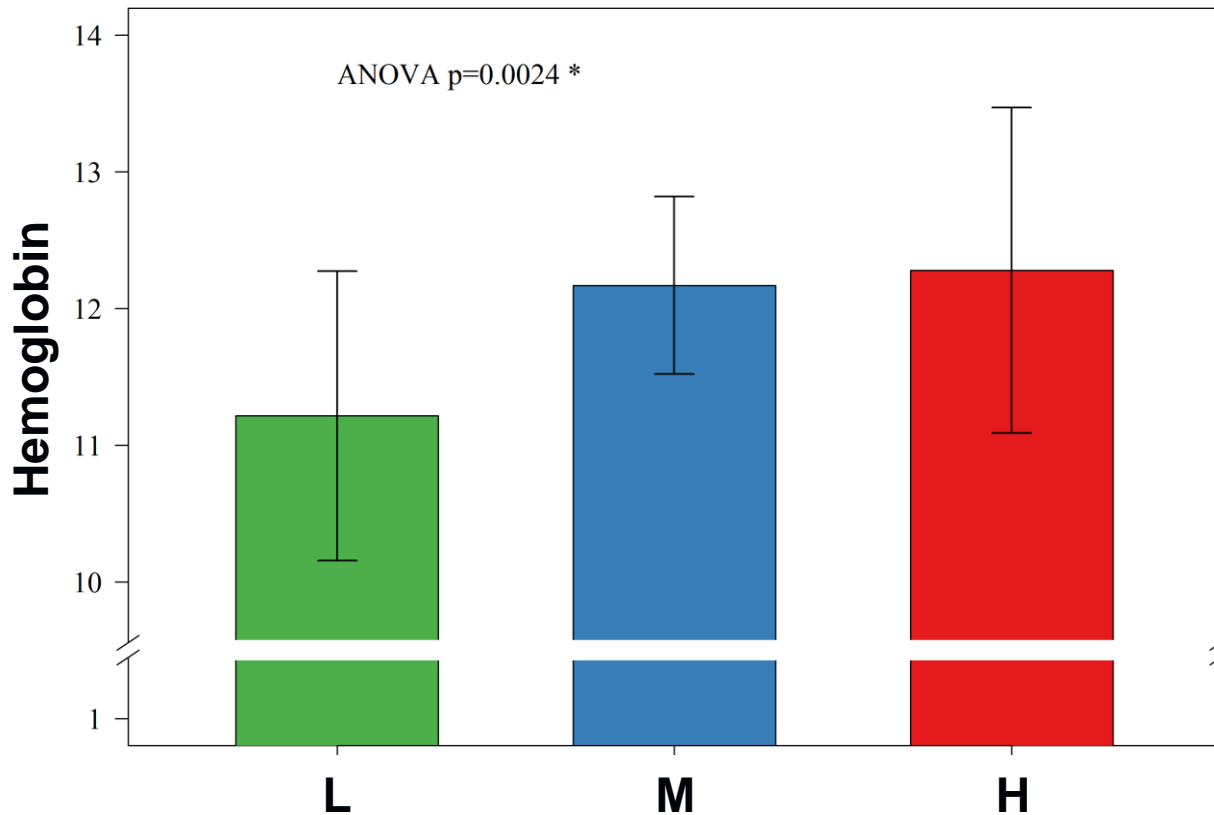
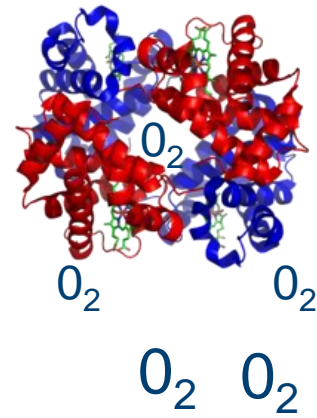
Temperature dependent heart rate



High training from 2-80 g resulted in a:

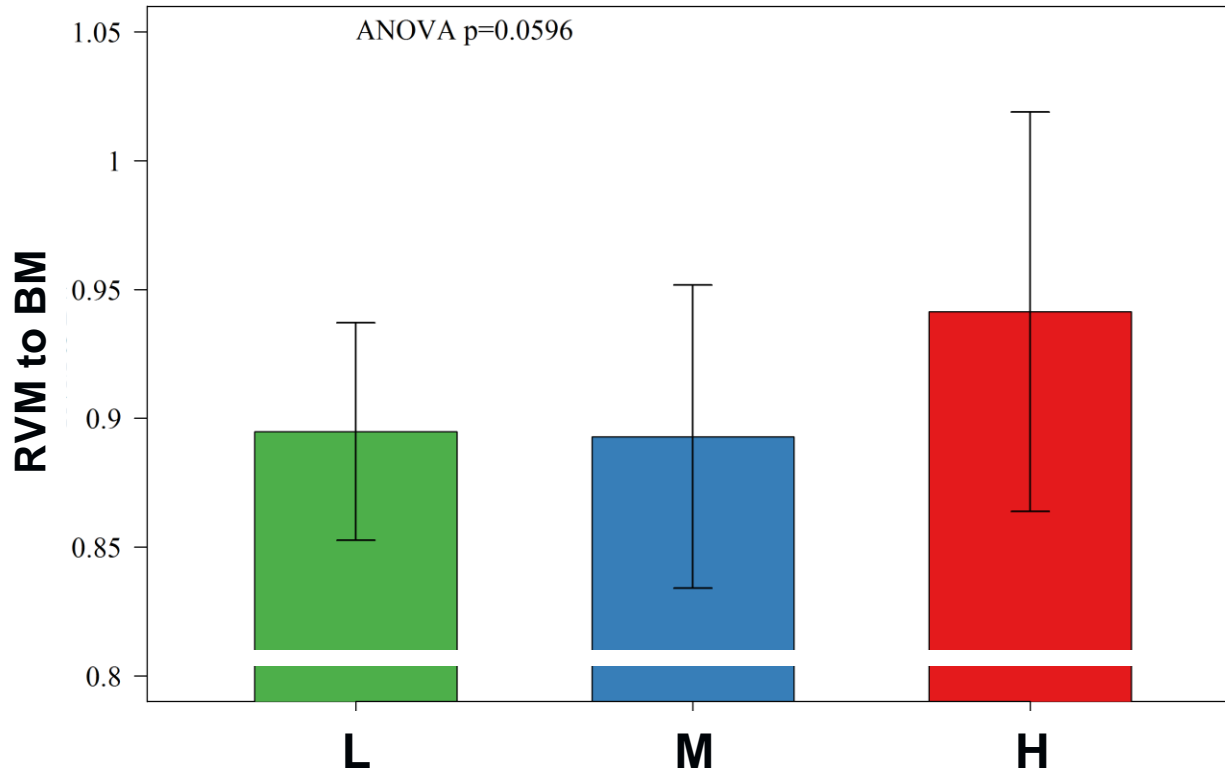
- Lower maximum heart rate at 18 °C
- A greater peak for maximum heart rate
- A higher upper temperature tolerance

Trained smolt have higher blood hemoglobin levels



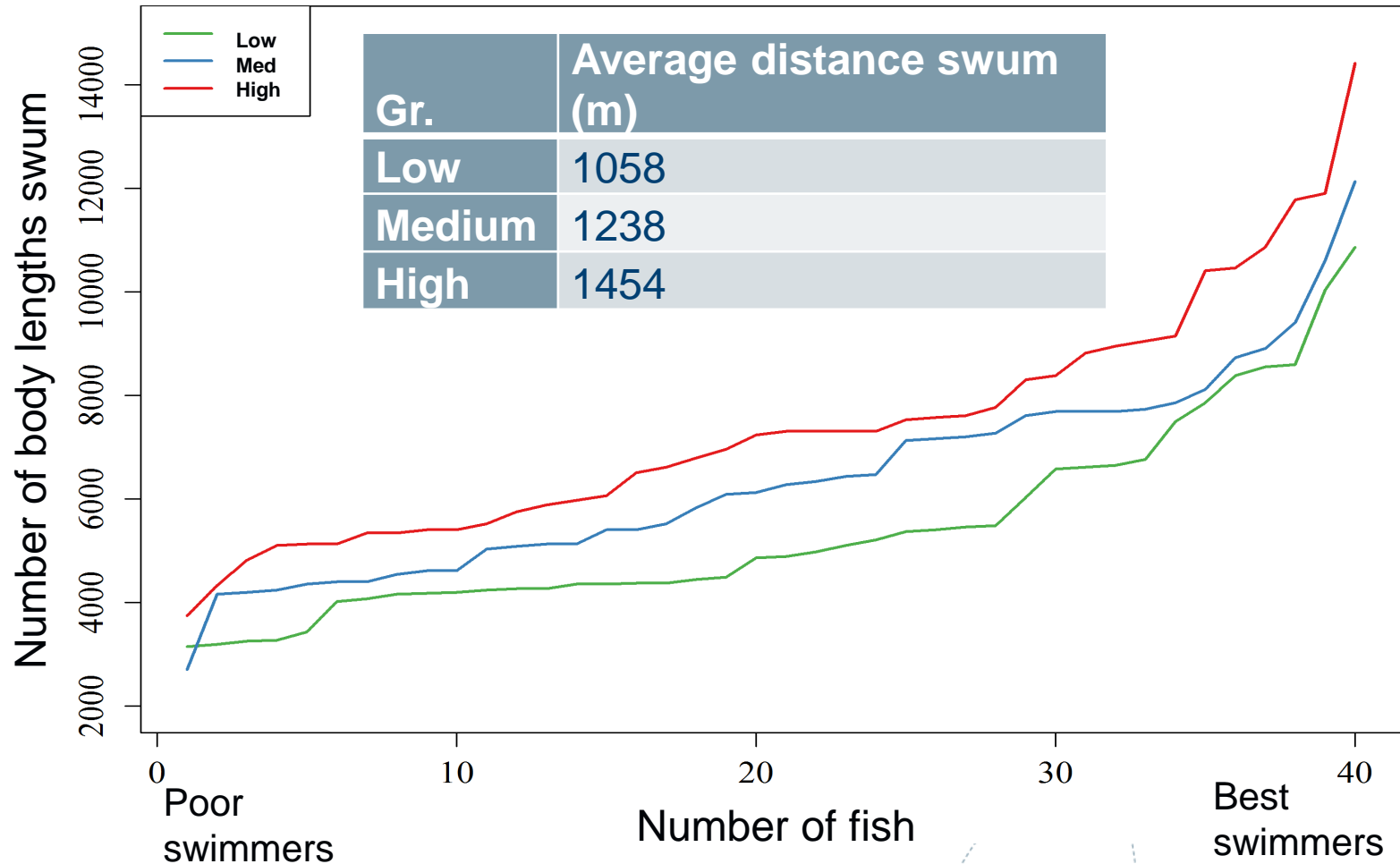
- High and Medium have significantly higher levels than Non-trained
- Improved capacity of oxygen transport

Trained smolt have bigger hearts



- High has significant larger relative ventricle mass than M and L
- **Training improves cardiac capacity by increasing stroke volume and oxygen transport (higher Hb) in smolts**
- **Training improves cardiac capacity by increasing heart rate in parr**

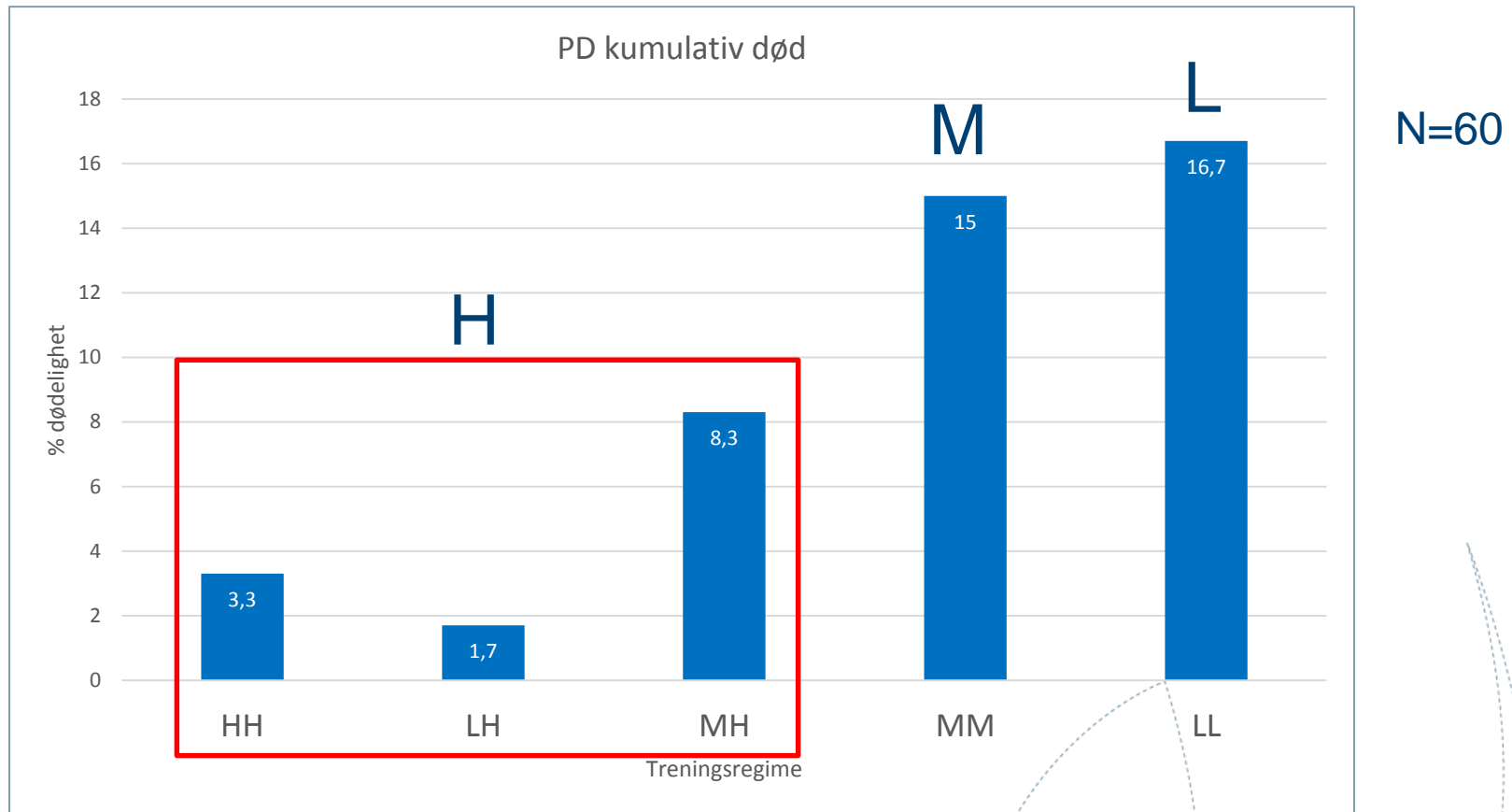
Trained smolts have much better endurance



- $H > M > L$ for both poor and good swimmers
- **Significance for survival and welfare during transport and performance first months in sea**

Trained smolts have increased PD survival

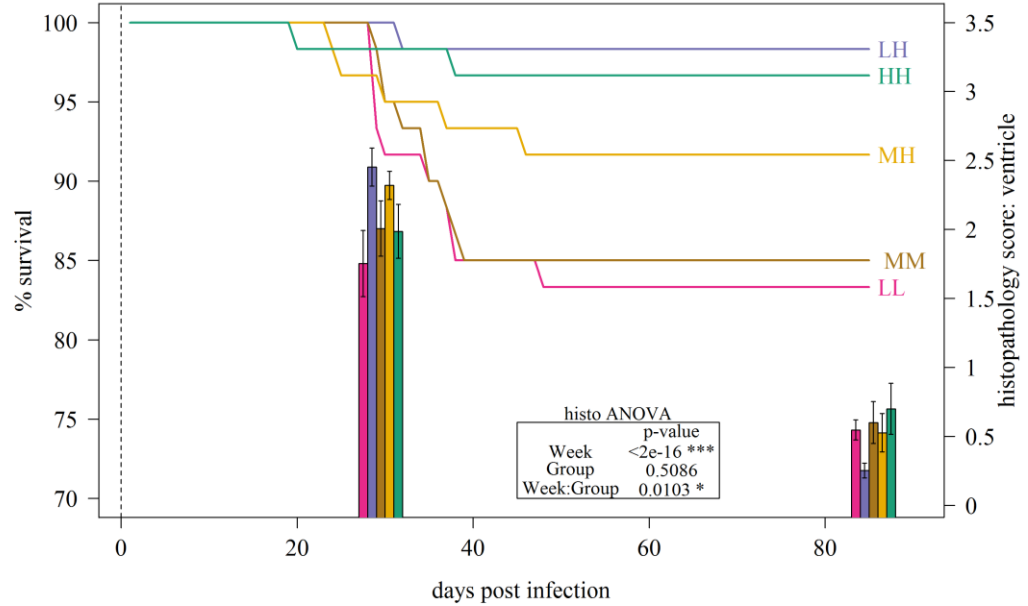
(SAV3 injection challenge of post-smolts for 12 weeks, Veso Vikan)



- High intensity training in last stage (parr-smolt) = significantly lower mortality vs medium & low intensity

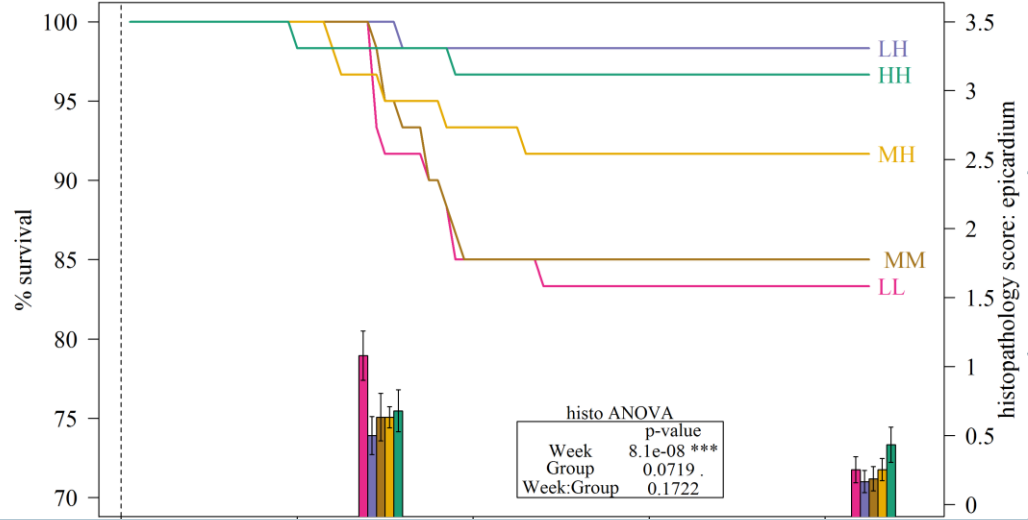
Heart histopathology vs survival

Ventricle:



No group differences in ventricle pathol

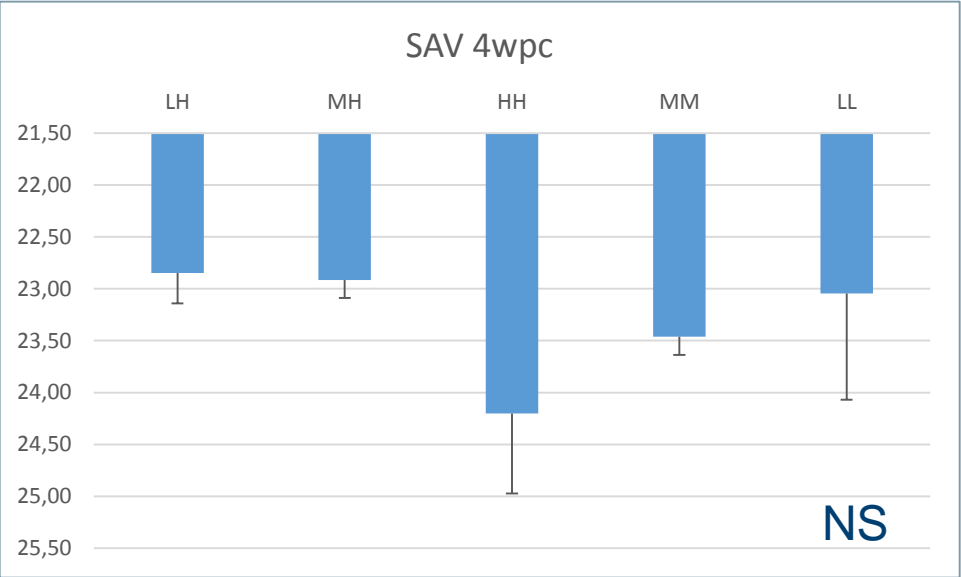
Epicard:



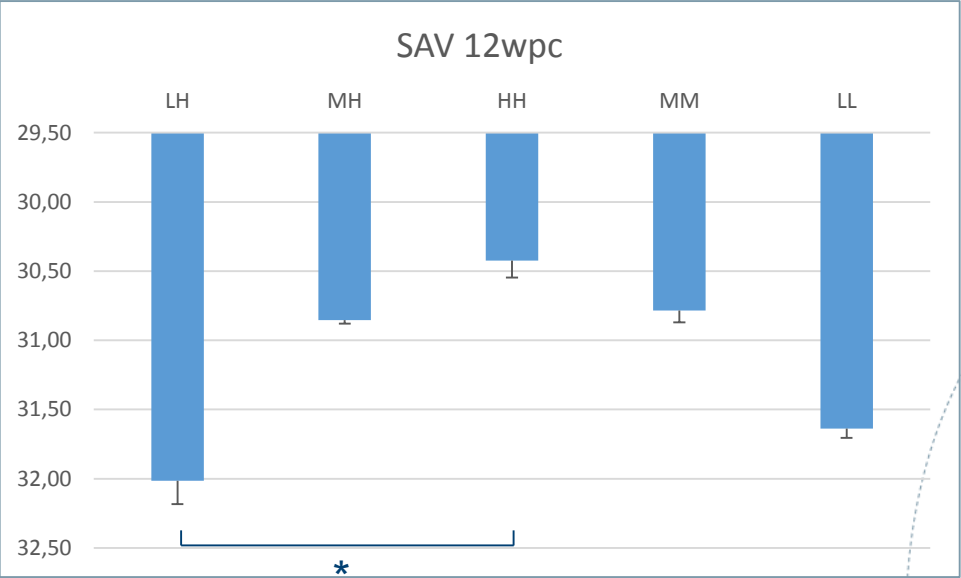
Untrained fish: lowest score in ventricle, highest in epicard at peak mortality

➤ No group differences for pancreas & atrium pathology

Virus load heart



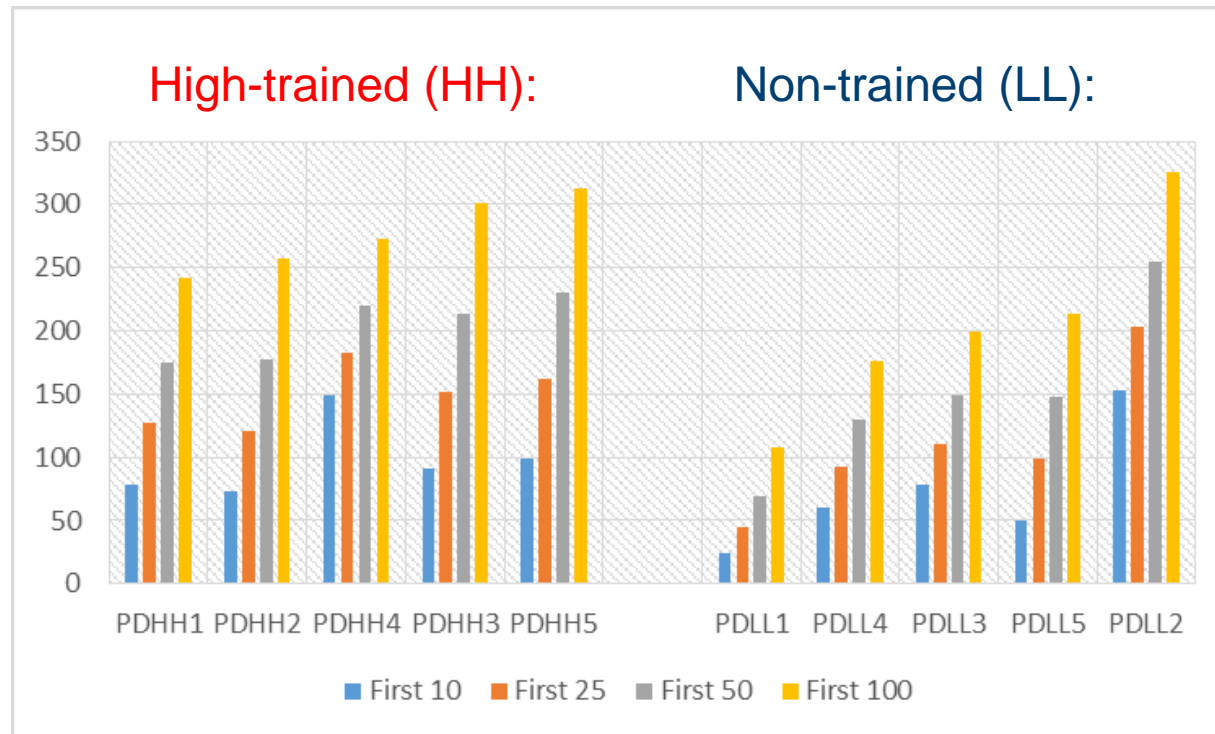
4 wpc:
No significant differences



12 wpc:
Highest virus in high-trained fish

Trained smolts have stronger antibody response?

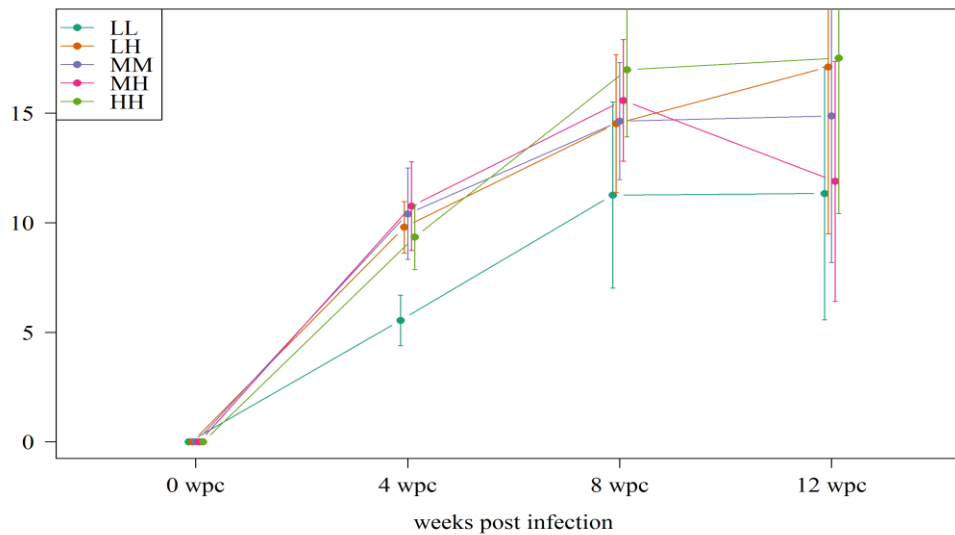
-Increased and broader expansion of IgM clonotypes (4 wpc)



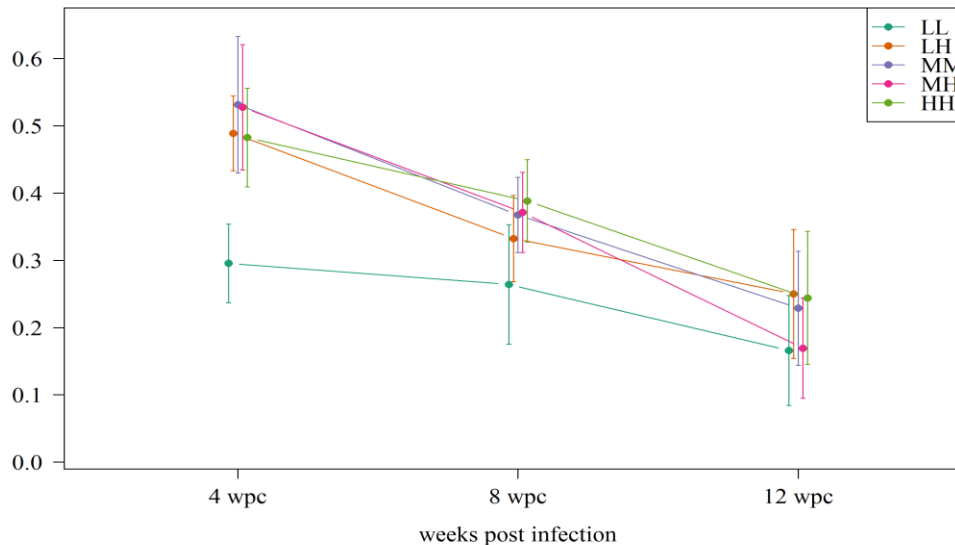
Ig-seq: Abundance of IgM variable region transcripts

Growth during infection

Weight gain relative to 0 wpc:



Thermal growth coefficient relative to 0 wpc:



Reduced growth in untrained (LL)

Oppsummering

- **Trening i hele ferskvannsfasen øker smoltens robusthet gjennom:**
 - **Økt vekst**
 - **Stimulert hjertevekst**
 - **Styrket kardiovaskulær helse**
 - **Økt svømmeutholdenhet (aerobisk kapasitet)**
 - **Økt overlevelse mot PD**