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

Optimal Salinity Conditions for Atlantic and Coho salmon growth in RAS

Colin J. Brauner,
Joshua Emerman, Victor Chan, Yuanchang Fang,
Matt Gilbert, Kevin Stiller & Jeffrey Richards

Department of Zoology,
University of British Columbia

Issues to Address in RAS

Small profit margins

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

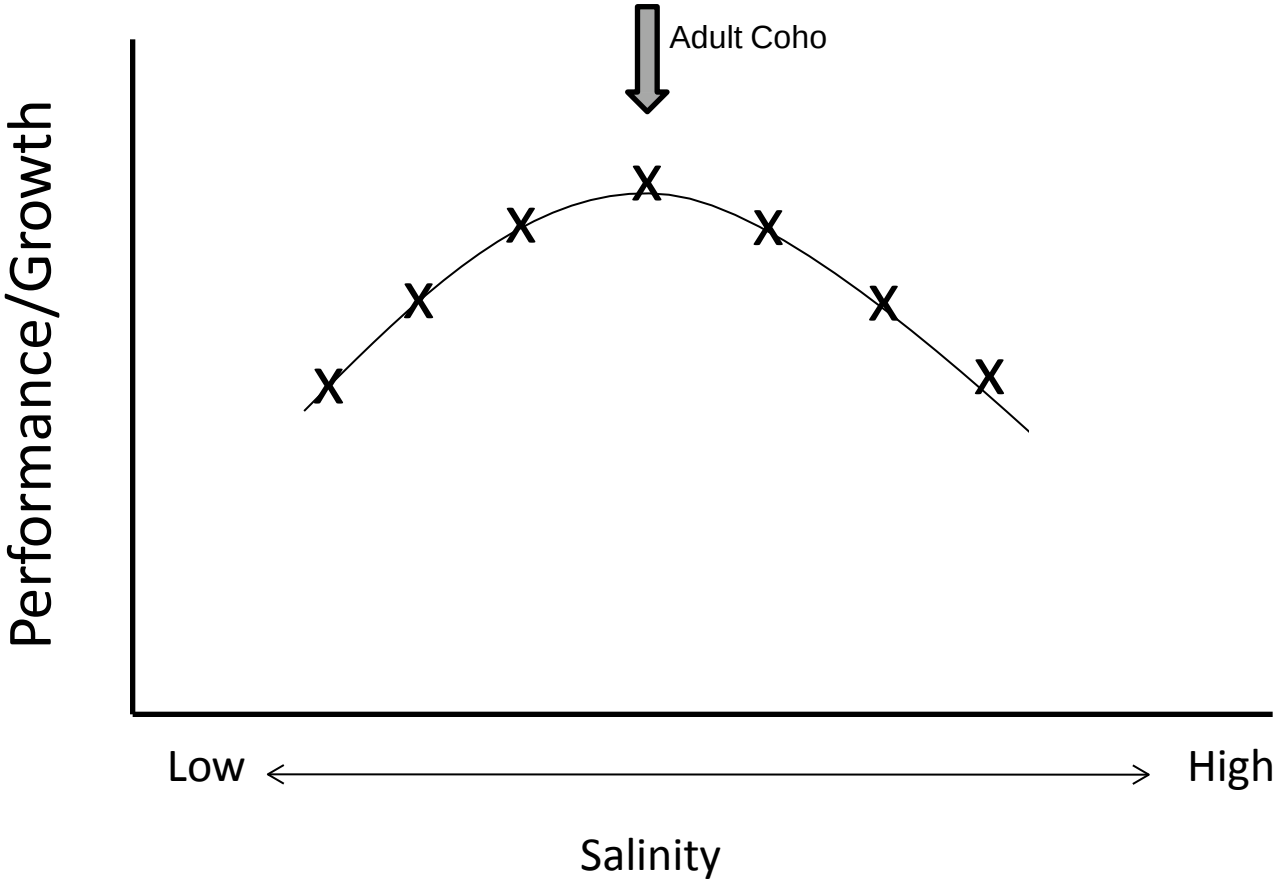
Optimal conditions for growth of salmon are unknown

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

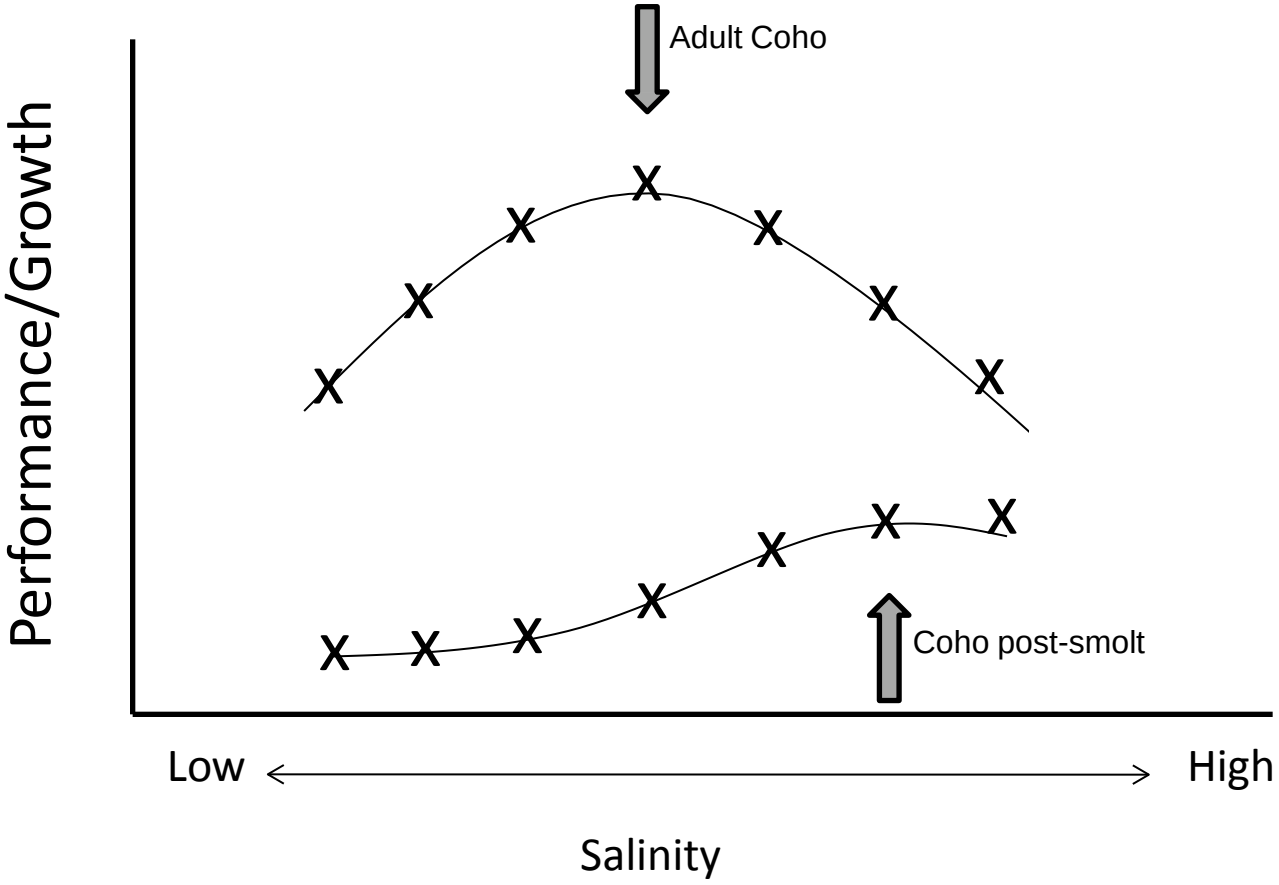
InSEAS RAS Research Facility

- 7 high-density independent recirculation systems (120 kg/m^3)
  Each system has 2 x 5m^3 tanks and 2 x 0.7 m^3 tanks
- Automatic feeders on large tanks
- Environmental control and monitoring systems

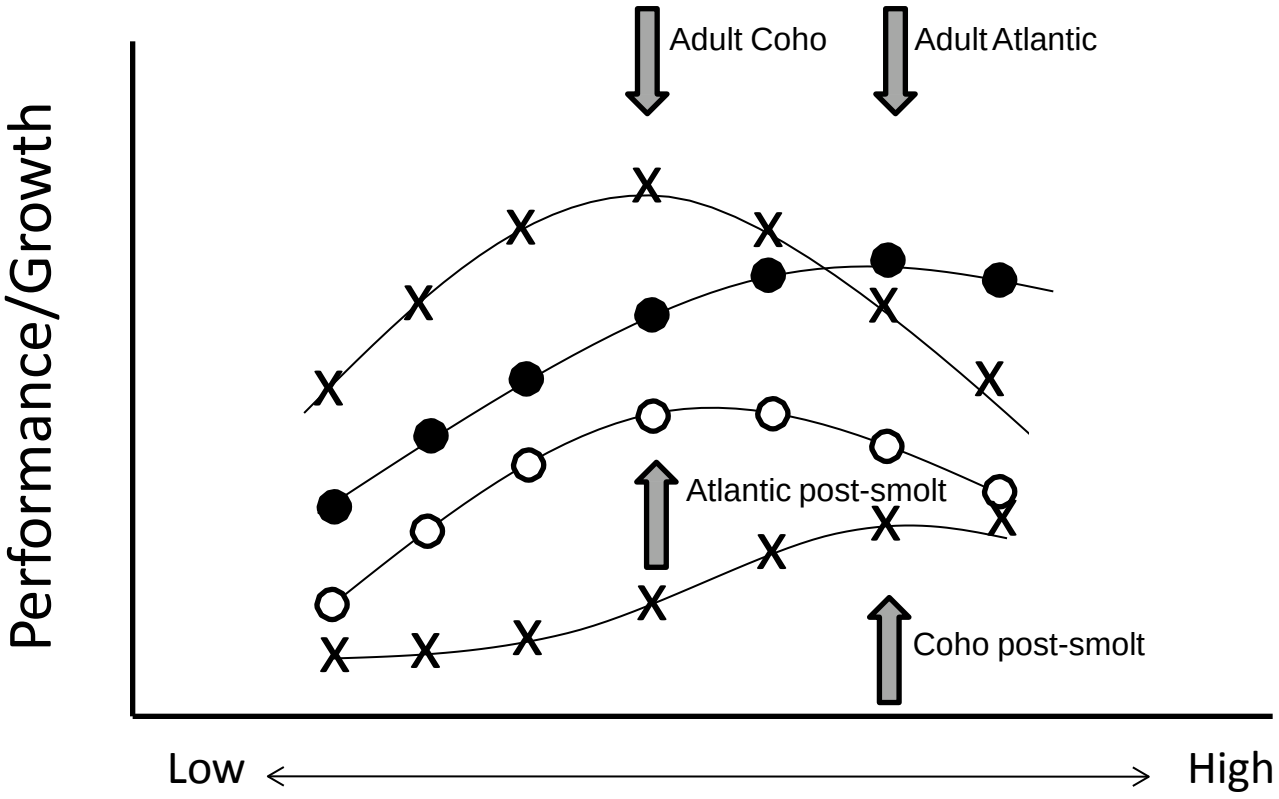
InSEAS Regression Approach



InSEAS Regression Approach



InSEAS Regression Approach



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

Effects of Salinity on Salmon Growth

Specific Research Goals:

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

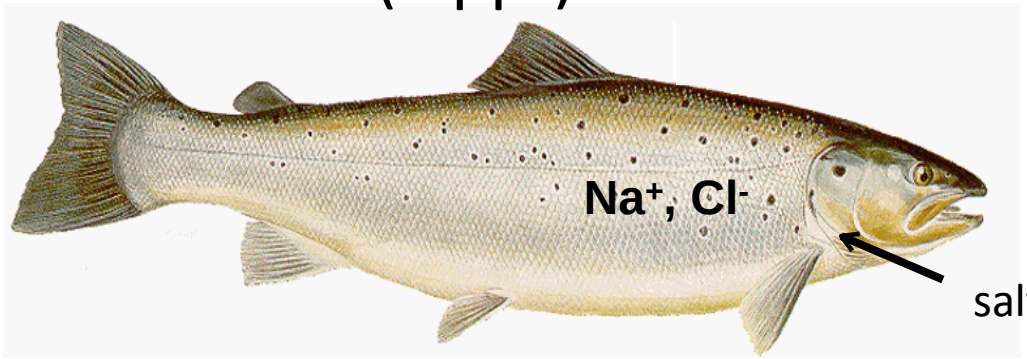
i) Growth

ii) Performance: Is there are tradeoff between growth and physiological performance (low O_2, swimming speed, high T)
    ie Biological Safety Factor?

iii) Effect of salinity on early maturation and cataract formation

Effects of Salinity on Salmon Growth

Salmon in fresh water (0 ppt)



Na+, Cl-

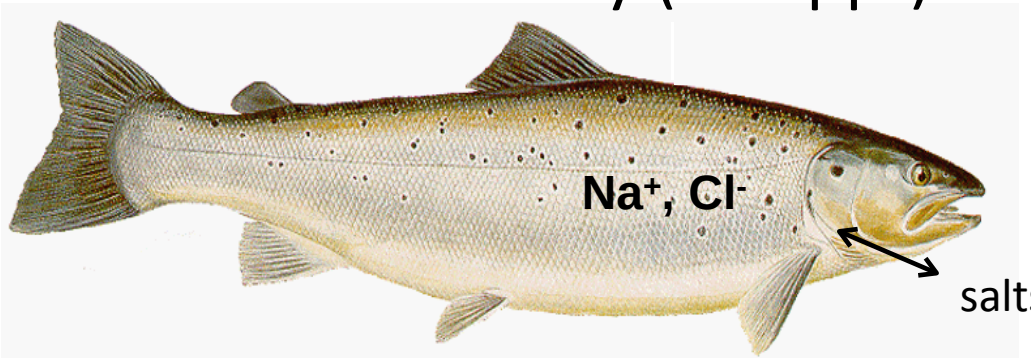
Salmon in sea water (30 ppt)

Na+, Cl-

Osmoregulation can account for 10-50% of standard metabolic rate (Bœuf & Payan, 2001)

Effects of Salinity on Salmon Growth

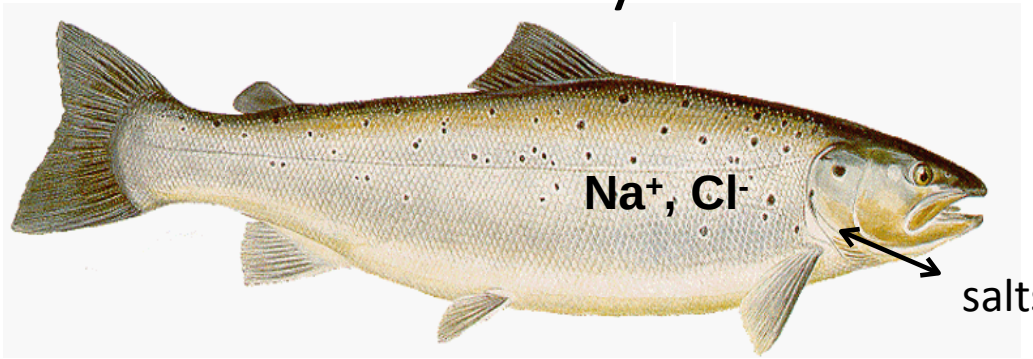
Salmon at intermediate salinity (~10 ppt)



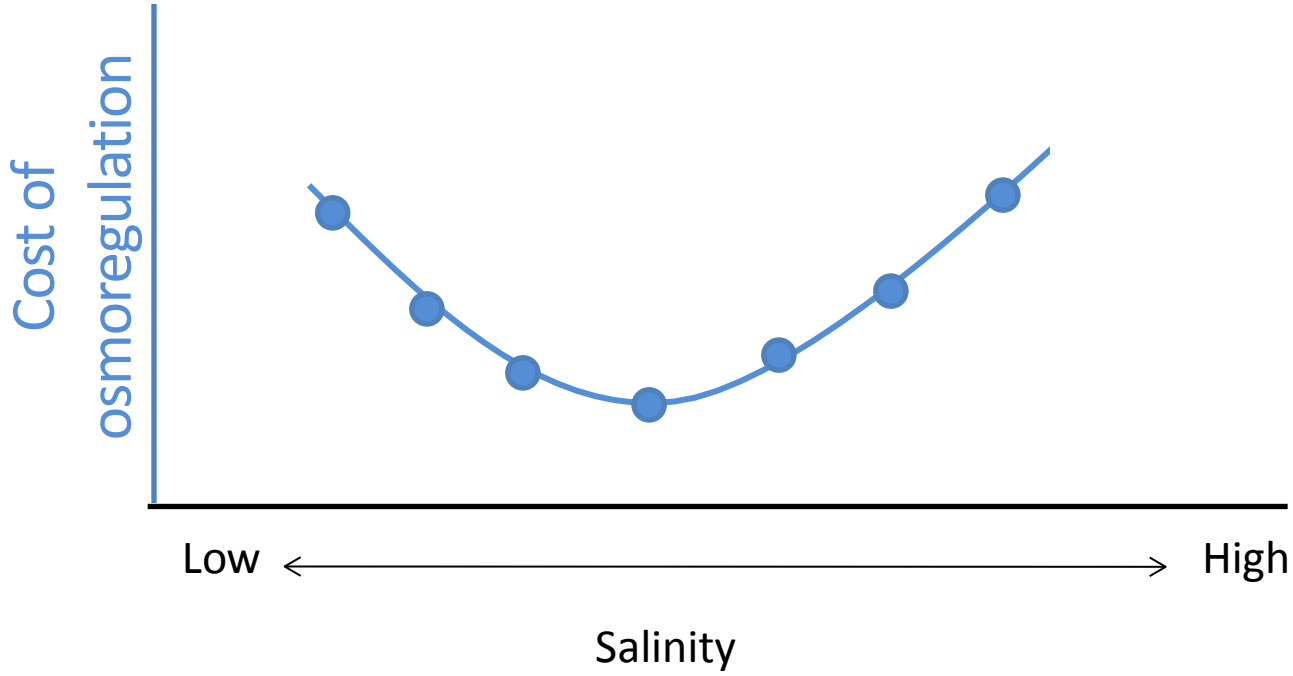
Na^+, Cl^-

Effects of Salinity on Salmon Growth

Salmon at intermediate salinity

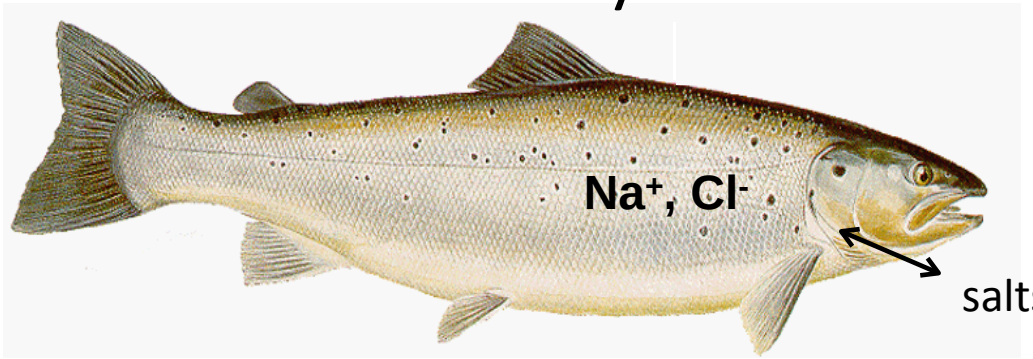


Na+, Cl-

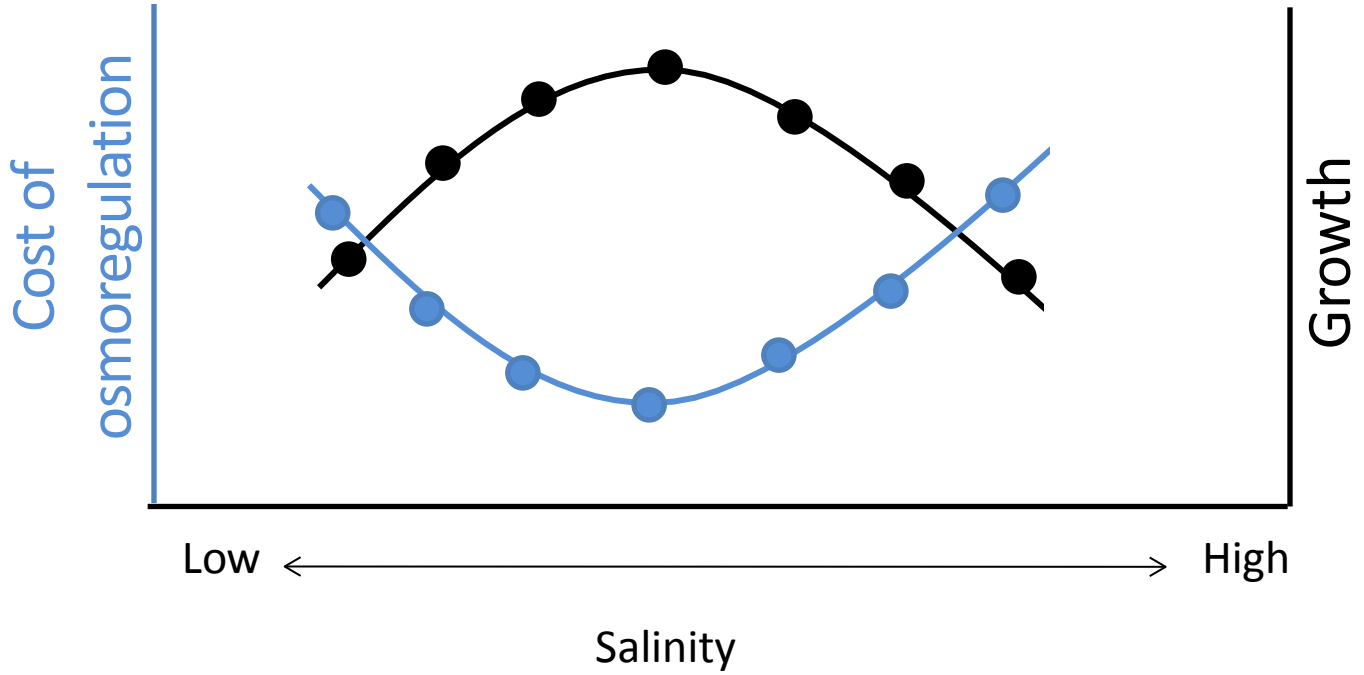


Effects of Salinity on Salmon Growth

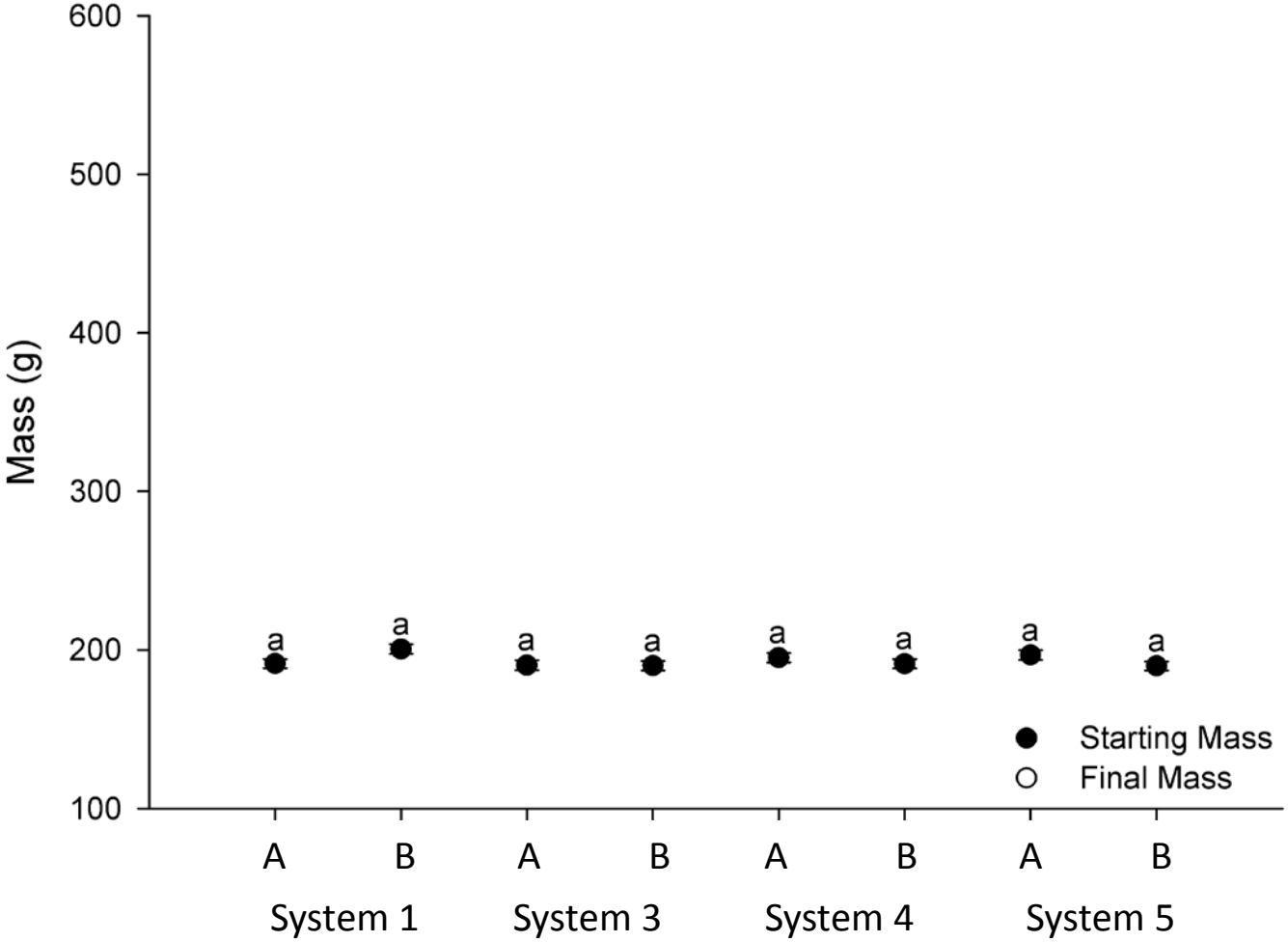
Salmon at intermediate salinity



Na+, Cl-



Is fish growth affected by system?

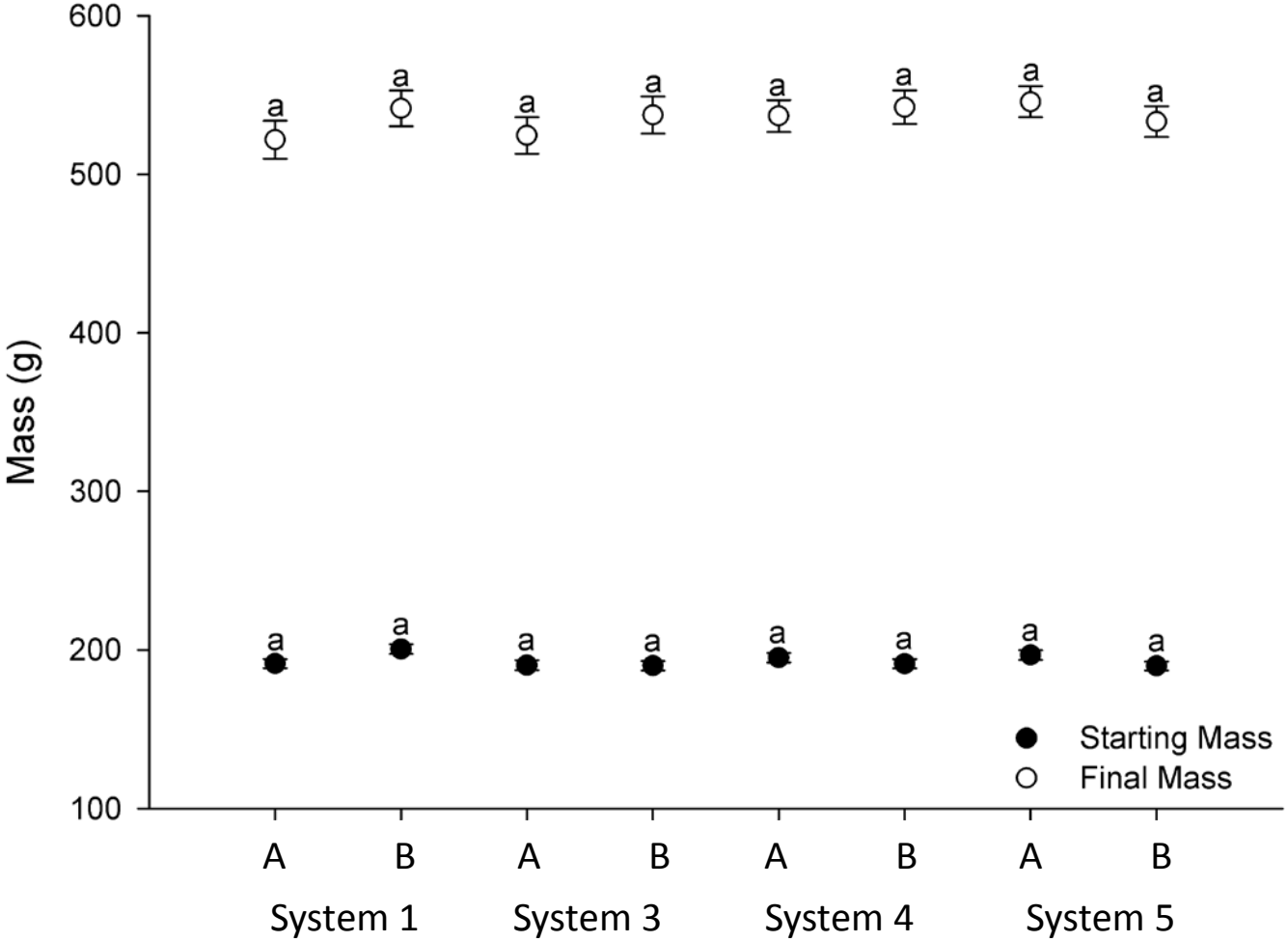


Coho salmon were reared in FW at 10°C for 5 months

14:10 photoperiod

Fed to satiation with automatic feeders

Is fish growth affected by system?



Growth rate is similar in all systems (0.7 %/day)

And consistent with industry (0.8%/day)

Defining Optimal Salinity

Coho & Atlantic salmon were reared for 12-15 months at 5 salinities ranging from FW to SW at 13°C (0, 5, 10, 20, and 30ppt)

Stocking density of 40 kg/m^3

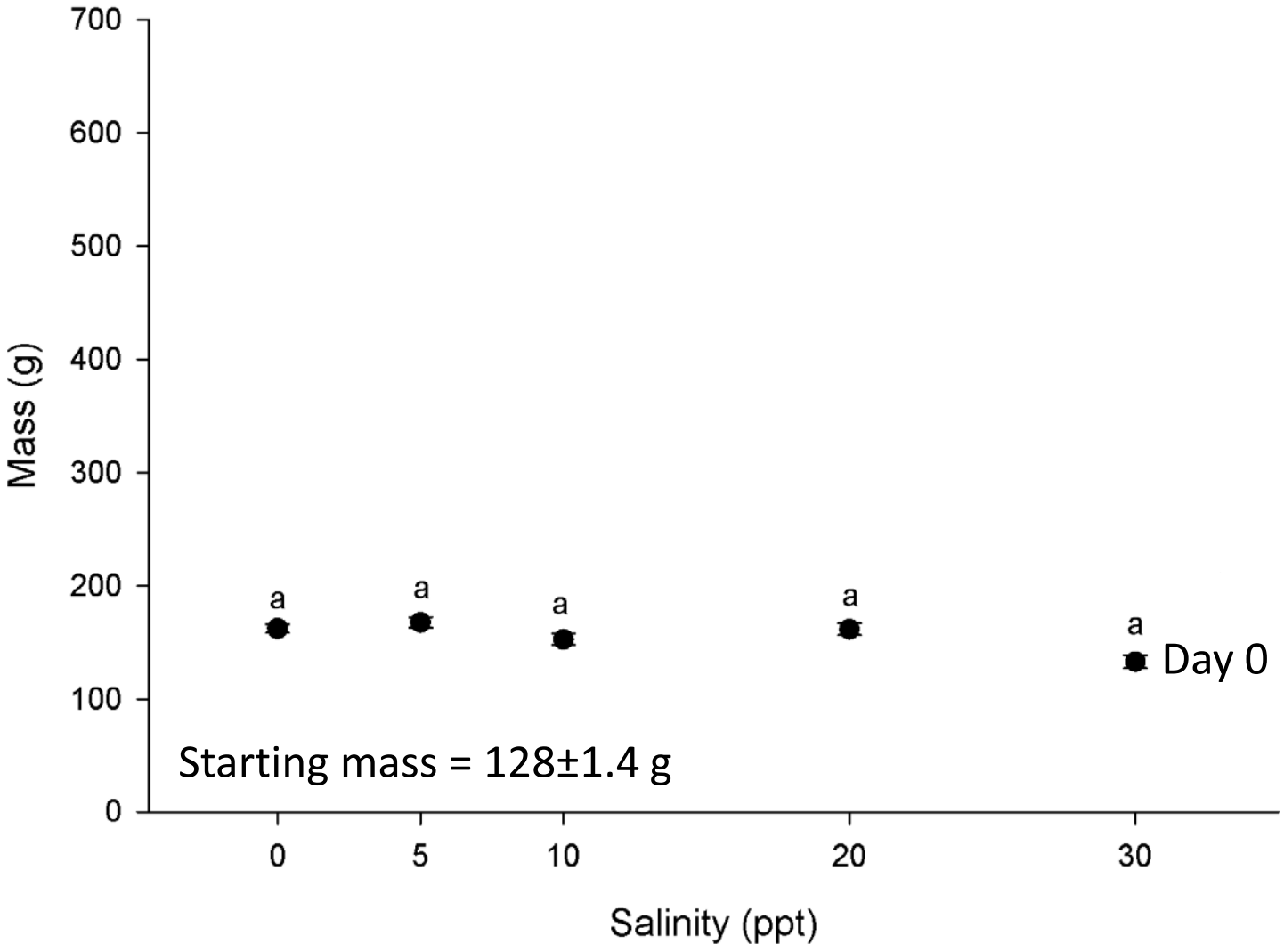
Fed to satiation

Reared under 24 h light

Monitored growth, feed conversion, physiological performance, maturation and cataracts

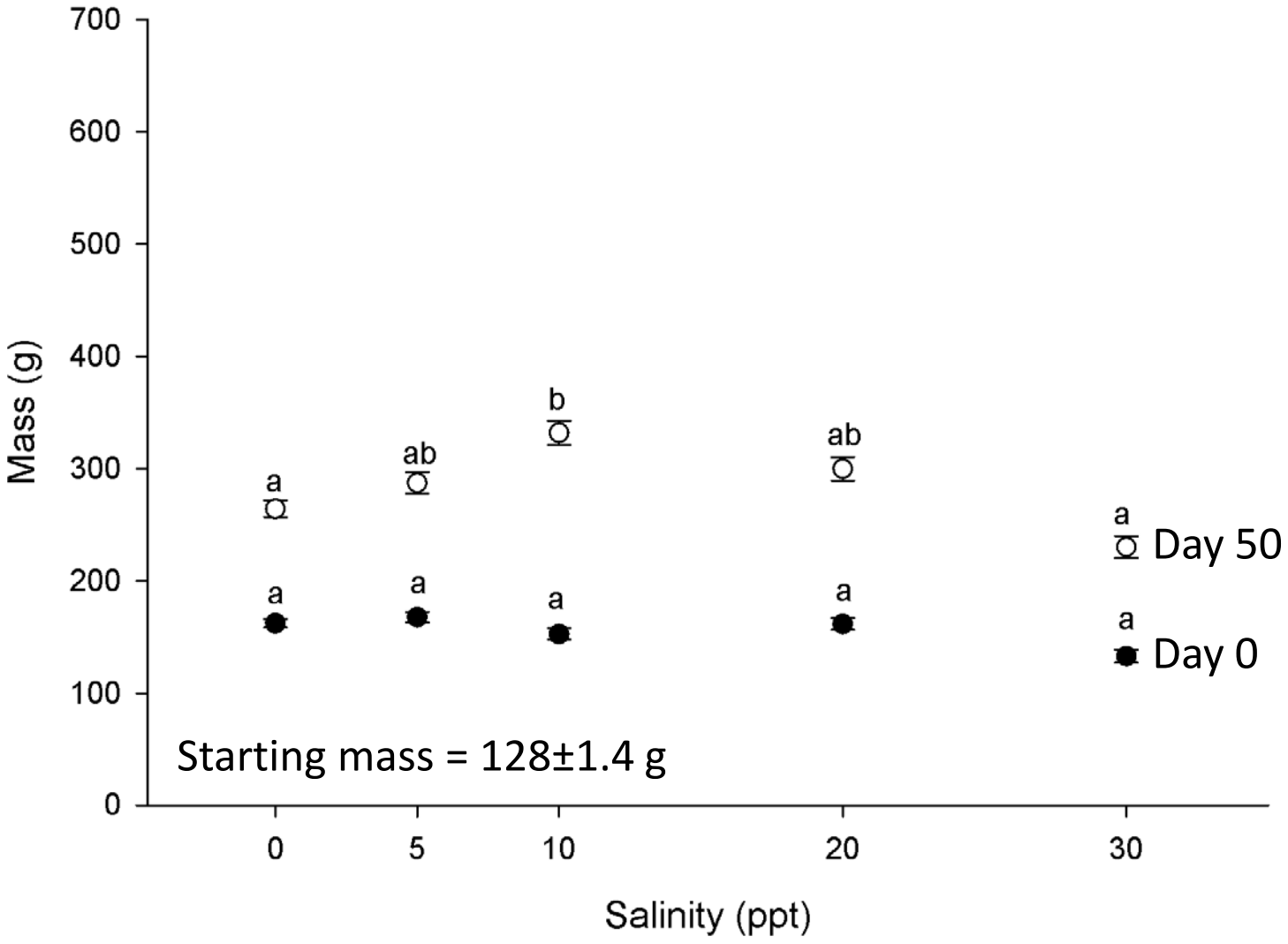
Coho Salmon

Growth in 5 m^3 tanks

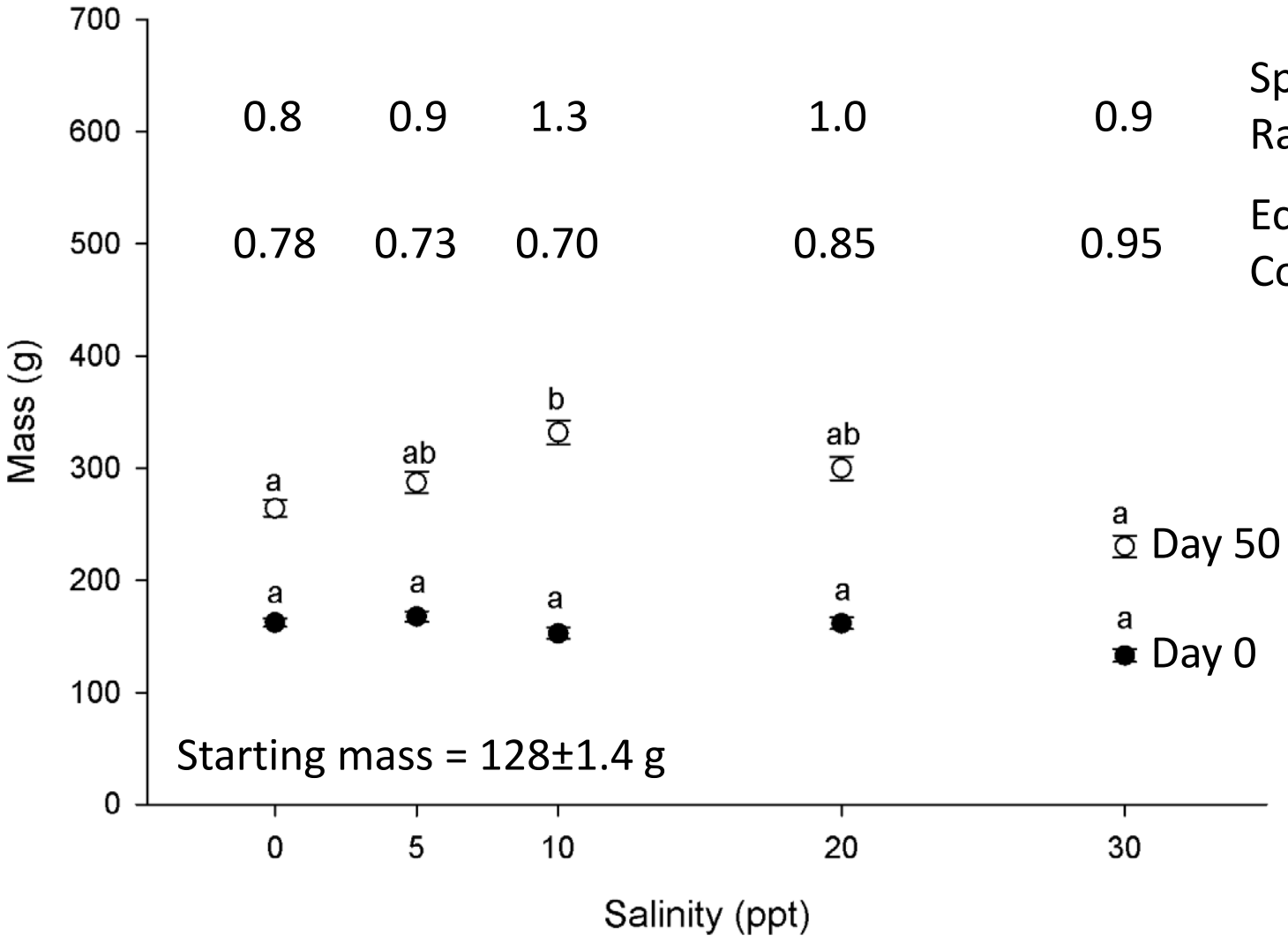


Coho Salmon

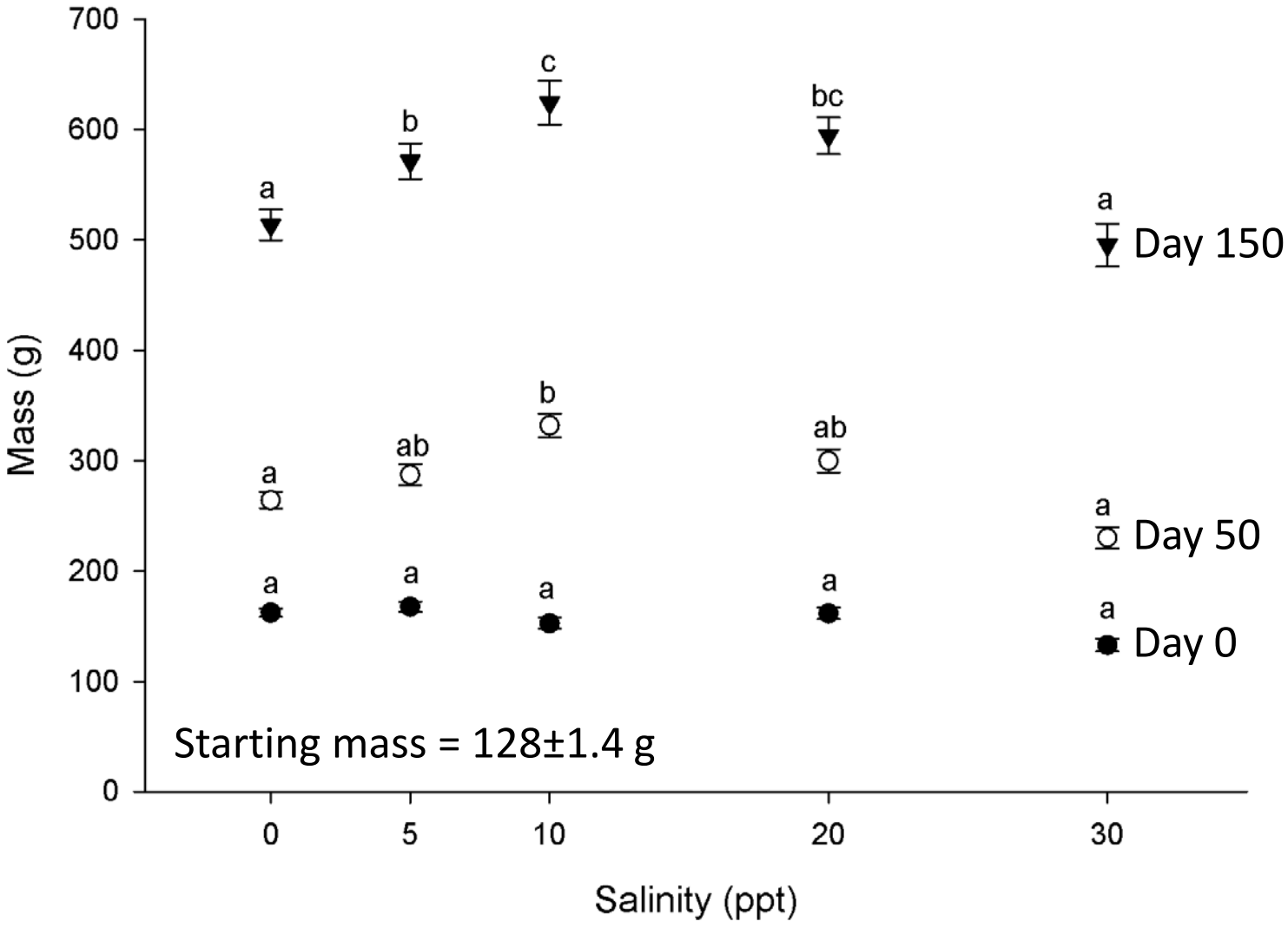
Growth in 5 m^3 tanks



Coho Salmon
Growth in 5 m^3 tanks

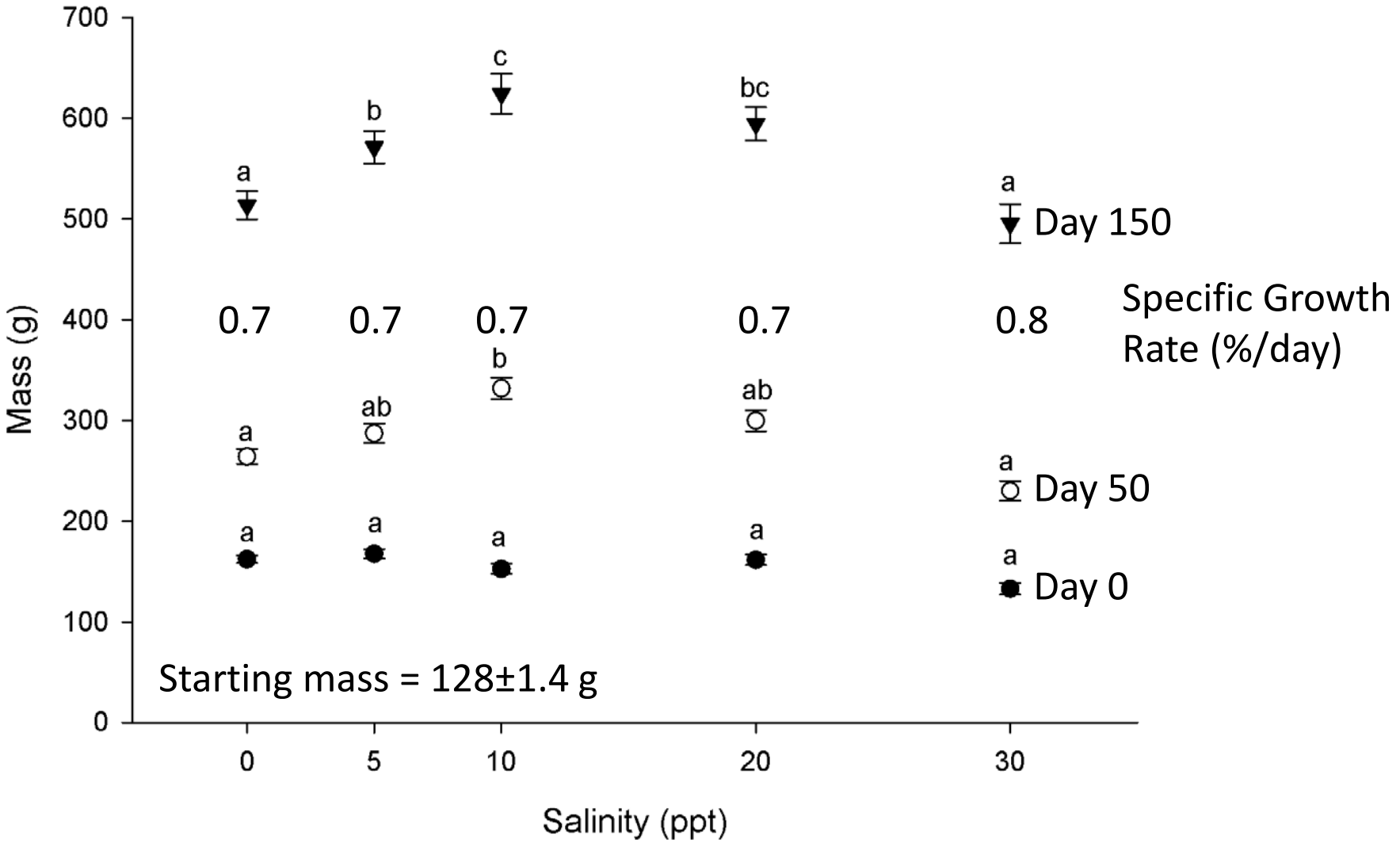


Coho Salmon
Growth in 5 m^3 tanks



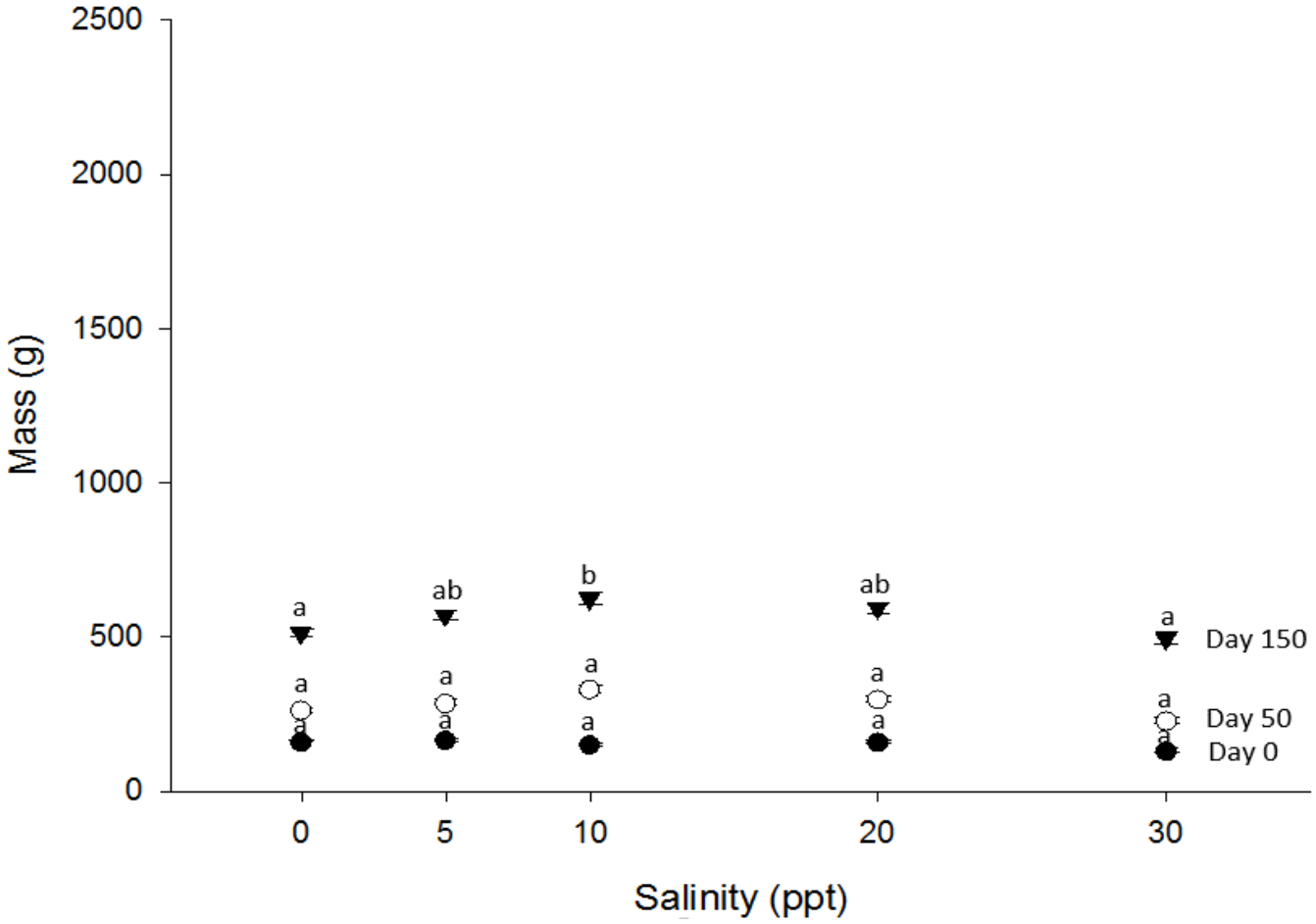
Coho Salmon

Growth in 5 m^3 tanks

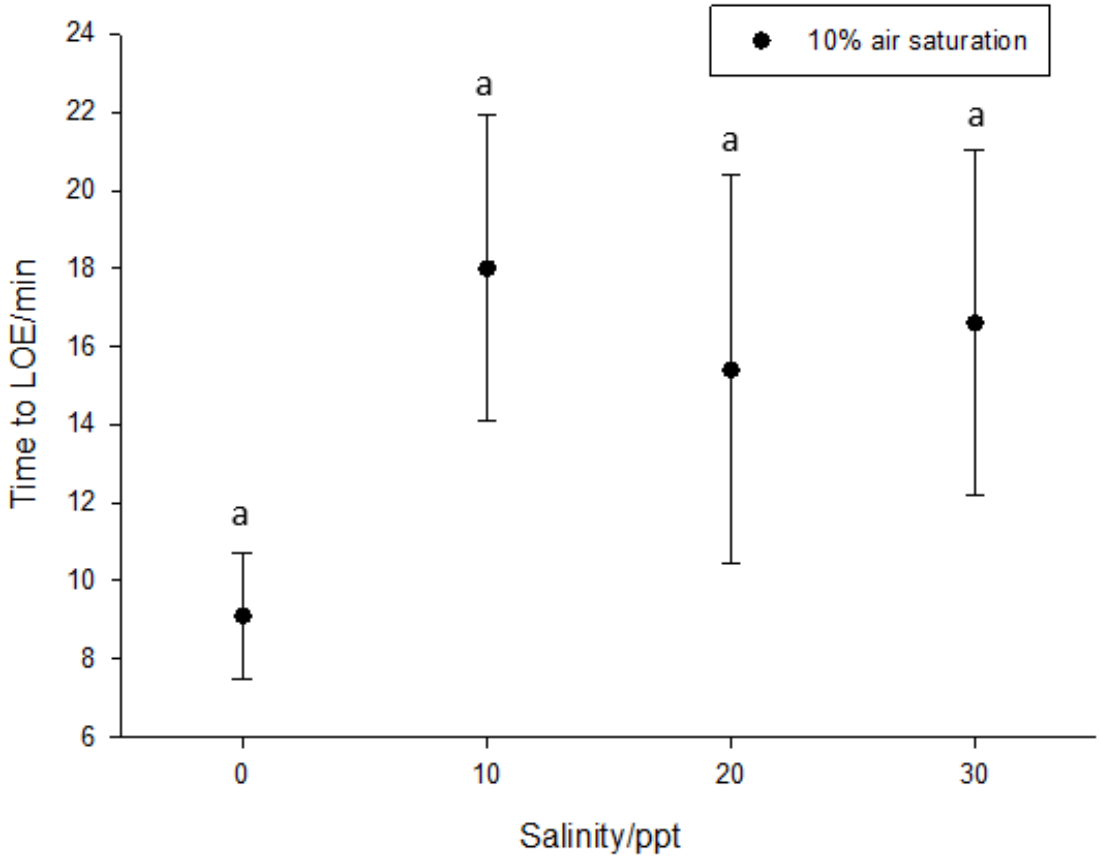


Coho Salmon

Growth in 5 m^3 tanks



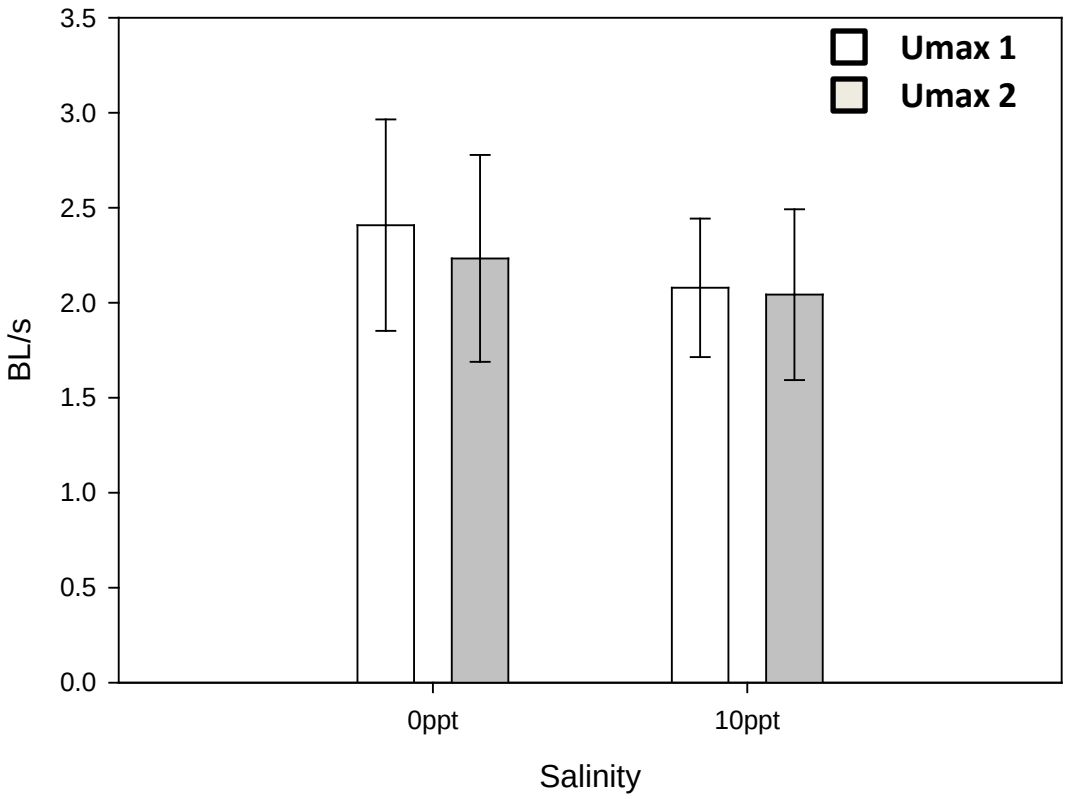
Coho Salmon Performance
Hypoxia Tolerance



No difference in time to loss of equilibrium (LOE) during exposure to low O_2.

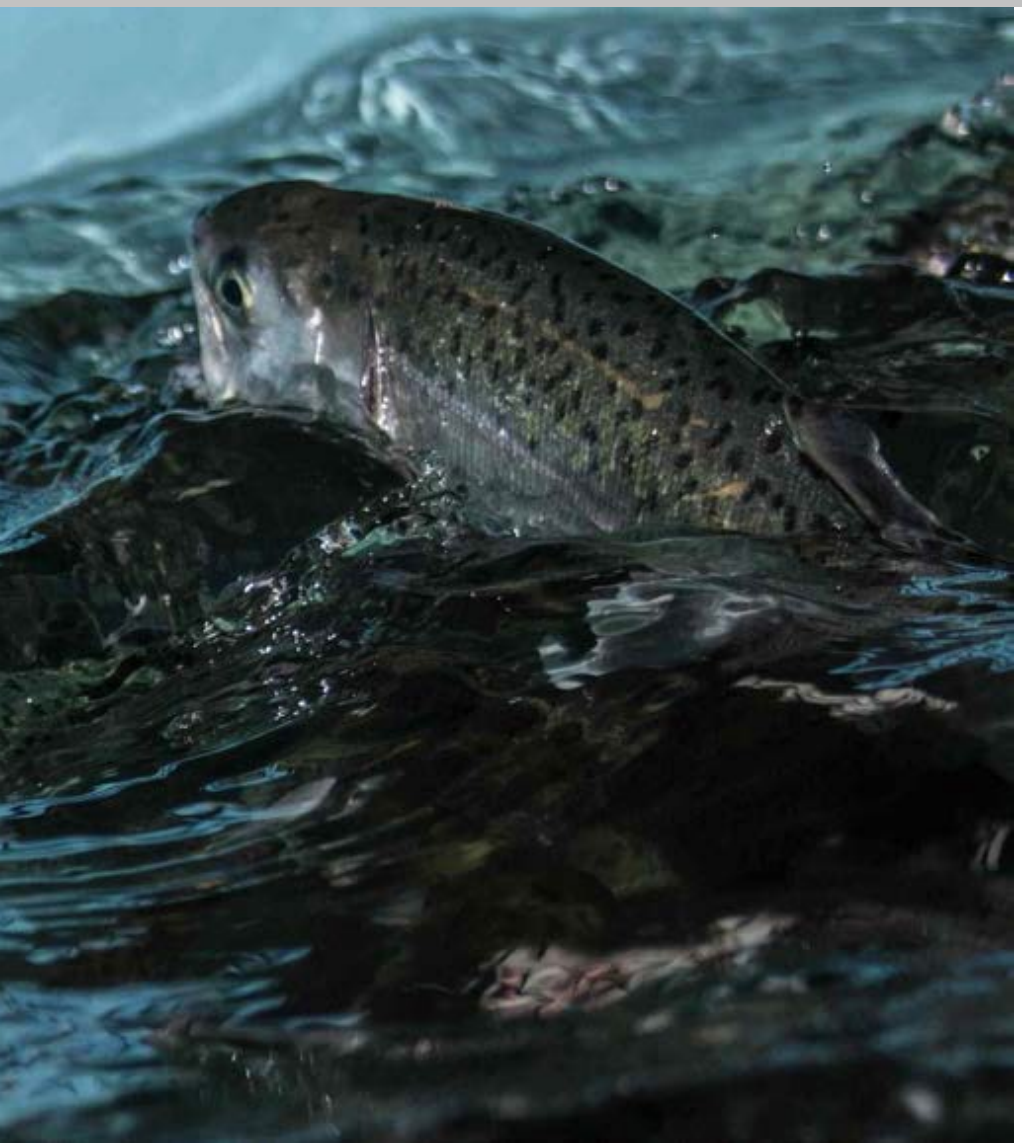
Coho Salmon Performance

Swimming Performance



No difference in swimming performance.

Summary
Coho Salmon in RAS



At small sizes, growth is enhanced by up to 50% at 10 ppt compared with other salinities

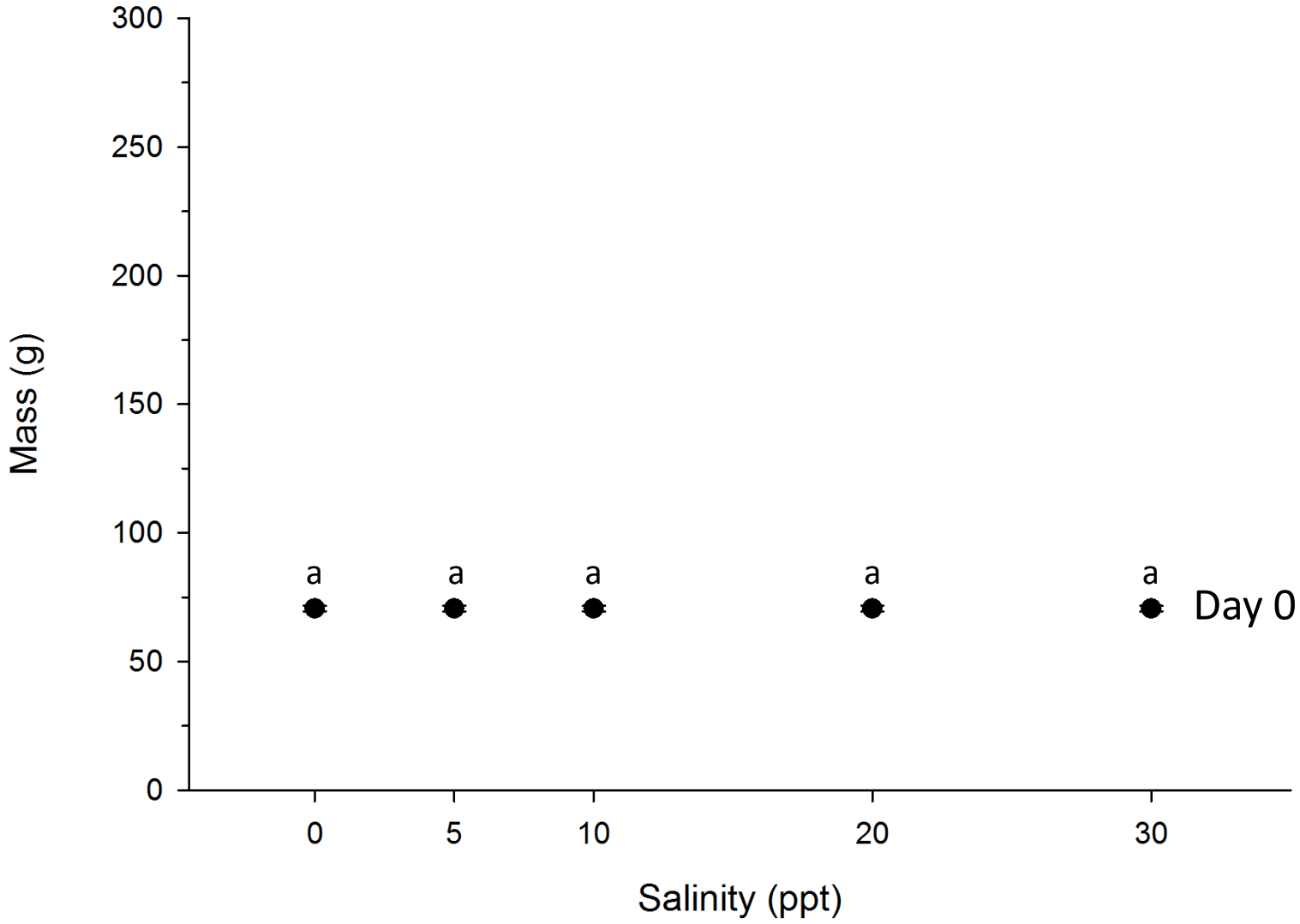
Better feed conversion at intermediate salinities

No difference in hypoxia tolerance or swimming performance

No early maturation (all female strain) or cataracts detected.

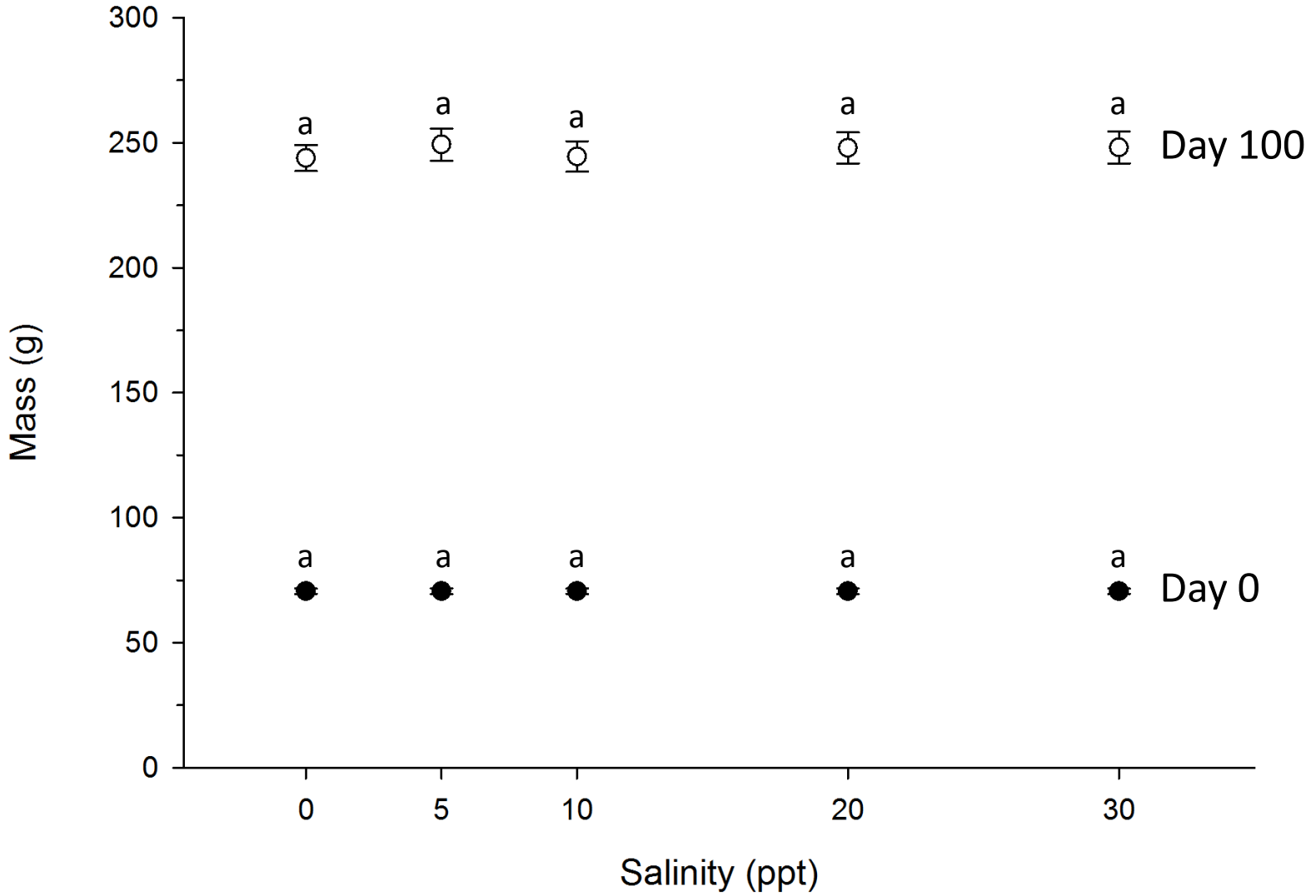
Atlantic Salmon

Growth in 5 m^3 tanks

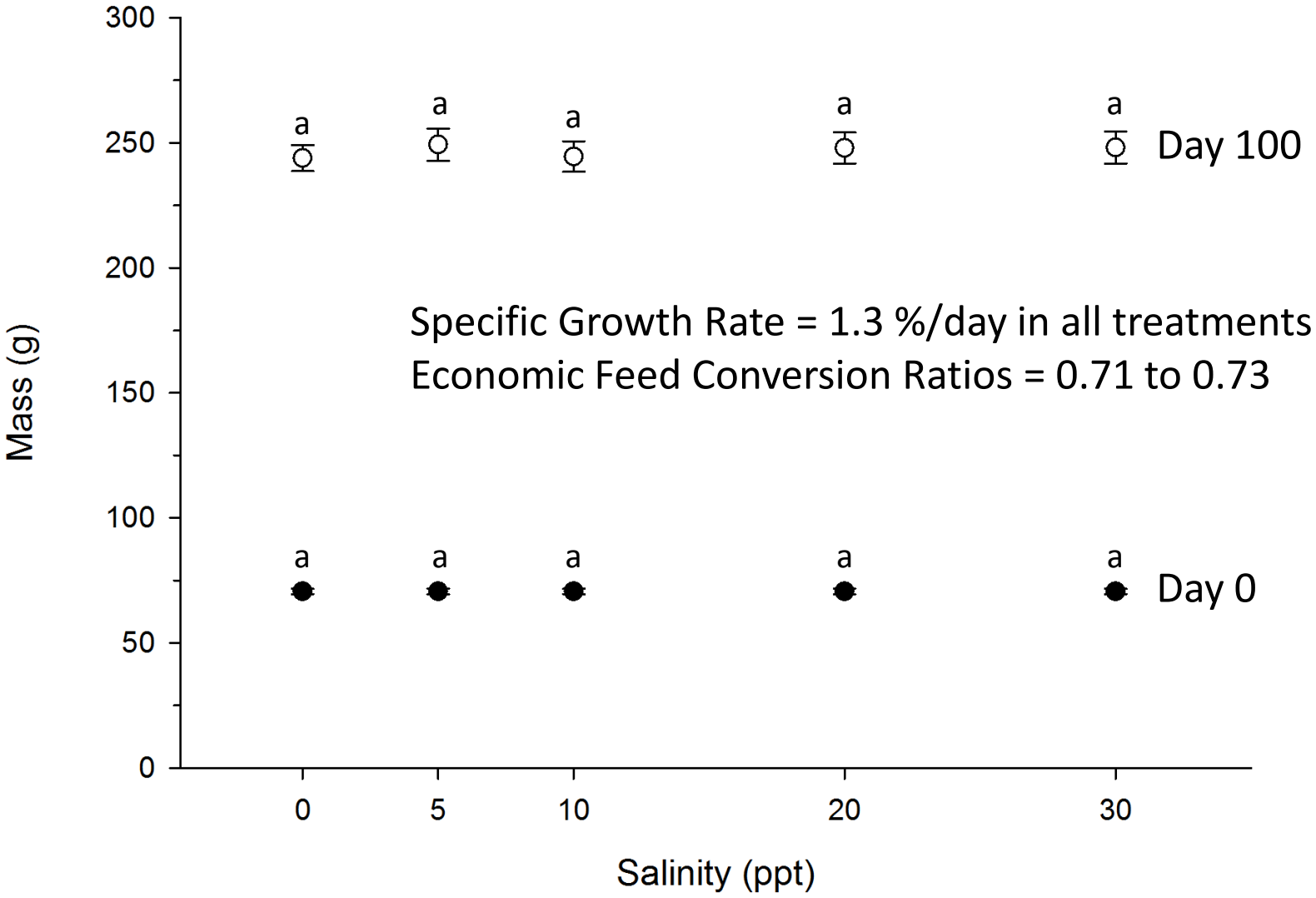


Atlantic Salmon

Growth in 5 m^3 tanks

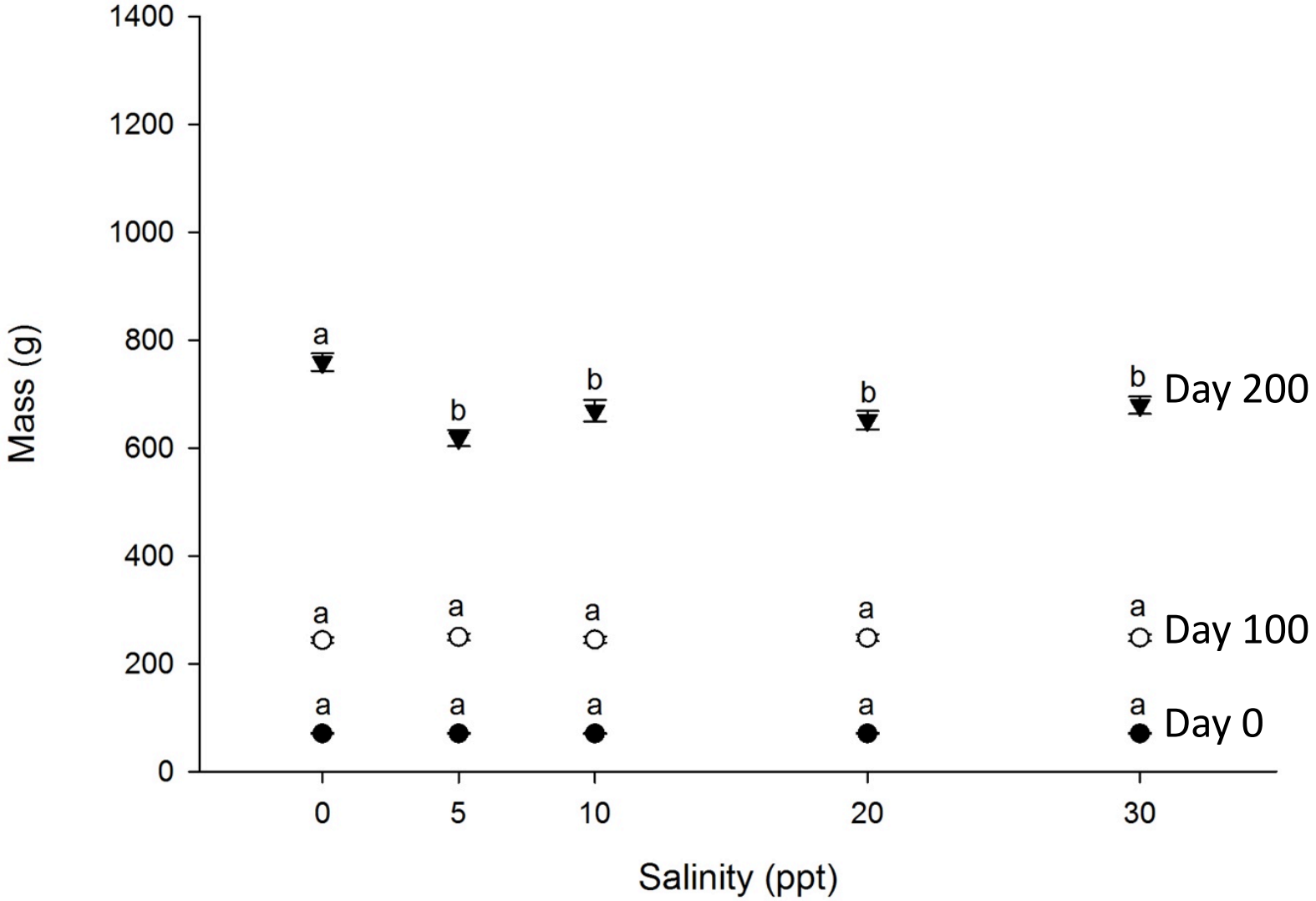


Atlantic Salmon
Growth in 5 m^3 tanks



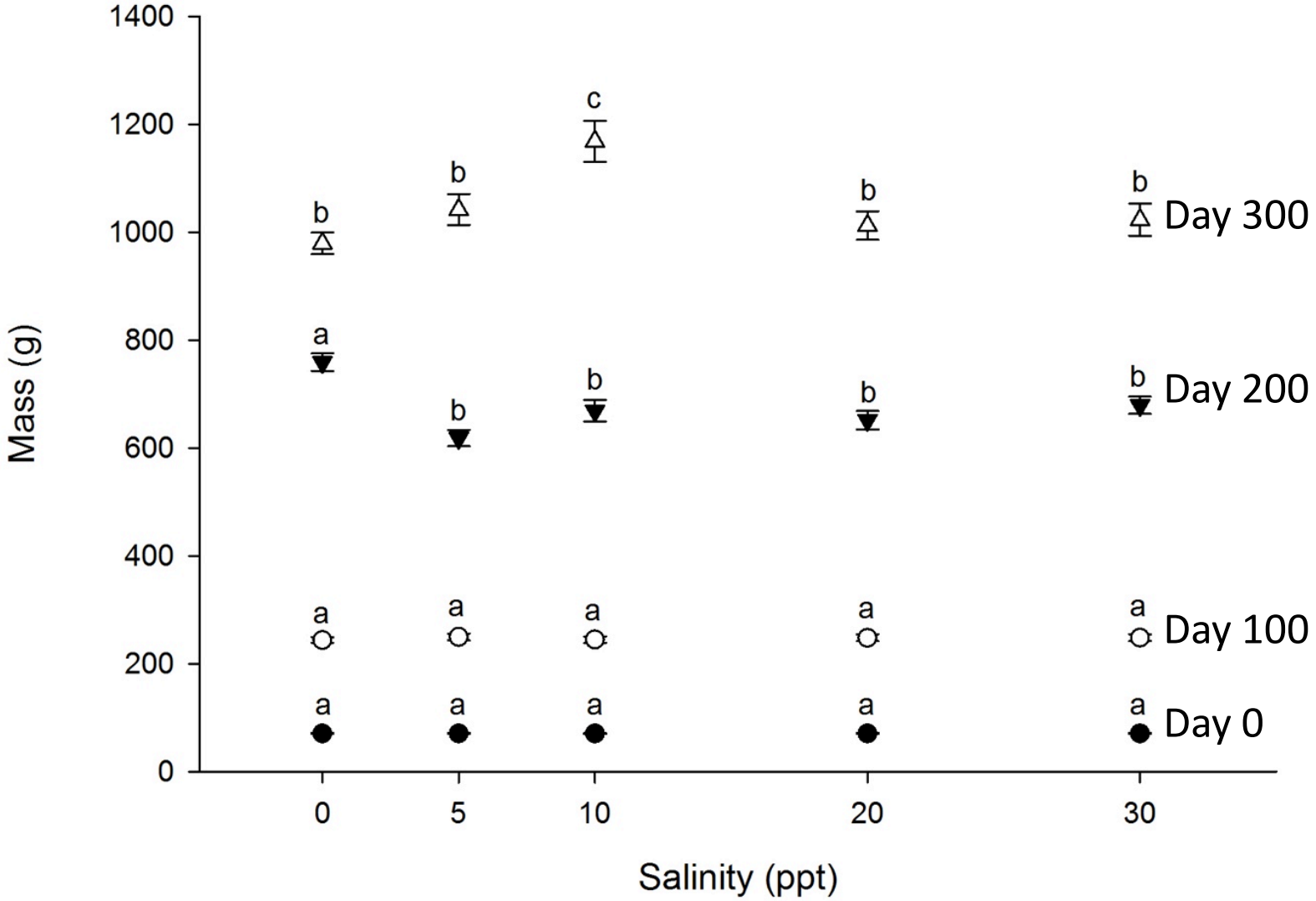
Atlantic Salmon

Growth in 5 m^3 tanks

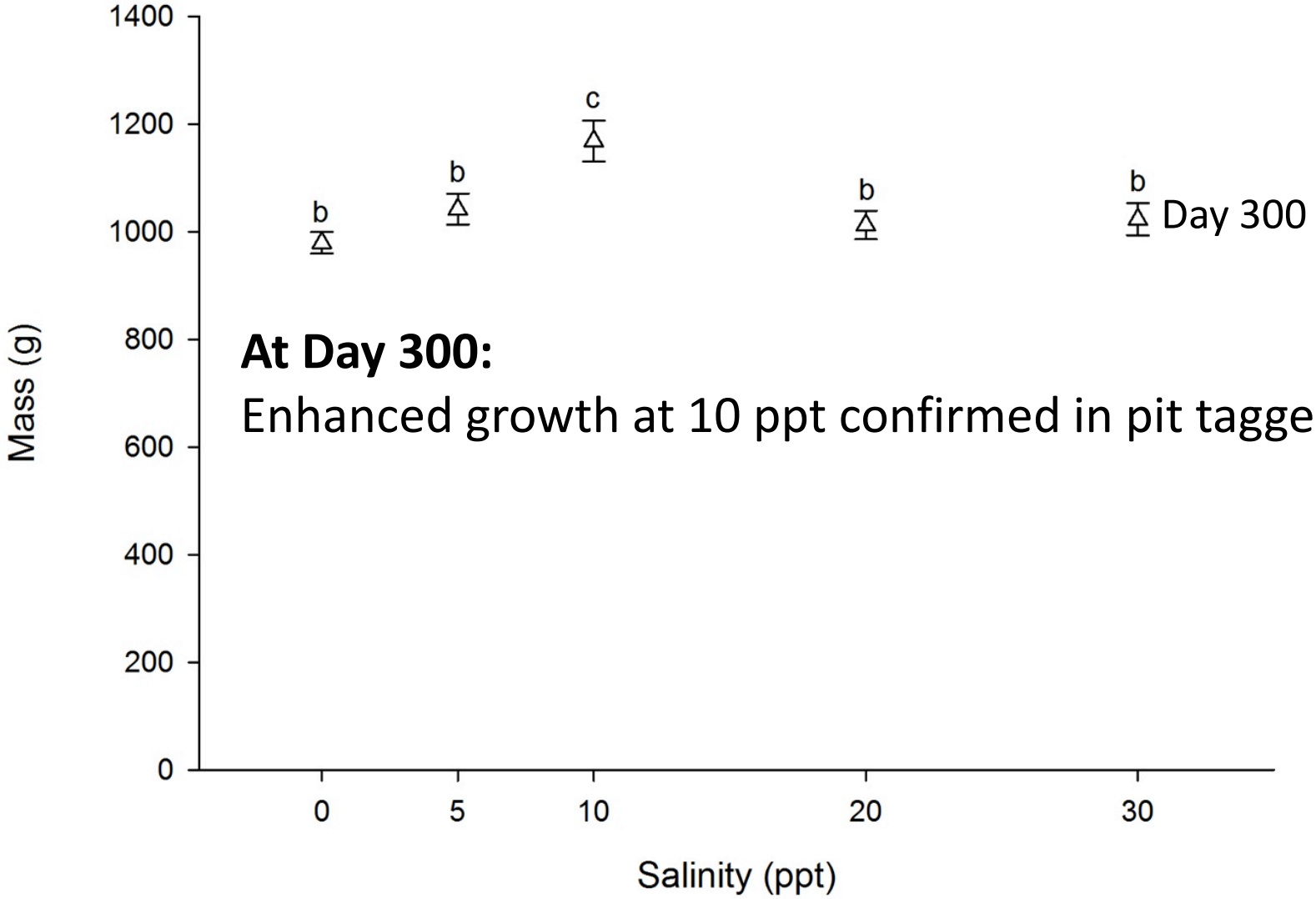


Atlantic Salmon

Growth in 5 m^3 tanks



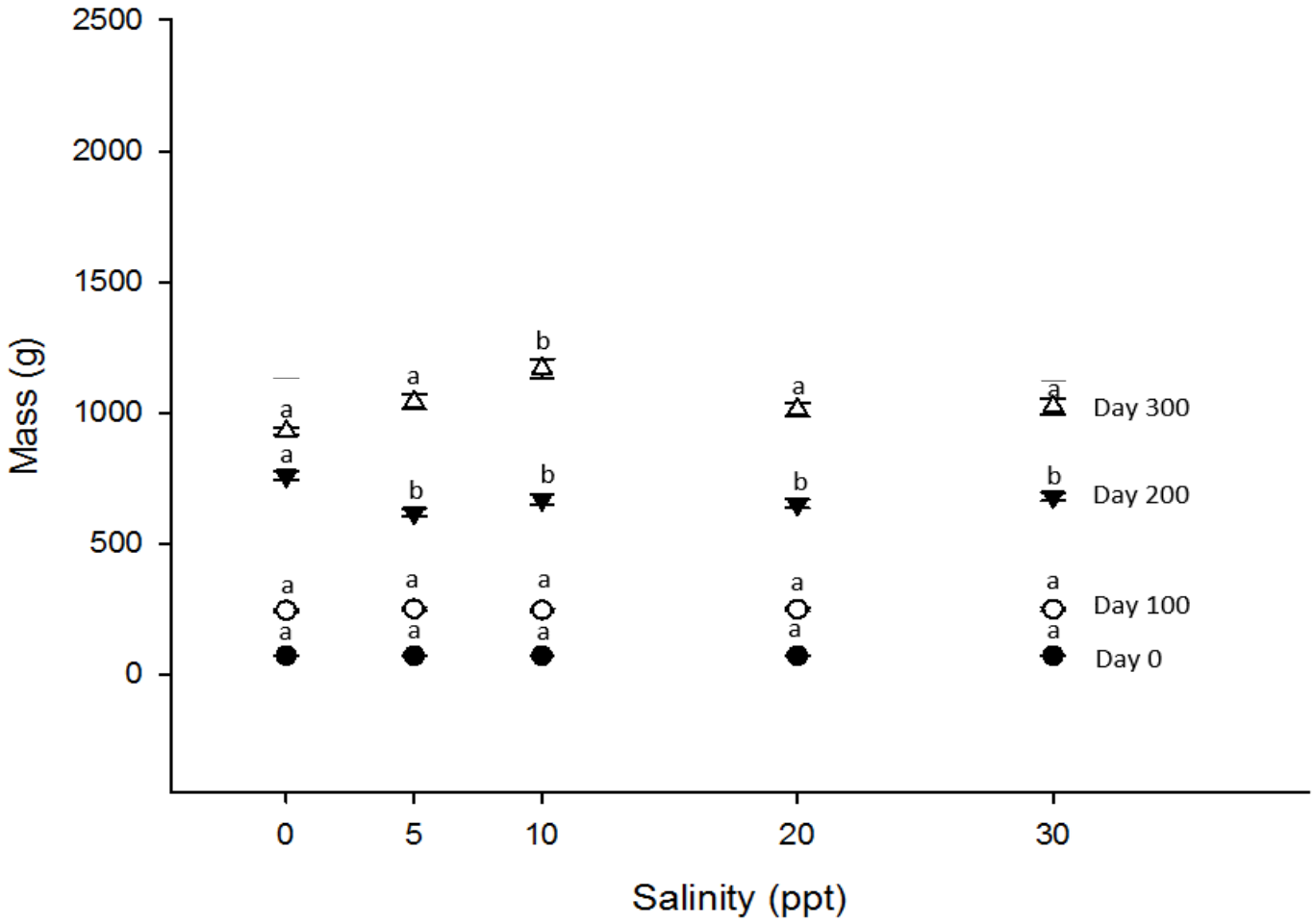
Atlantic Salmon
Growth in 5 m^3 tanks



At Day 300:

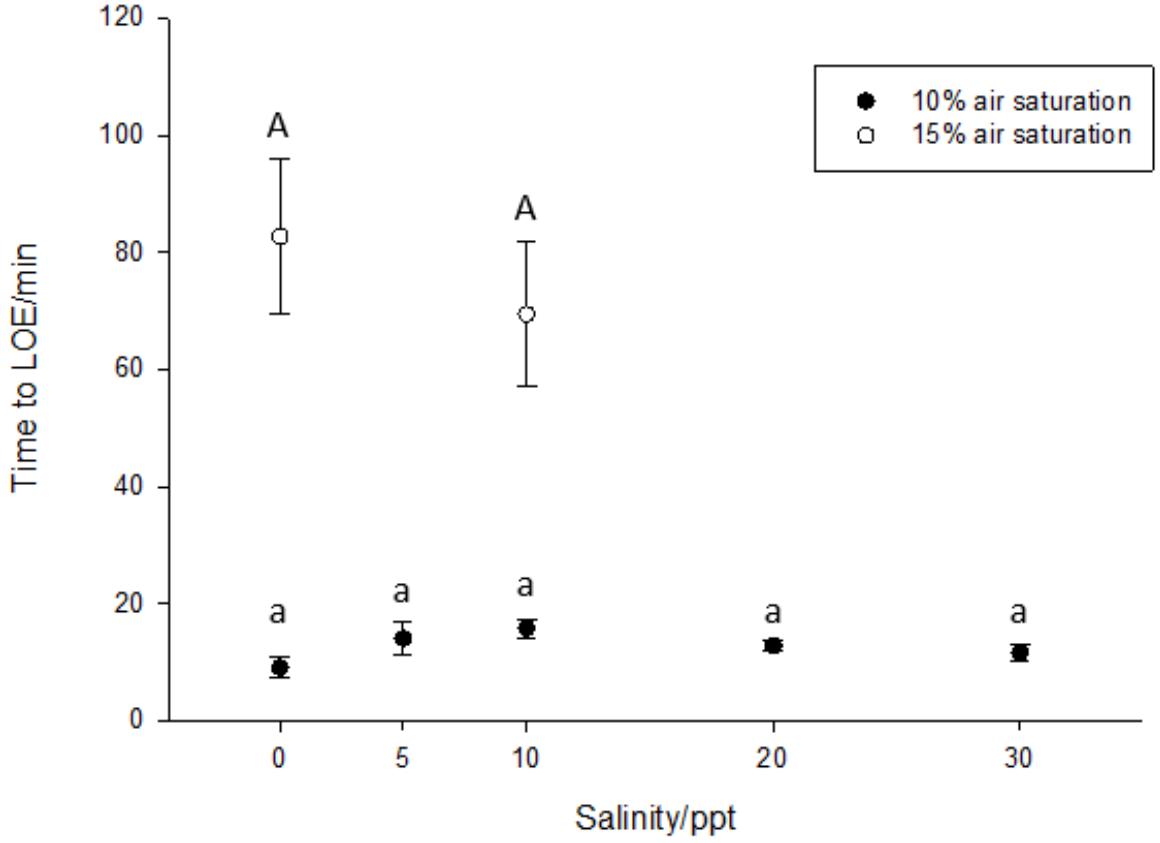
Enhanced growth at 10 ppt confirmed in pit tagged fish

Atlantic Salmon
Growth in 5 m^3 tanks



Growth is enhanced at intermediate salinities beyond day 200.

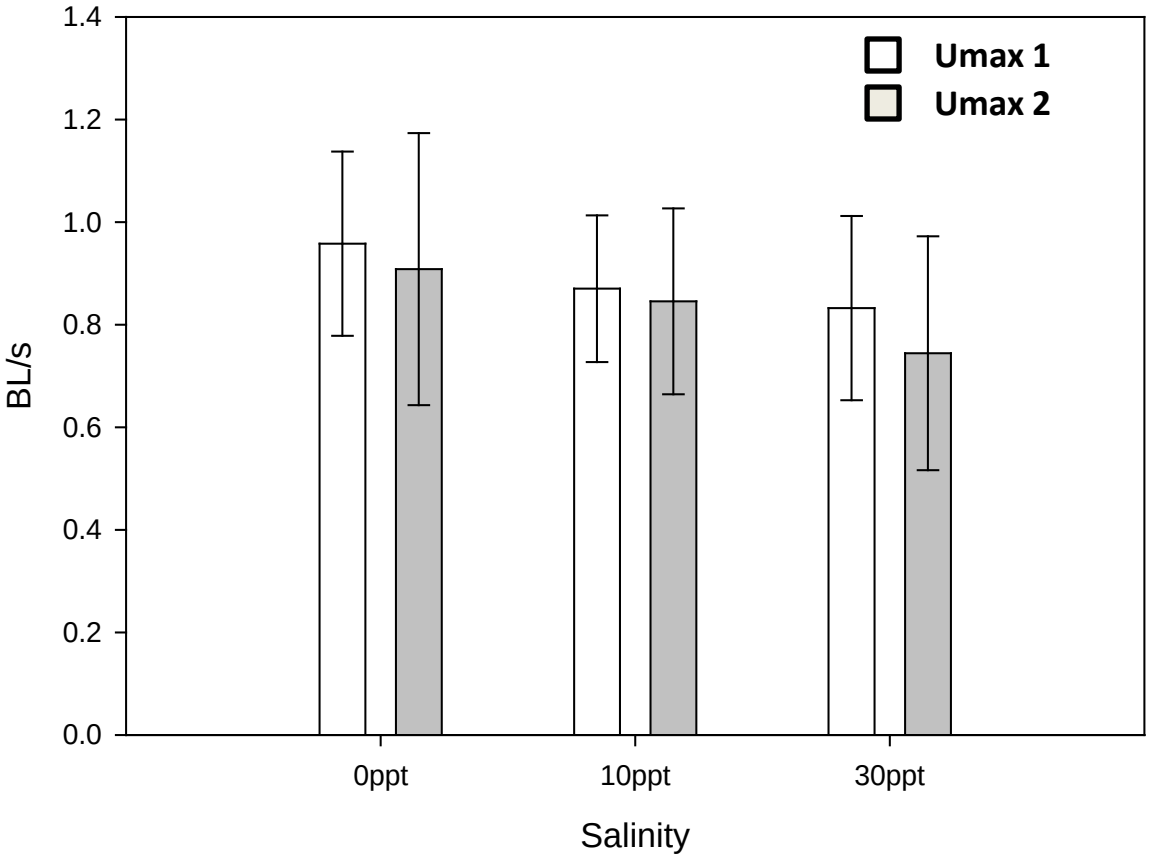
Atlantic Salmon Performance
Hypoxia Tolerance



No difference in time to loss of equilibrium (LOE) during low O_2 despite differences in growth rate.

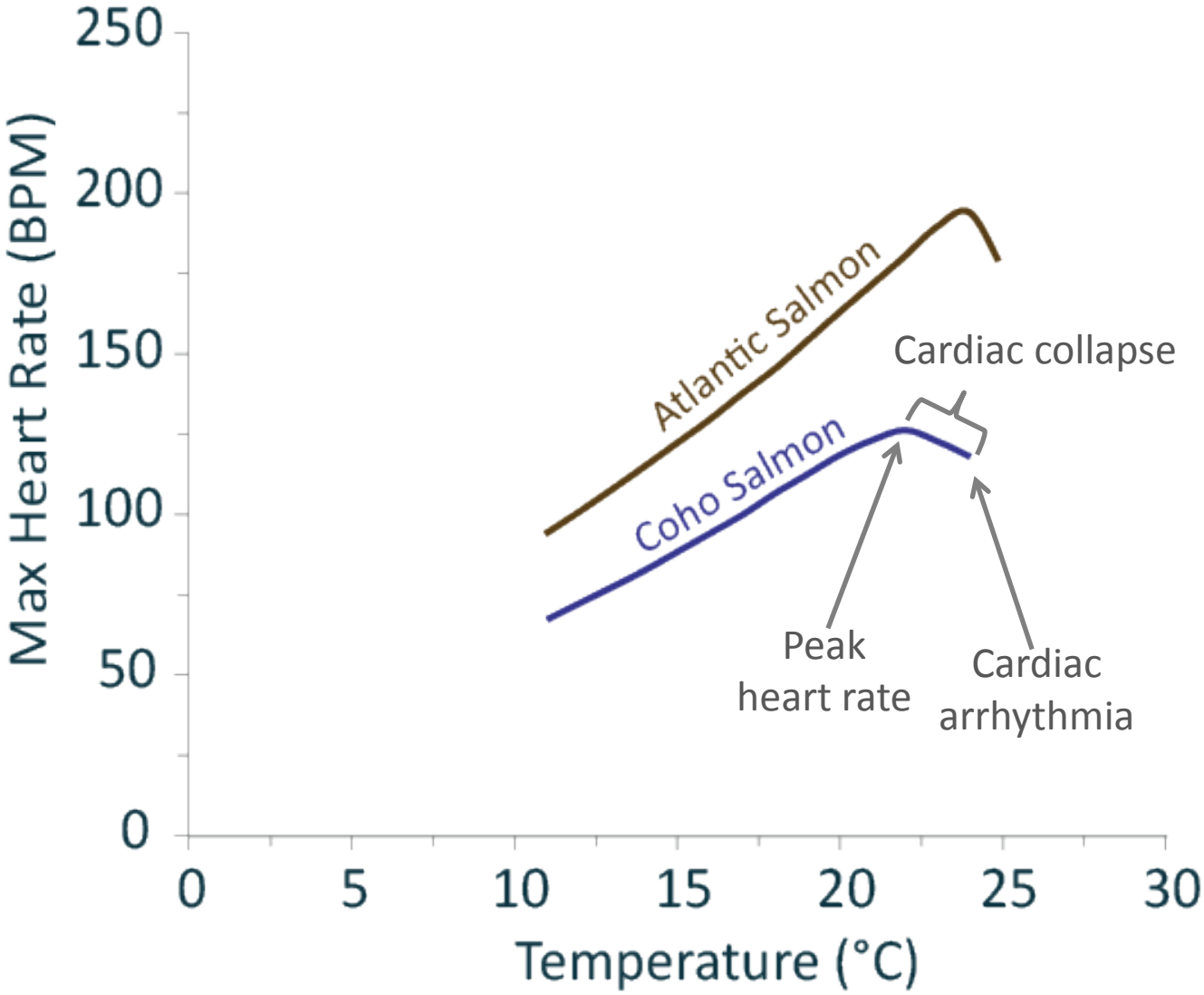
Atlantic Salmon Performance

Swimming Performance

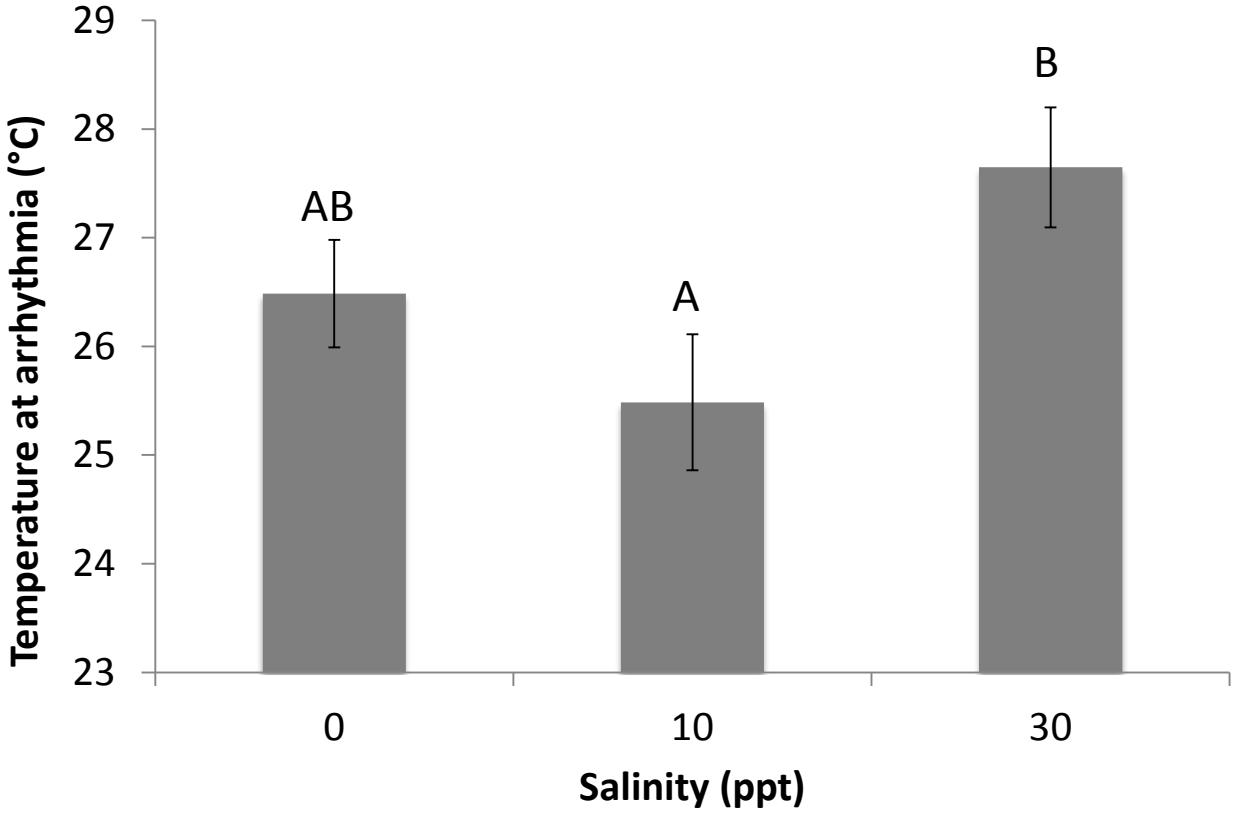


No difference in swimming performance despite differences in growth rate.

Atlantic Salmon Performance
Upper Thermal Tolerance

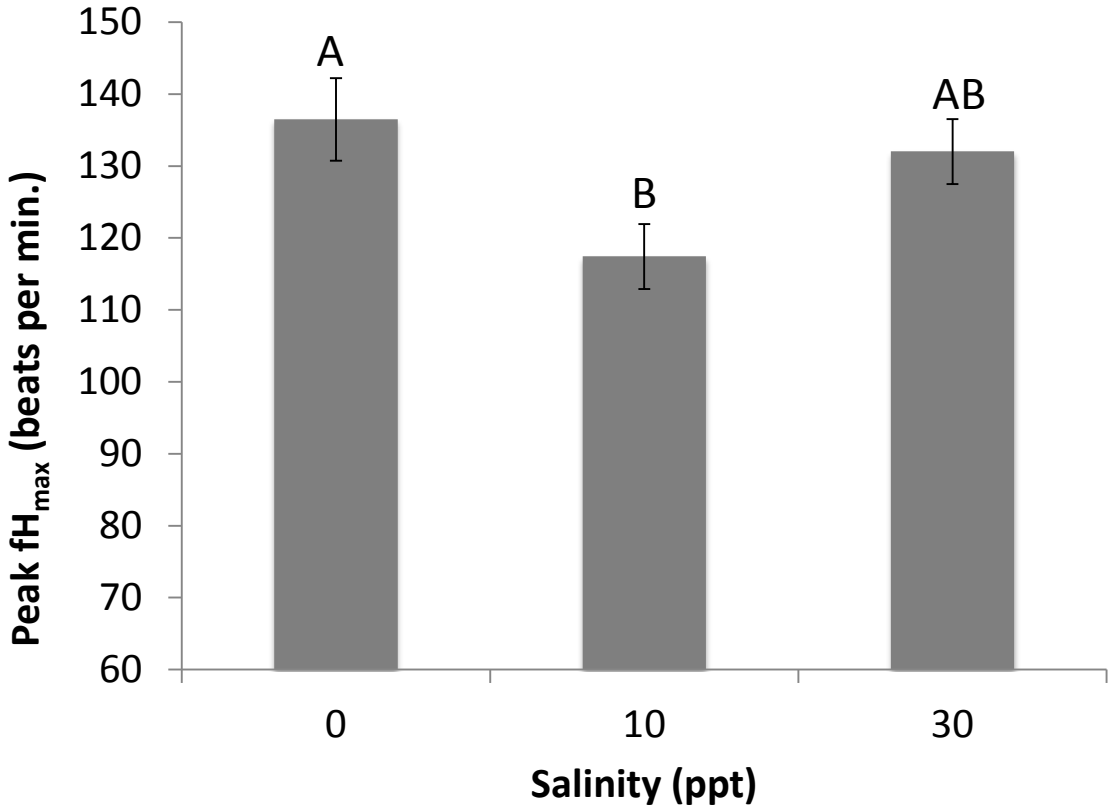


Atlantic Salmon Performance
Upper Thermal Tolerance



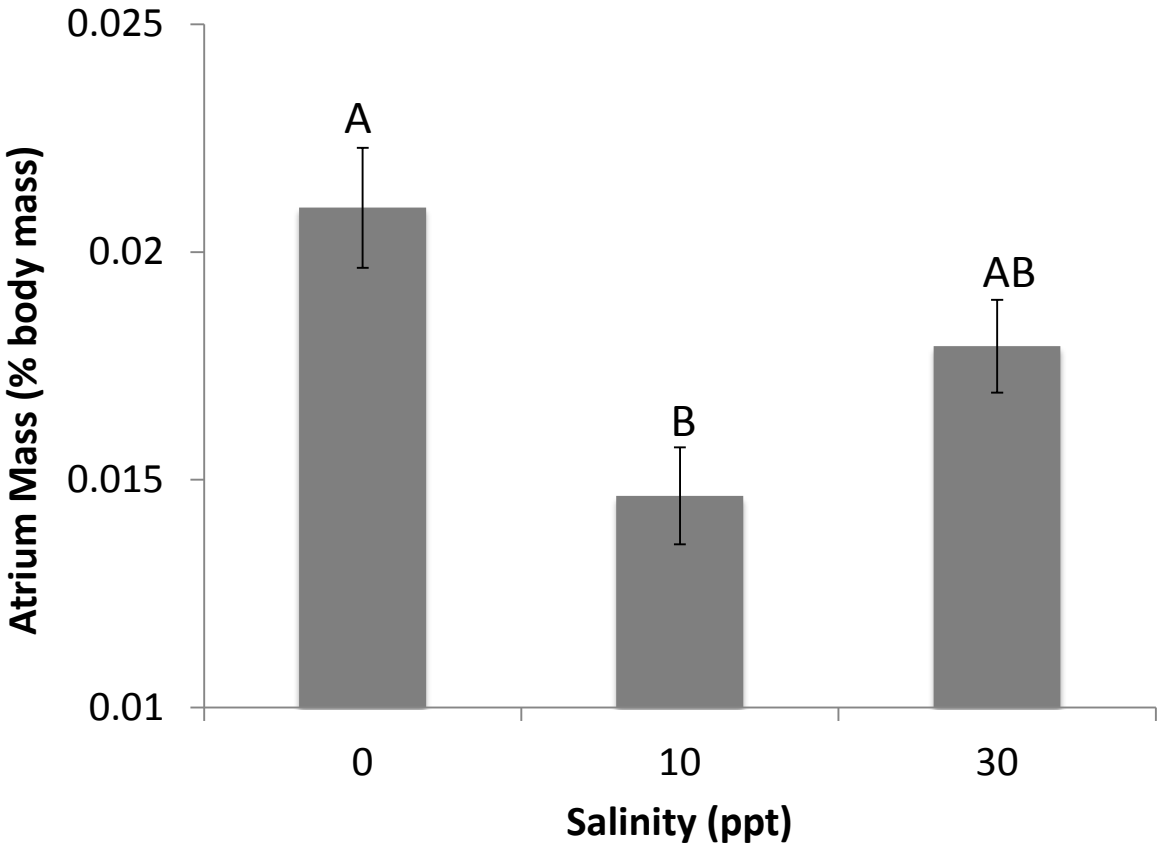
Heart rate becomes irregular at a lower T in 10 ppt fish indicating lower T tolerance.

Atlantic Salmon Performance
Upper Thermal Tolerance



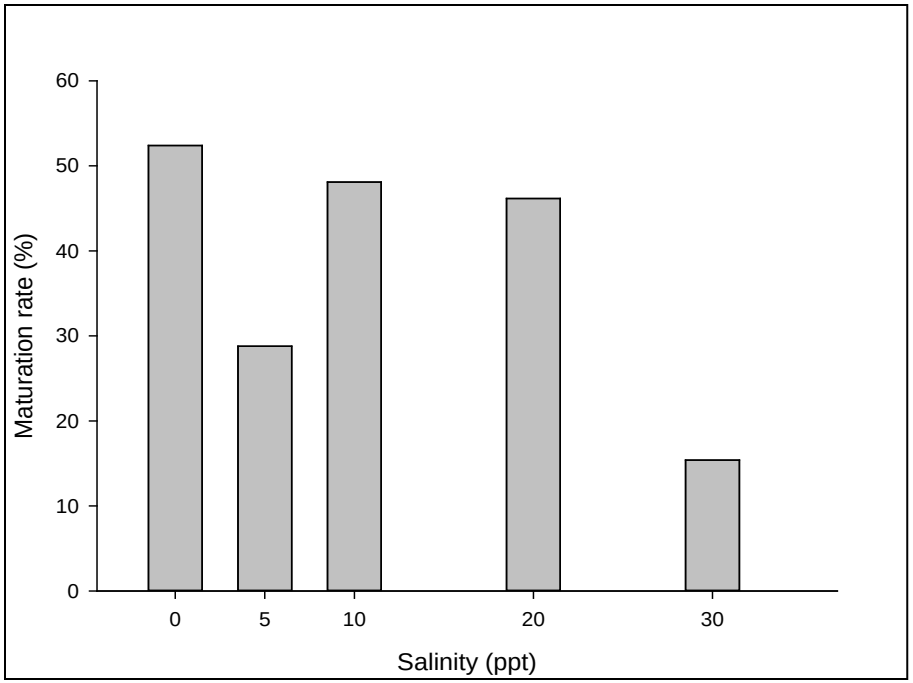
Maximum heart rate during increasing T is reduced at 10 ppt.

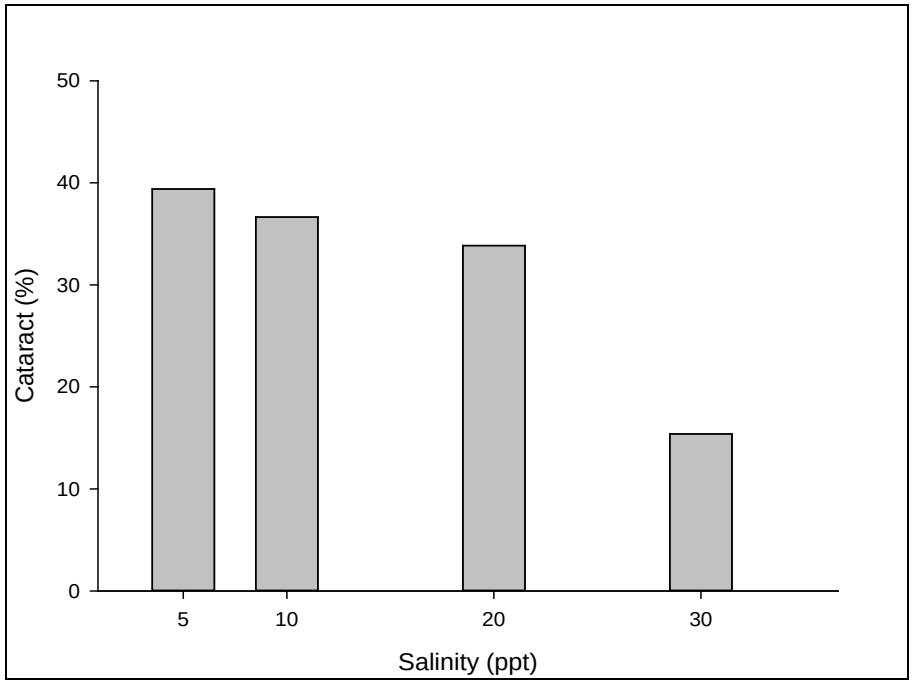
Atlantic Salmon Performance
Upper Thermal Tolerance



Fish reared at 10 ppt have a lower heart (atrium) mass.

Atlantic Salmon
Early Maturation and Cataracts





Maturation is reduced at 5 ppt (when growth is greatly enhanced) and 30 ppt.
Cataracts are reduced at 30 ppt.

Conclusions
Coho & Atlantic Salmon

Atlantic Salmon

- Up to ~600 g, salinity does not appear to affect growth.
- Above ~600 g, intermediate salinities enhance growth.
- No effect of salinity on hypoxia tolerance or swimming performance.
- Intermediate salinities (10 ppt) may affect cardiovascular function at high temperature.
- Thus some evidence of trade-offs between growth and performance.
- Higher salinity appears to reduce early maturation and cataracts. Maturation may be reduced at 5 ppt.

Conclusions
Coho & Atlantic Salmon

Coho Salmon

- At a small size (<350 g), intermediate salinities appear to improve growth and feed conversion compared with freshwater and seawater.
- Effects persist over a year of growth.
- No effect of salinity on hypoxia tolerance or swimming performance. Thus, there is no trade-off between growth and performance.
- Minimal effects on early maturation (all female strain) and cataracts. The latter differs greatly from Atlantics.

Thank you

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Collaborators

TARGETMARINE HATCHERIES

NORTHERN DIVINE The Canadian Caviar

KUTERRA SUSTAINABILITY HAS LANDED

TAPLOW FEEDS

FROM PURE ARTESIAN WATERS Miracle Springs

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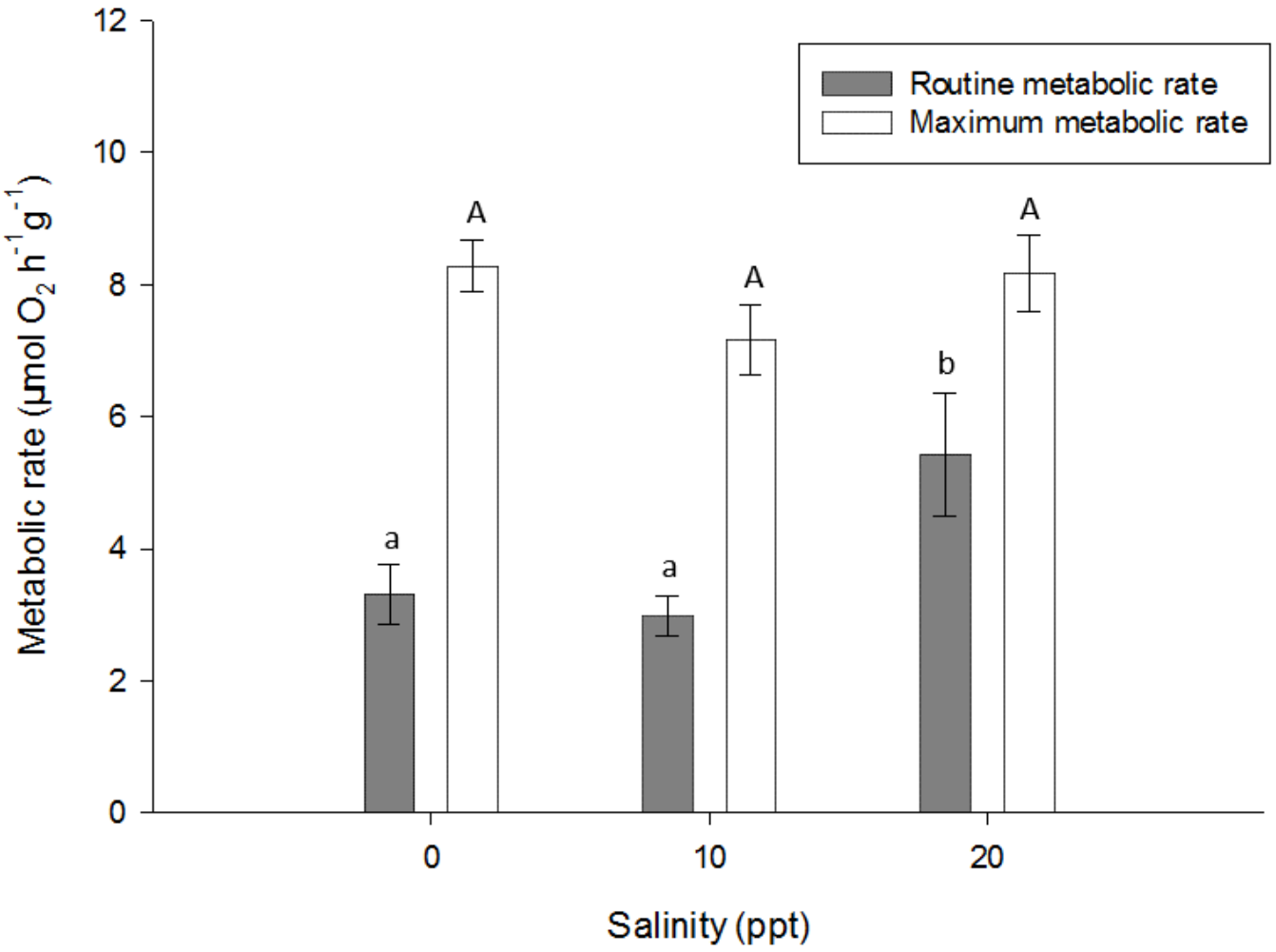
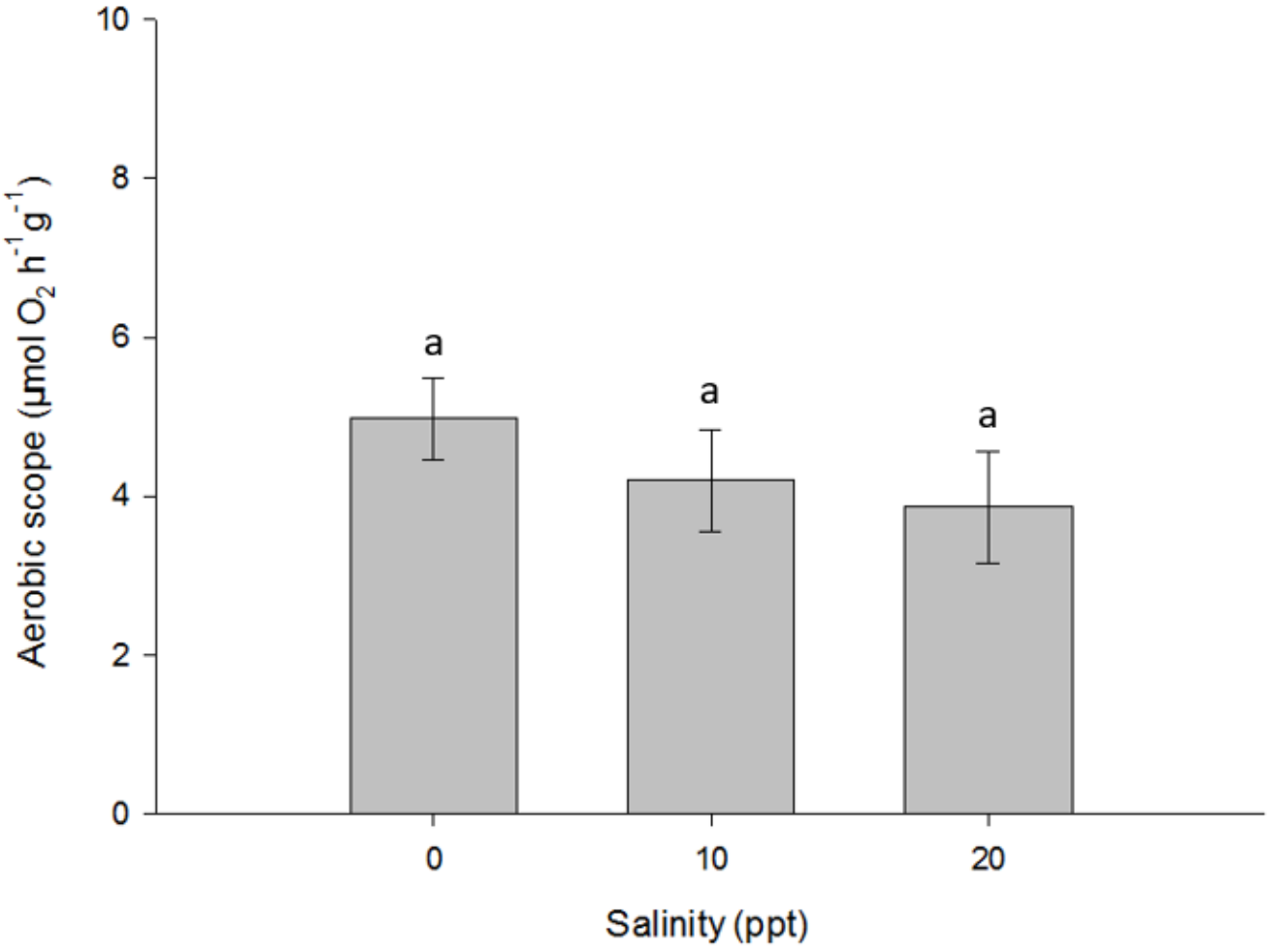
Integrated Aqua Systems, Inc.

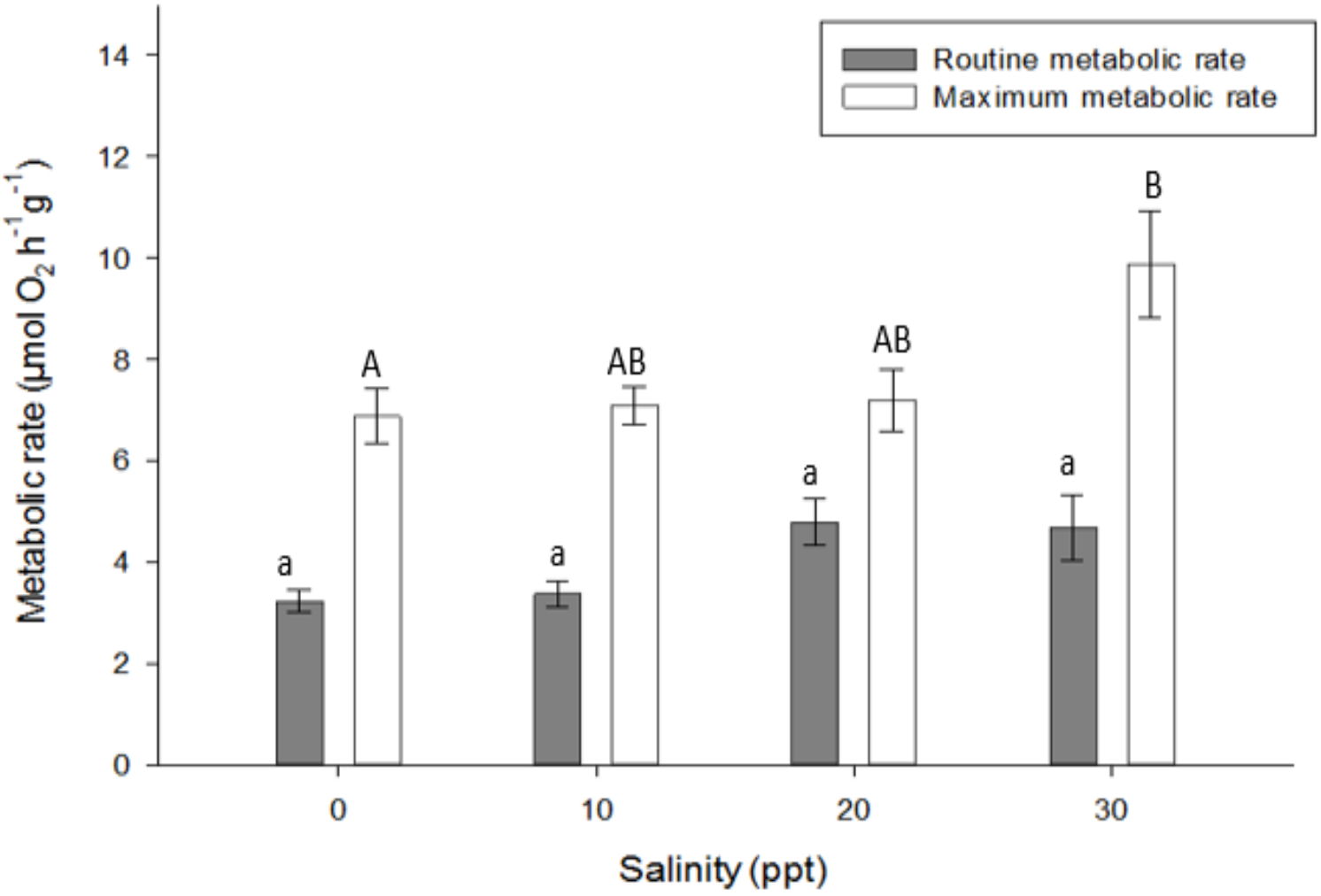
Coho Salmon
Oxygen Consumption Rates



Coho Salmon
Oxygen Consumption Rates



Atlantic Salmon
Oxygen Consumption Rates



Atlantic Salmon
Oxygen Consumption Rates