# Managing for diversity in *O. mykiss*: opportunities and challenges

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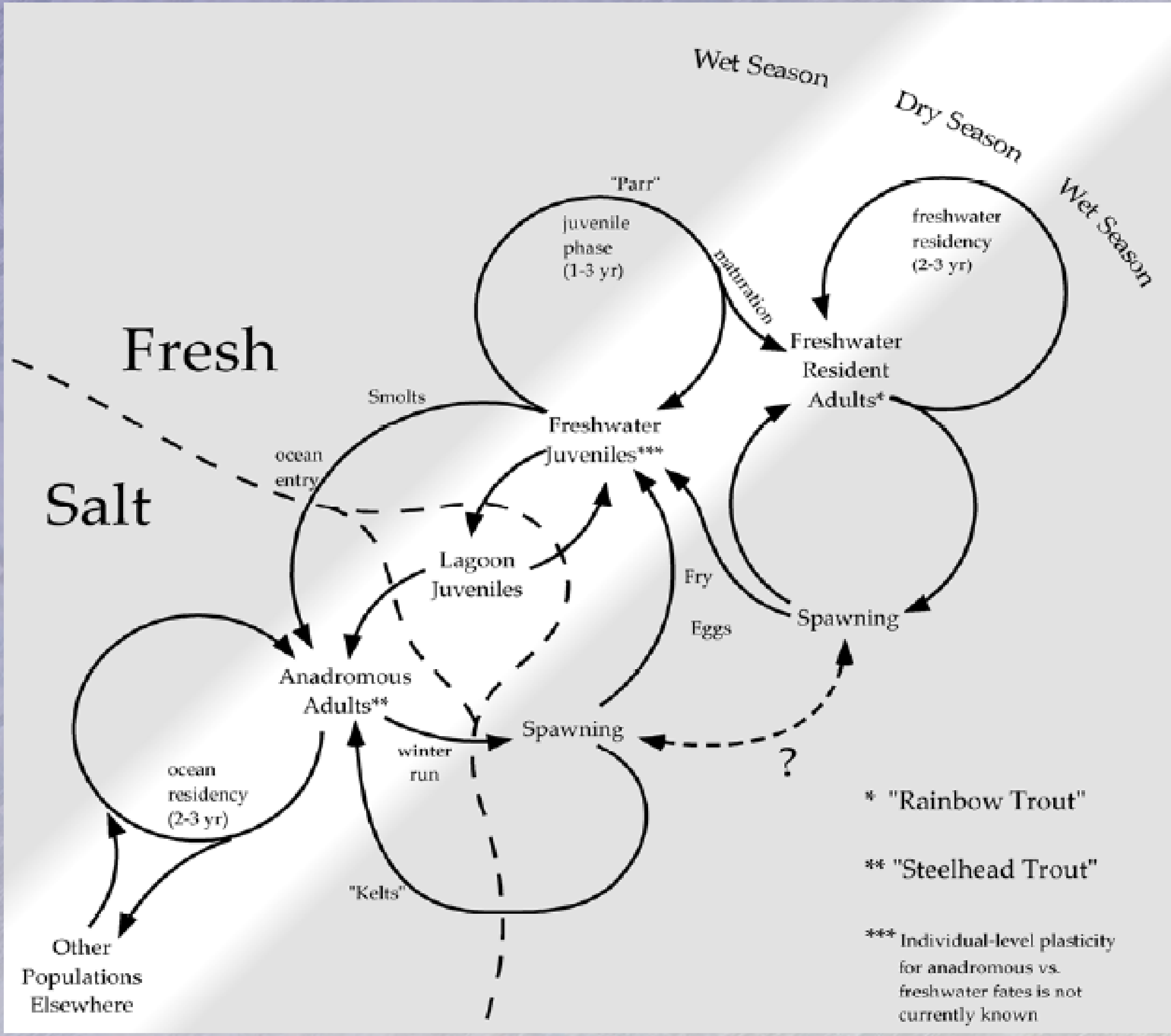
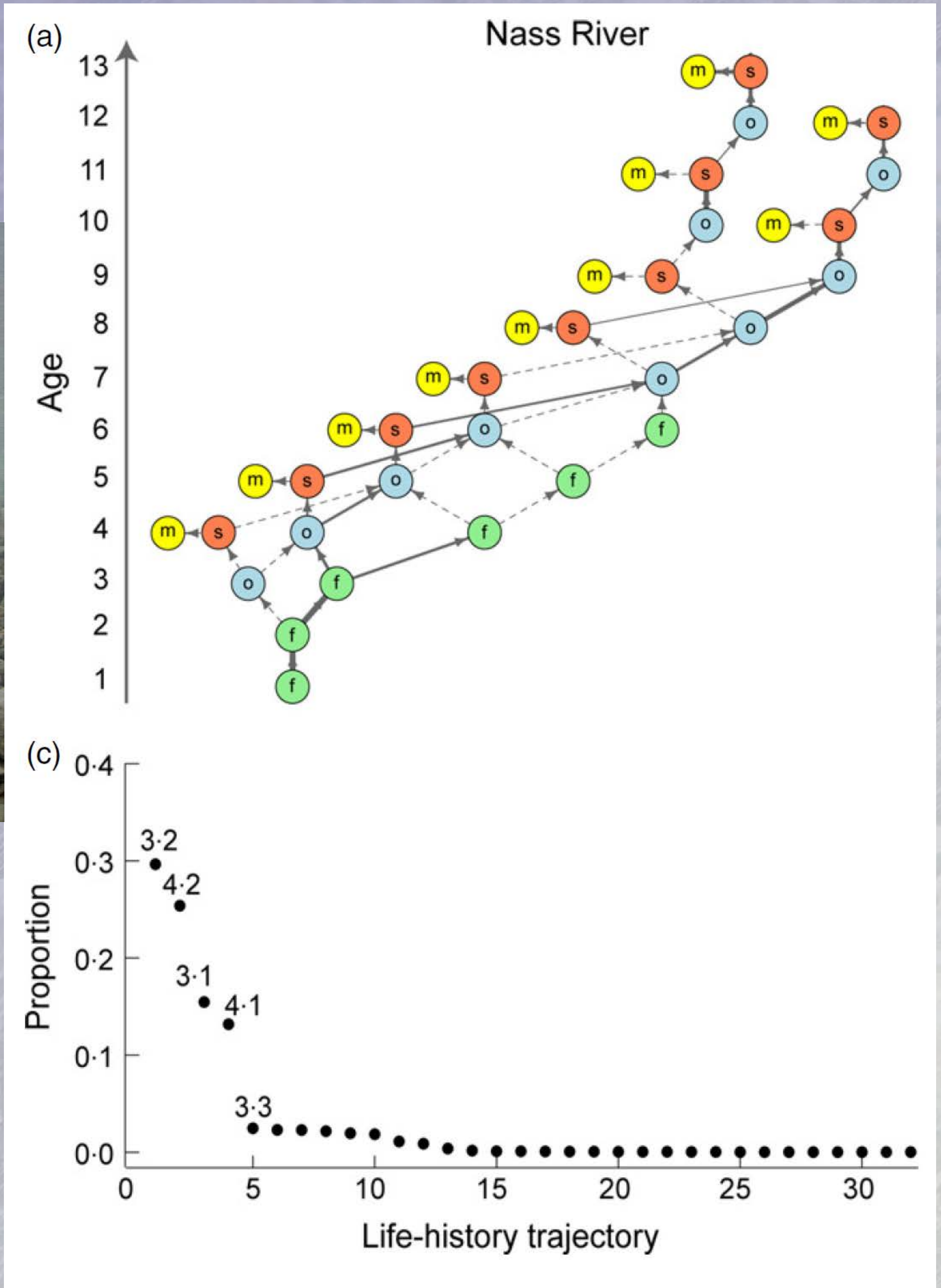
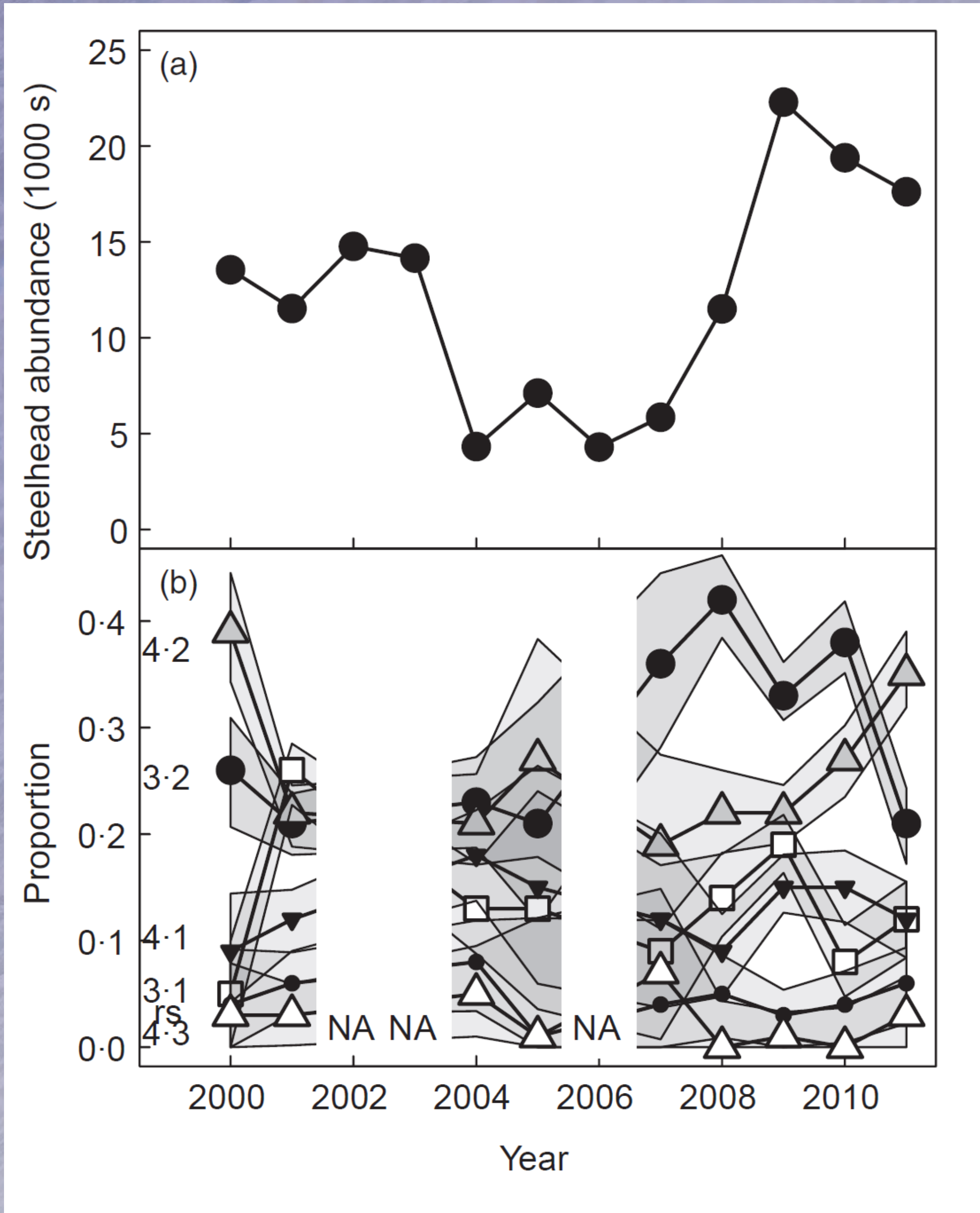
# The Steelhead/Rainbow Trout Life Cycle




Boughton et al. 2005.

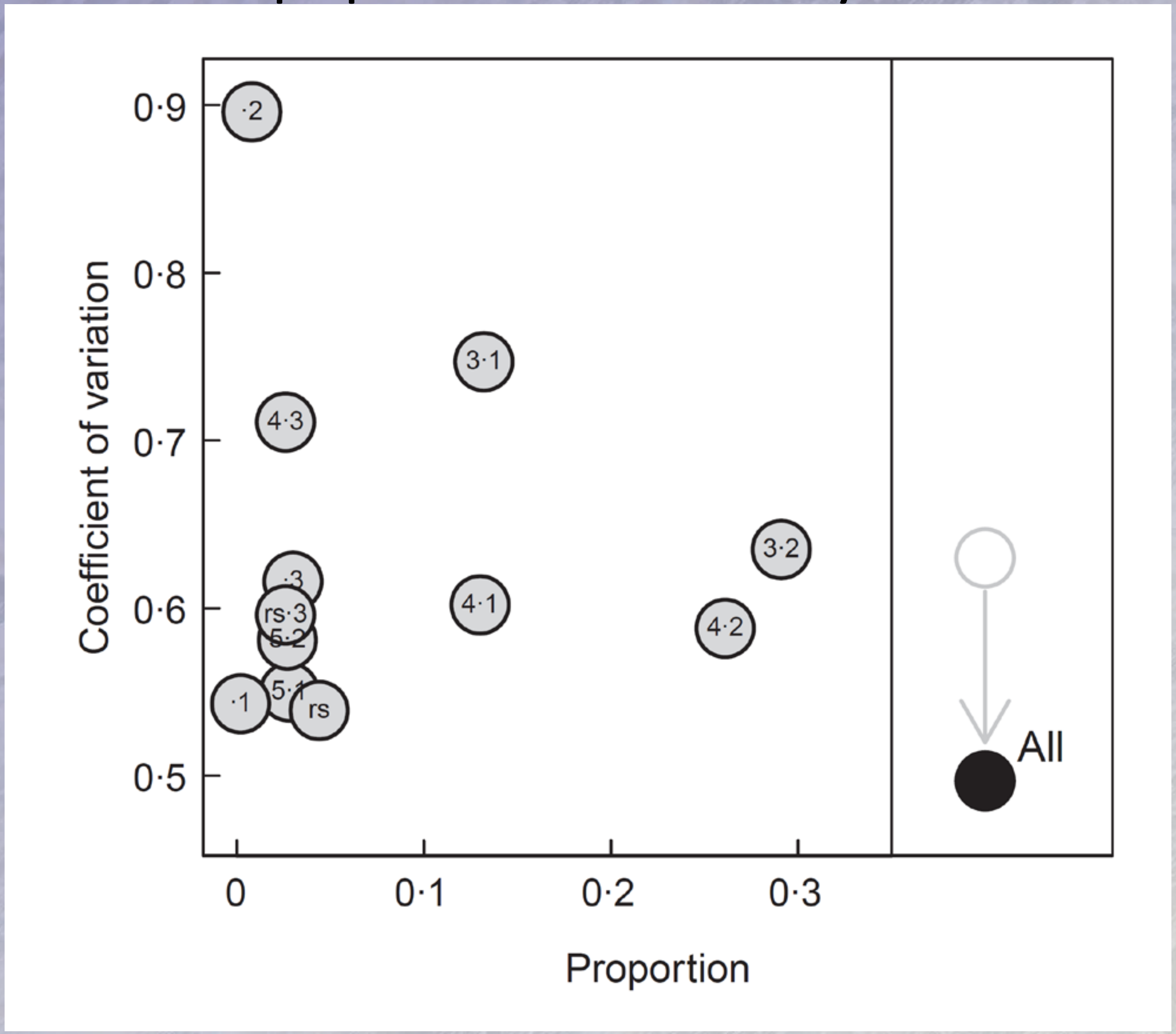

Moore et al. 2014. J. App. Ecol.




Steelhead populations are comprised of life history classes with asynchronous variation in relative abundance over time

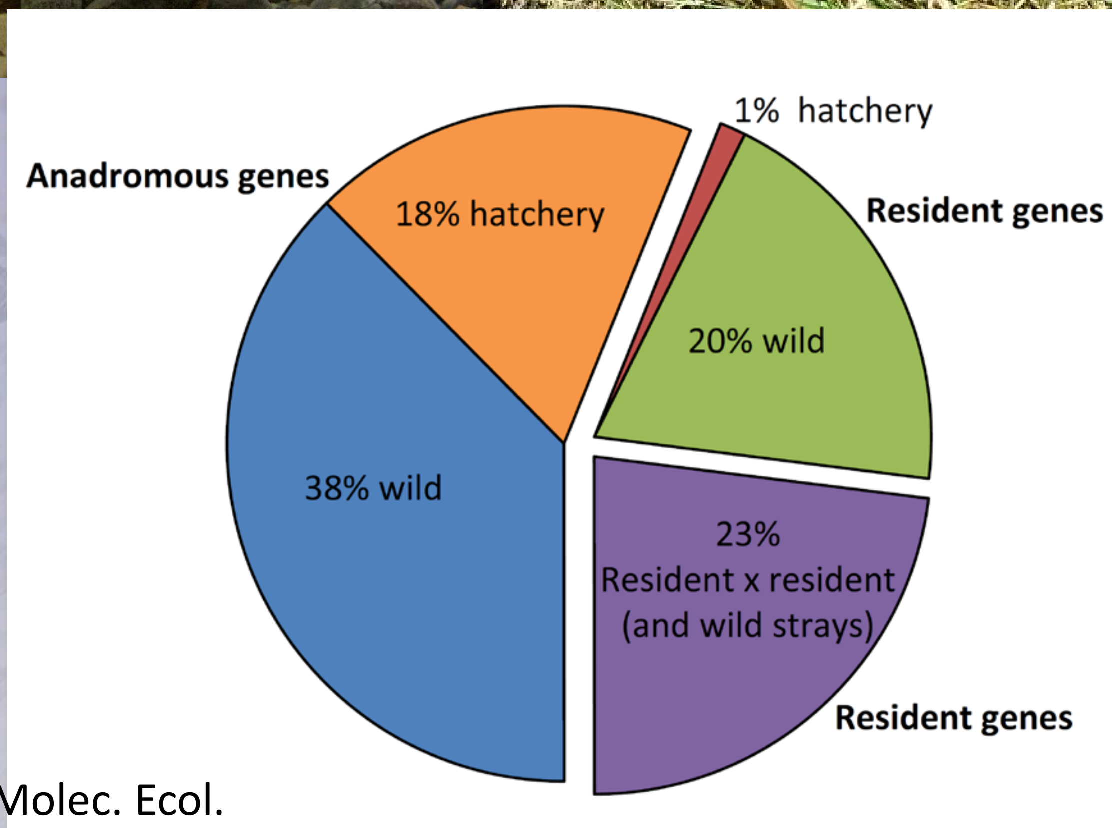
Moore et al. 2014. J. App. Ecol.

# Asynchrony in life history components decreases population variability




Moore et al. 2014. J. App. Ecol.





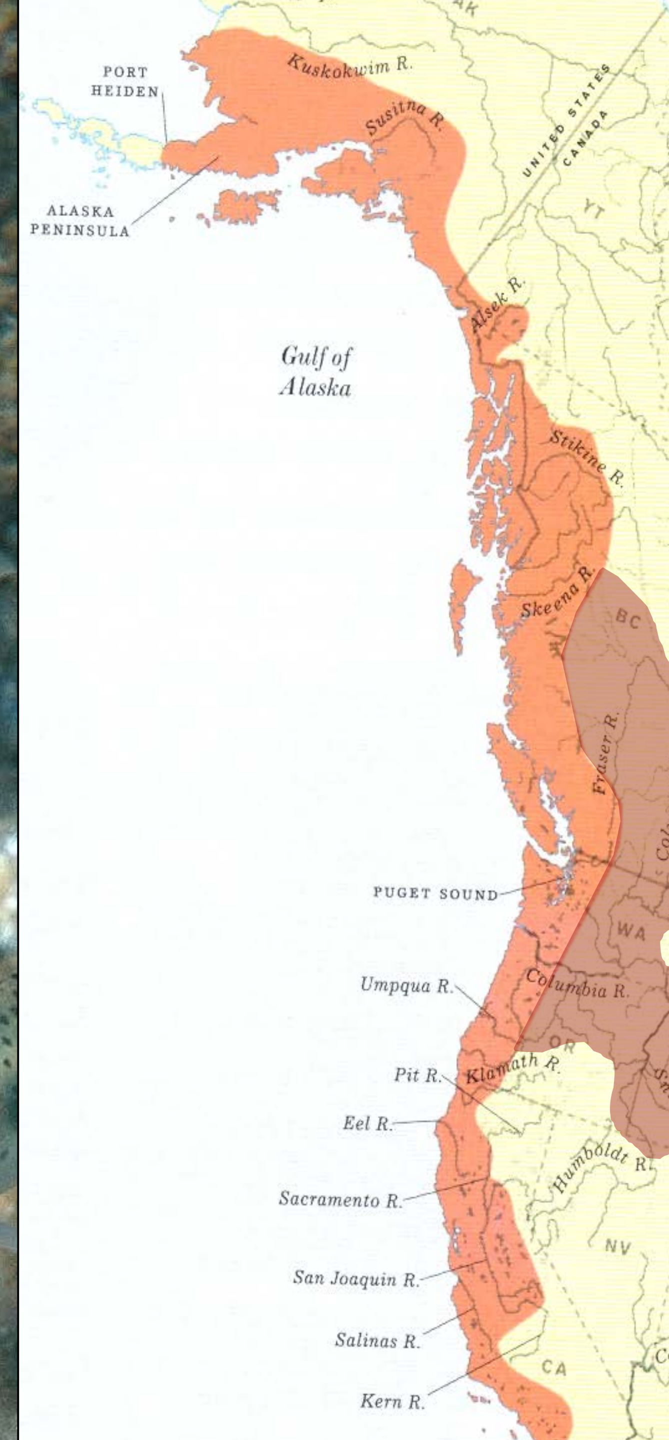

Christie et al .2014. Molec. Ecol.

*O. mykiss* diversity

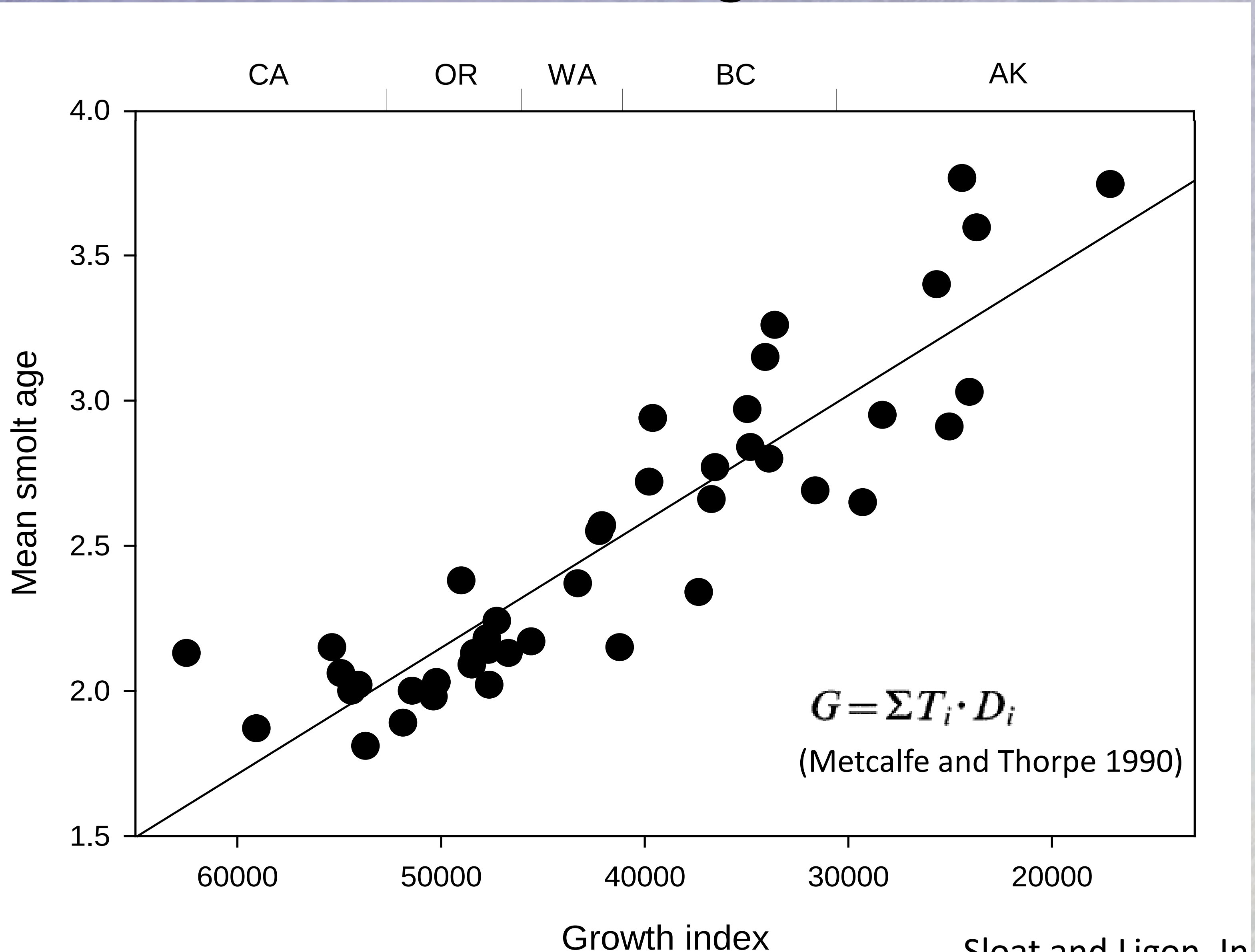
Anadromous life history diversity

- range-wide
- basin-scale

Anadromy and residency

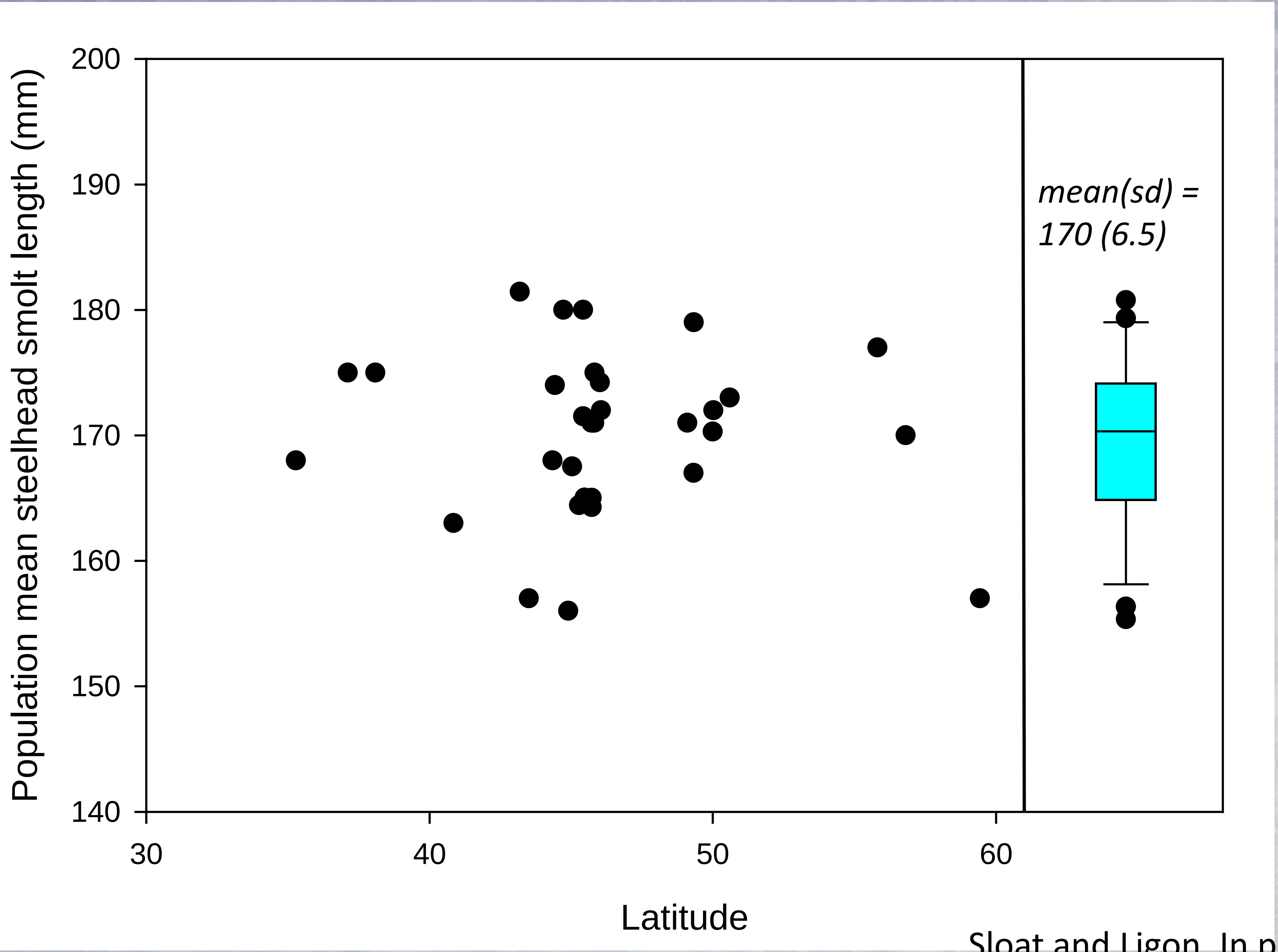


# Growth opportunity explains variation in smolt age



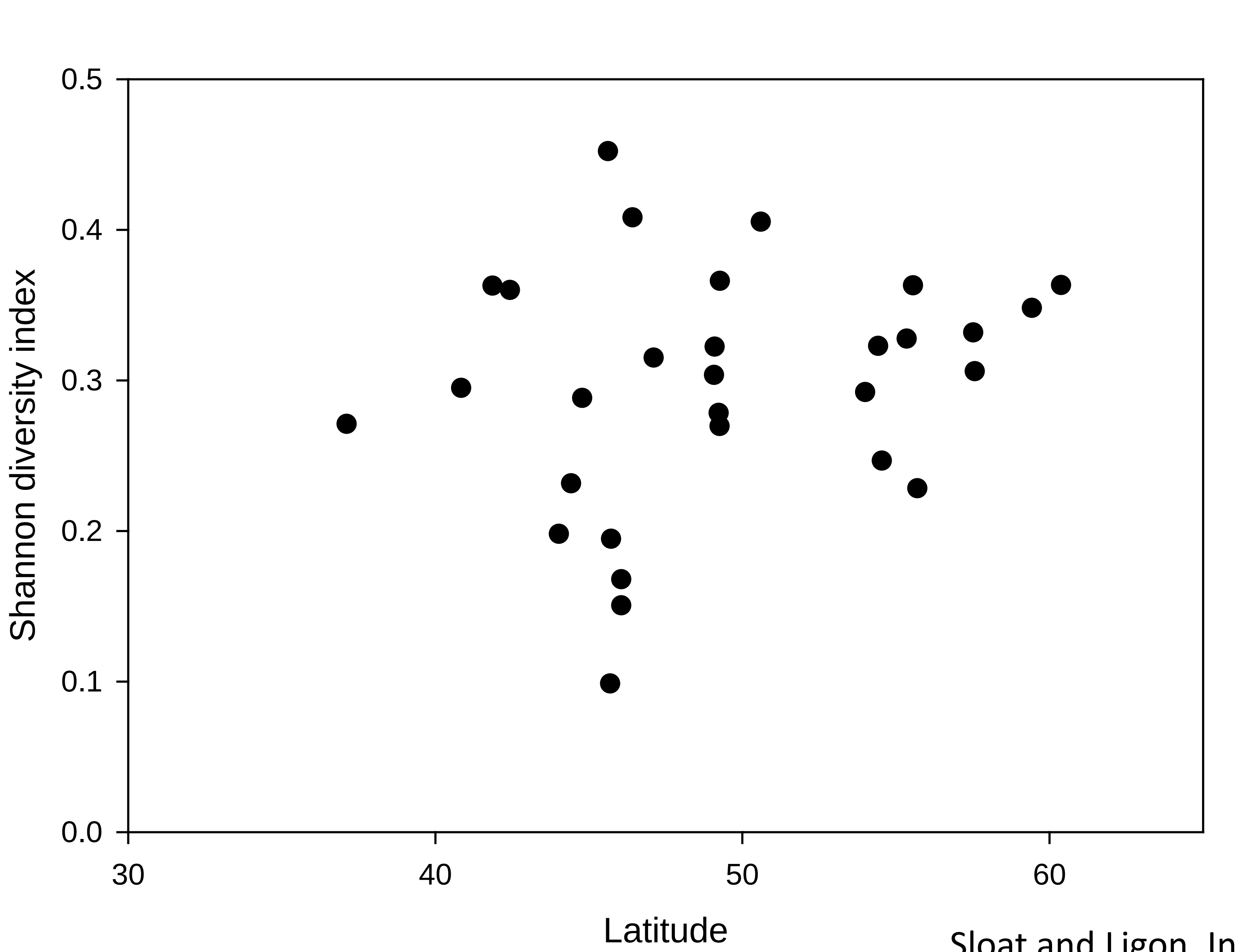

Sloat and Ligon. In prep.

# No latitudinal cline in steelhead smolt size




Sloat and Ligon. In prep.

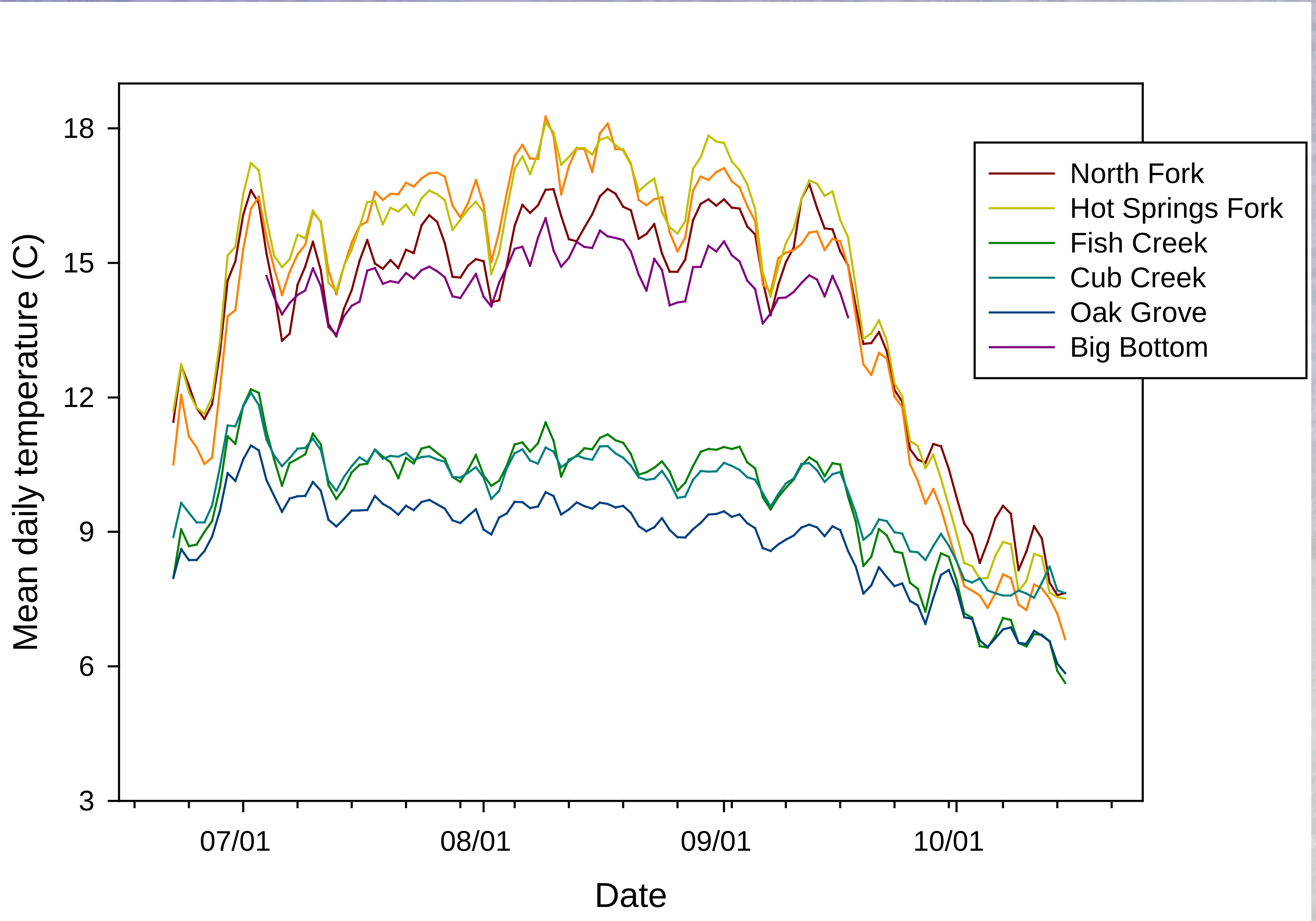
# No latitudinal cline in steelhead smolt age diversity



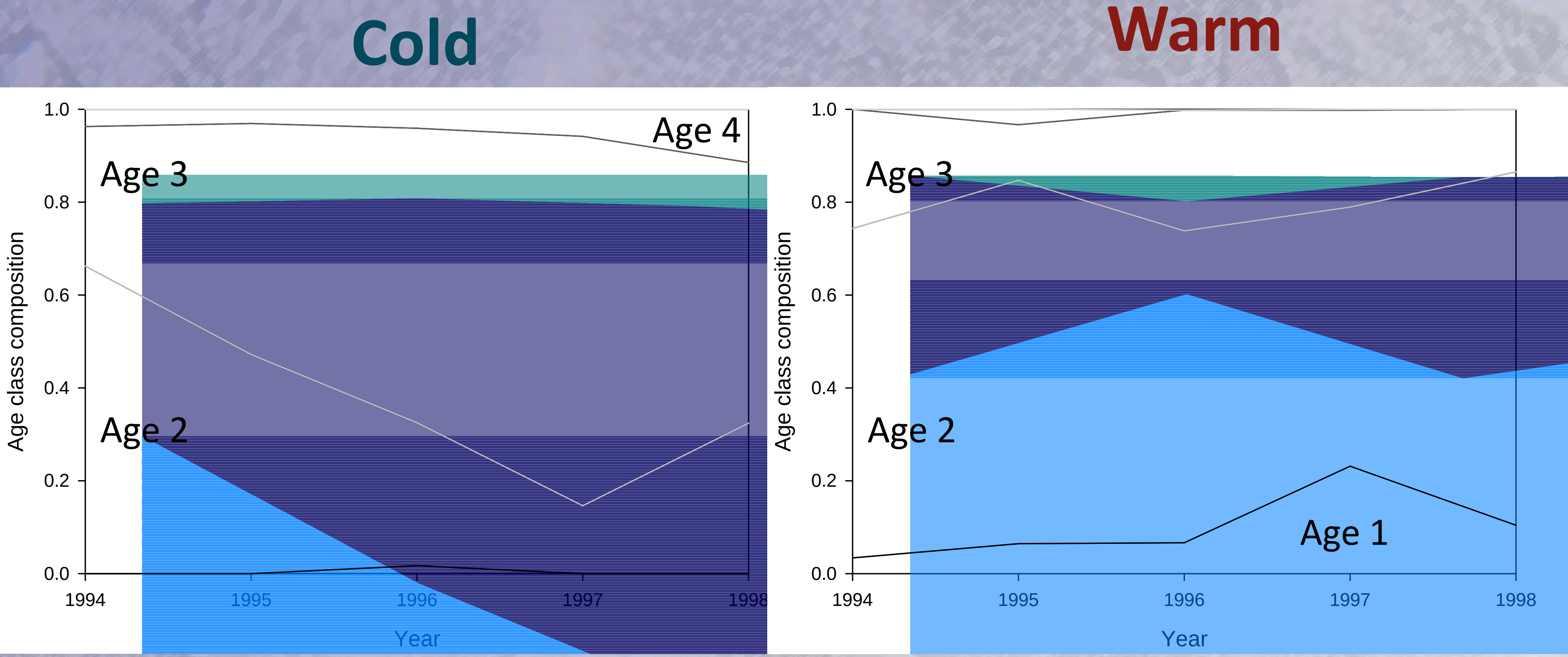

Sloat and Ligon. In prep.

# Basin-scale habitat heterogeneity and *O. mykiss* life history diversity

# Clackamas Stream Temperatures



# Clackamas River subbasin thermal regimes and smolt age composition

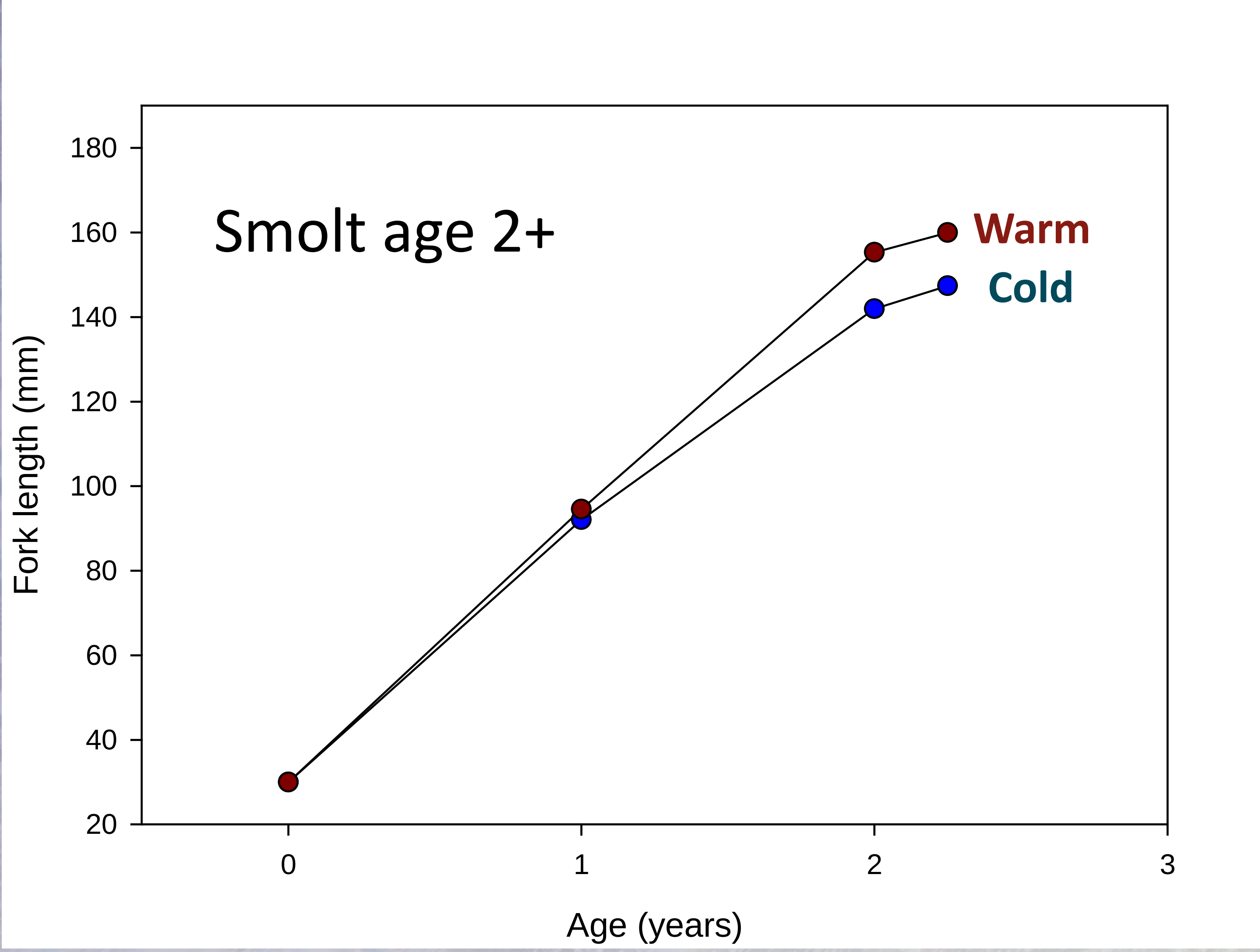



Mean age: 2.63 yrs
Mean length: 161 mm

Mean age: 2.11 yrs
Mean length: 163 mm

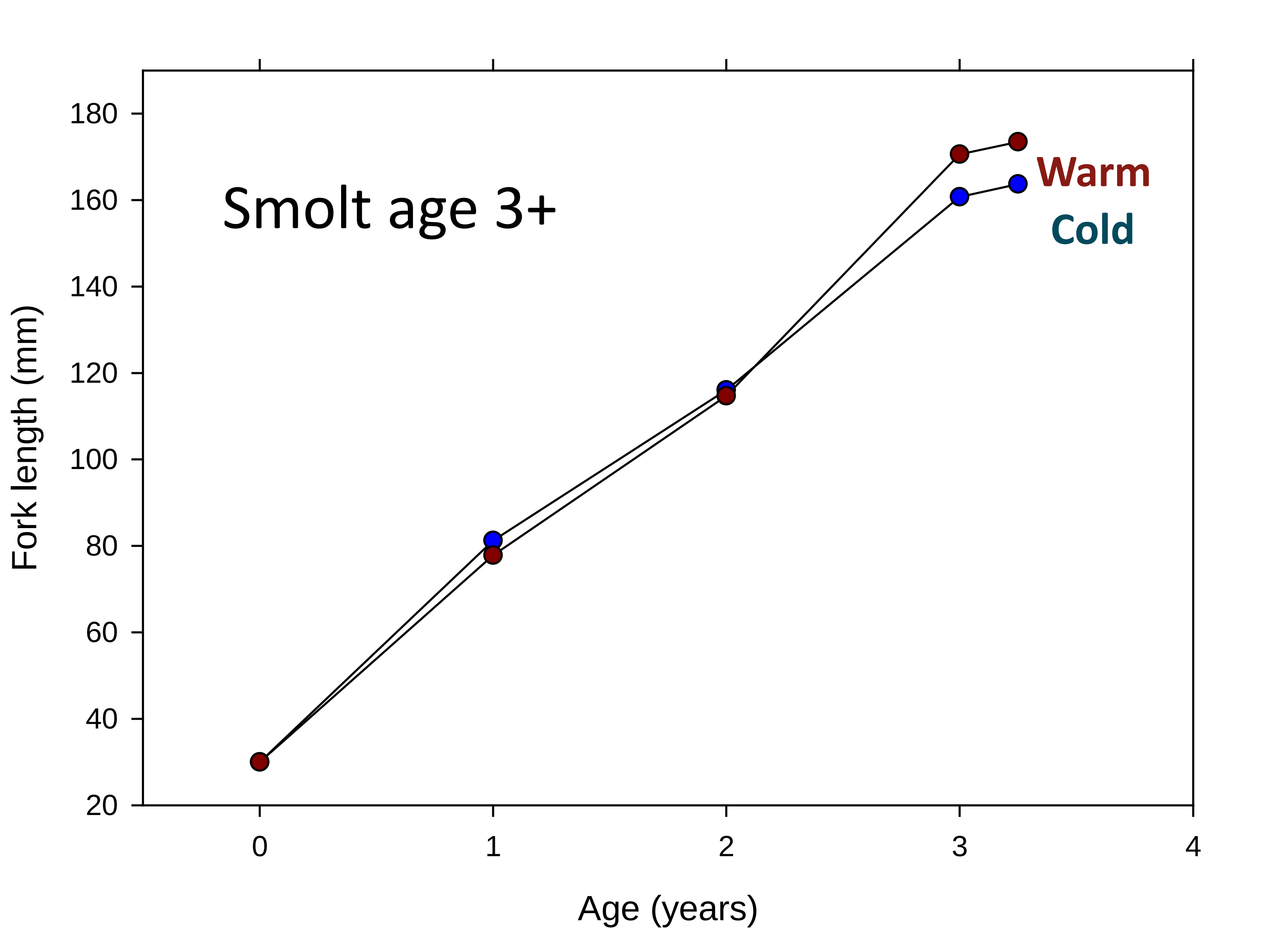
Sloat, Reeves, and Hansen. In prep.

# Clackamas River temperature regimes growth and smolt age




Sloat, Reeves, and Hansen. In prep.

# Clackamas River temperature regimes growth and smolt age



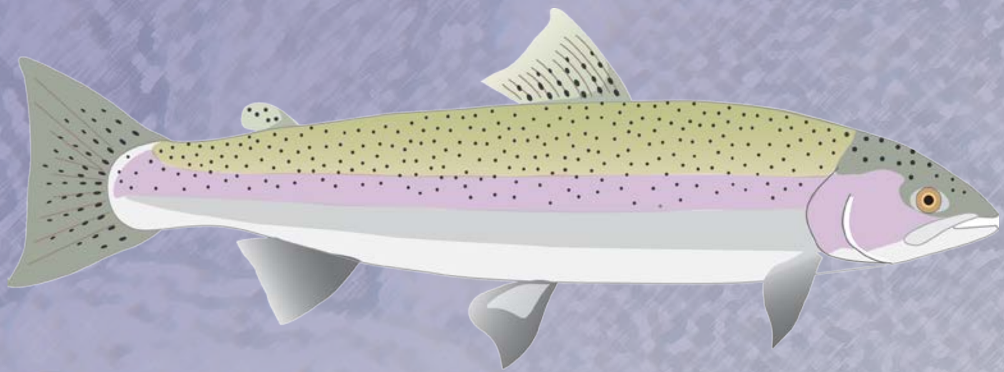

Sloat, Reeves, and Hansen. In prep.

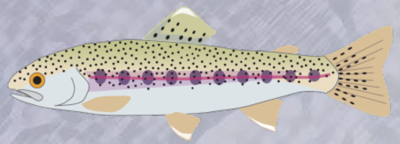
# Take homes

- Relatively simple models using size-at-age as an index of growth show promise for explaining patterns in diversity of anadromous life histories.

- Habitat heterogeneity, among other factors, promotes life history diversity by diversifying growth trajectories.

# Beyond fish size: energy allocation and resident and anadromous life histories



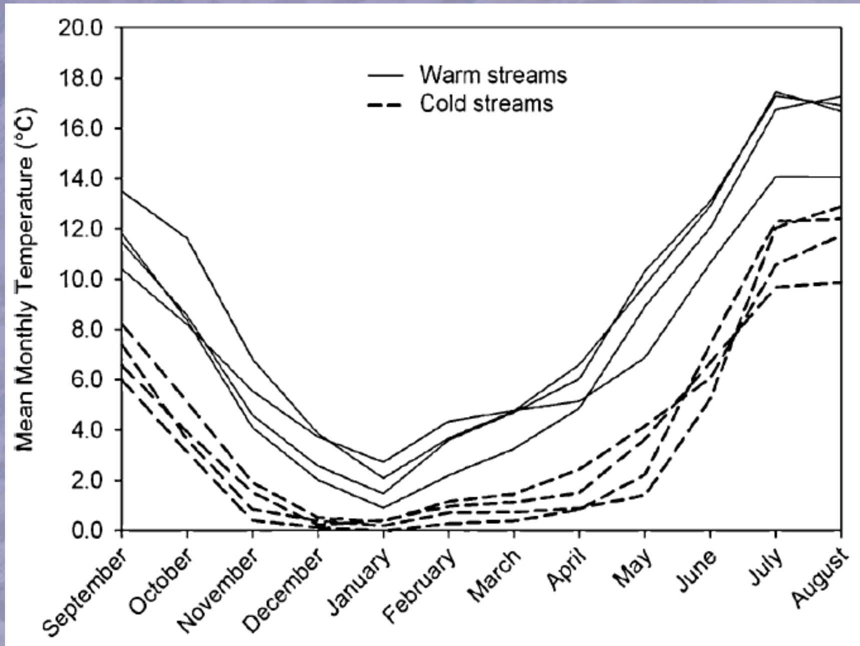


**Steelhead**
Anadromous life history

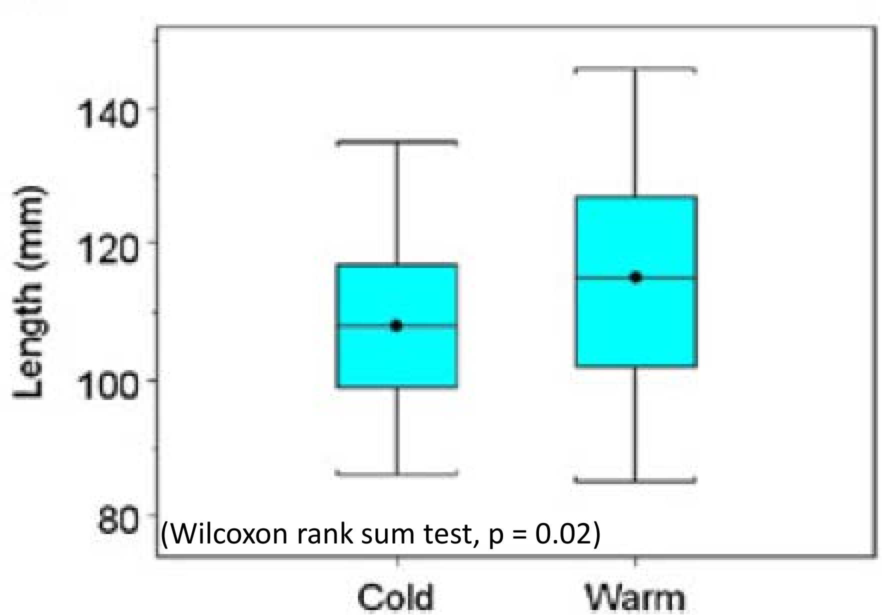
**Rainbow Trout**
Resident life history

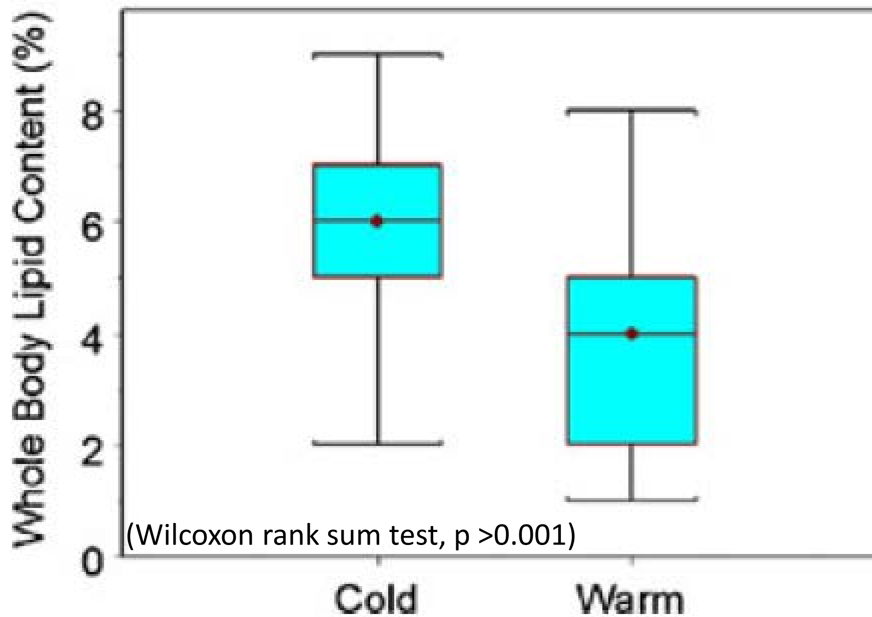
# Energy allocation tradeoffs John Day River O. mykiss

McMillan et al. (2011) Env. Bio. Fish.

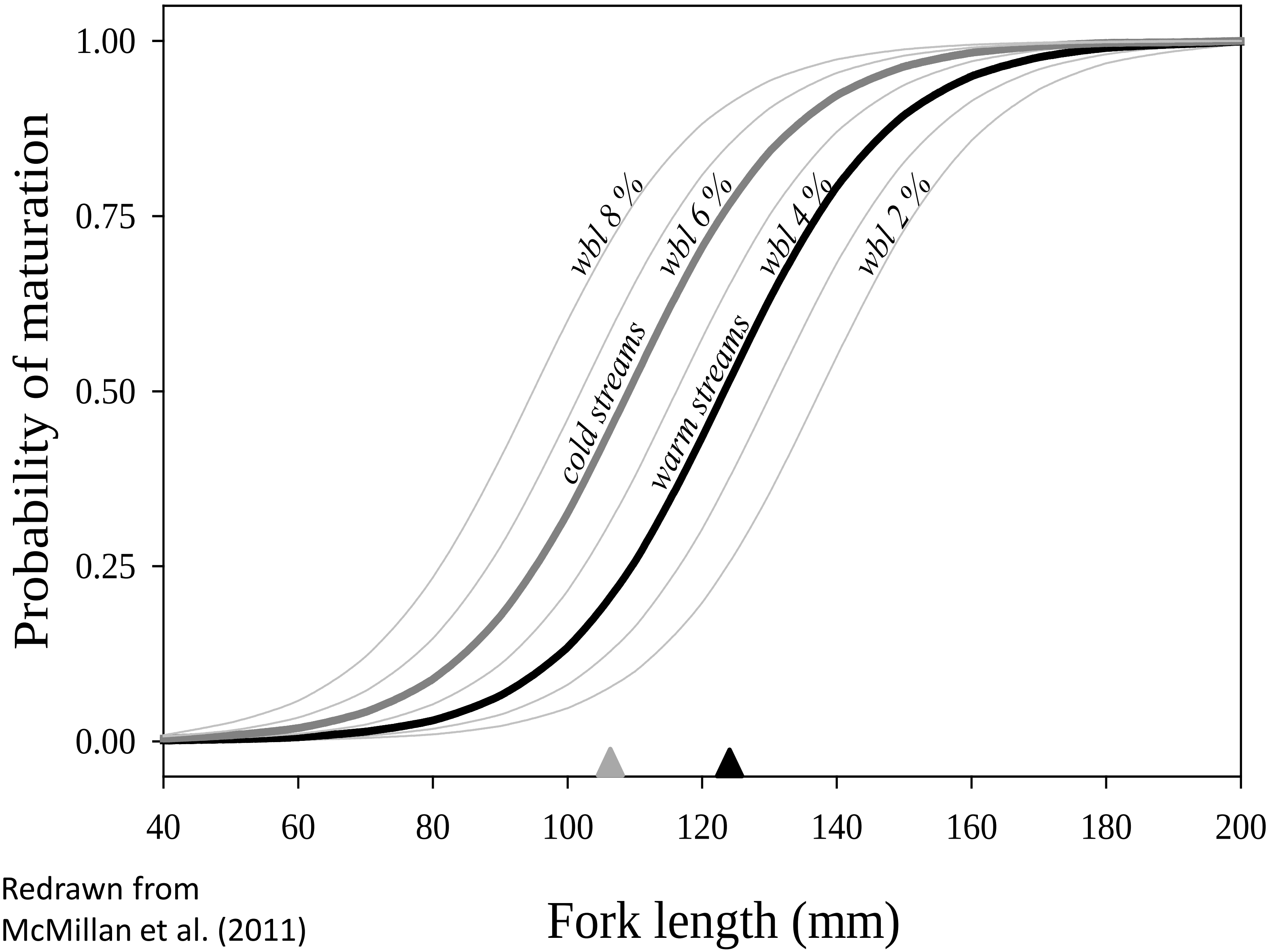



Lipid storage greater in cold streams and growth (i.e., length) greater in warm streams.



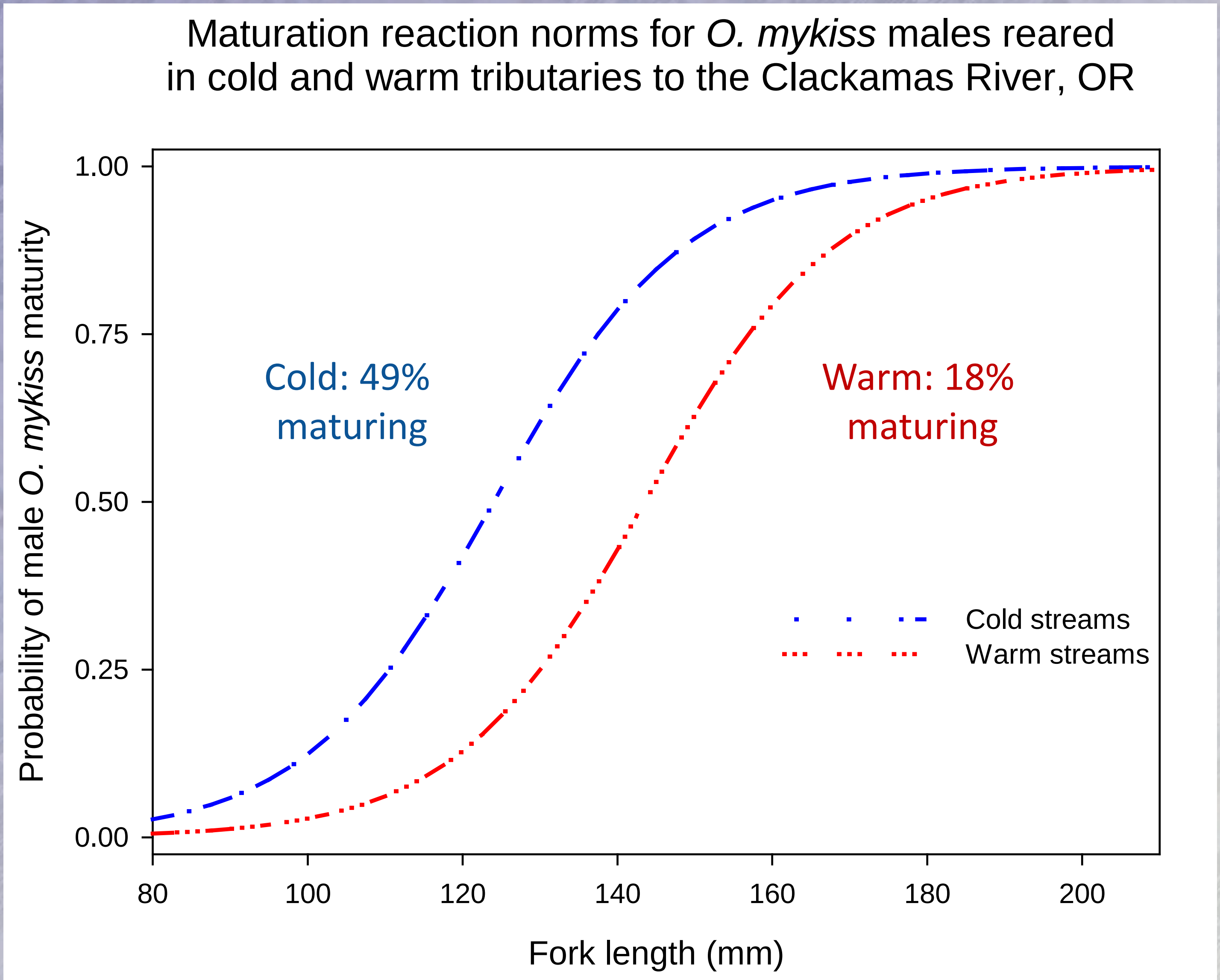



# Temperature changes body size thresholds for alternative life histories: John Day River




Redrawn from McMillan et al. (2011)

# Temperature changes body size thresholds for alternative life histories: Clackamas River




Sloat and Reeves. In Prep.

# Take homes

- Size-based models can be unreliable when transferred across growth environments, especially across temperature regimes.

- Cryptic (unmeasured) bioenergetic processes confound size-based thresholds for life histories.

## Summary

- Maintaining or restoring habitat heterogeneity is likely to promote life history diversity by diversifying growth trajectories.

- More work still needed to recognize and integrate the role of resident fish into management plans for steelhead.

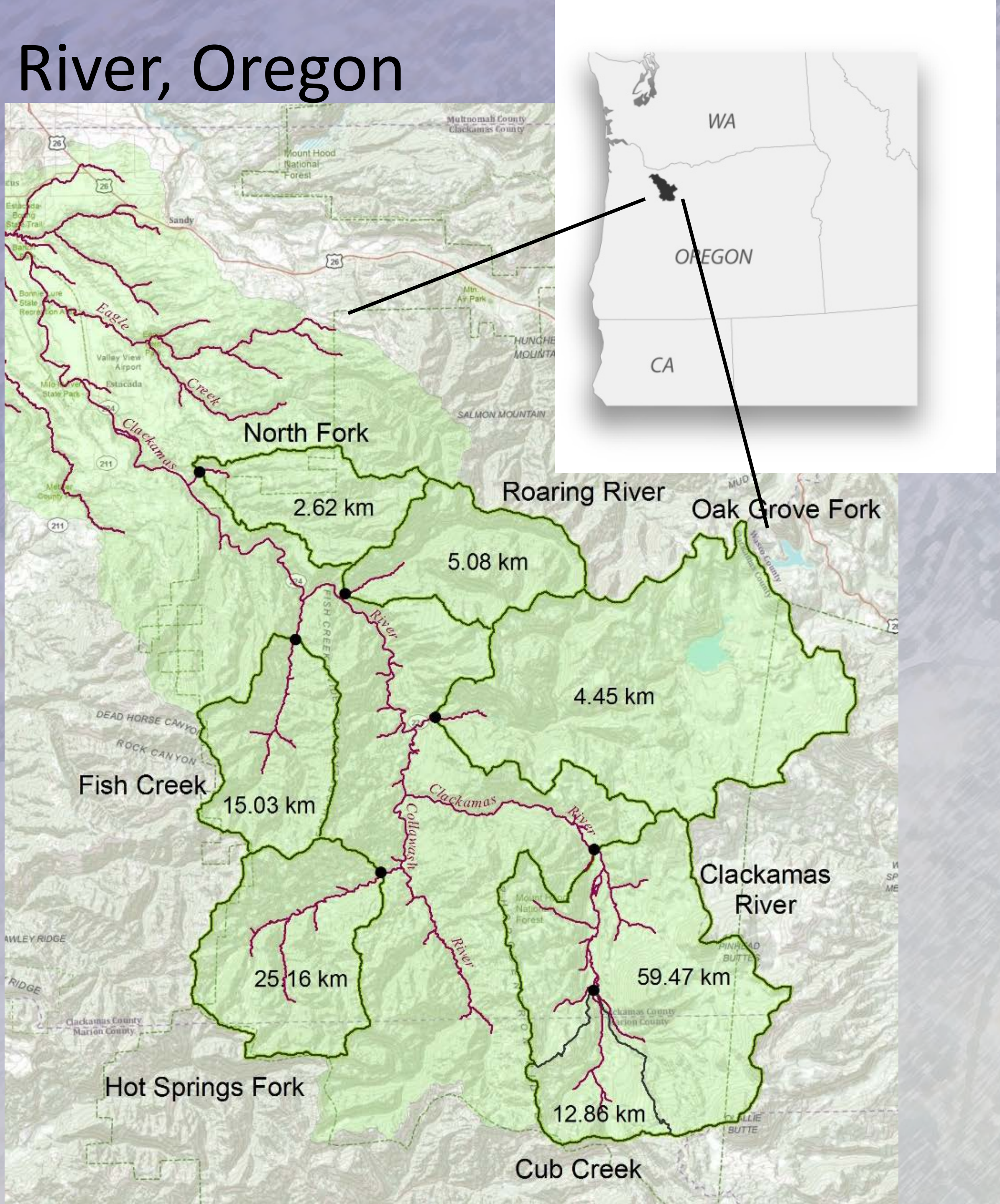
# Acknowledgements:

Thanks for field support: Jason Dunham, Haley Ohms, Loretta Ellenburgh, Tara Blackman, Daniel Trovillion, Kelly Christiansen.

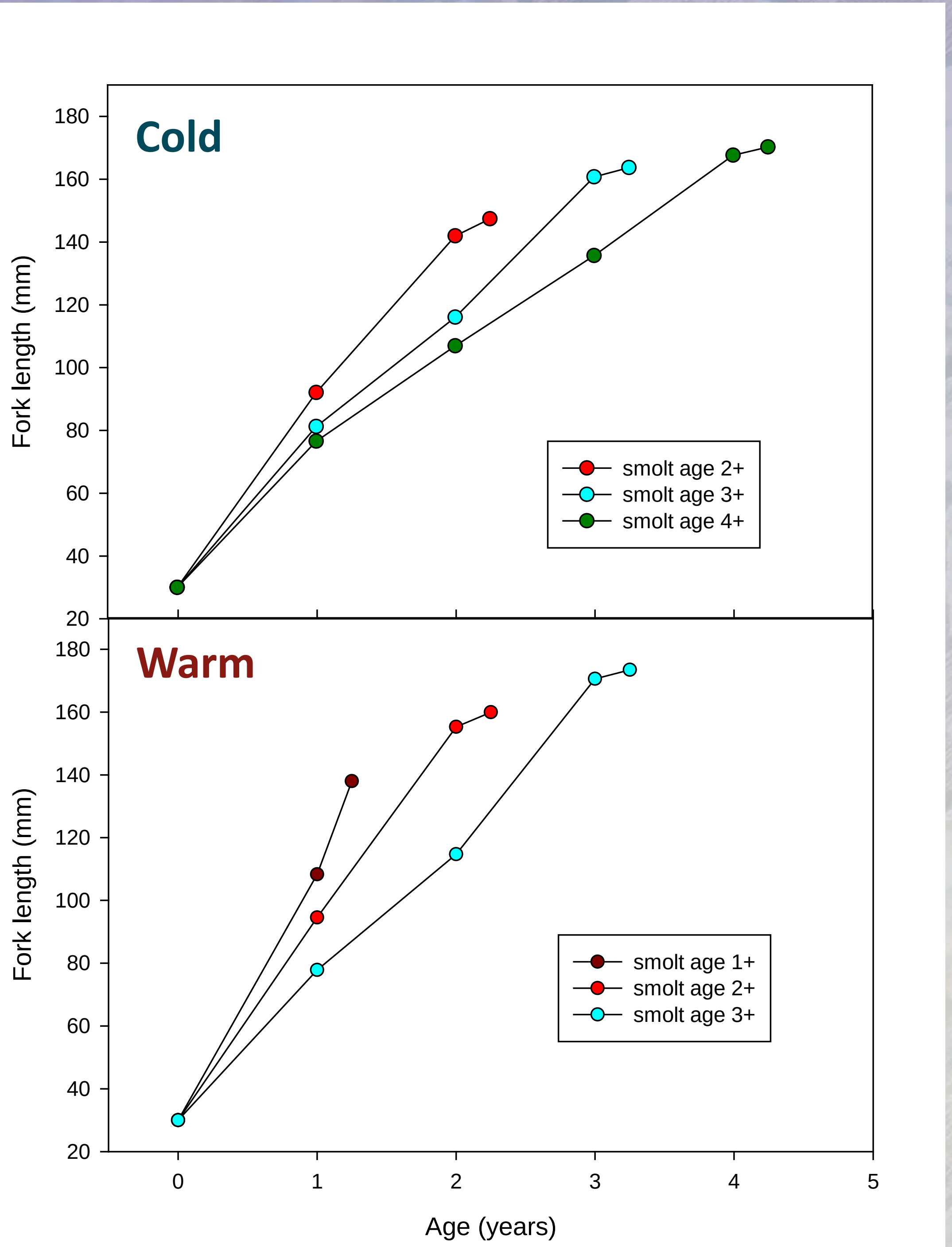
Thanks to the countless monitoring crews of the West Coast States and Provinces.

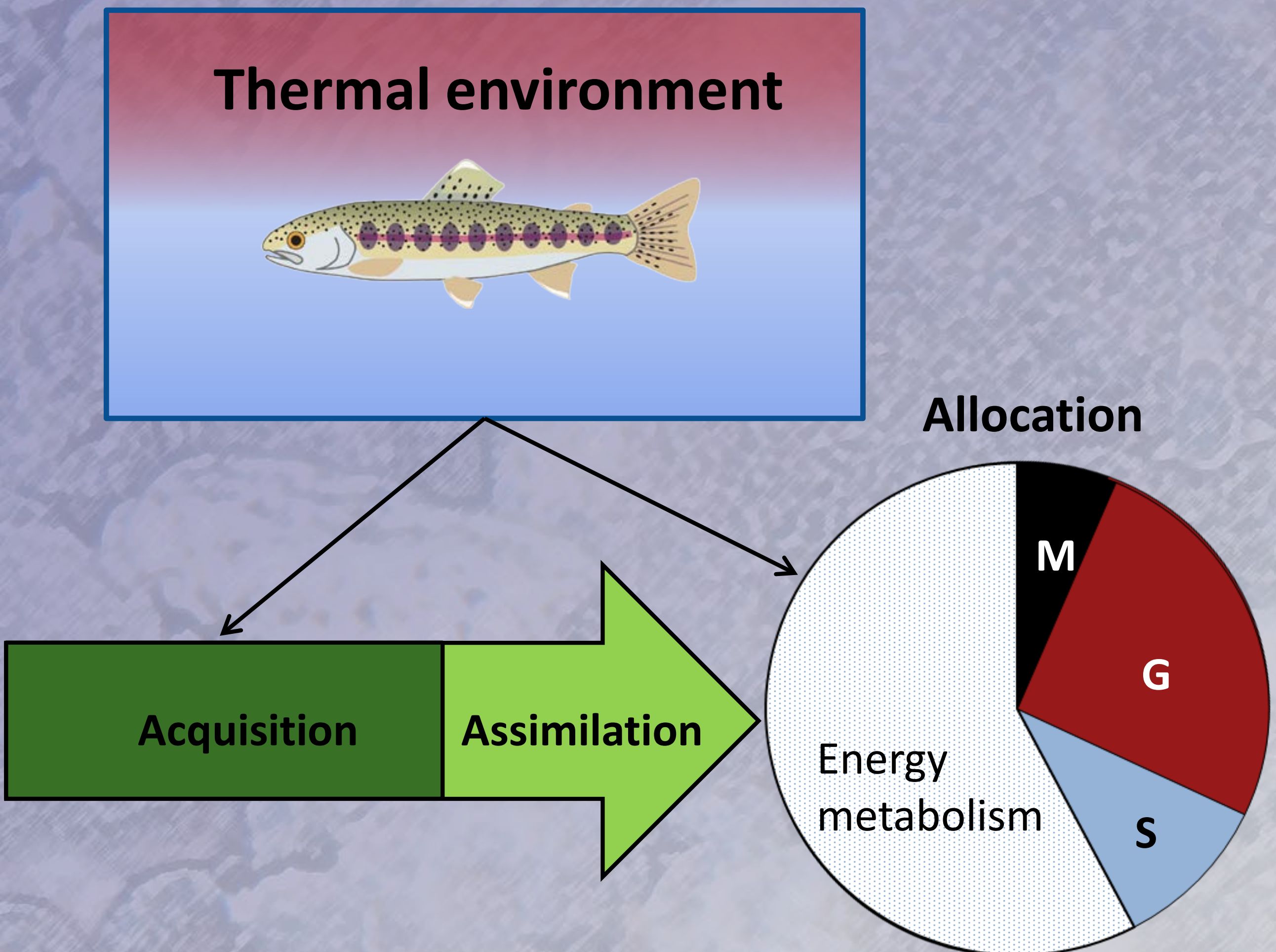
# Questions

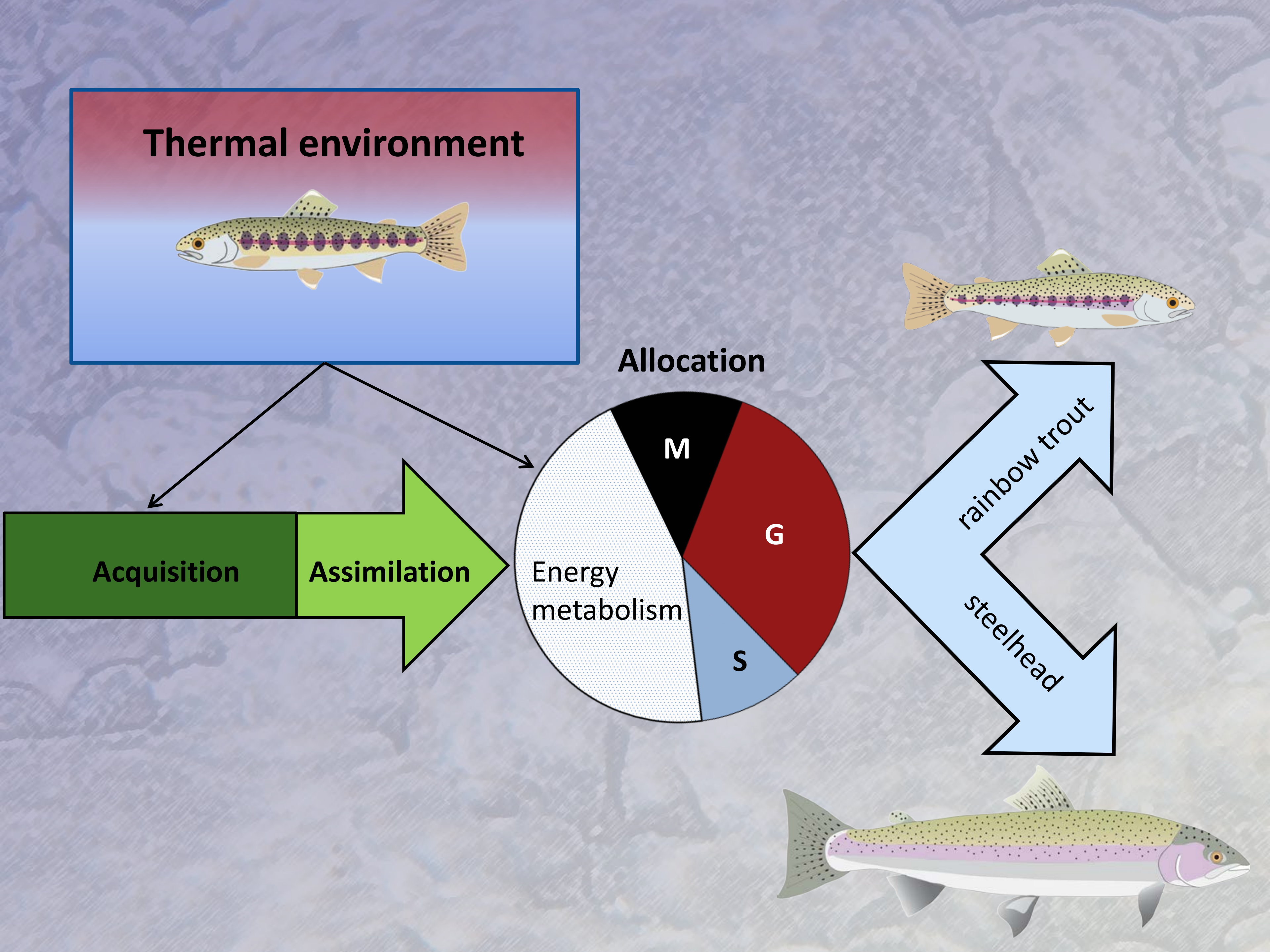
# Clackamas River, Oregon



# Clackamas basin thermal heterogeneity, fish growth, and smolt age



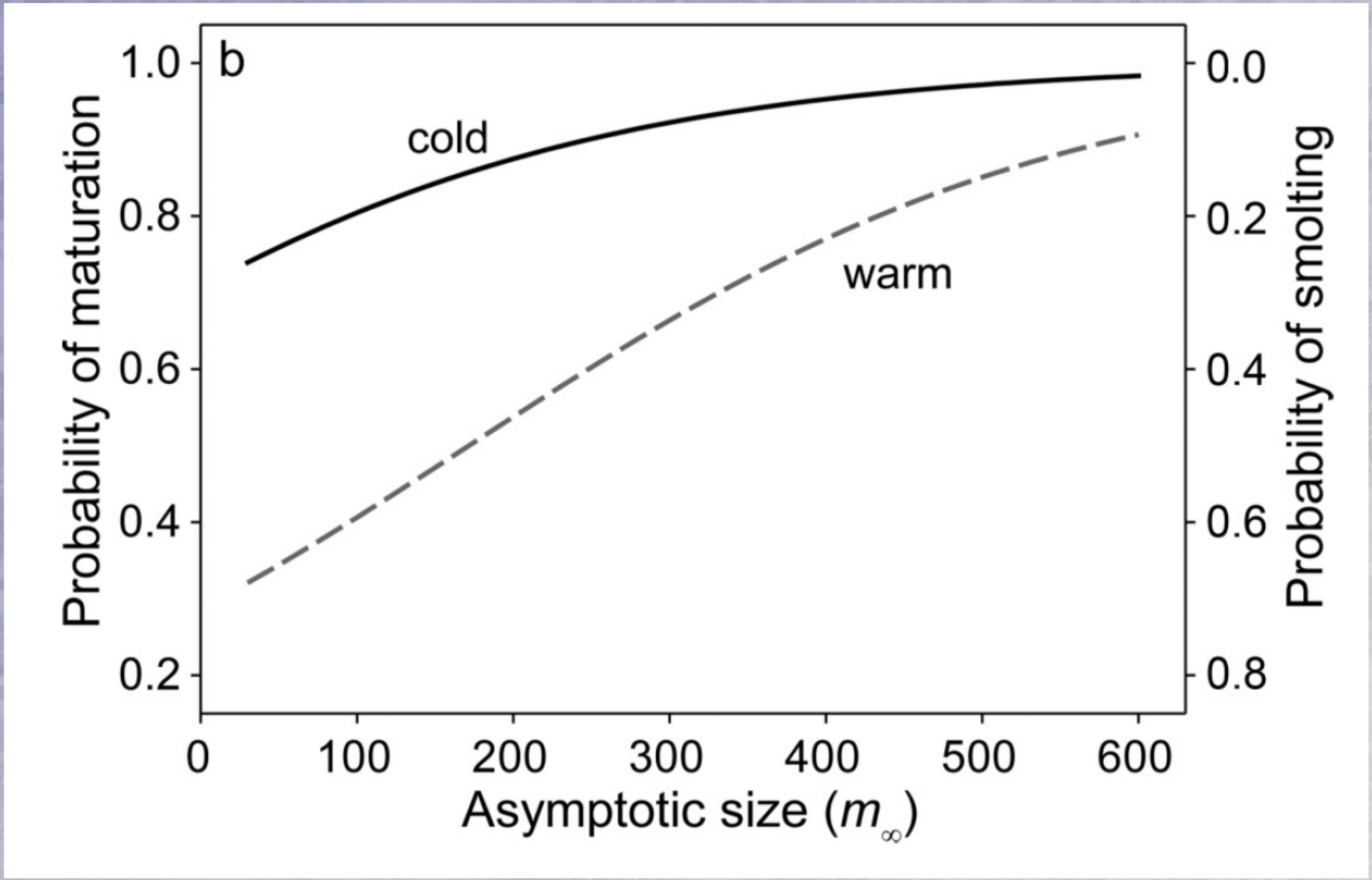

Thermal environment
Allocation
M
G
S
Energy metabolism
Acquisition
Assimilation



Thermal environment
Allocation
M
G
S
Energy
metabolism
Acquisition
Assimilation
rainbow trout
steelhead

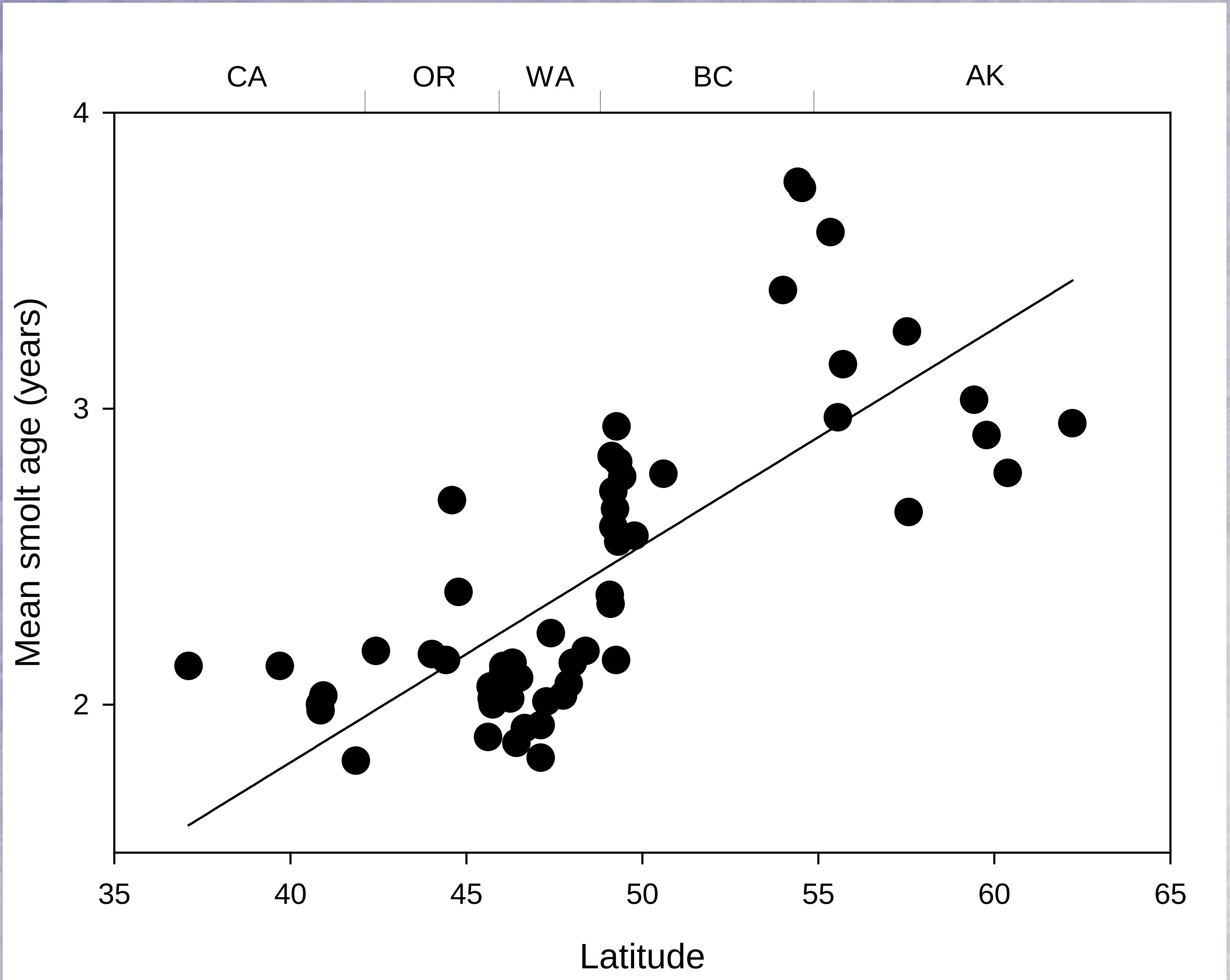
# Temperature changes body size thresholds for alternative life histories: Clackamas River lab

Temperature (-), Asymptotic size (+), Growth rate (+)



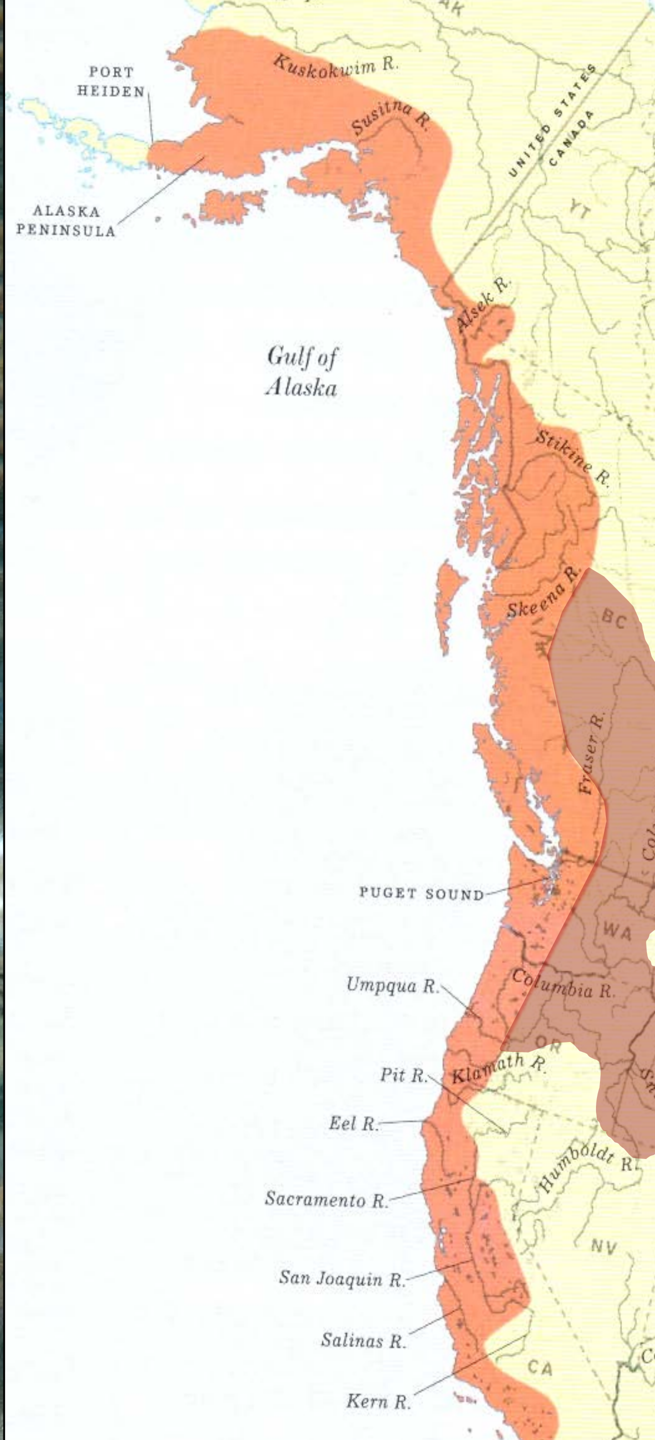

Sloat and Reeves (2014) CJFAS

# Increased steelhead smolt age with latitude



*O. mykiss* distribution

Allocation tradeoffs over geographic spatial scales?



# Pre-winter lipid stores in brown trout *Salmo trutta* along altitudinal and latitudinal gradients

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*Department of Biology, Norwegian University of Science and Technology (NTNU), NO-7491 Trondheim, Norway and ‡Norwegian Institute for Nature Research (NINA), NO-7485 Trondheim, Norway*

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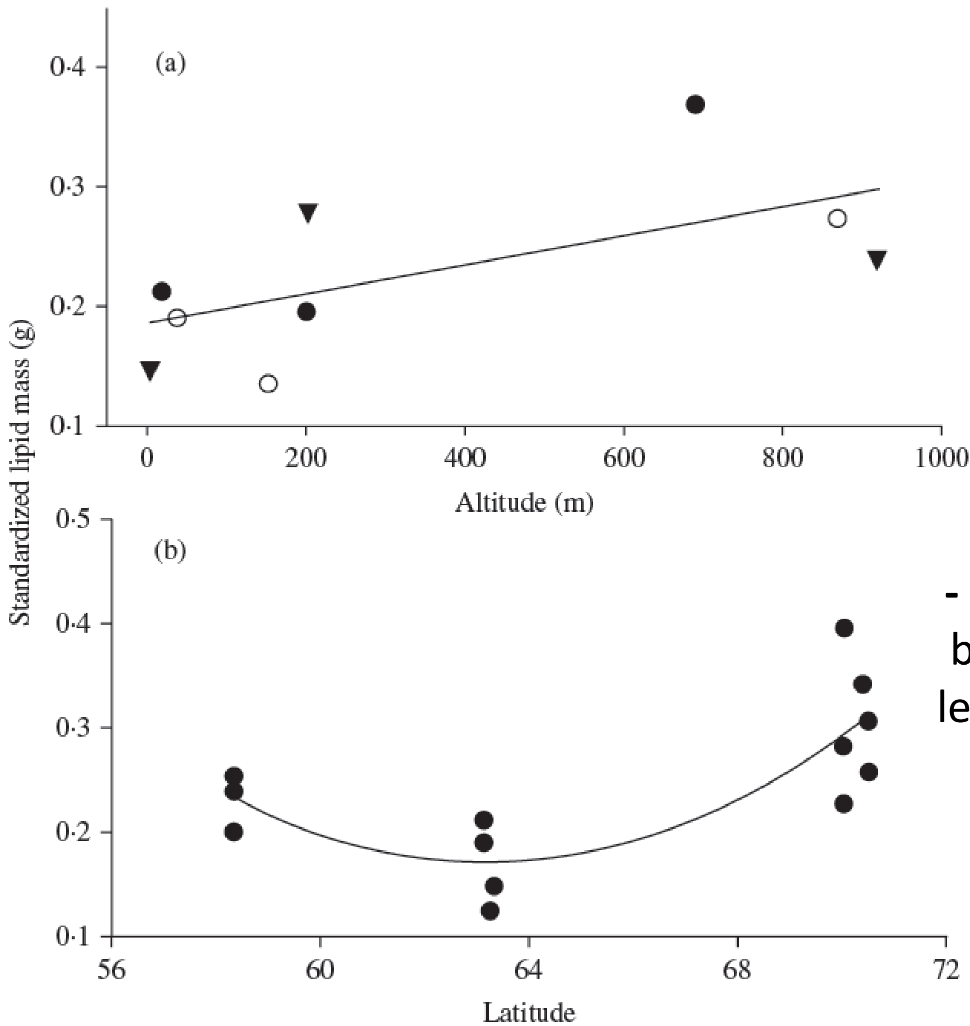
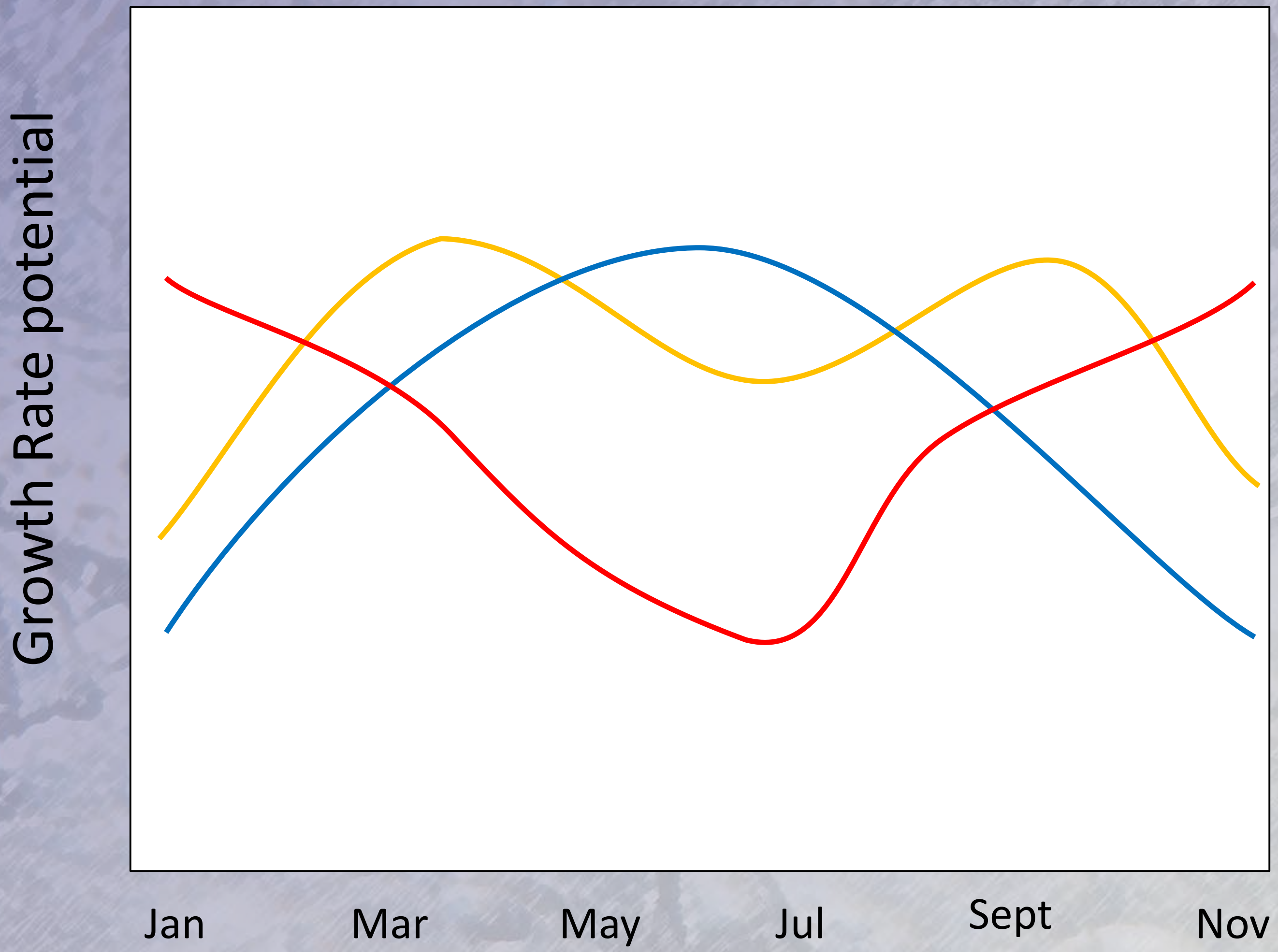


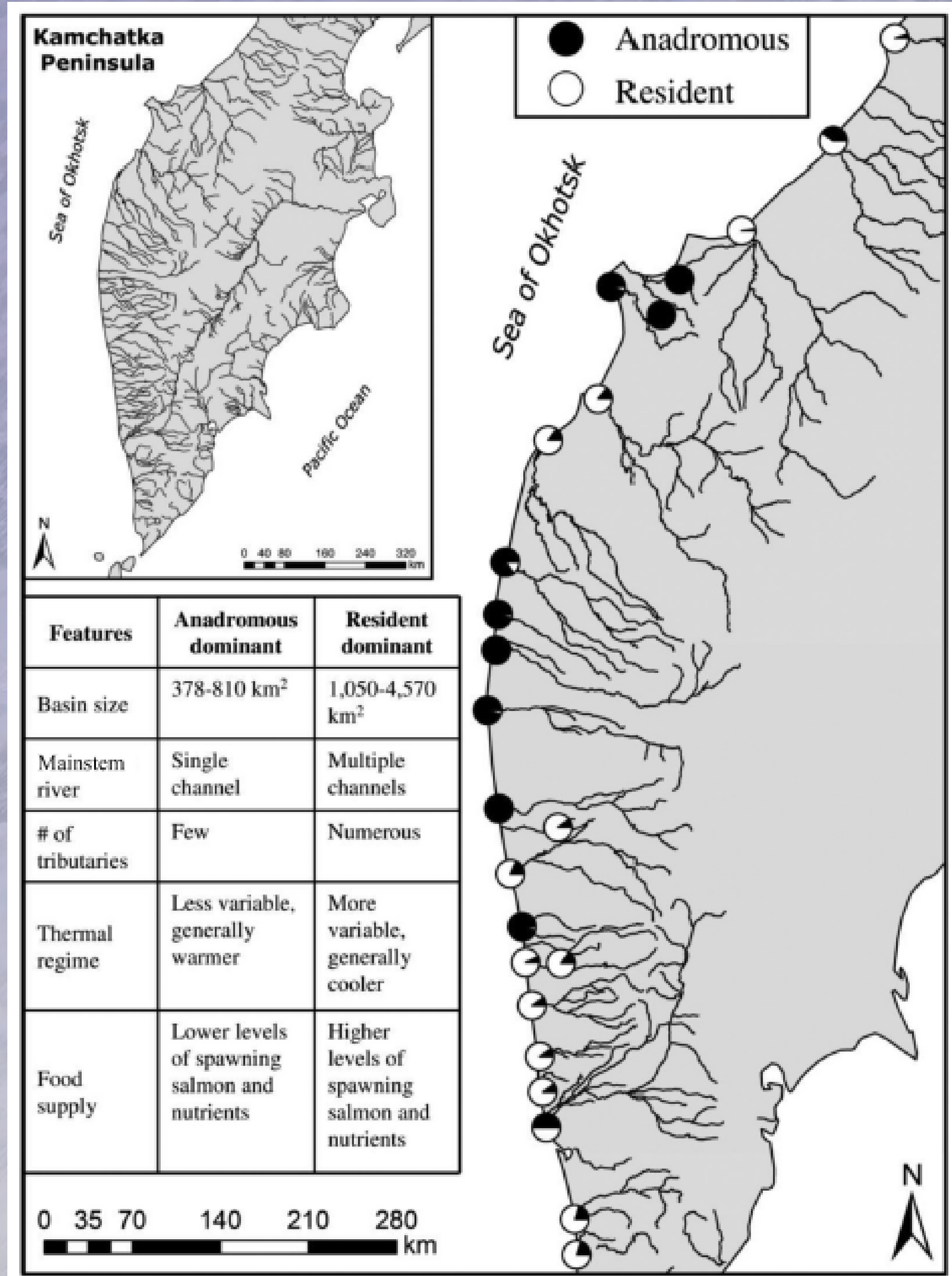

- 20% body length

# Feeding and Growth

## riverscape growth trajectories




Courtesy of Joe Ebersole



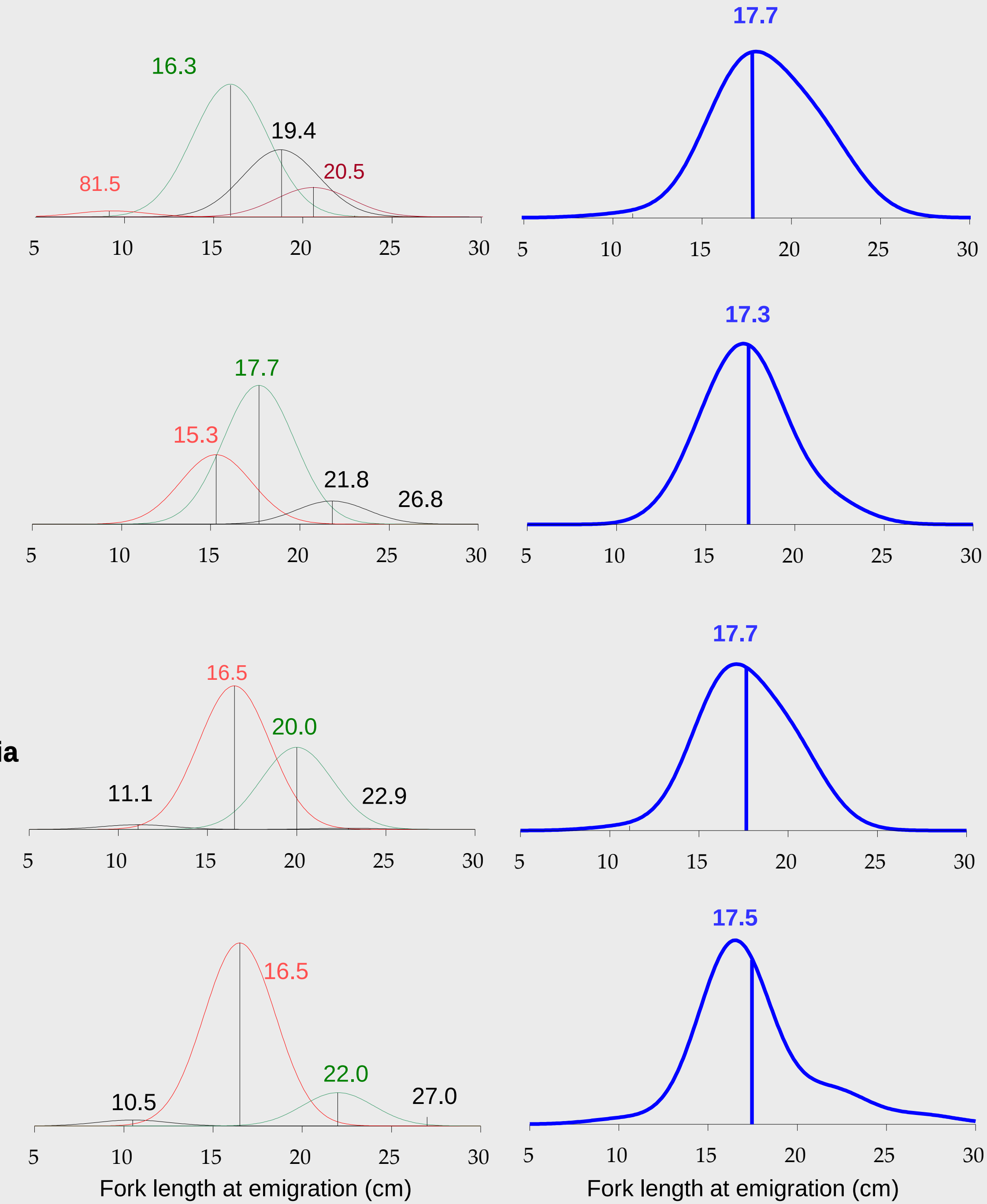

| Features | Anadromous dominant | Resident dominant |
| --- | --- | --- |
| Basin size | 378-810 $km^2$ | 1,050-4,570 $km^2$ |
| Mainstem river | Single channel | Multiple channels |
| # of tributaries | Few | Numerous |
| Thermal regime | Less variable, generally warmer | More variable, generally cooler |
| Food supply | Lower levels of spawning salmon and nutrients | Higher levels of spawning salmon and nutrients |

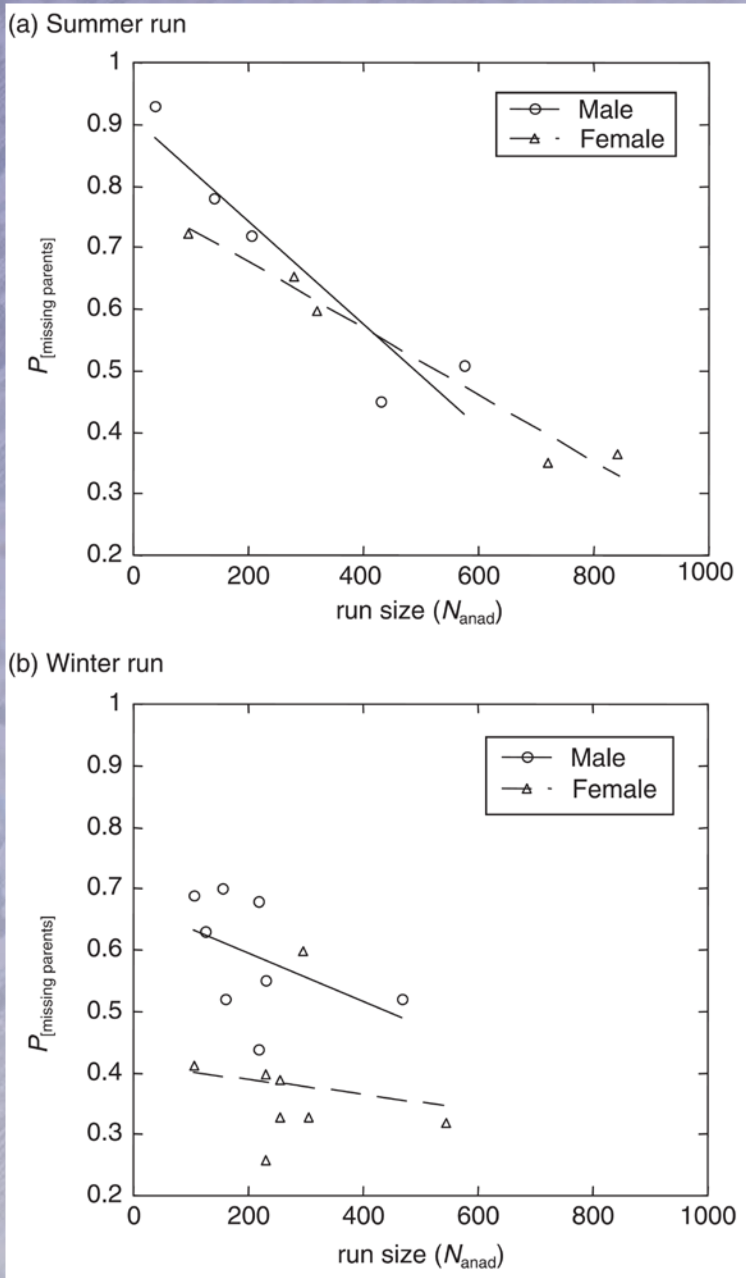
**Harding and Jones (1992)**
**Peterson Creek, Alaska**
**USA 58.4° N**

**Ward and Slaney (1988)**
**Keogh River, British Columbia**
**Canada 50.6° N**

**Maher and Larkin (1954)**
**Chiliwack River, British Columbia**
**Canada 49.1° N**

**Shapovalov and Taft (1954)**
**Waddel Creek, California**
**USA 37.1° N**






**Effective population size of steelhead trout: in**
**variance in reproductive success, hatchery prog**
**genetic compensation between life-history for**

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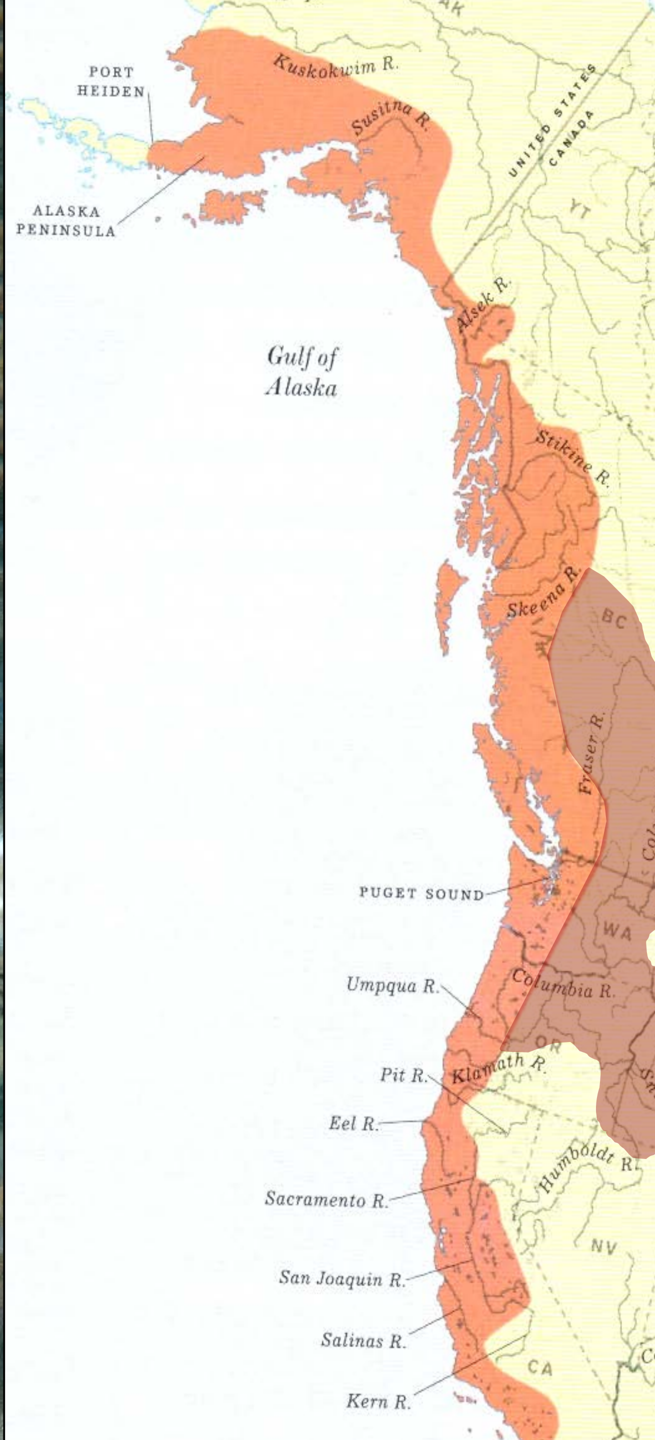
*O. mykiss* distribution

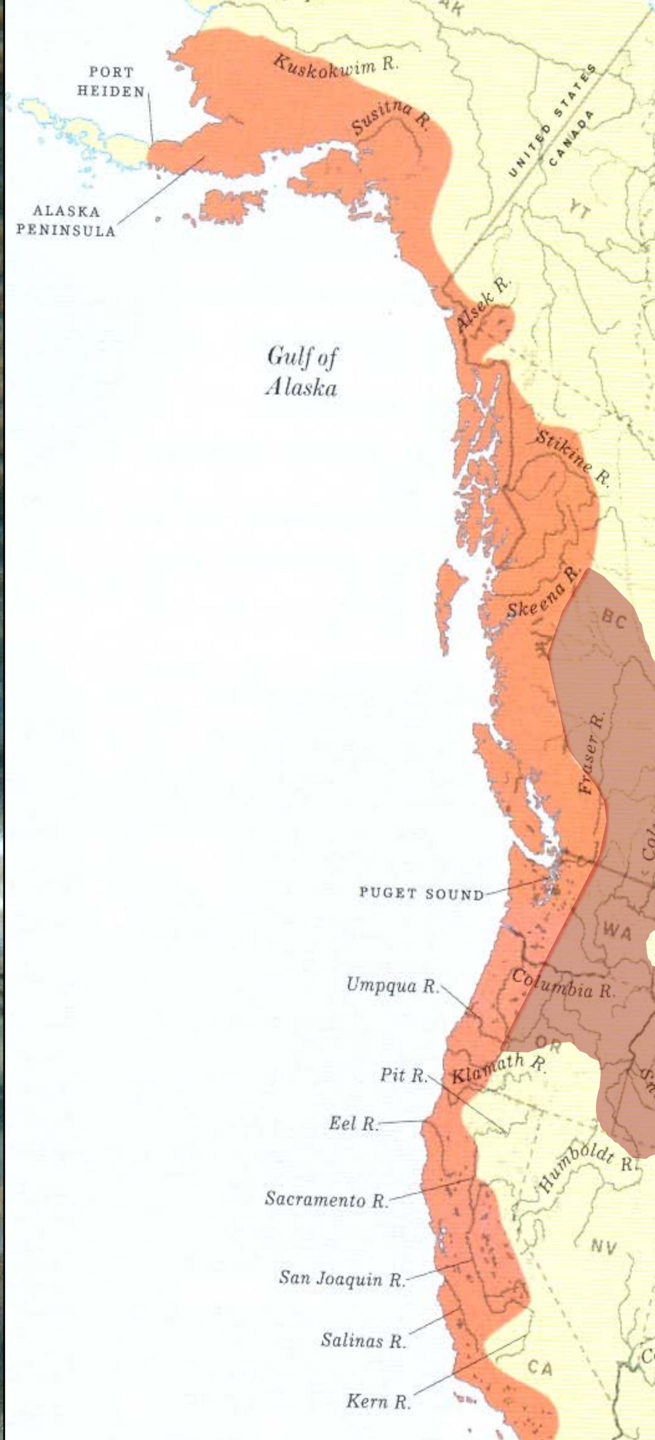
Anadromous populations span a latitudinal range of ~ 30 ° (34° – 62 ° N)

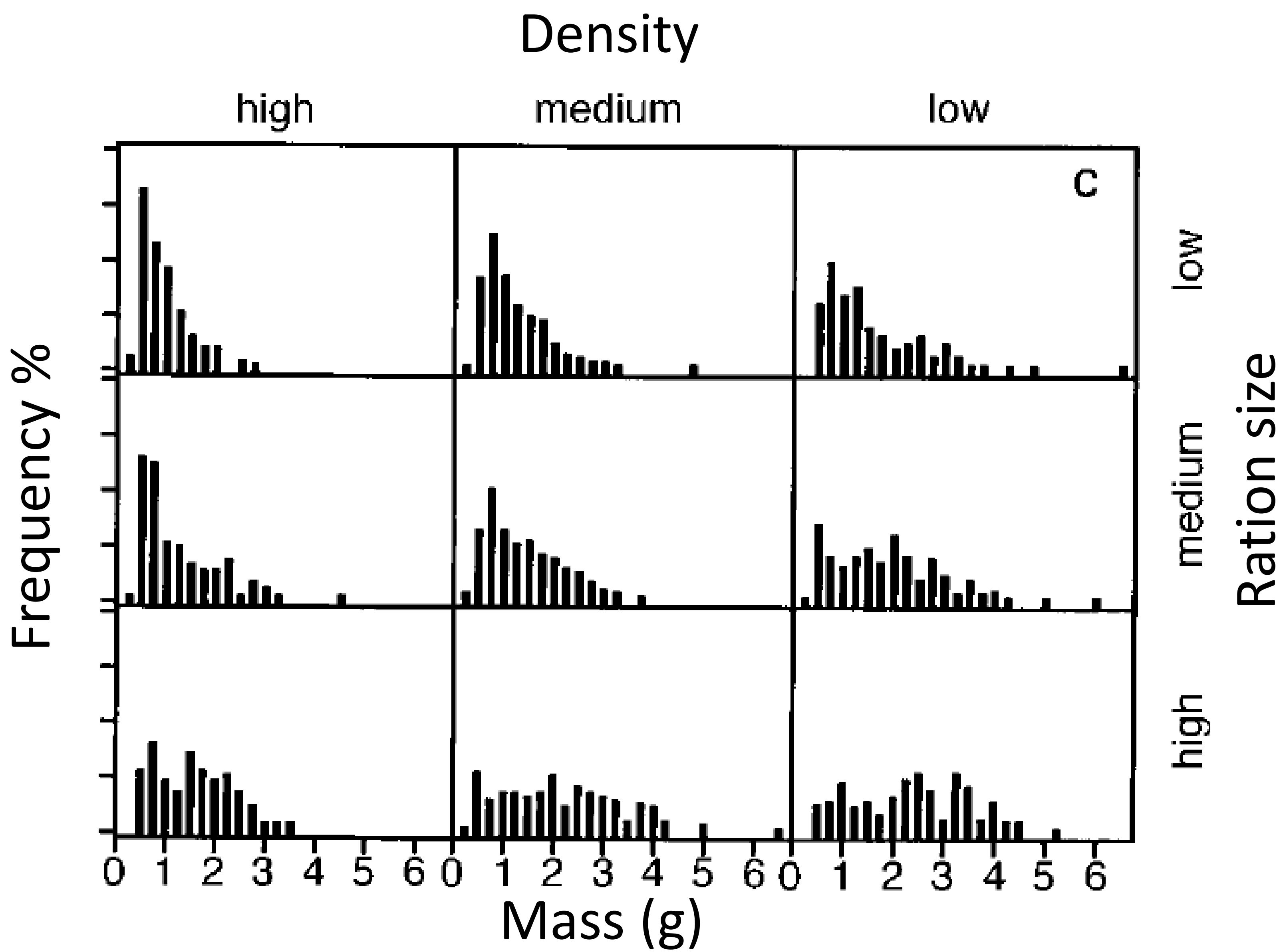
Diversity in age at smolting (1 – 5 years)



# *O. mykiss* distribution

How does mean and variance in smolt age and smolt size change across North American populations?



Density
high
medium
low
c
low
medium
high
Ration size
Frequency %
0 1 2 3 4 5 6
0 1 2 3 4 5 6
0 1 2 3 4 5 6
Mass (g)

# How are we losing the parts?

- Taking down the stage: loss of floodplains

J. R. Sedell & J. L. Froggatt, Importance of streamside forests 1831

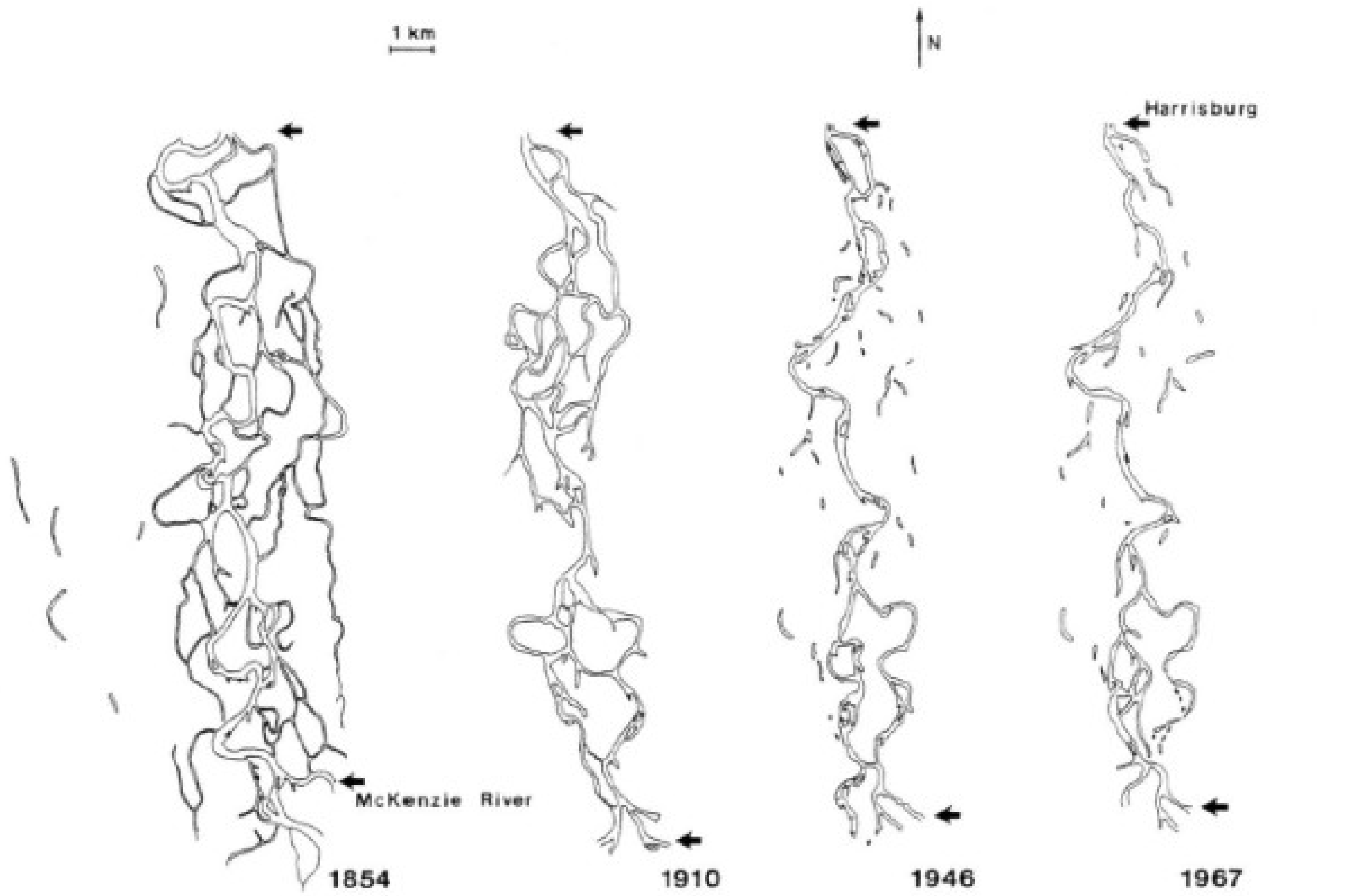
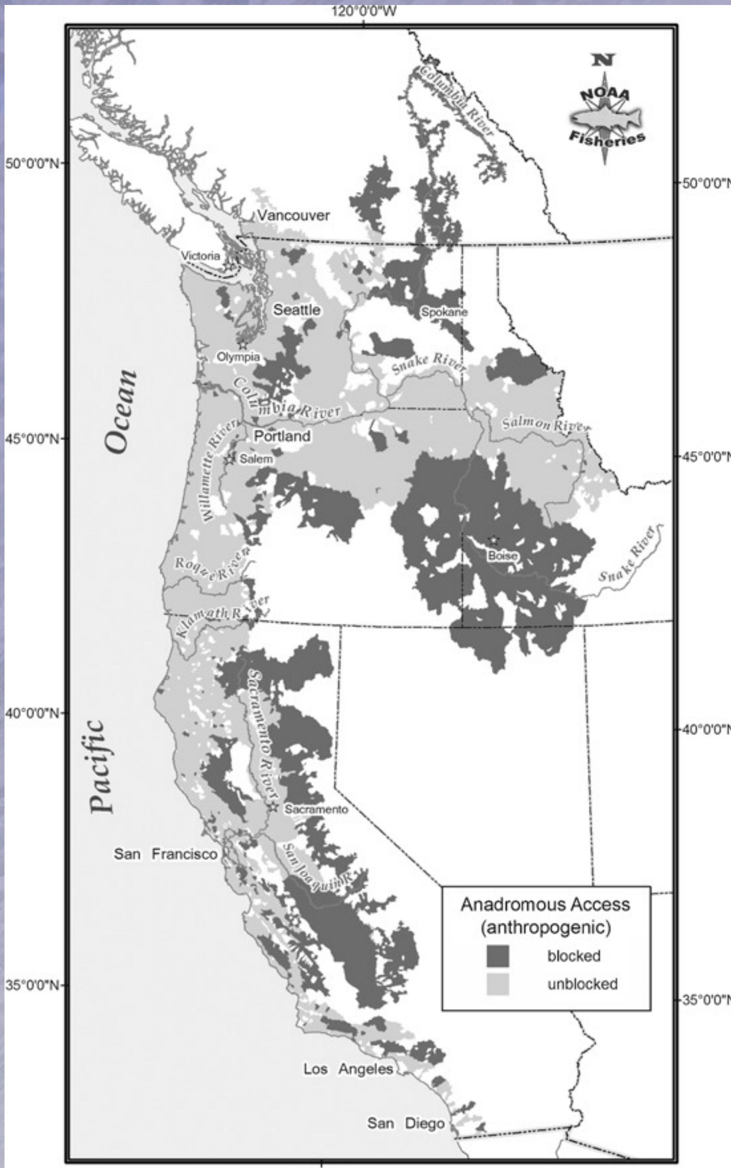
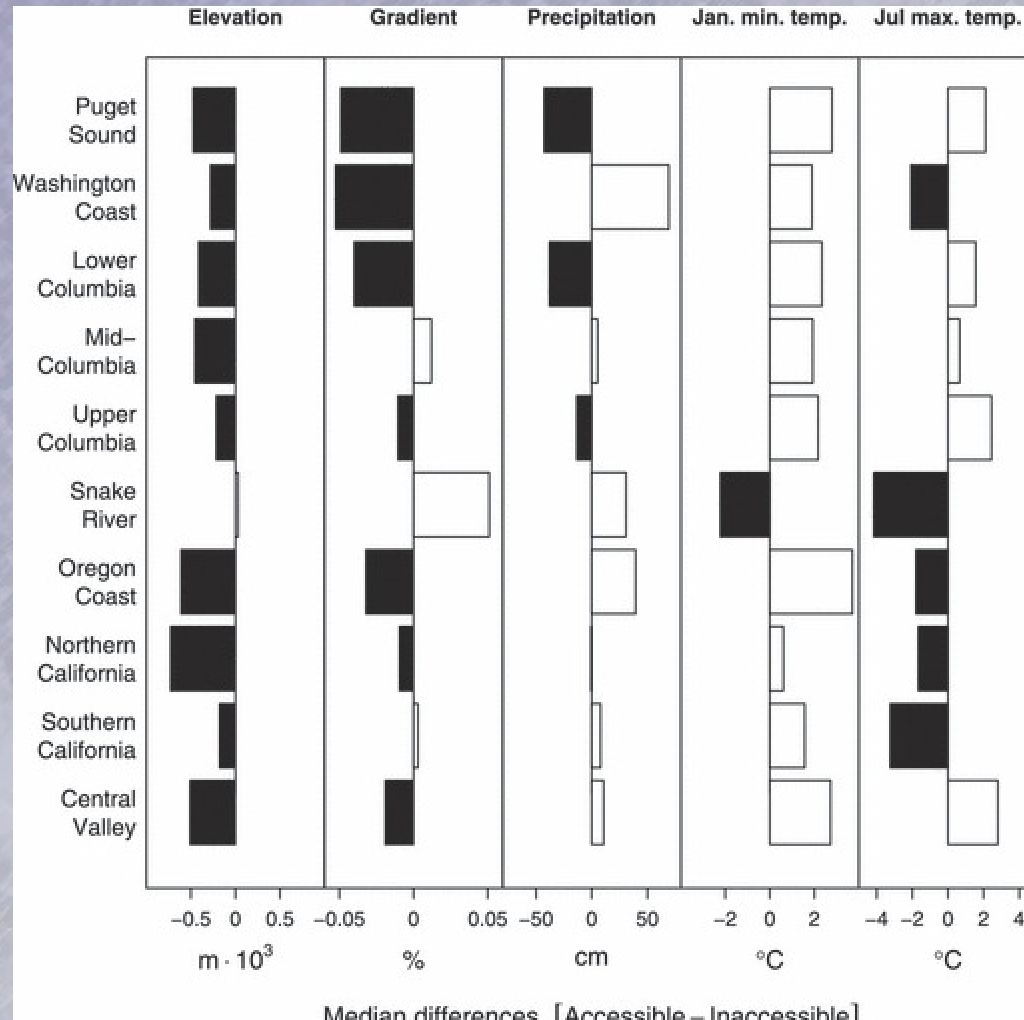



Fig. 2. The Willamette River from the McKenzie River confluence to Harrisburg, showing reduction of multiple channels and loss of shoreline 1854—1967.

# How are we losing the parts?

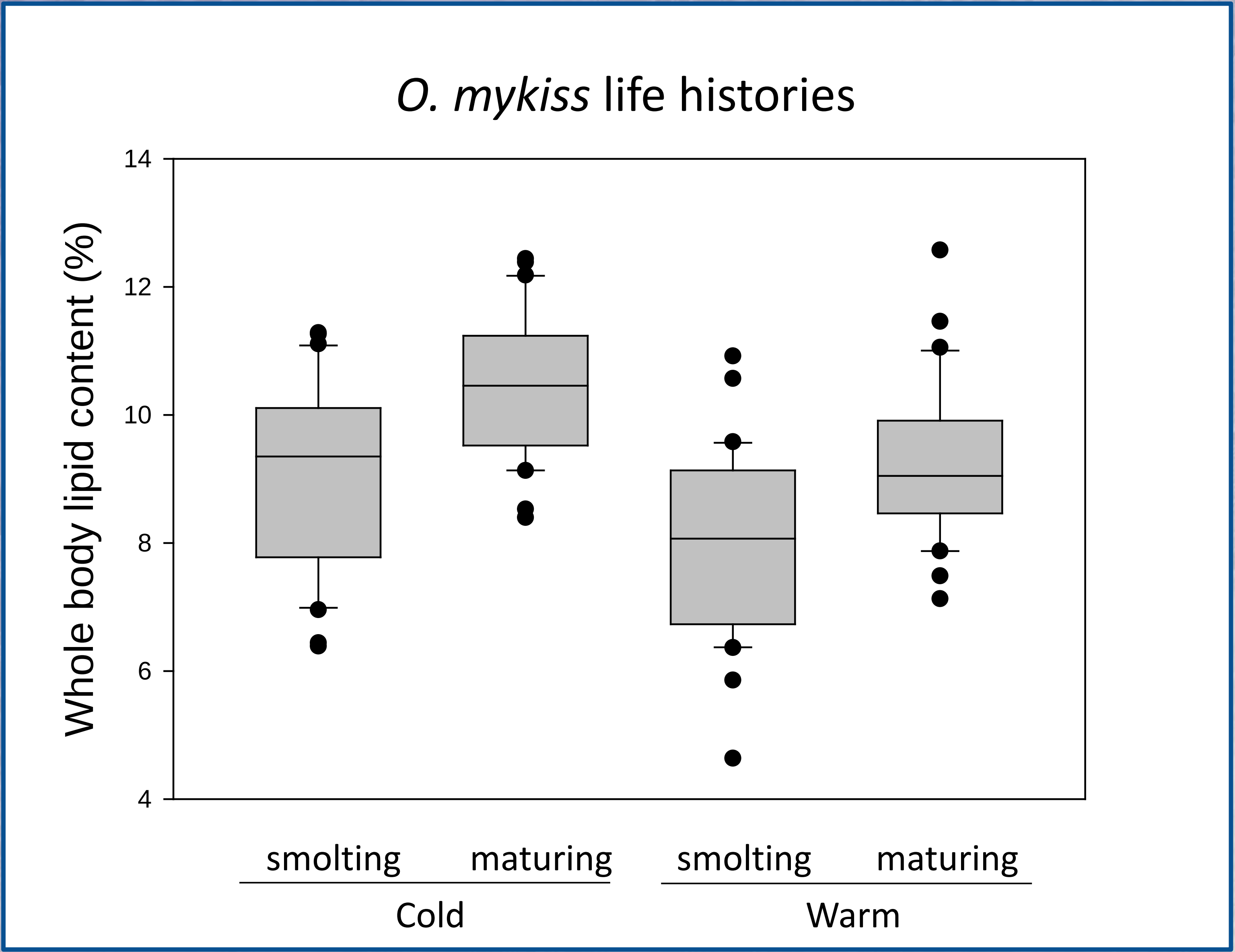
- Taking down the stage: loss of headwaters




http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3352431/

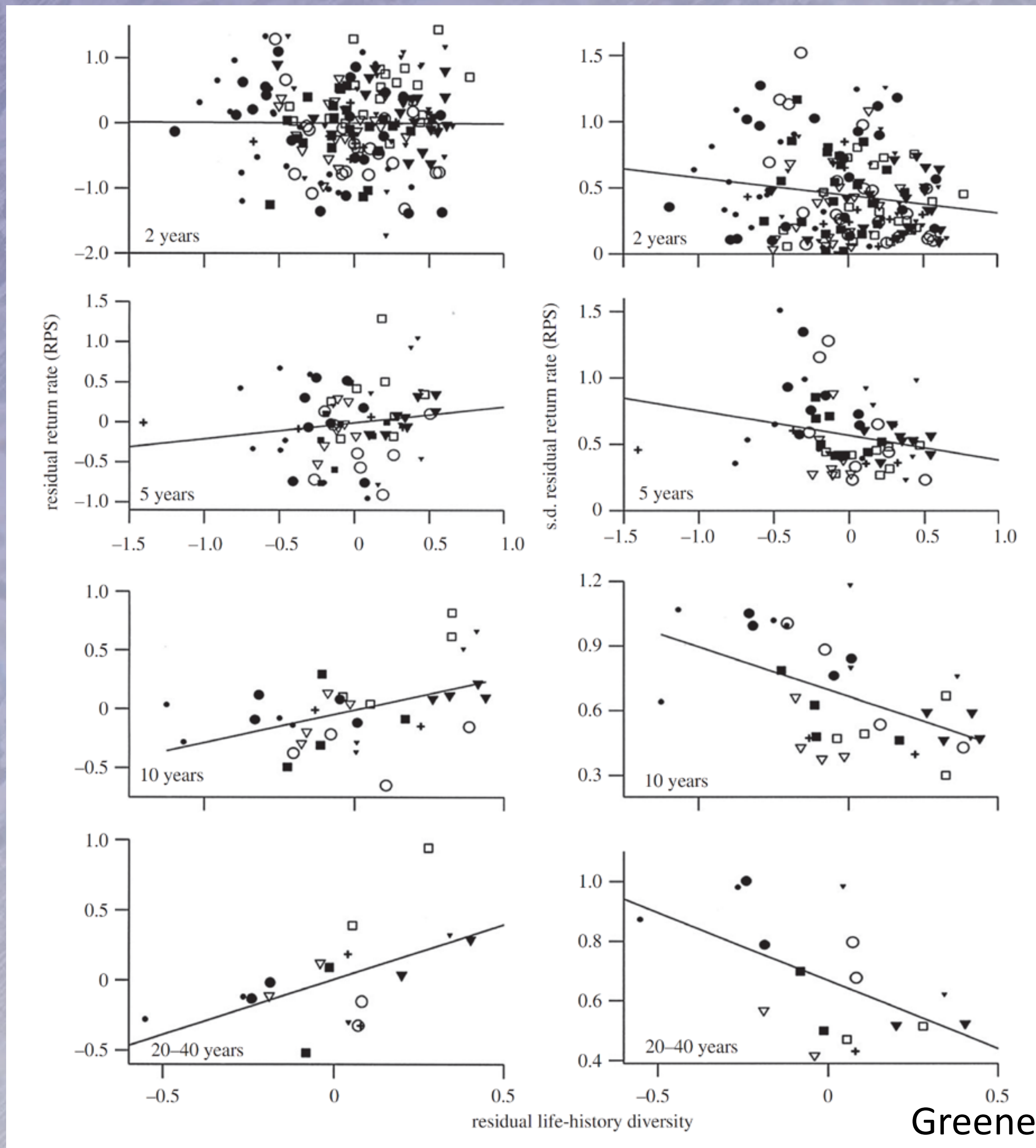
# Is fat where it's at?




Sloat and Reeves 2014. CJFAS

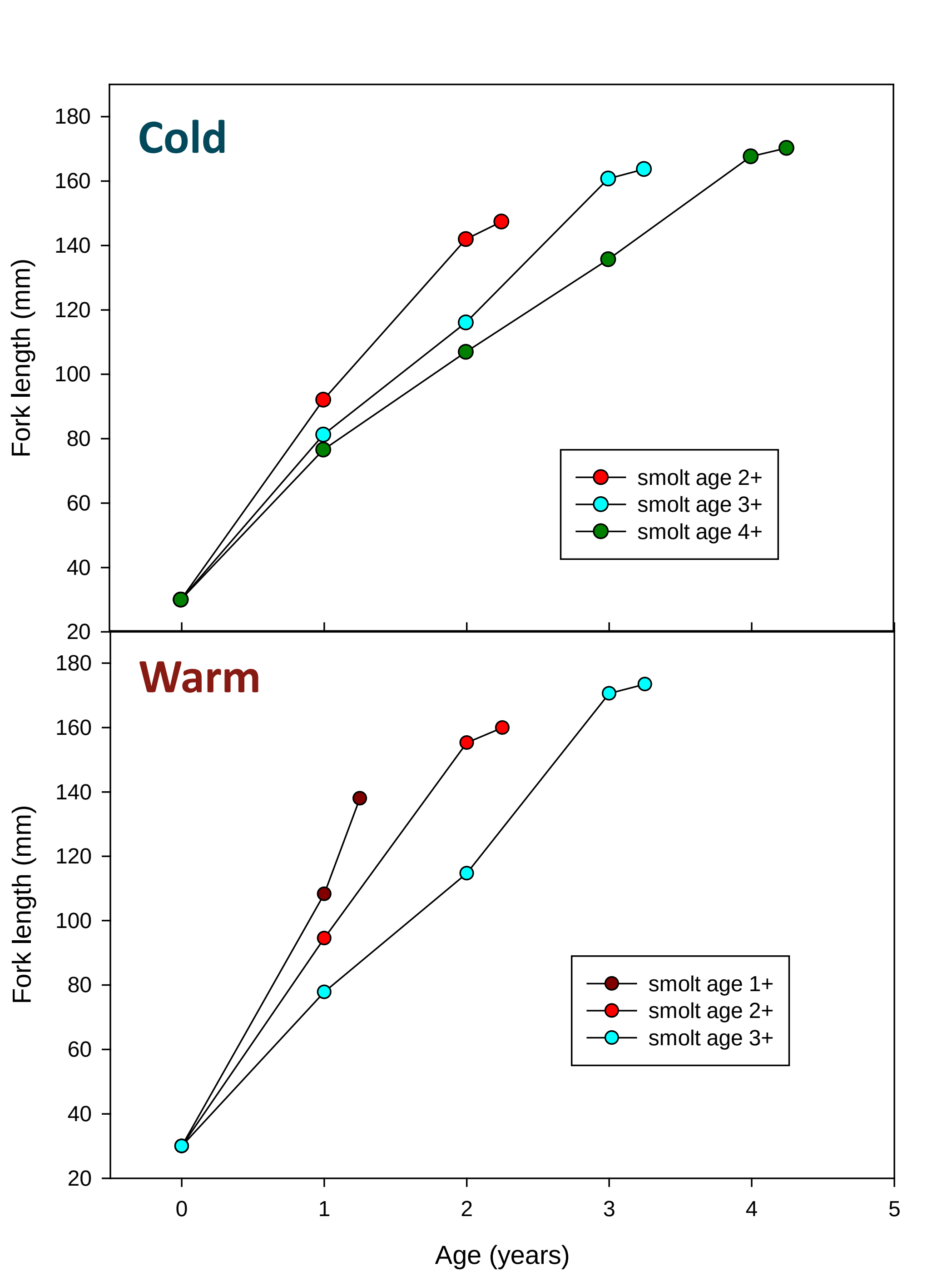
Population productivity | Variation in Productivity

Increased time




Greene et al. 2010. Biol. Letters

# Clackamas basin thermal heterogeneity, fish growth, and smolt age




Sloat, Reeves, and Hansen. In prep.