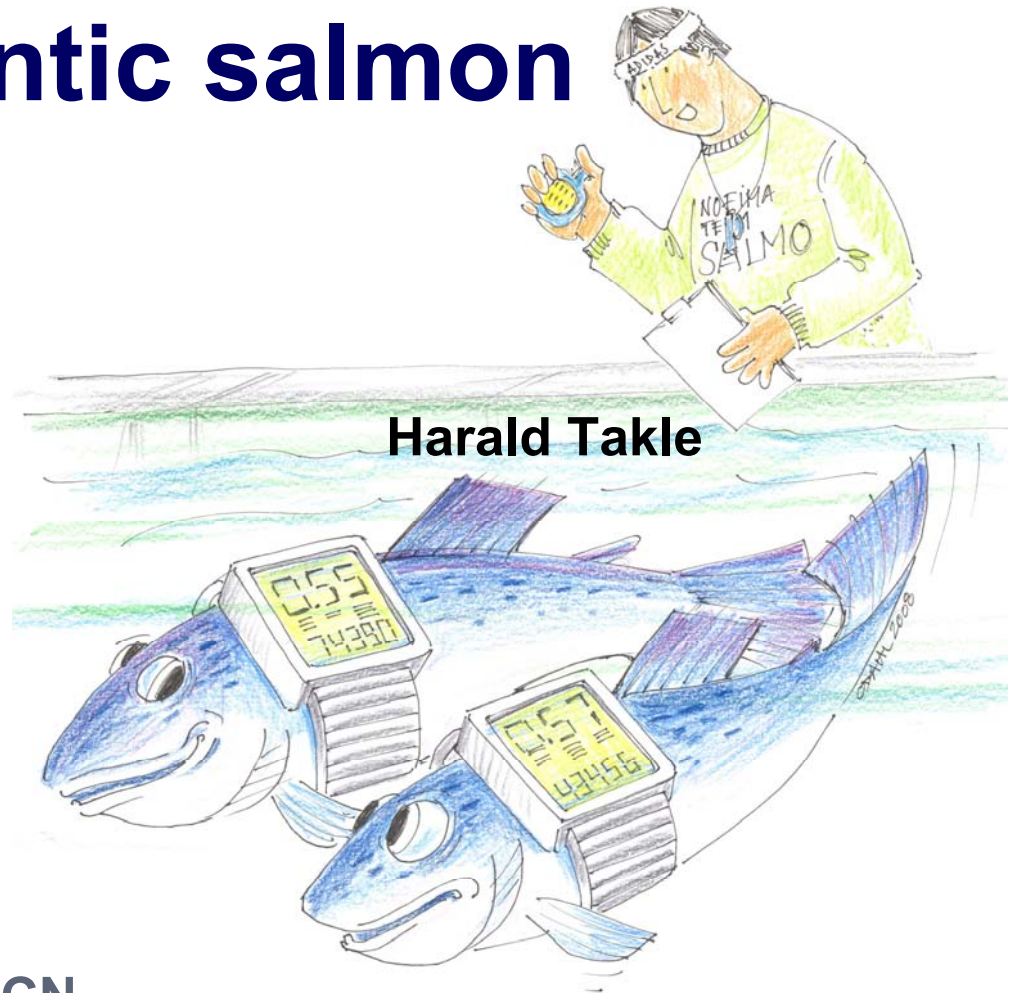


Exercise training to improve performance and robustness of Atlantic salmon

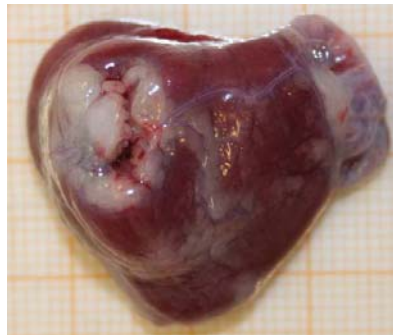


Harald Takle

Funded by FHF and RCN

Background

- Improving robustness of the fish is a key issue in aquaculture
- A fish in good condition perform better:
 - Faster growth with better feed utilization
 - More disease resistant
 - Better welfare
- However! The industry is balancing on the edge of having a sustainable production
 - ISA
 - PD
 - CMS
 - Lice
 - Epicarditis etc
 - Deformities

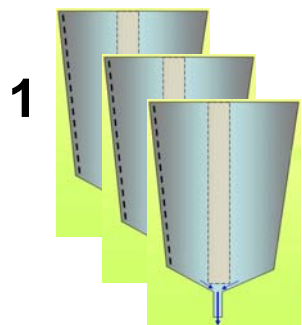


Aim for the project

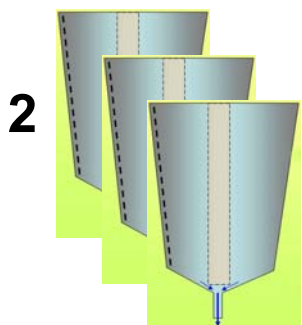
- Optimize the beneficial effect of aerobic endurance training to improve **growth, cardiac performance** and **health** in A. salmon.
- Test different **endurance training programmes** of variable intensities and duration during the freshwater stage and evaluate the training effects on:
 - *cardiac performance and ability to face environmental constraints*
 - *disease resistance* by conducting challenge tests and examine gene responses.
 - *appetite, growth responses and nutrient utilization* by standard nutritional measurements

Outline first trial

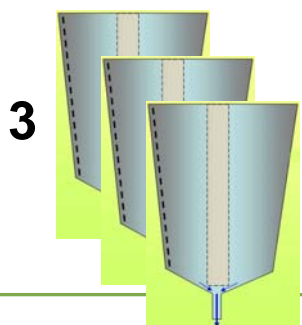
~50 gr
120 fish per
500 liter tank



Low intensity continuously:
~ 0.05 bodylength/s⁻¹



Medium intensity continuously:
~ 0.80 bodylength/s⁻¹



Medium+ intensity interval:
~ 1.0 bodylength/s⁻¹ 8hrs
~ 0.80 bodylength/s⁻¹ 16hrs

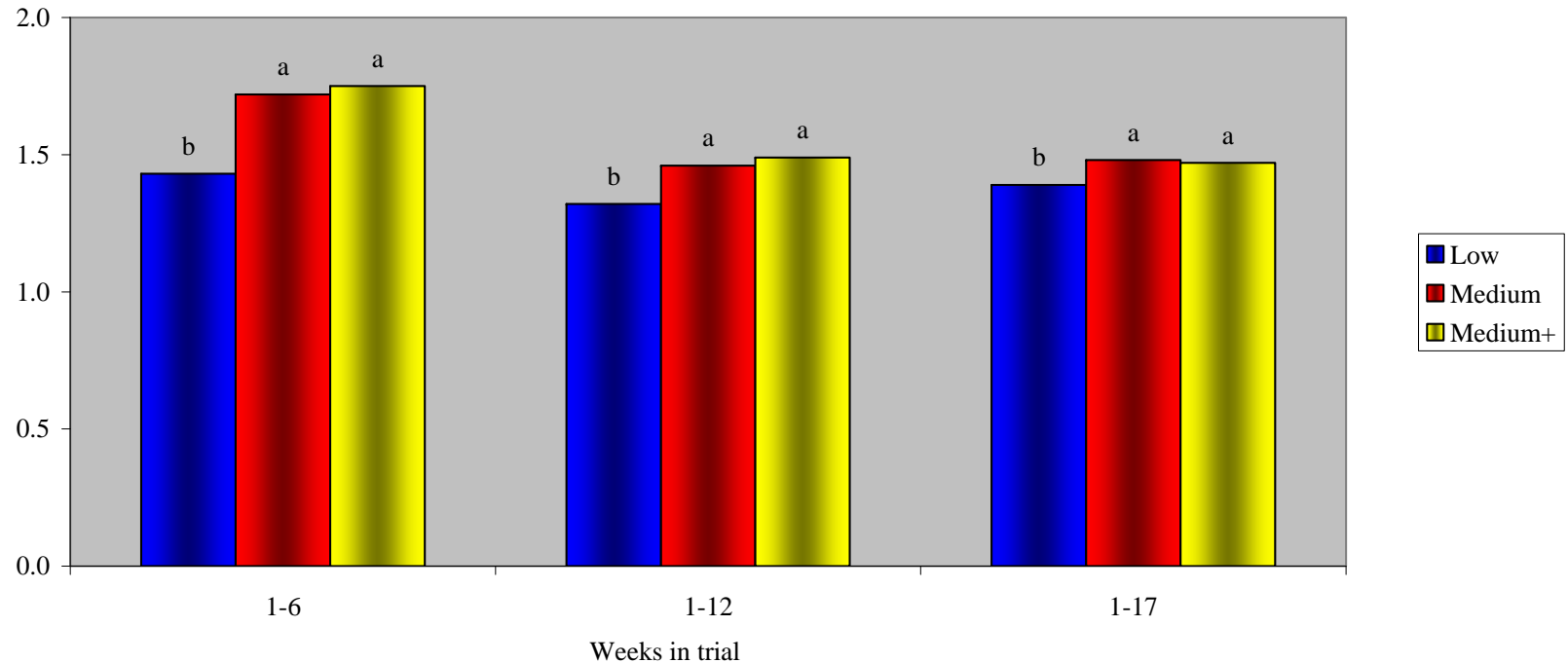
**Fish were
pooled and
divided in
two tanks**

**Gr 1 transferred
to saltwater to
examine
performance**

**Gr 2 were
challenged with
IPN**

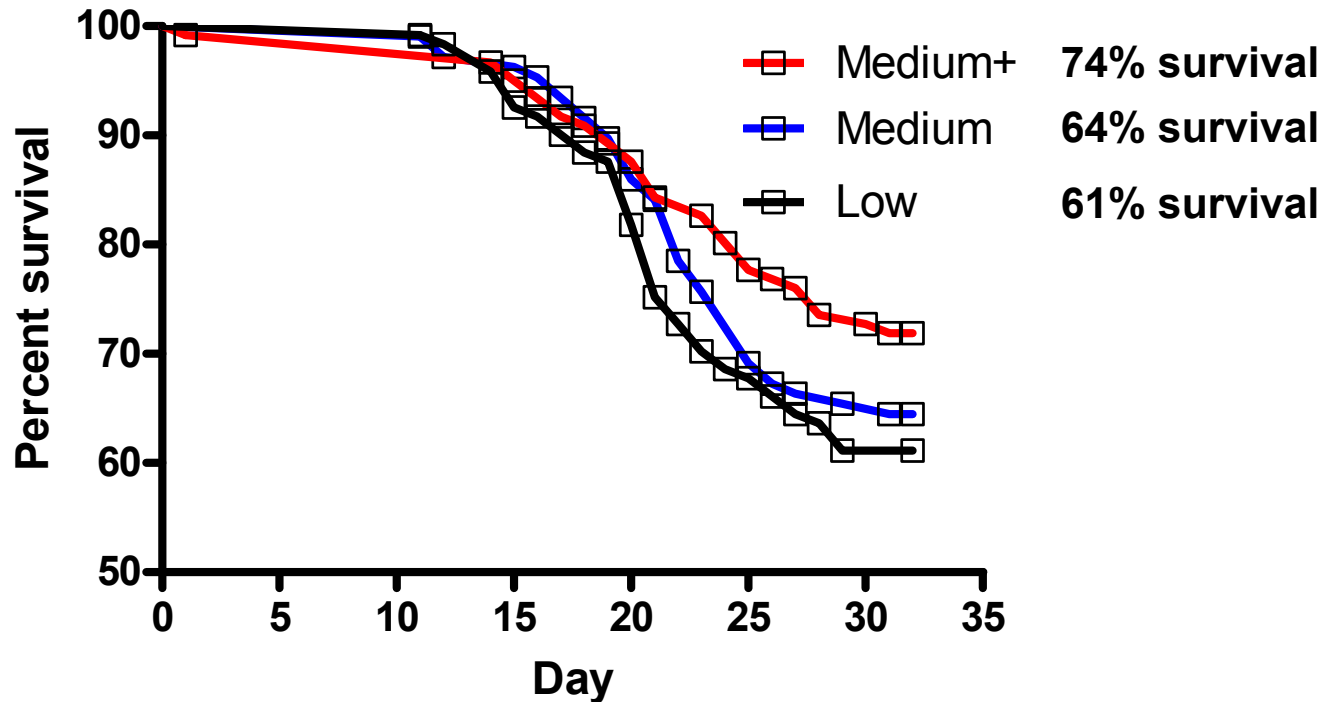
Growth

Thermal Growth Coefficient



- Growth rate improved by 20-22% in exercised fish
- FCR not affected

IPN challenge test

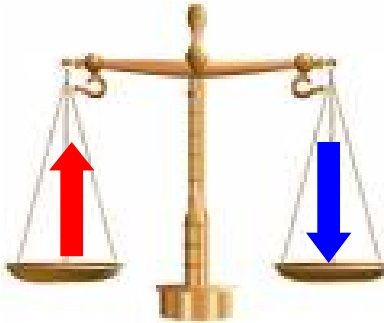


- Could the improved survival of trained fish be explained by a modulation of the immune system?
- Could the difference in survival between M and M+ fish be explained by gene activity?

Exercise and the immune system

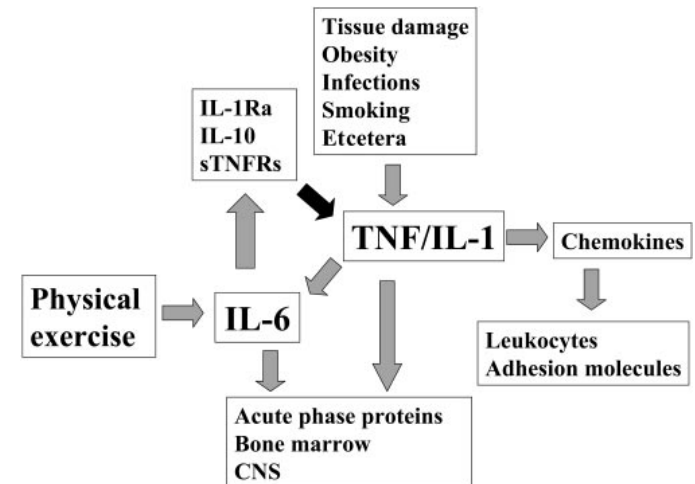
The burden of low level chronic inflammation

- Inactivity
- Morbidity
- Obesity
- Infections
- High fat intake
- Injury



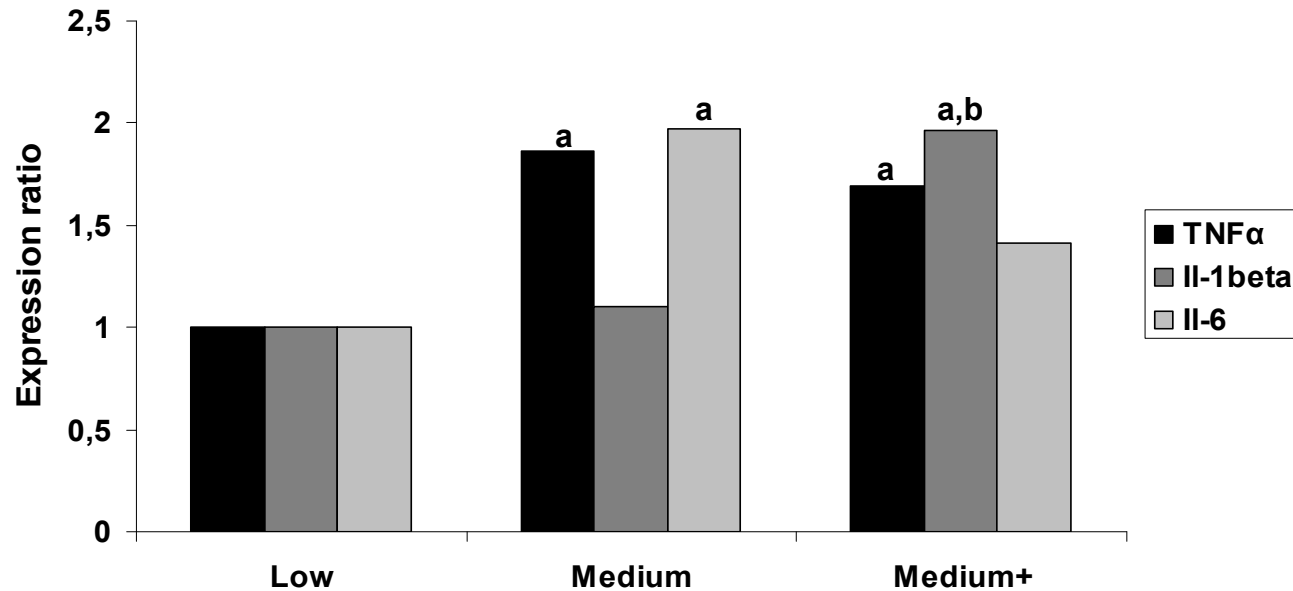
- **Exercise**

- Humans:
 - During exercise: TNF α , IL-1 β and IL-6 
 - Recovery: TNF α , IL-1 β and IL-6 



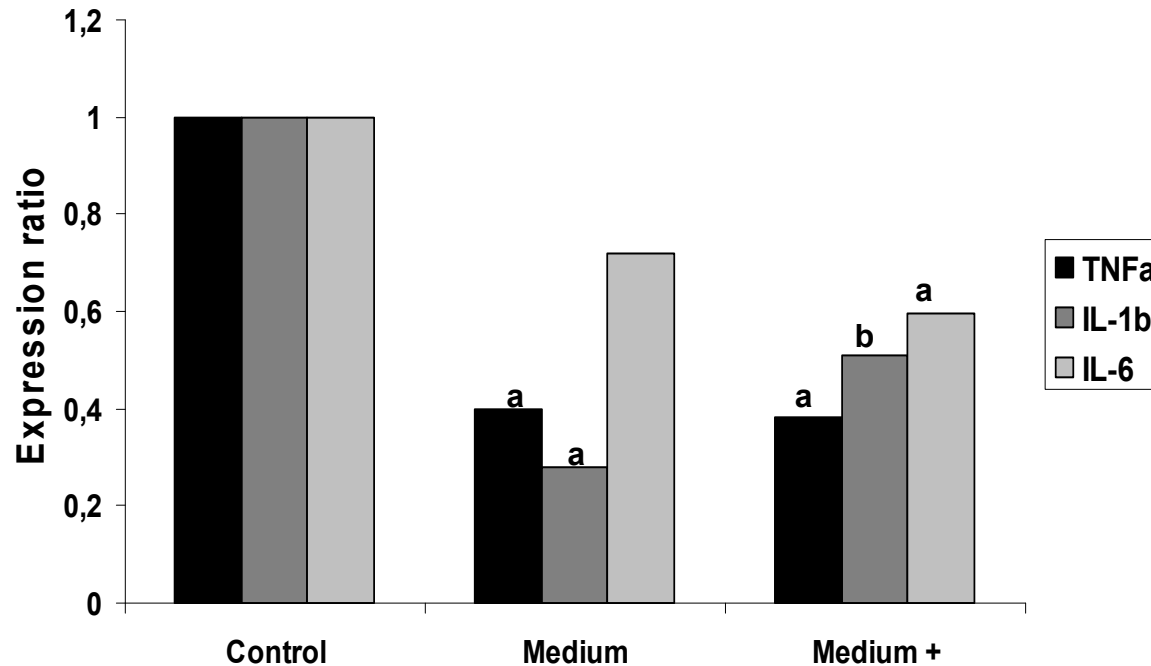
➤ How is the situation in salmon?

Exercise and the immune system



- High levels of inflammatory cytokines may reflect cellular stress/damage
- Higher basal inflammatory levels
- No adaptation to exercise yet?

Exercise and the immune system



- Decreased level of inflammatory status

➤ Improved disease resistance at challenge

SFA 2 Microarray (1.8 K; cDNA)



HEART

Medium	Medium+
--------	---------

Inflammation:



Eicosanoid pathway and NF-kB pathway

Complement:



First line of host defence:
 i) amplifying the immune response
 ii) labeling for destruction
 iii) killing pathogens

Antigen proces. & pres:



Ubiquitin-Proteasome System and MHC-I
 → Lowered resting level of antiviral response machinery

Adhesion:



Possibly more immune cells in the heart of M+ fish

Antioxidants:



Better protection against oxidative stress

Tissue remodeling:



Improved cardiac capacity?

FitnessFish exercise training lab

First trial:

Velocity regulated by the inlet water pressure and by the size of the die gap on the inlet pipes

- Little flexibility for interval training
 - Manual adjustments necessary to conduct interval training
- Limited maximum water velocity (17 cm/s)

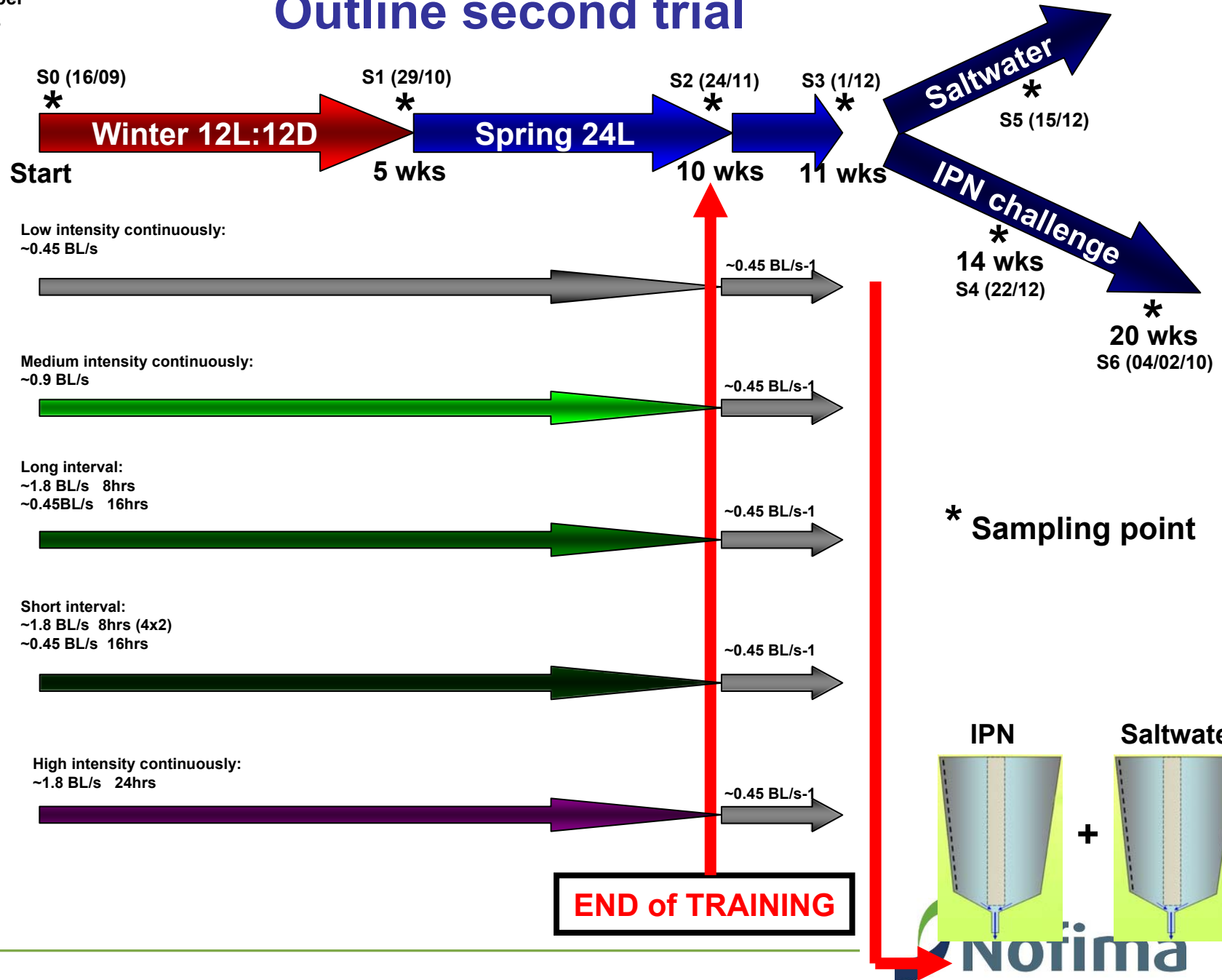
FitnessFish:

Velocity regulated by individual pumps for each tank

- Great flexibility for interval training
 - Automatic control of the interval programming
 - Fast change of water velocity
- Increased maximum water velocity (27 cm/s)

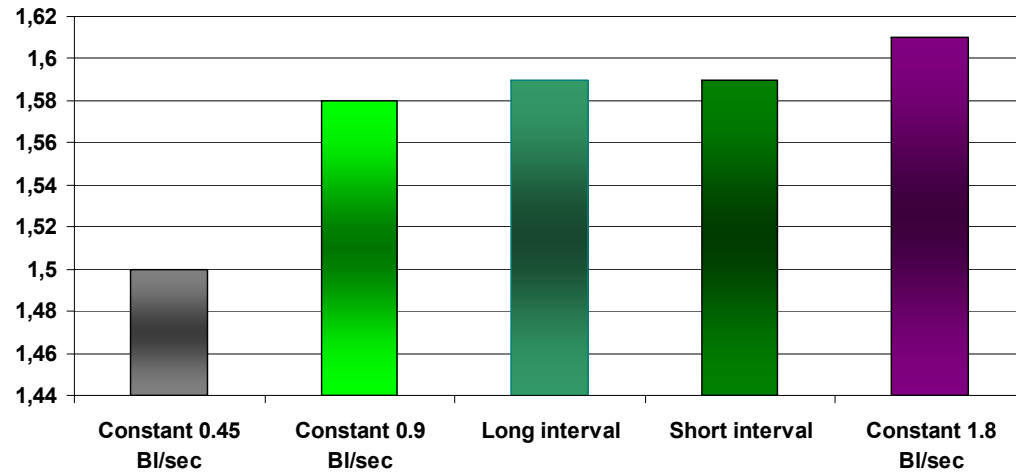
~35 g 87 fish per
500 litre tanks

Outline second trial

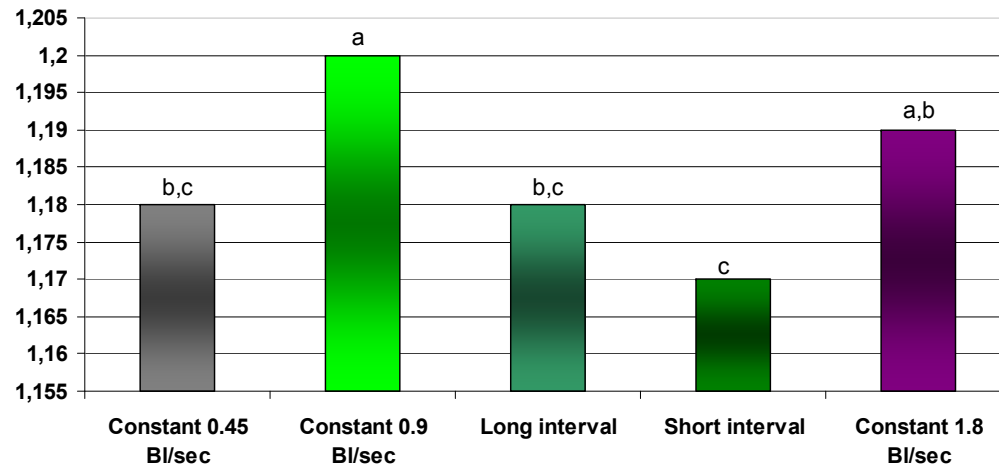


Growth response

TGC

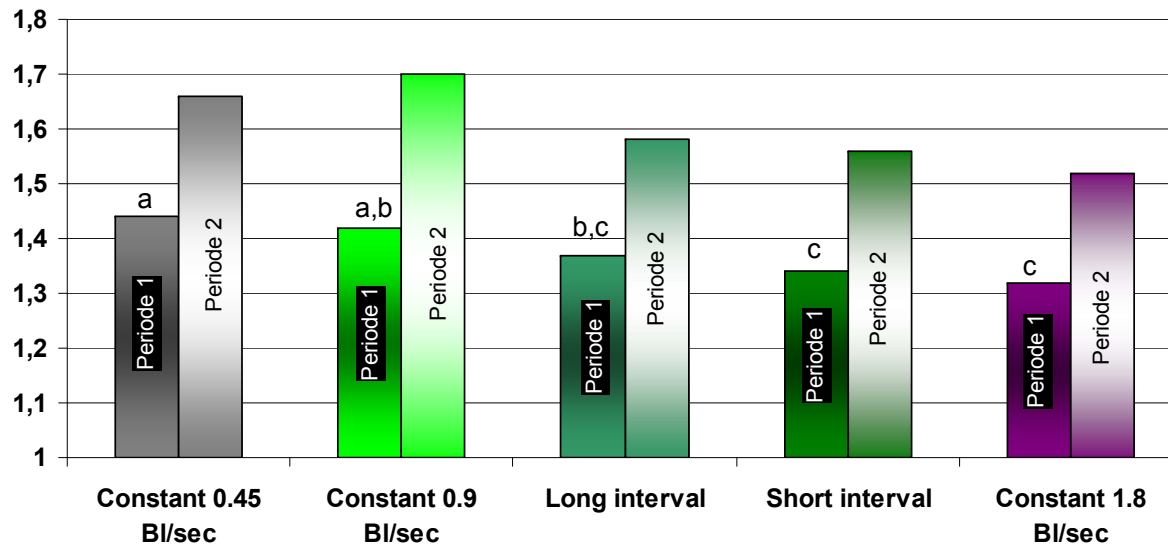


Condition factor

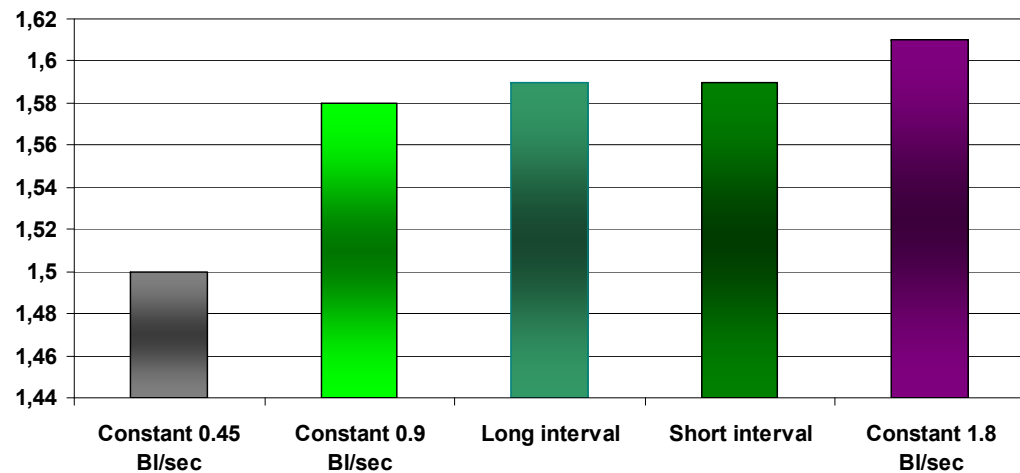


Growth response

Feed efficiency



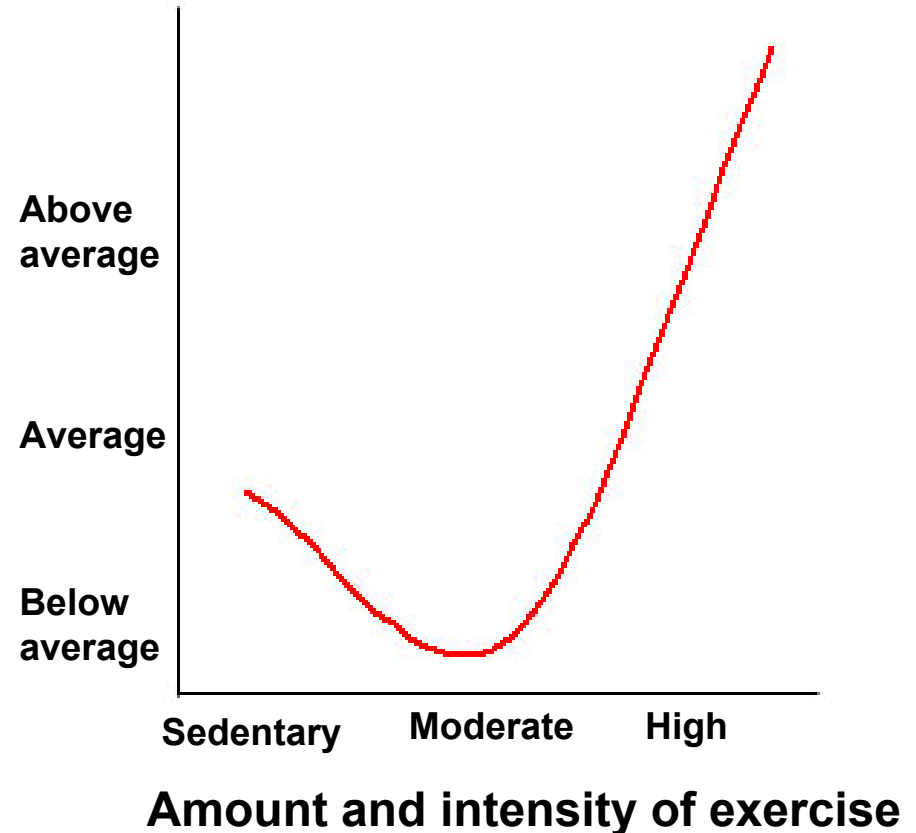
TGC



Exercise intensity and immune function

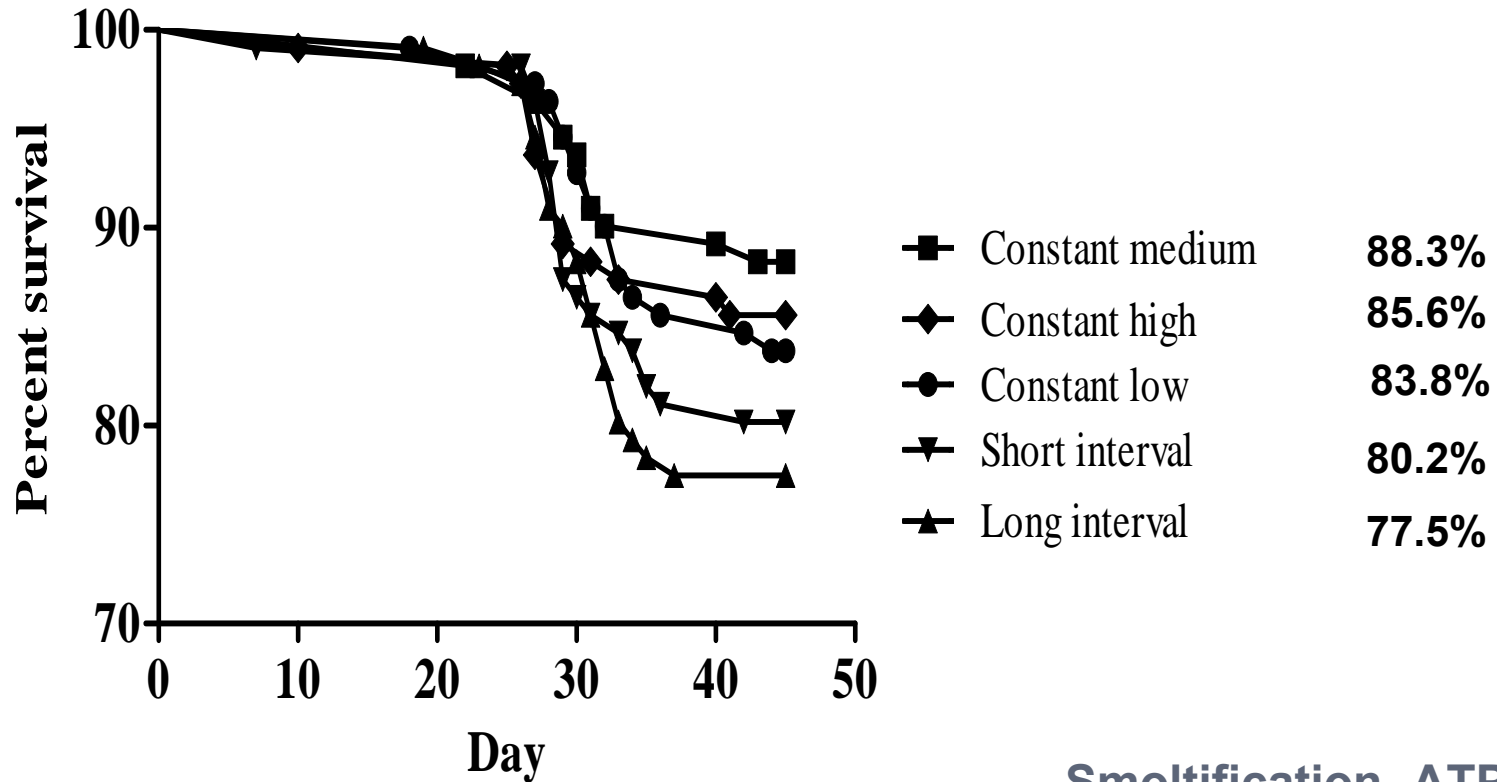
Risk of disease

- Exercise above a certain duration and intensity induce a temporary immunosuppression
- Severe immunosuppression may occur if the immune system are not allowed to recover before a new bout of exercise
- Too hard training can result in chronic inflammatory responses and lead to inflammation and disease

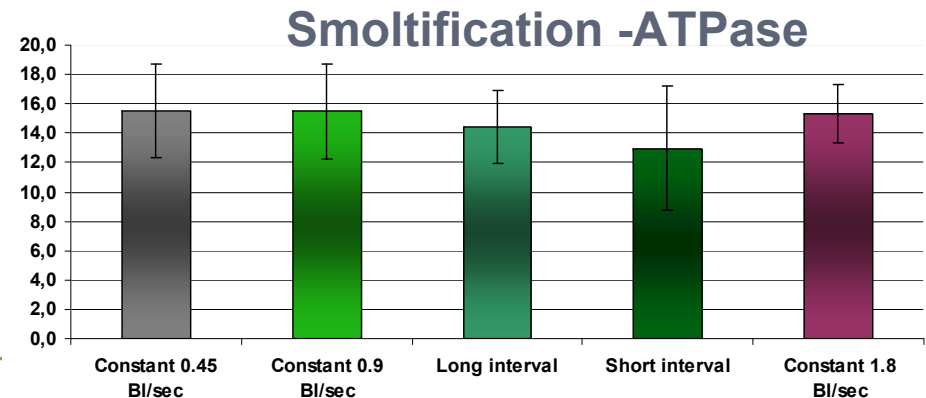


➤ **Critical to identify exercise protocols with optimal duration and intensity**

Effect of exercise in survival in IPN challenge test

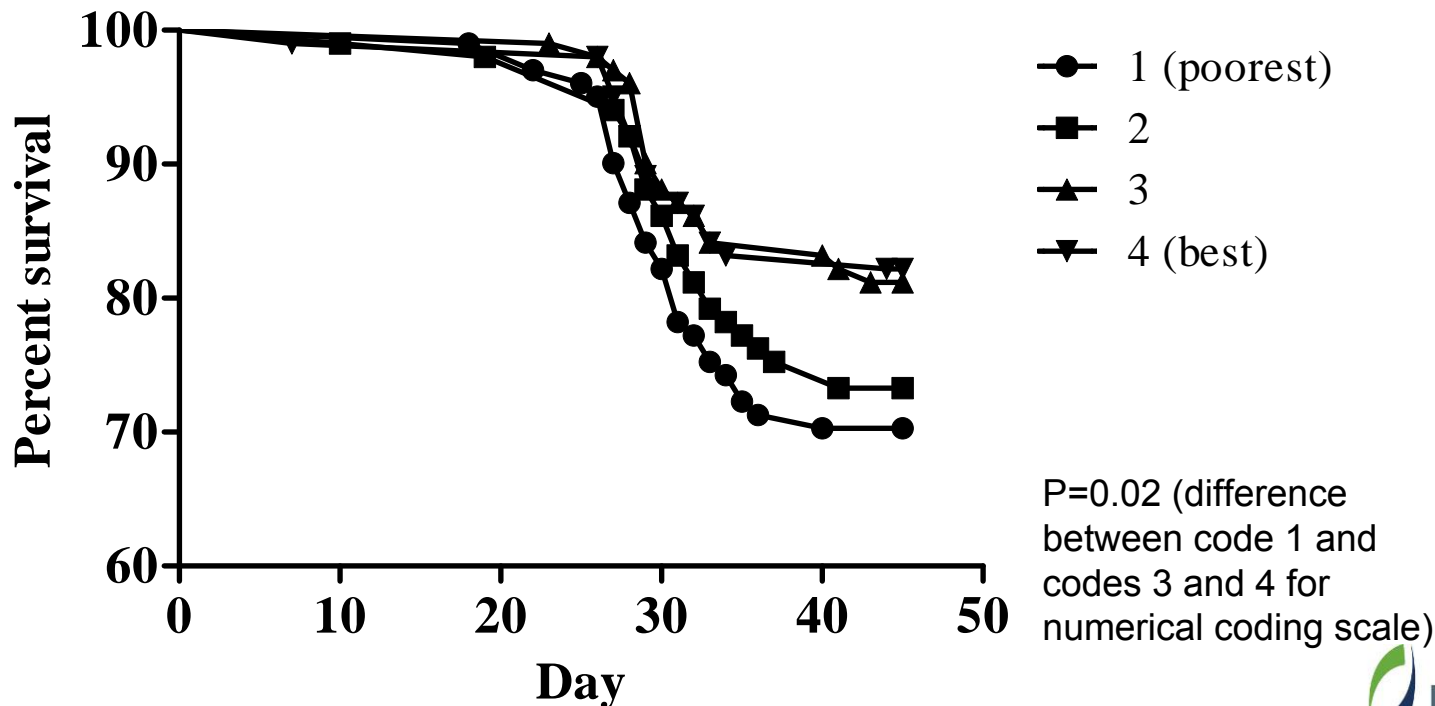


- Results will be followed up by mRNA and protein expression studies



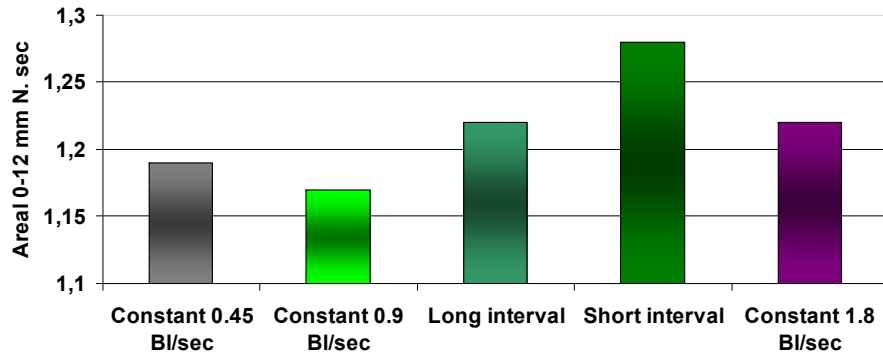
Effect of swimming capacity at start of training on survival in IPN challenge test

- Swimming performance tested for all fish at start of trial
- Category 1 till 4 (poor – good swimmers)
- Great variation in performance

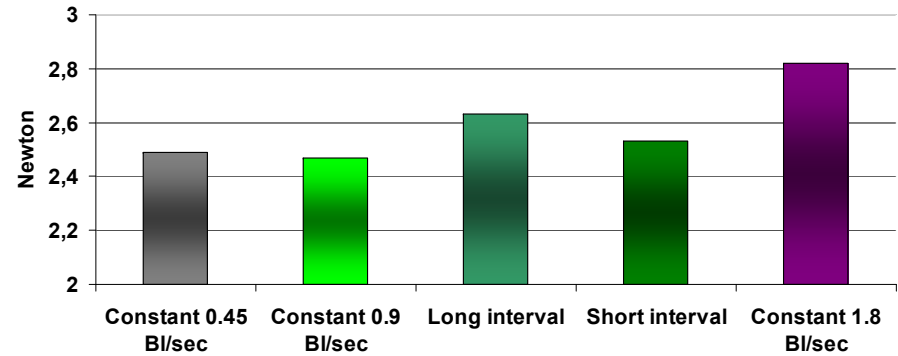


Quality parameters after 10 weeks of training

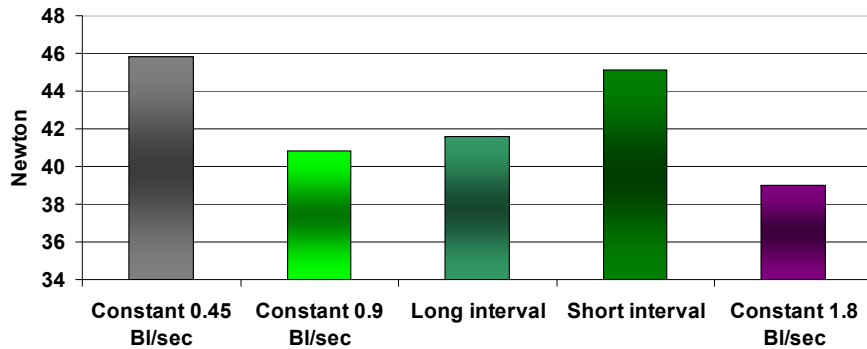
Muscle firmness



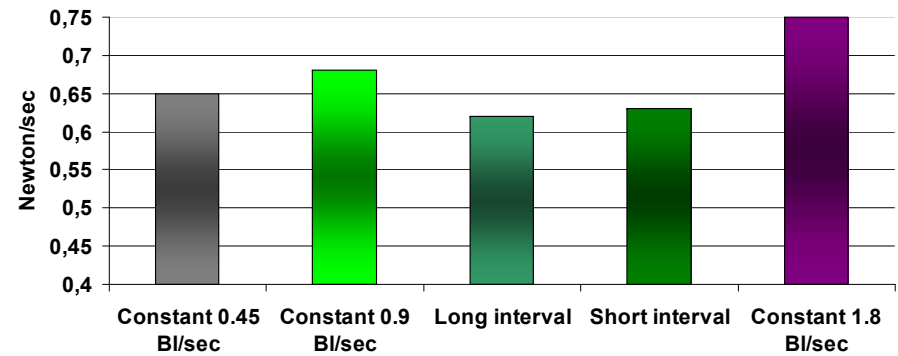
Skin strength



Bone strength



Skin elasticity



Conclusions

- Exercise training has a positive effect on:
 - Growth
 - Disease resistance, but duration and intensity seems to be essential
 - Immune system
- Great variance in inherited swimming capacity
- Swimming capacity of parr might correspond to disease resistance

Contributors

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Thank you! Muchas gracias!