Energetics and Physiology of Columbia/Snake Steelhead Provide Insight to Likely Iteroparity

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Snake River Steelhead

- **Migrate > 400 km**
- **Stream-maturation**
  - **Enter in summer/early fall**
  - **Fast 6 to 12 months**

- **Repeat-spawning low**
  - **2-4% (Long & Griffin 1937)**
  - **1.6% (Whitt 1954)**
  - **0.5-1.2% (Keefer et al. 2008)**
- **“Effectively semelparous”**
  (Burgner et al. 1992)

Research Questions

- **What are the effects of prolonged fasting on target tissues?**
- **How does stored energy (in tissues) change during upstream migration, reproduction & what remains post spawning?**
- **Are inland SH preparing for ocean re-entry?**
- **Are inland SH energetically different from SH with higher rates of iteroparity?**

SH Migrate Downstream Post Spawning

Kelt at Potlatch River, ID

Kelt at Lower Granite Dam, WA

Kelt at Fish Creek, ID

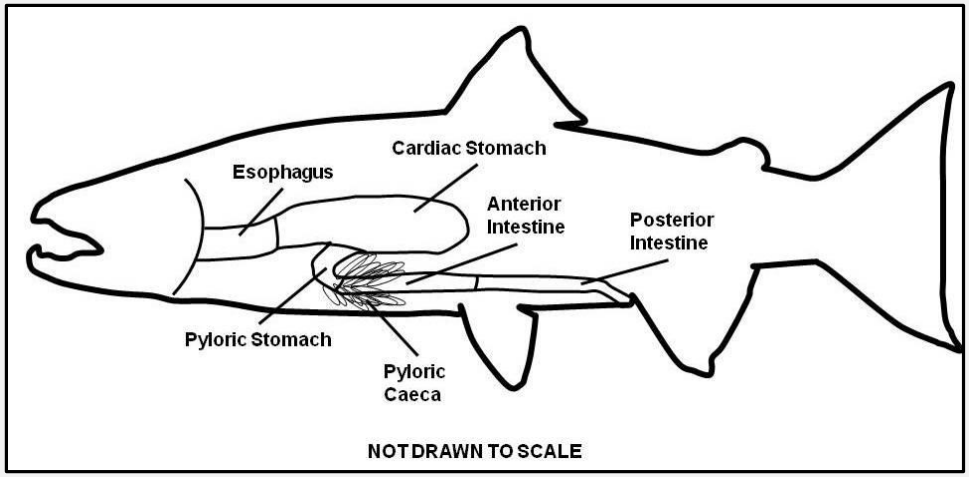
Kelt at Lower Granite Dam, WA

Tissue Profiles

What are the effects of prolonged fasting on selected tissues?

Why Do SH Fast?

- **G.I. tract costs energy (40%)**
- **Freshwater not as productive as sea**
- **Maximize benefits of cold water**



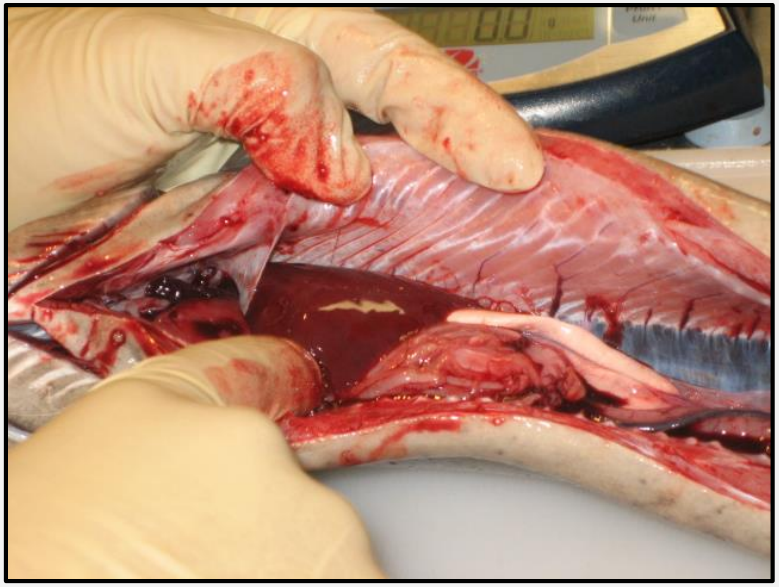
Objective

Necropsy and evaluate microstructure between sexually mature & good condition kelt steelhead

Fasting vs. Recovering

Lethal Sampling

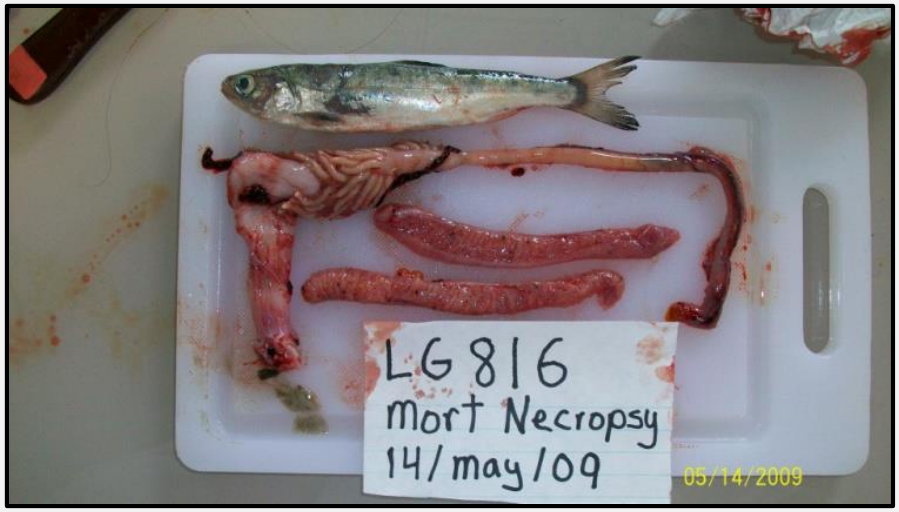
- **Necropsy**
  - **G.I. tract examined for food**
- **Selected tissues preserved**
  - **Pyloric stomach**
  - **Liver**
  - **Spleen**
  - **Ovary (kelts only)**
- **Micro-structural analysis**
  - **H&E stain**



Evidence of Feeding

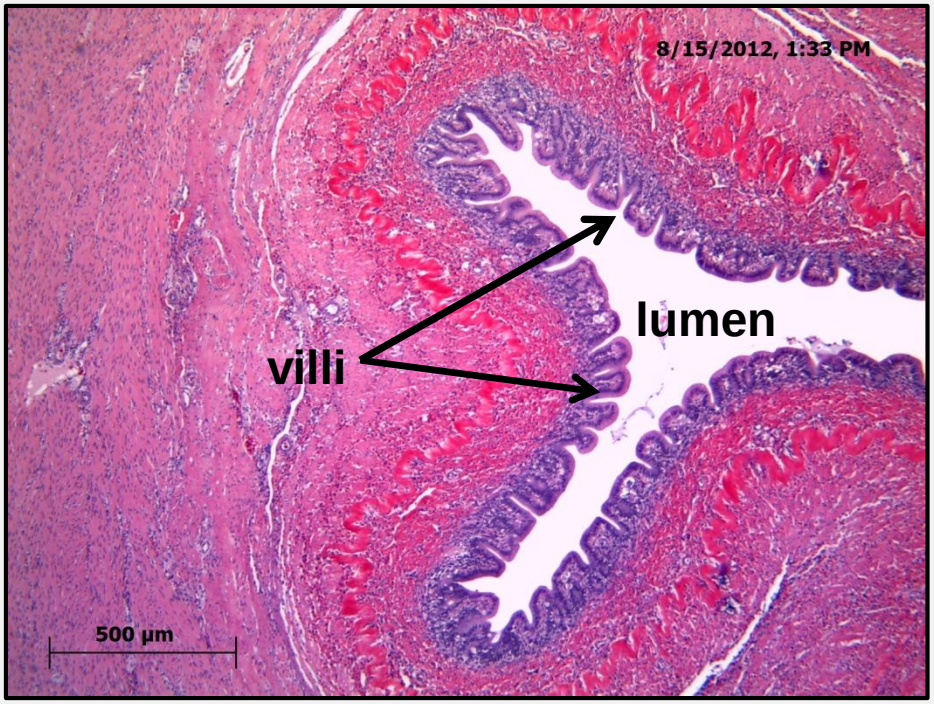
- **38% of LG kelts were feeding**
- **58% of good condition females had food or fecal material in the G.I. tract**

Smolts & other fish



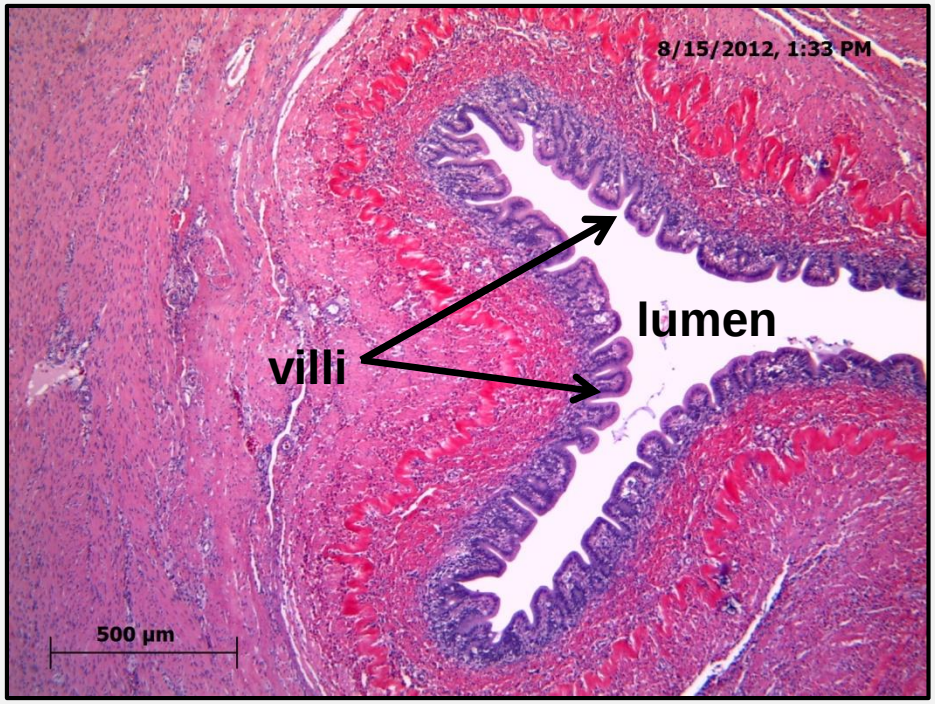
Invertebrates

Pyloric Stomach

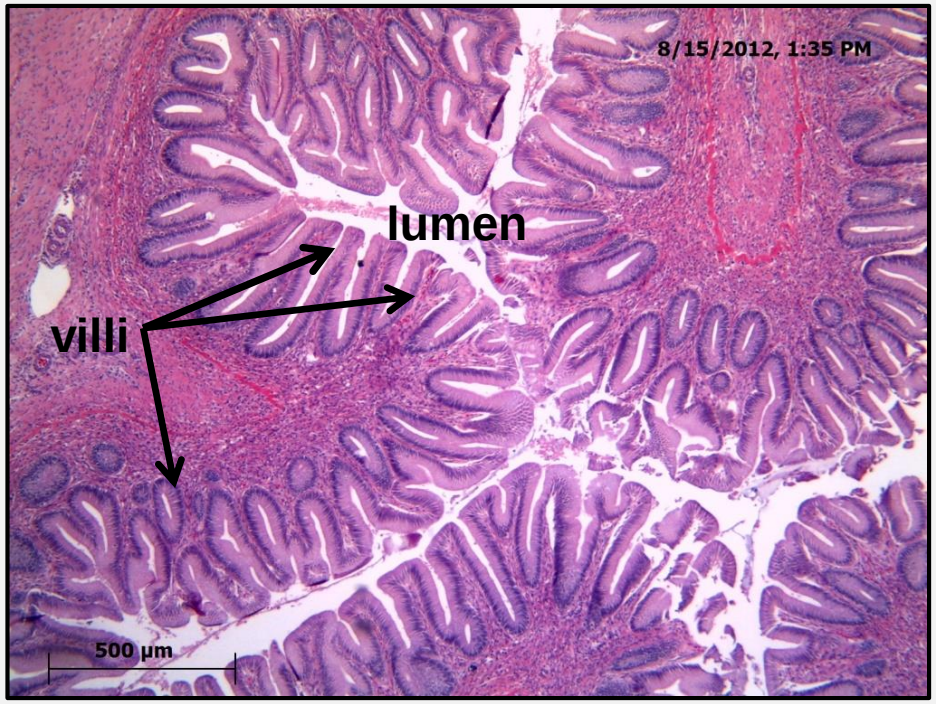


Sexually Mature

Pyloric Stomach



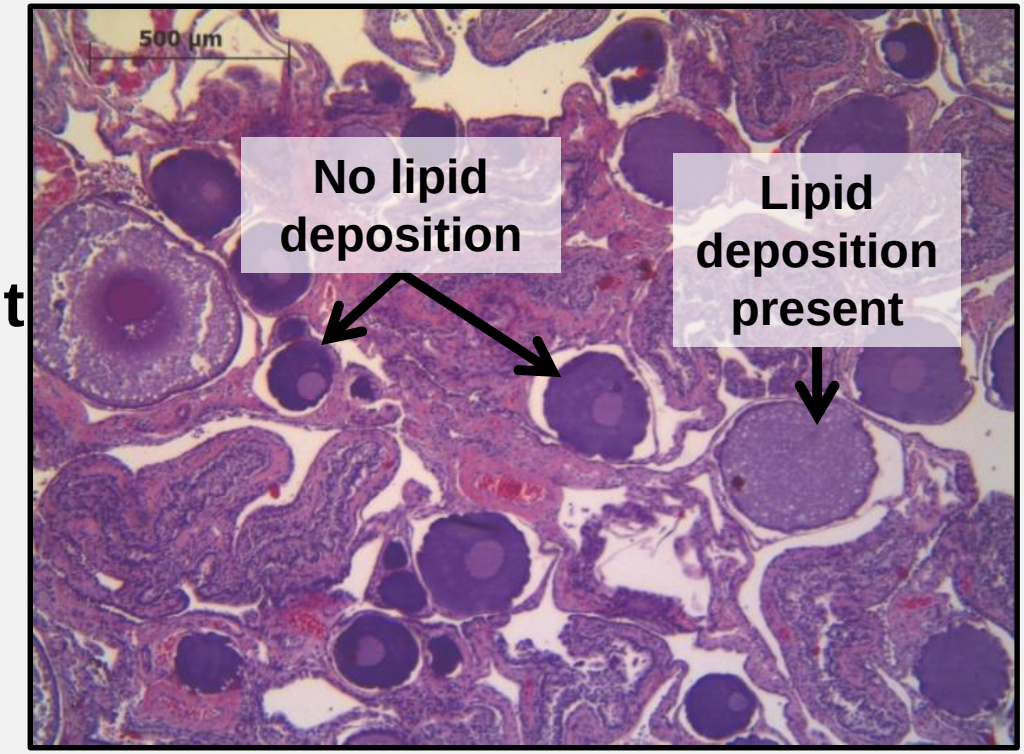
Sexually Mature



Kelt

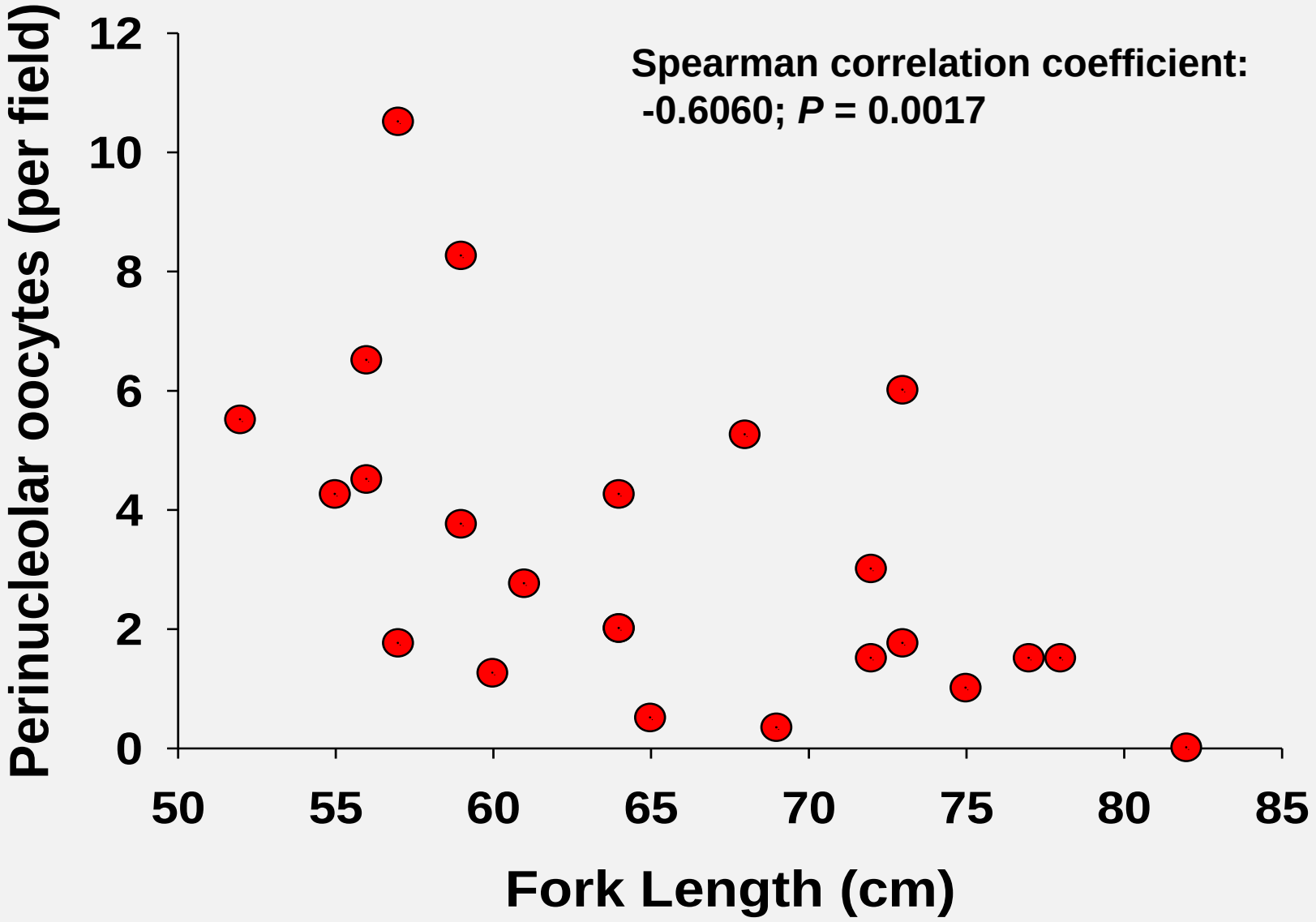
Ovary Tissues- Oocytes Present

- **Perinucleolar oocytes**
- **Early/late stage cortical alveolus oocytes present**
- **No vitellogenic oocytes observed**



Opportunity for repeat spawning in kelts either sequential or skip

Fork Length vs. Perinucleolar oocytes



Summary

- **Kelt organ recovery & feeding begins in freshwater**

- **G.I. tract is off at maturity**
- **Kelts turn G.I. back on**

- **Little necroses in tissues**

- **Oocytes present**

More Information

Rev Fish Biol Fisheries
DOI 10.1007/s11160-013-9338-2

RESEARCH PAPER

Histological assessment of organs in sexually mature and post-spawning steelhead trout and insights into iteroparity

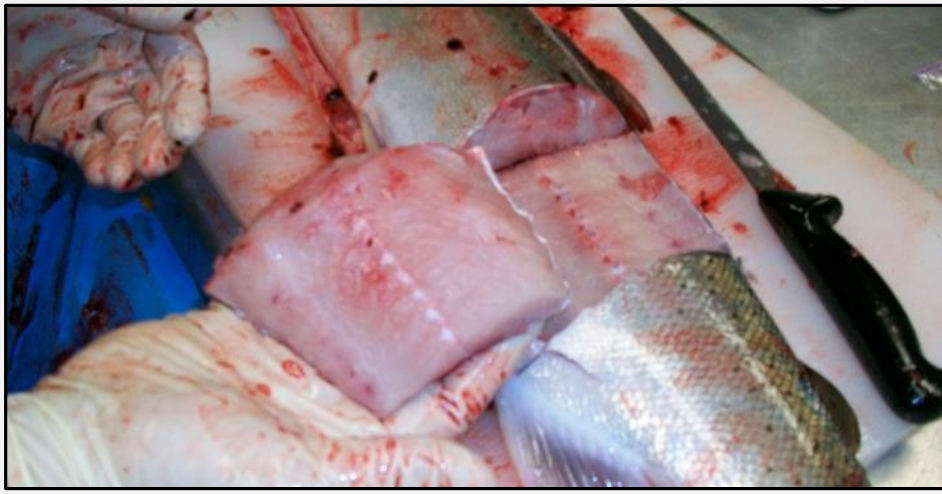
Zachary L. Penney · Christine M. Moffitt

Objective

Quantify broad scale changes in lipid, protein, & energy content from early migration to kelt emigration

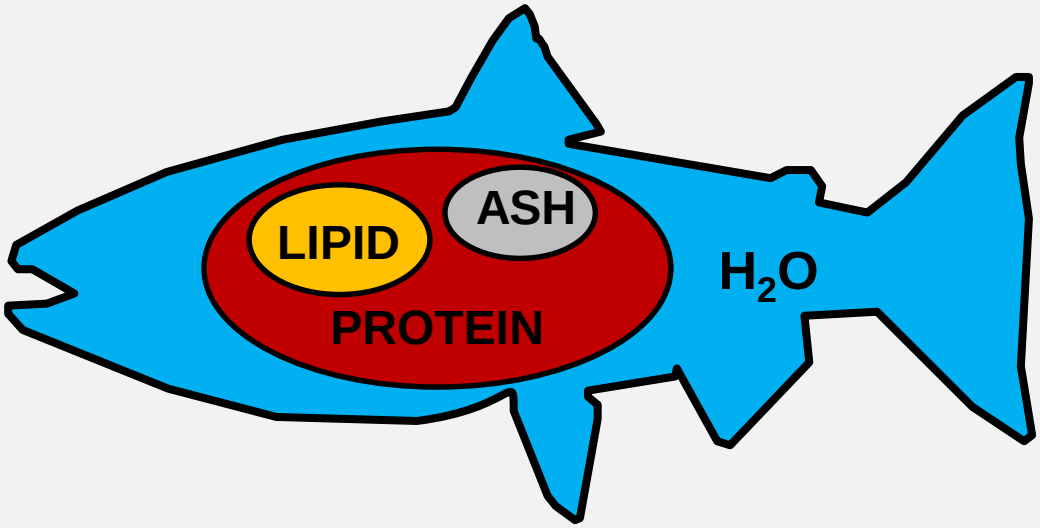
White muscle target

(60% by mass)



Energetic Analysis

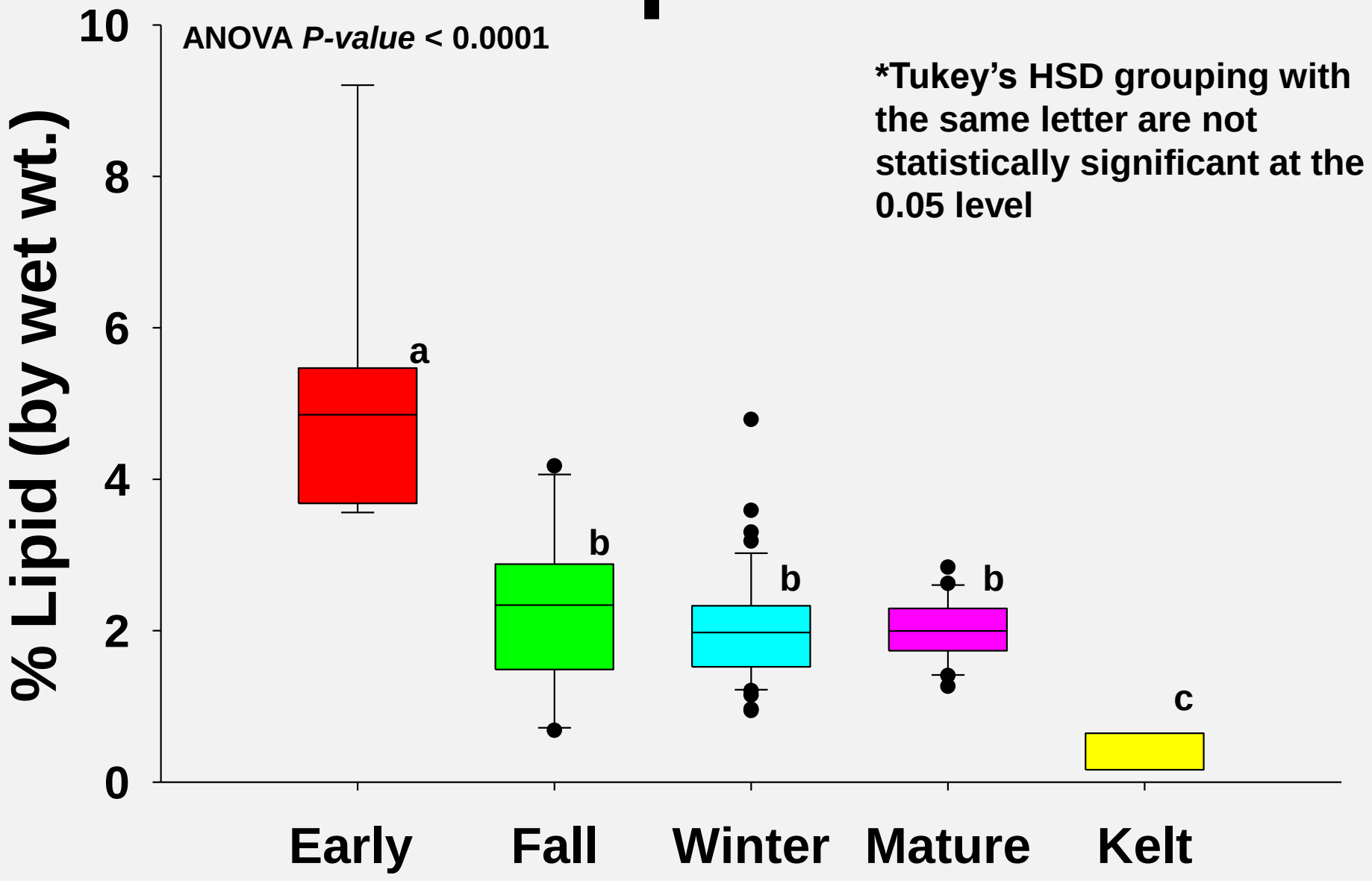
- **Proximate**
- **Bomb Calorimetry (kJ/g)**
- **Converted to wet wt.**



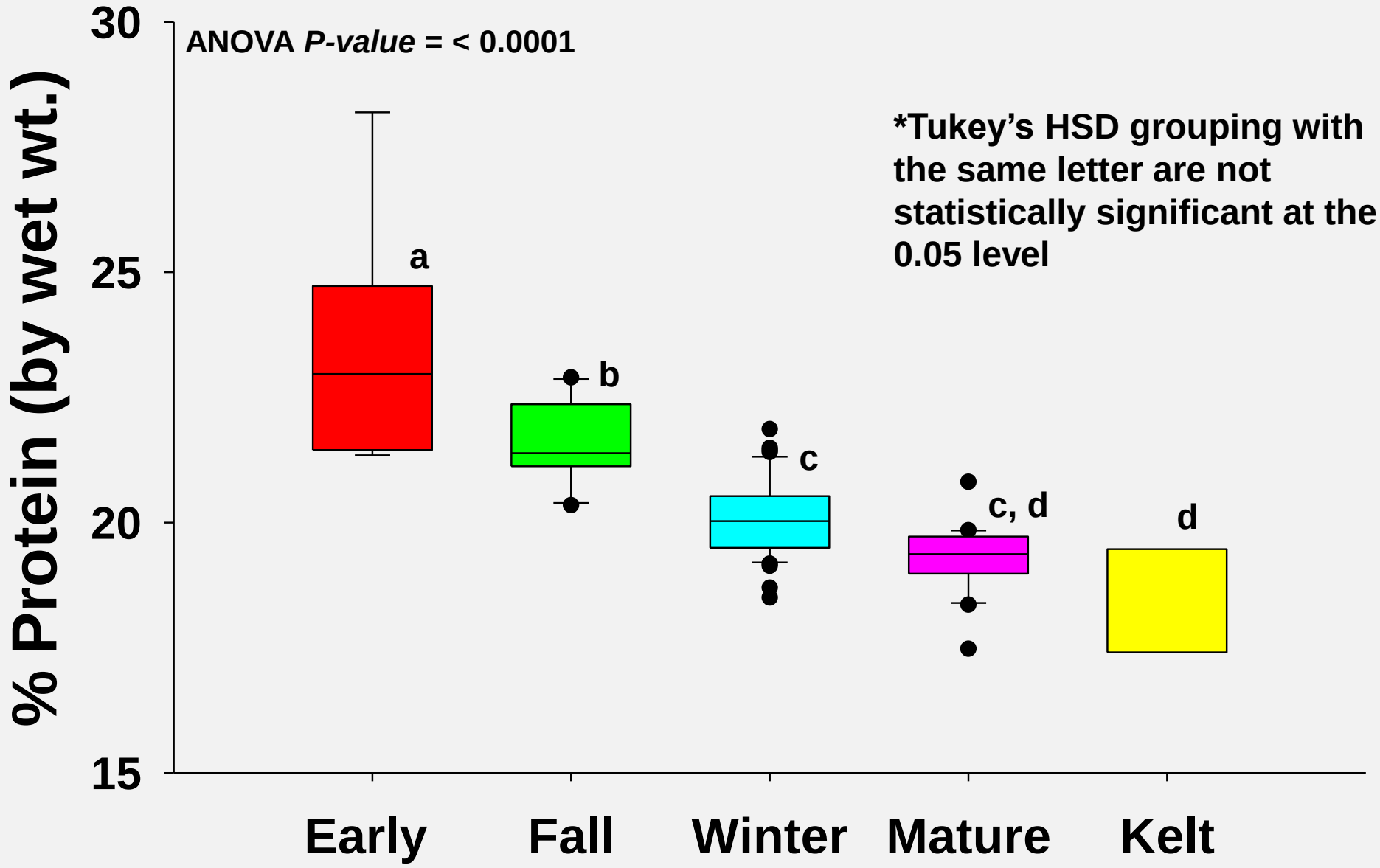
Energy Content of Tissues

- **Lipid (26.4 kJ/g)**
- **Protein (20.1 kJ/g)**
- **<u>Spawning costs</u>**
  - **Upstream migration**
  - **Gonadal maturation**
  - **Secondary sexual characters**
  - **Redd building/competition**

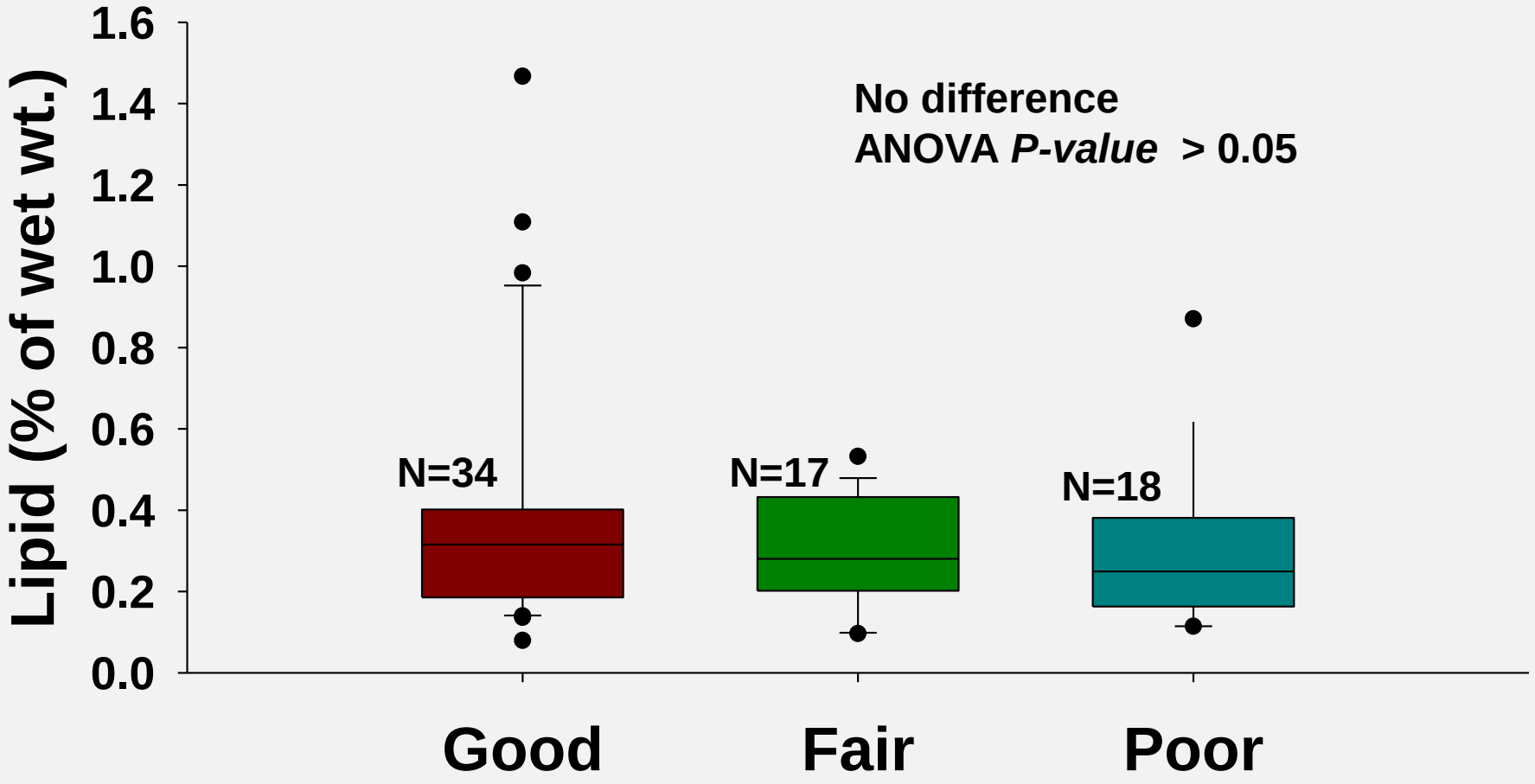
Lipid


ANOVA *P-value* < 0.0001
*Tukey's HSD grouping with the same letter are not statistically significant at the 0.05 level
% Lipid (by wet wt.)
10
8
6
4
2
0
a
b
b
b
c
Early
Fall
Winter
Mature
Kelt

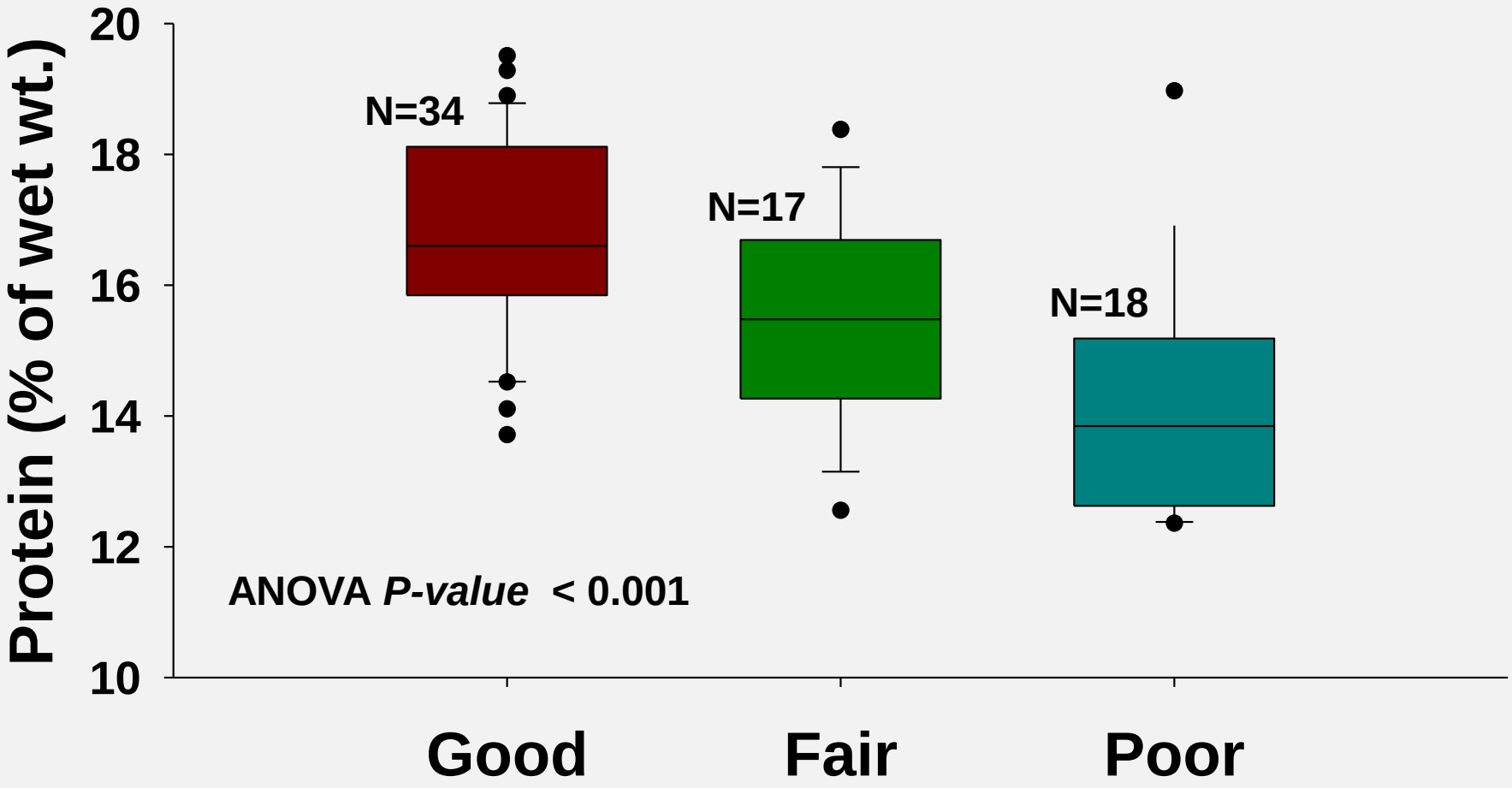
Protein


ANOVA *P-value* = < 0.0001
*Tukey's HSD grouping with the same letter are not statistically significant at the 0.05 level
% Protein (by wet wt.)
30
25
20
15
a
b
c
c, d
d
Early
Fall
Winter
Mature
Kelt

Lipids in Kelts by Condition (Females)

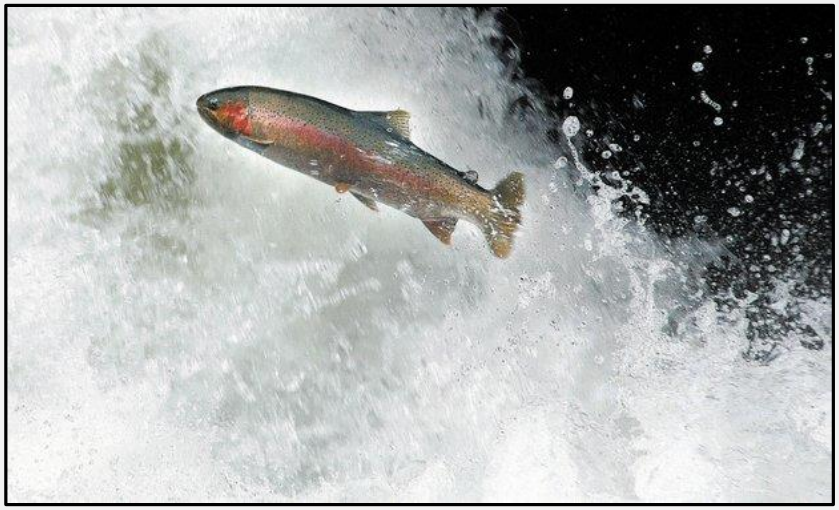


Protein By Kelt Condition (Female only)



Summary

- **Lipids are prioritized**
- **Little change during winter (4°C)**
- **Poor condition kelts have less energy**
- **Protein only remaining energy**



More Information

Transactions of the American Fisheries Society 143:399–413, 2014

ISSN: 0002-8487 print / 1548-8659 online
DOI: 10.1080/00028487.2013.862184

ARTICLE

Proximate Composition and Energy Density of Stream-Maturing Adult Steelhead during Upstream Migration, Sexual Maturity, and Kelt Emigration

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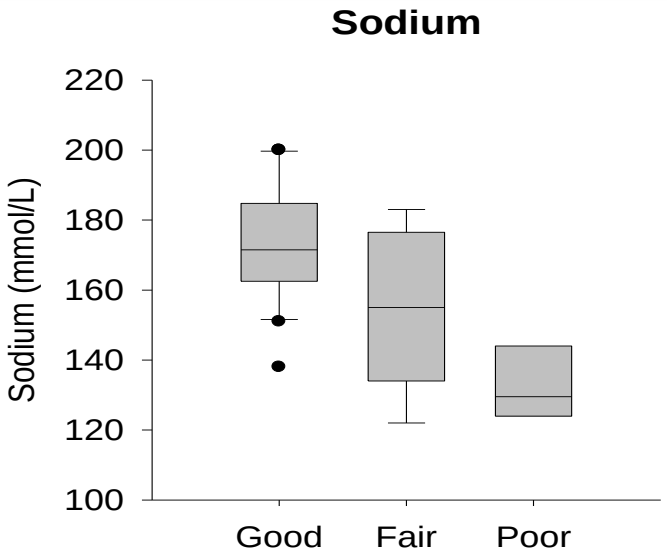
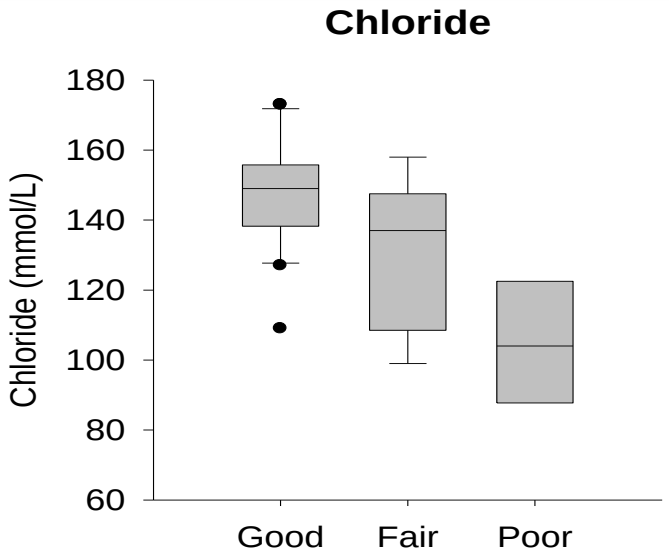
Are Kelts Preparing for Seawater?

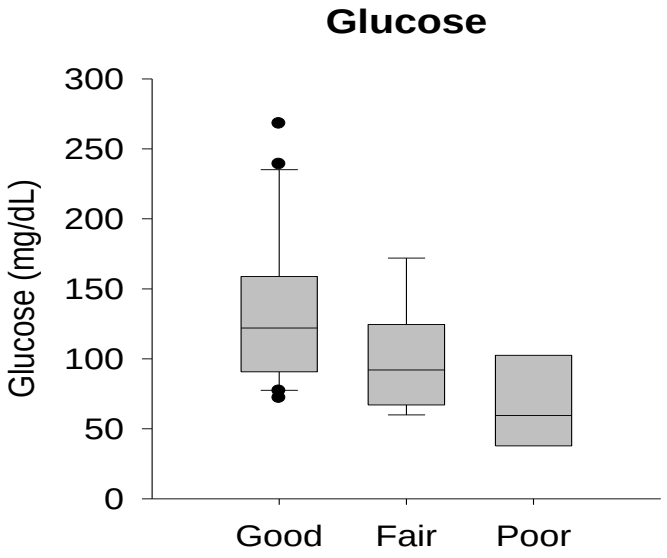
Compare steelhead at sexual maturity and as migrating kelts using metrics used for smolts.

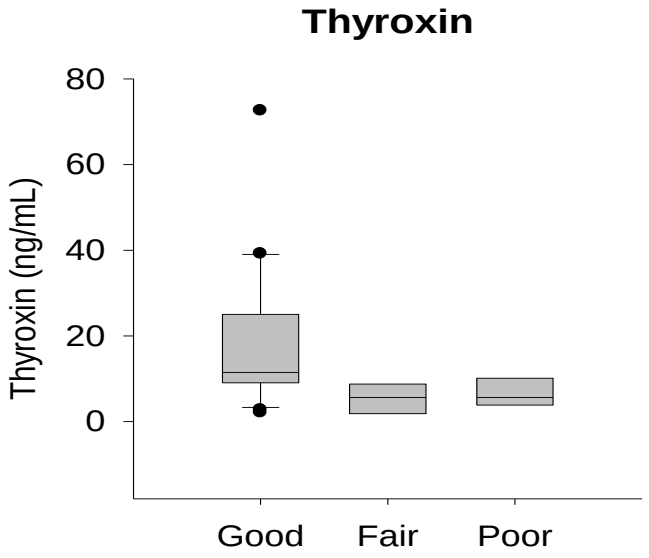
- **Gill Na^+-K^+-ATPase (NKA)**
- **Plasma sodium, chloride, glucose**
- **Thyroxine (T4)**
- **Body silvering**

Kelt Condition Affects Plasma Metrics

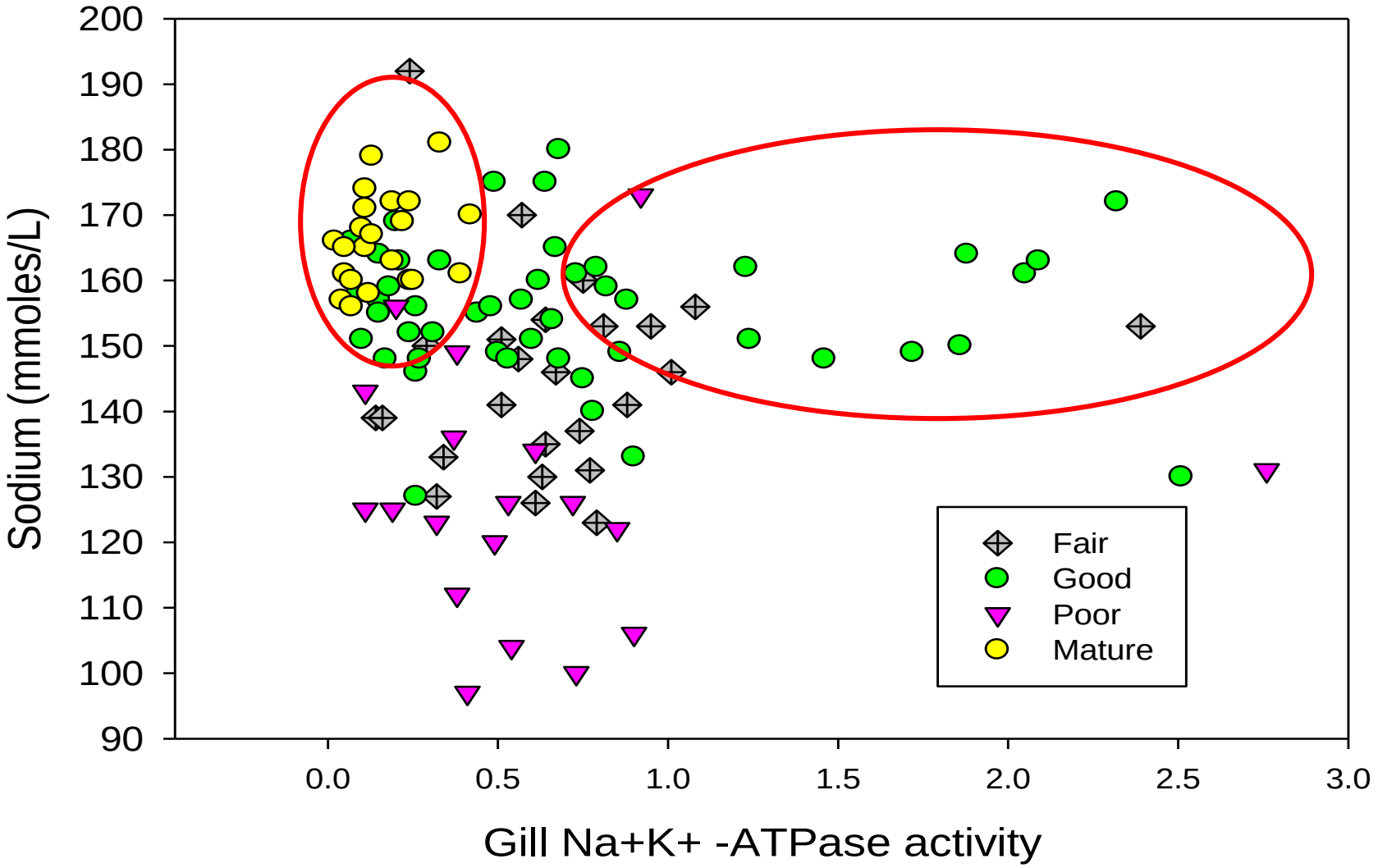




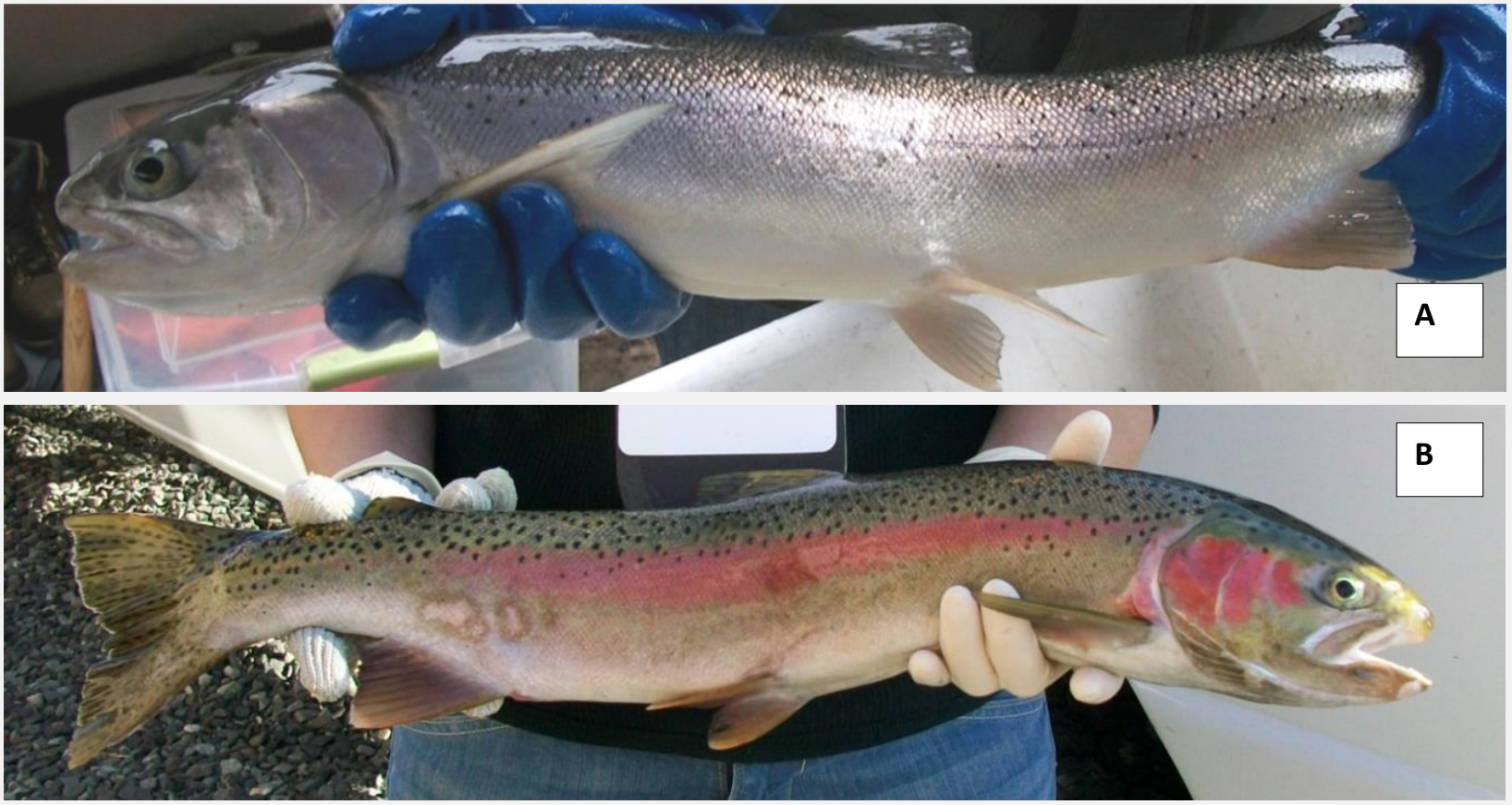




Kelts in Good Condition Have Elevated NKA over Mature SH



Silvery kelts



More Information

Ecology of Freshwater Fish 2014

ECOLOGY OF FRESHWATER FISH

Physiological indices of seawater readiness in postspawning steelhead kelts

Jessica Buelow[1], Christine M. Moffitt[2]
[1]Idaho Cooperative Fish and Wildlife Research Unit, University of Idaho, Moscow, Idaho USA
[2]US Geological Survey, Idaho Cooperative Fish and Wildlife Research Unit, University of Idaho, Moscow, Idaho USA

Accepted for publication January 23, 2014

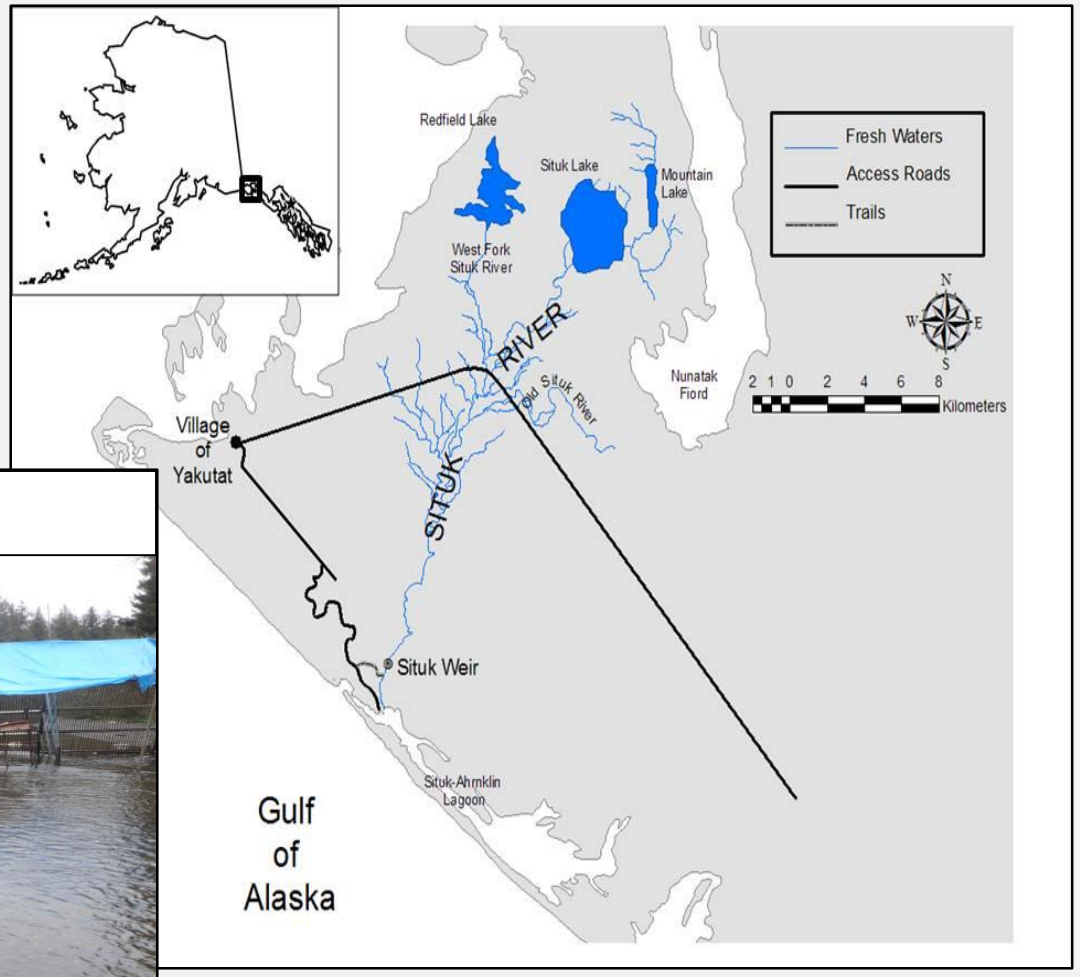
Large-sized Inland vs. Coastal Stocks with different rates of iteroparity

Inland Columbia/Snake River Steelhead

Coastal Situk River Steelhead

Situk River Weir (ADFG)

- **Iteroparity rate: (9-25%)**
- **35.2 km**
- **Stream-maturing**
- **Ocean-maturing**

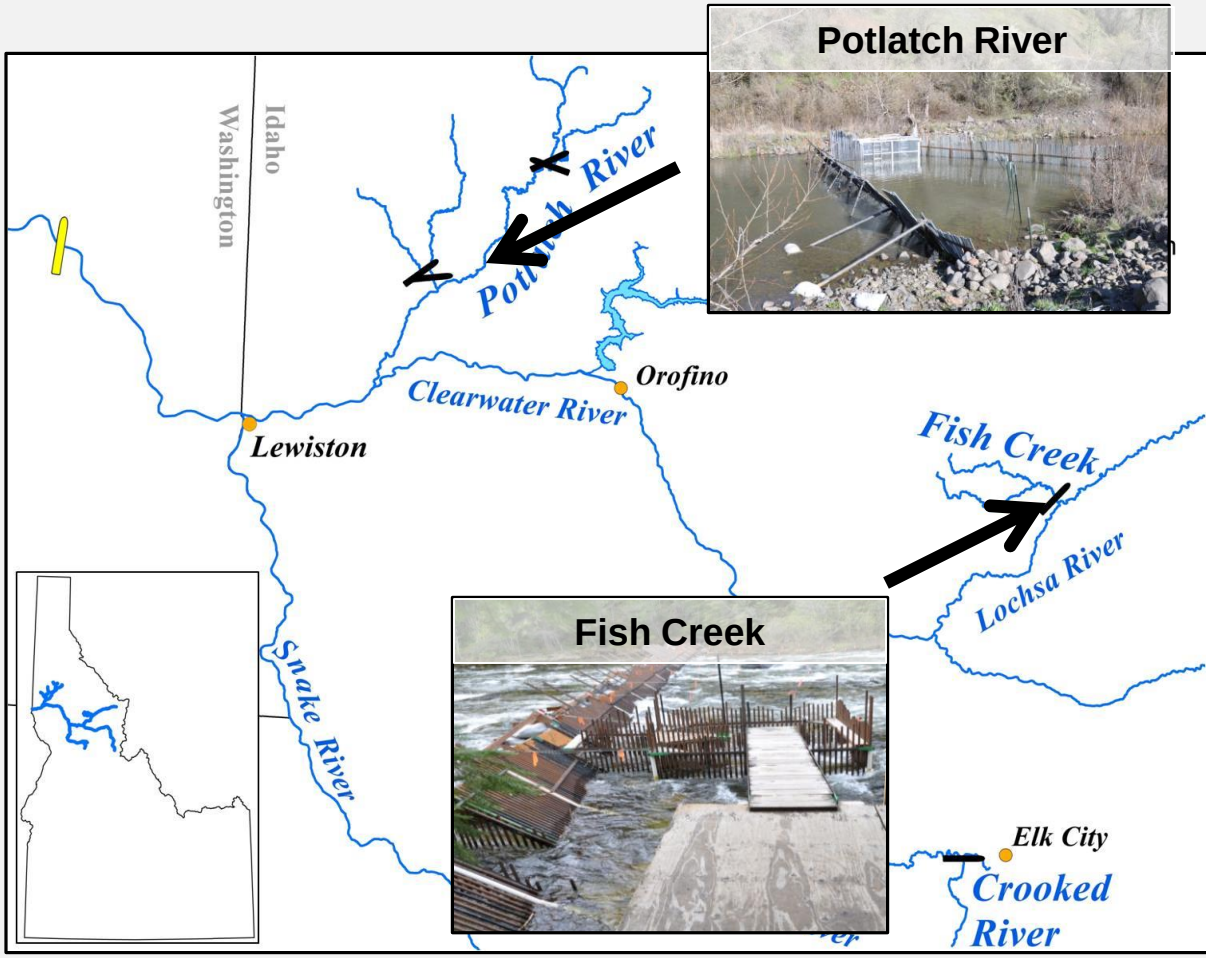


Situk River weir

Clearwater Weirs (IDFG)

Potlatch River
- Little Bear (~795 km)
- Big Bear (~793 km)
- East Fork (~835 km)
- West Fork (~853 km)

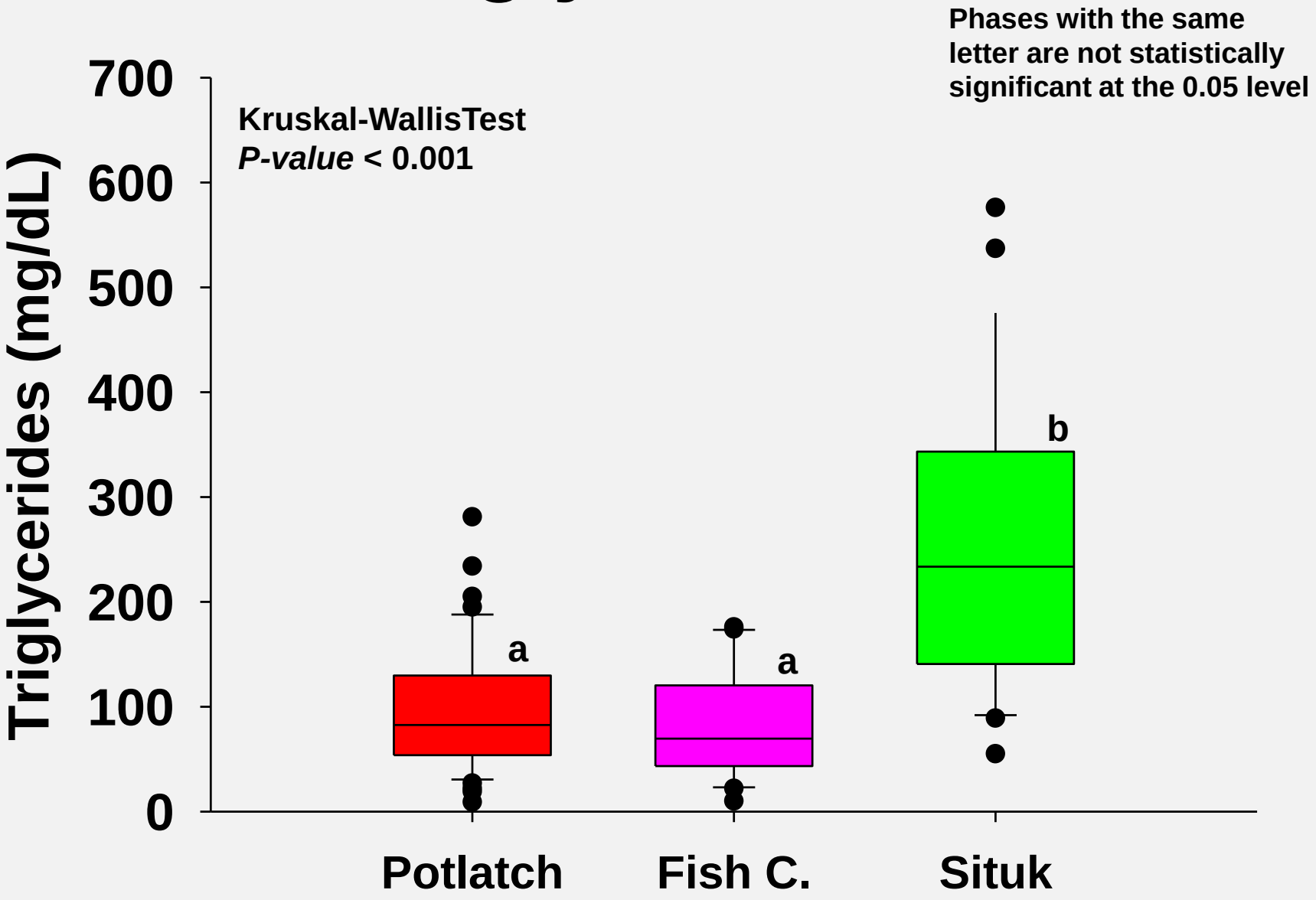
Upper Clearwater River
- Fish Creek weir (~942 km)



Non-lethal Blood Sampling

- **<u>Plasma metrics can be grouped to describe</u>**
  - **Nutritional**
  - **other factors**

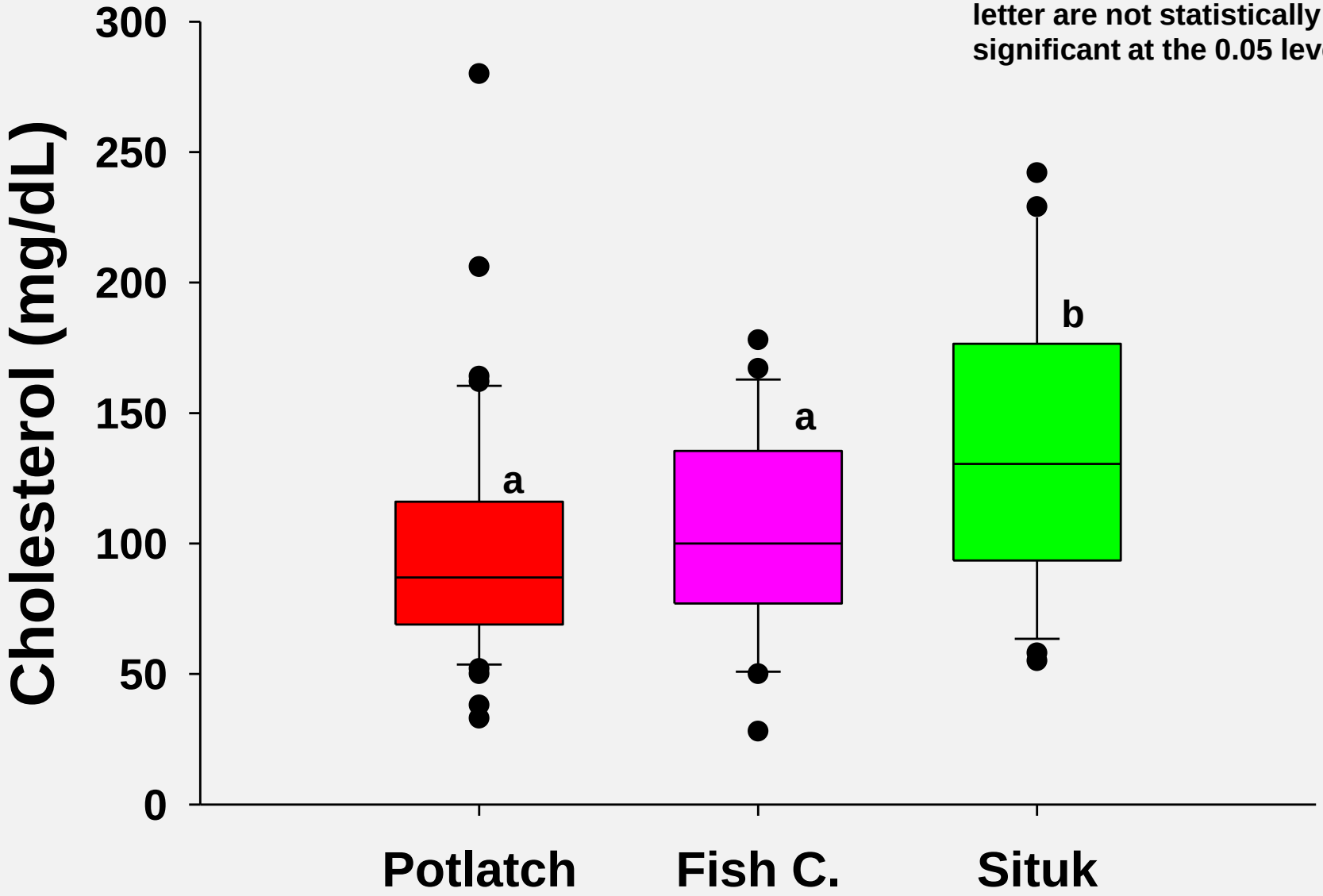
Triglycerides



Kruskal-WallisTest
P-value < 0.001

Cholesterol

Phases with the same letter are not statistically significant at the 0.05 level



Kelt Median Fork Lengths

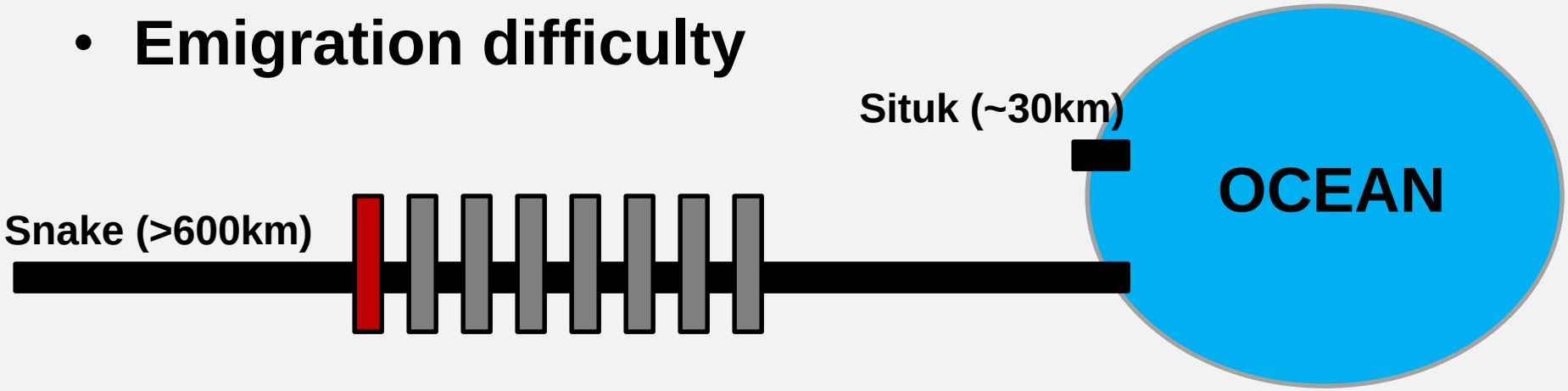
- Potlatch (69 cm)
- Fish Creek (75 cm)
- Situk (80 cm)
- Larger gas tank
  - Better mileage?
  - Harder to re-fill?

Fish Creek Kelt

Situk Kelt

Summary

- **Nutritional & energy plasma factors are higher in Situk River kelts**
- **Plasma electrolytes & enzymes variable**
  - **Tissue damage**
  - **Osmoregulation**
  - **Stress**
- **Emigration difficulty**



Conclusions

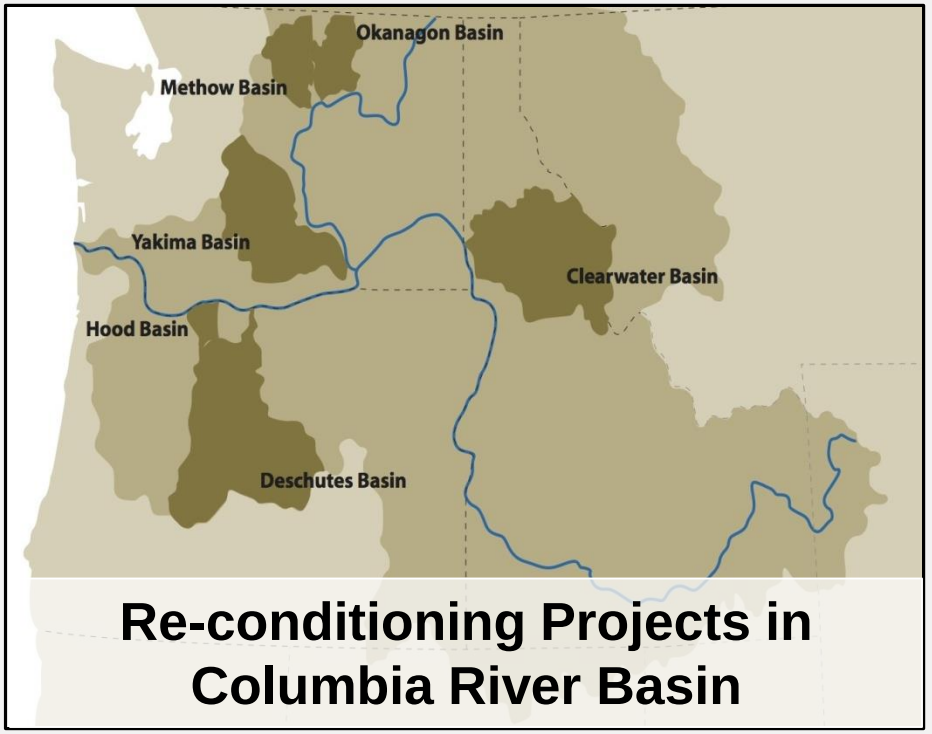
- **Inland Snake River steelhead <u>are</u> iteroparous**
- **Kelts rely on protein for emigration**
- **Energetically constrained**

Managing For Iteroparity

- **Kill spawn vs. live spawn**
- **Large emaciated smolts**
- **Barriers & passage**
- **Non-turbine routes**
  - **Wertheimer & Evans (2005)**
  - **Colotelo et al. (2013)**

Kelt Re-Conditioning

- **CRITFC**
  - **Yakima**
  - **Warm Springs**
  - **Colville**
  - **Nez Perce**
- **When to intervene?**
- **Kelt selection**
- **What do kelts need?**



Re-conditioning Projects in Columbia River Basin

Acknowledgements

Funding :

- **CRITFC (2009-2013)**
- **USGS (2013)**

University of Idaho:

- Boling Sun
- Carol Hoffman
- Kala Hamilton
- Andrew Pape
- Brad Ryan
- Jon Treasure
- Joe Evavold
- William Schrader
- Amber Barenberg
- James Nagler
- Chris Williams
- Dennis Scarnecchia
- Ron Hardy
- Victor & Lubia Cajas
- BJ Schenck and machine shop
- REU/CRISP/EPSCoR students
- UI work-study

Tribal Harvests:

- Begay family
- Samuels family
- Taylor Family
- Penney Family

Dworshak NFH:

- NPT&USFW hatchery staff

Lower Granite Dam:

- U.S. Army Corp of Engineers
- WDFW

Nez Perce Tribe:

- NPT DFRM
- Kelt staff

CRITFC:

- CRITFC kelt staff

Idaho Fish&Game:

- IDFG staff
- Timothy Copeland, Brett Bowersox

Alaska Fish&Game:

- ADFG staff, & Brian Marston