Evaluation of Two decades of Hatchery Supplementation Program impact on natural-origin Spring Chinook Population

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Background

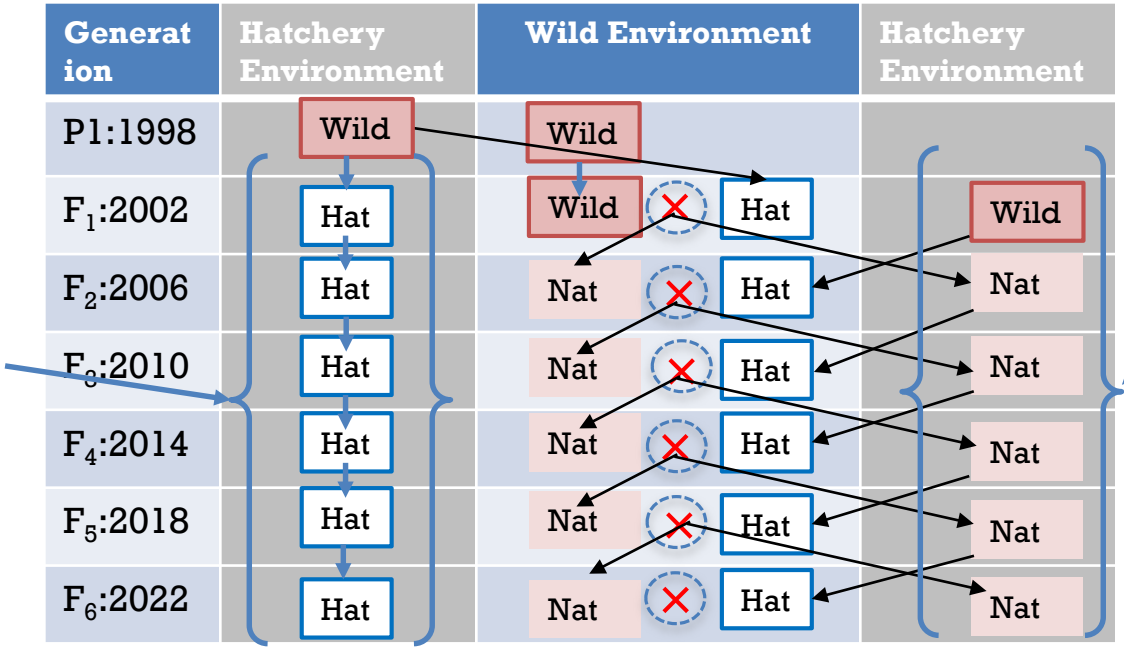
- Supplementation program is being implemented to reduce the declines of the population size and conserve natural-origin populations
- **Supplementation program:**
  - A fraction of an adult population is taken into a hatchery for reproduction and rearing, and their progeny are released back into the natural environment
- Potential Positive Effects:
  - Refugia: Hold fish from remnant populations through high-mortality life stages
  - Reintroduction: re-establish extirpated stocks
  - Treaty obligations: hatcheries provides harvest opportunities and help maintain essential elements of tribal subsistence and culture
- Potential Negative Effects:
  - Ecological: Competition, direct predation or disease transmission
  - Domestication: Loss of local adaptation leading to decreased fitness of both hatchery and wild fish reproducing in the natural environment
  - Inbreeding depression: Decrease in fitness due to mating between related individuals

Background

- Supplementation programs increased abundance at some of the life stages of Chinook, and negative effects did not persist into the post-supplementation phase and had no apparent influence on post-supplementation productivity (Venditti et al. 2018)
- Productivity of hatchery fish pairs spawning naturally was not significantly lower than for wild fish pairs of Chinook in the Salmon River basin. It suggested that the program can successfully boost population size with minimal impacts on the fitness of salmon in the wild (Hess et al. 2012)
- Hatchery programs have reported reduced fitness of hatchery-origin fish relative to natural-origin fish spawning in the wild (Araki et al. 2007; reviewed in Araki et al. 2008; Christie et al. 2011, 2012; Hayes et al. 2013)
- There were few or no negative effects on fitness of wild populations due to hatchery influence (Heggenes et al. 2006; Sharma et al. 2006; Schroder et al. 2008, 2010; Hess et al. 2012; Anderson et al. 2013)

Evaluation of long-term hatchery effects on wild populations is warranted.

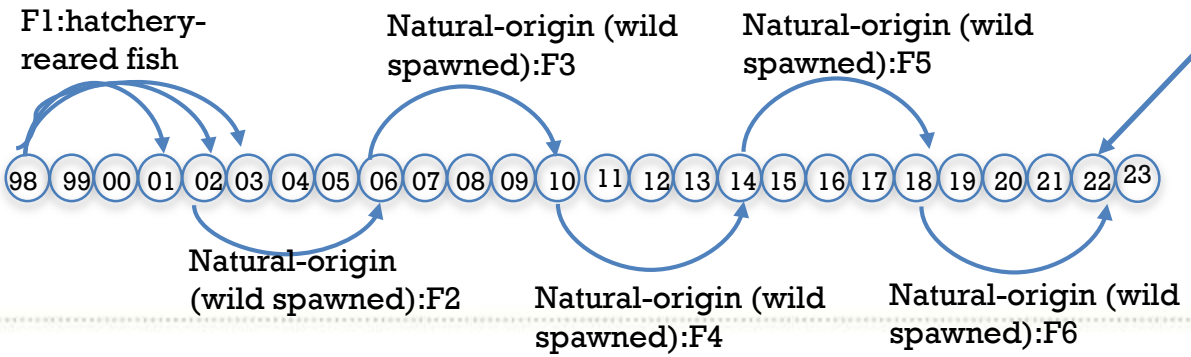
Supplementation program in Yakima Basin



Segregated (minimize interbreeding between hatchery stock & natural pop^{n})

Integrated (minimize genetic divergence between the hatchery and the natural pop^{n})

Nat= Natural origin
Hat=Hatchery Origin

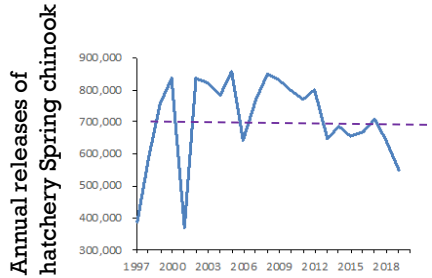


Circles represent brood years (BYs). The progeny of each brood return to the upper Yakima River to spawn 3–5 years later.

Yakima River Basin and the area of supplementation program implementation

American and Naches Rivers

- Few anthropogenic impacts
- Cold water temperature
- Favorable spawning & rearing habitat for Chinook, and other salmonids
- Not supplemented



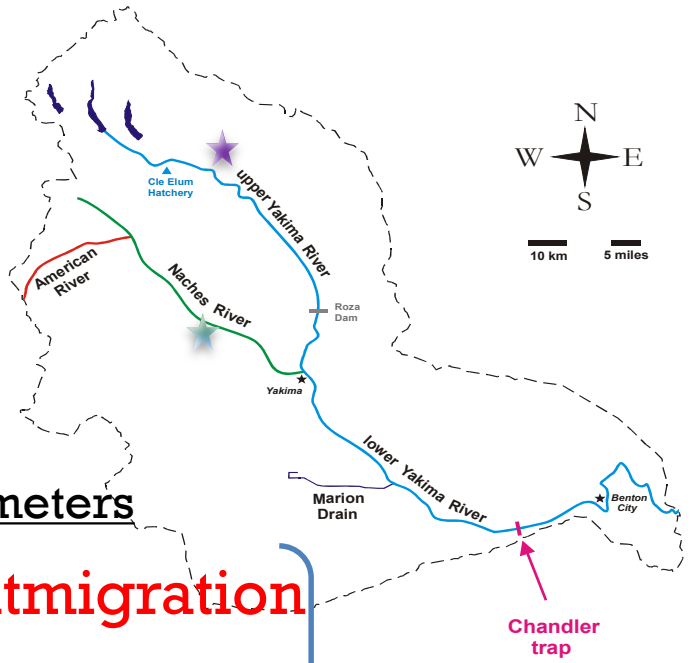
Upper Yakima River

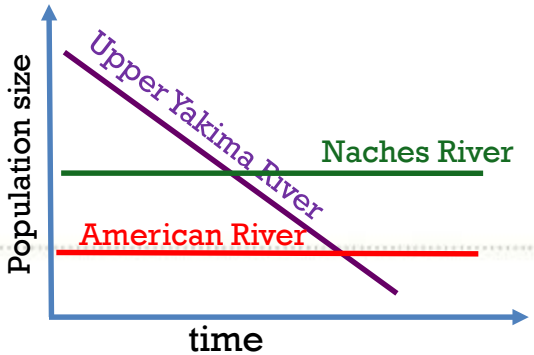
- The upper Yakima spring Chinook population is the target of hatchery supplementation, with an annual release of ~700,000 smolts.

Wild Yakima Basin Spring Chinook Stocks & hypothesis

- The three wild Yakima Basin Spring Chinook populations (Upper Yakima River, Naches River, and American River) are reproductively isolated and differ in productivity

- Because the Upper Yakima population is supplemented but not the American and Naches populations, we can hypothesize that rate of decline of wild Spring Chinook should be higher in the Upper Yakima than in the American and Naches rivers if the hatchery program has affected the wild productivity



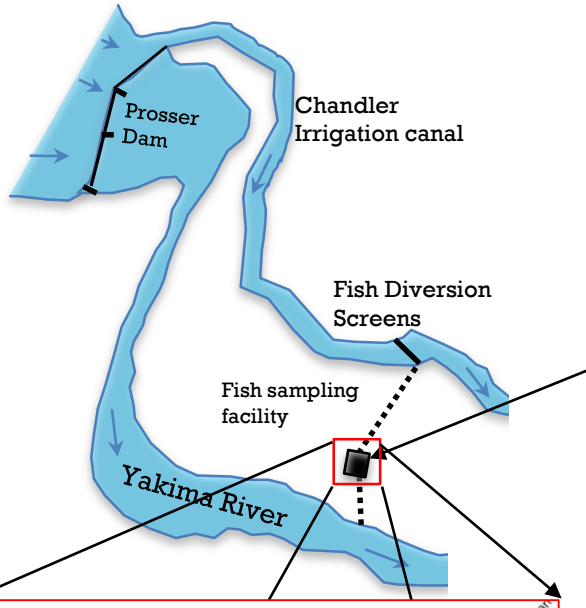


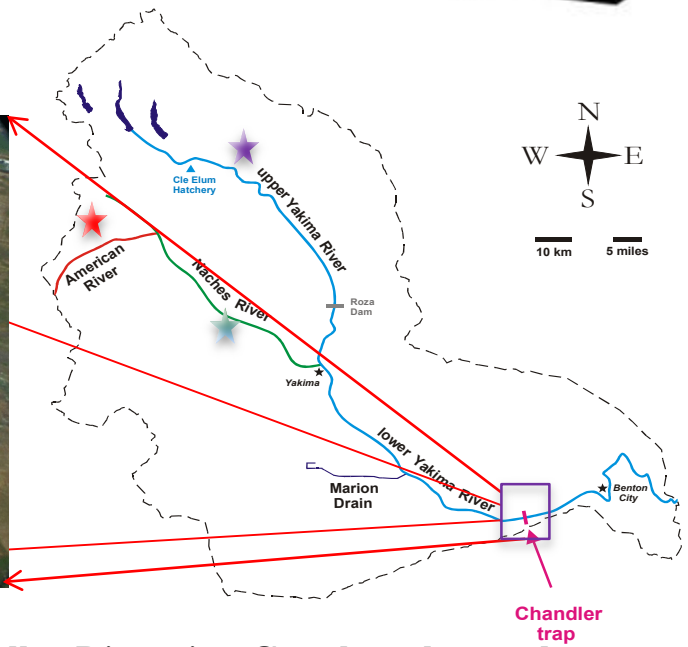
Evaluation Parameters

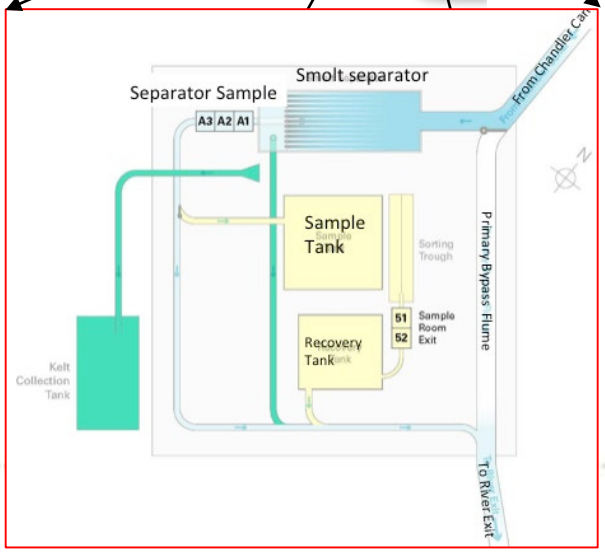
- # of Smolt Outmigration
- Adult returns

Methodology

- # of Smolt Outmigration



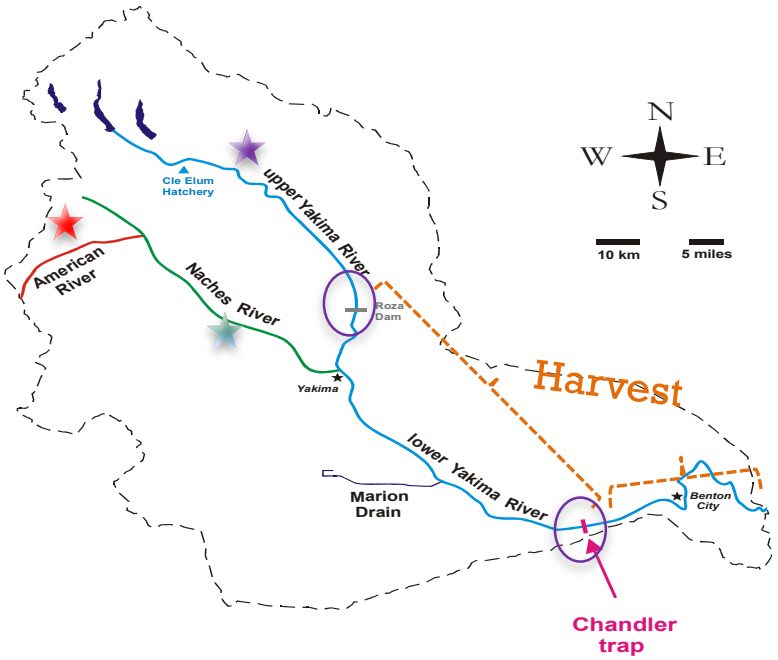


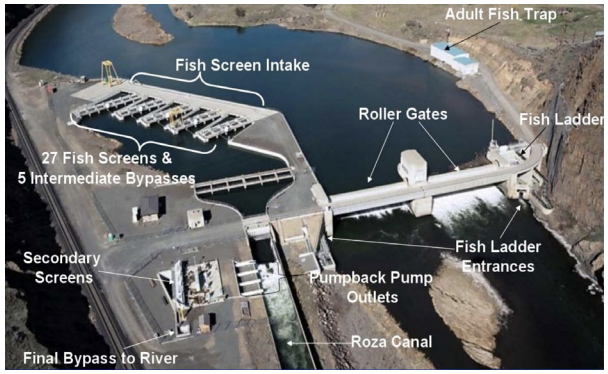


- The Prosser Dam and Chandler Diversion Canal are located downstream from virtually all salmonid spawning and rearing in the Yakima Basin, conveying approx.. Max 1500 cfs during the out-migration season
- All species entering the juvenile bypass system are counted over the entire out-migration period January-July.
- Genetic samples are also taken to determine population of origin (Upper Yakima, American, Naches) and hatchery-produced smolts are identified from external marks
- Counts by species and population are expanded to total passage using flow-entrainment and canal survival models.

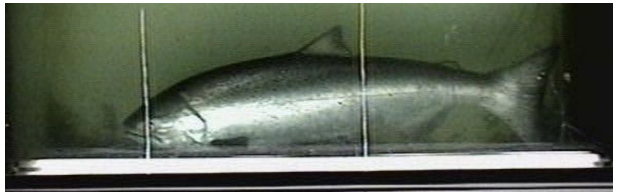
Methodology

- Adult Returns in Yakima Basin





Roza Dam



Video Adult counts/or captured

Prosser Dam

- Adult counts + Harvest → total adult returns in Yakima basin
- Genetic analysis → stock identification

Results: Smolt out-migration from Prosser (smolt outmigration in Yakima river)

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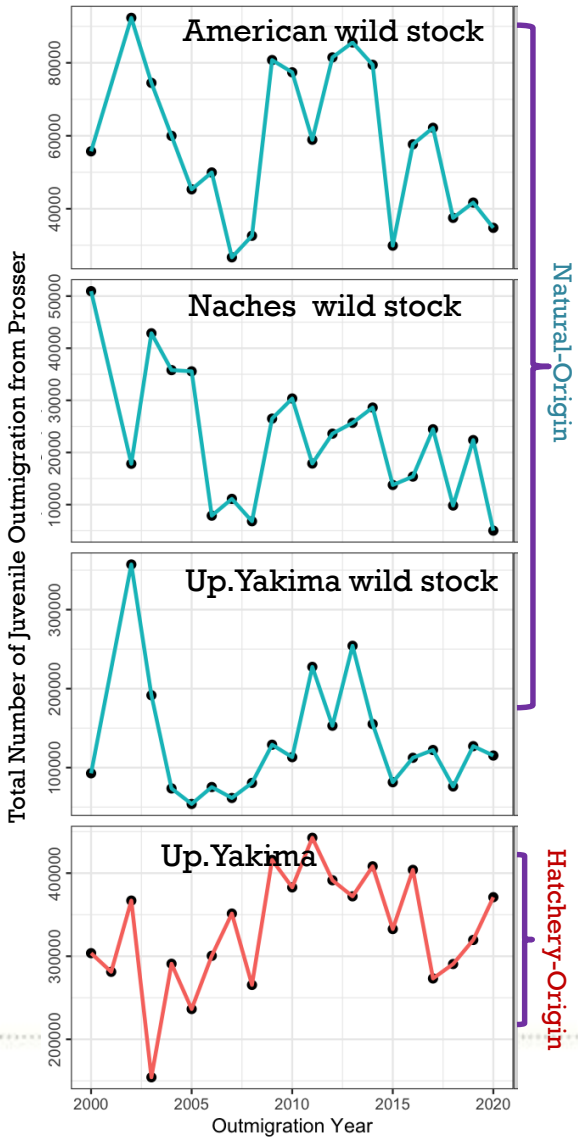
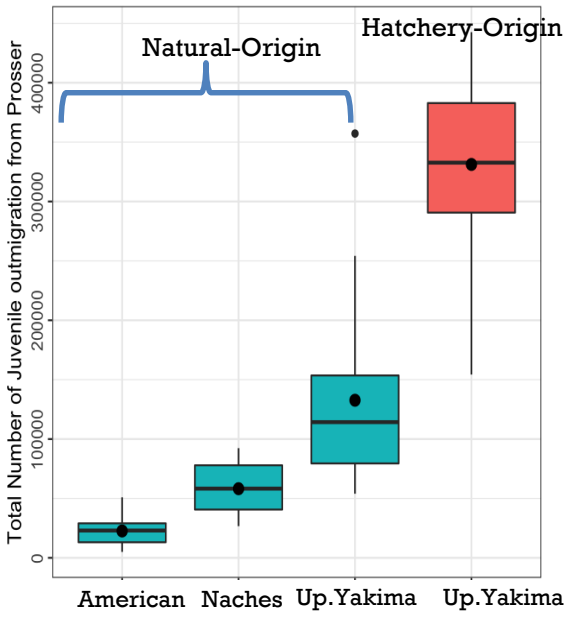
Spring Chinook

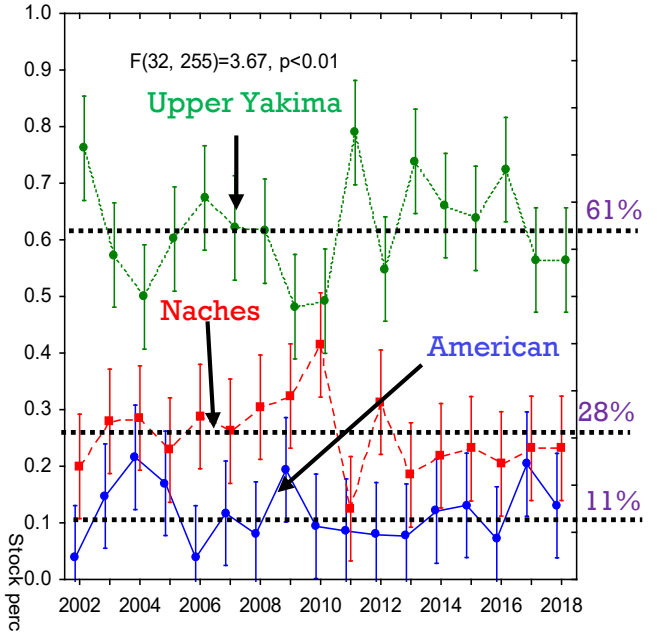
A. Temporal trend



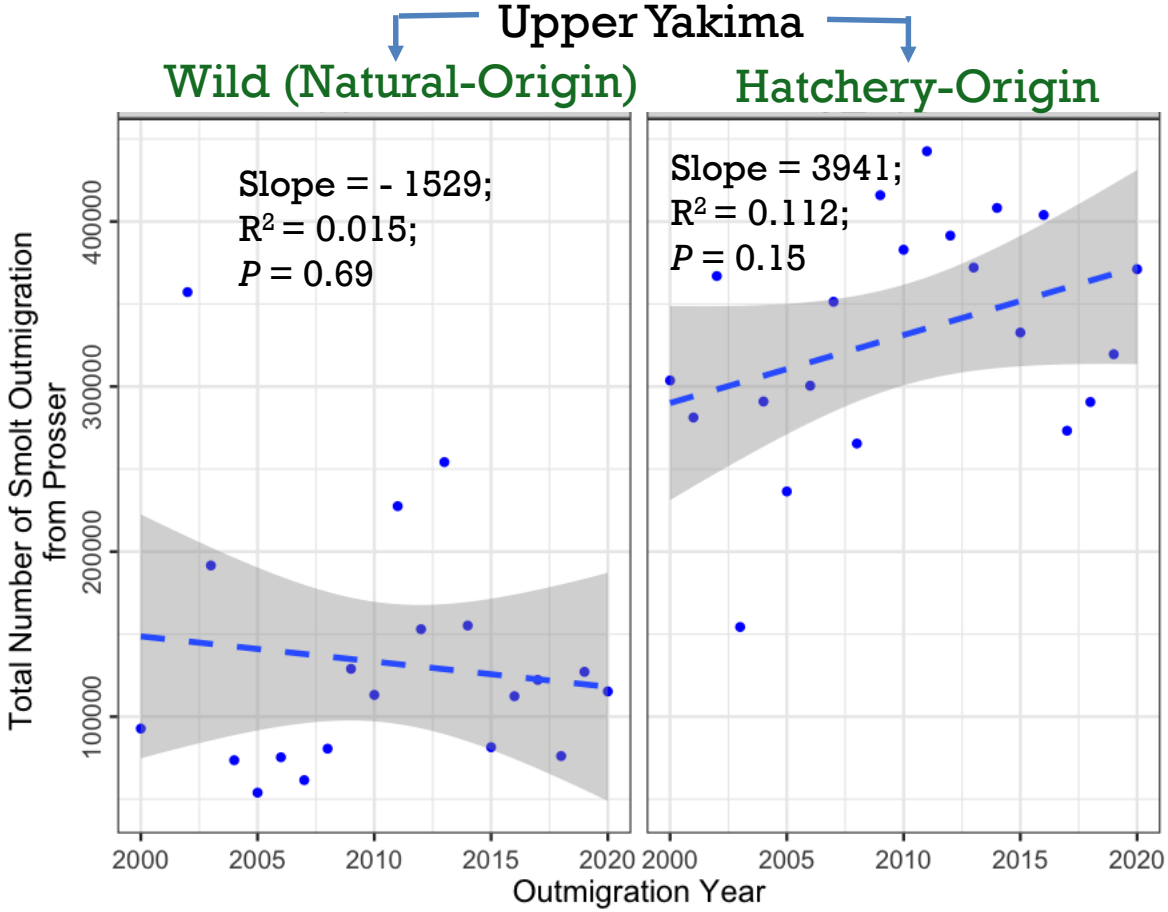
B. Total Juvenile outmigration

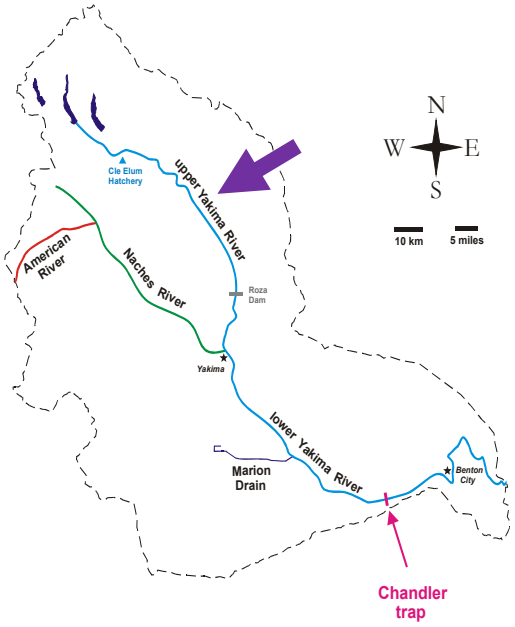


C. Genetic variation in outmigration (natural) smolts



Results: # Smolt Outmigration (Natural vs. Hatchery)





The total number of natural-origin spring chinook smolts has decreased over time but the hatchery-origin out-migration has increased

Results: # Smolt outmigration (Natural-origins only)

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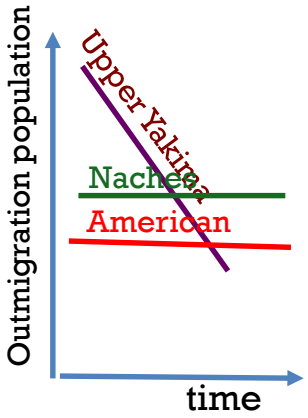
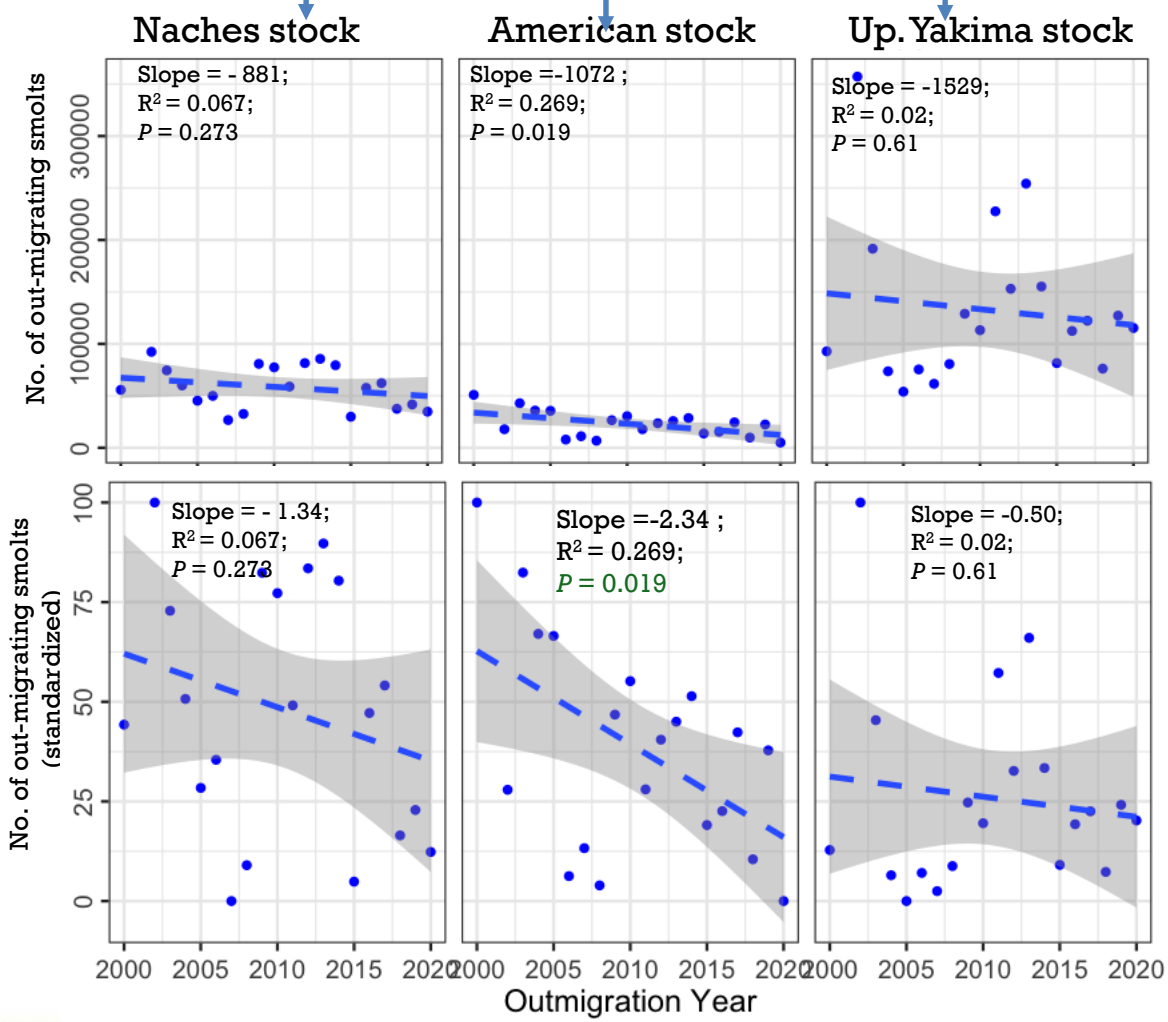
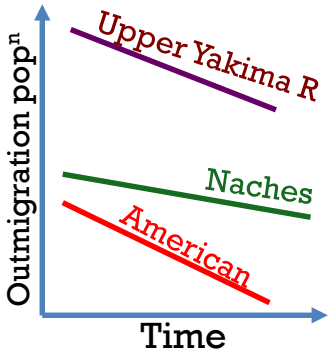
Hypothesis



Wild (Natural-Origin)

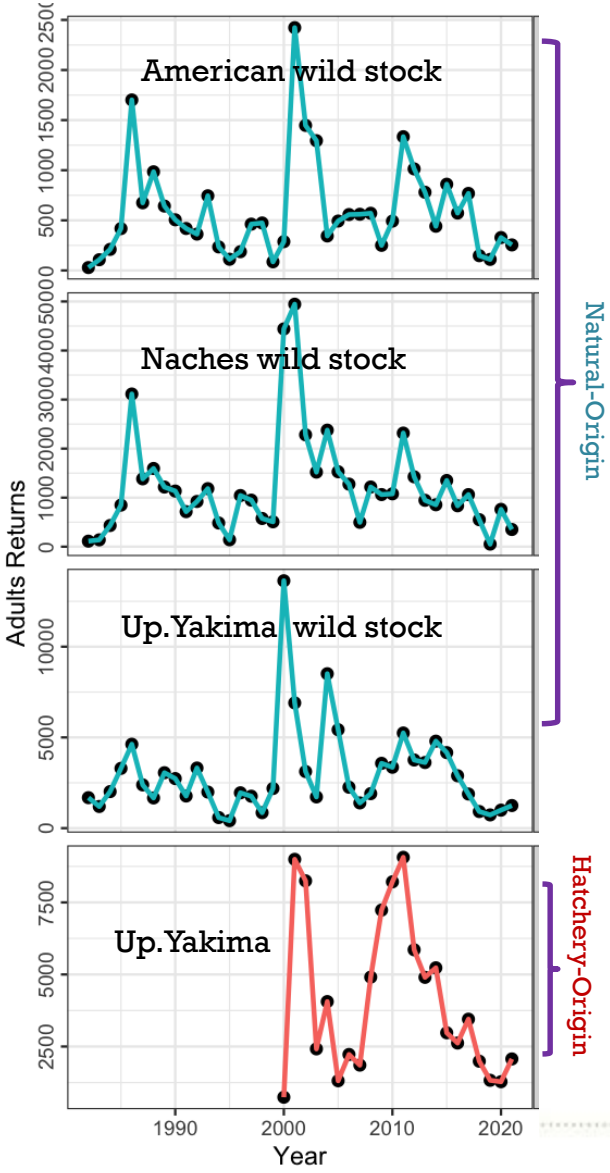


Results

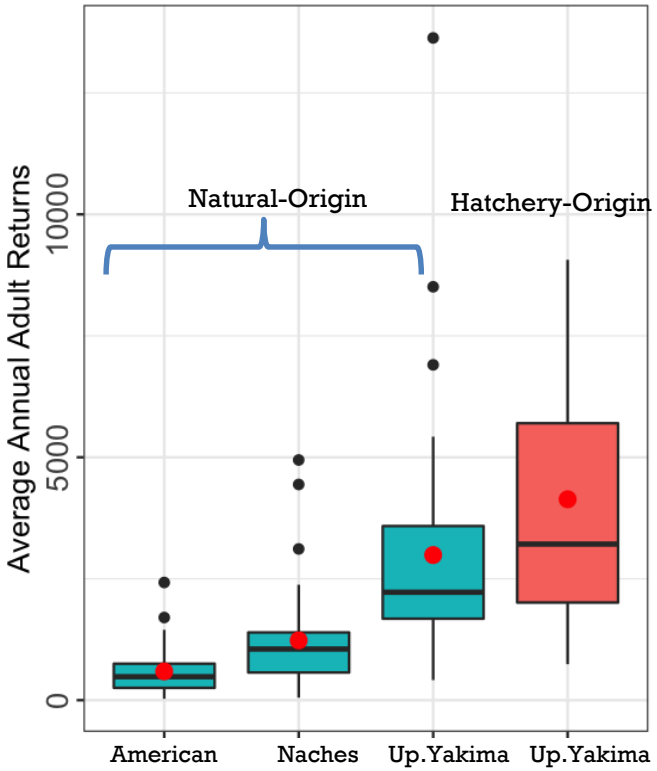


The outmigration of all the wild/natural stocks declined, but the Upper Yakima outmigration declined the least

Results: Adult Returns in Yakima River



Spring Chinook



Adult return% based on # of smolt outmigration

Origins	Smolts	Adults	%
American	22613	592	2.62
Naches	58217	1230	2.11
Upper Yakima	132685	2988	2.25
Upper Yakima	331203	4135	1.25

Results: Adult returns (Natural vs. Hatchery)

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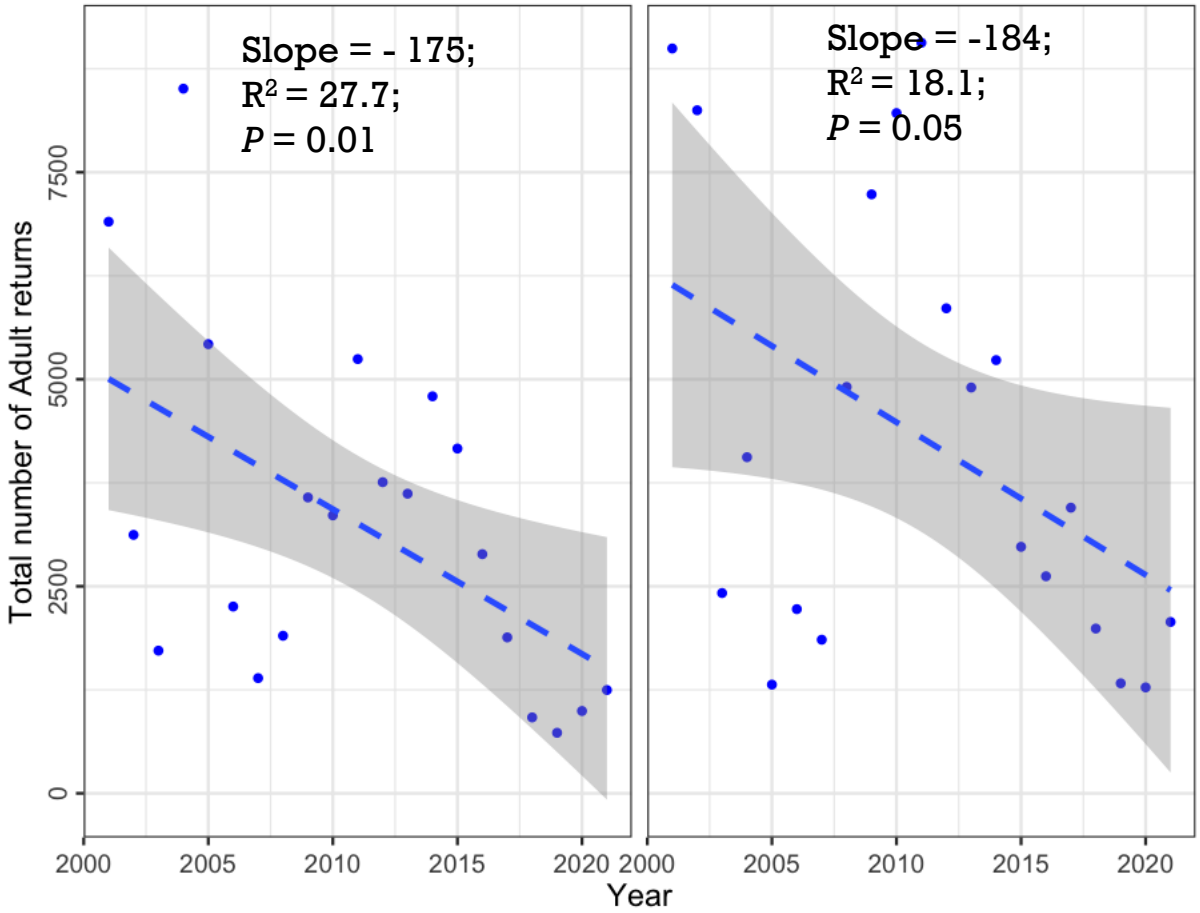
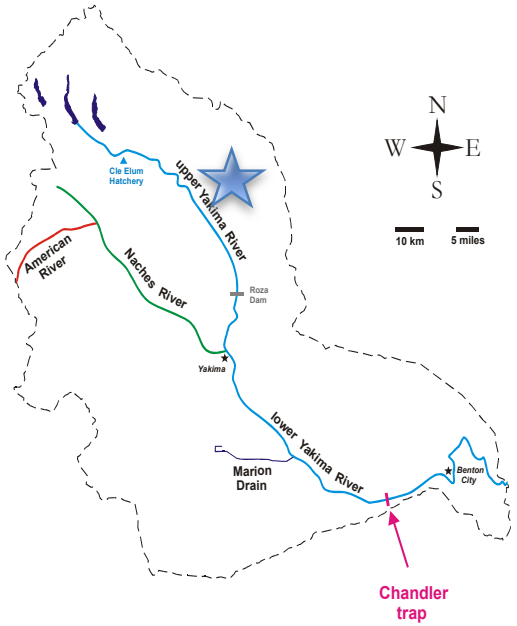
Upper Yakima

Wild (Natural-Origin)

Hatchery-Origin





Returns of both Upper Yakima groups are decreasing over time

Results: Adult Returns (Natural-Origins only)

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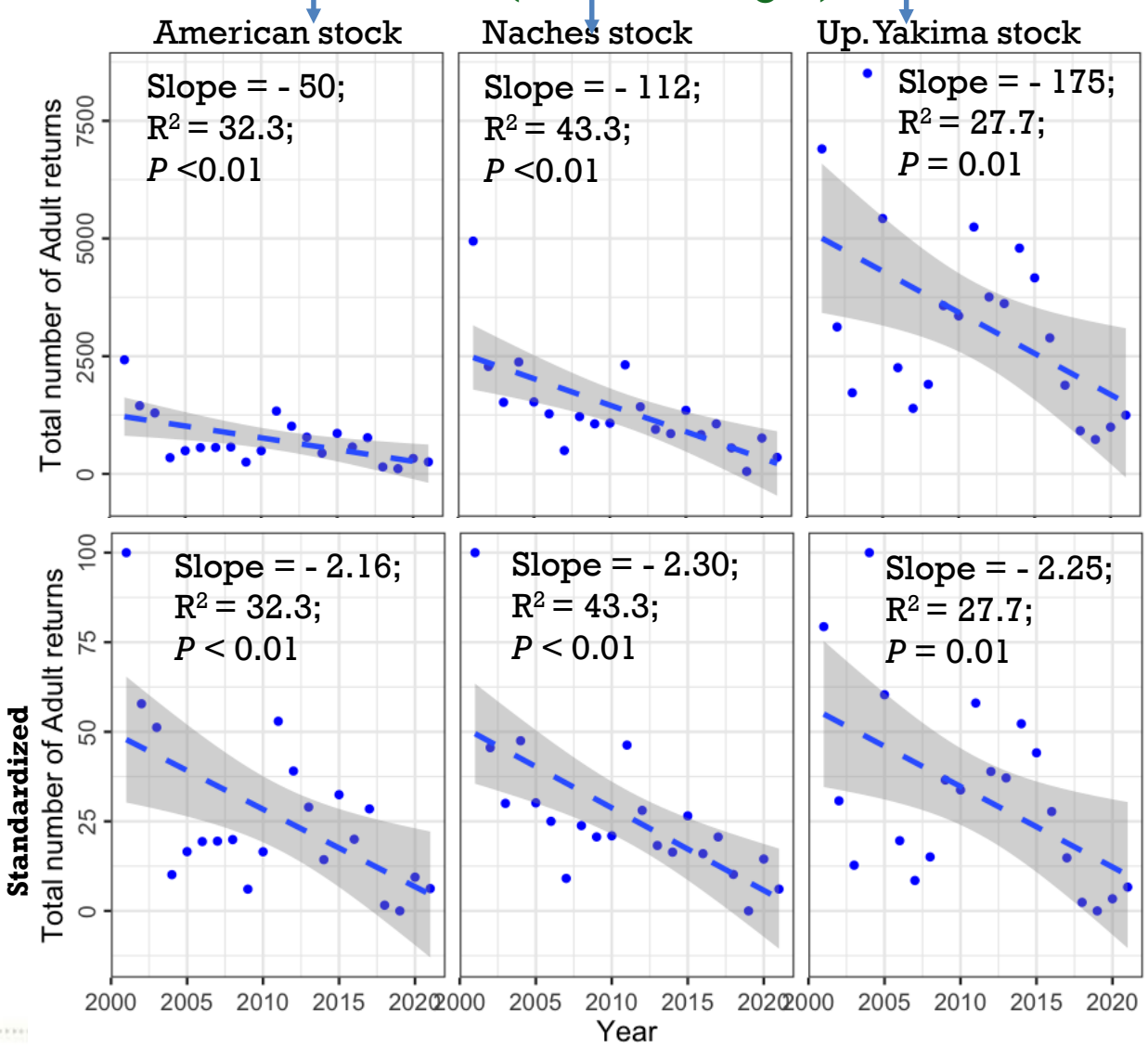
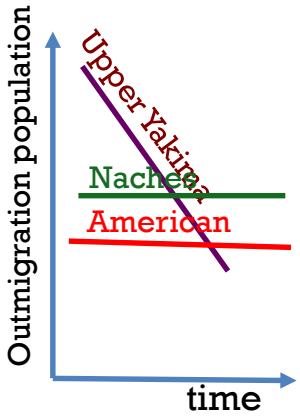
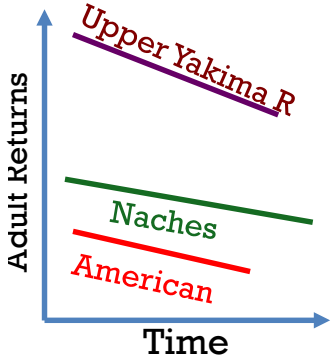
Wild (Natural-Origin)



Hypothesis

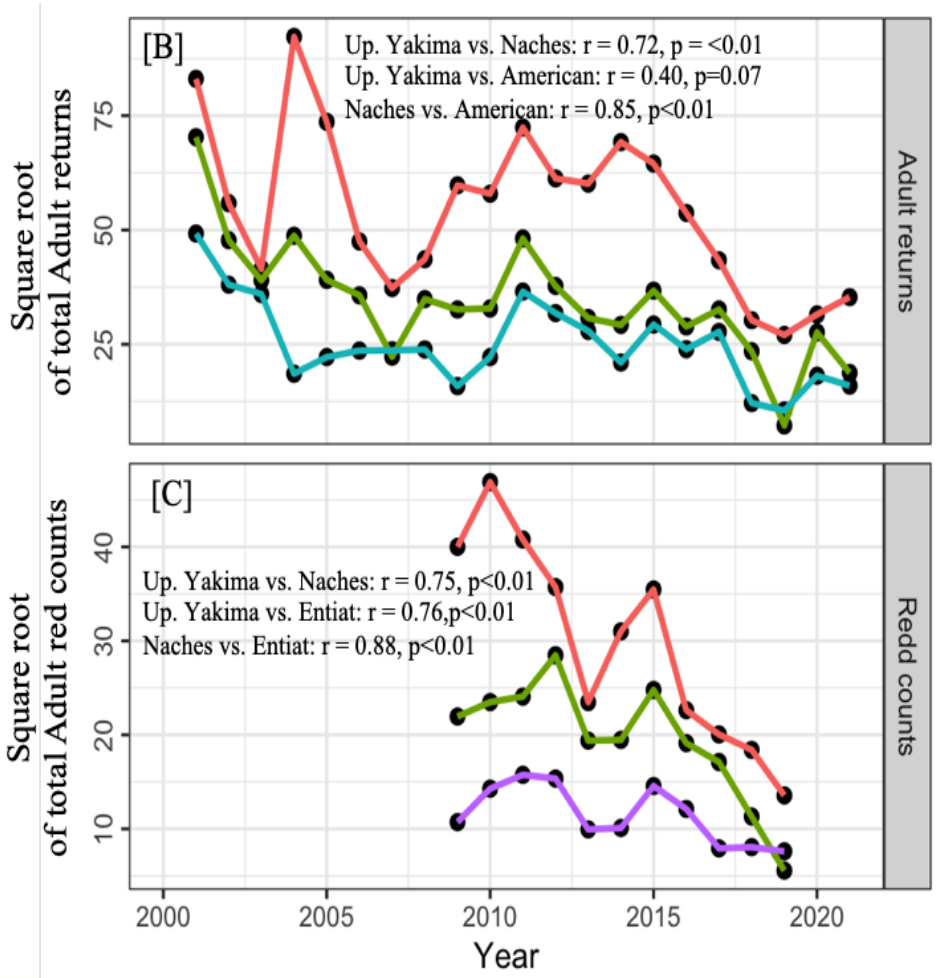


Results

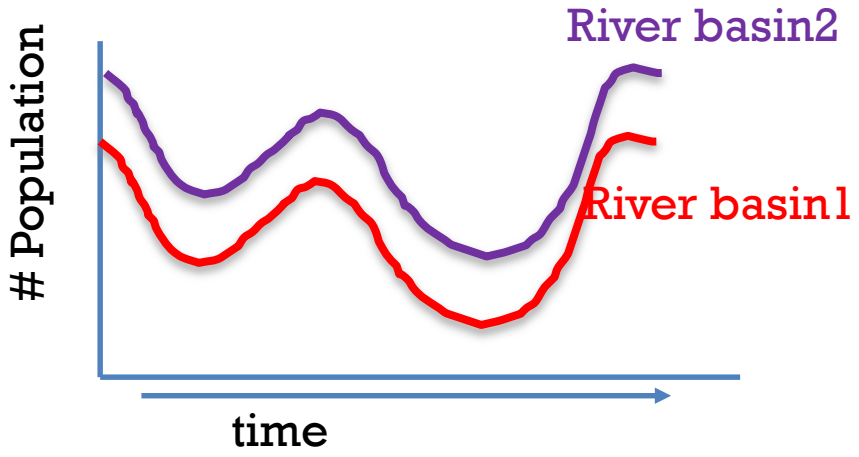


The rate of decline of adult returns was slightly higher in Naches, then by upper Yakima; and the slowest decline was in the American river (but not significantly different)

Results: populations fluctuations among sub-basins



If it is synchronized, both river basins experienced similar levels of the effects of internal or local factors, such as predation, density dependence, habitat conditions, or external factors like weather or ocean condition.



Summary/take home message

- The total number of wild/natural-origin **smolt outmigration** declined over time, but the hatchery-origin smolt productivity has been increasing
- Although # no of **smolt outmigration** of all three wild/natural stocks has decreased, the Upper Yakima wild/natural stocks' smolt outmigration declined the least
- The number of **adult returns** of all three wild stocks as well as hatchery of upper Yakima river have decreased over time, but the highest decline was in Naches wild stock, followed by Upper Yakima wild stock, and lowest in American stock but they were not significantly different
- The study suggests that hatchery supplementation seemed to have a positive effect on the Upper Yakima natural stock, protecting it from steep declines (served as a buffer to mitigate greater impacts)
- The study suggests that change in freshwater and marine productivity are the primary driver of declines in natural production

Acknowledgment

- All crew members who are collecting samples in the Chandler monitoring facility
- As well as Gabriel M. Temple, Anthony Fritts, Garrett J. McKinney and Todd R. Seamons of WDFW for reviewing the manuscript as well as processing genetic samples

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Questions?