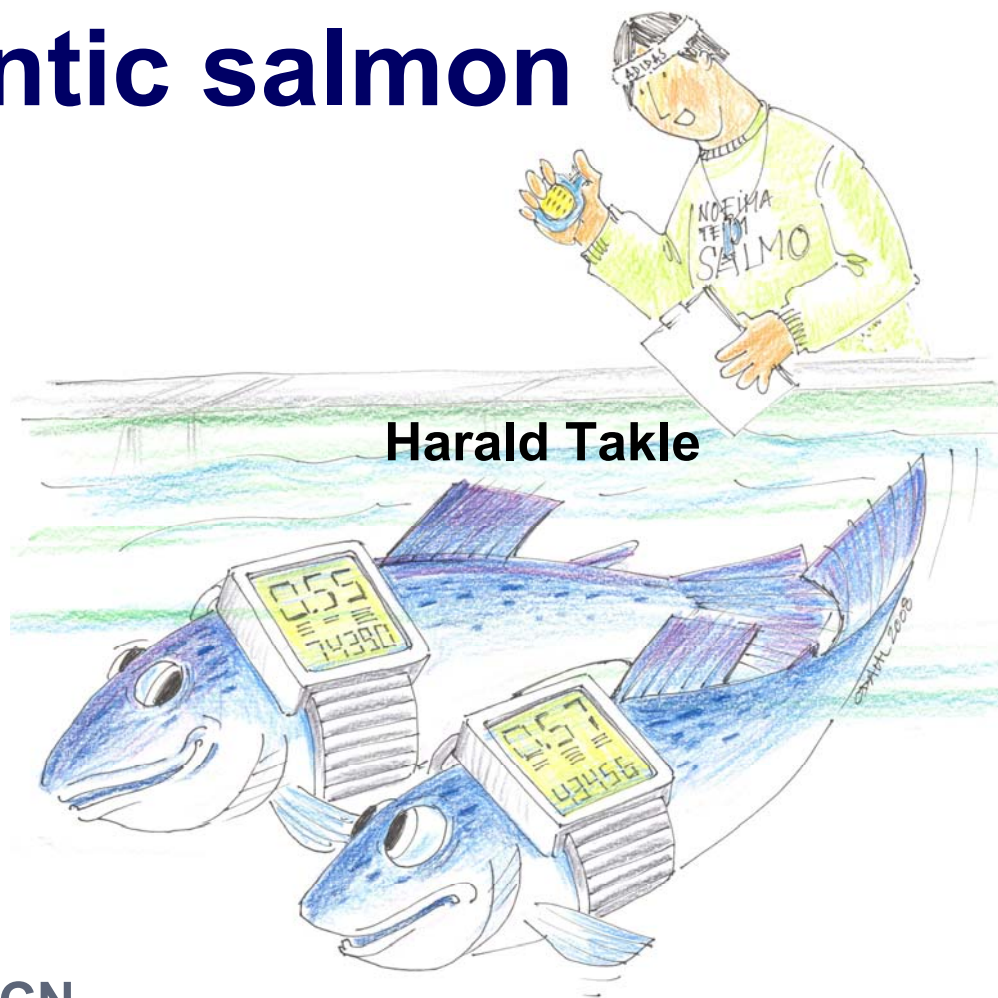


# Exercise training to improve performance and robustness of Atlantic salmon

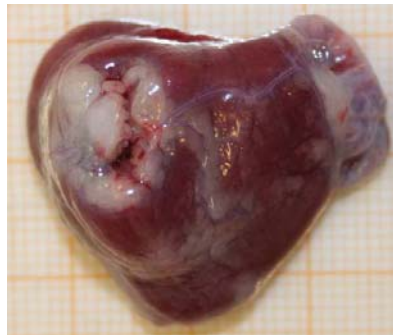


Harald Takle

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

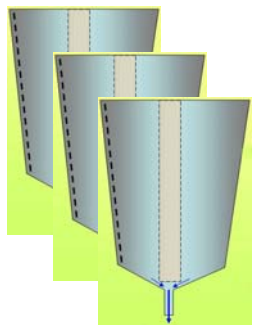
- Optimize the beneficial effect of aerobic endurance training to improve **growth, cardiac performance** and **health** in A. salmon.
- Test different **endurance training programmes** of variable intensities and duration during the freshwater stage and evaluate the training effects on:
  - *cardiac 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

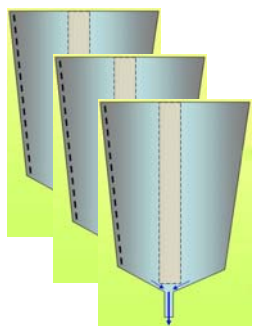


1



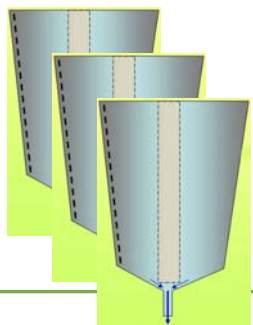
**Low intensity continuously:**  
~ 0.05 bodylength/s<sup>-1</sup>

2



**Medium intensity continuously:**  
~ 0.80 bodylength/s<sup>-1</sup>

3



**Medium+ intensity interval:**  
~ 1.0 bodylength/s<sup>-1</sup> 8hrs  
~ 0.80 bodylength/s<sup>-1</sup> 16hrs

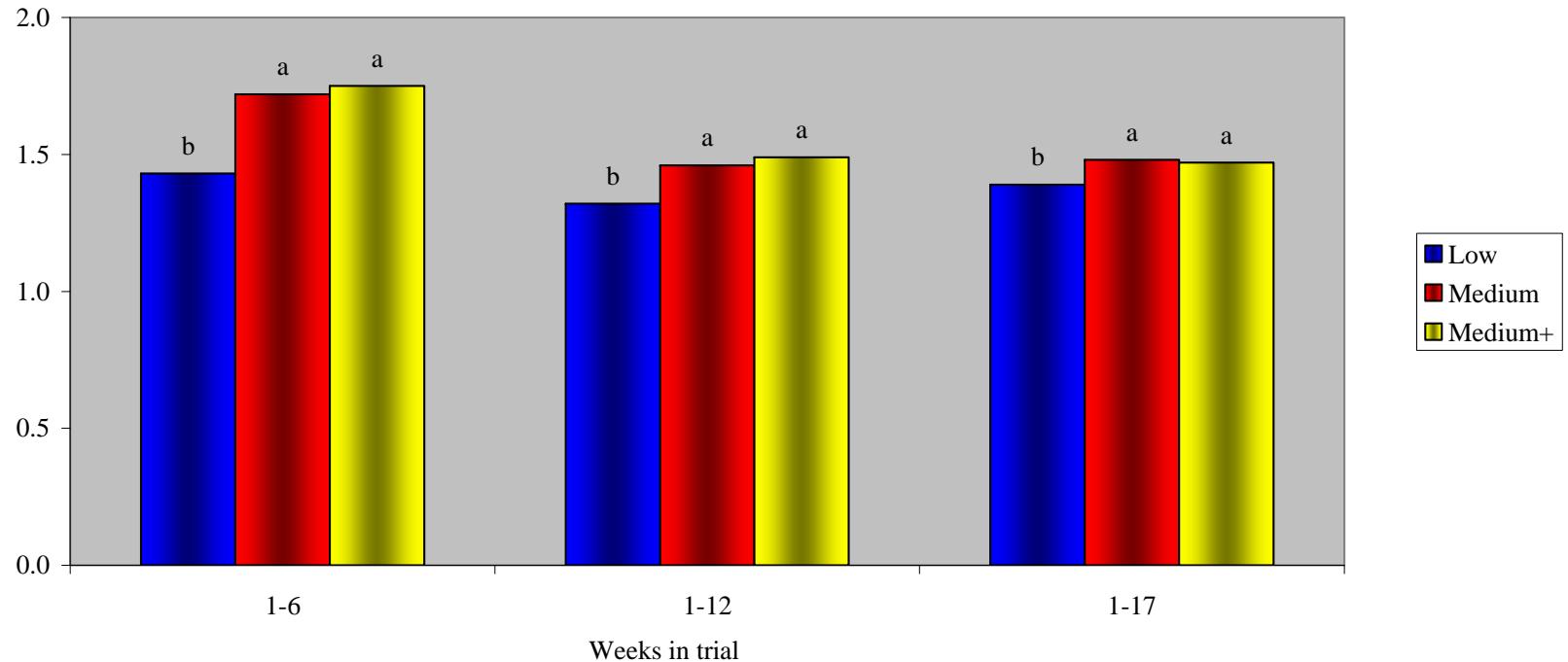
Fish were  
pooled and  
divided in  
two tanks

Gr 1 transferred  
to saltwater to  
examine  
performance

Gr 2 were  
challenged with  
IPN

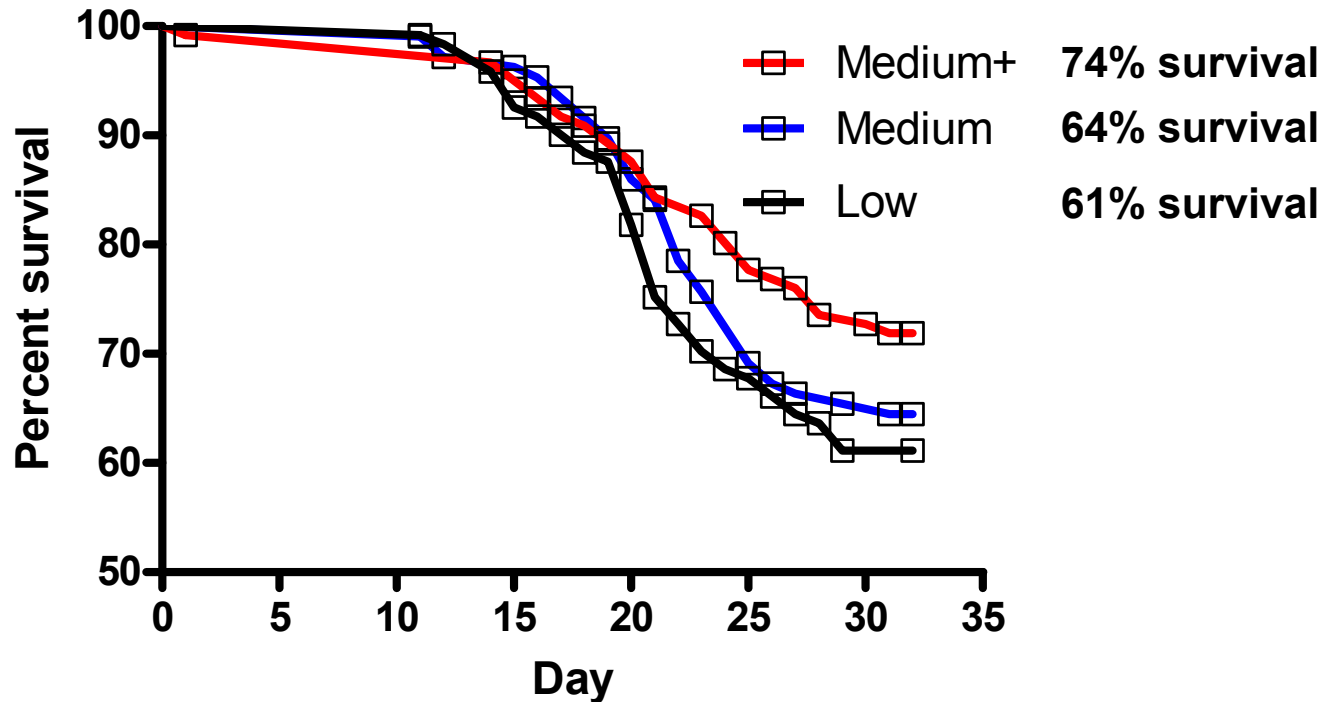
# Growth

Thermal Growth Coefficient



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

# IPN challenge test

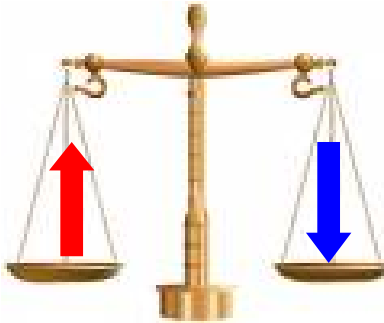


- Could the improved survival of trained fish be explained by a modulation of the immune system?
- Could the difference in survival between M and M+ fish be explained by gene activity?

# Exercise and the immune system

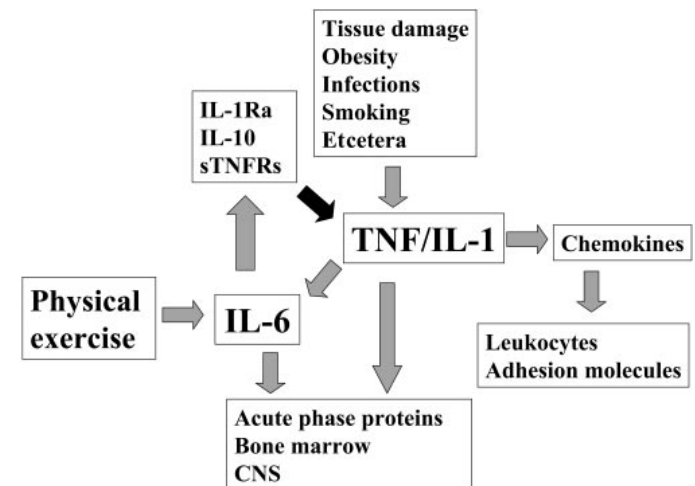
## The burden of low level chronic inflammation

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



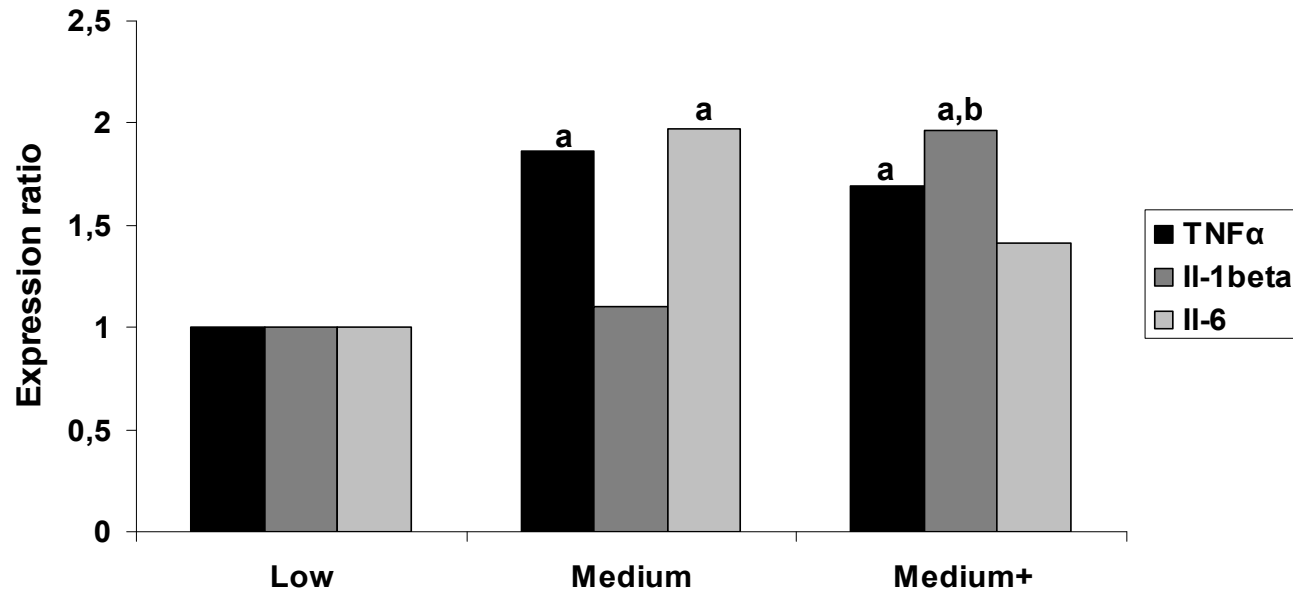
- **Exercise**

- Humans:
  - During exercise:  $\text{TNF}\alpha$ ,  $\text{IL-1}\beta$  and  $\text{IL-6}$  
  - Recovery:  $\text{TNF}\alpha$ ,  $\text{IL-1}\beta$  and  $\text{IL-6}$  



➤ How is the situation in salmon?

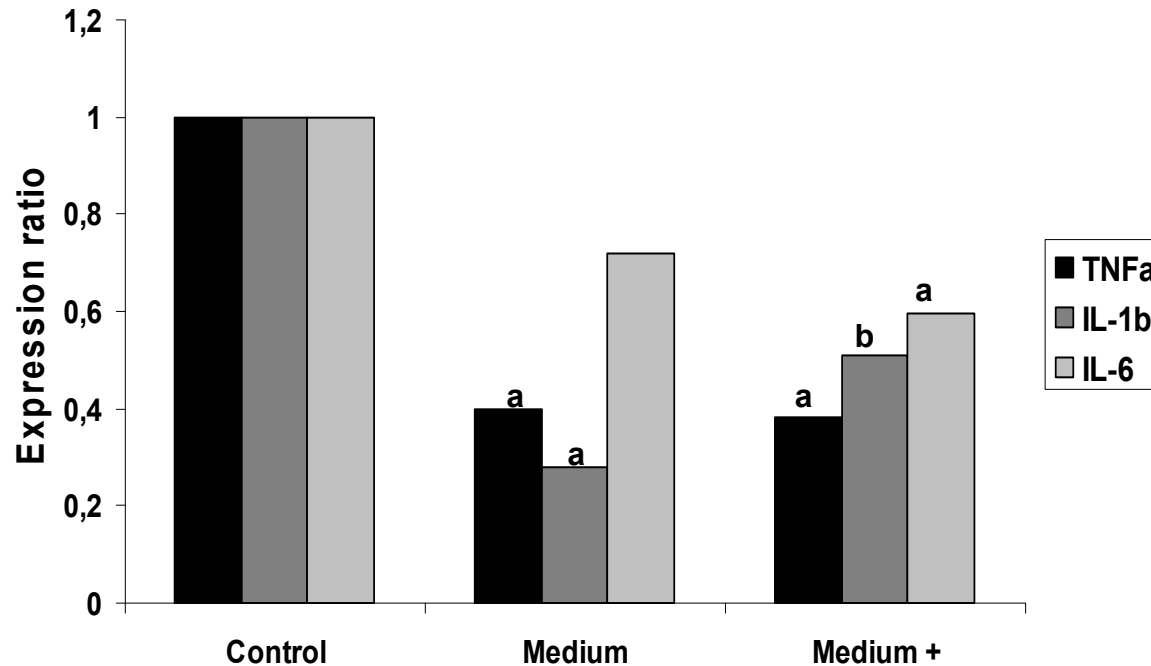
# Exercise and the immune system



- 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)

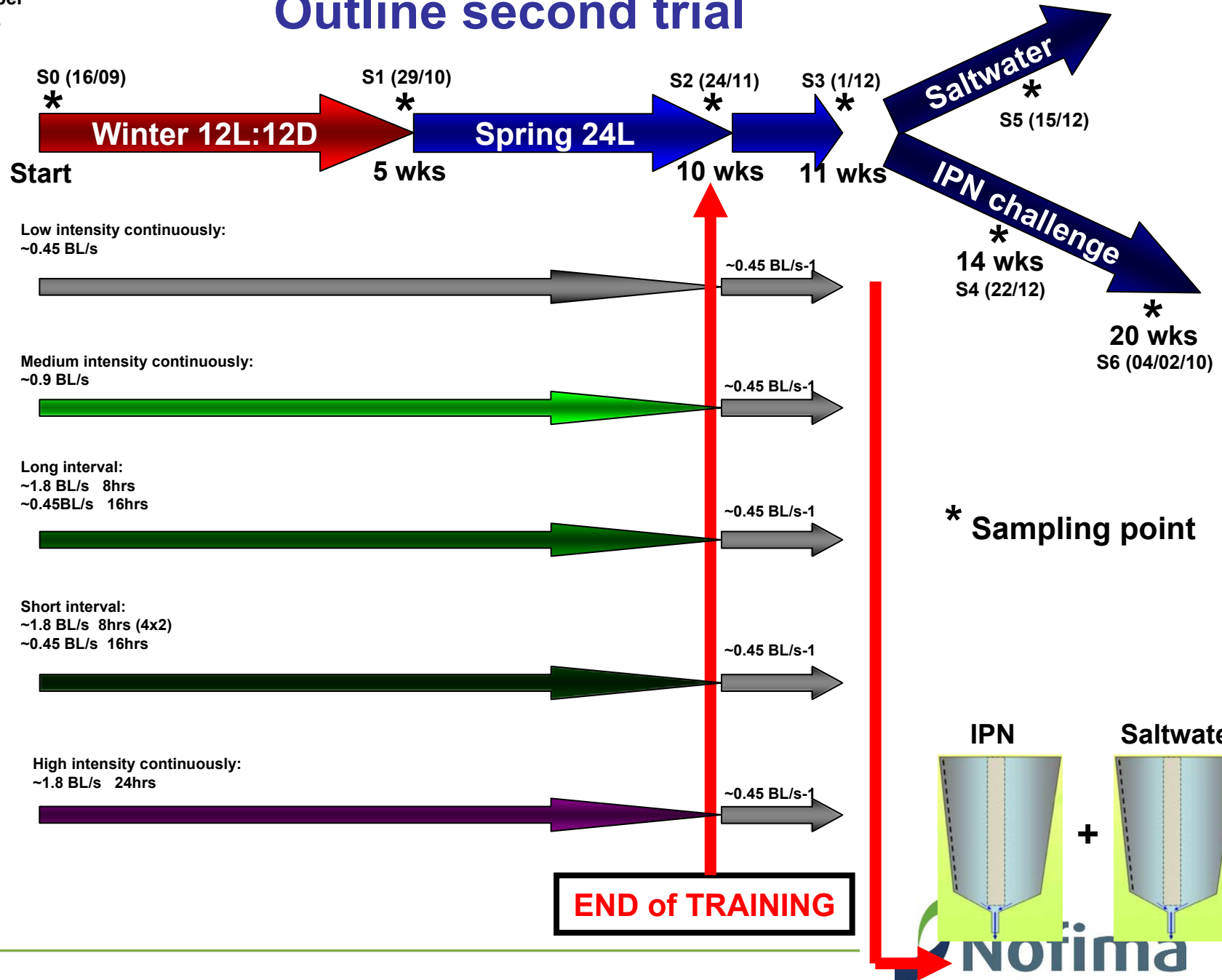
## FitnessFish:

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)

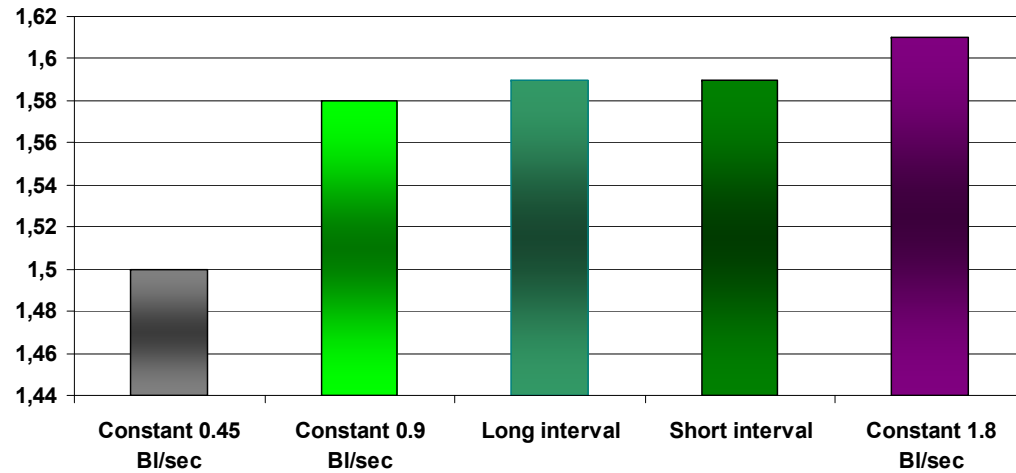
~35 g 87 fish per  
500 litre tanks

# Outline second trial

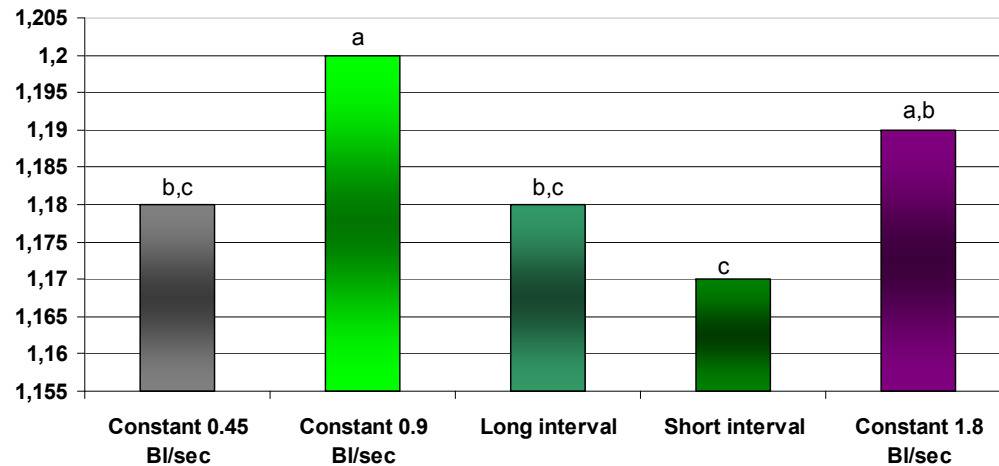


# Growth response

TGC

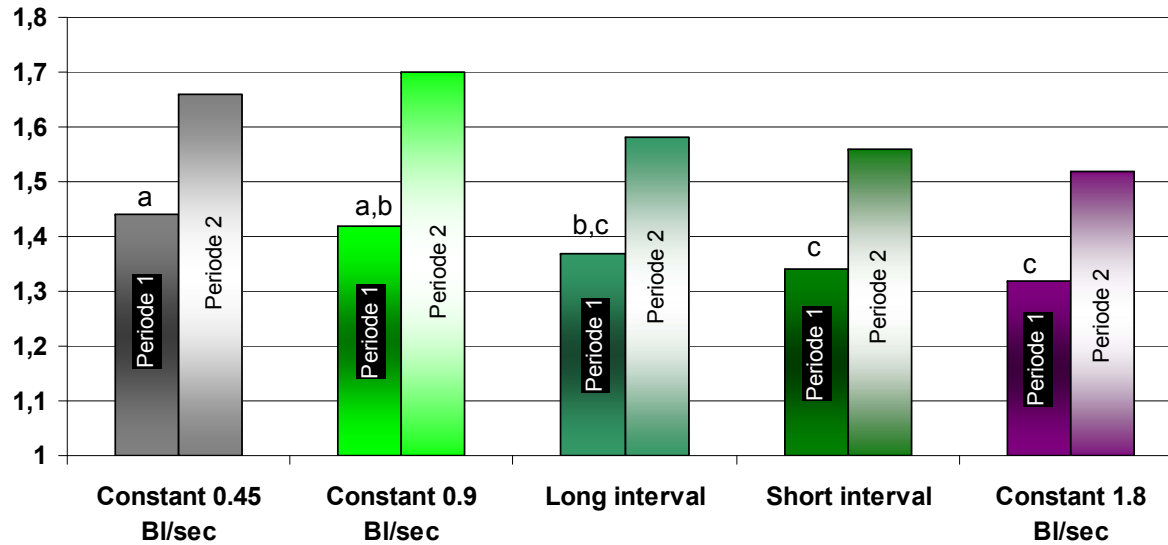


Condition factor

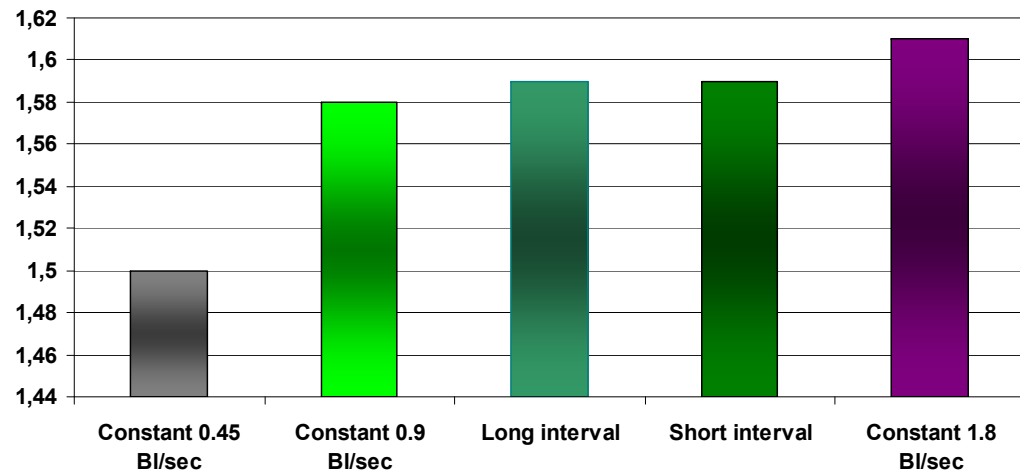


# Growth response

## Feed efficiency



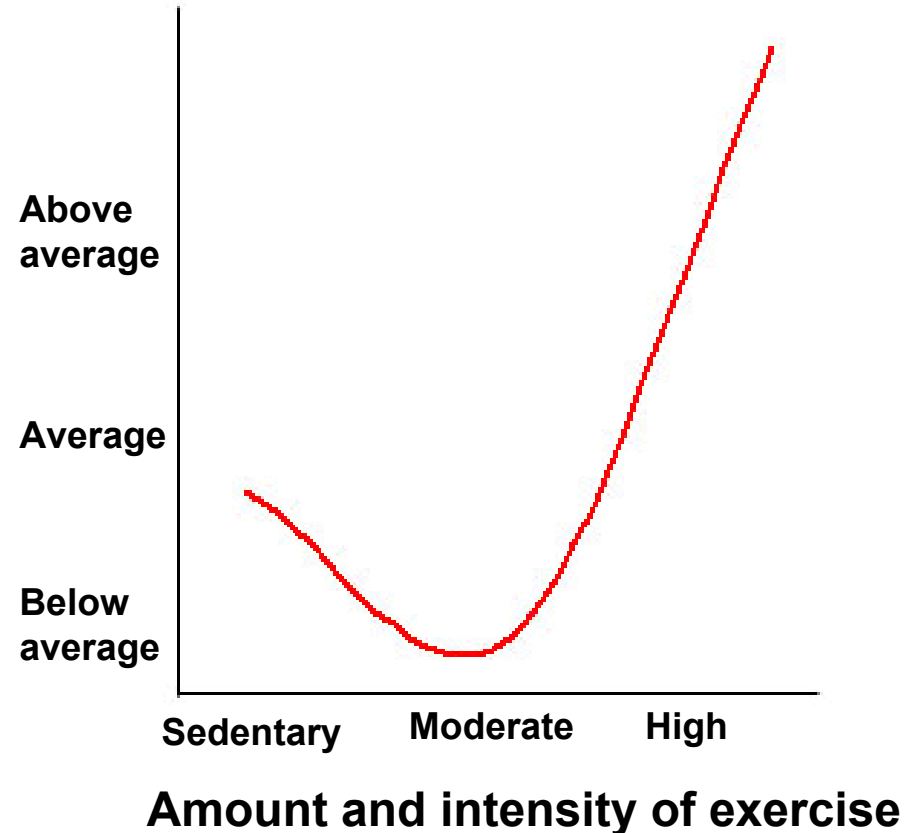
## TGC



# Exercise intensity and immune function

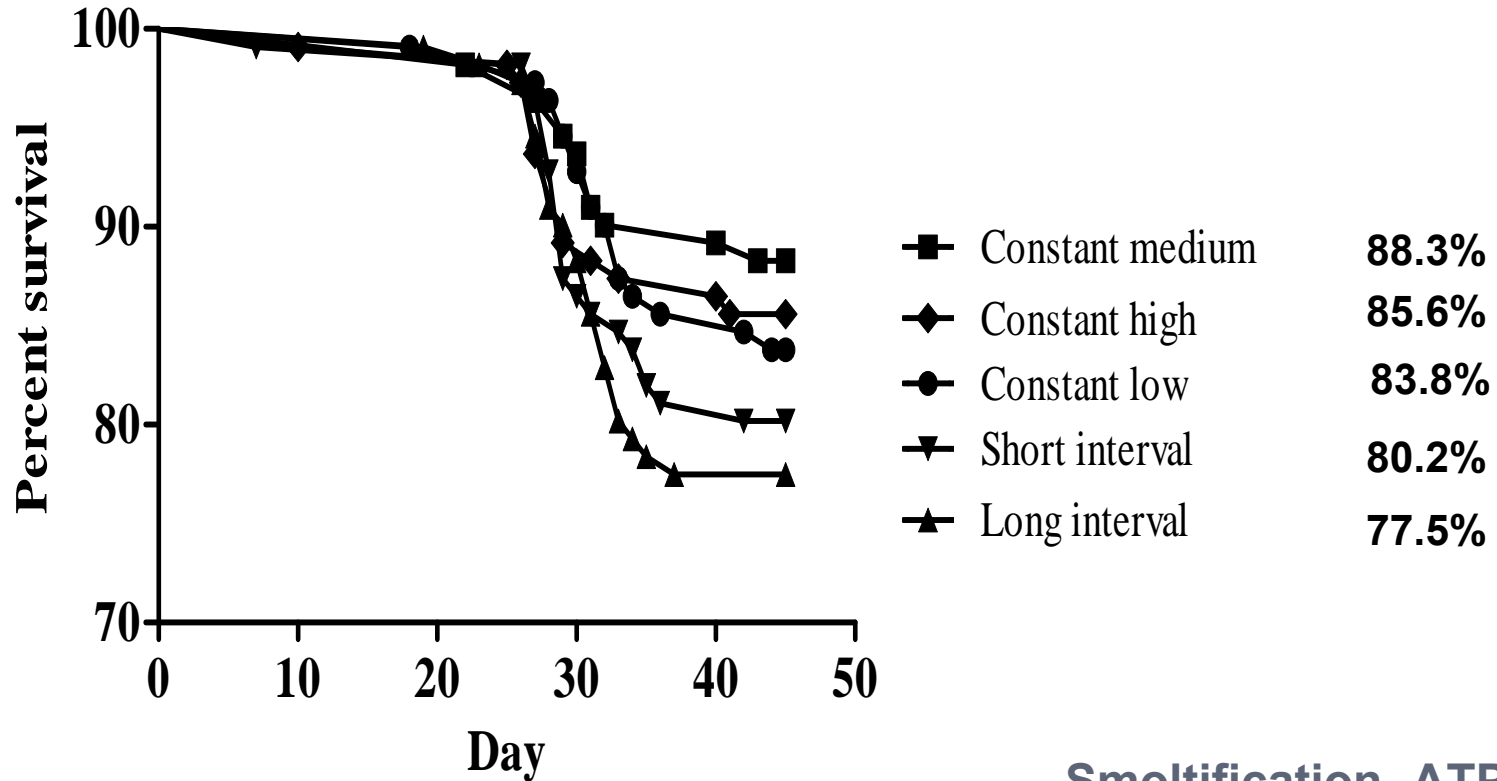
## Risk of disease

- 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

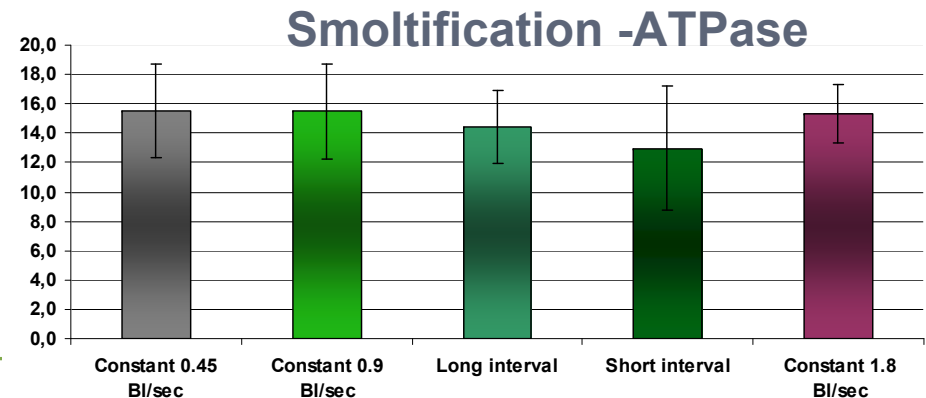


➤ **Critical to identify exercise protocols with optimal duration and intensity**

# Effect of exercise in survival in IPN challenge test



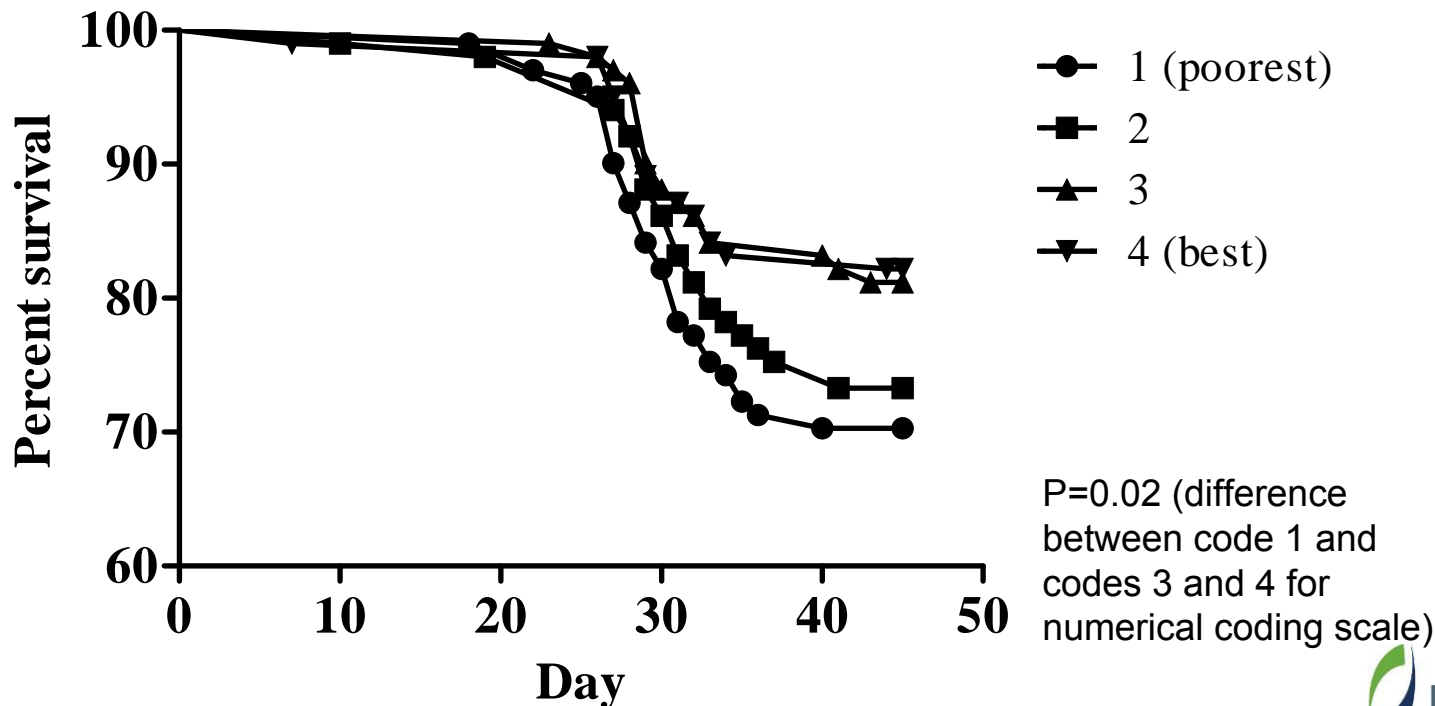
- Results will be followed up by mRNA and protein expression studies





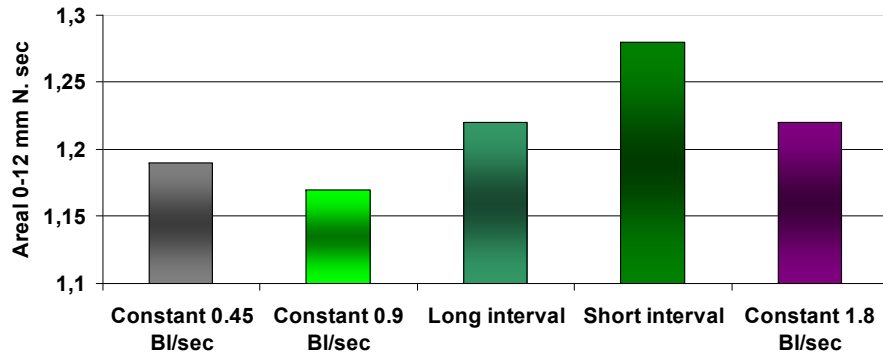
# Effect of swimming capacity at start of training on survival in IPN challenge test

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

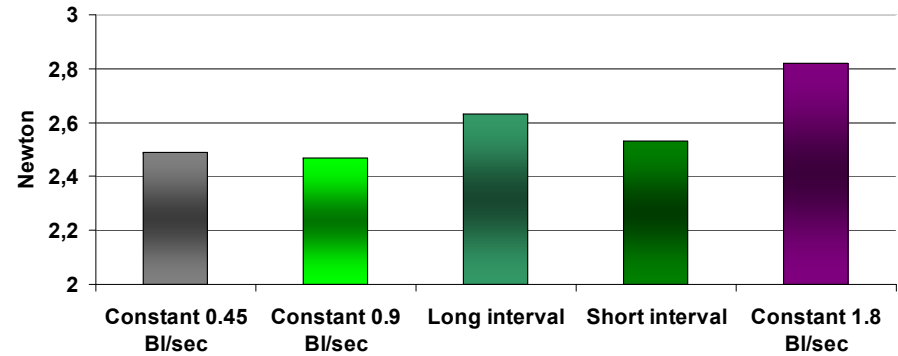


# Quality parameters after 10 weeks of training

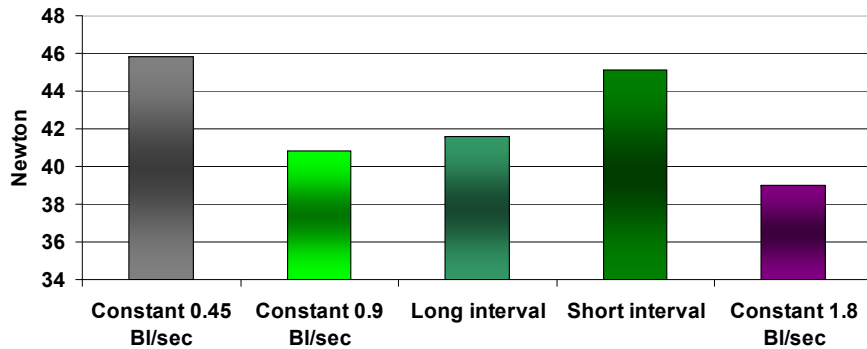
## Muscle firmness



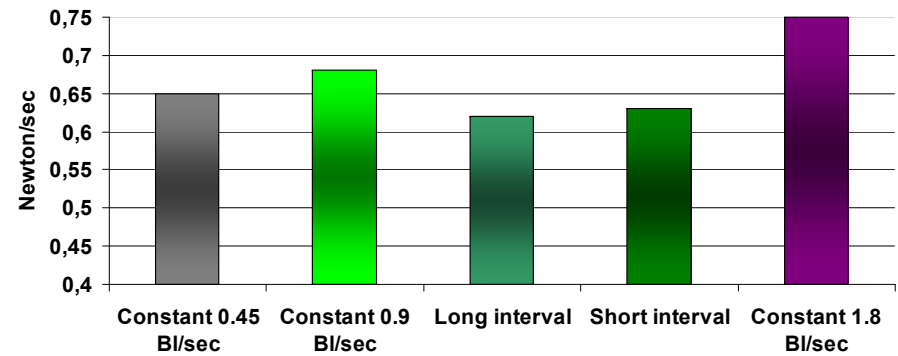
## Skin strength



## 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!**