Precocious maturation rates of coho salmon (*Oncorhynchus kisutch*) in the Russian River Watershed, California

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Introduction

- Coho salmon (*Oncorhychus kisutch*) are federally endangered in the Central California Coast ESU. Conservation hatcheries produce and stock coho to supplement populations in hopes of reestablishing a self-sustaining run.
- The Russian River Coho Salmon Captive Broodstock Program based at Don Clausen Warms Springs Hatchery releases coho salmon into the Russian River watershed and tracks their movement and survival using PIT tag technology detection systems. This information has been used to document the rate of precocious maturation in males.
- Two life history strategies have been observed in Russian River coho salmon: returning to freshwater to spawn as larger 3-year old adults, or maturing precociously and returning at smaller size at 2 years of age, known as 'jacks'.
- The Russian River coho salmon run appears to harbor a high proportion of jacks, but rates are highly variable among years (Figure 1).
- Genetic composition and size at smolting are two factors that can influence age at maturity in salmonids (Vøllestad, 2004). In this study, we explore whether either of these factors are contributing to the high jack rates found in the Russian River coho populations.

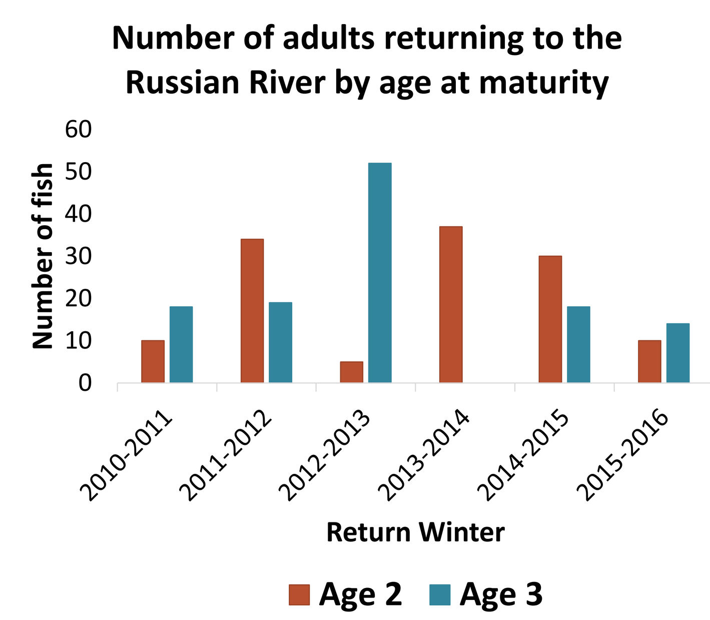

Figure 1. Proportion of PIT-tagged coho salmon returning at age-2 and age-3 in the Russian River.

Objectives

- Compare ratios of jacks to 3 year-old adults in hatchery coho raised in tanks versus hatchery coho released as juveniles into the natural environment.
- Determine whether the average size at smolting is larger in fish that mature as jacks than fish that mature at age-3.

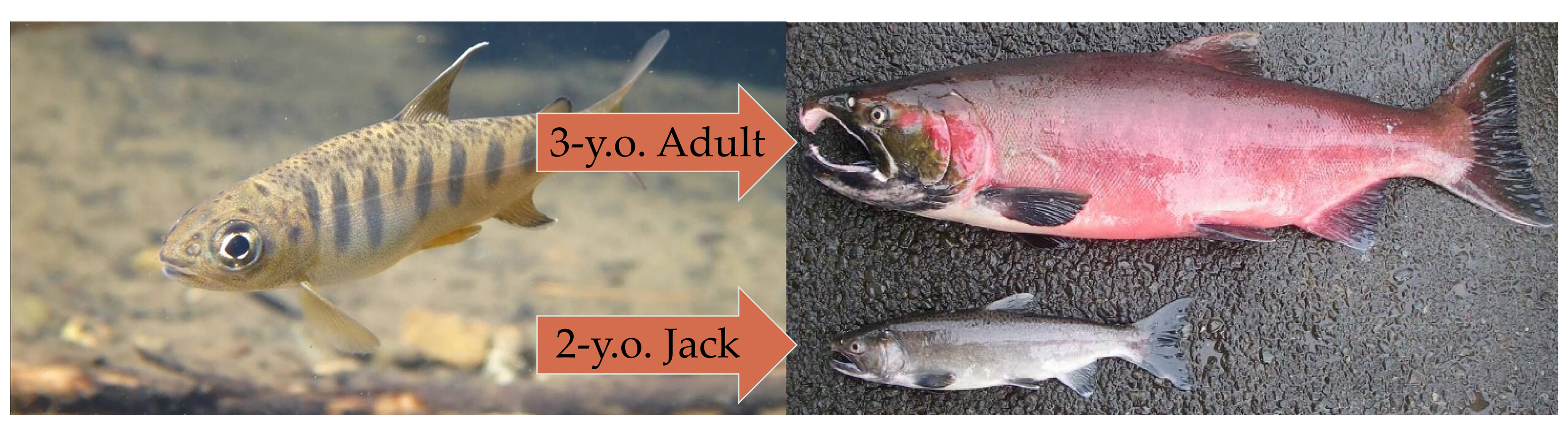

Figure 2. Coho can mature at 2 years of age, known as 'jacks'. Photo credit: University of Washington

Study Area

- The Russian River watershed (3,600km^2) is located in the Central California Coast ESU.
- The Russian River runs southwards 110 miles from Mendocino County, through Sonoma County, and empties at Jenner, CA. The mouth of the river closes seasonally, and is generally open in winter through spring when high flows breach its sand bar. It harbors steelhead, coho and chinook salmon populations.
- The watershed is a focal point for population recovery, Pacific salmon monitoring and stream restoration.
- UC operates downstream migrant traps (DSMT) on three tributaries to the Russian River: Green Valley Creek, Mill Creek, and Willow Creek.

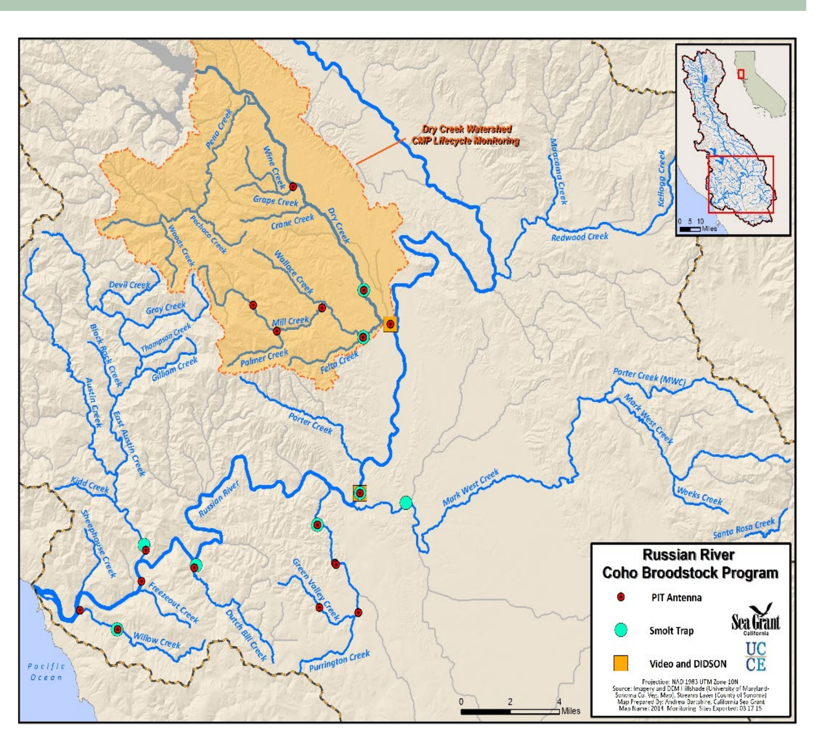

Figure 3. Study streams, PIT antenna locations and downstream migrant traps.

References

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- Vollestad, L., Peterson, J. & Quinn, T. (2004) Effects of freshwater and marine growth rates on early maturity in male coho and chinook Salmon. *Transactions of the American Fisheries Society*, 133 (3).

Acknowledgments

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Data Collection & Analysis

- Fork length and weight measurements were collected at the smolt stage from PIT-tagged coho broodstock raised at the hatchery, and from PIT-tagged individuals captured in downstream migrant traps (Figure 4).
- For hatchery-reared broodstock, age at maturity was recorded and related back to size at the smolt stage.
- For coho rearing in the natural environment, PIT tag antennas located throughout the watershed (Figure 3) were used to detect returning adult coho. Individual PIT tag numbers were then used to determine age at maturity and size at smoltification for individuals previously captured in smolt traps.
- Comparisons of smolt size between fish that matured at age-2 versus age-3 were made for both hatchery and stream-reared fish. Data was tested for normality before running one-sided, non-paired t-tests to determine significance of body size parameters in jacks versus 3 year-old adults.
- Body size during hatchery tagging, prerelease, and downstream migrant trapping was compared between different life history strategies for released coho salmon.

Figure 4. Downstream migrant trap operation.

Preliminary Results

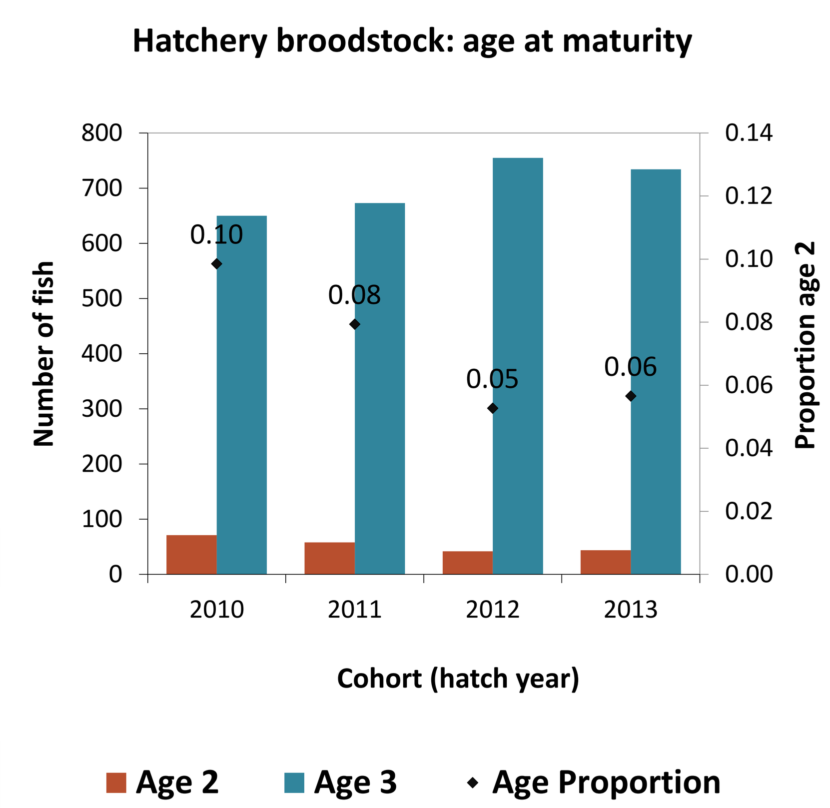

Figure 5. Number of fish in the hatchery broodstock program that matured at age-2 and age-3.

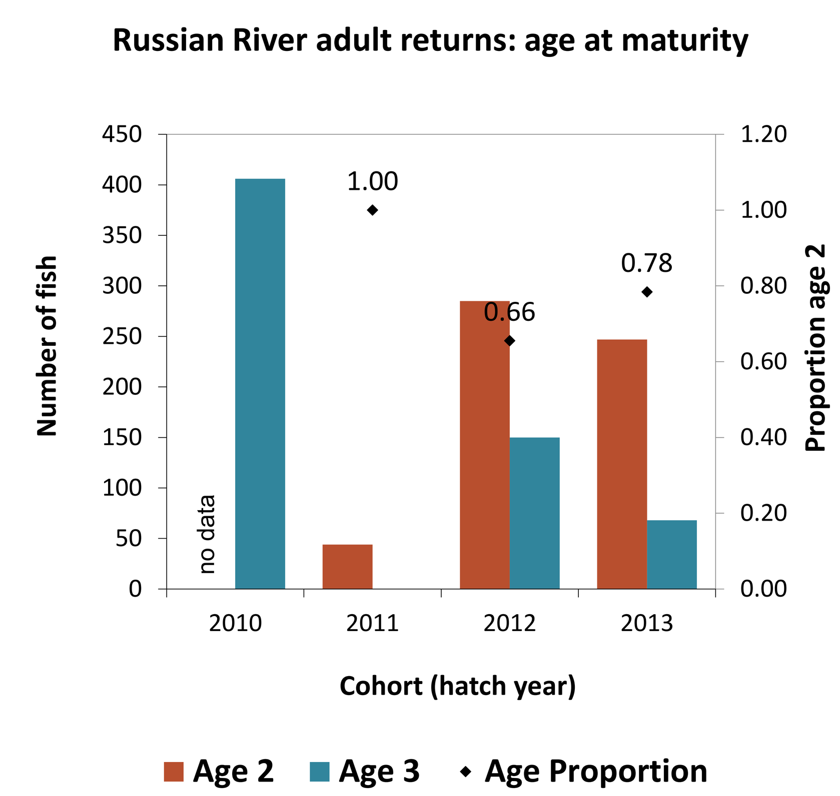

Figure 6. Number of fish in the Russian River that returned at age-2 and age-3 as detected by PIT antennas.

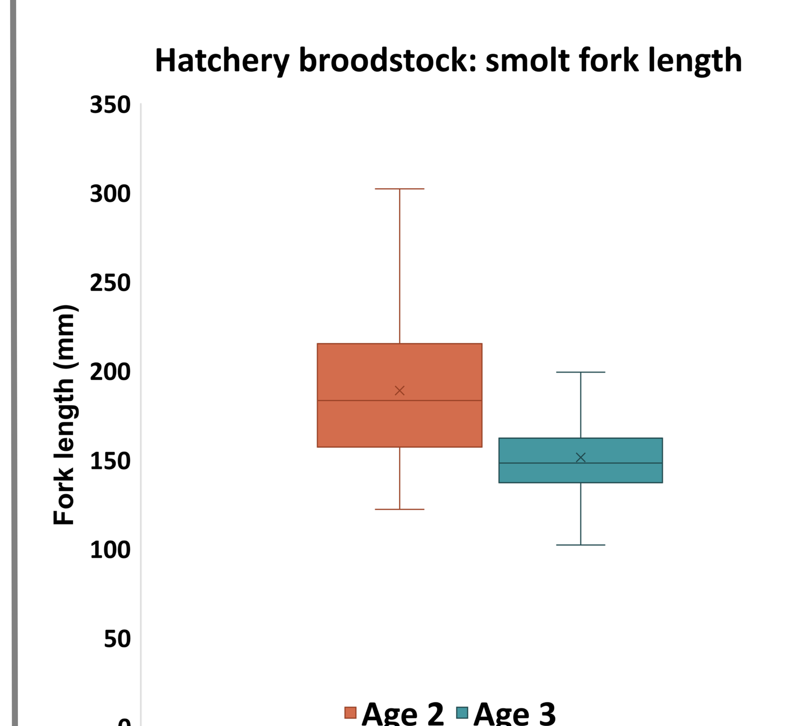

Figure 7. Comparison of smolt fork length for hatchery broodstock that matured at age-2 and age-3.

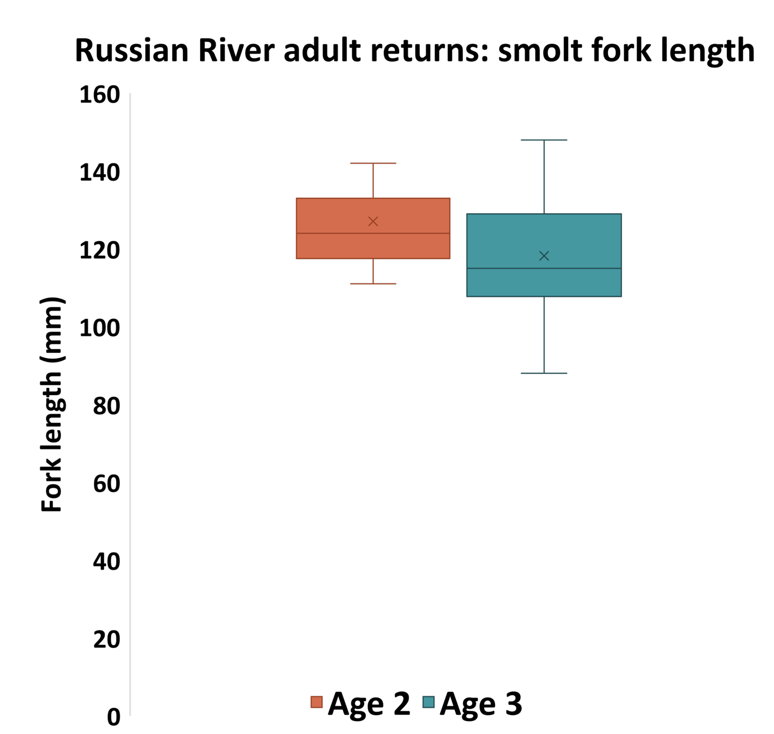

Figure 8. Comparison of smolt fork length for adult returns that matured at age-2 and age-3 as detected by PIT antennas.

- Jack proportions in coho reared in tanks at the hatchery averaged 7%, ranging between 5% and 10% (Figure 5).
- For all cohorts, jack proportions of fish released into the natural environment were higher than those raised at the hatchery (Figure 6).
- Size at smolting was larger for fish that matured at age-2 versus age-3 in both hatchery-raised populations and in populations released into the natural environment (Figures 7-8).

Conclusions & Applications

- Smolt size at outmigration appears to influence age at maturity for Russian River coho. These results are consistent with other recent research that has found larger smolt size to be an indicator of early maturation (Lum, 2003).
- Although there are potential survival benefits to releasing large juveniles from the hatchery, conservation hatchery programs should also consider the potential unintended consequence of artificial selection for the jack life tactic when setting target sizes for juvenile releases.
- Other tradeoffs must be considered as well. Jacks may be important for recovery in a genetically homogenous population because they allow inter-cohort mixing and gene exchange. Returning as a 2 year old increases the likelihood of survival to reproduction by limiting exposure to marine mortality risk, however they may not be as effective as 3 year old spawners. If the majority of 2 year olds are males, the number of returning females may then become a limiting factor, as skewed sex ratios favoring males are common with high jack rates (Healey, 2009).
- Although lower jack rates in the hatchery reared population suggest that environmental influences are a more likely cause for the higher jack rates observed in the Russian River, the genetic composition of the hatchery-reared coho was not identical to the coho released into the natural environment, therefore more direct comparisons controlling for genetic composition are necessary to further understand the role of genetics. It is also possible that genetic effects interacting with environmental influences may play a role.
- Ocean survival of coho is highly variable among years and, in turn, can have a strong influence on jack proportions for a given cohort. In order to gain a better understanding of the role of ocean conditions, we intend to compare Russian River adult return data with other wild coastal California coho populations.
- Promoting more in-depth research into the causes and consequences of coho salmon jacks in a recovering, stochastic population may be critical to long-term success.