Reach-scale productivity of spring Chinook salmon in the Upper Yakima River Basin

Christopher Johnson
Nick Mankus
Tim Webster

Washington Department of Fish and Wildlife
Ecological Interactions Team
Ellensburg, Washington

Life-stage specific measures of productivity

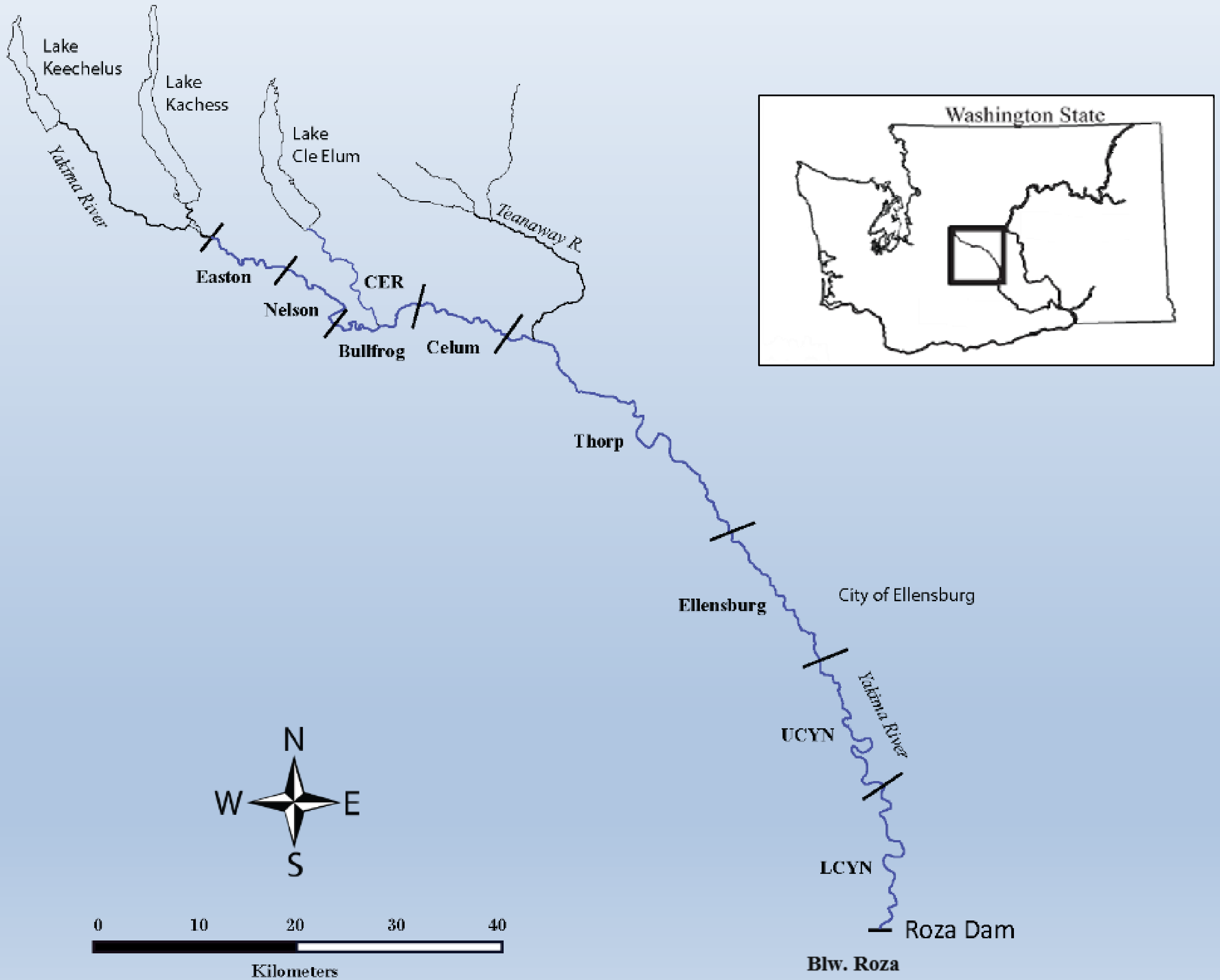
Spring Chinook Competition and Capacity Project

Focus: Identifying and evaluating differences in survival, development, and growth, attributable to environmental factors; over large spatial and temporal scales

- Incubation
- Swim-up and emergence
- Post-emergence
- Summer parr



Study Area



Lake Keechelus
Lake Kachess
Lake Cle Elum
Yakima River
Teanaway R.
Washington State
Easton
Nelson
CER
Bullfrog
Celum
Thorp
Ellensburg
City of Ellensburg
Yakima River
UCYN
LCYN
Roza Dam
Blw. Roza
N
W
E
S
0
10
20
30
40
Kilometers

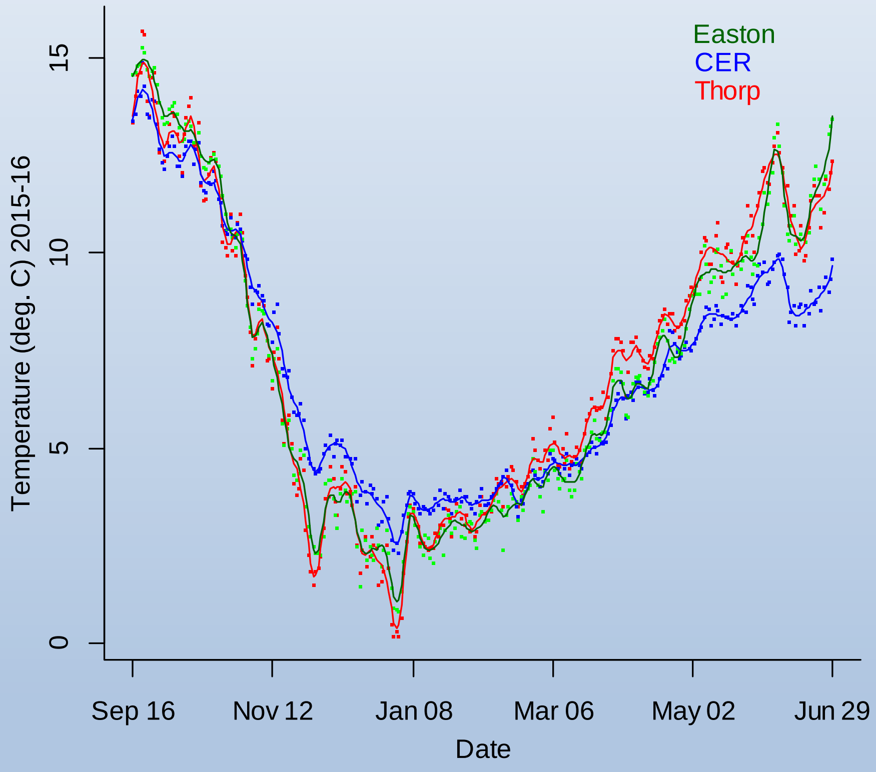
Post emergence growth

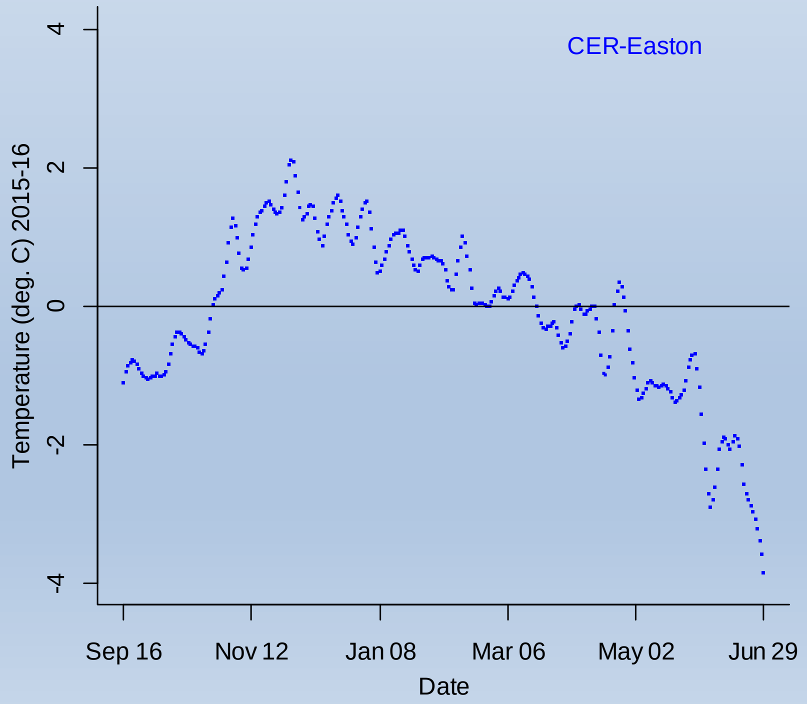
- March – early June
- Spring Chinook fry ~ 30 -70 millimeters in length

- Subset of factors potentially affecting growth in this time period:
  - Temperature (magnitude, variability)
  - Physical habitat suitability (e.g. cover, depth)
  - Flow (magnitude, variability)
  - Density dependence

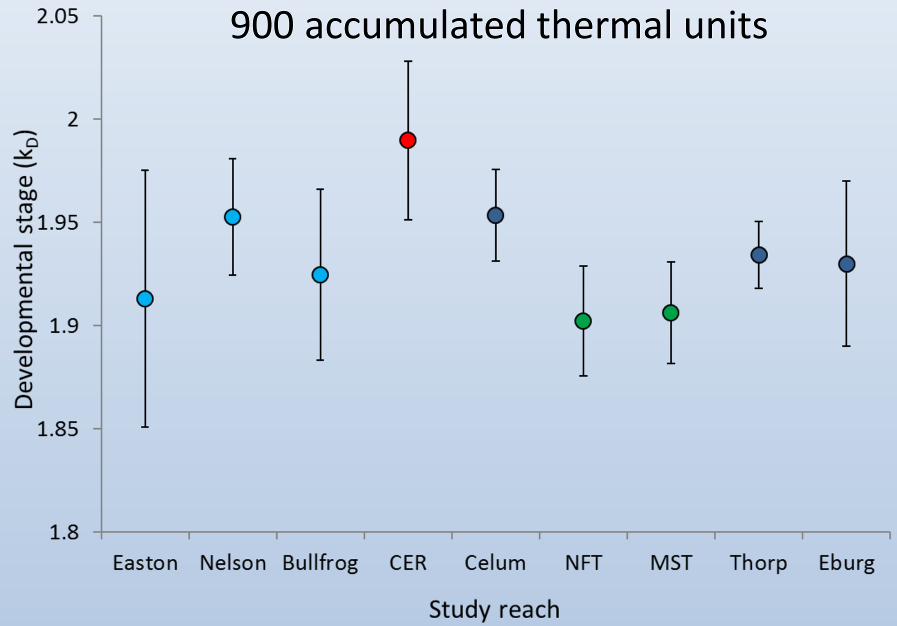
Reach scale examples…

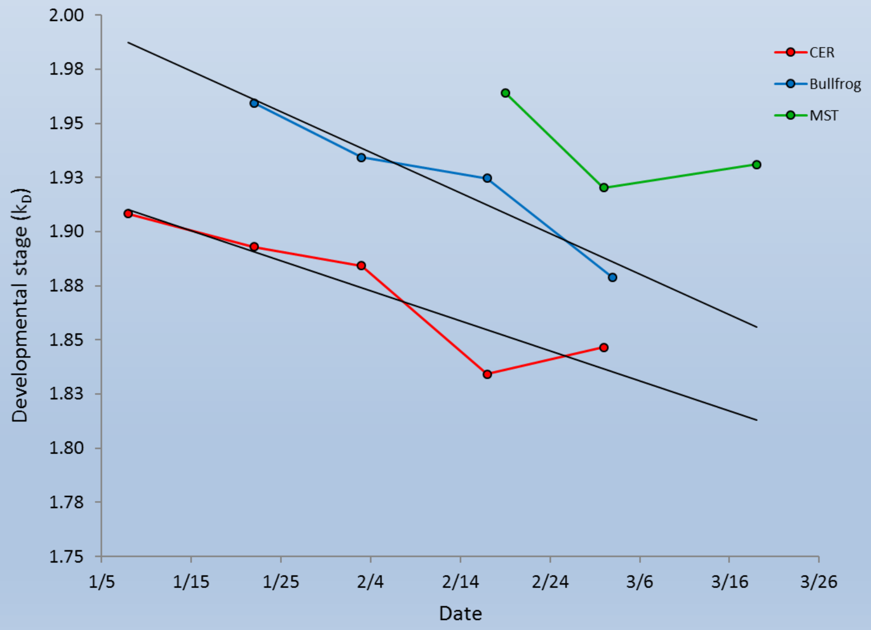
Temperature delivery by study reach





Yakima River Chinook alevin development



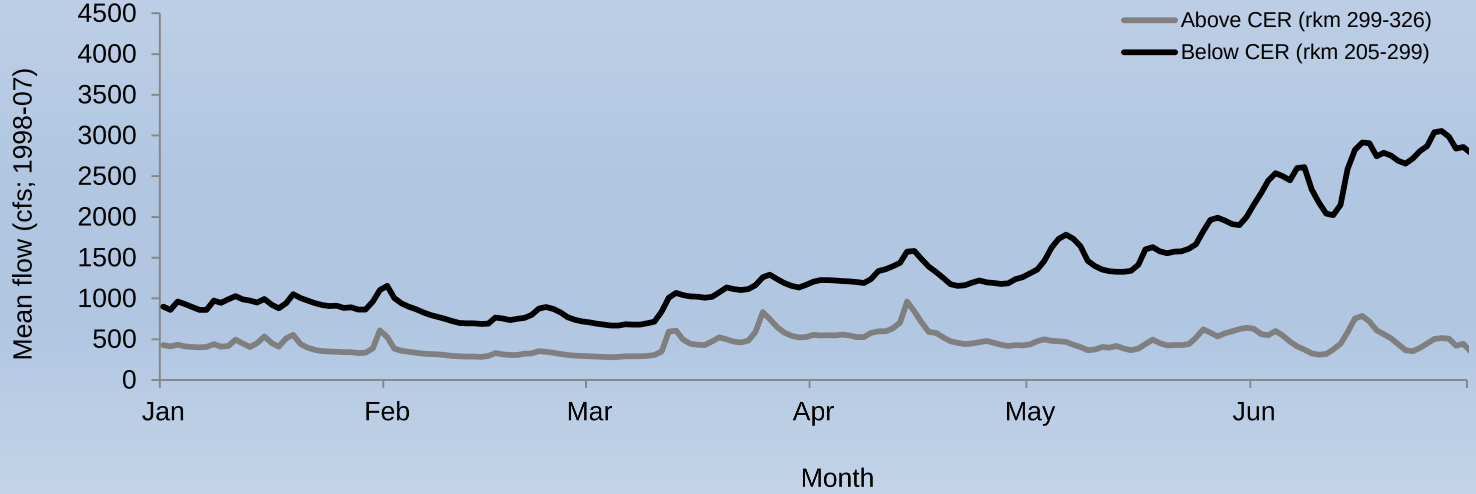


Reach-specific habitat

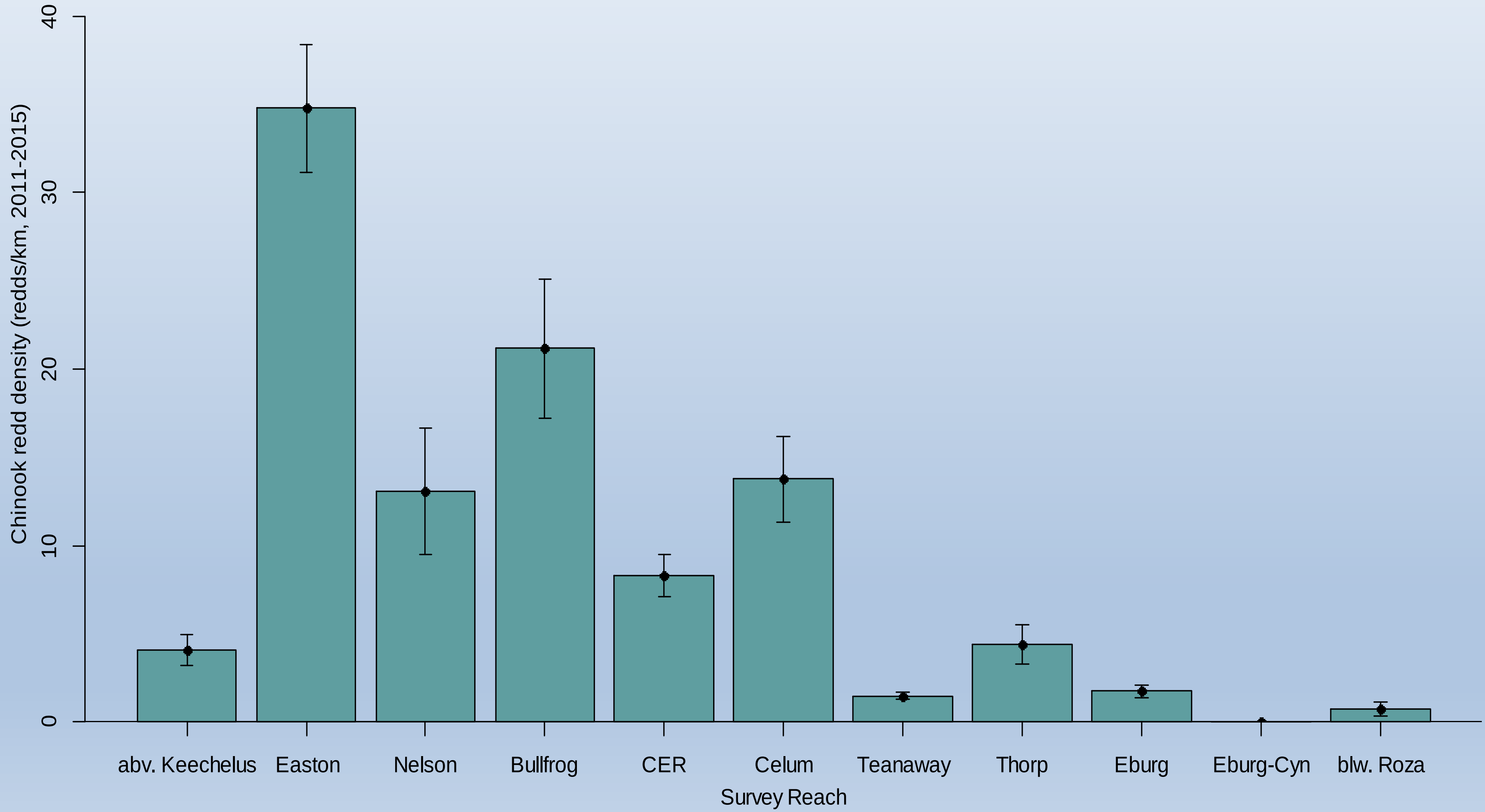
Spatial and temporal environmental differences

Easton

Thorp



Density index
redd density by study reach



YKFP redd counts; available: www.ykfp.org

Post-emergence objectives 2016-17:

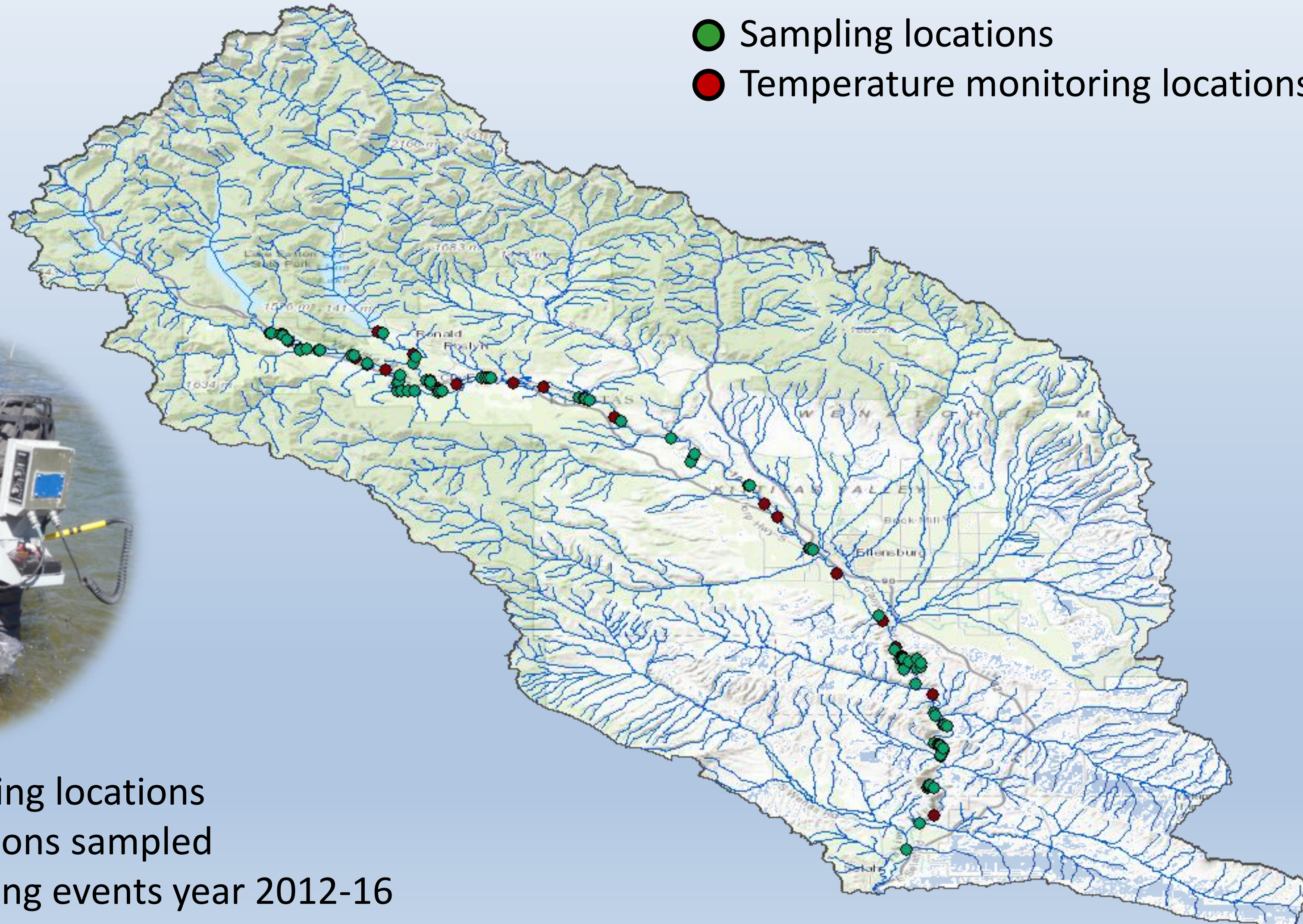
Hypothesis:

- Differential habitat conditions (spatial or temporal) result in a measurable growth response in post-emergent spring Chinook fry in the upper Yakima River Basin.

Objectives:

- Given available data, determine if growth rates can be effectively monitored over time
- Attempt to detect differences in growth attributable to temporal (year) or spatial (reach) effects
- Investigate specific environmental factors potentially predictive of Yakima Chinook salmon fry growth rates
- Determine if growth can be effectively modeled using a preliminary subset of possible predictor variables.

Post-emergent growth study area and methods



10 Reach sampling locations
75 unique locations sampled
329 total sampling events year 2012-16
23 temperature monitoring locations

Data description

- **Length**: mean length (mm) of spring Chinook; Response variable
- **Collection date**: Time series variable; two week intervals
- **ATU**: Accumulated thermal units ($\sum \overline{X}\ \mathrm{temp/day}$) from September 1 of the brood year; nearest temperature monitoring location.
- **Reach**: Sampling reach (n =10)
- **Year**: Year of collection (2012-16, n=5)
- **Spawner density**: Number of Chinook redds/rkm by brood year within the collection reach (YKFP surveys).
- **Flow:** Water velocity at the location of sampling
- **Distance to cover**: distance in meters to nearest available cover
- **Distance to bank:** distance in meters to the nearest bank
- **Depth:** mean water depth at the location of sampling

Analysis

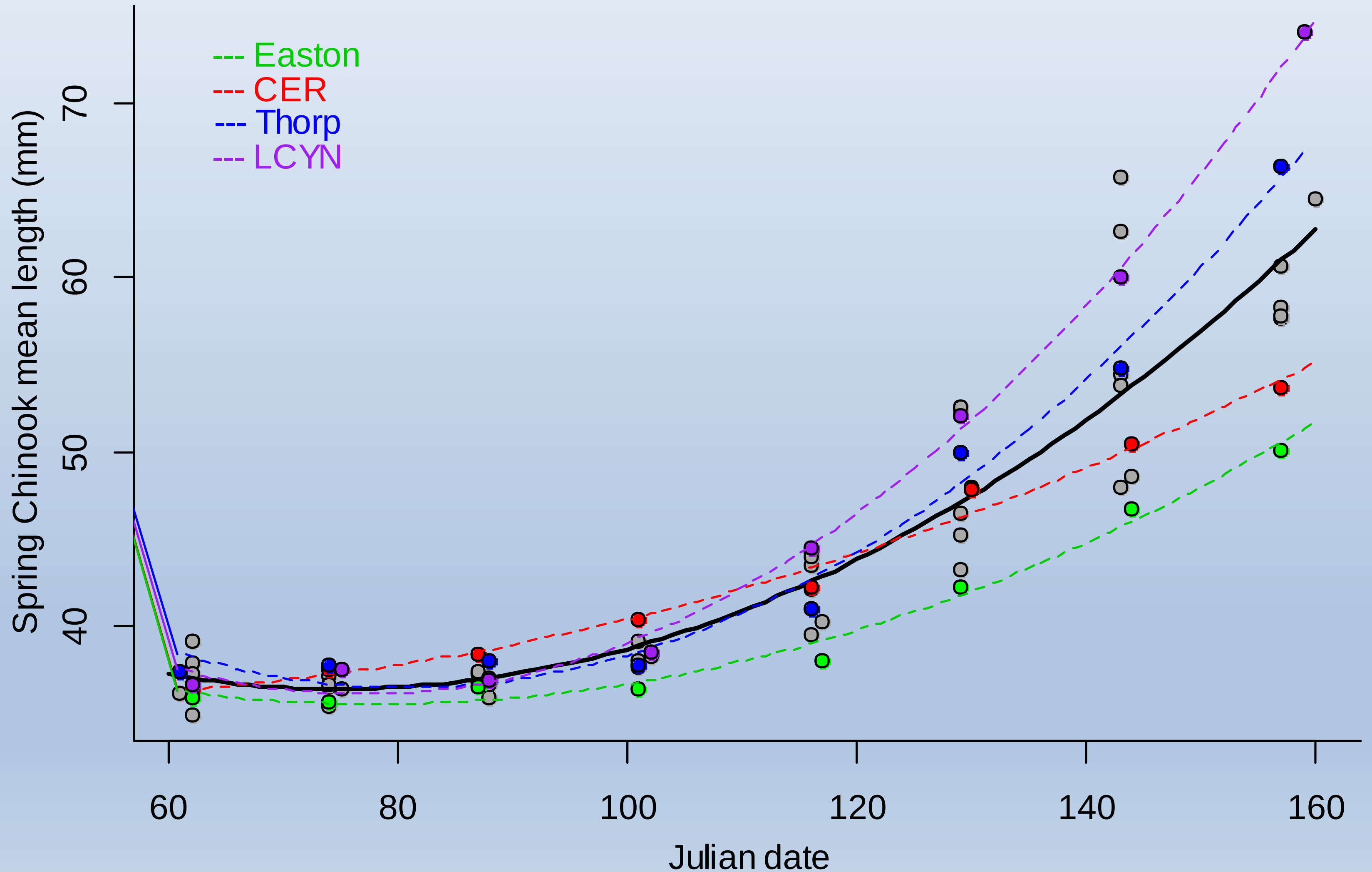
Polynomial regression:

- Preliminary fit (descriptive) of untransformed lengths by reach over time for 2016 data only

Multiple linear regression:

- Power transformation of the response variable (Box-Cox transformation, R package: MASS)
- Whitening transformation to remove influence of temporal autocorrelation (R package: zoo)
- Stepwise regression (both forward and backward) to identify significant predictive variables and combinations of predictors.
- Homogeneity of slopes (ANCOVA)
- Model selection using Akaike information criterion (AIC)

Results
observed growth (2016)



Results
Predictive model

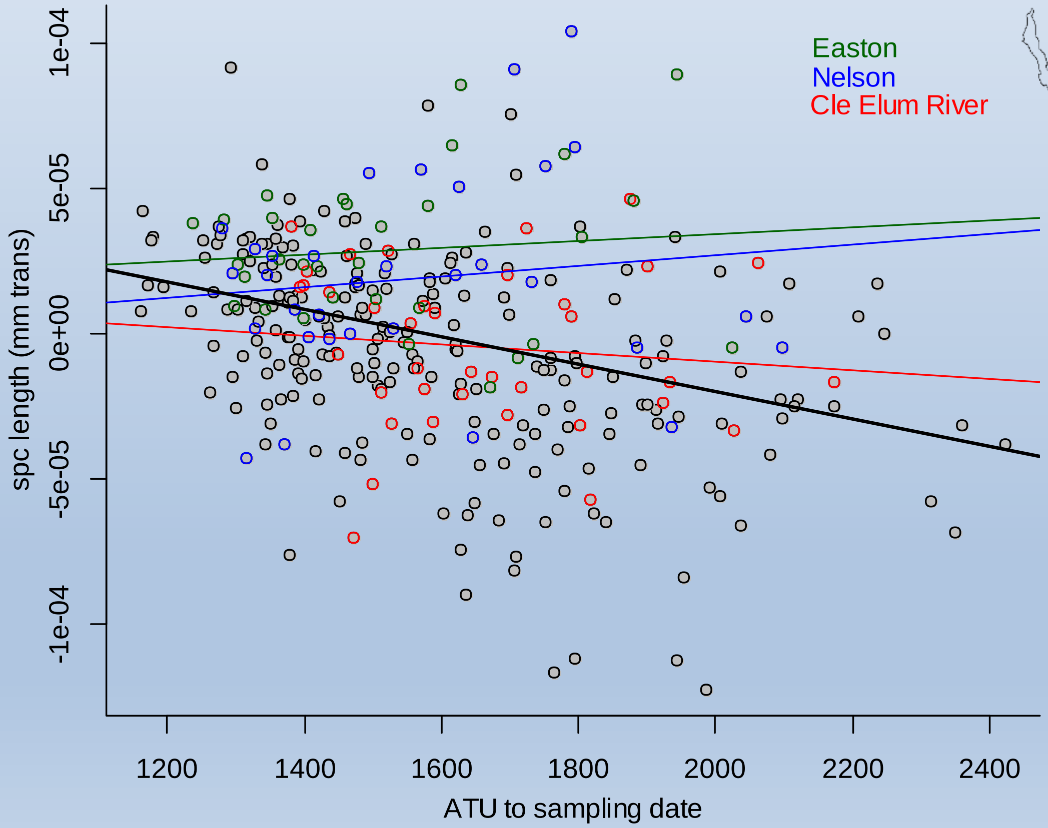
1. **Spawner density**, **Year**, **Flow**, **Depth**, and **Distance to cover** were not significant predictors of spring Chinook length (2012-2016)

2. Model selection:

Model	Parameters	n par.	adj. R^2	AIC	ΔAIC
A	$Length^{-2}$ ~ ATU	1	0.11	-5674.68	48.34
B	$Length^{-2}$ ~ ATU + Reach	2	0.25	-5719.22	3.80
C	$Length^{-2}$ ~ ATU + Reach + Dist.bank	3	0.25	-5721.38	1.64
D	$Length^{-2}$ ~ ATU * Reach	3	0.27	-5720.44	2.58
E	**$Length^{-2}$ ~ ATU * Reach + Dist.bank**	**4**	**0.28**	**-5723.02**	**0**

Results
predictive model

- Significant difference in regression slope for Easton, Nelson, and Cle Elum River reaches.



Summary

Preliminary findings:

- Results suggest that fry length can be effectively measured over the period of study.
- Location within the watershed and temperature delivery appear to significantly affect growth trajectories.
- No evidence of density dependent or year-specific influence to post-emergent Chinook length.
- End model suggests significance in predictor variables, but that additional or refined measures are likely necessary to address residual variance.

2017-18

- Expansion of the analysis to include pre-2012 data
- Evaluate condition factor in growth response
- Spatial Stream Network (SSN) parameter modeling (upstream distance, improved estimates of temperature accumulation and daily variance)
- Incorporation of additional and finer scale habitat measures (e.g. gradient, reach-characteristics, categorical habitat classifications)
- Non-linear modeling vs. transformation

Acknowledgements

- Field surveys: Trenton De Boer, Scott Coil, Alex Hedrick, Zach Lessig, Cade Lillquist, Ryan Fifield, Ryan Steele, Jeff Bates, Seth Shy, Tommy Wachholder
- Redd surveys: Mark Johnston and YKFP crews
- Administrative assistance and a cool line map: Amy Julsrud
- BPA: Michelle O'Malley

End