

Photoperiod: A potentially underappreciated phenomenon in salmon physiology and culture?

**Dina Spangenberg, Abby Fuhrman,
Don Larsen, Brian Beckman**



Outline of Talk

- **Background**
- **Experimental design**
- **Data**
- **What? Why? When?**
- **Implications for hatchery managers**
- **Conclusions**

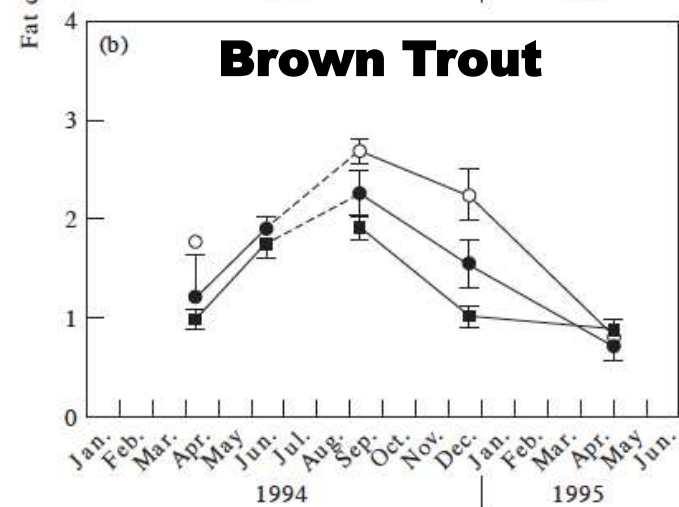
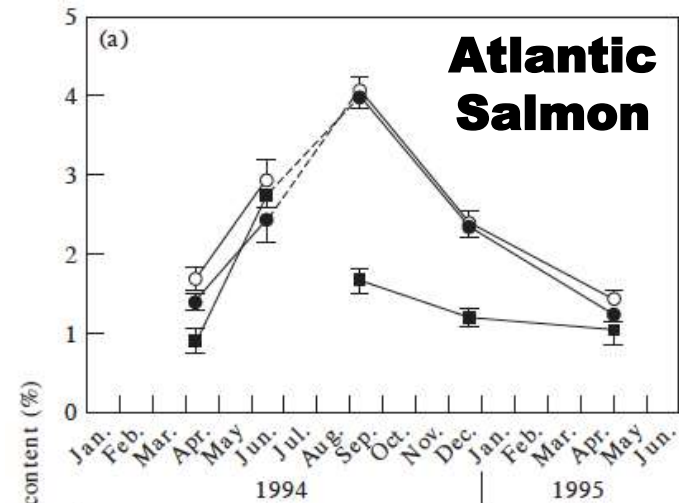


Outline of Talk

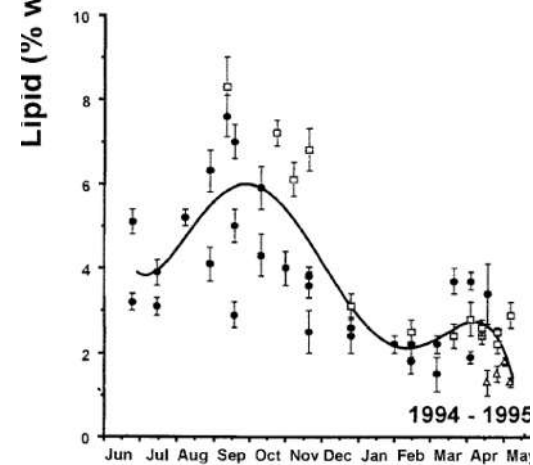
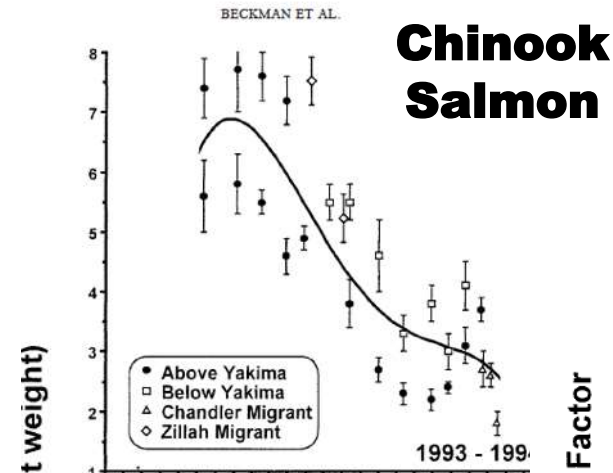
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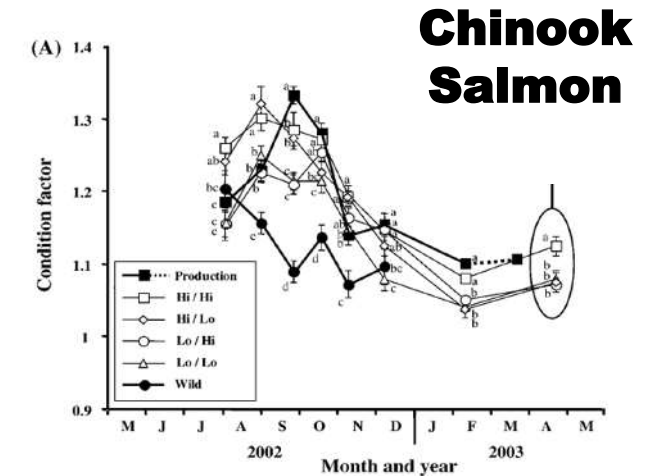
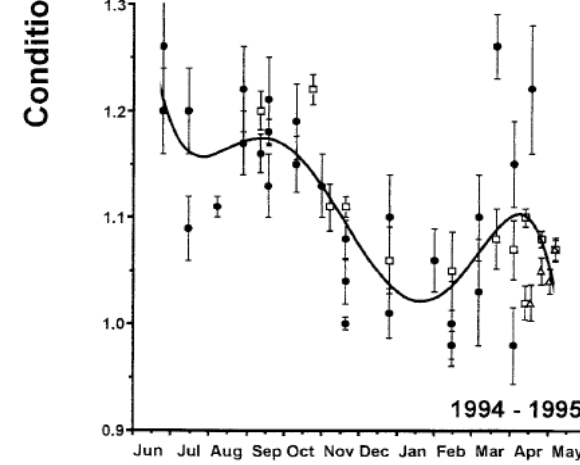
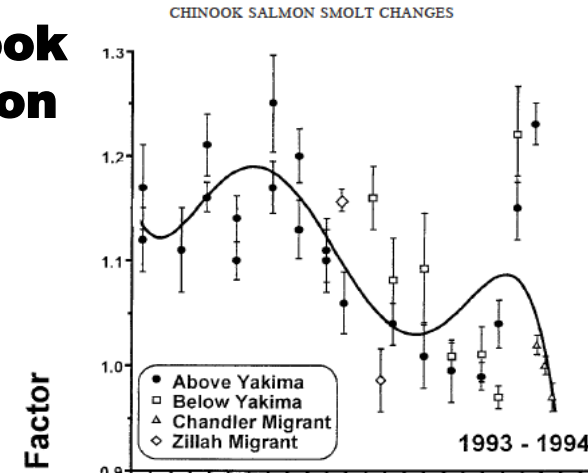
Changes Over Time in Lipid Levels and Condition Factor Are Well Documented



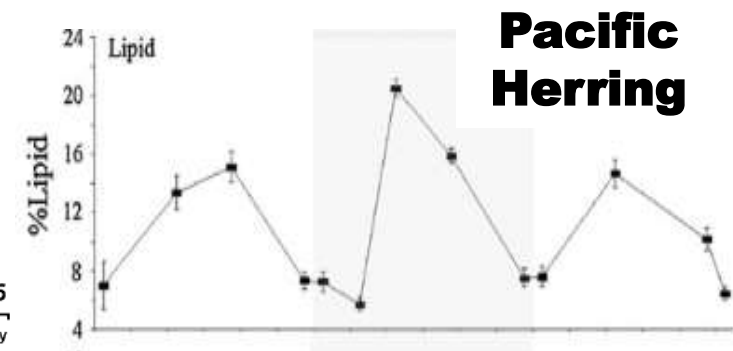
Berg & Bremset, 1998



Beckman et al., 2000

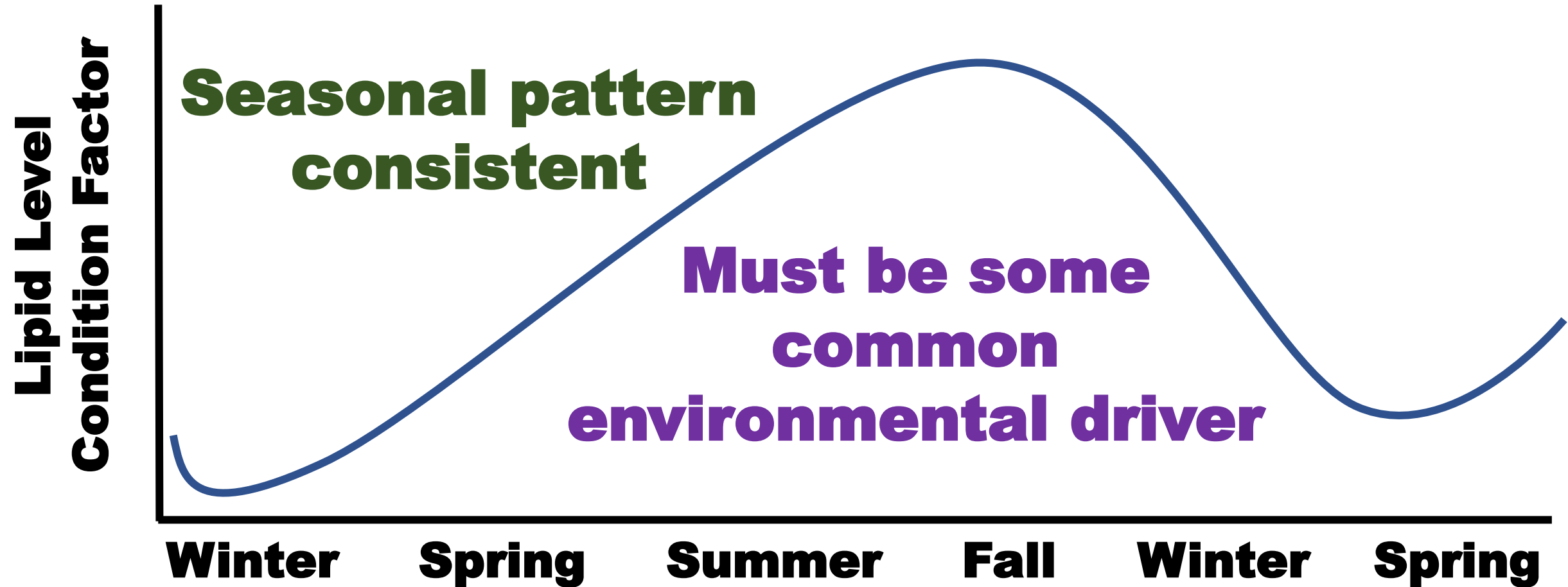


Larsen et al., 2006



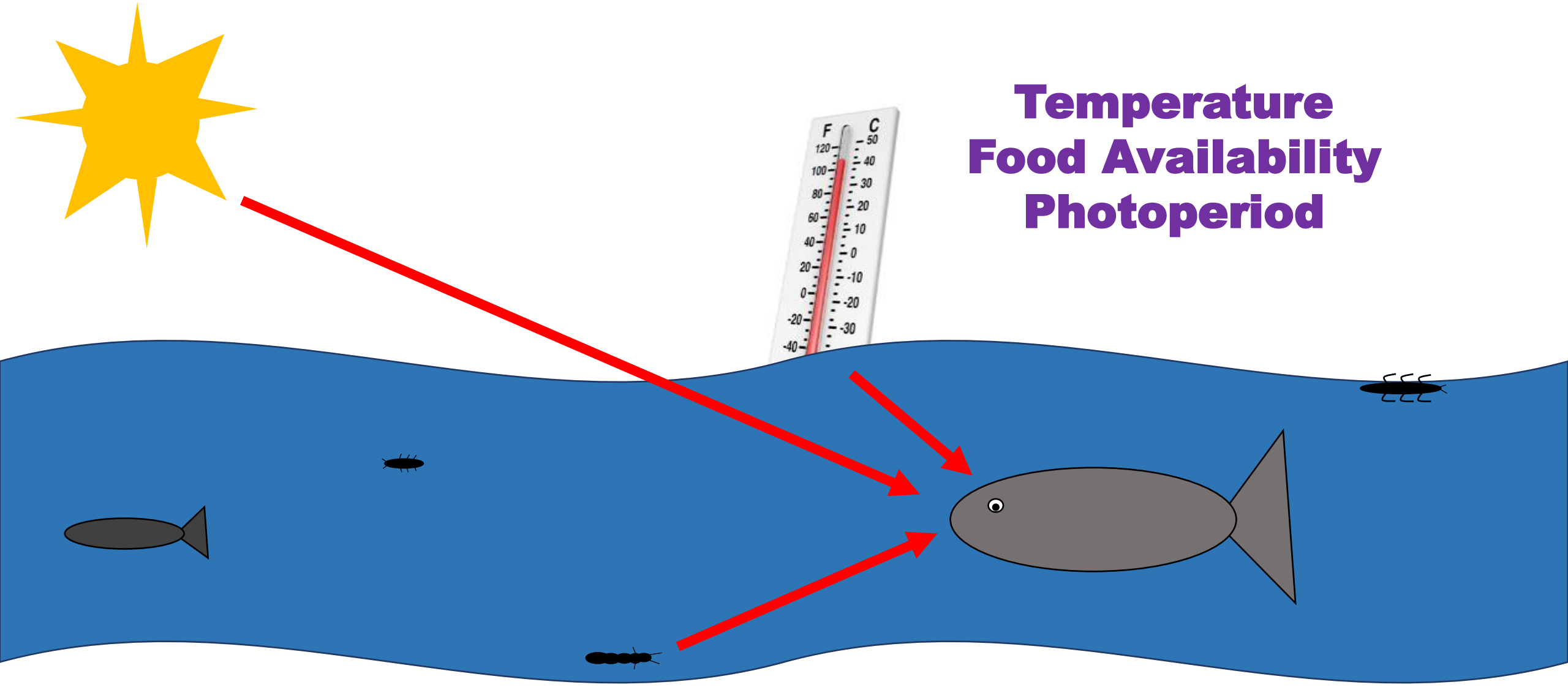
Vollenweider et al., 2011

In General Lipid Levels & Condition Factor are Lowest in the Winter and Highest in Late Summer Early Fall



Environmental Cues Are Important to Fish

Help Regulate A Variety of Physiological Processes



Extensive Research on Temp, Food Availability, and Photoperiod but Most Growth Models Only Include Temp and Feed



Comparative Biochemistry and Physiology Part B:

Aquaculture

Volume 217, Issues 1–4, 17 March 2003, Pages 633–645



Effects of photoperiod and light intensity on growth and activity of juvenile haddock (*Melanogrammus aeglefinus*)

Edward A Trippel  , Steven R.E Neil

T. HANSEN , S. STEFANSSON, G. L. TARANGER

Photoperiod: A potentially underappreciated phenomenon in salmon physiology and culture?

Objective – What is the effect of photoperiod on lipid levels and condition factor under constant temperature and feed ration

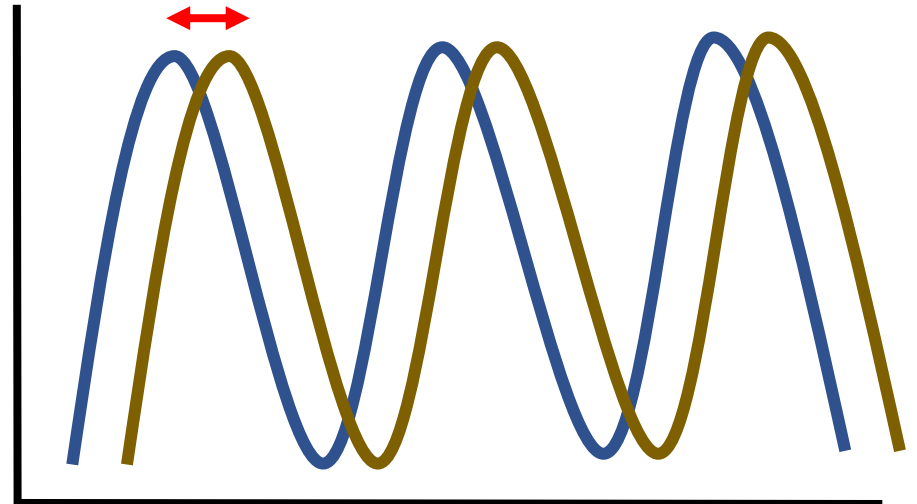
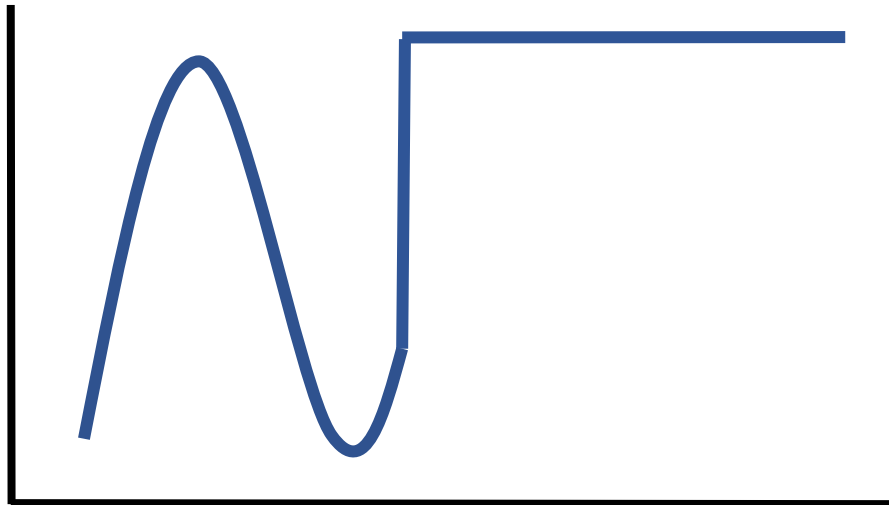
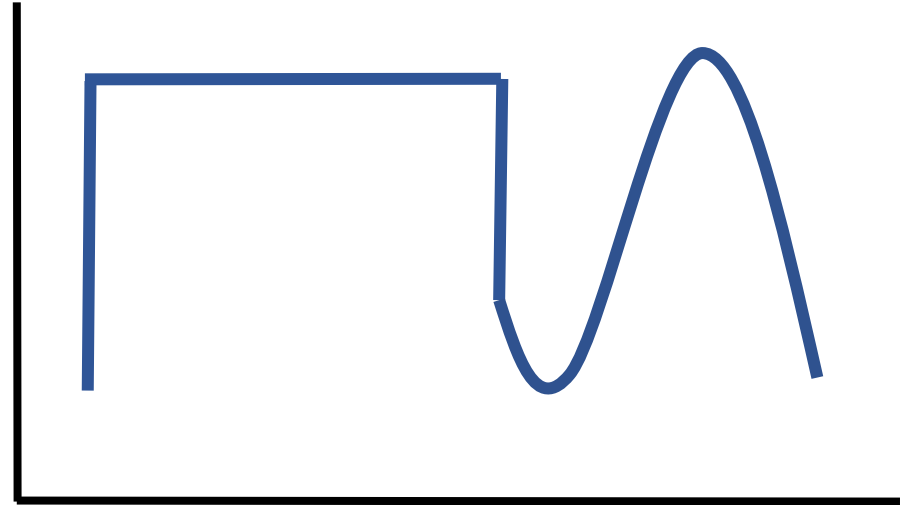
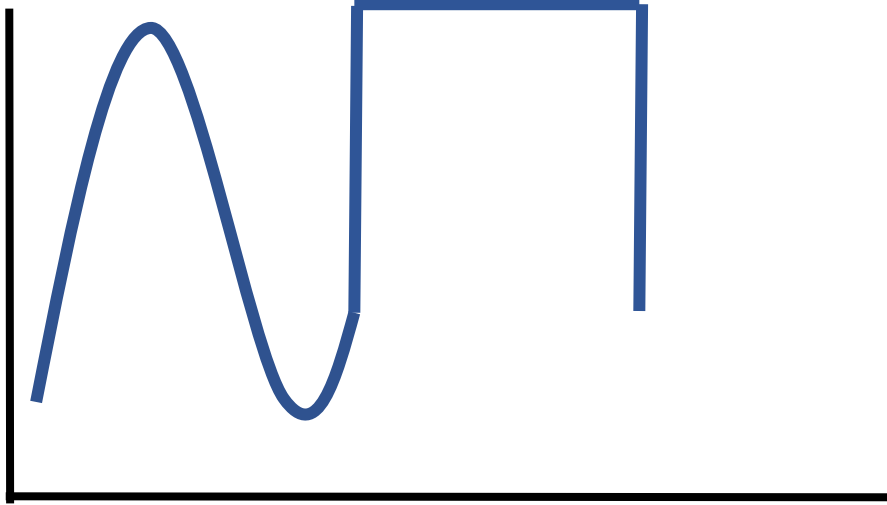
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Different Methods of Manipulating Photoperiod

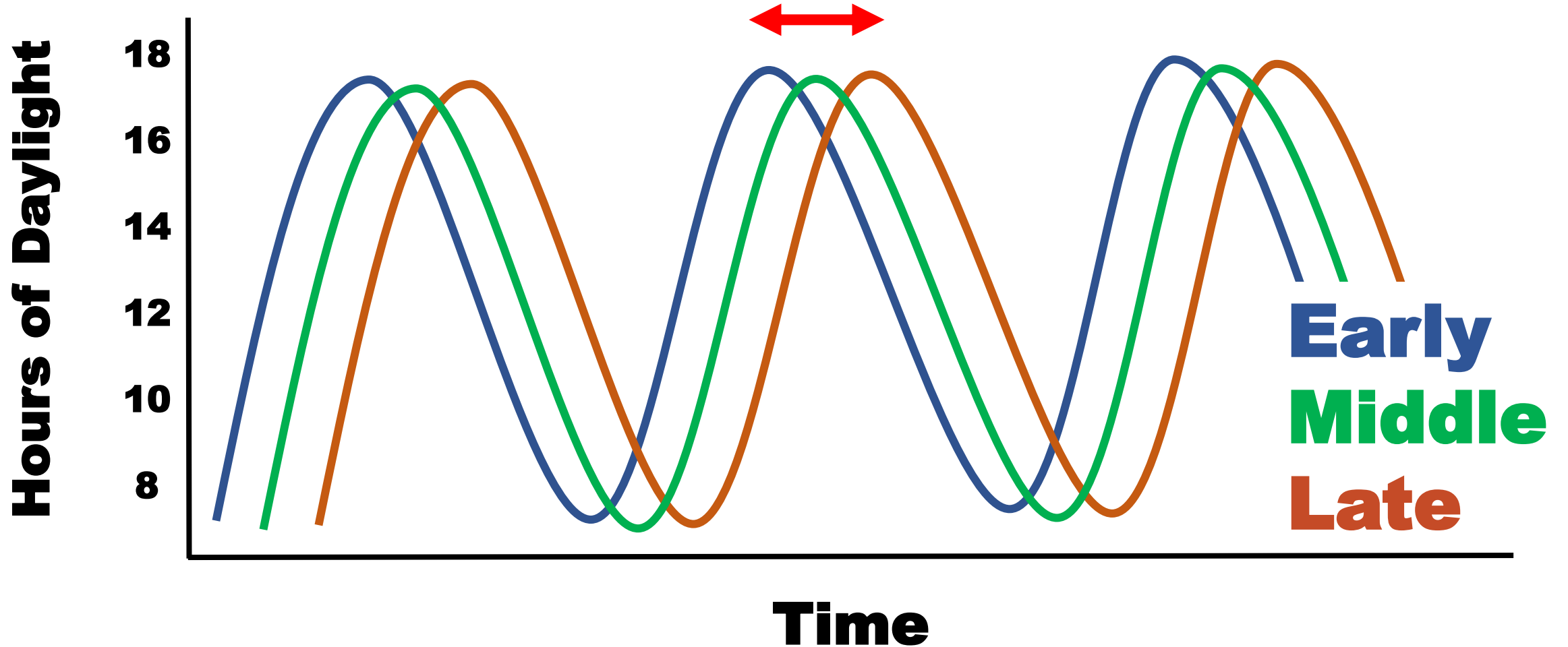
Hours of Daylight



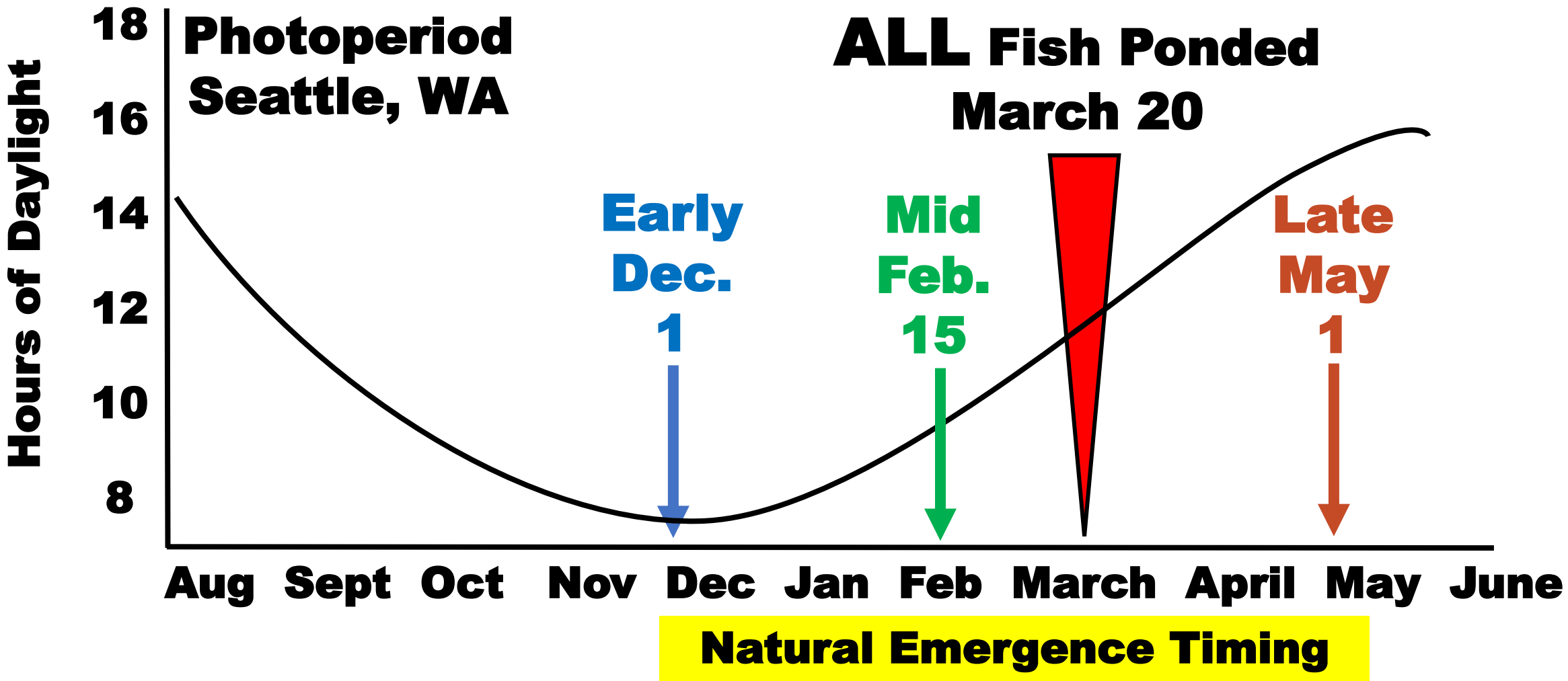
Time

Unique Experimental Design

Mimics the natural photoperiod



Fish Ponded on the Same Calendar Date but Experience Different Photoperiods Based on Treatment Group

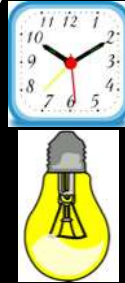


Experimental Design

**March
20**

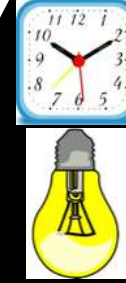


**300
fish**



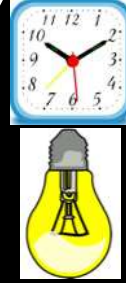
**Early
Dec 1**

**300
fish**



**Middle
Feb 15**

**300
fish**

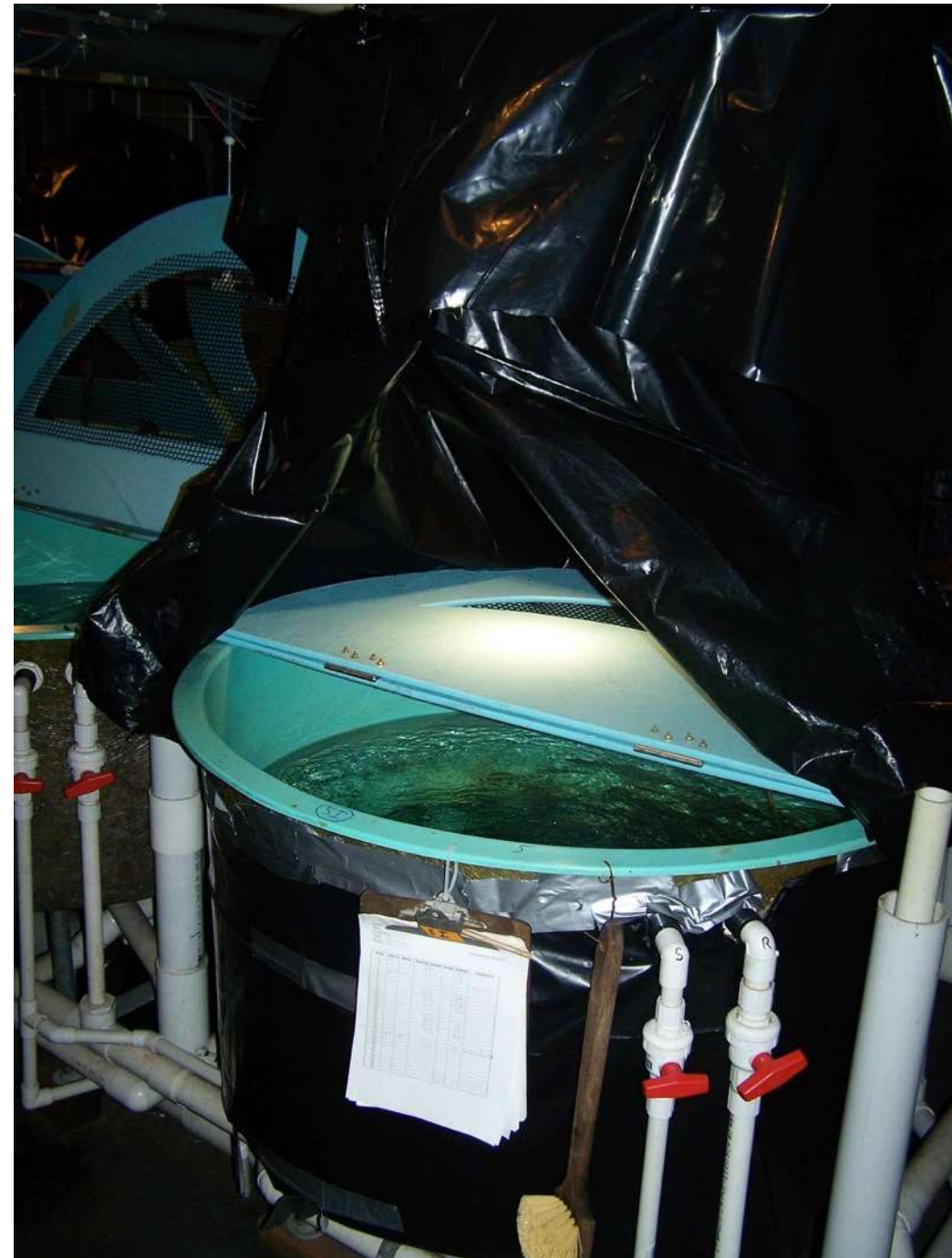


**Late
March 1**

Experimental Design

Rearing

- **Yakima Spring Chinook ponded into 1 meter diameter tanks**
- **Tanks had individual timer and light source**
- **Photoperiod set to Seattle and adjusted periodically**
- **Temperature Consistent (8-10 C)**
- **Batch weights taken monthly**
- **Fish Pair Fed**
 - 1.15-2.3% BW/day**



Experimental Design

Sampling

- **5 Sampling Points**
- **25 fish per sampling**
 - **Length & weight**
 - **Condition factor**
 - **Bodies for whole body lipid analysis**



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Calendar vs Photoperiod Date

Calendar Date –

Same for all treatments; all data points lined up because based on calendar



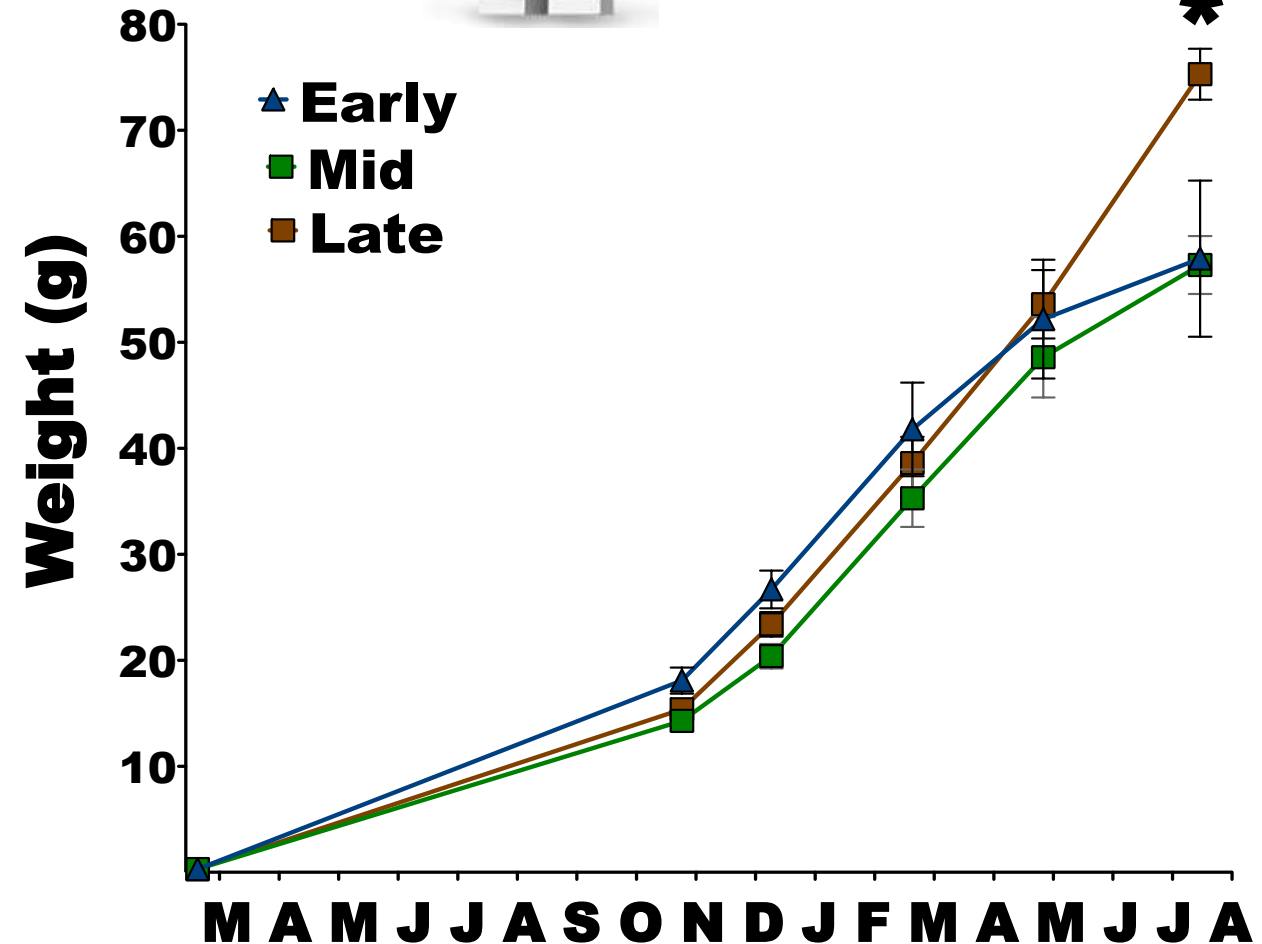
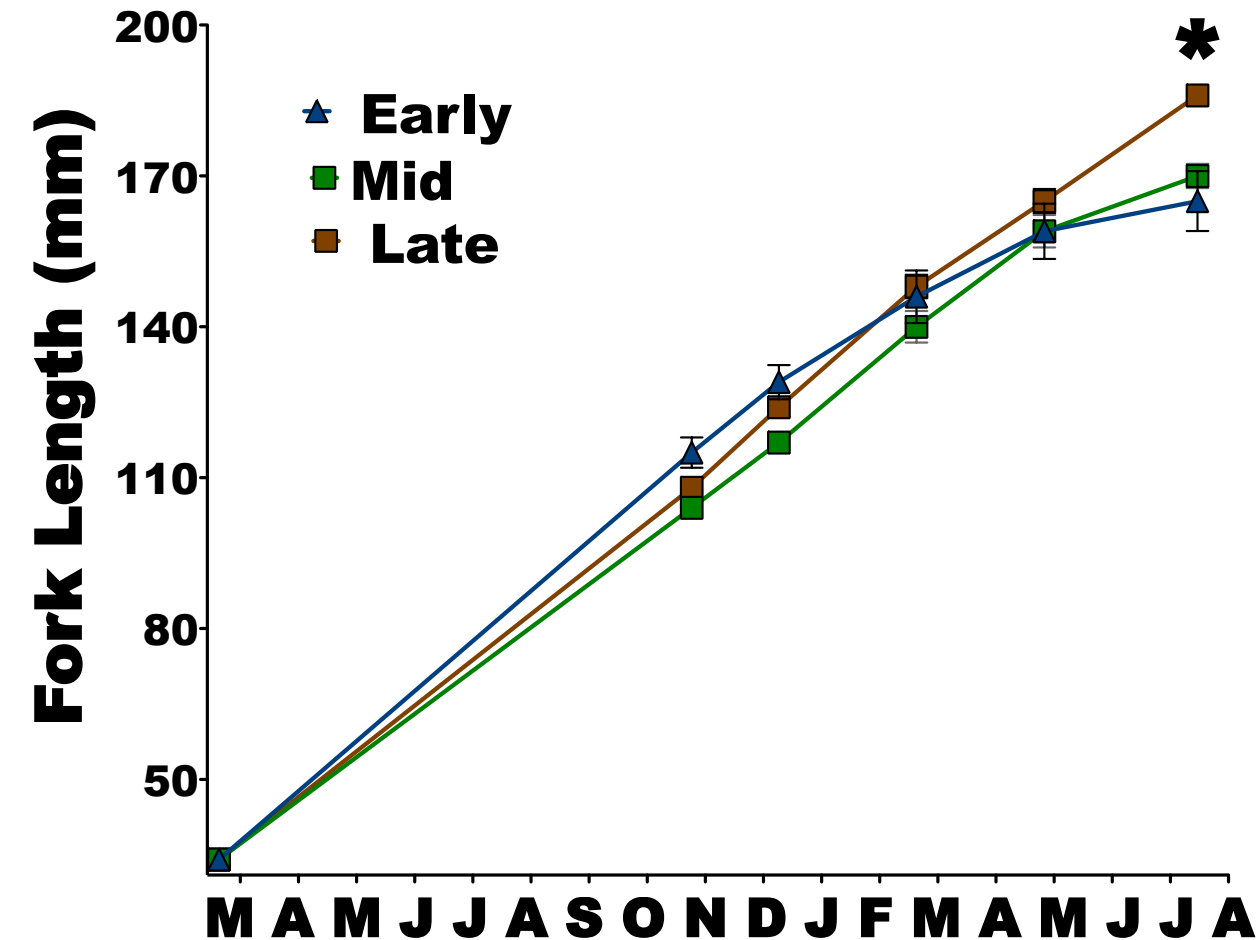
Photoperiod Date –

Not the same for all treatments; data points not aligned because based on perceived date of fish



Fish Were of Similar Size Throughout Experiment

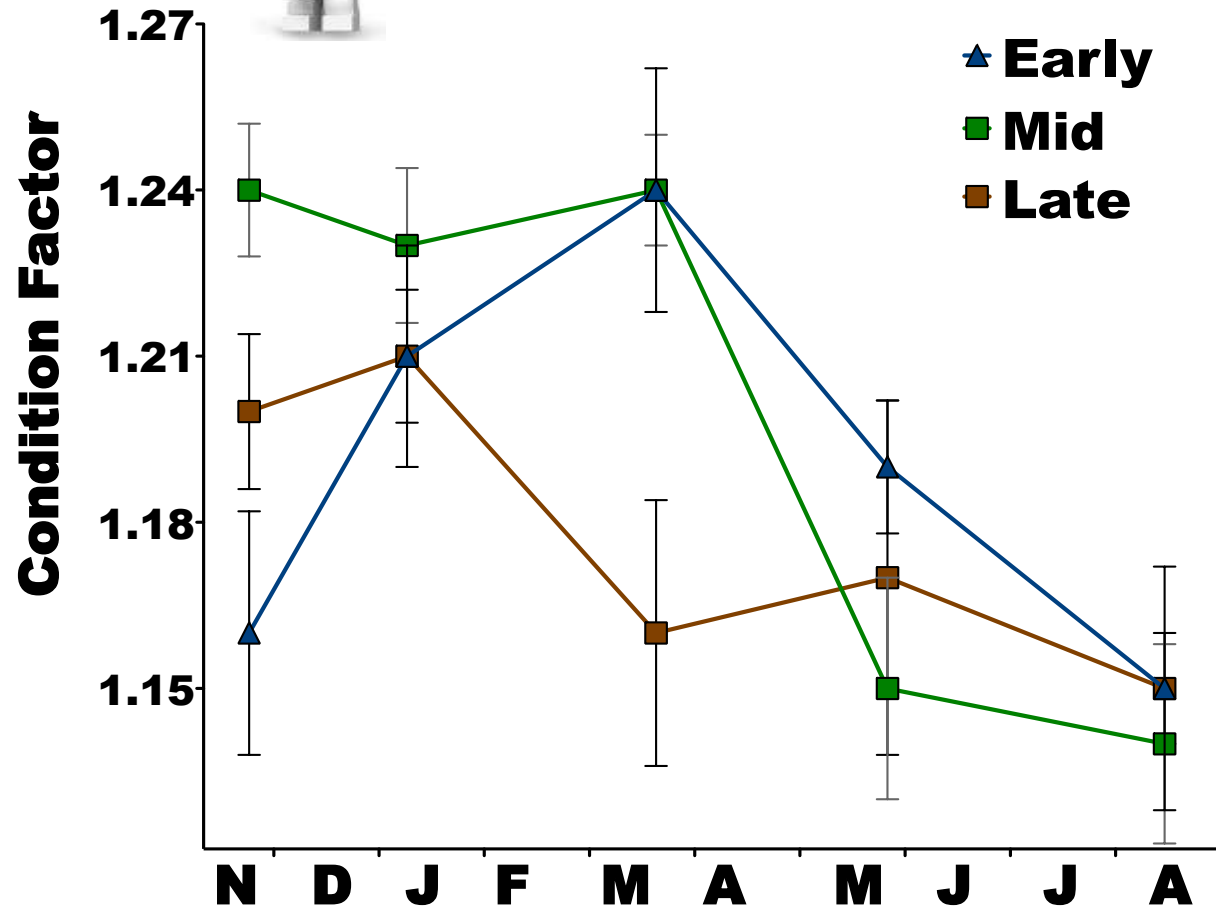
Calendar Date



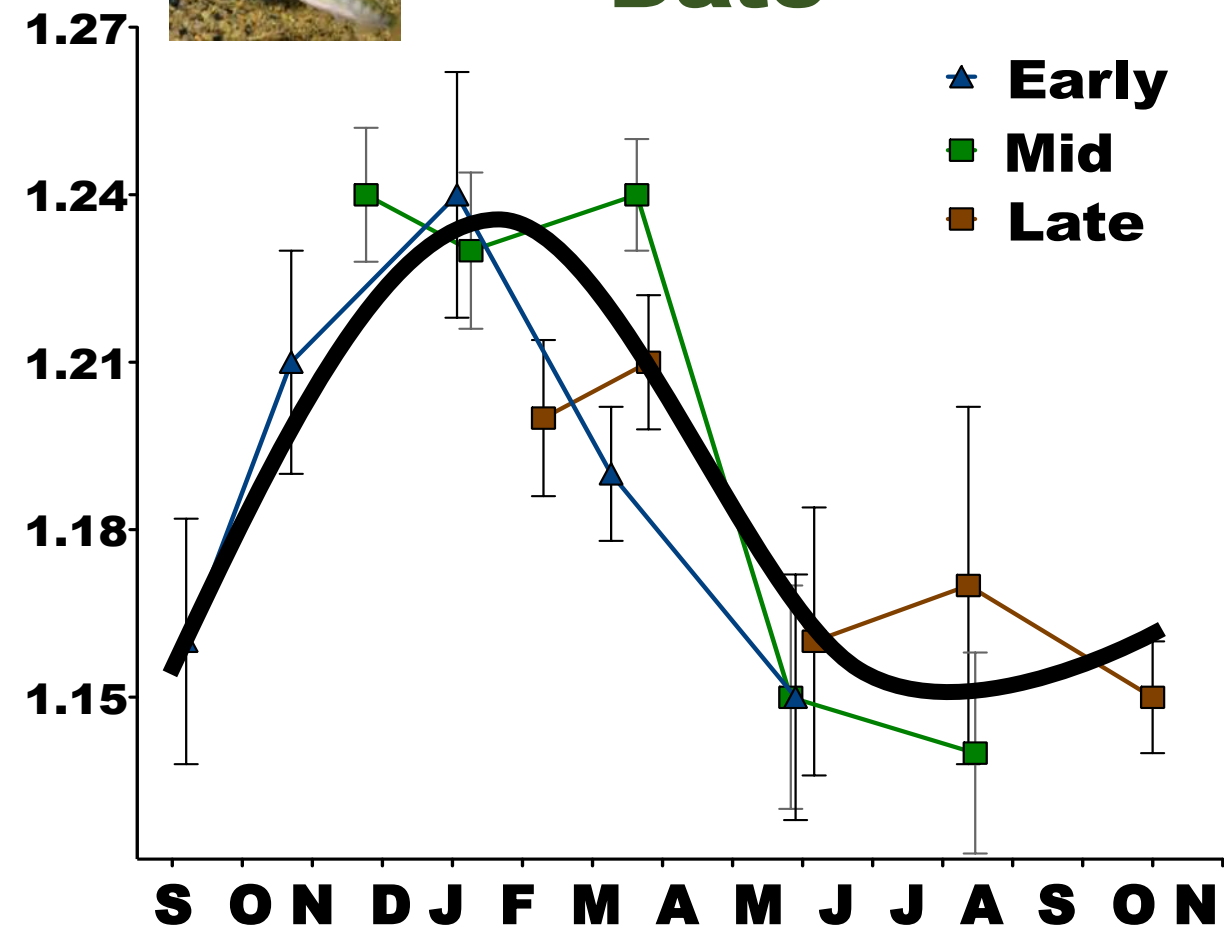
CF Data Looks Different When Plotted by Calendar Date vs Photoperiod Date



Calendar Date



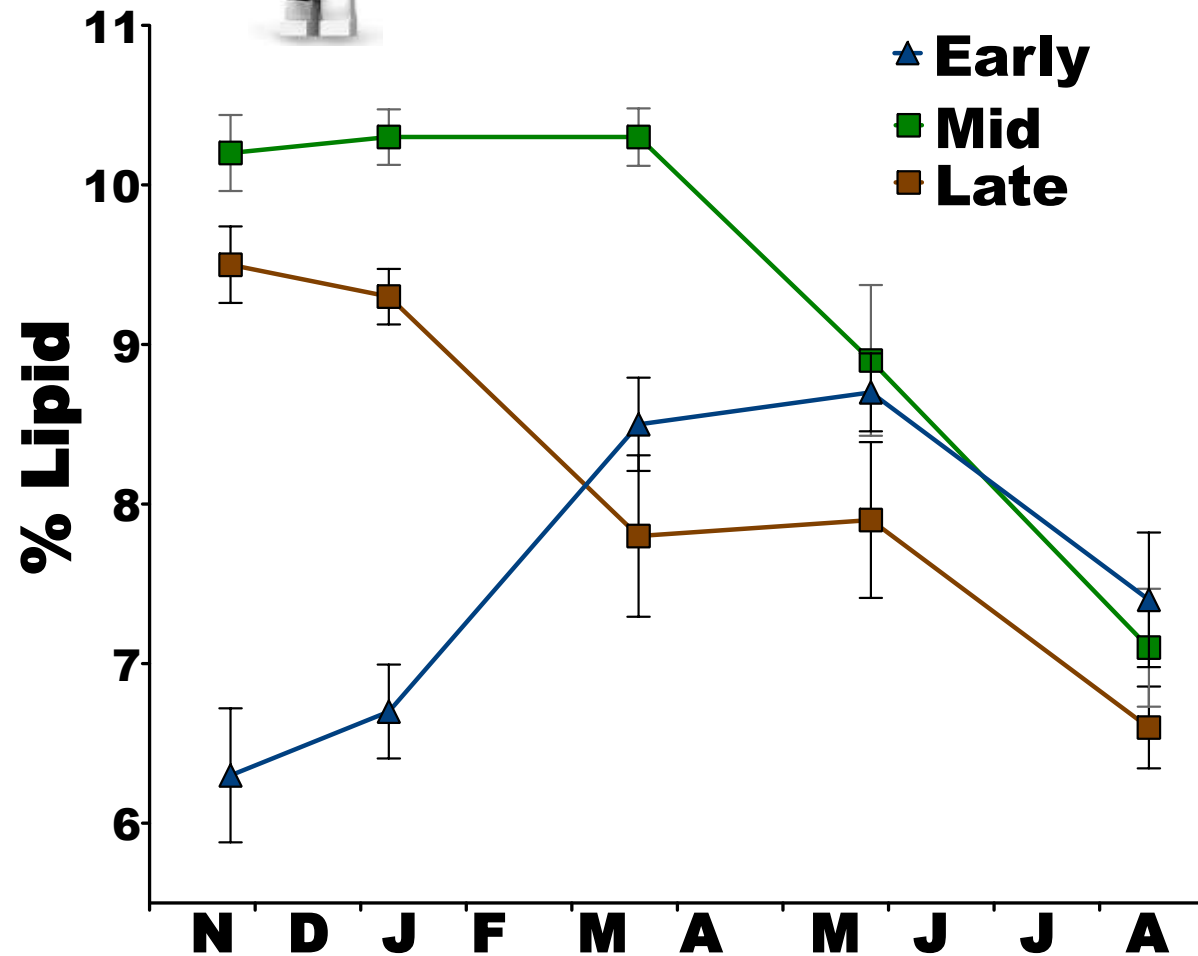
Photoperiod Date



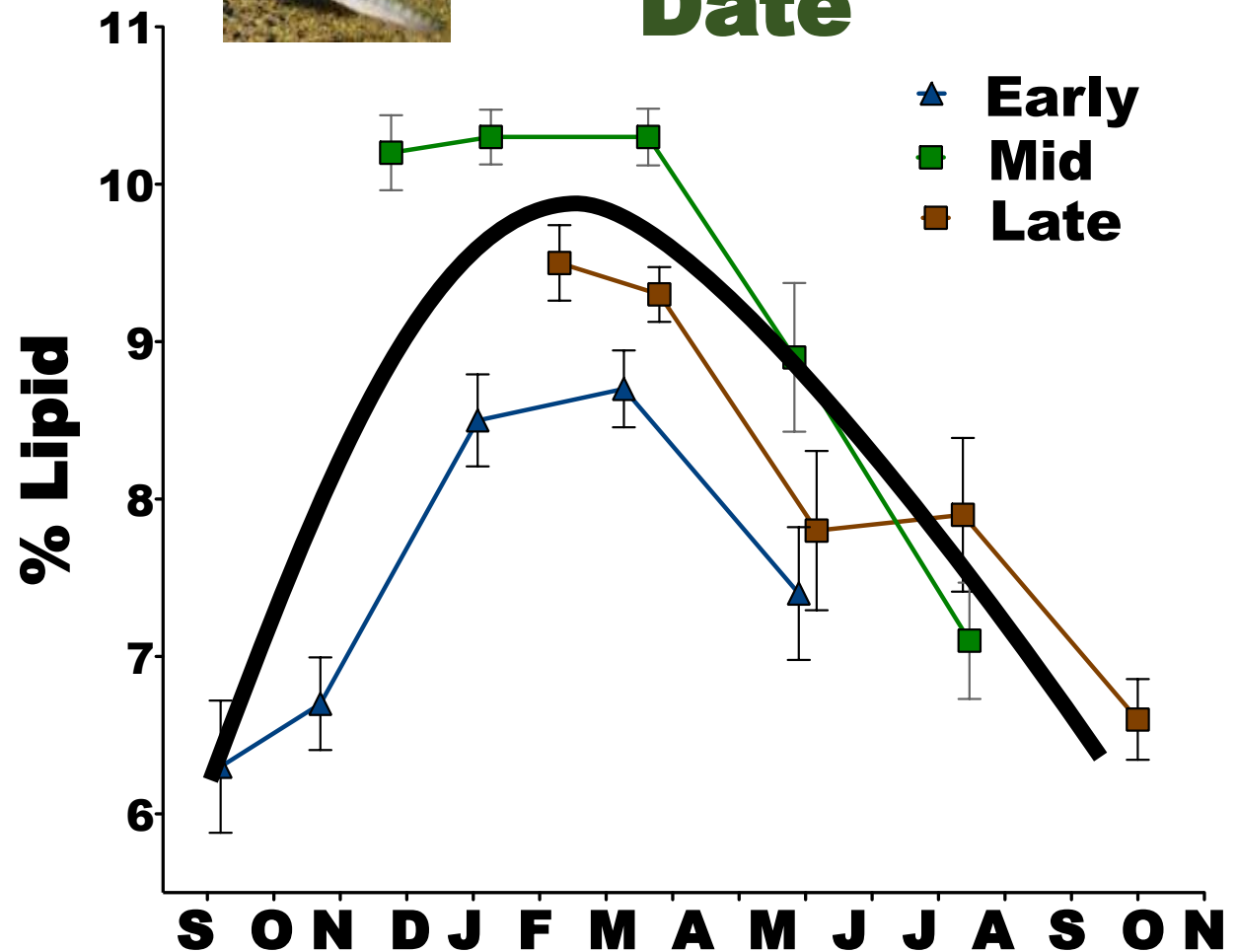
Lipid Data Looks Different When Plotted by Calendar Date vs Photoperiod Date



Calendar Date



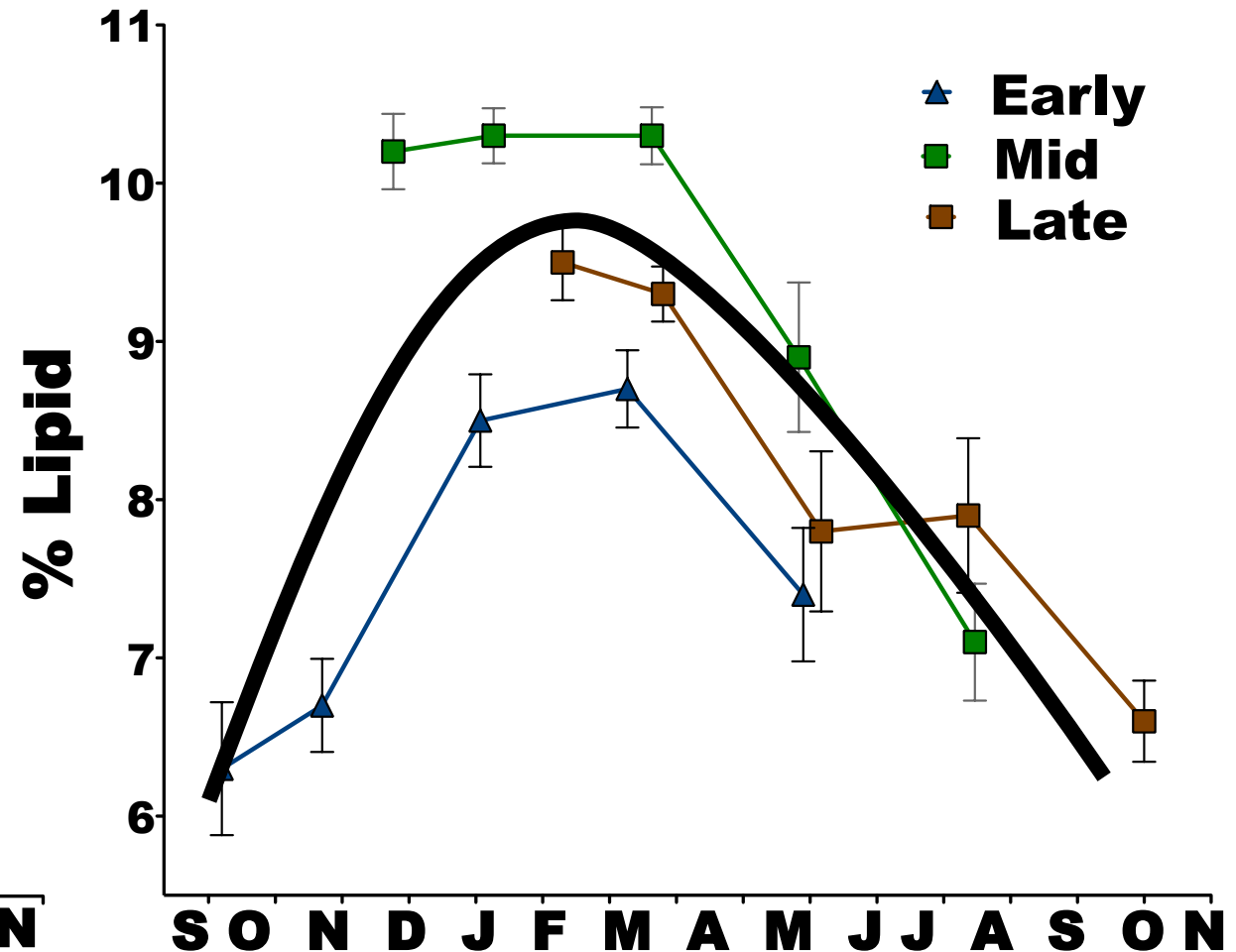
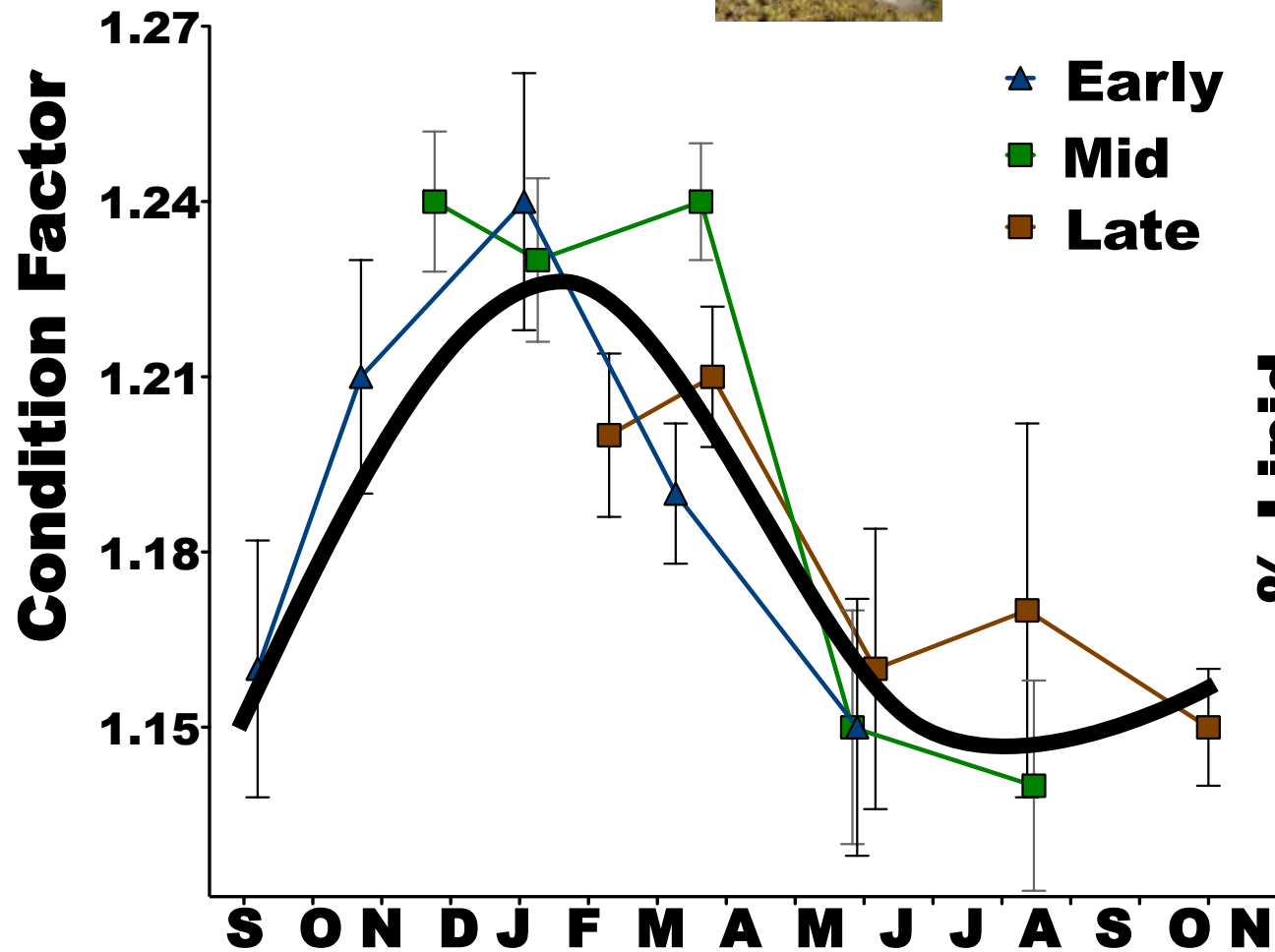
Photoperiod Date



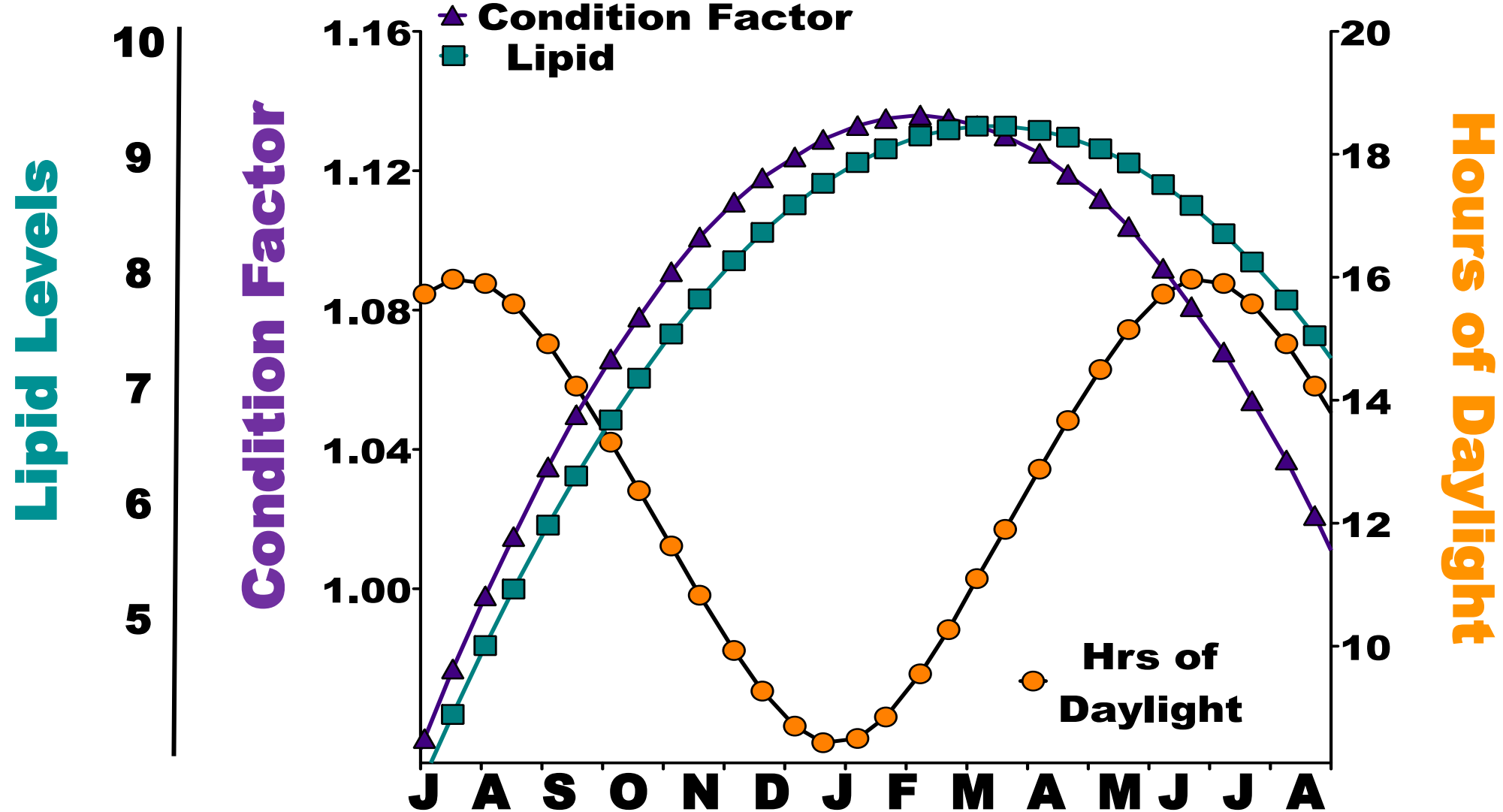
The Seasonal Pattern is Similar for Both Condition Factor and Lipid Levels



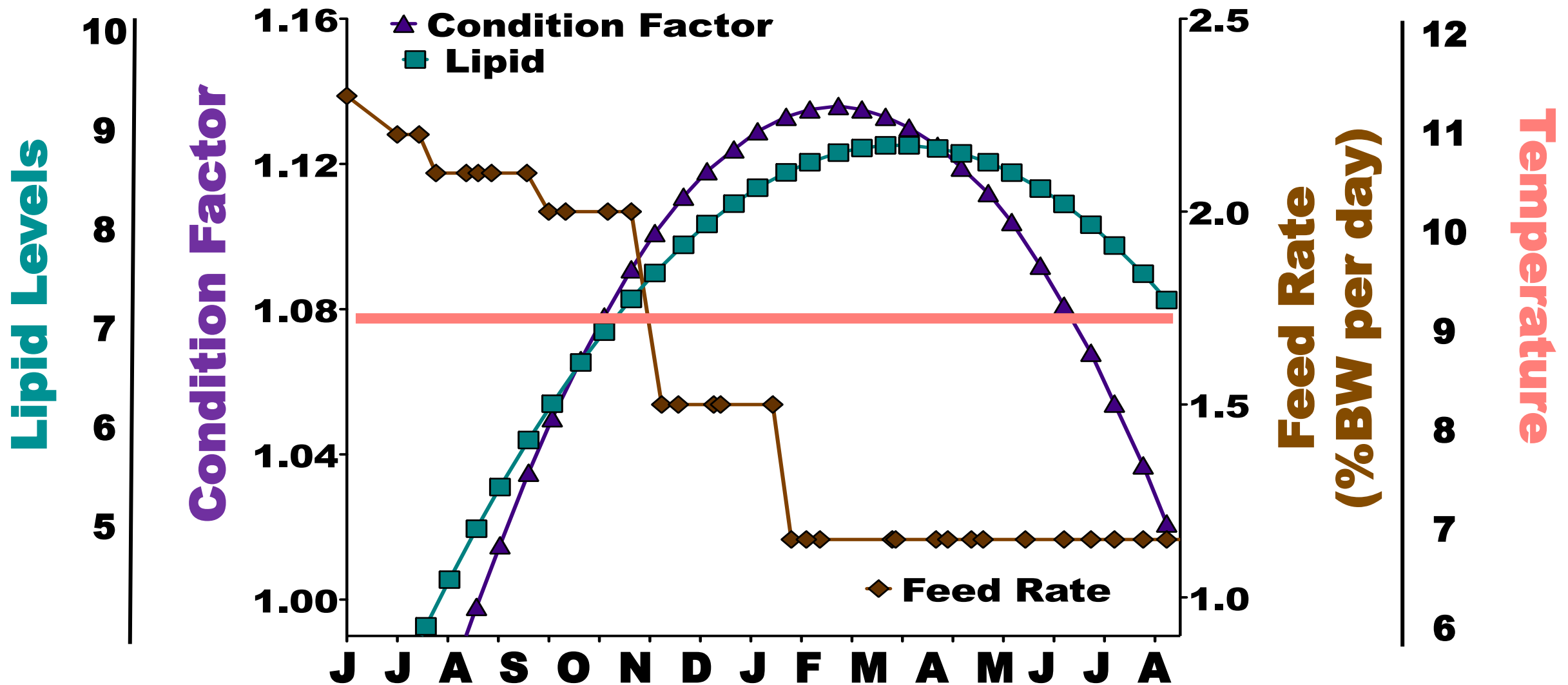
Photoperiod Date



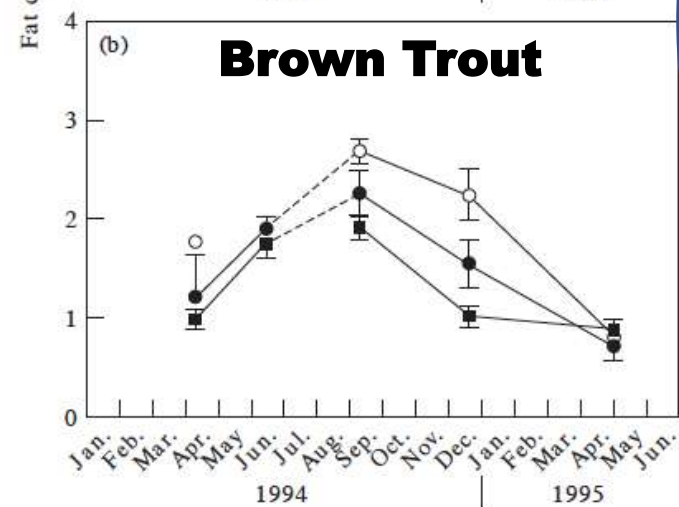
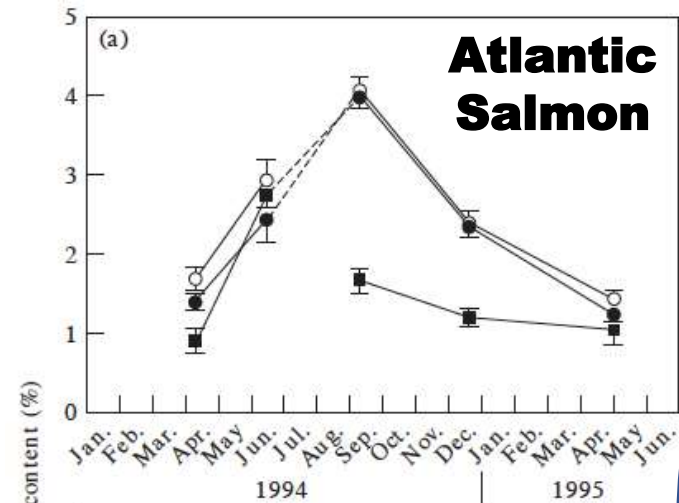
Lipid Levels and Condition Factor Cycled Opposite to Hours of Daylight



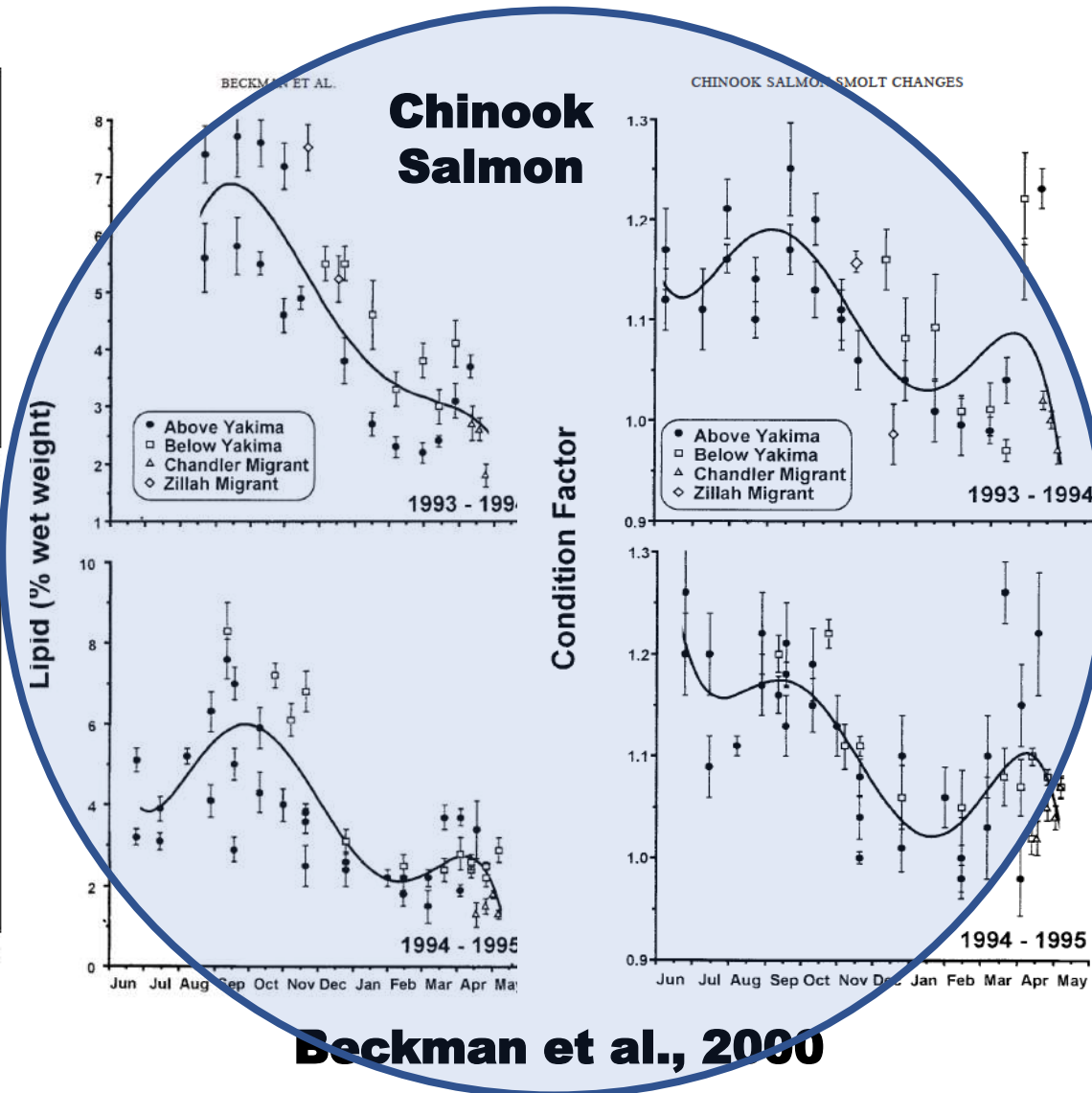
Lipid Levels and Condition Factor Increased Despite a Decreasing Ratio



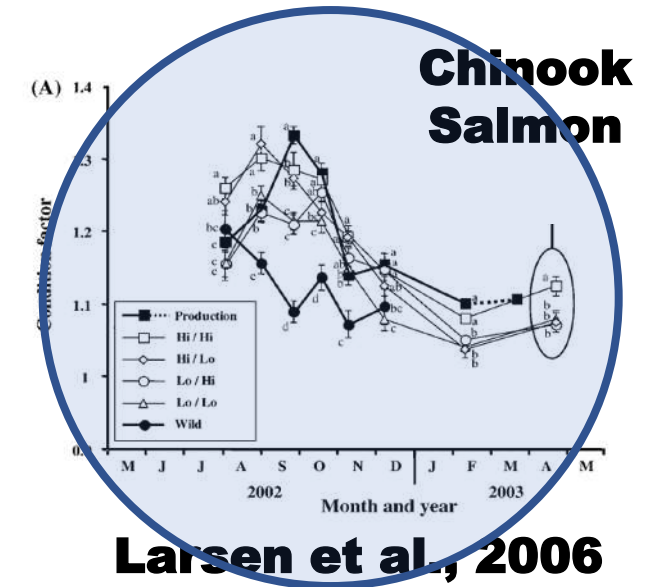
Our Results Were Similar to These Other Studies



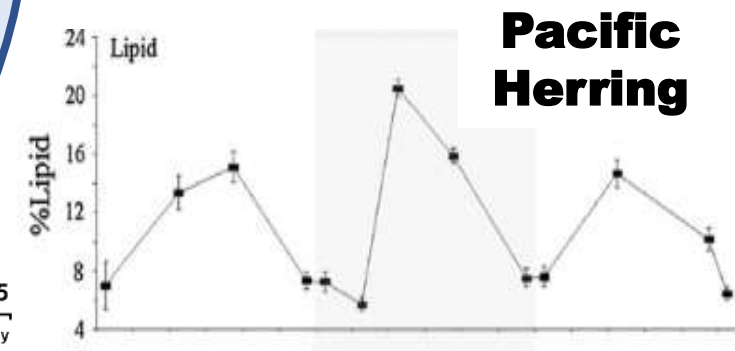
Berg & Bremset, 1998



Beckman et al., 2000

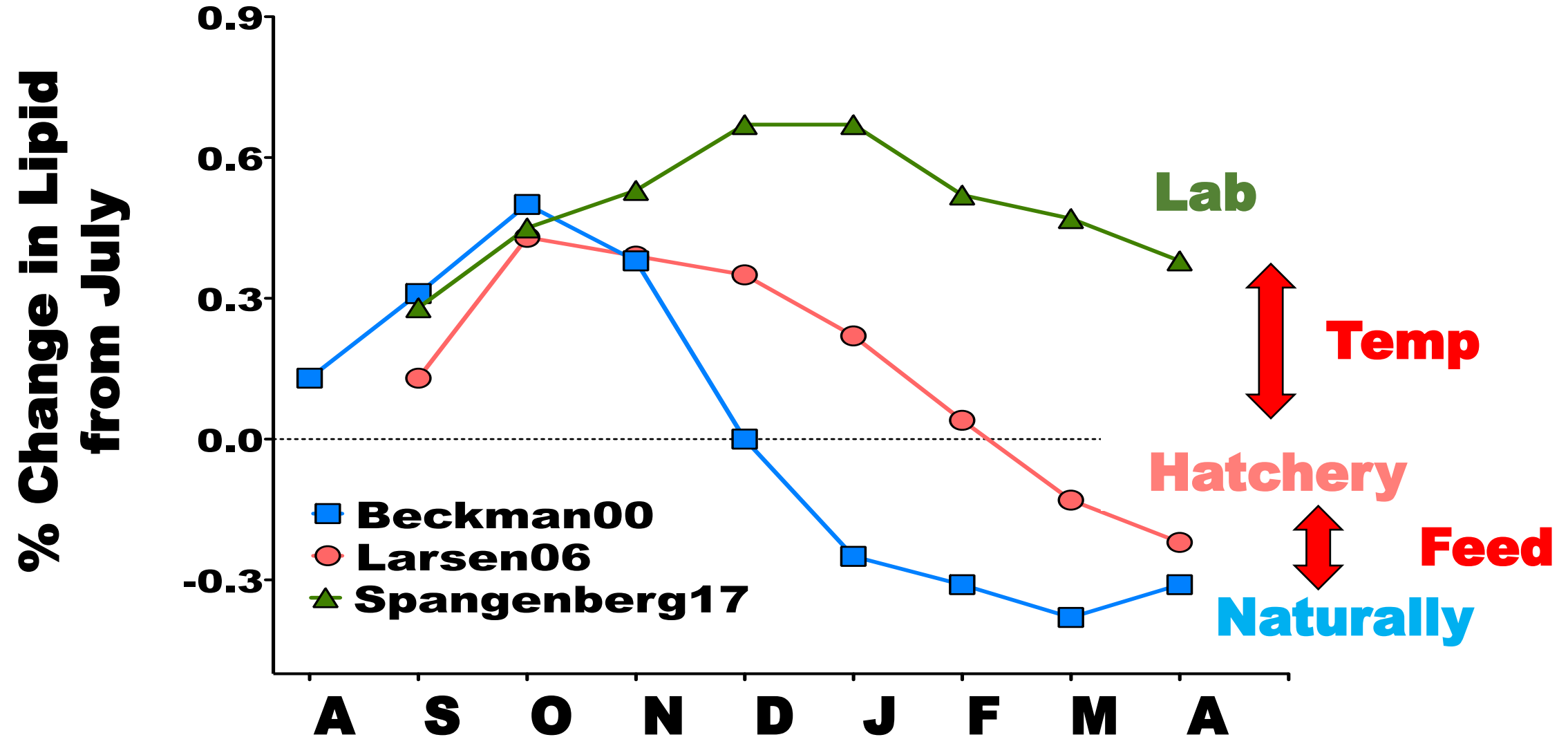


Larsen et al., 2006



Vollenweider et al., 2011

Seasonal Changes in Lipid Levels have been Observed in Both Hatchery and Naturally Reared Yakima Fish



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What is the Need For Seasonal Changes?

- Most organisms experience reduced food availability in winter

Migrate

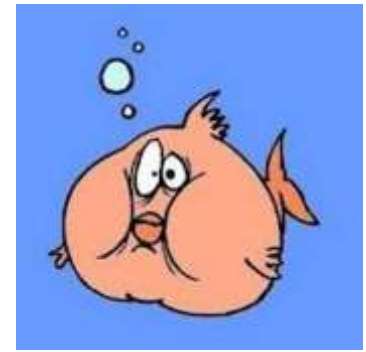


Hibernate

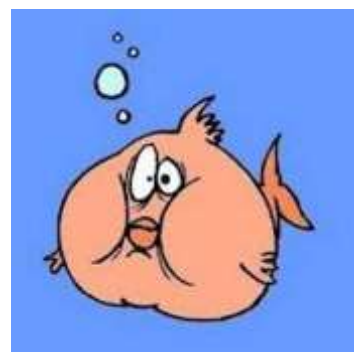


Adapt

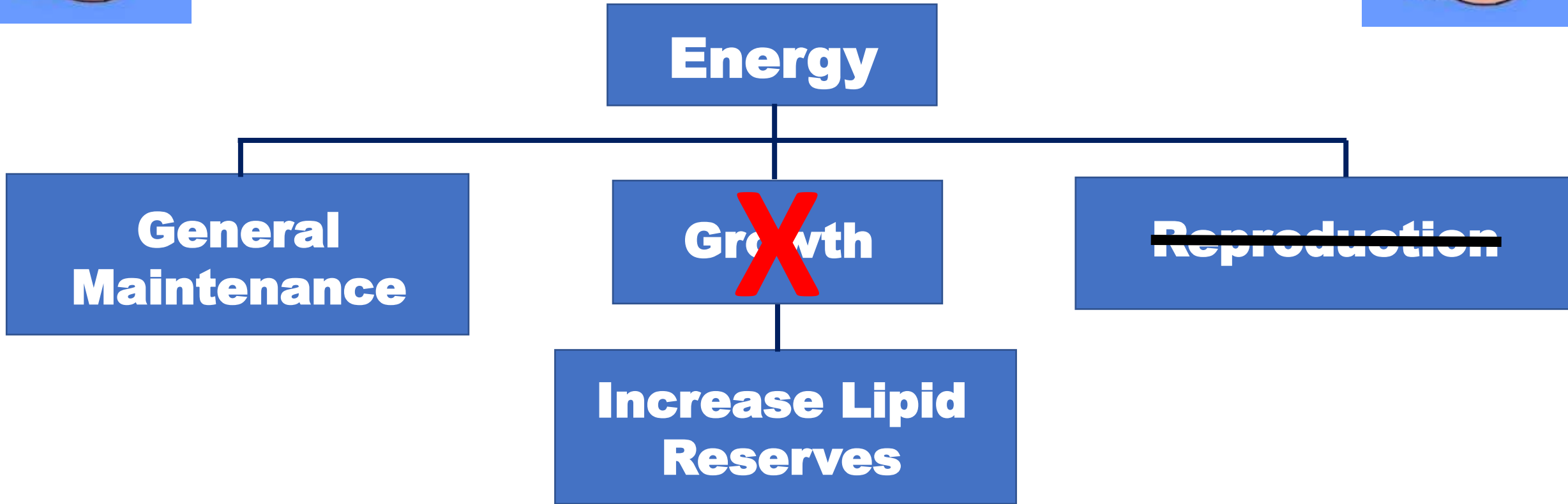




Fish Can “Adapt” and Get Fat

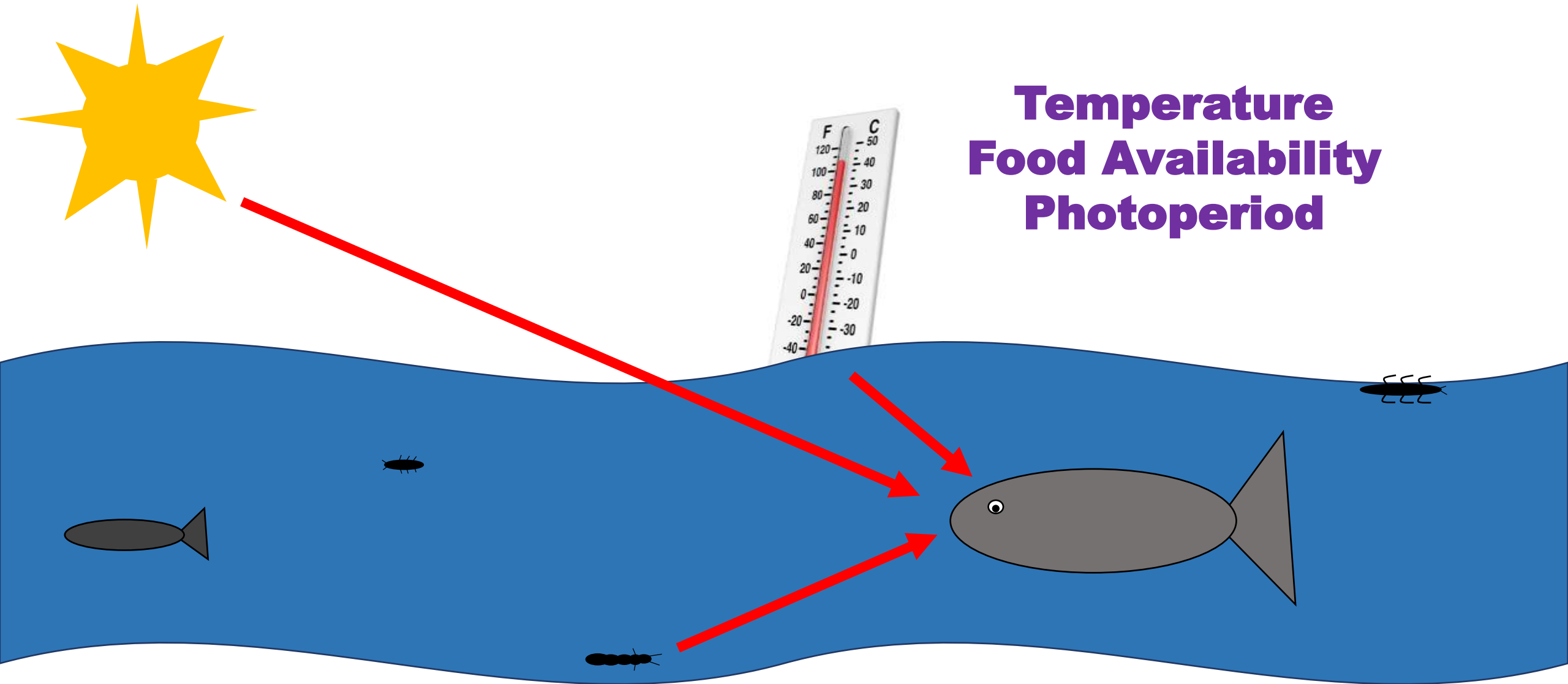


- **Lipids are a good energy source**



How does an organism know to switch their energy allocations

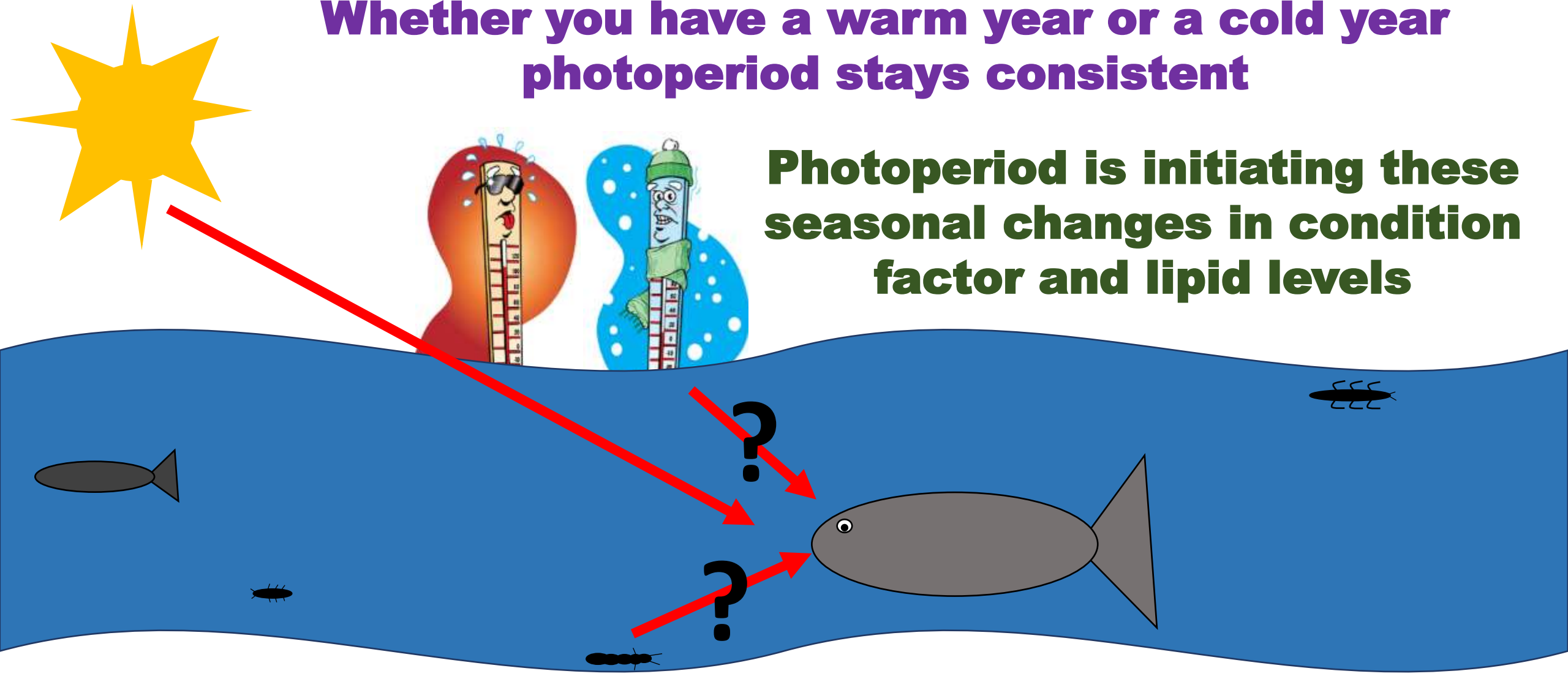
Environmental Cues Act As Switches



How Does an Organism “Know” to Switch Their Energy Allocations

Whether you have a warm year or a cold year
photoperiod stays consistent

Photoperiod is initiating these
seasonal changes in condition
factor and lipid levels



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Minijacks Are Common At Hatcheries

Spring

Cle Elum 40%
Parkdale 31%
Round Butte 25%
Winthrop 23%
Carson 23%
Leavenworth 19%

Summer

Carlton 34%
Entiat 24%
Dryden 18%
Bonaparte 15%
Similkameen 10%

Fall

Umatilla 40%

Variation in Minijack Rate among Hatchery Populations of Columbia River Basin Chinook Salmon. Harstad et al., 2014.

Three Factors Studies Have Shown Can be Manipulated to Affect Salmon Life-History

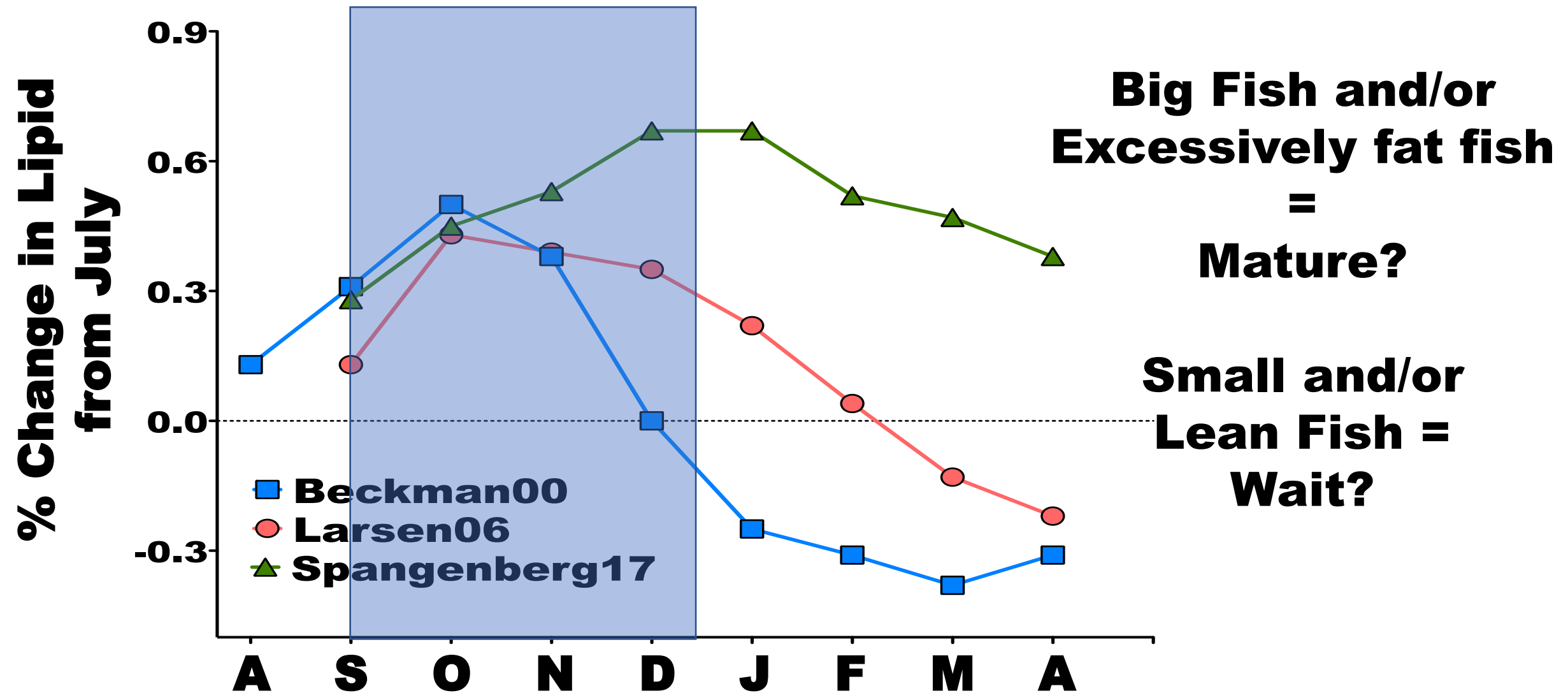
➤ Growth Rate/Size in the First Year

- **Higher Growth In The Fall/Winter Is Related To Increases In Early Male Maturation**
(Yakima River spring Chinook)
Donald A. Larsen & Brian R. Beckman

➤ Dietary Lipid Level

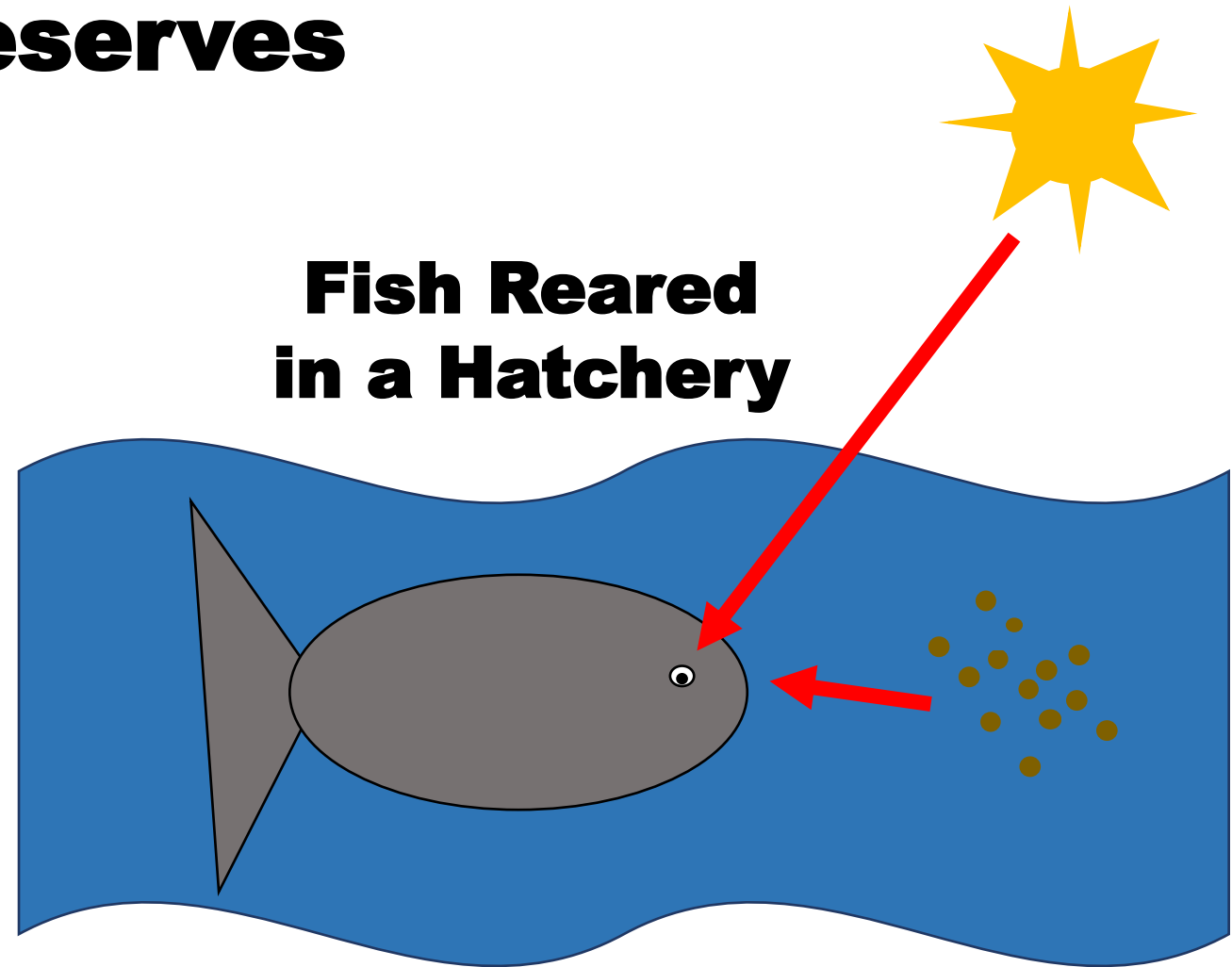
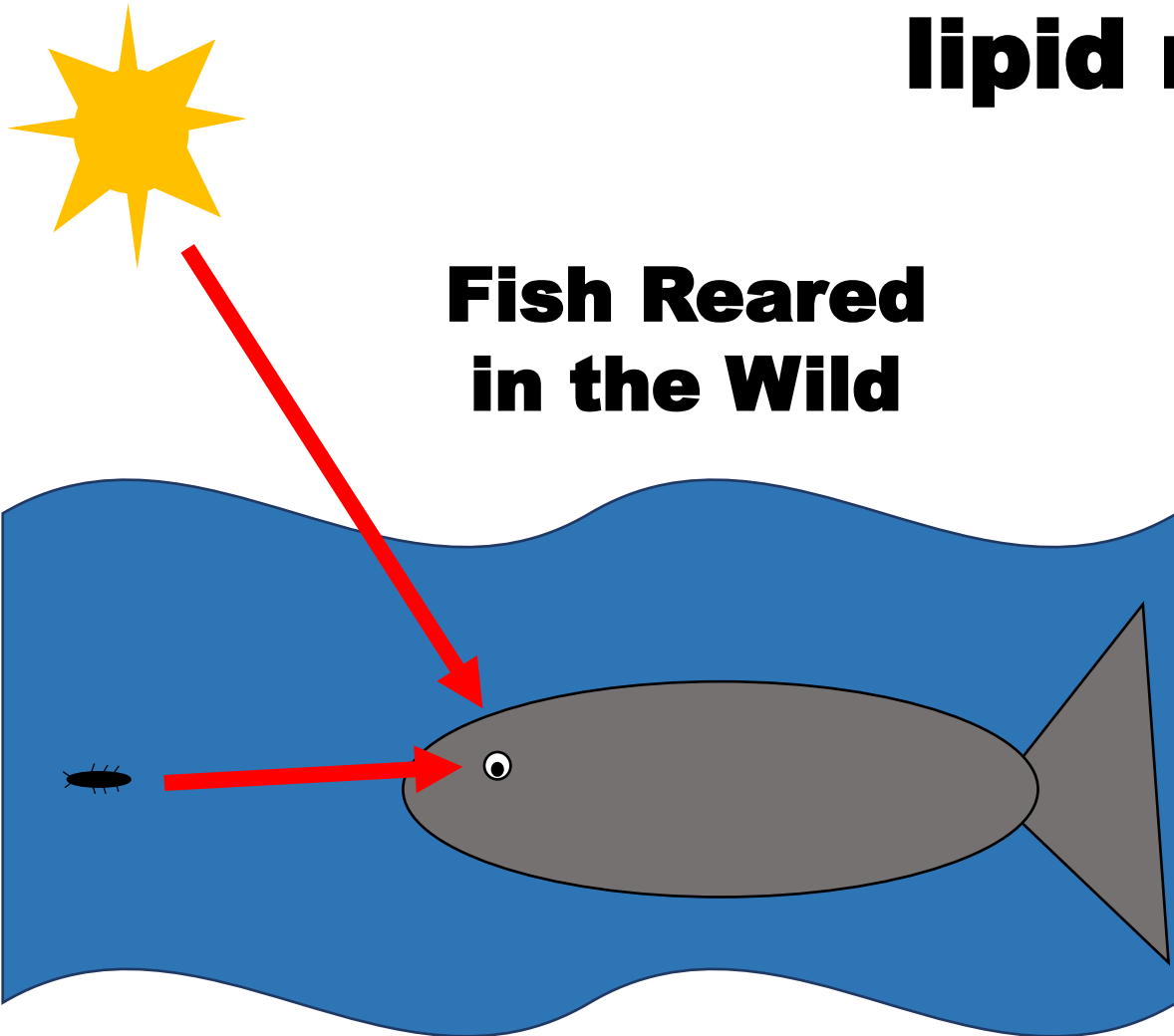
- **The Effect of Whole Body Lipid on Early Sexual Maturation of 1+ Age Male Chinook Salmon (*Oncorhynchus tshawytscha*)**
Karl D. Shearer & Penny Swanson paper

There is a Window of Opportunity For When Fish Decide to Mature



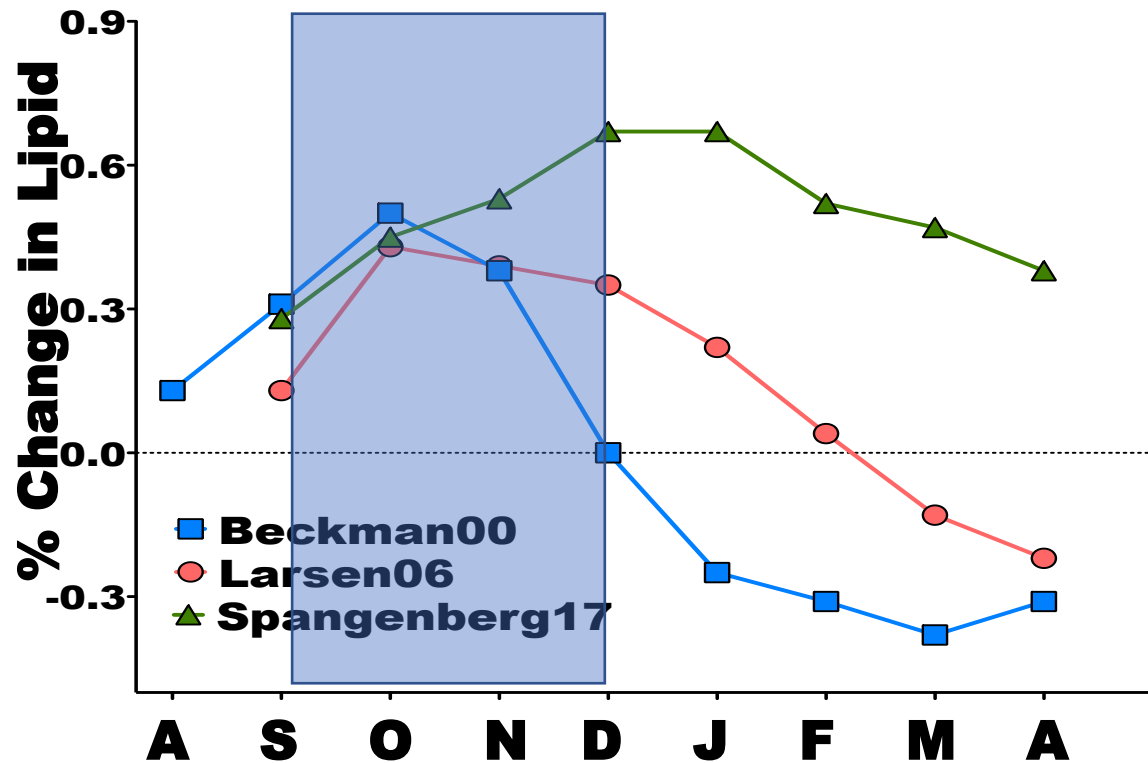
Implications for Hatchery Managers

Day length – decreasing
Cues fish to start laying down winter lipid reserves

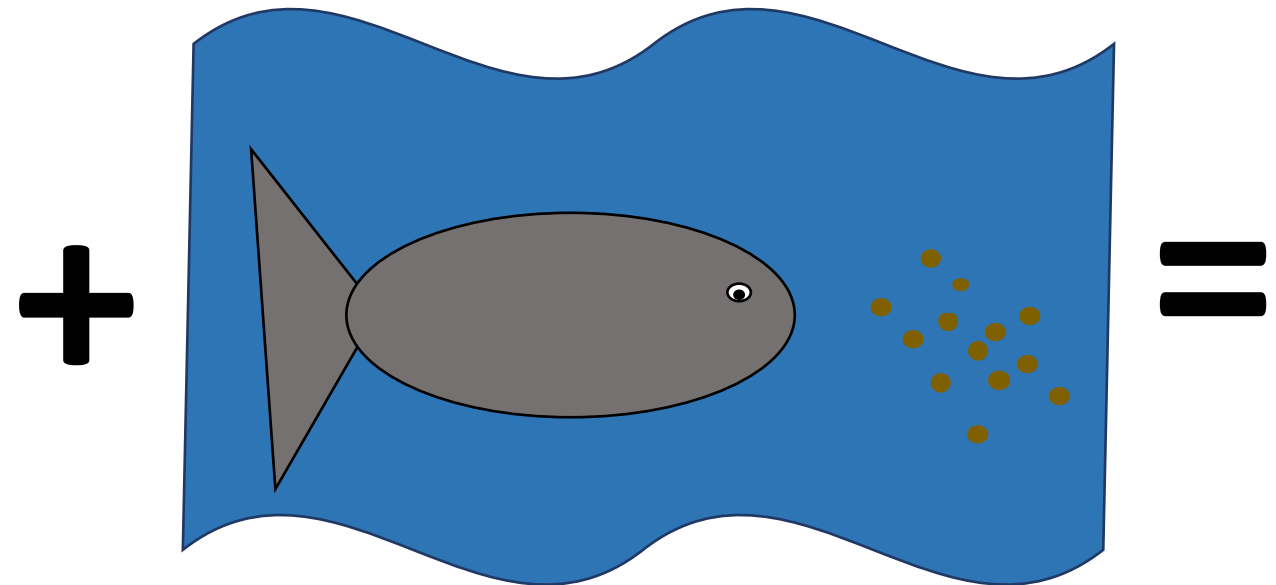


How Might Managers Unintentionally be Creating Minijacks

Window of opportunity



Two factors that can be manipulated to affect age at maturation



MINI-



Spring

Cle Elum 40%
Parkdale 31%
Round Butte 25%
Winthrop 23%
Carson 23%
Leavenworth 19%

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Carlton 34%
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Fall

Umatilla 40%

Conclusions

- **Lipid levels and condition factor followed seasonal pattern**
- **Seasonal pattern driven by photoperiod**
 - **Cycled in a manner opposite to photoperiod**
- **Photoperiod is a dominant cue for fish**
- **Hatchery implications**
 - **Feed – what? when? how much?**

Acknowledgements

- **Yakima Tribe for supplying eggs**
- **BPA for funding**
- **Experimental support - Deb Harstad**



Questions

