Yakima River Basin Spring Chinook Competition and Capacity Studies; Early Growth and Development

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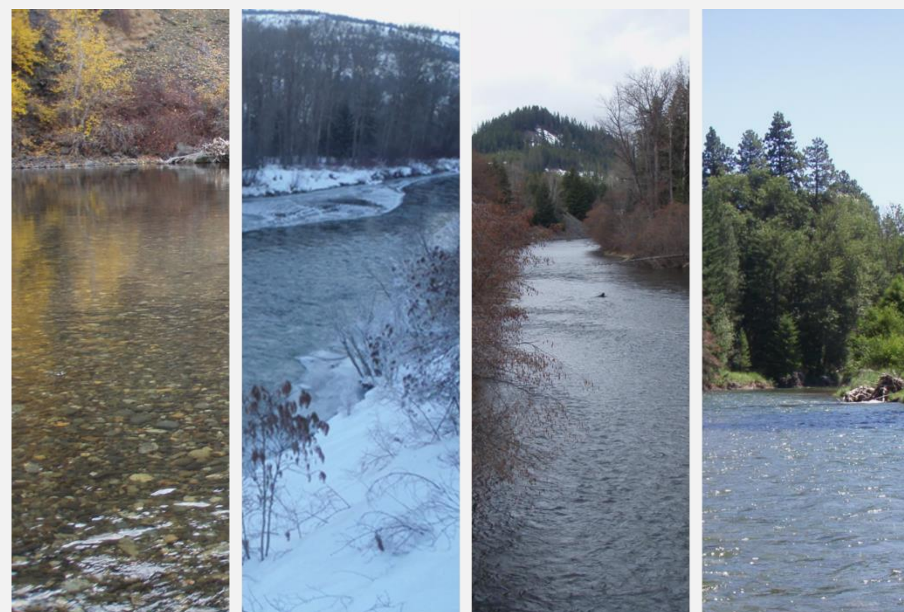


Life-stage specific measures of productivity

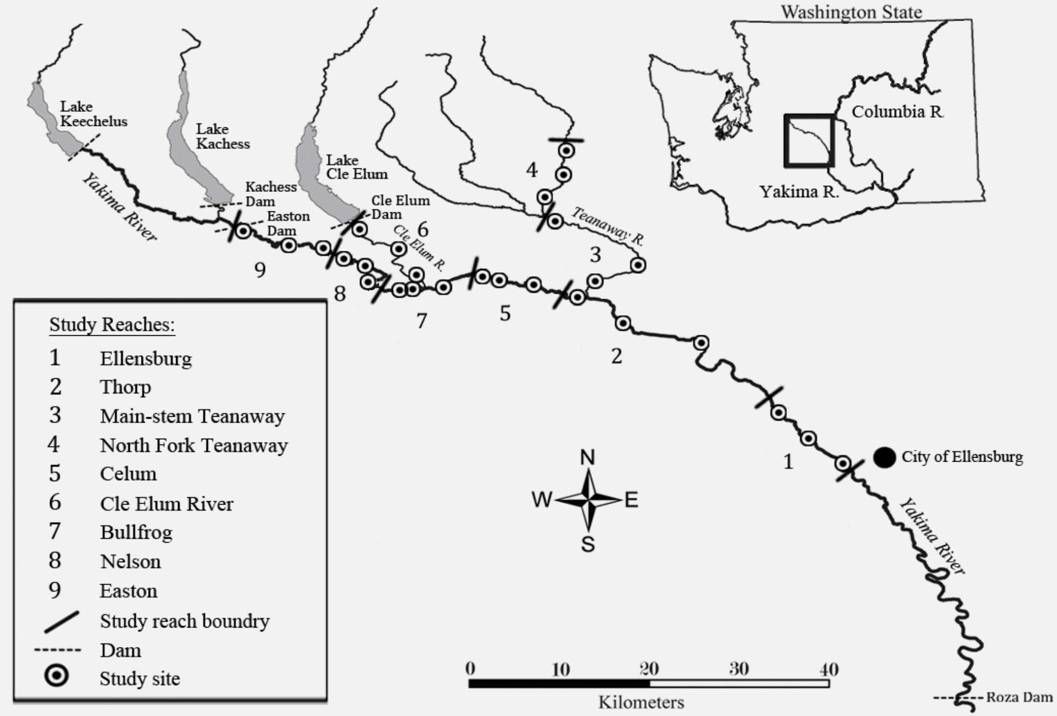
Identifying and evaluating differences in survival, development, and/or growth, attributable to environmental factors; over large spatial and temporal scales

- Incubation conditions
- Developmental rates
- Emergence timing
- Post-emergence growth

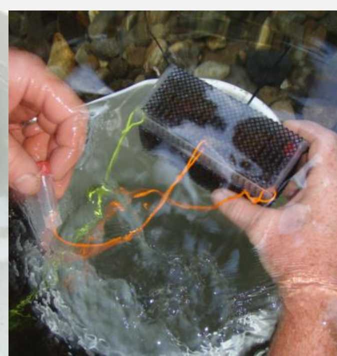
Incubation conditions

Egg-to-Fry Survival Study 2009-2012

- Nine study reaches, 2009-2013 brood years. Controlled parental cross, egg deposition, and spawn timing. n = 81 artificial redds/year
- Water temperature recorded hourly at 31 locations throughout the upper Yakima River
- Estimates of survival and developmental stage at approximately 50% emergence based on temperature unit accumulation (900 ATU)



Johnson, C. L. P. Roni, G. R. Pess. 2012. Parental effect as a primary factor limiting egg-to-fry survival of spring Chinook salmon in the upper Yakima River basin. Transactions of the American Fisheries Society 141(5):1295-1309


Incubation conditions

Egg-to-fry survival study 2009-2012

ANOVA (*P*-values)

Brood Year	Parental	Environmental
	Survival	
2009	< 0.01	0.06
2010	0.73	< 0.01
2011	< 0.01	0.65
2012	0.01	0.11
	Development (k_D)	
2009	< 0.01	< 0.01
2010	< 0.01	< 0.01
2011	< 0.01	< 0.01
2012	< 0.01	< 0.01

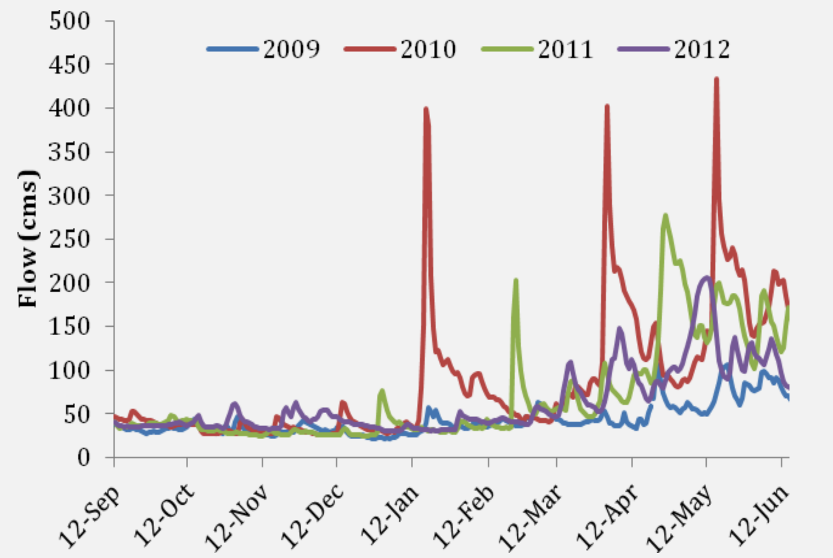
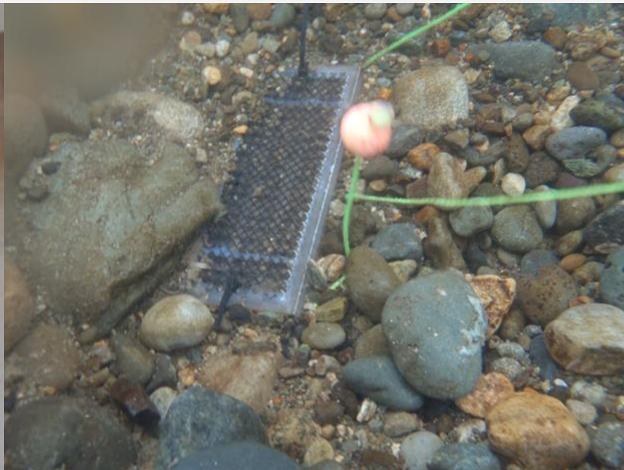


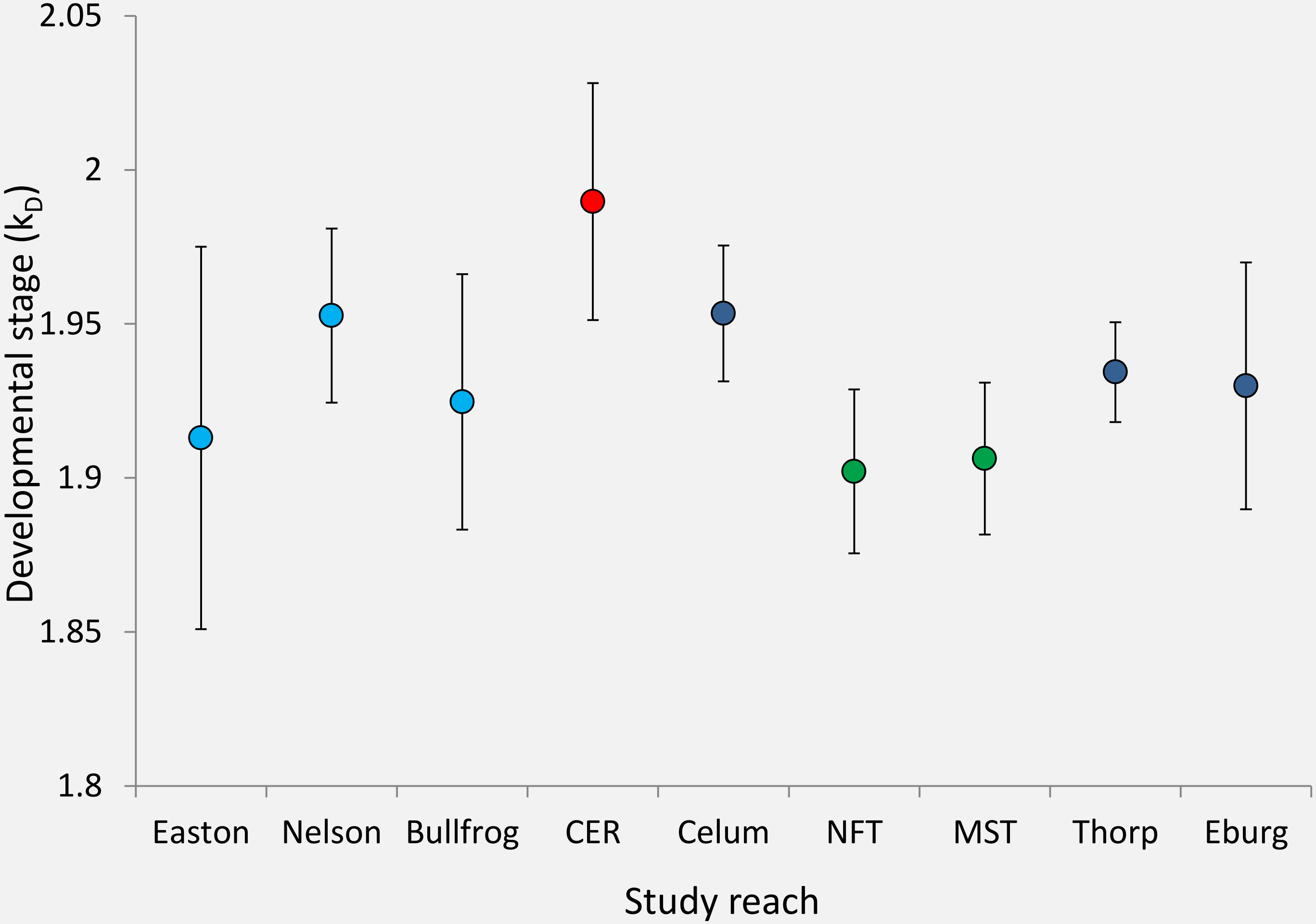
Figure from Roni et al. (in prep)



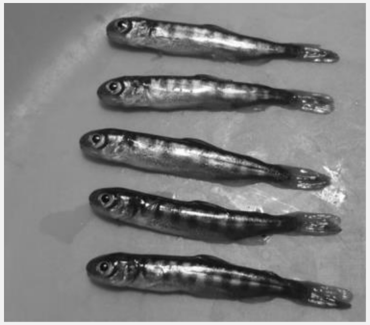


Developmental stage

900 accumulated thermal units

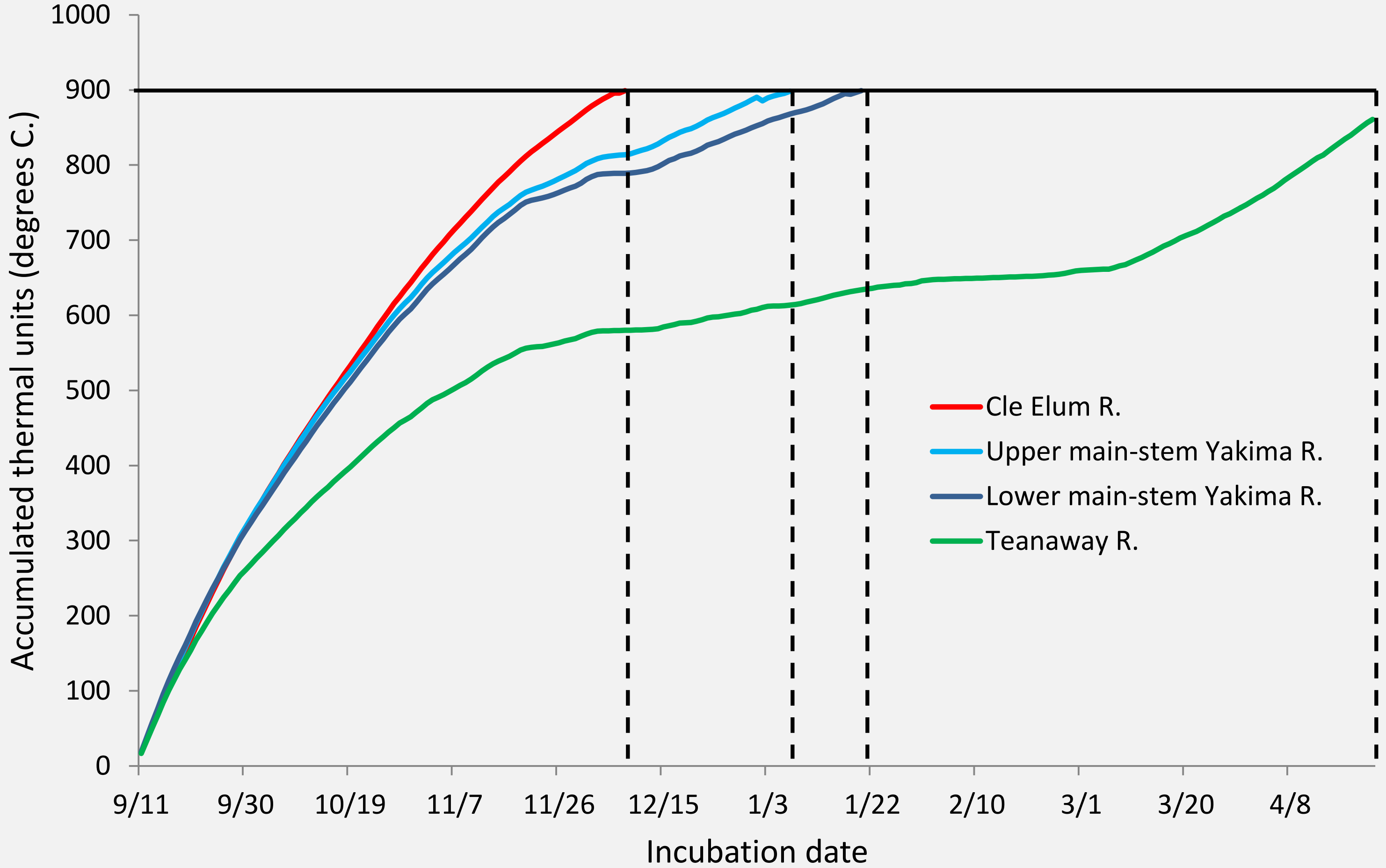


CER k_D = 1.9861

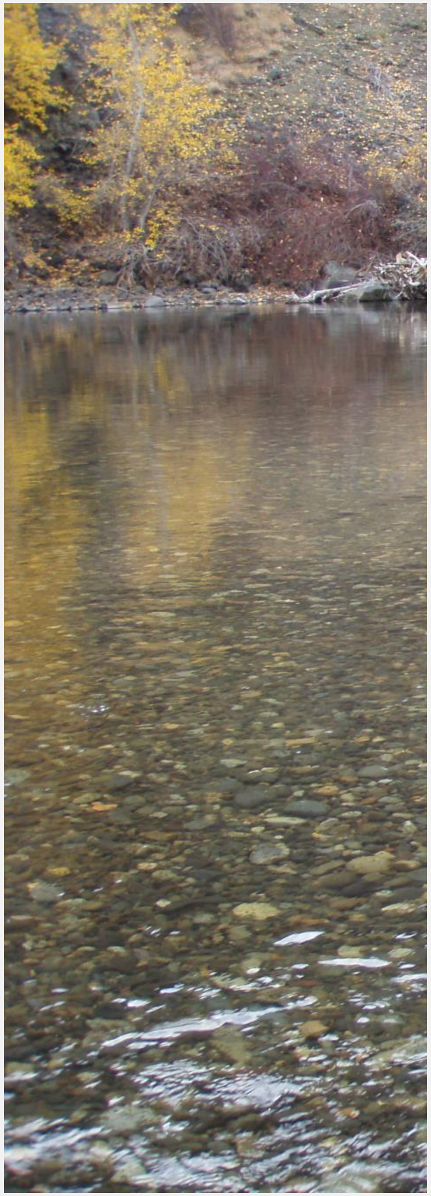


Twy k_D = 1.8779

Upper Yakima River thermal unit accumulation



*Literature a*ssessing relationships between temperature and developmental rate of Chinook salmon 1901-1990



Wallich, C. 1901. A method of recording egg development, for use of fish culturists. United States Bureau of Fisheries, Washington D. C., Rep. Commissioner of Fisheries for 1900, Fisheries Document 452: 185-194

Seymour, A. H. 1956. Effects of temperature upon young chinook salmon. PhD. Thesis. University of Washington, Seattle Wash. xi-+127p.

Alderdice, D. F., and F. P. J. Velsen. 1978. Relation between temperature and incubation time for eggs of Chinook salmon (*Oncorhynchus tshawytscha*). Journal of the Fisheries Research Board of Canada 35:69–75.

Heming, T. A. 1982. Effects of temperature on utilization of yolk by Chinook salmon (*Oncorhynchus tshawytscha*) eggs and alevins. Canadian Journal of Fisheries and Aquatic Sciences 39:184–190.

Beacham, T. D., and C. B. Murray. 1990. Temperature, egg size, and development of embryos and alevins of five species of Pacific salmon: a comparative analysis. Transactions of the American Fisheries Society 119:927–945

Factors influencing salmonid developmental rates

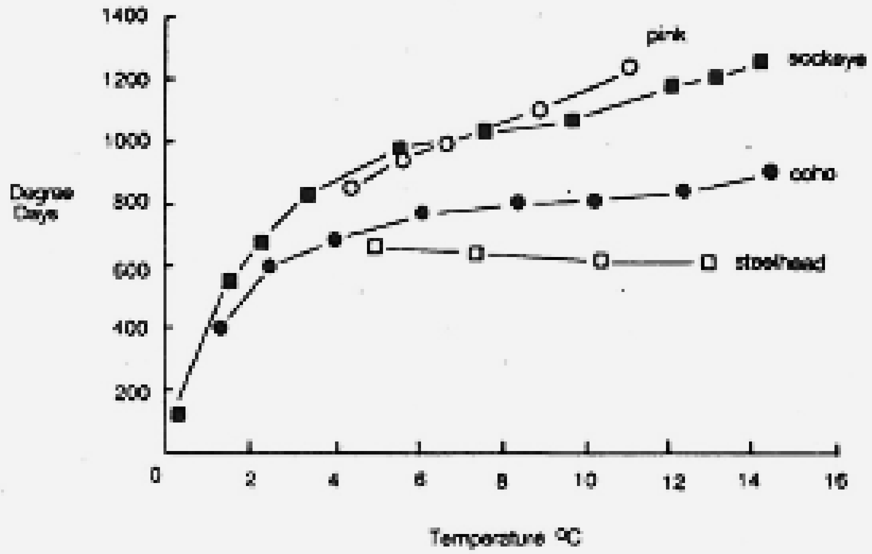
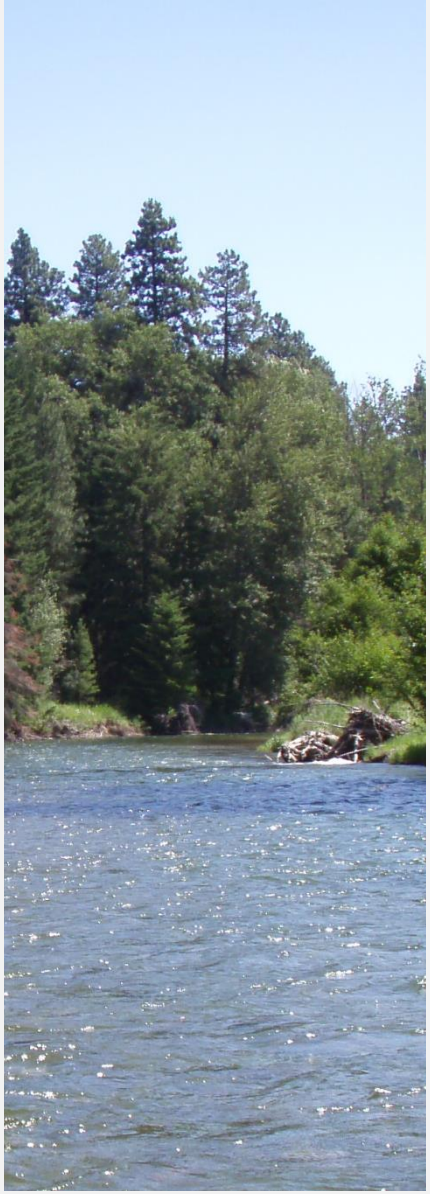


FIG. 2. Relationship between temperature (°C) and degree days to yolk absorption for salmon and steelhead incubated at constant temperatures.

Figure: Brannon (1987)



Compensatory mechanisms result in the ability to maintain synchronous emergence under variable environmental conditions, and have been noted among salmonid species, populations, and subpopulations (Brannon et al. 1987; Whitney et al. 2014).

Limiting factors: Fine sediment accumulation/availability of dissolved oxygen (Chapman 1988; 2014; Greig et al. 2005; Malcolm et al. 2011), high or low temperatures (Beacham and Murray 1990; Heming 1982), variation in temperature (Steel et al. 2012).

Spring Chinook development and emergence

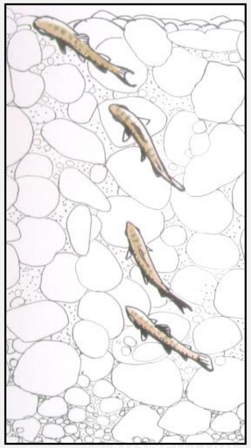


Image: fedflyfishers.org

- Acquisition of habitat[1]
- Competitive ability[2]
- Predator avoidance[3]
- Post-emergence growth[4]

[2]Andersson, M. Å., U. W. Khan, Ø. Øverli, H. M Gjøen, and E. Höglund. 2013. Coupling between stress coping style and time of emergence from spawning nests in salmonid fishes: Evidence from selected rainbow trout strains (*Oncorhynchus mykiss*). Physiology & Behavior 116:30-34.

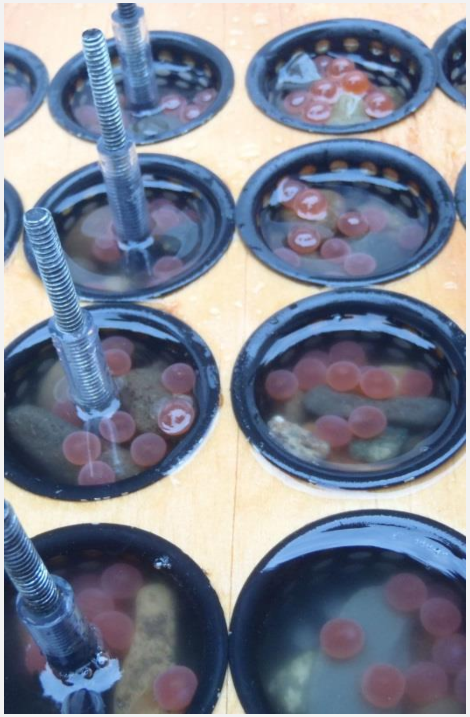
[2-3]Brännäs, E. 1995. First access to territorial space and exposure to strong predation pressure: a conflict in early emerging Atlantic salmon (*Salmo salar L.)* fry. Evolutionary Ecology 9:411-420.

[3]Brannon, E. L. 1987. Mechanisms stabilizing salmonid fry emergence timing. p. 120-124. In H. D. Smith, L. Margolis, and C. C. Wood, editors. Sockeye salmon (*Oncorhynchus nerka*) population biology and future management. Canadian Special Publication of Fisheries and Aquatic Sciences: 96.

[1-4]Quinn, T. P. 2005. The behavior and ecology of Pacific salmon and trout. University of Washington Press, Seattle Washington.

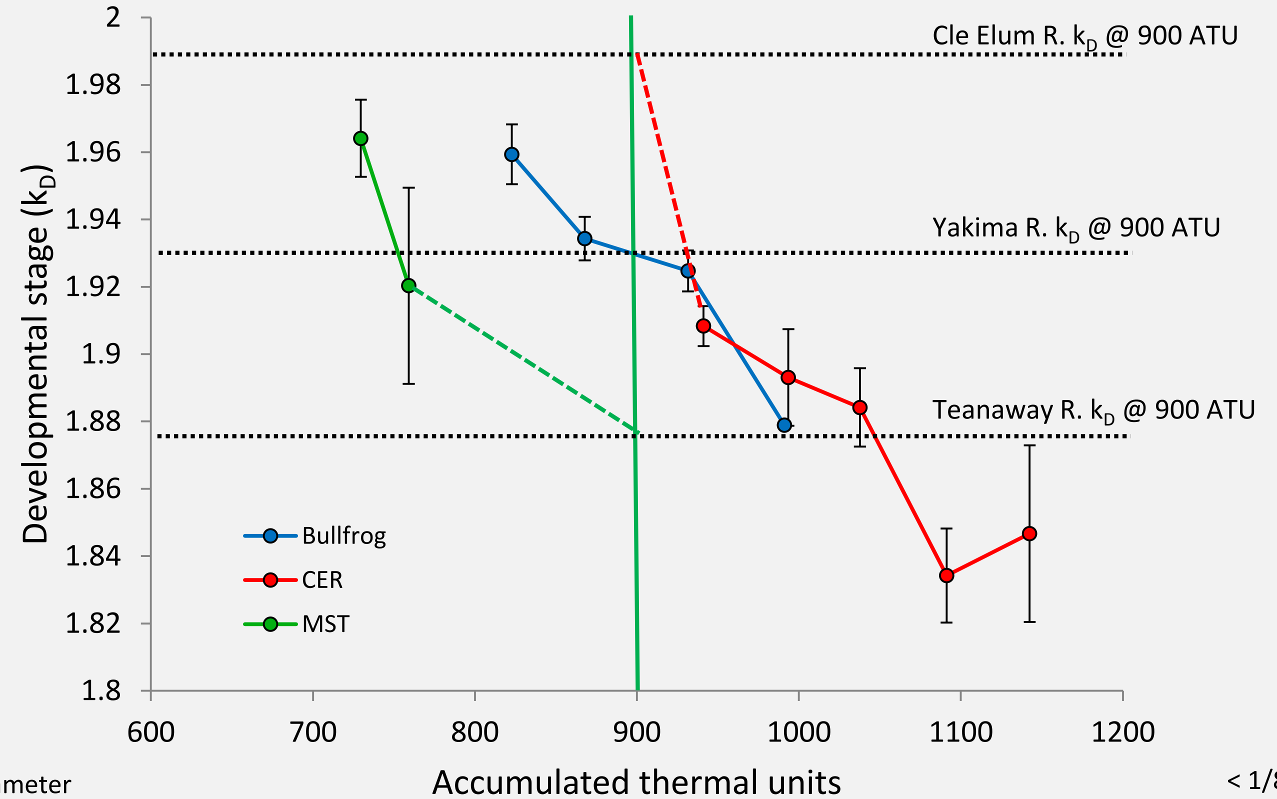
Developmental Incubation Pods (DIPs)
pilot study

- Controlled for parental effects
- Cle Elum River, Main-stem Yakima River, and Teanaway River study locations
- Ten pods/study area (pilot)

Developmental rates

2014-15 Pilot Study

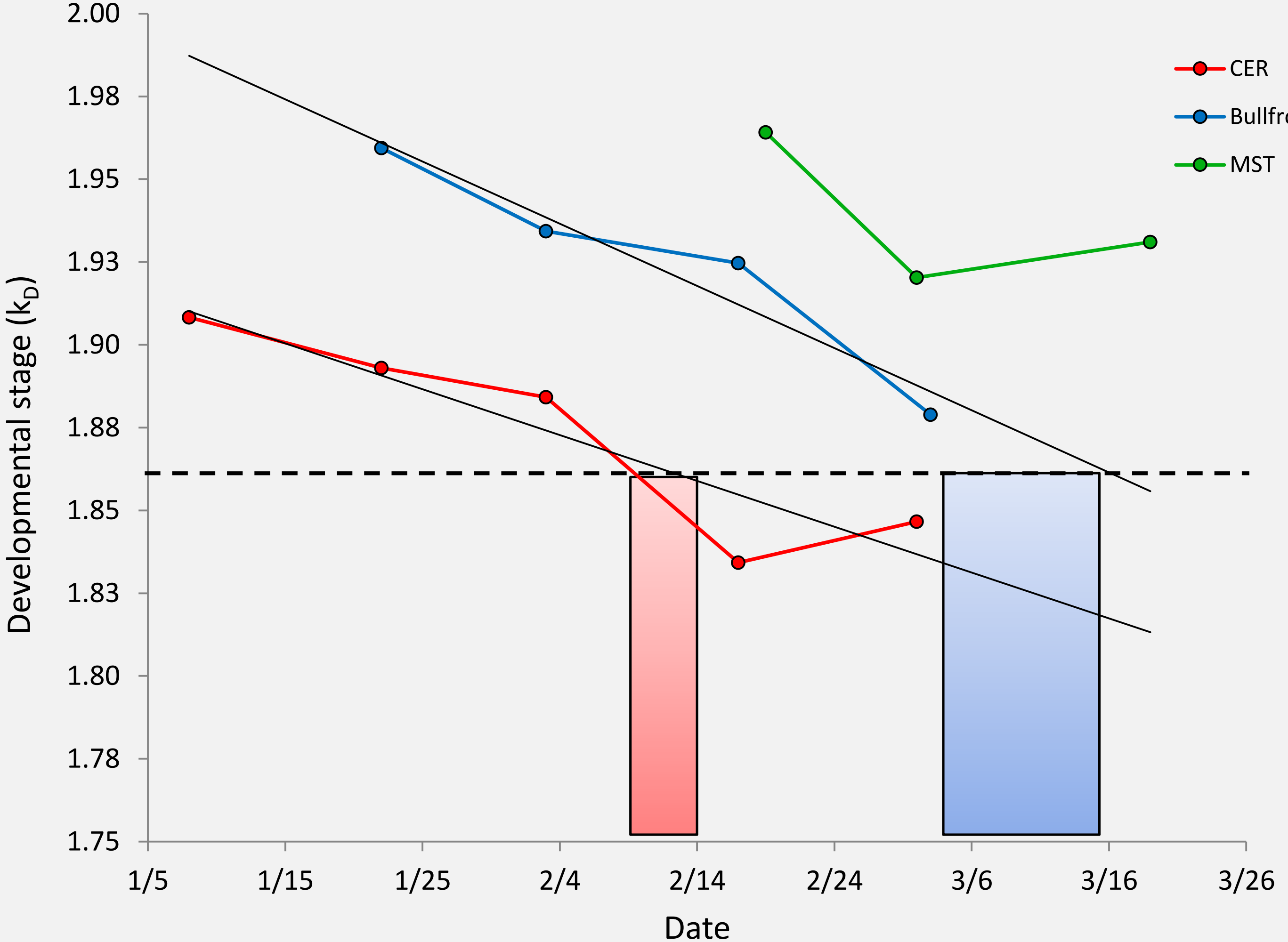


1/8-inch in diameter

< 1/8-inch in diameter

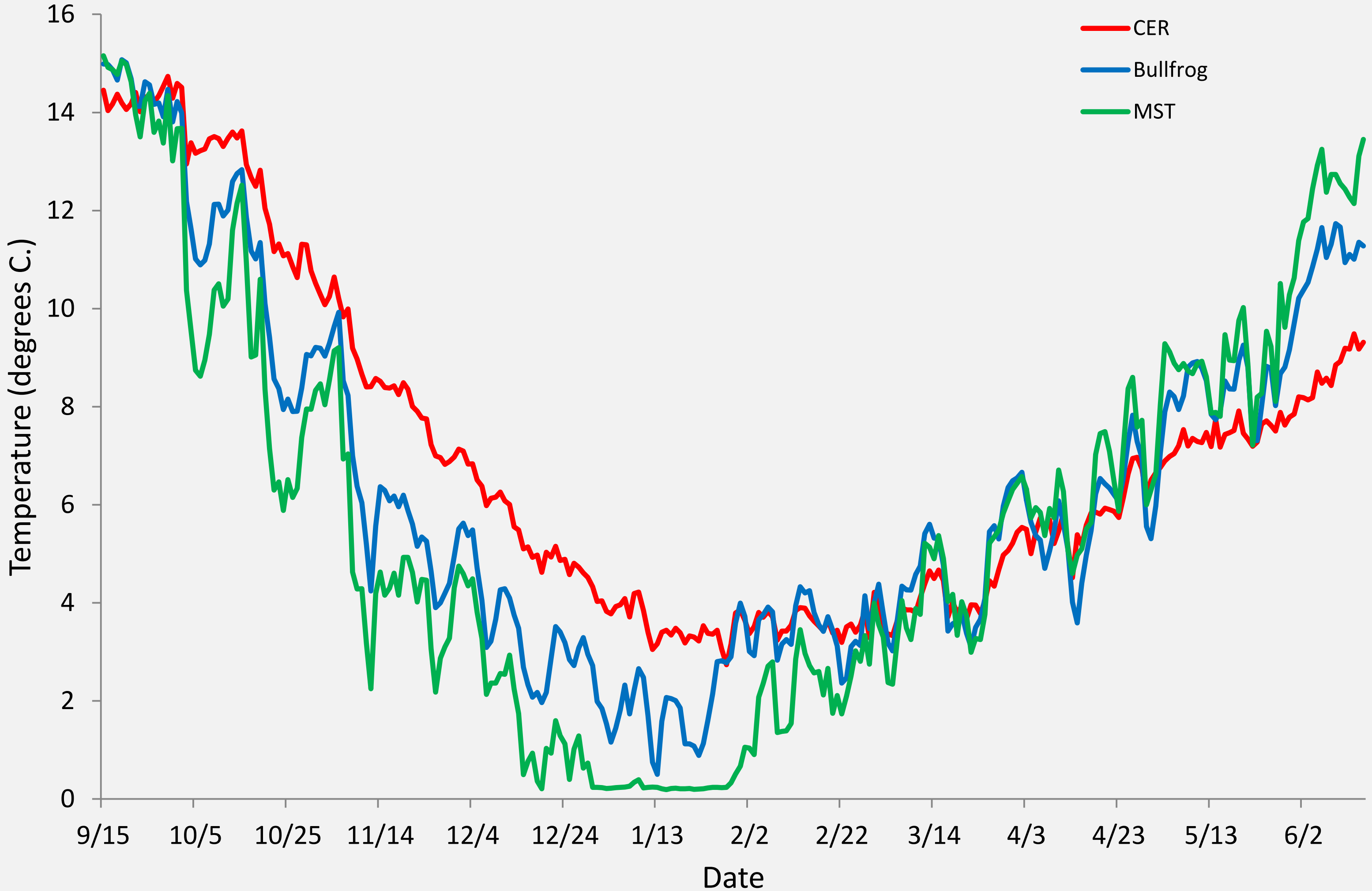
Developmental rates

Estimated emergence

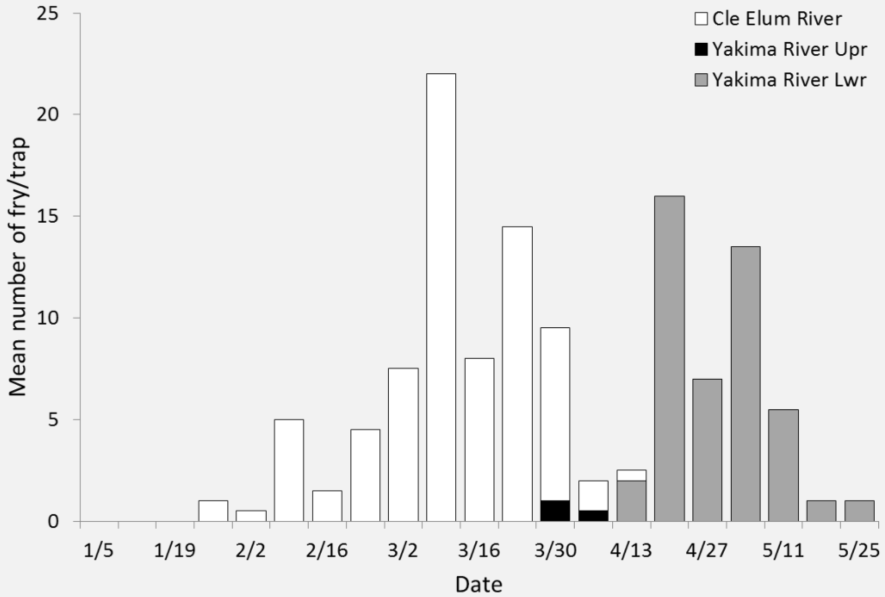


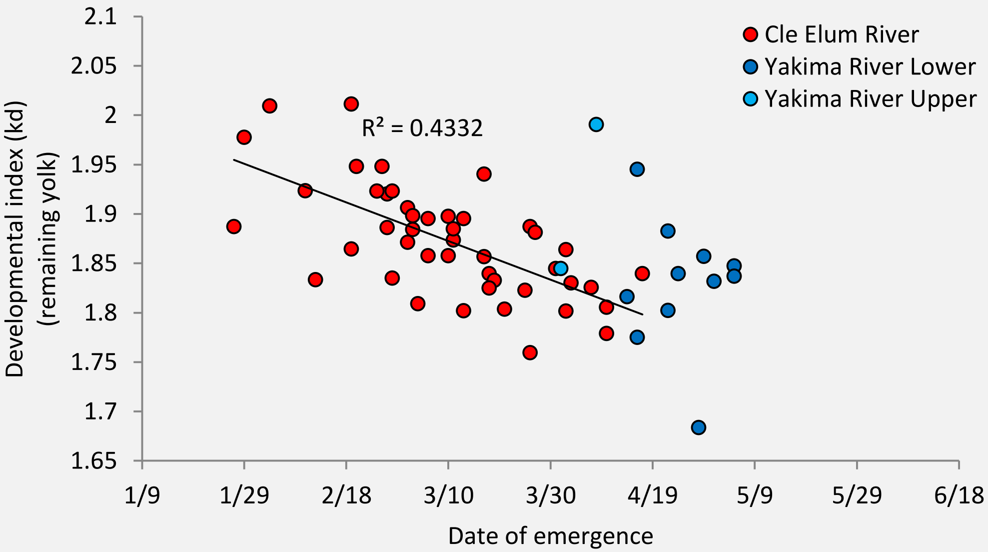
Homogeny of slopes: $P = 0.40$
Bullfrog vs. CER, ANCOVA: $P < 0.01$

Upper Yakima River temperature



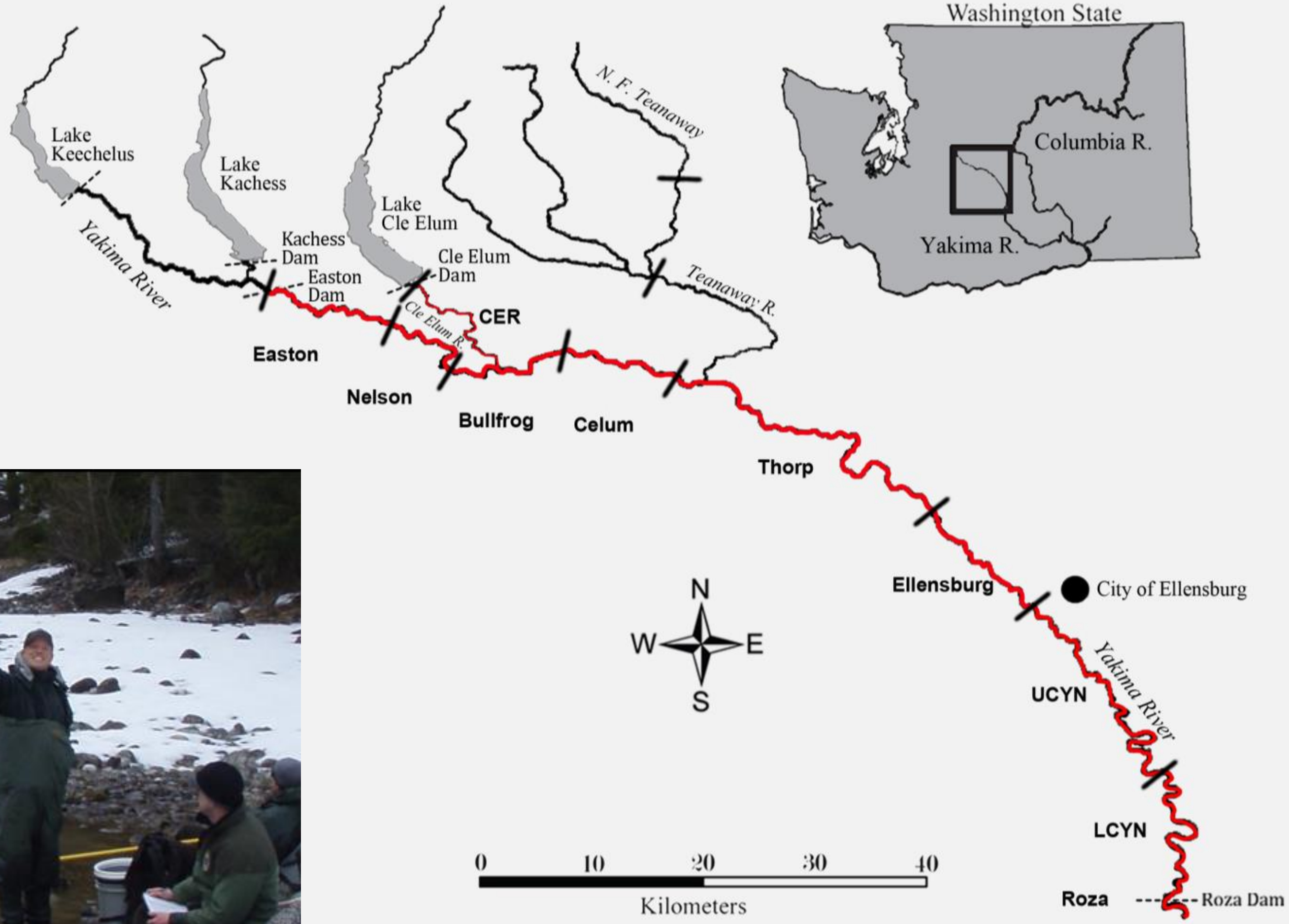
Emergence Timing



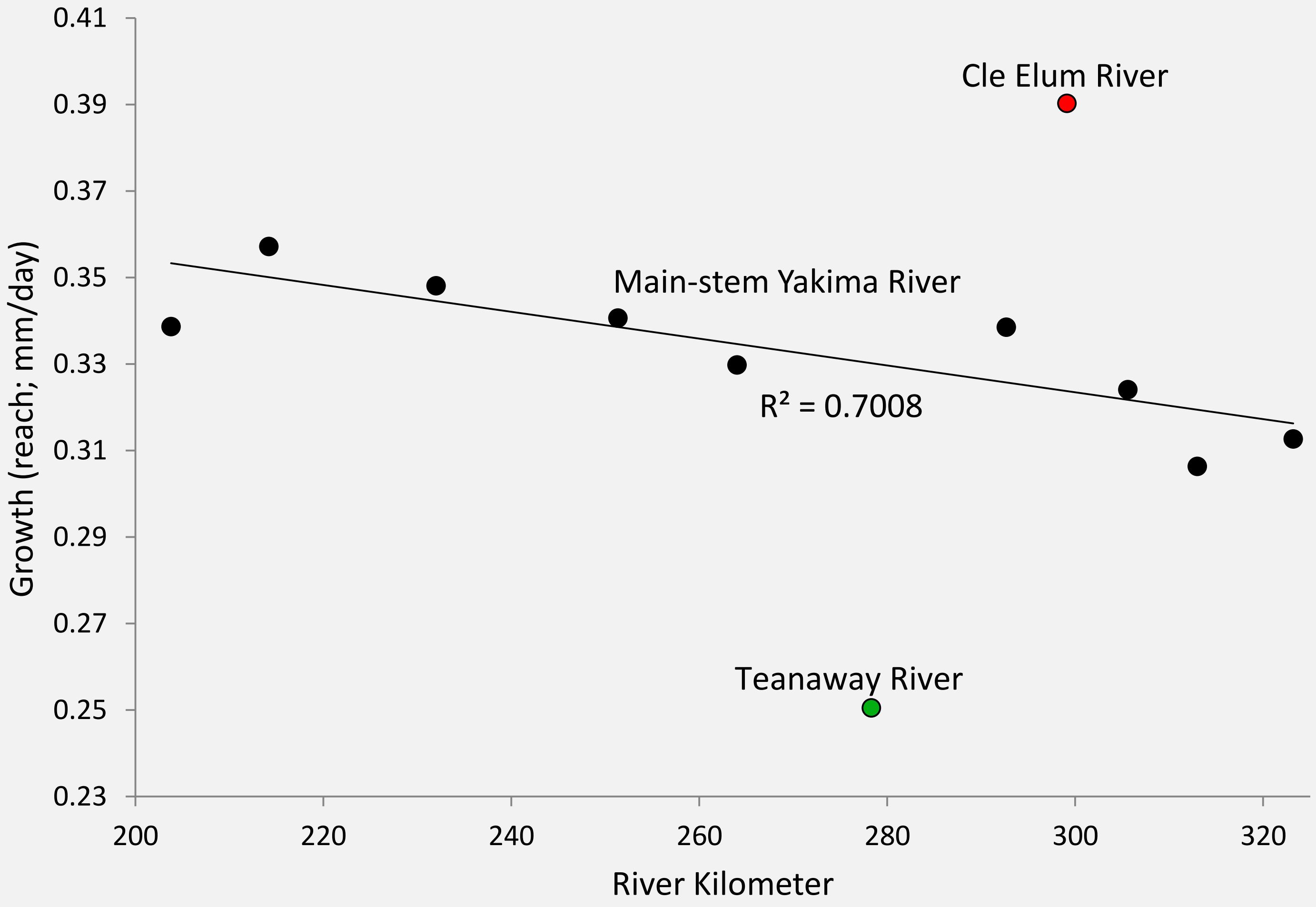


Post-Emergent Growth

Study area



Post-Emergent Growth



Summary

- Both parental and environmental factors appear to have an effect on early survival.
- Indirect evidence (k_D within egg boxes at recovery) suggest differential development, attributable to reach specific environmental conditions.
- Preliminary data suggests differences in the rate of development among study reaches, likely occurring in early stages of development
- Preliminary data suggest differences in the timing of emergence among study reaches, corresponding with observed alevin development over time.
- Post-emergent growth rates also appear to correspond with reach scale differences in developmental rate and emergence timing.

Additional information: WDFW, YKFP WDFW M&E Report, 5/1/2012 - 12/31/2013 Annual Report to Bonneville Power Administration, 1995-063-25. Submitted December 2014; Available (soon) www.bpa.gov

Acknowledgements

- WDFW:
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End