

# Somatic Lipid Content of Summer and Winter Steelhead Returning to the Kalama River, WA

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# *O. mykiss* Life Decisions

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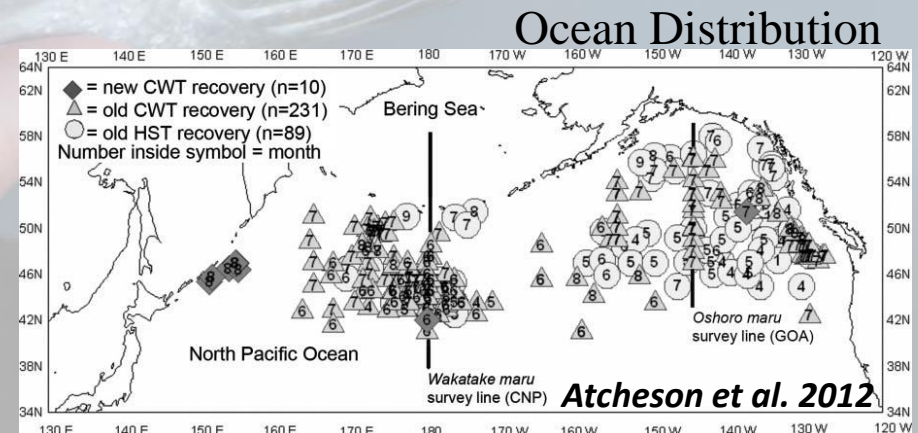
- Complex life history strategies
- Anadromous/resident
- Multiple freshwater and ocean residence times
- Various run-timings and state of maturity at return (e.g. ocean-maturing and freshwater-maturing)
- “Decisions” made to maximize lifetime fitness



# Anadromous Form - Steelhead

## Why go to the ocean?

- Take advantage of nutrient-rich environment for growth and
- Store energy for return migration, freshwater residency (especially stream-maturing steelhead), maturation, and behavioral demands of spawning.



# Freshwater Residency Has High Energetic Demand

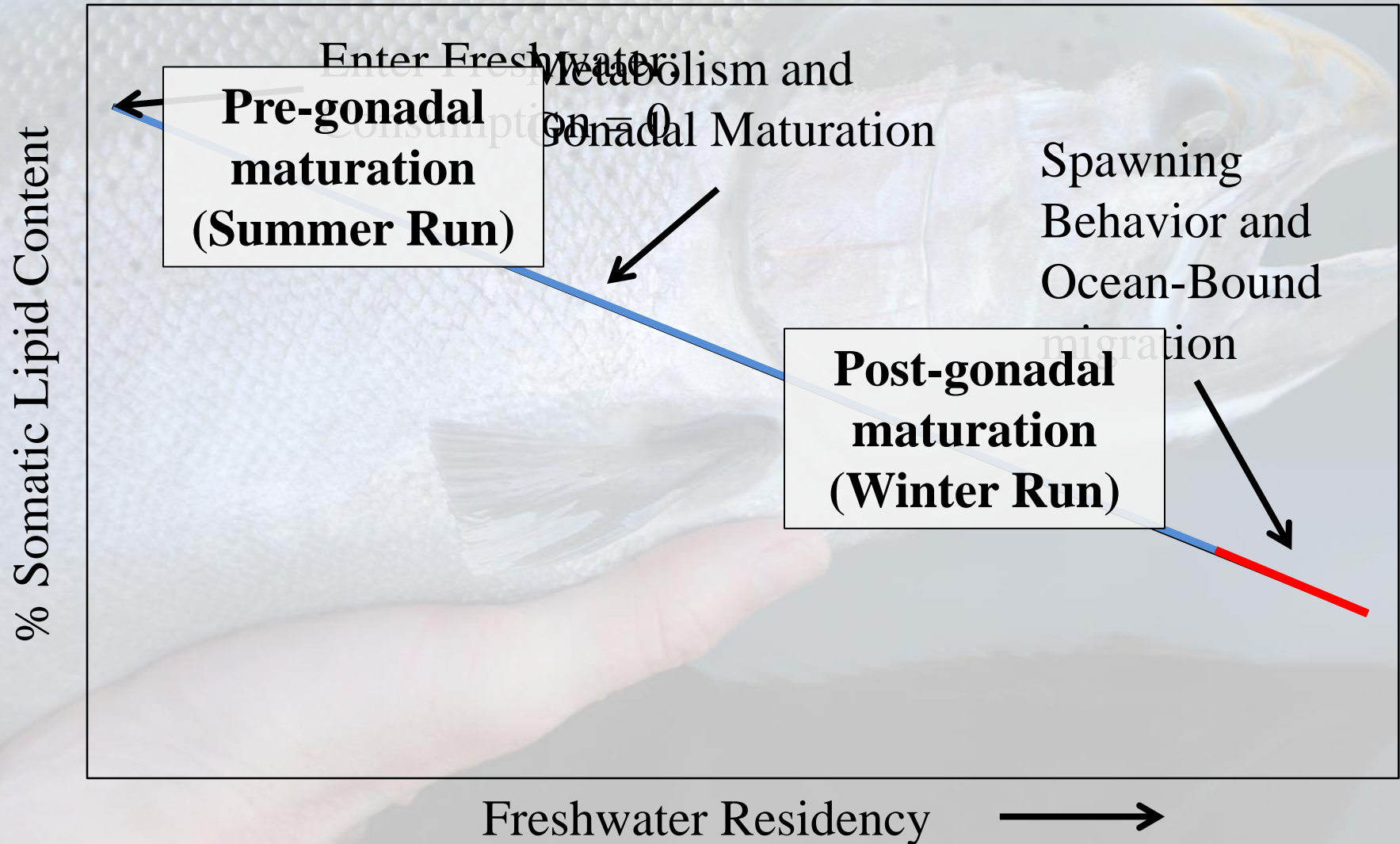
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Consumption = Metabolism + Waste + Growth

Steelhead in Freshwater

$$0 = \mathbf{M} + 0 + \mathbf{G}_{\text{somatic}} + \mathbf{G}_{\text{gonadal}}$$

# Somatic Lipid Content Decreases in Freshwater



# Energy Consumption May Be Different for Hatchery Fish

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- Selected for early return and quick maturation (Crawford 1979).
- No need to allocate energy to behavioral aspects of spawning.
- Expect difference at post-gonadal maturation stage.
- No difference at pre-gonadal maturation stage.



# Females Invest 5x More in Body Weight Toward Gamete Production

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- Range of percent body weight used (Fleming and Reynolds 2004)
  - Females = 8 % - 27%
  - Males = 1.5% - 10%
- Expect difference at post-gonadal maturation stage.
- No difference at pre-gonadal maturation stage.



# Increased Marine Residence = Increased % Somatic Lipid Content



*Kalama River data, mean +/- S.E.*

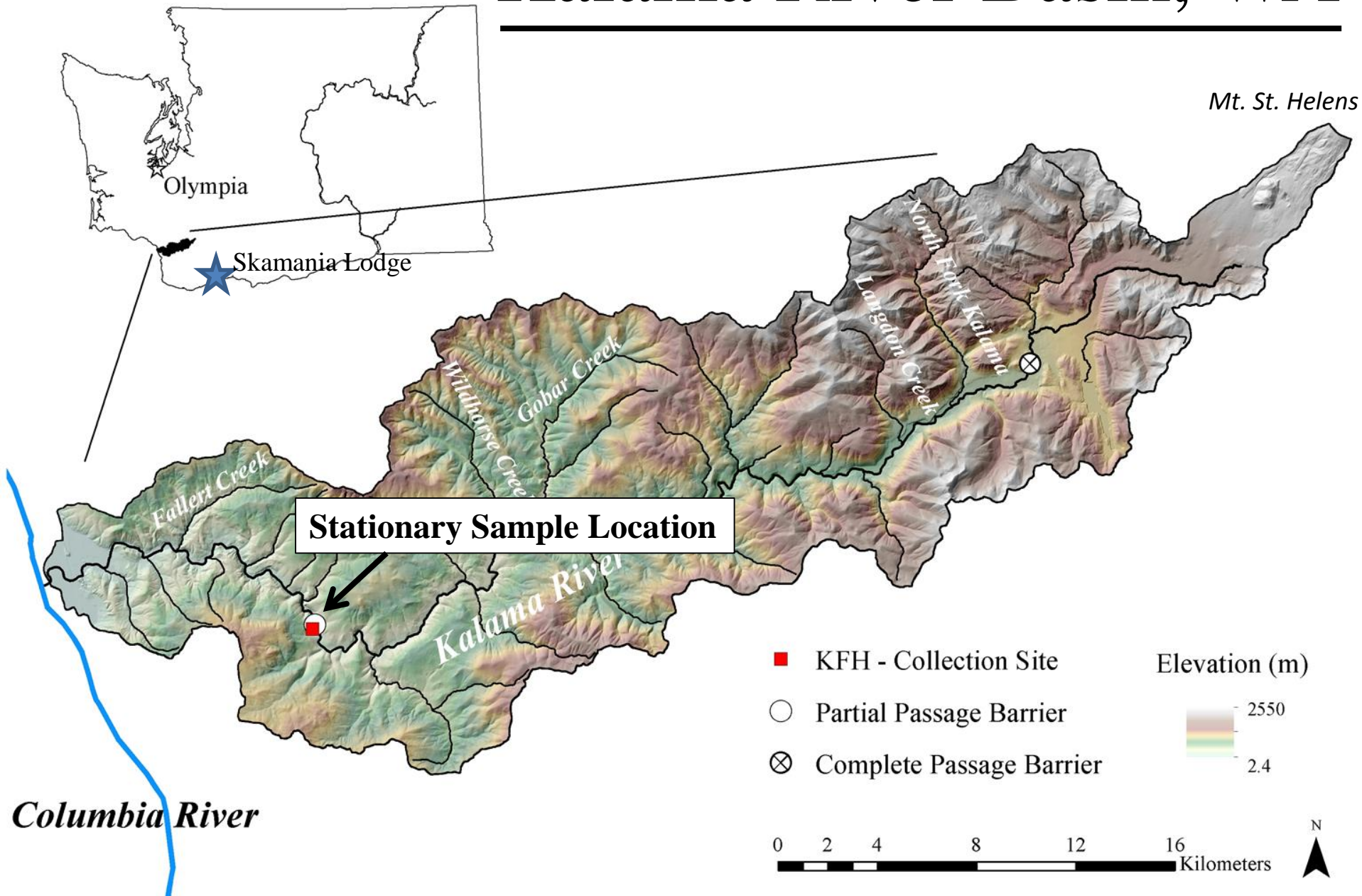


# Hypotheses or Factors That May Affect % Somatic Lipid Content At Return

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Comparison	Prediction	
	Pre-GM (SR)	Post-GM (WR)
Wild/Hatchery	$W = H$	$W > H$
Sex	$M = F$	$M > F$
Ocean Age	Older > Younger	Older > Younger

# Kalama River Basin, WA



# Six Kalama River Steelhead Stocks

## Summer Run

- Wild – Natural production
- Traditional Hatchery
  - Skamania stock
- Kalama-origin Hatchery
  - Wild broodstock program

## Winter Run

- Wild – Natural production
- Traditional Hatchery
  - Chambers stock
- Kalama-origin Hatchery
  - Wild broodstock program

# Focus – Wild and Traditional Hatchery Stocks

## Summer Run

- **Wild – Natural production**
- **Traditional Hatchery**
  - **Skamania stock**
- Kalama-origin Hatchery
  - Wild broodstock program

## Winter Run

- **Wild – Natural production**
- **Traditional Hatchery**
  - **Chambers stock**
- Kalama-origin Hatchery
  - Wild broodstock program

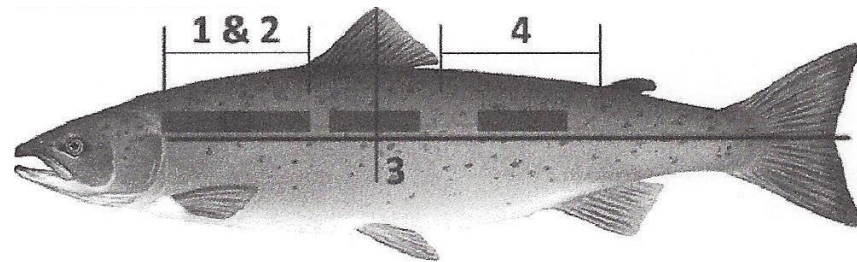
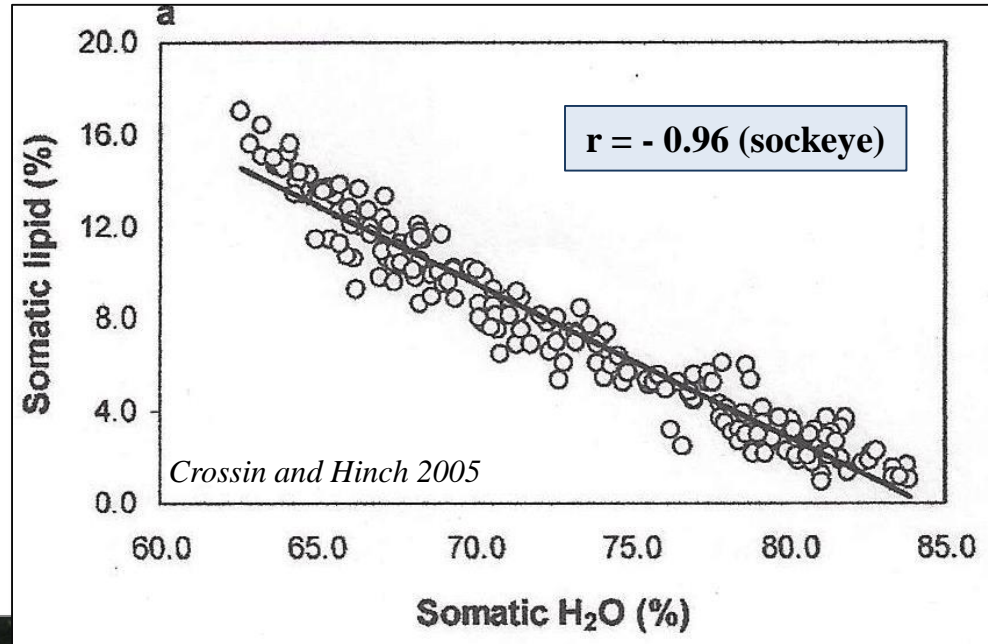
# Data Collection



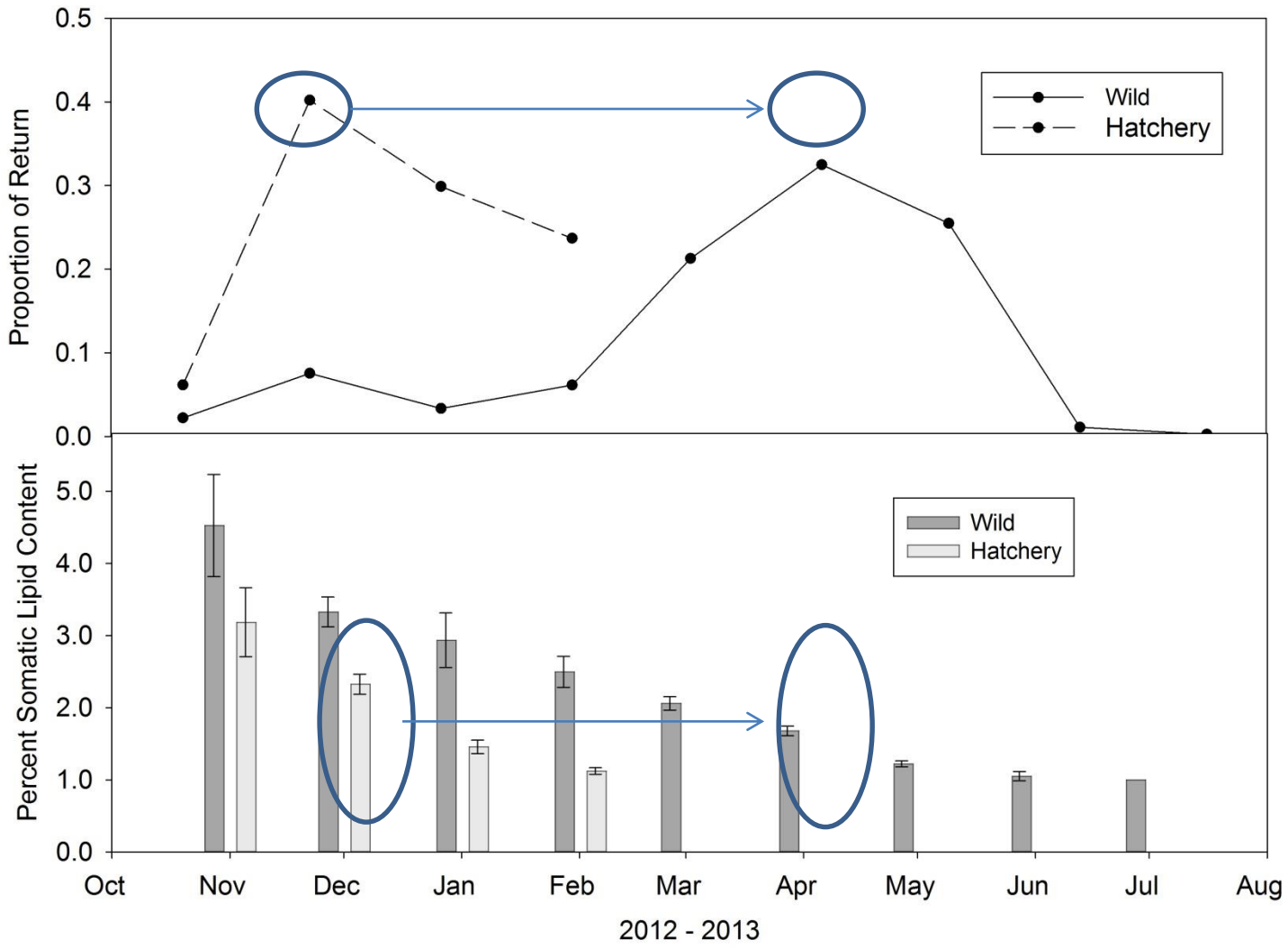
- Nov 2012 – Nov 2013
- Systematic sample
- ID to stock
- Length
- Scales
- % Somatic lipid content



# Distell Fatmeter



# Center *Winter* Run Timing for Comparisons



# Analysis:

## Linear Model – 15 terms

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**Ln Lipid** ~ Date + Origin + Sex + Ocean Age ← Main Effects

+ Date\*Origin

+ Date\*Sex

+ Date\*Ocean Age

+ Origin\*Sex

+ Origin\*Ocean Age

+ Sex\*Ocean Age

+ Date\*Origin\*Sex

+ Date\*Origin\*Ocean Age

+ Date\*Sex\*Ocean Age

+ Ocean\*Sex\*Ocean Age

+ Date\*Origin\*Sex\*Ocean Age ← 4-way Interaction Term

2-way Interaction Terms

3-way Interaction Terms



# Pre-Gonadal Maturation (Summer)

Significant terms in *red* ( $\alpha = 0.05$ )

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Ln Lipid ~ **Date** + **Origin** + **Sex** + **Ocean Age** ← Main Effects

+ Date\*Origin

+ Date\*Sex

+ Date\*Ocean Age

+ Origin\*Sex

+ Origin\*Ocean Age

+ **Sex\*Ocean Age**

+ **Date\*Origin\*Sex**

+ Date\*Origin\*Ocean Age

+ Date\*Sex\*Ocean Age

+ Ocean\*Sex\*Ocean Age

+ Date\*Origin\*Sex\*Ocean Age ←

2-way Interaction Terms

3-way Interaction Terms

4-way Interaction Term

# Post-Gonadal Maturation (Winter)

Significant terms in *red* ( $\alpha = 0.05$ )

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$\ln \text{Lipid} \sim$  **Date** + Origin + **Sex** + **Ocean Age** — Main Effects

+ **Date\*Origin**

+ Date\*Sex

+ **Date\*Ocean Age**

+ Origin\*Sex

+ Origin\*Ocean Age

+ **Sex\*Ocean Age**

+ Date\*Origin\*Sex

+ Date\*Origin\*Ocean Age

+ Date\*Sex\*Ocean Age

+ Ocean\*Sex\*Ocean Age

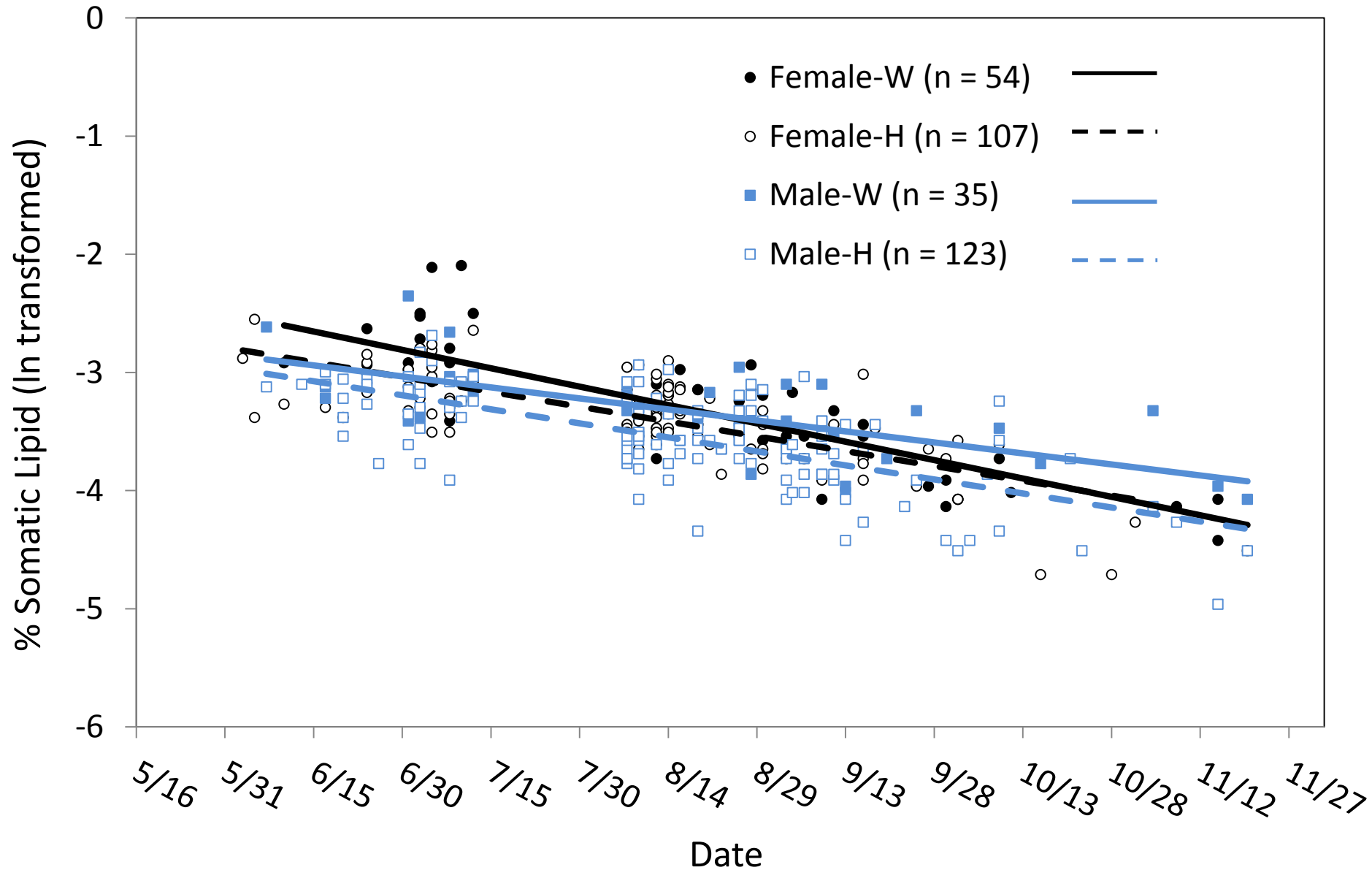
+ Date\*Origin\*Sex\*Ocean Age

2-way Interaction Terms

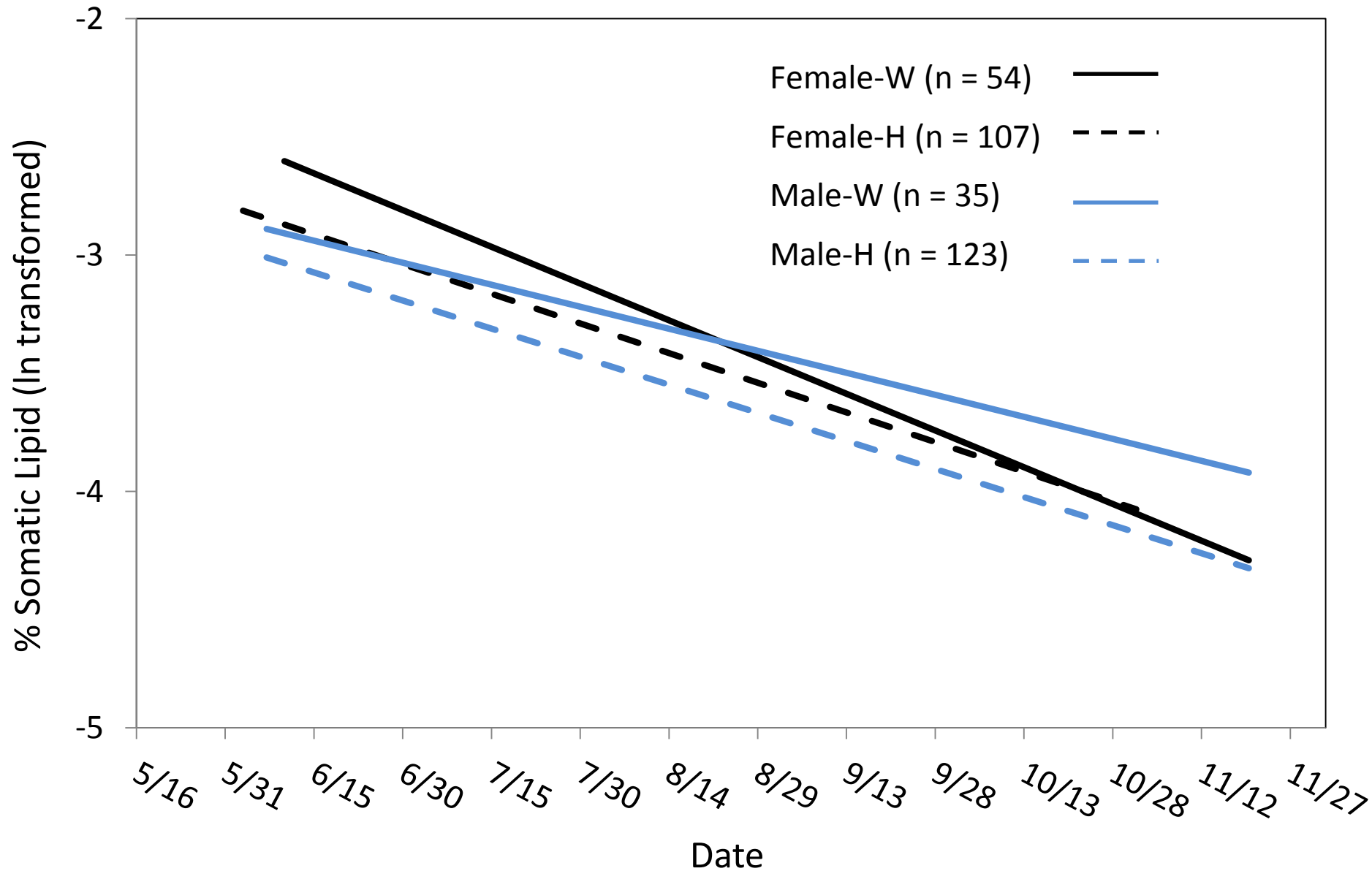
3-way Interaction Terms

4-way Interaction Term

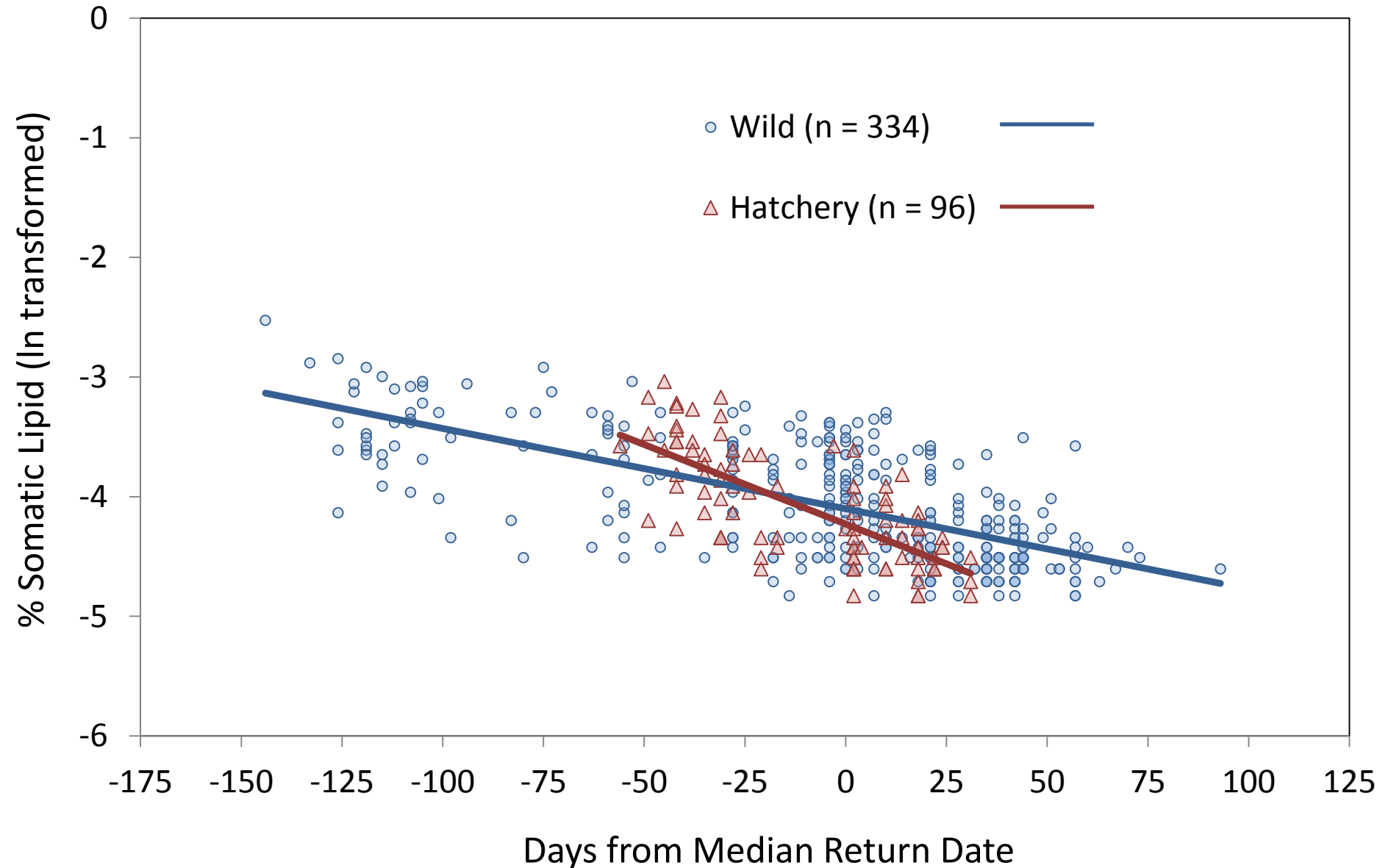
# Date\*Origin\*Sex Interaction- *Pre-GM (SR)*



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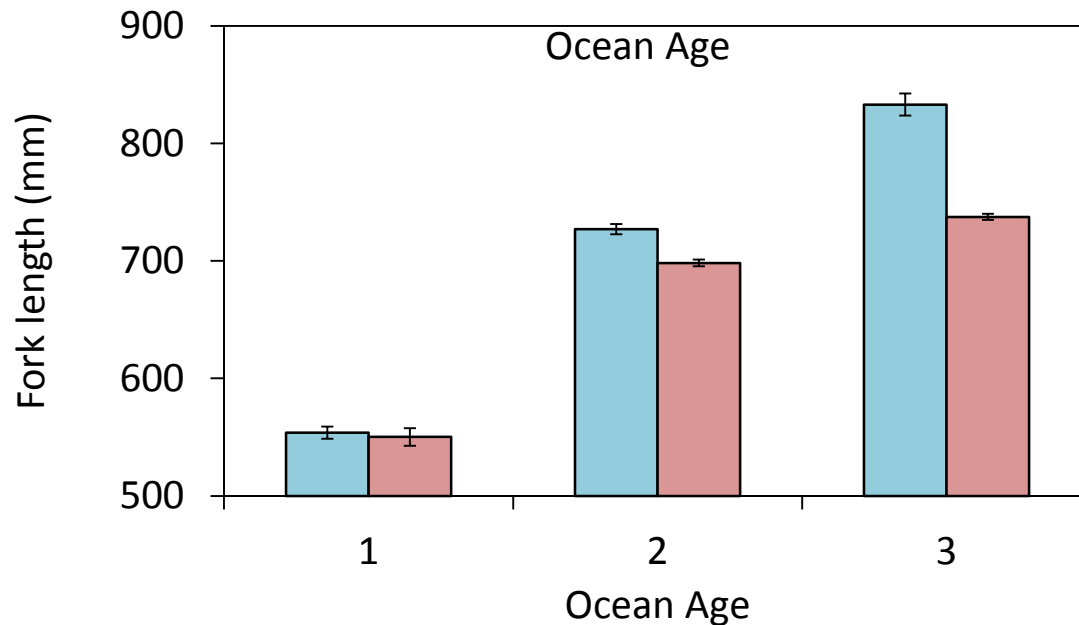
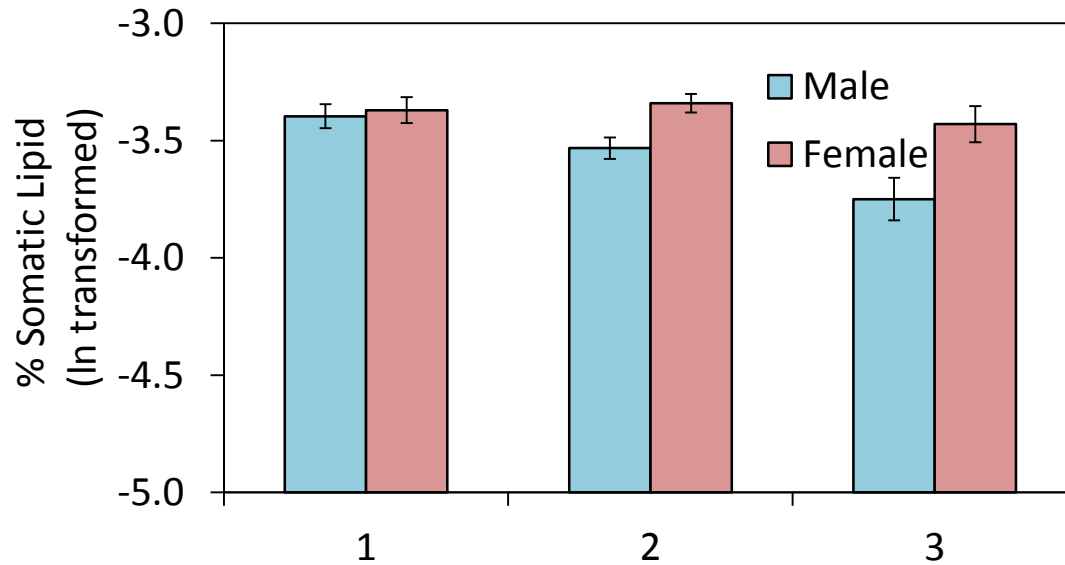


# Date\*Origin Interaction- *Post-GM (WR)*



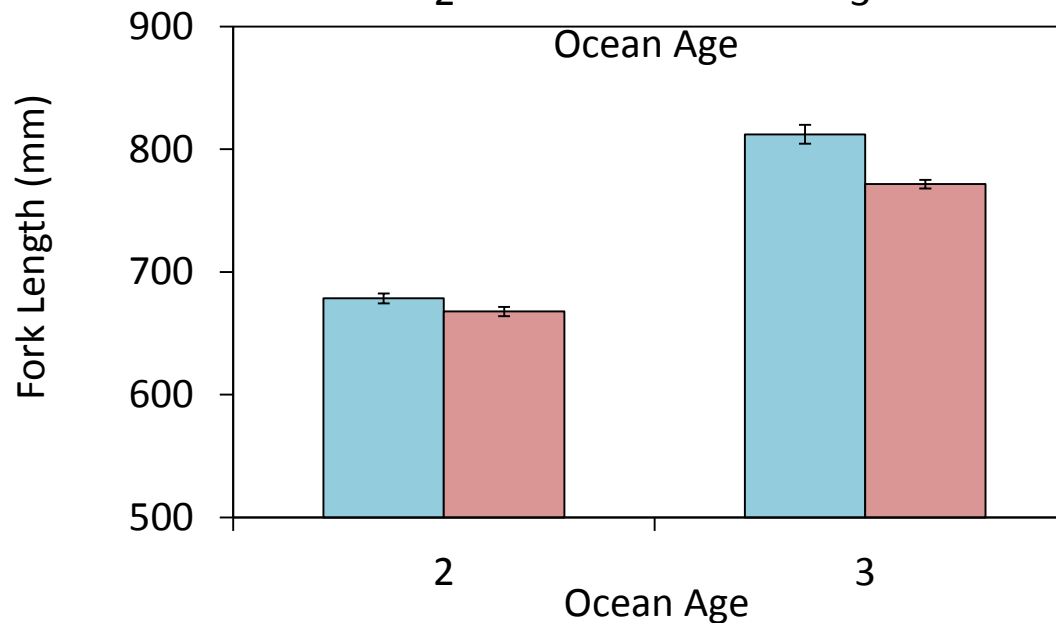
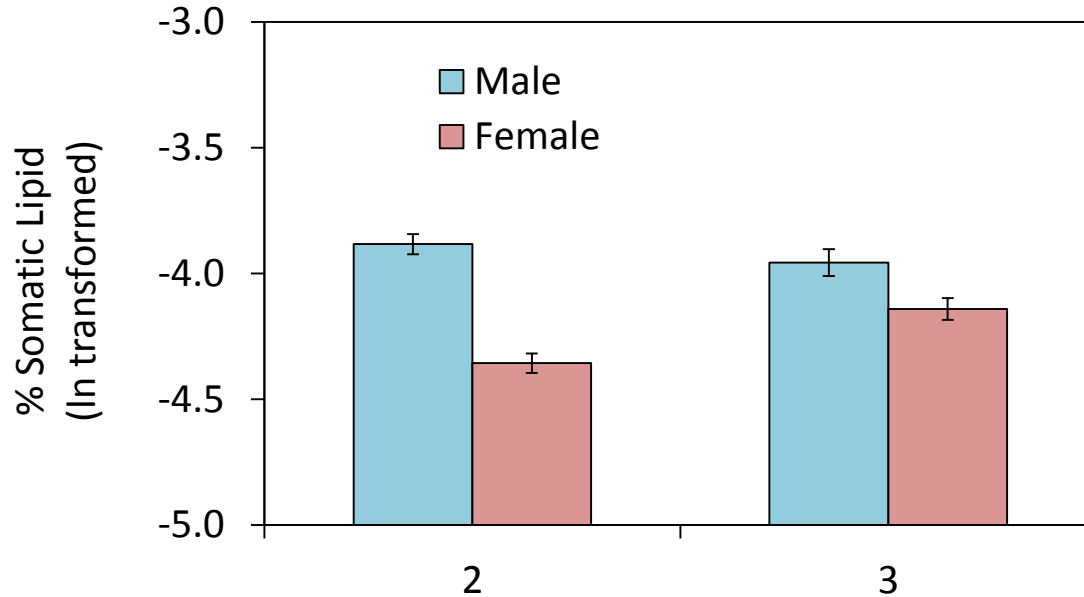
# Sex\*Ocean Age Interaction- *Pre-GM (SR)*

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# Sex\*Ocean Age Interaction- *Post-GM (WR)*

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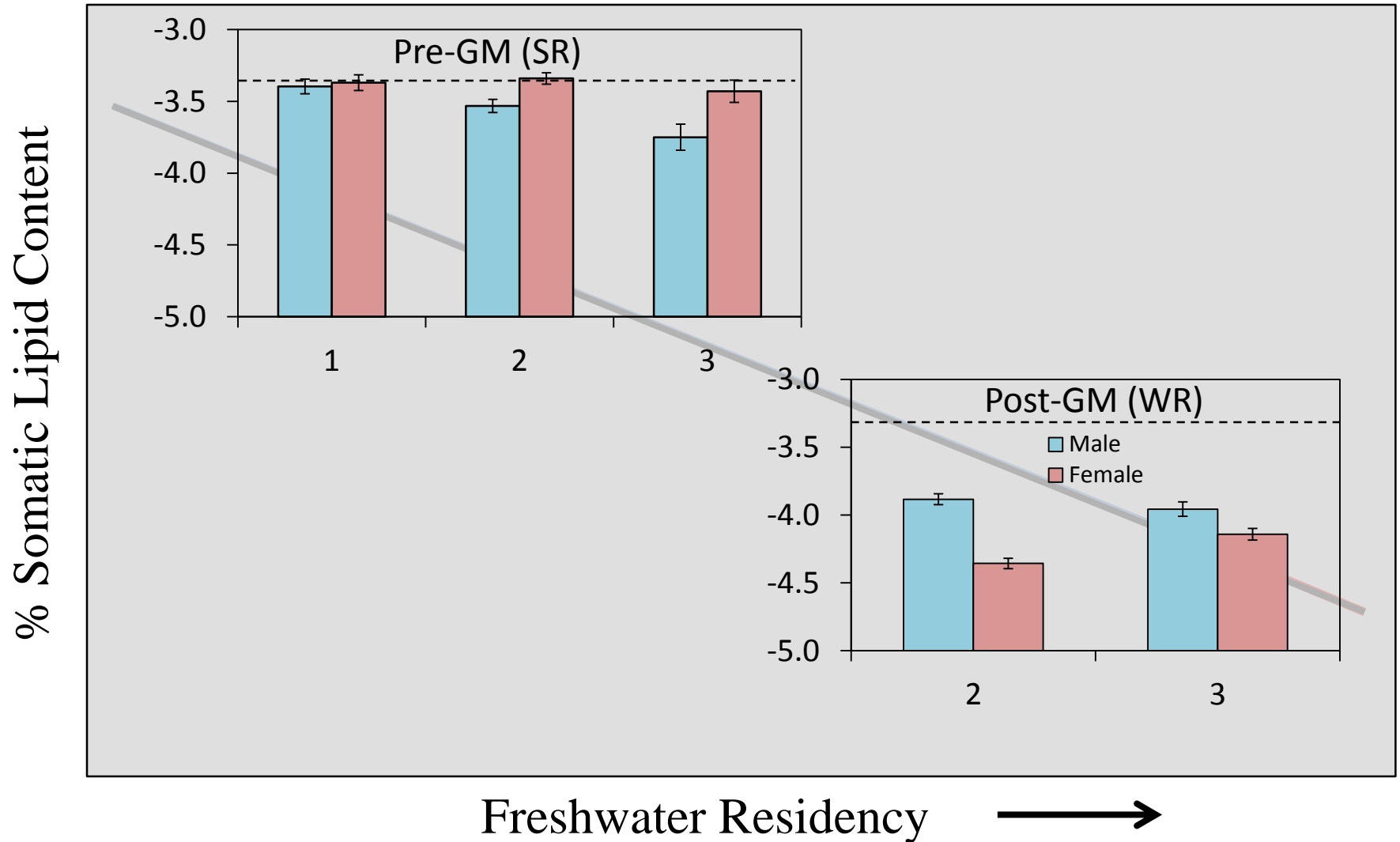
# What did we learn about % somatic lipids?

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- Steelhead lipid reserves are depleted over time in freshwater.
- Prior to gonadal maturation:
  - Older males < Younger males (off set by body size differences?)
  - Females did not differ with age
  - Unexpected date\*origin\*sex interaction
- Post gonadal maturation:
  - Older females > Younger females
  - Males did not differ with age
  - Hatchery steelhead deplete lipids at faster rate than wild steelhead.



# Cost of Gonadal Maturation?



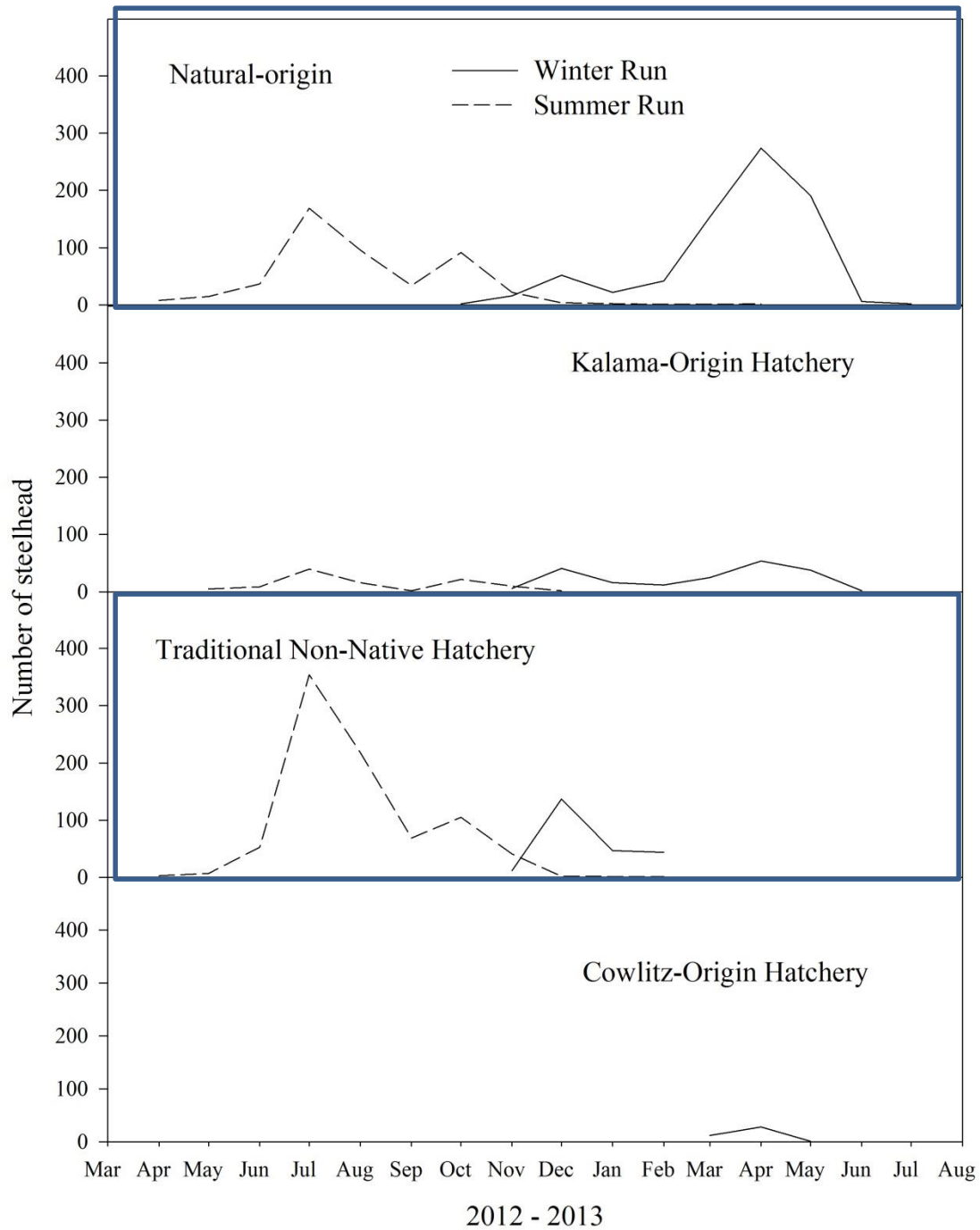
# Acknowledgements

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The End



2012 - 2013