UBC *InSEAS* (*In*itiative for the *S*tudy of *E*nvironment and its *A*quatic *S*ystems)

THE EFFECT OF SALINITY AND PHOTOPERIOD ON ATLANTIC AND COHO SALMON GROWTH, MATURATION AND PHYSIOLOGICAL PERFORMANCE IN RAS

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Issues to Address in RAS

Small profit margins

- Profitability depends on maximizing growth and/or increasing feed conversion efficiency

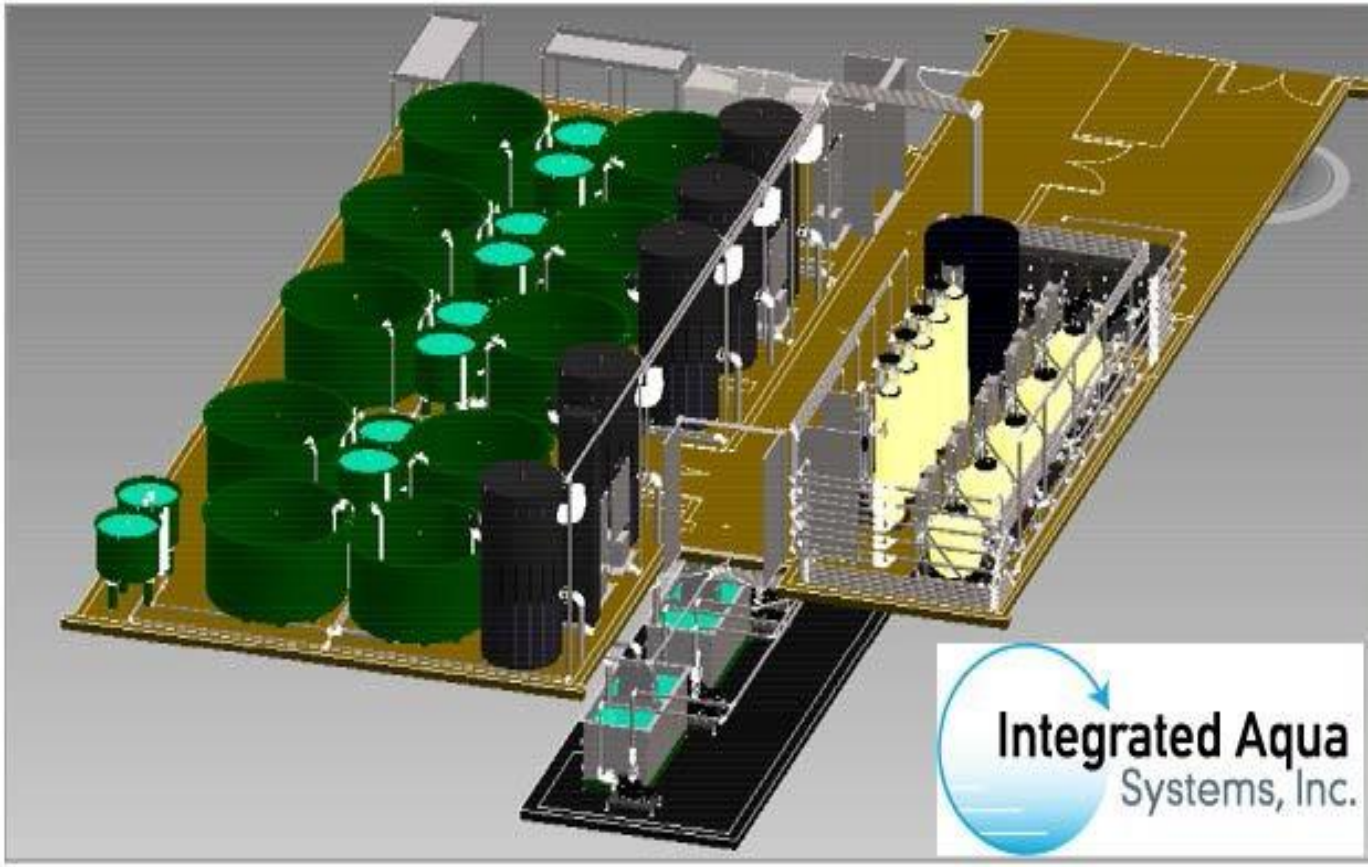
Optimal conditions for growth of salmon are still not determined

- Temperature, photoperiod, salinity, oxygen, pH, ammonia, etc

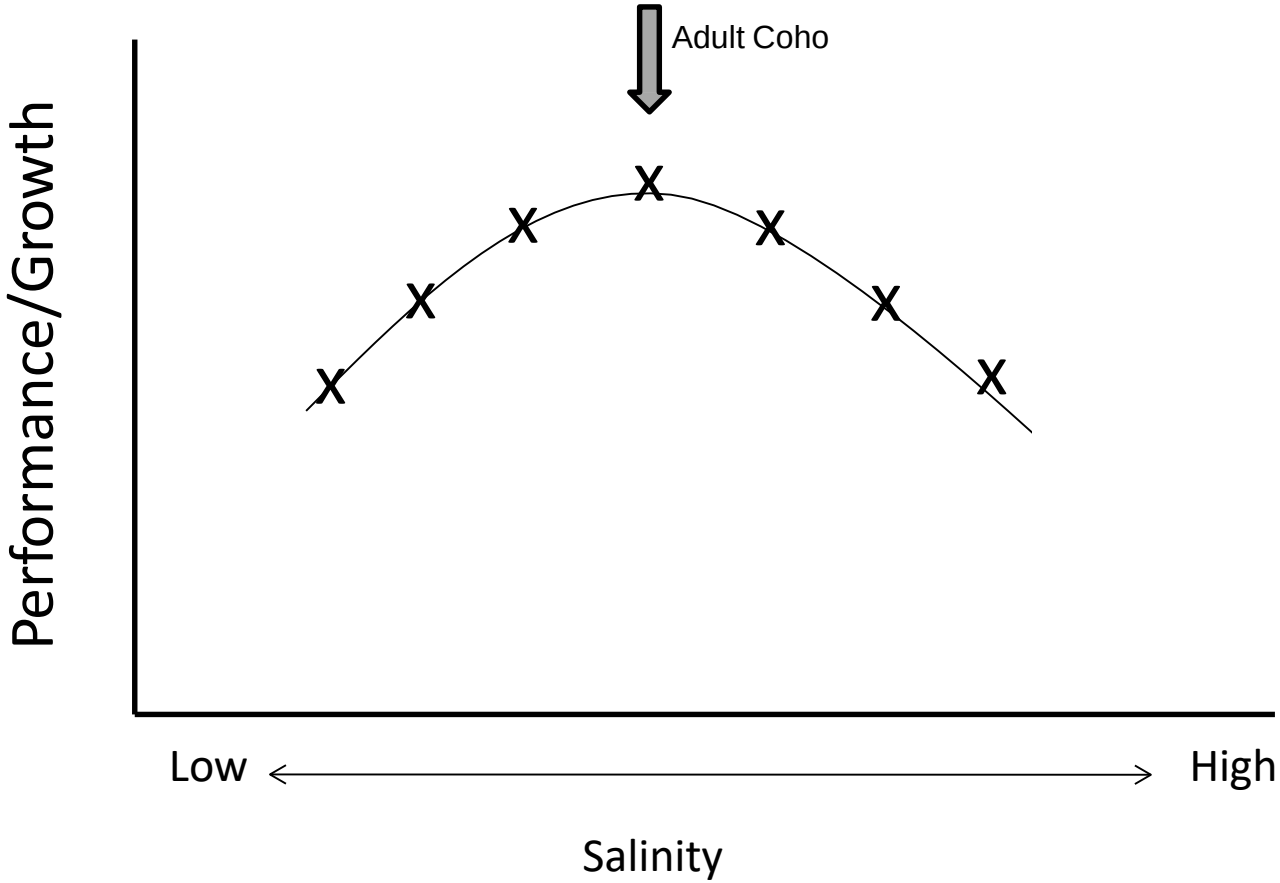
InSEAS RAS Research Facility

- 7 independent recirculation systems
- Each system has 2 x 5 m^3 tanks and 2 x 0.7 m^3 tanks
- Automatic feeders on large tanks
- Environmental control and monitoring systems

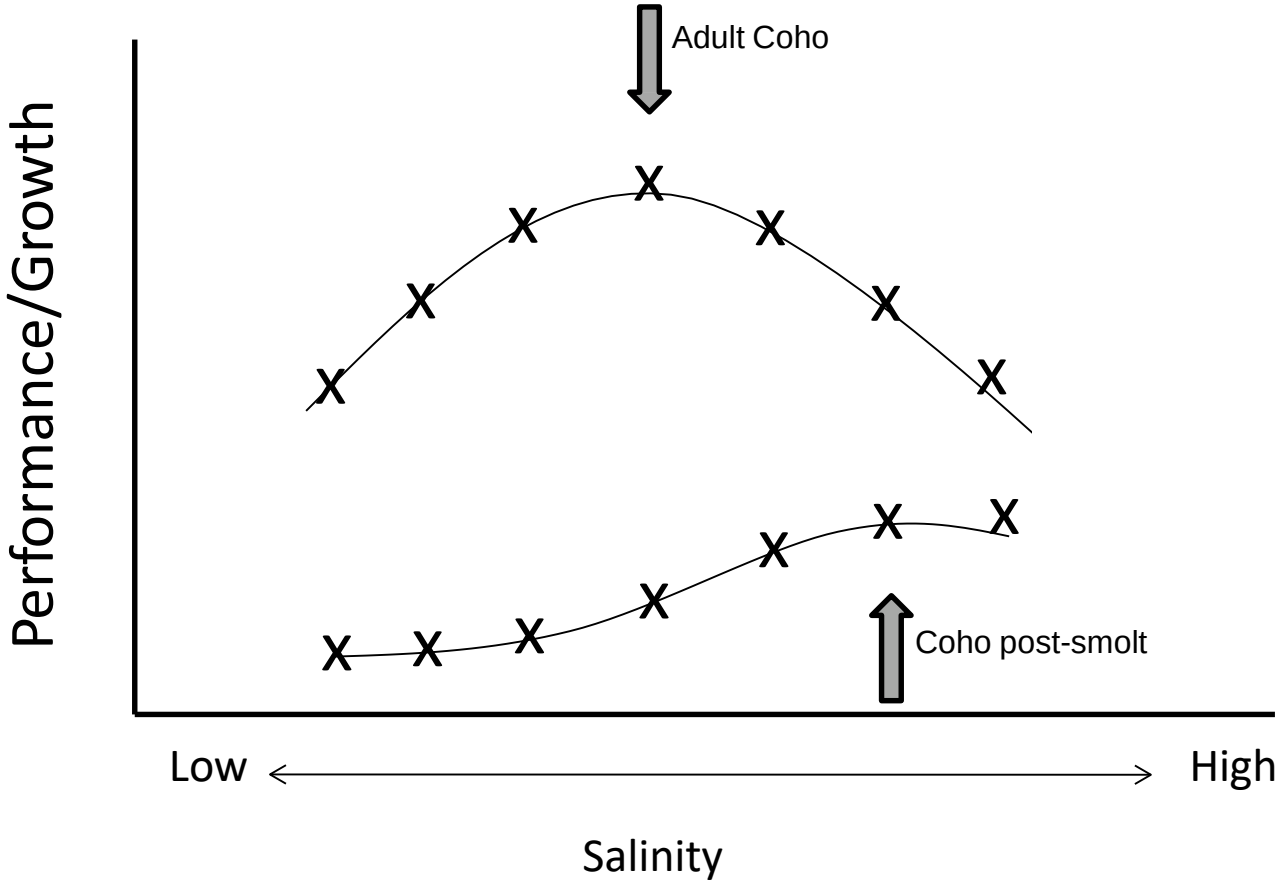
InSEAS RAS Research Facility



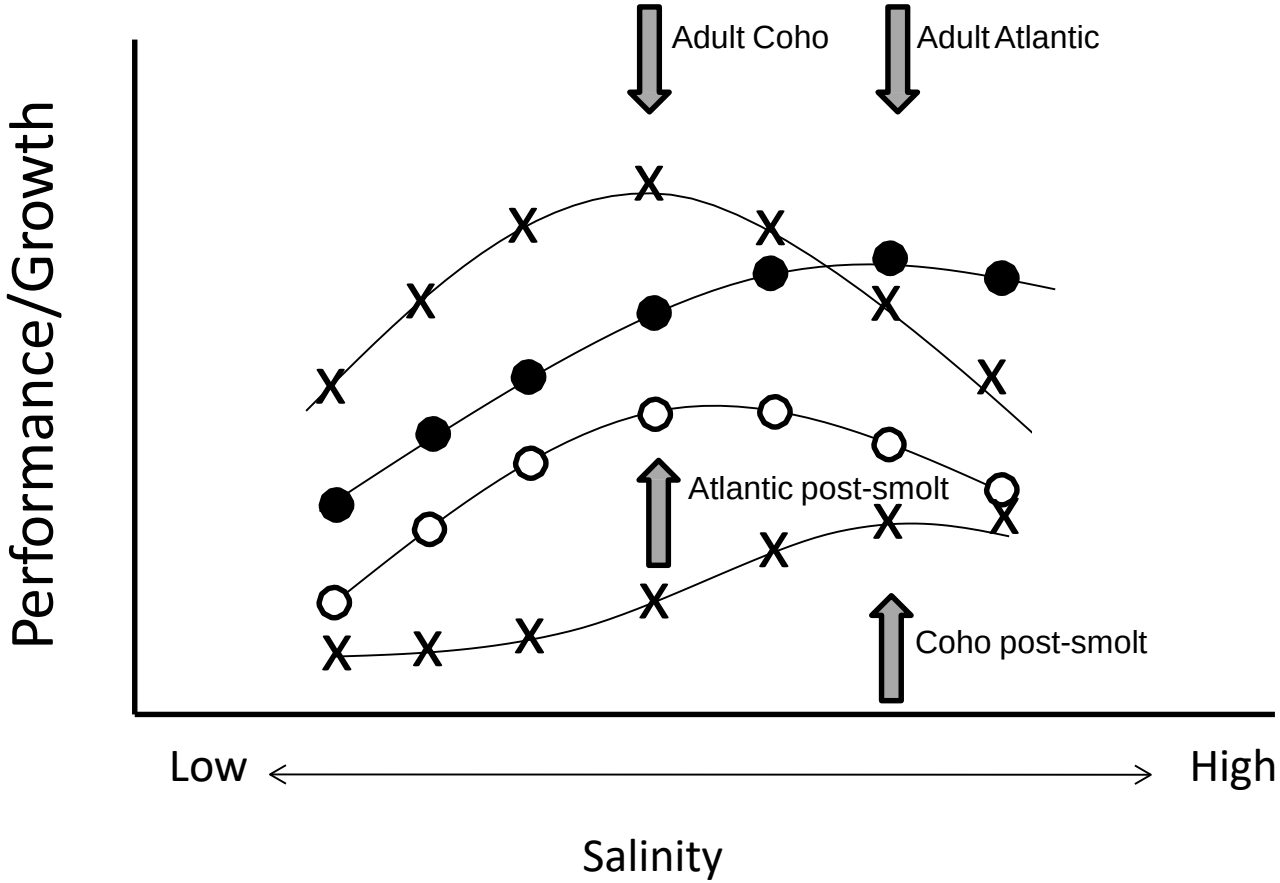
InSEAS Regression Approach



InSEAS Regression Approach



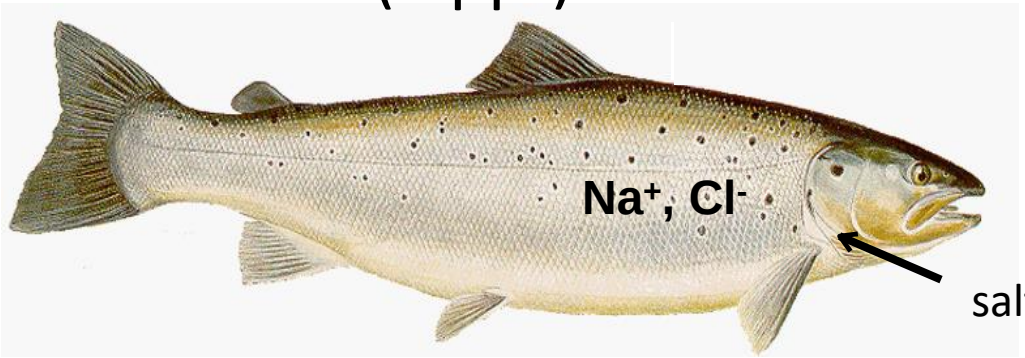
InSEAS Regression Approach



In a single experiment, we can determine optimal values for a given parameter in two species across multiple life stages.

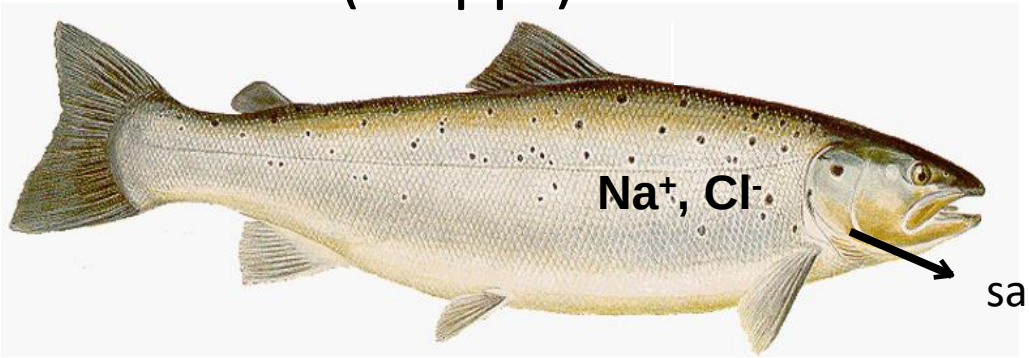
Effects of Salinity on Salmon Growth

Salmon in fresh water (0 ppt)



Na^+, Cl^-

Salmon in sea water (30 ppt)



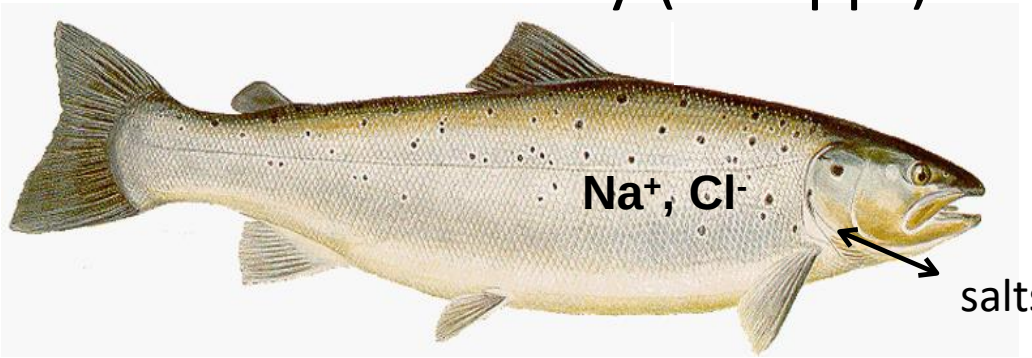
Na^+, Cl^-

Osmoregulation can account for 10-50% of standard metabolic rate

(Bœuf & Payan, 2001)

Effects of Salinity on Salmon Growth

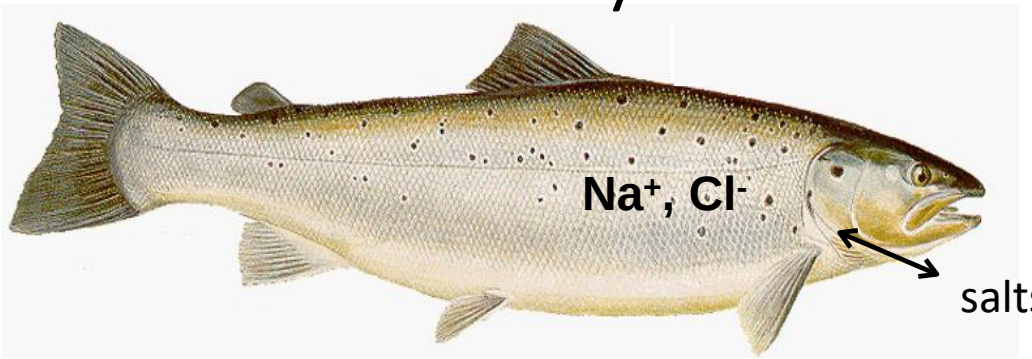
Salmon at intermediate salinity (~10 ppt)



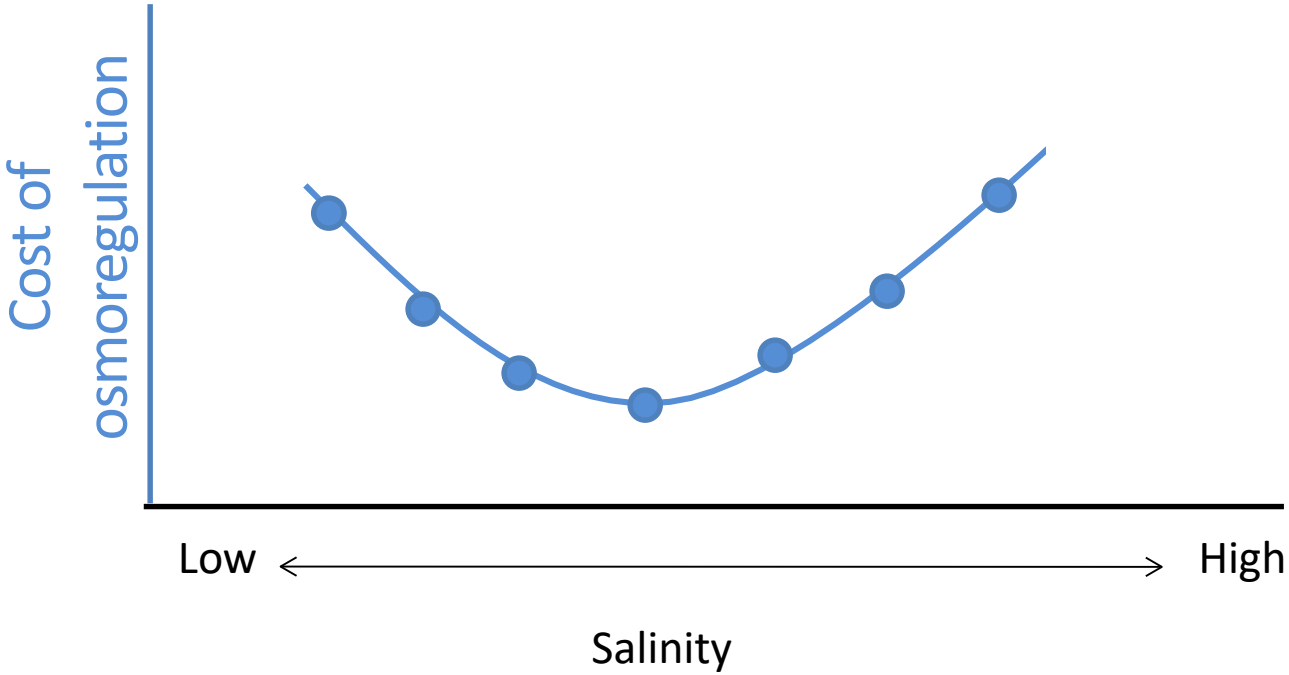
Na^+, Cl^-

Effects of Salinity on Salmon Growth

Salmon at intermediate salinity

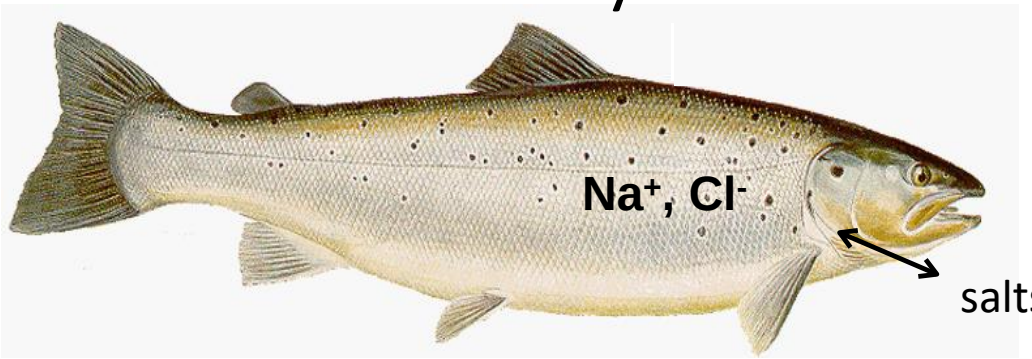


Na^+, Cl^-

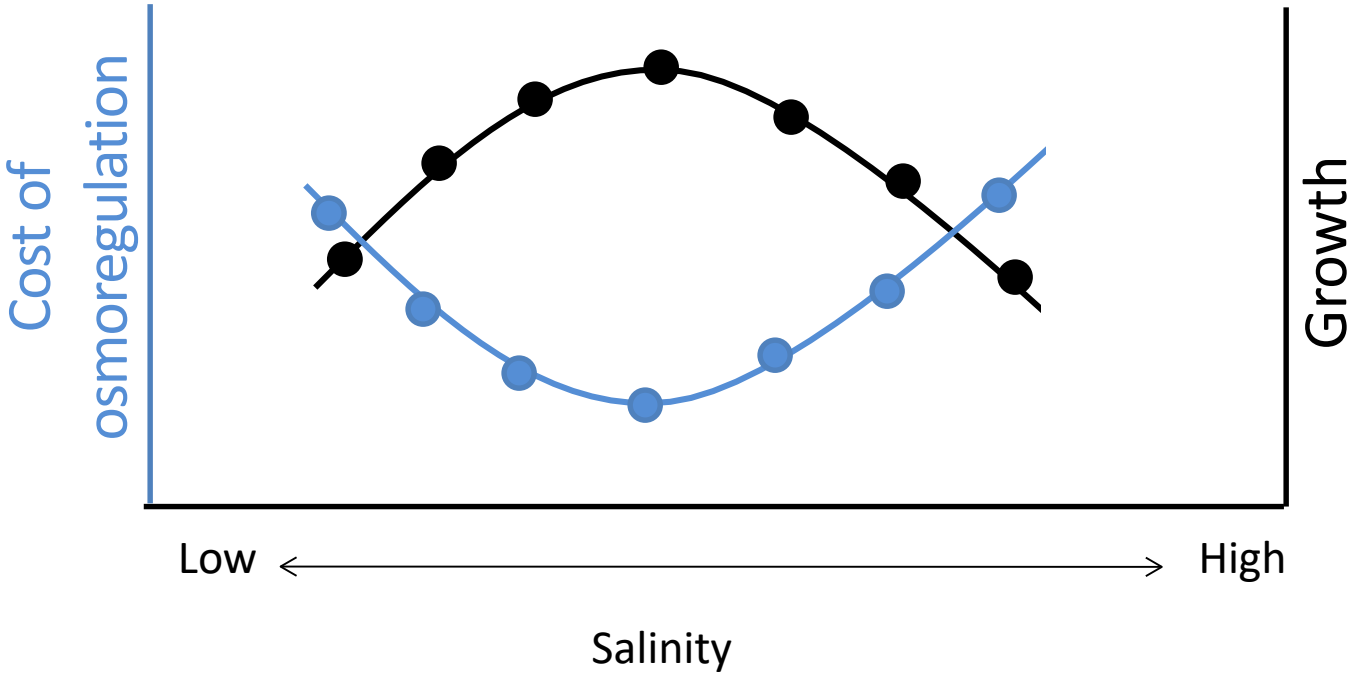


Effects of Salinity on Salmon Growth

Salmon at intermediate salinity

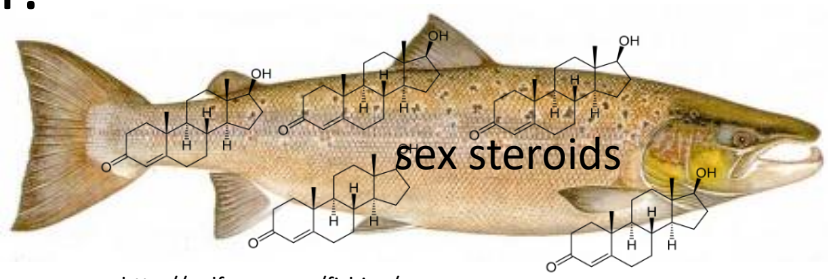


Na^+, Cl^-

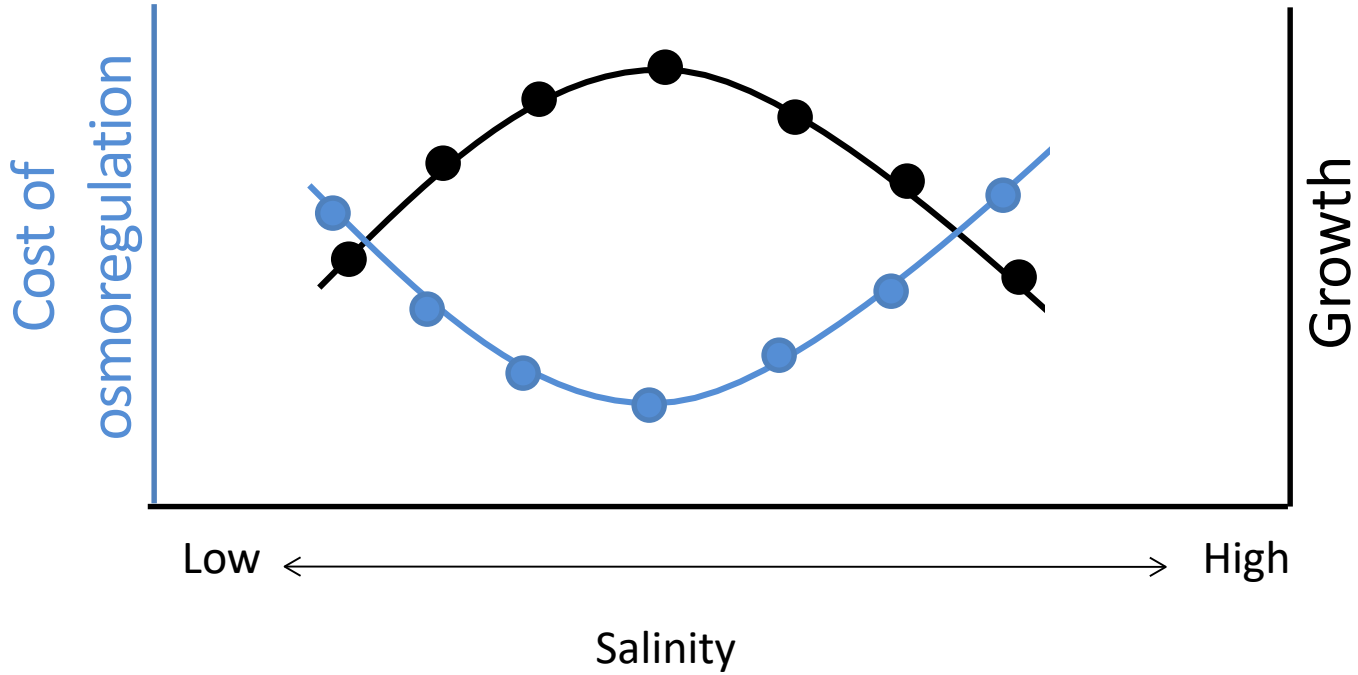


Effects of Salinity on Salmon Growth

How does photoperiod interact with salinity on growth and maturation?



http://wdfw.wa.gov/fishing/



Effects of Salinity & Photoperiod

Specific Research Goals:

Determine optimal salinity & photoperiod for growth and performance of coho salmon and Atlantic salmon reared in RAS from smolt to adult.

i) Growth

ii) Effect on early maturation

iii) Fitness: Is there are tradeoff between growth and physiological performance (Thermal tolerance, Hypoxia tolerance, Maximum swimming speed and Behavior)

Effects of Salinity & Photoperiod: Growth

Fish

- Atlantic salmon smolts = Initial weight ~100 g (6000 mixed sex)
- Coho salmon smolts = Initial weight ~170 g (6000 all female)
- 100 individuals per tank were pit tagged.
- End weight ~ 2000 g
- Density: up to 60 kg m^{-3}

Feeding

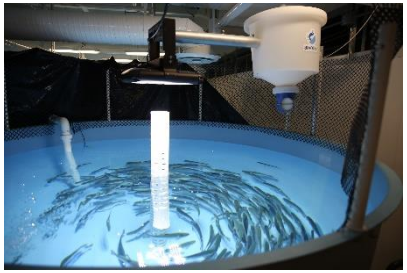
- restricted feeding 1% BW (12h light), automated feeders

Duration

- 400 days (currently at day 300)

Sampling

- Every 60-100 days



Treatments

Photoperiod \ Salinity [ppt]	2.5	5	10	30
12:12	x	x	x	
24	x	x	x	x

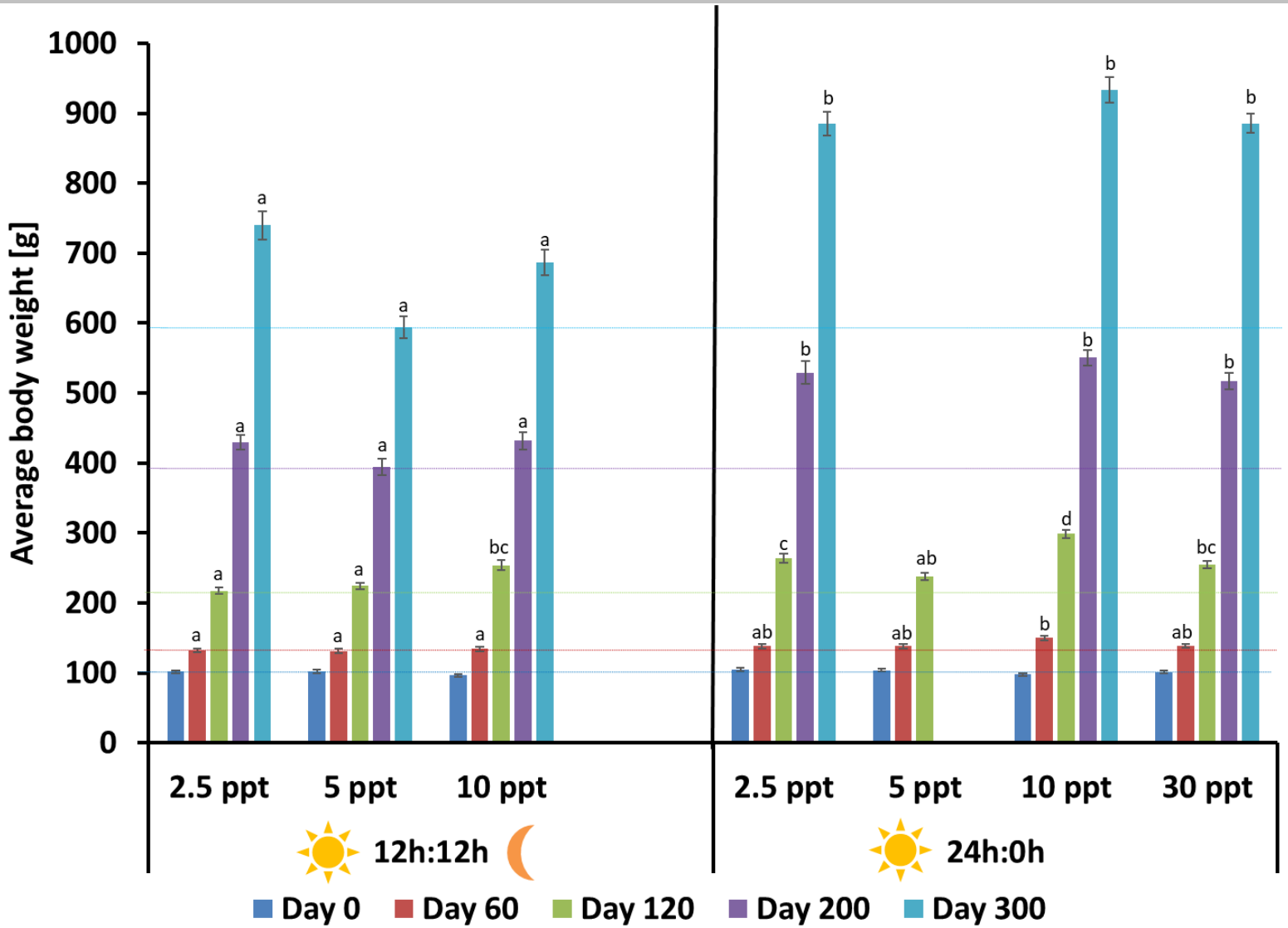
Effects of Salinity & Photoperiod:

Atlantic Salmon

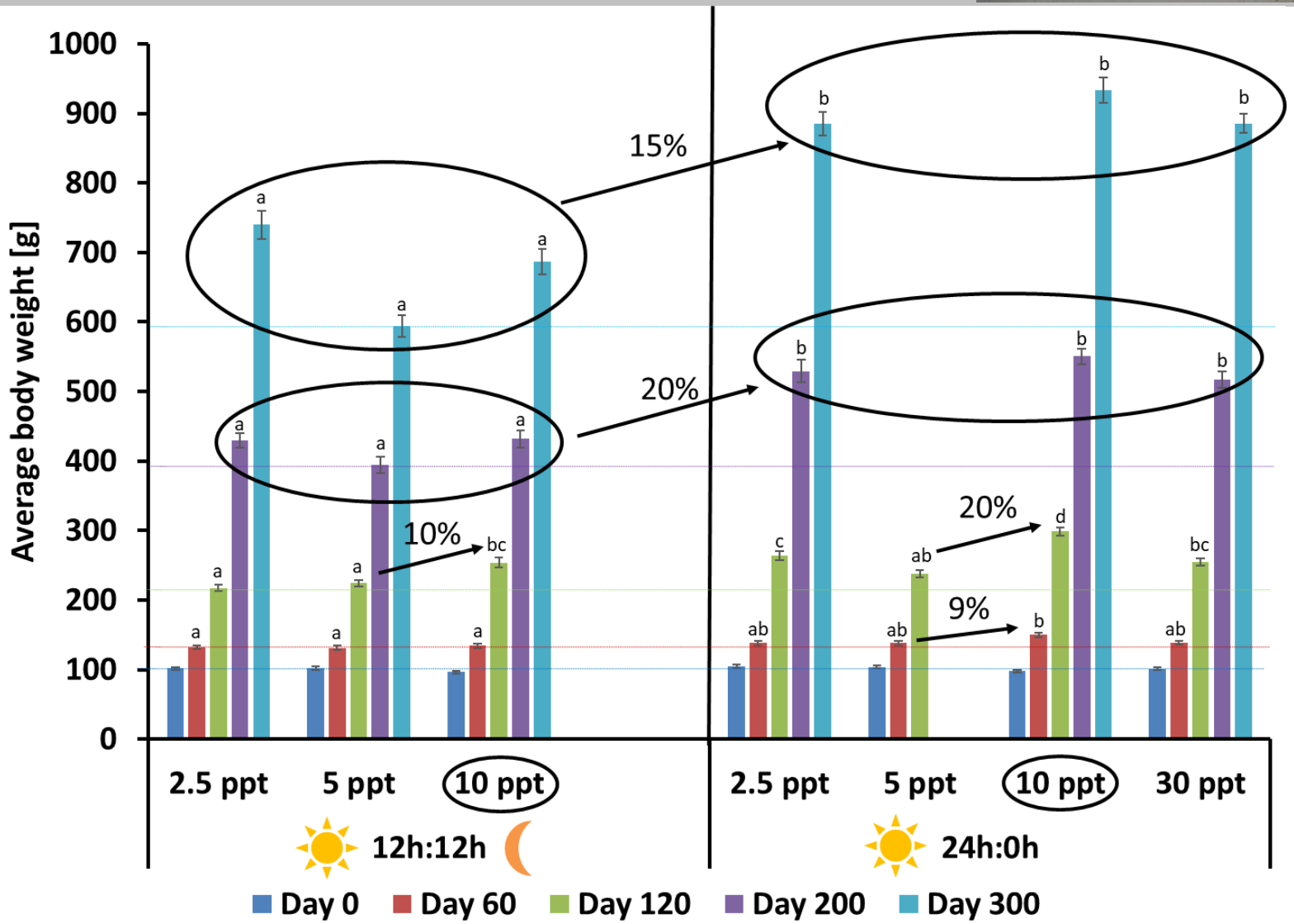
Performance

1. **Growth**
2. Maturation

Atlantic Salmon
Growth in 5 m^3 tanks



Atlantic Salmon
Growth in 5 m^3 tanks



Effects of Salinity & Photoperiod:

Atlantic Salmon

Performance

1. Growth
2. **Maturation**

Atlantic Salmon
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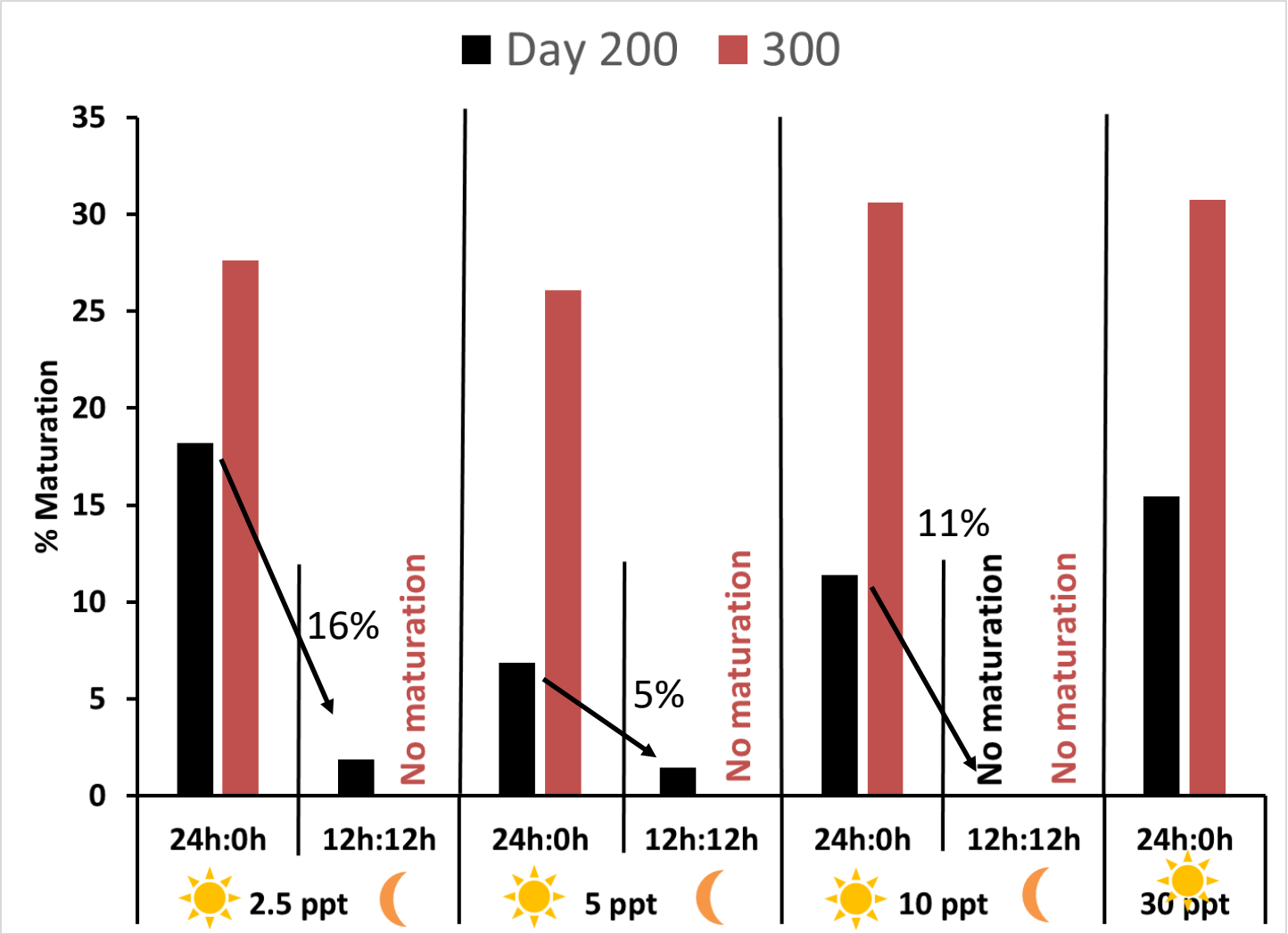
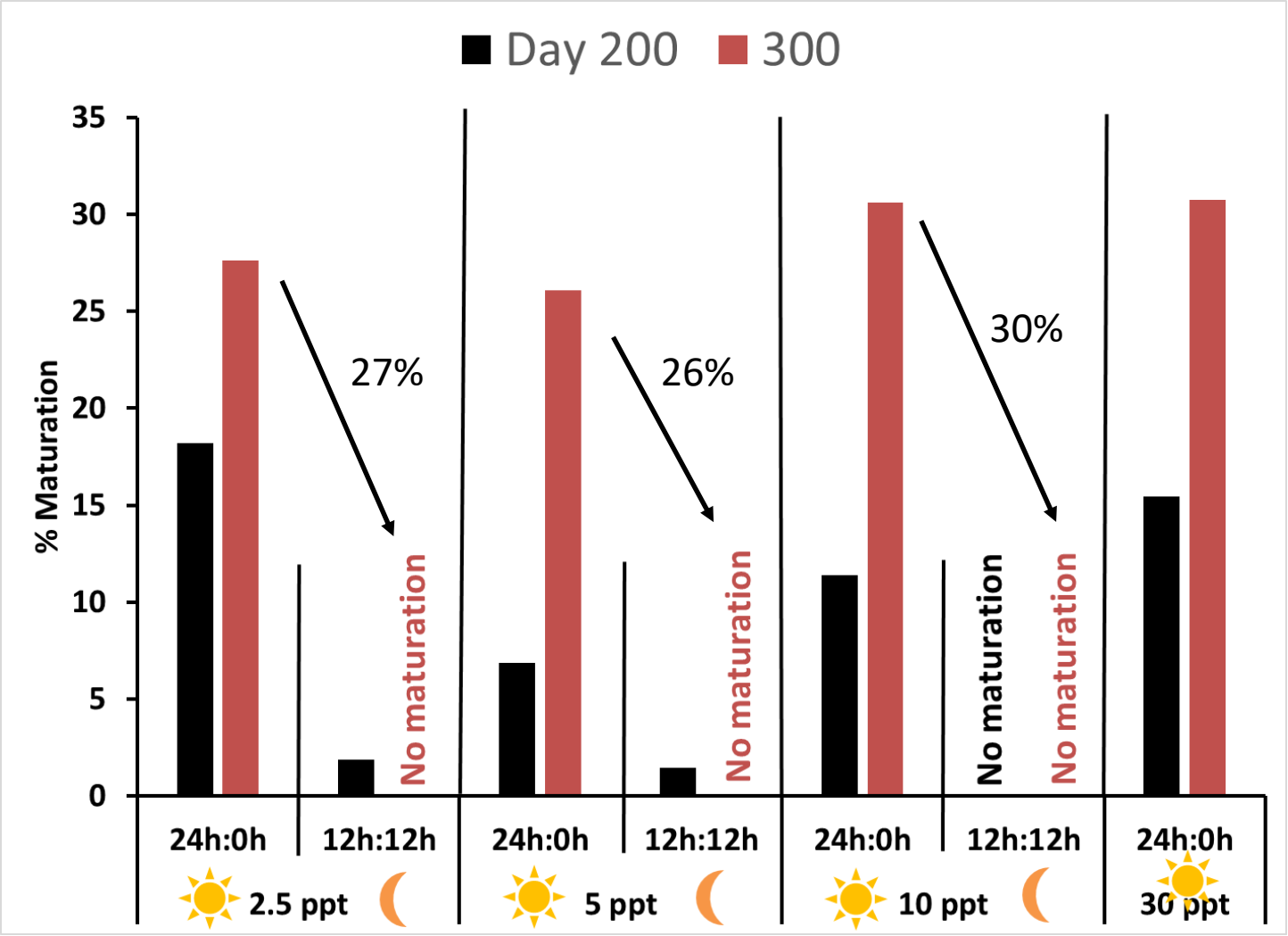


Atlantic Salmon
Growth in 5 m^3 tanks



Conclusions
Atlantic Salmon

Atlantic Salmon

- Until day 120, a salinity of 10 ppt results in a 10% increase in body mass relative to 5ppt.
- 24 h light photoperiod results in a 15-20% increase in body mass at days 200 and 300.
- 24 h light results in 10-15% maturation at day 200 and 25-30% at day 300 which is virtually eliminated on a 12:12 h photoperiod.

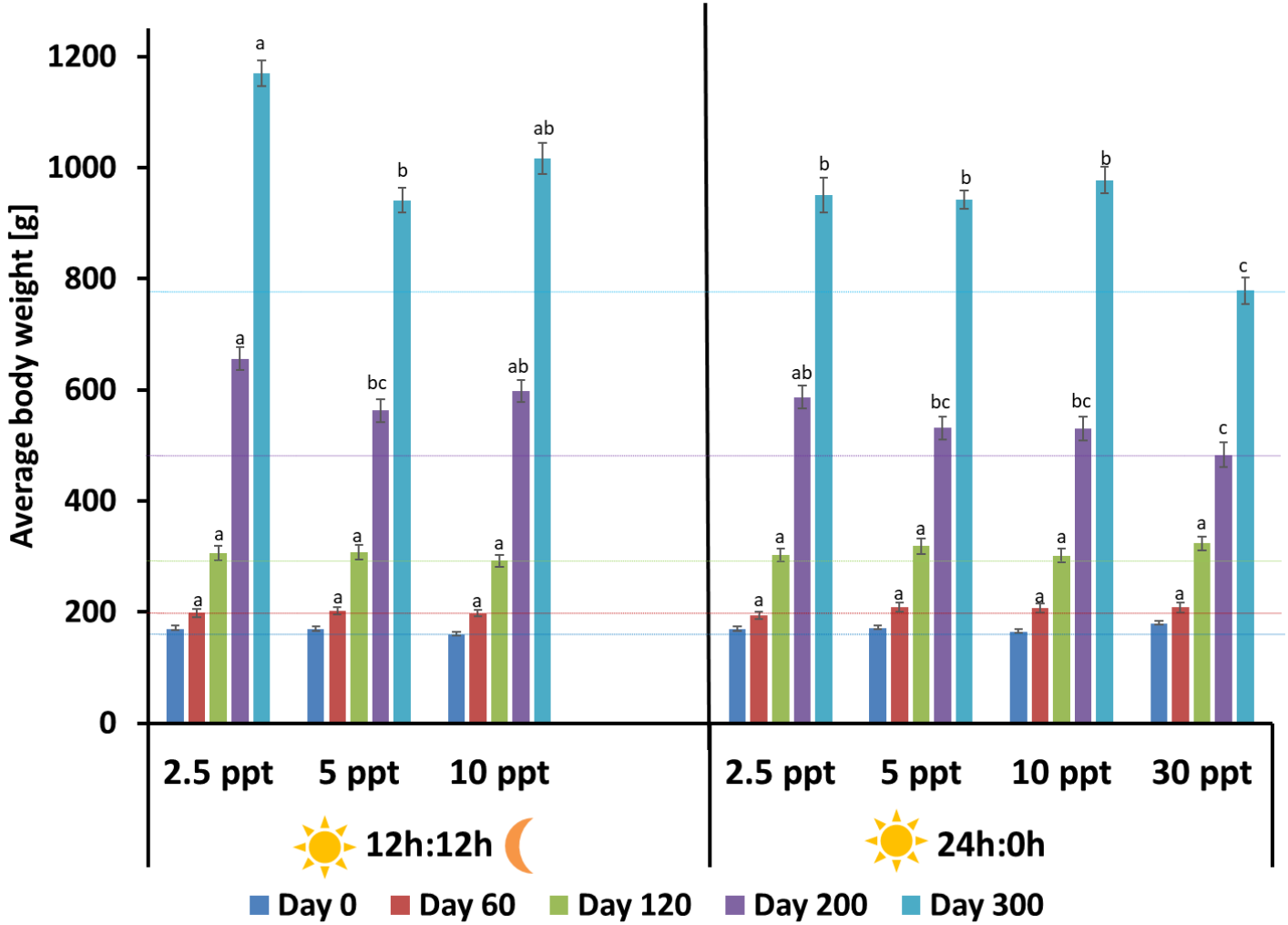
Effects of Salinity & Photoperiod:

Coho Salmon

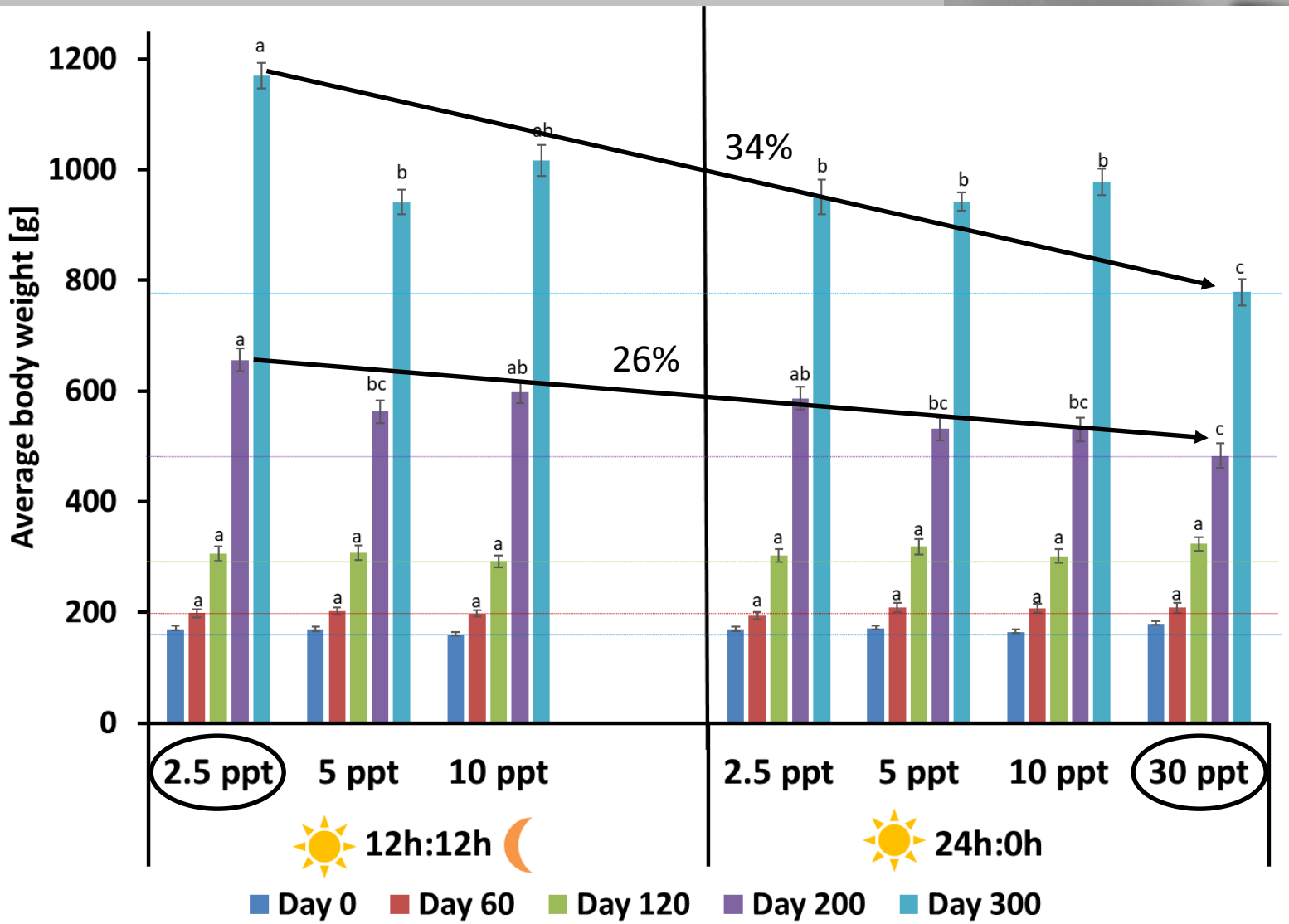
Performance

1. **Growth**
2. ~~Maturation~~

Coho Salmon
Growth in 5 m^3 tanks



Coho Salmon
Growth in 5 m^3 tanks



Effects of Salinity & Photoperiod:

Coho Salmon

Performance

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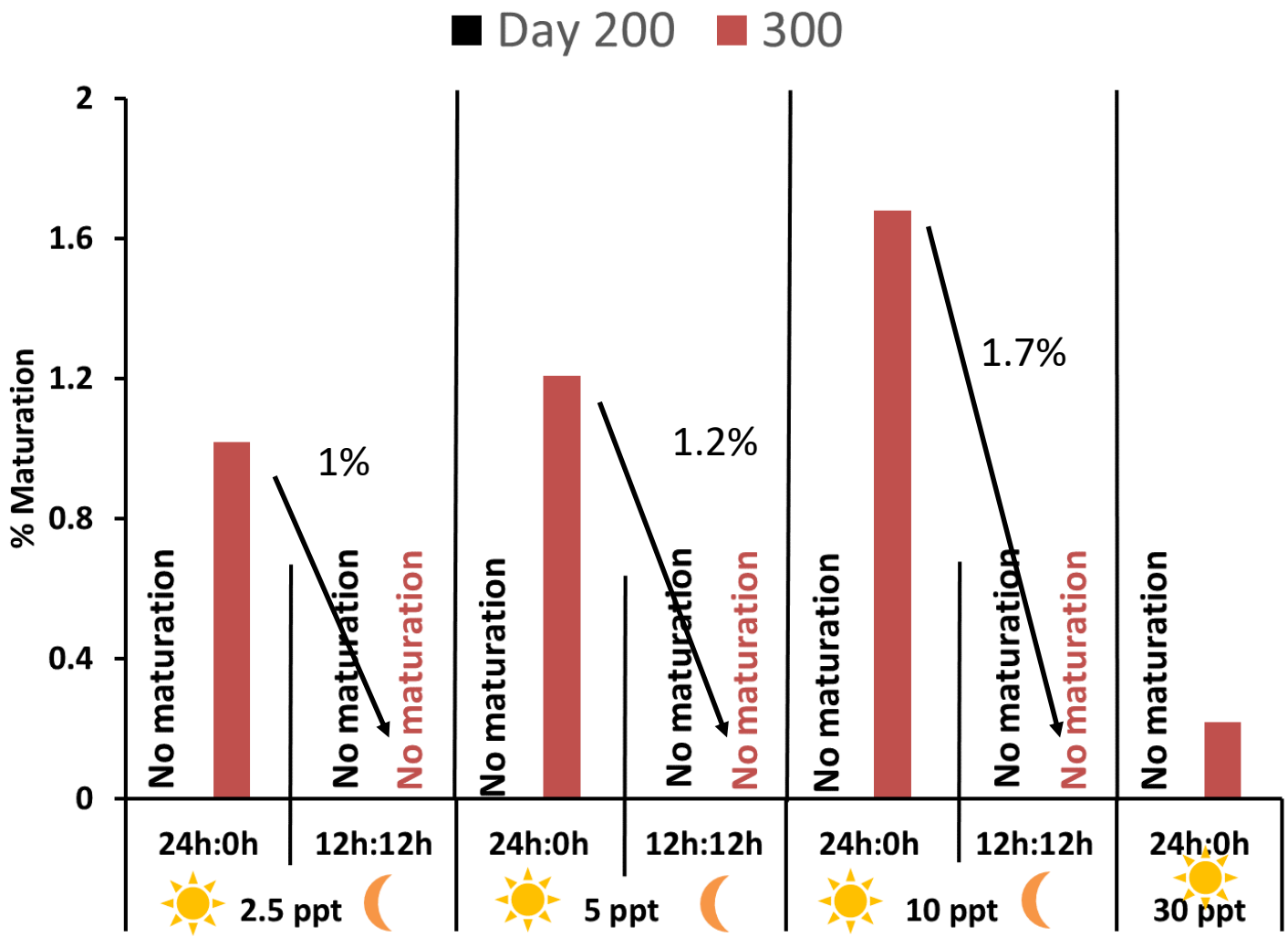
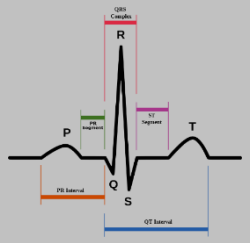
2. **Maturation**

Coho Salmon
Growth in 5 m^3 tanks

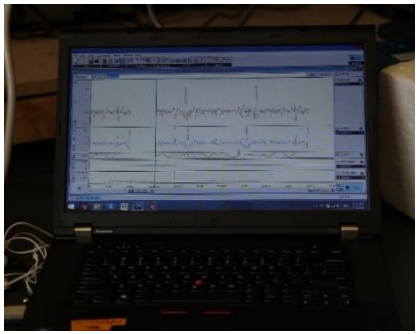


Effects of Salinity & Photoperiod: Physiological fitness proxies



Performance

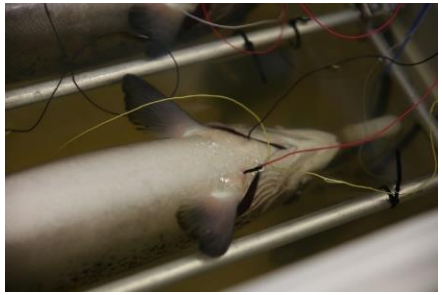
1. Growth
2. Maturation

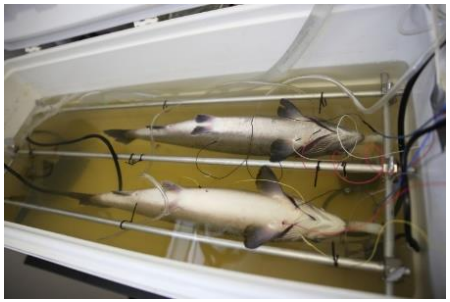


Physiological fitness proxies

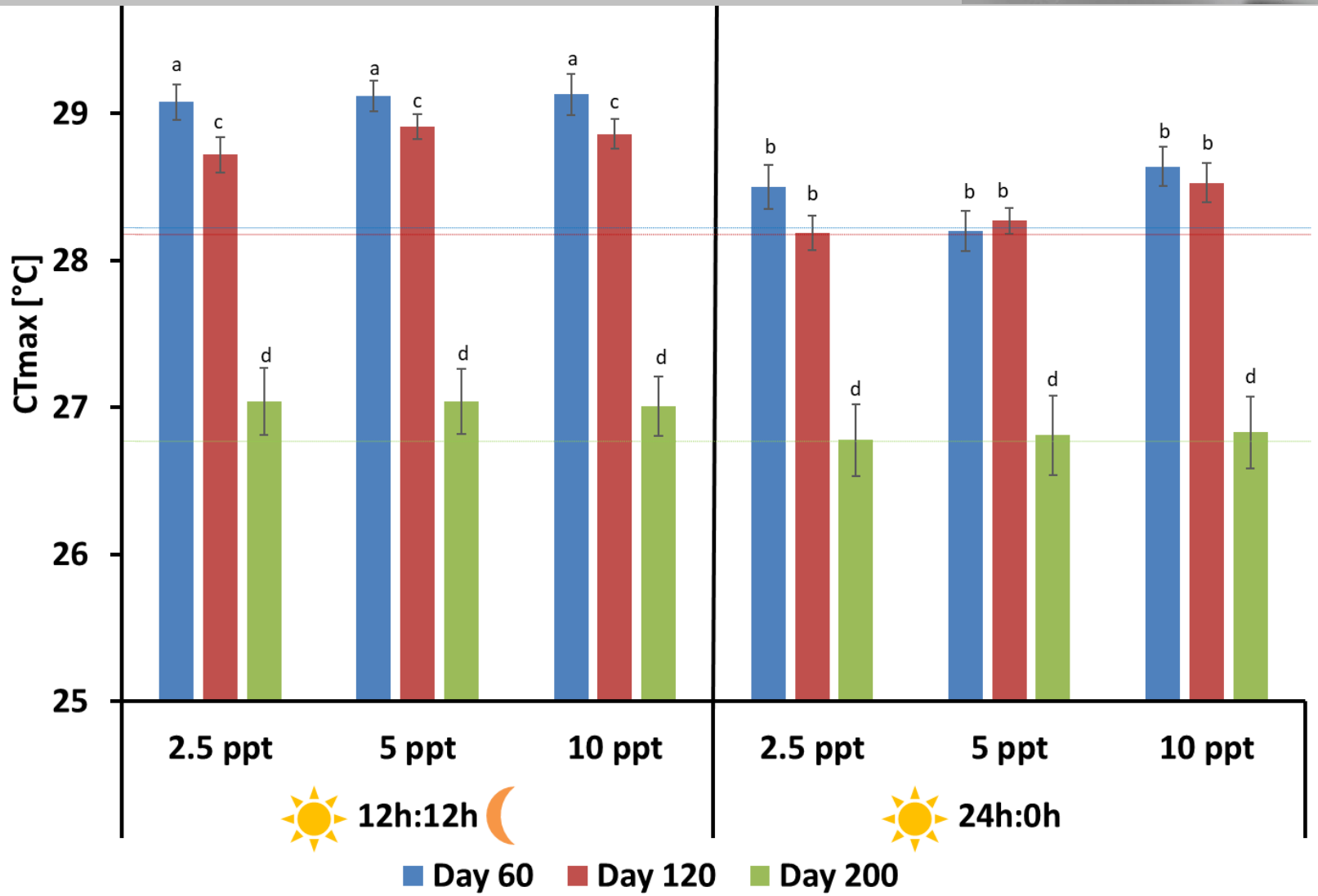
3. Thermal tolerance

4. Hypoxia tolerance
5. Maximum swimming speed
6. Behavior

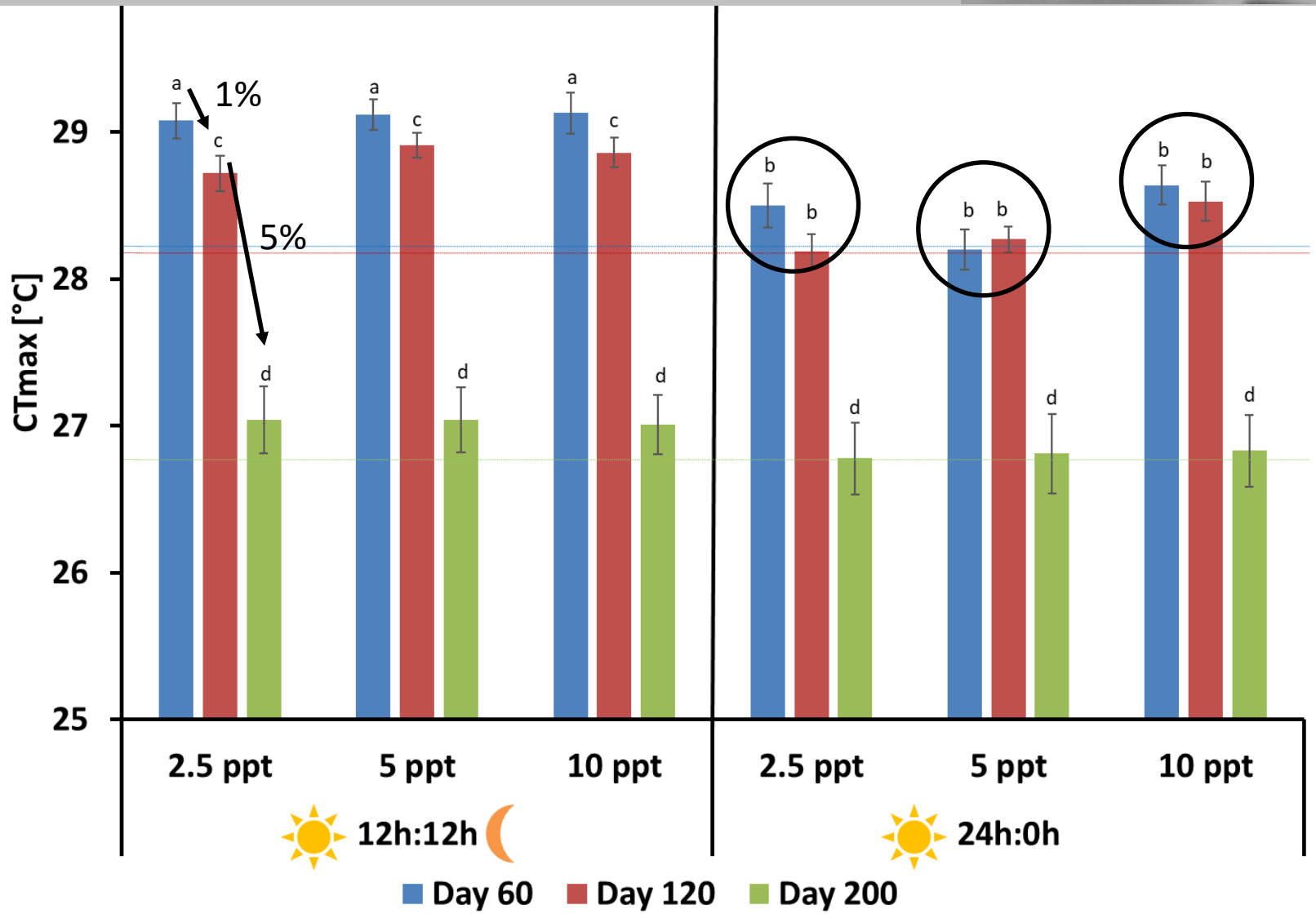




Coho Salmon Performance
Upper Thermal Tolerance



Coho Salmon Performance
Upper Thermal Tolerance



Effects of Salinity & Photoperiod: Physiological fitness proxies

Performance

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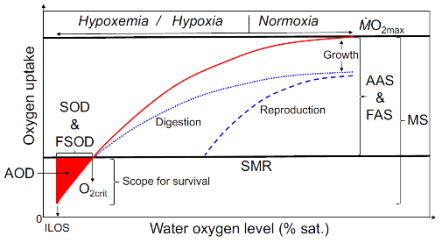
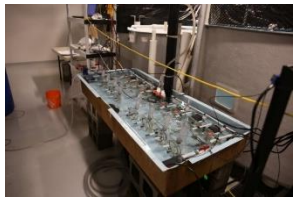
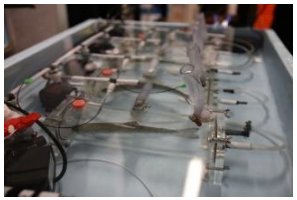
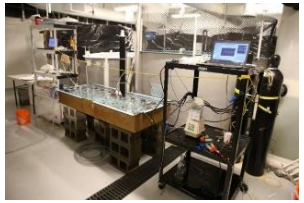
2. Maturation





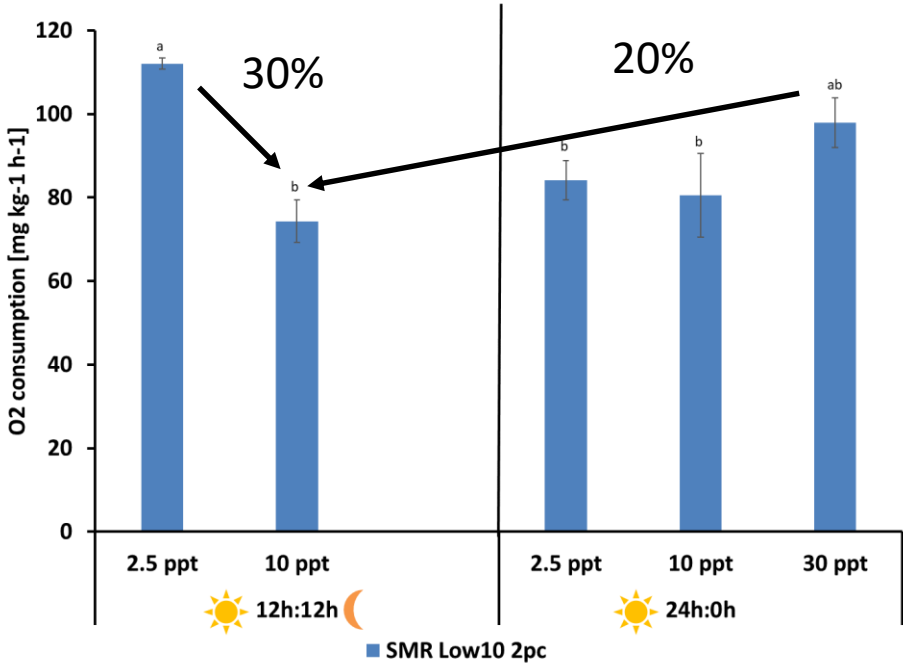


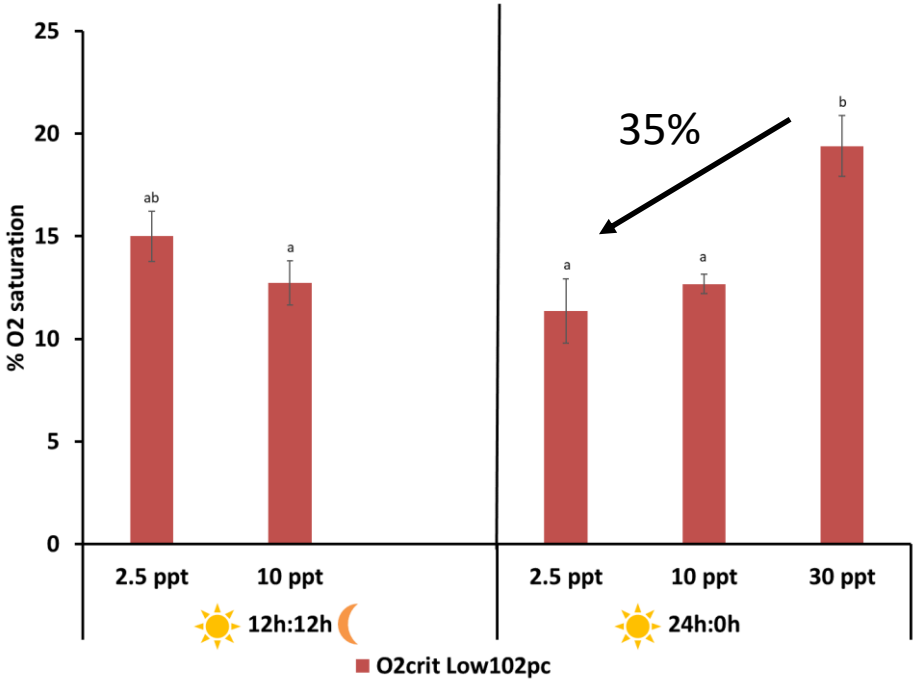


Physiological fitness proxies

3. Thermal tolerance
4. **Hypoxia tolerance**
5. Maximum swimming speed
6. Behavior

Coho Salmon Performance
Hypoxia tolerance





standard metabolic rate

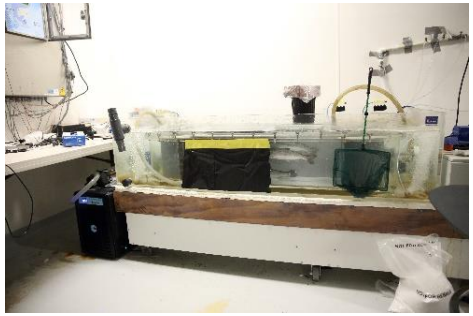
critical oxygen concentration

SMR is lowest at 10 ppt and hypoxia tolerance is lowest at 30 ppt

Effects of Salinity & Photoperiod: Physiological fitness proxies

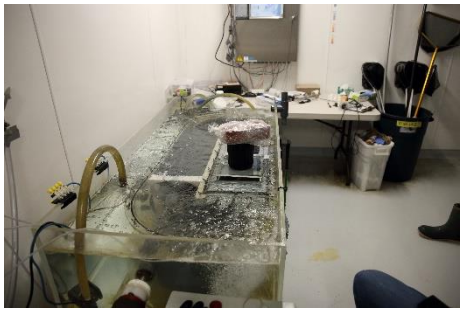
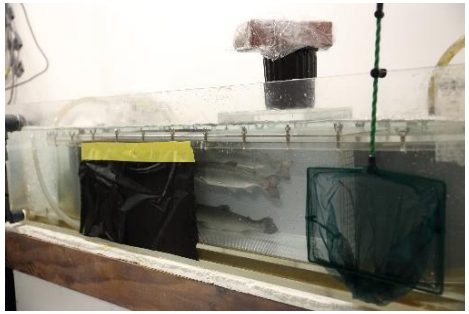
Performance

1. Growth
2. Maturation

Physiological fitness proxies

3. Thermal tolerance
4. Hypoxia tolerance
5. **Maximum swimming speed**
6. Behavior

No difference in Maximum swimming speed and recovery!

Effects of Salinity & Photoperiod: Physiological fitness proxies

Performance

1. Growth
2. Maturation

Physiological fitness proxies

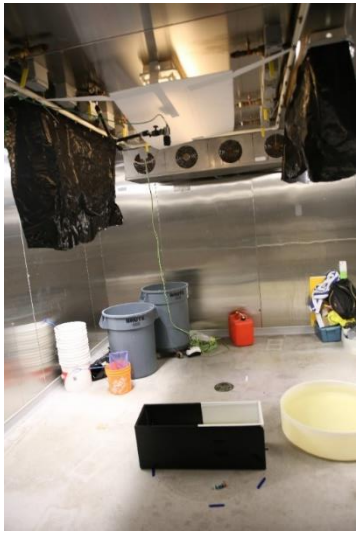
3. Thermal tolerance

4. Hypoxia tolerance

5. Maximum swimming speed

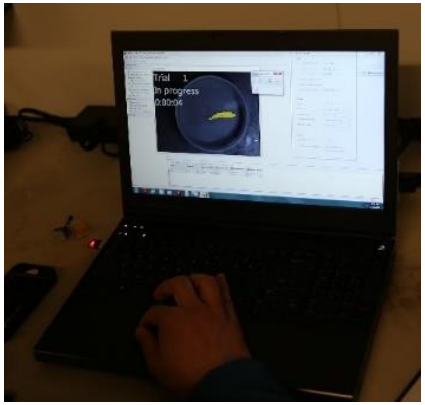
6. Behavior

Light/Dark Test



Open Field

Jumping Behaviour



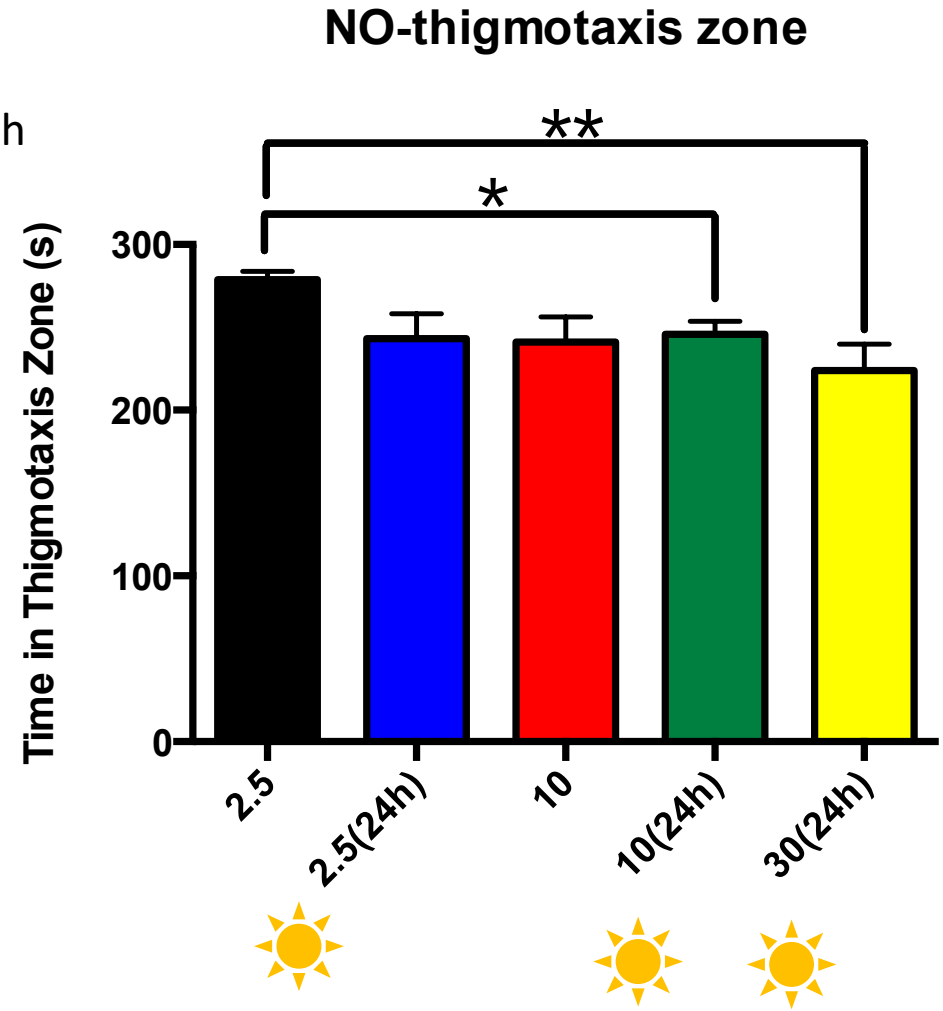
Novel Object Approach

Chlordiazepoxide exposure

Coho Salmon Behavior

Novel Object Approach

Open Field



More time in that zone indicates greater anxiety

Summary
Coho Salmon in RAS

Salinity and photoperiod had no effect on Coho growth until day 120.

2.5 ppt resulted in greater body mass at days 200 and 300 relative to 30 ppt, but also had a greater resting metabolic rate and anxiety level.

Early maturation was observed at a low level in 24 h light but not 12:12 h light.

24 h light photoperiod resulted in reduced temperature tolerance at days 120 and 200.

Hypoxia tolerance was greater at intermediate salinities but no differences in swimming performance were observed.

Conclusions
Coho & Atlantic Salmon

- 10 ppt appeared to improve growth in Atlantic salmon and reduce metabolic rate in coho with no effect on growth in coho.
- 30 ppt reduced hypoxia tolerance in coho salmon

- 24 h light had a positive effect on growth in Atlantic salmon but no effect in coho.
- 24 h light resulted in high levels of early maturation (up to 30%) in Atlantic salmon that was eliminated by in 12:12 h photoperiod. A similar trend in coho.
- 24 h light reduced thermal tolerance in coho salmon

Acknowledgement

Collaborators

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Myron Roth

Brad Hicks

Wendy Vandersteen

Mike Cunning

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