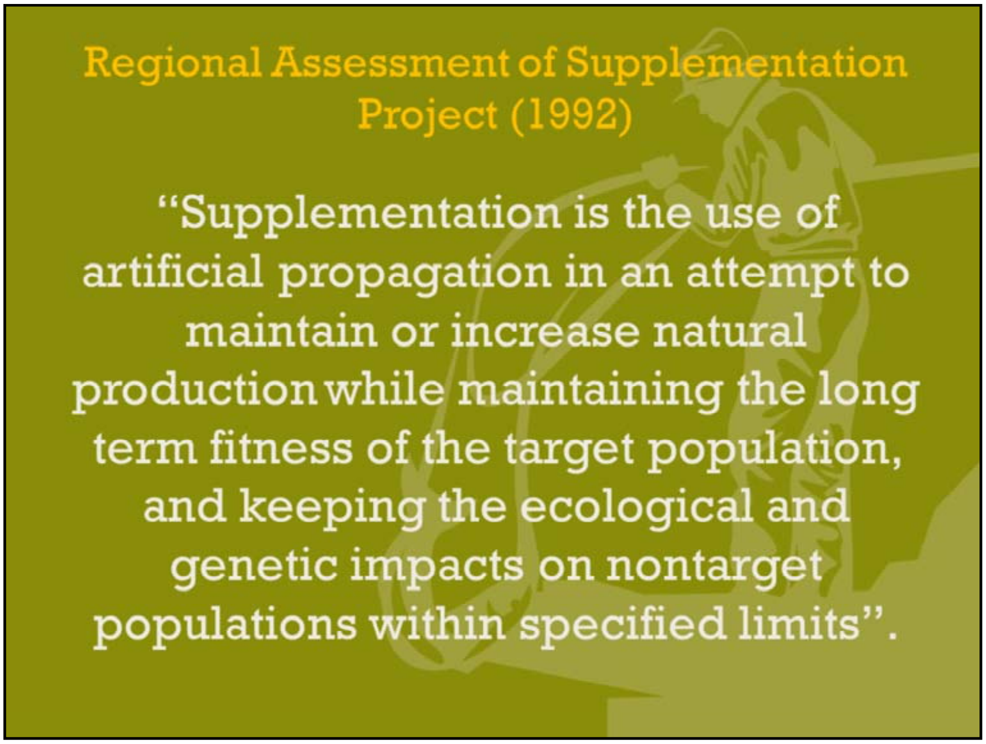
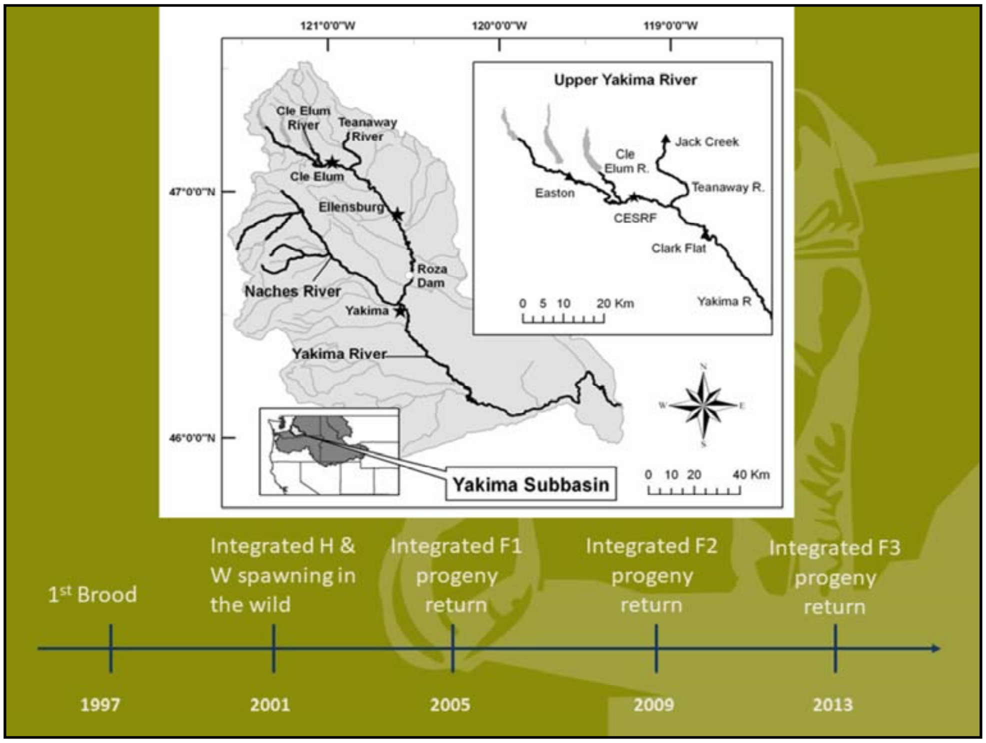
Presentation Title: Spring Chinook Salmon Supplementation in the Yakima River Basin – 25-year Summary

Abstract: After years of planning and design, the Levi George Spring Chinook Salmon Supplementation and Research Facility in Cle Elum, WA (CESRF) was constructed in 1996. This program is a supplementation effort targeting the upper Yakima River population and is designed to test whether artificial propagation can be used to increase natural production and harvest opportunities while limiting ecological and genetic impacts. It is an integrated hatchery program because only natural-origin brood-stock are used and returning hatchery-origin adults are allowed to spawn in the wild. The program employs "best practice" hatchery management principles including reduced pond densities, strict disease management protocols, random brood-stock selection, and factorial mating to maximize effective population size. Fish are reared at the central facility, but released from three acclimation sites located near the central facility at: Easton approximately 25km upstream of the central facility, Clark Flat about 25km downstream of the central facility, and Jack Creek about 12km upstream from the Teanaway River's confluence with the Yakima River. The CESRF collected its first spring Chinook brood-stock in 1997, released its first fish in 1999, and age-4 adults have been returning since 2001. The first generation of offspring of CESRF and wild fish spawning in the wild returned as adults in 2005. The program also includes a small segregated component as a hatchery control, and uses the adjacent, un-supplemented Naches River population as an environmental and wild control system. This talk summarizes results from 25 years of supplementation.

Monitoring and evaluation efforts in the Yakima River Basin are the result of a cooperative effort by many individuals from a variety of agencies including the Yakama Nation Fisheries Program, the Washington Department of Fish and Wildlife, the United States Fish and Wildlife Service, the Columbia River Inter-Tribal Fish Commission, the National Oceanic and Atmospheric Administration Fisheries department as well as some consultants and contractors. We also wish to acknowledge and thank the Yakama Nation Tribal Council, U.S. Bureau of Reclamation, Yakima Subbasin Fish and Wildlife Recovery Board, Pacific States Marine Fisheries Commission, U.S. Forest Service Naches Ranger District, University of Idaho, Lars Mobrand and associates, University of Washington, and Central Washington University for their many contributions to this project including both recommendations and data services.

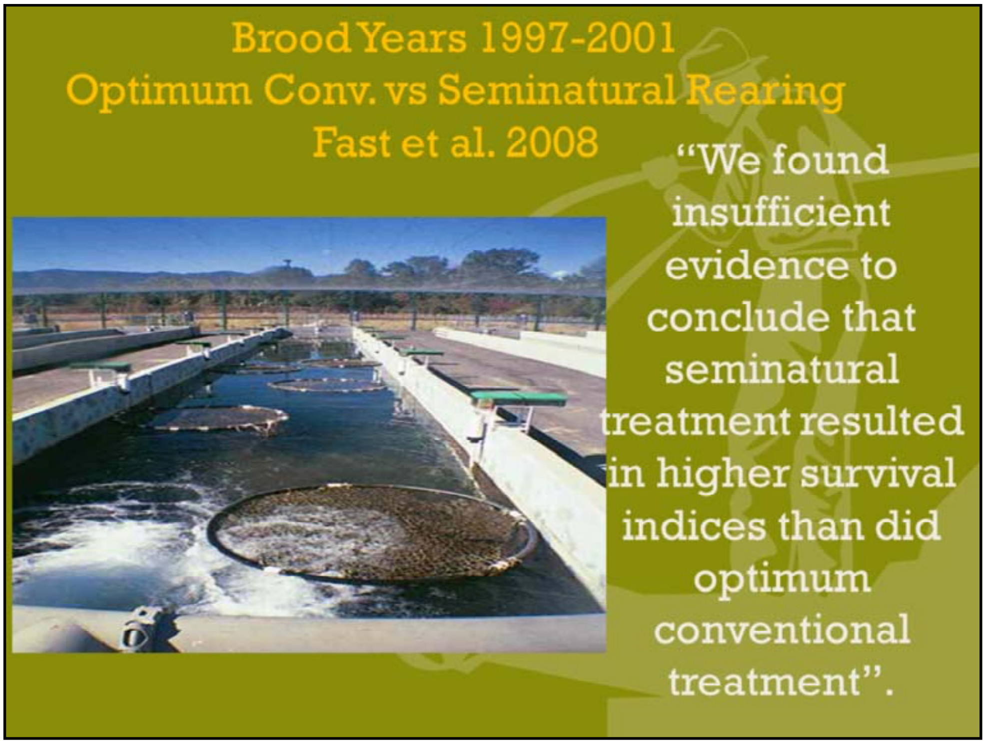


Given this mouthful and the high priority placed on this project from the beginning to research and evaluate hatchery effects/uncertainties, a LOT of work went into design and implementation of a comprehensive monitoring program. This talk is a "whirlwind tour" of what we've learned so far.



Some background on the Cle Elum spring chinook program in the upper Yakima. The project was designed to implement the "gravel-to-gravel" hatchery reform concept where a central facility is used to rear fish, but fish are released from acclimation sites near spawning and rearing areas so that returning fish can return to these areas, spawn naturally, and "integrate" with returning natural-origin fish. The 1st brood cycle began in 1997 with brood collection. The 1st age-4 returns spawning in the wild returned in 2001. The 1st generation age-4 returns from integrated (HoR and NoR) spawners returned in 2005, the 2nd generation returns in 2009, etc. Only NoR fish (unmarked and untagged fish) are used for brood stock.

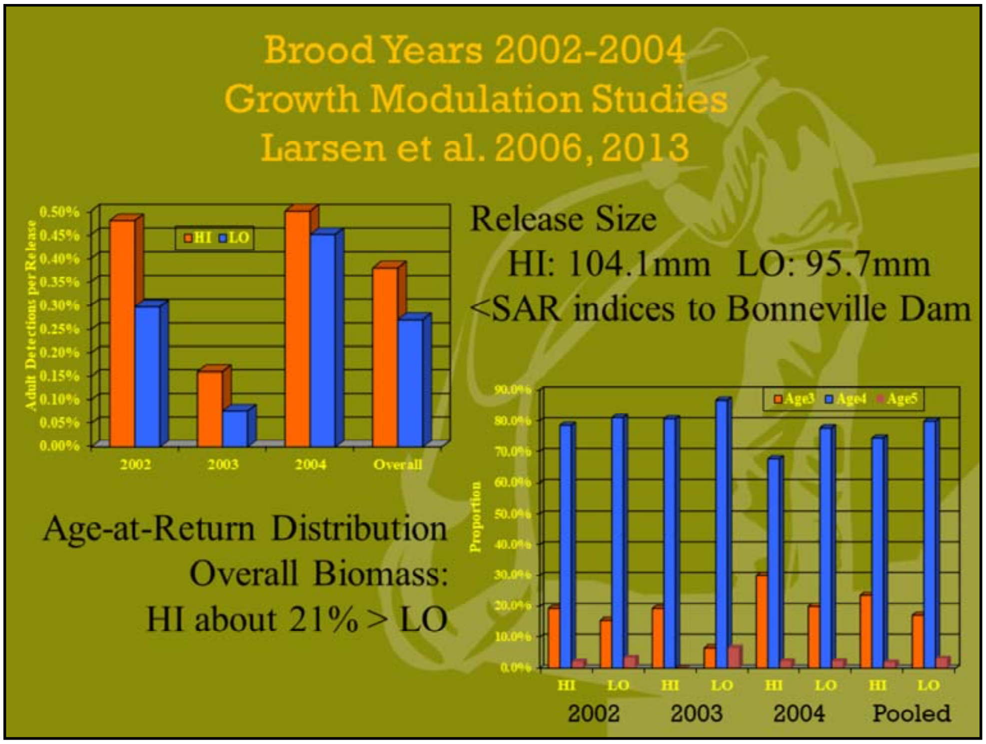
The Naches River is being used as a control stream. Both the upper Yakima and Naches systems experience very similar environmental conditions, e.g., droughts and floods rarely if ever occur in one stream without impacting the other as well. Also, historical data suggest there are virtually no upper Yakima fish which stray into the Naches system. Thus, differences in these two populations over time can be attributed to supplementation.



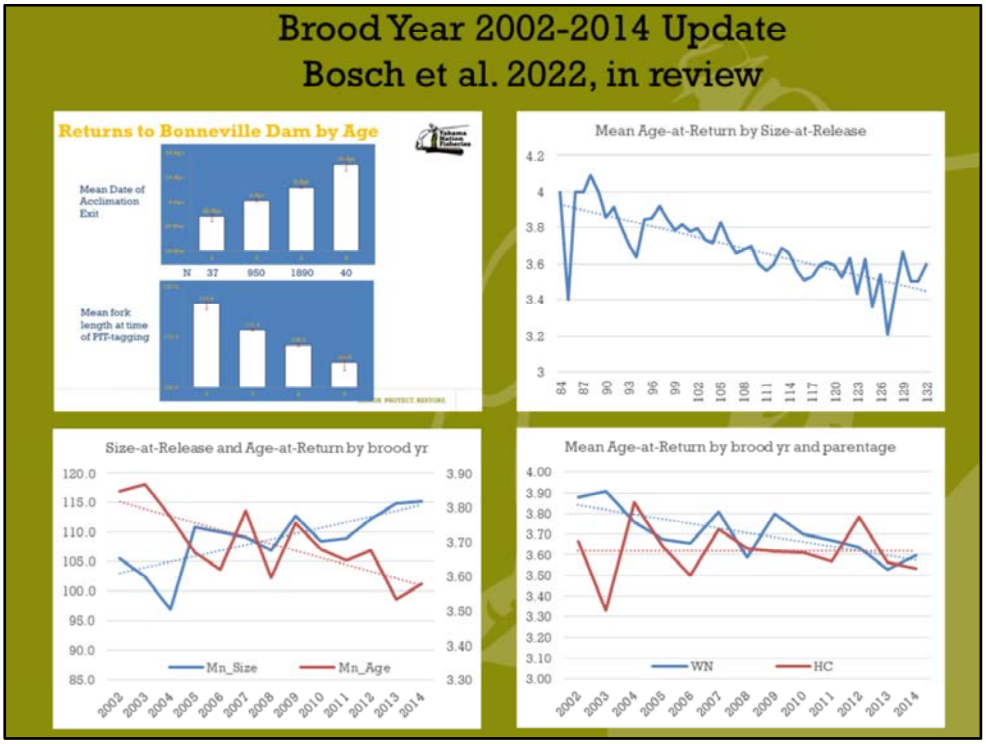
This study compared a traditional hatchery raceway (optimum conventional treatment-OCT) with a semi-natural treatment (SNT; i.e., rearing in camouflage-painted raceways with surface and underwater structures and underwater feeders) designed to induce more natural coloration and behavior in juvenile fish.

Brood Years 1997-2001
Wild vs Integrated Hatchery Traits
Knudsen et al. 2006, 2008

Reported differences in lengths, weights, spawn timing, female egg mass, and fecundity suggesting likely fitness reductions in integrated HOR fish.

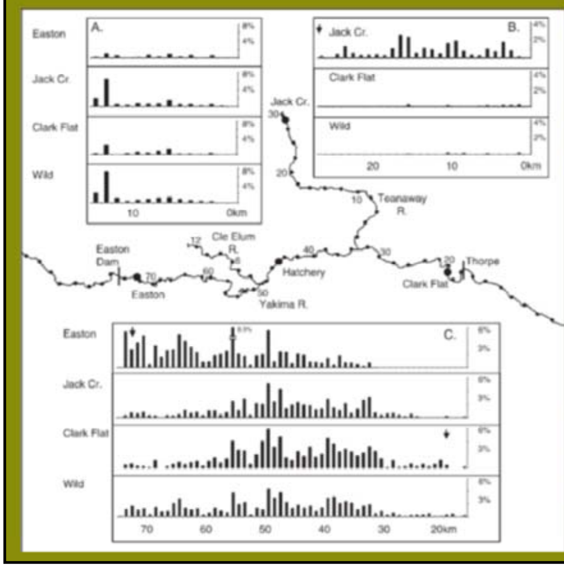


This study used a more natural, or slower growth regime (LO) and compared it to a traditional hatchery feeding regime (HI). As expected, the HI feeding regime produced larger fish at release which outperformed smaller (LO) fish in terms of smolt-to-adult return (SAR) indices. However, science has only recently started to look more closely at age-at-return; in every case the age-at-return distribution was older (which equates to larger returning adults) for the LO treatment relative to the HI growth treatment.

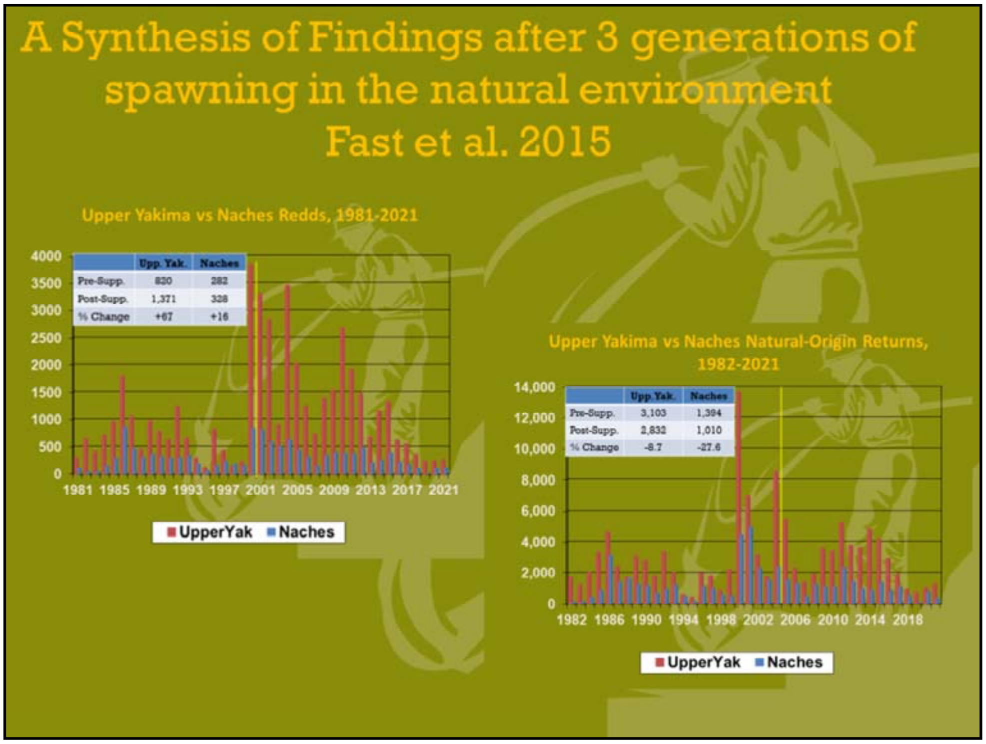


This is an opportunistic study that investigated demographic, environmental condition, and survival relationships for PIT-tagged fish detected exiting the acclimation sites over 13 brood years using fork length at PIT-tagging as a surrogate for smolt release size. These graphs are pooled data for 3068 PIT-tagged fish released as juveniles from CESRF and detected at Bonneville Dam as returning fish over 13 brood years. The upper two slides depict the main findings in Bosch et al. 2022 (submitted to Environmental Biology of Fishes and in peer review) – larger fish at release exited acclimation sites earlier and returned at younger ages than did smaller fish at release. The lower panels depict temporal and origin trends in the data that warrant further investigation as to potential causes, e.g., changes in feeding/growth rearing regime, changes in feed nutrient content, changes in rearing water temperature, or possibly changes in wild/natural fish used for brood stock, i.e., a genetic change that might be causing younger age-at-return (see Waters et al. 2021).

Brood Years 2002-2010
Homing and Spatial Distribution
Dittman et al. 2010

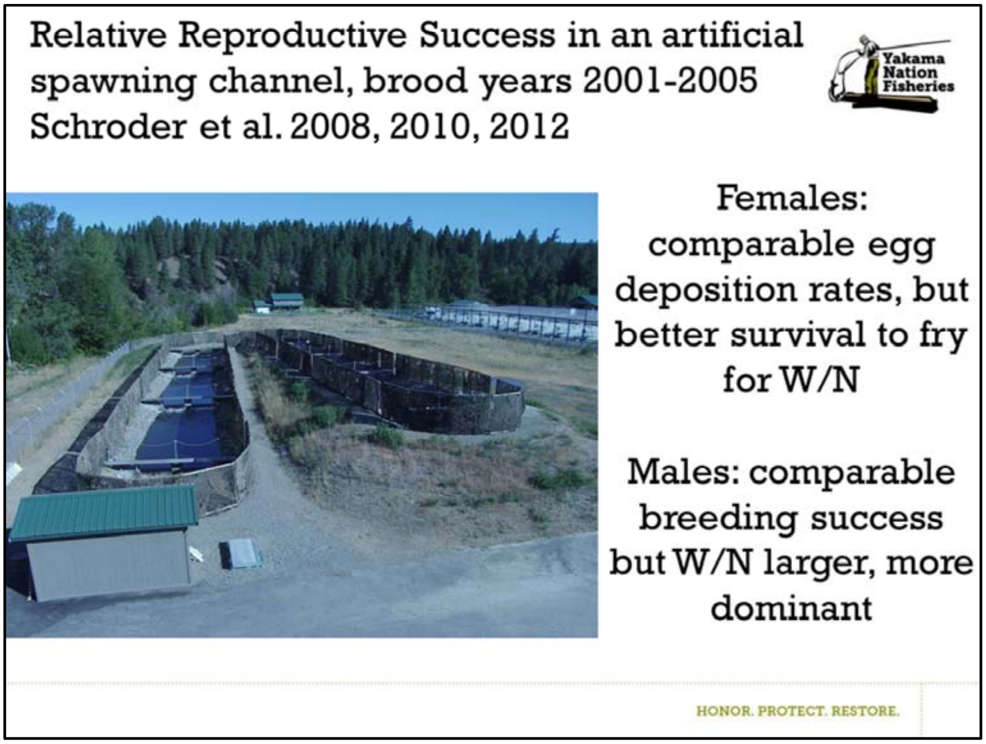


"Final spawning location depended strongly on where fish were released as smolts, but many fish also spawned in the vicinity of the central rearing hatchery".

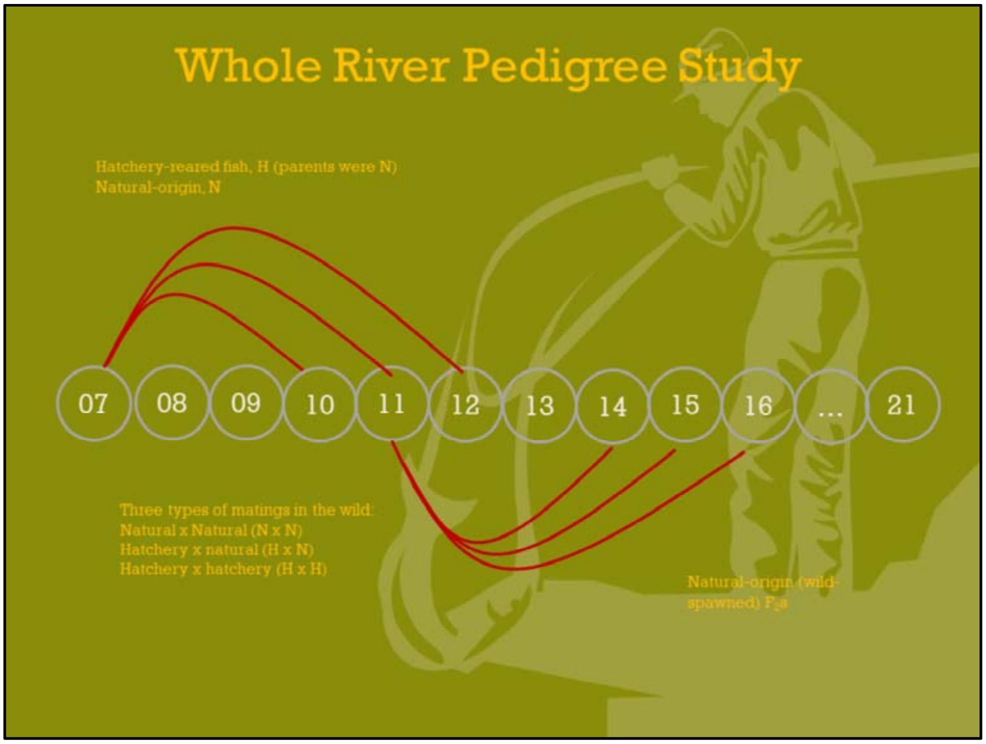


The observed increase in redd abundance in the supplemented Upper Yakima from the pre- to post-supplementation period (p=0.06) is more than 4 times greater than that observed in the unsupplemented Naches population (p=0.49). Note that only 10 redds were observed in the Naches system in 2019. Changes in natural-origin returns were not significant in either case, but note that the downward trend in the Naches population post-supplementation is about 3 times greater than that observed in the Upper Yakima population.

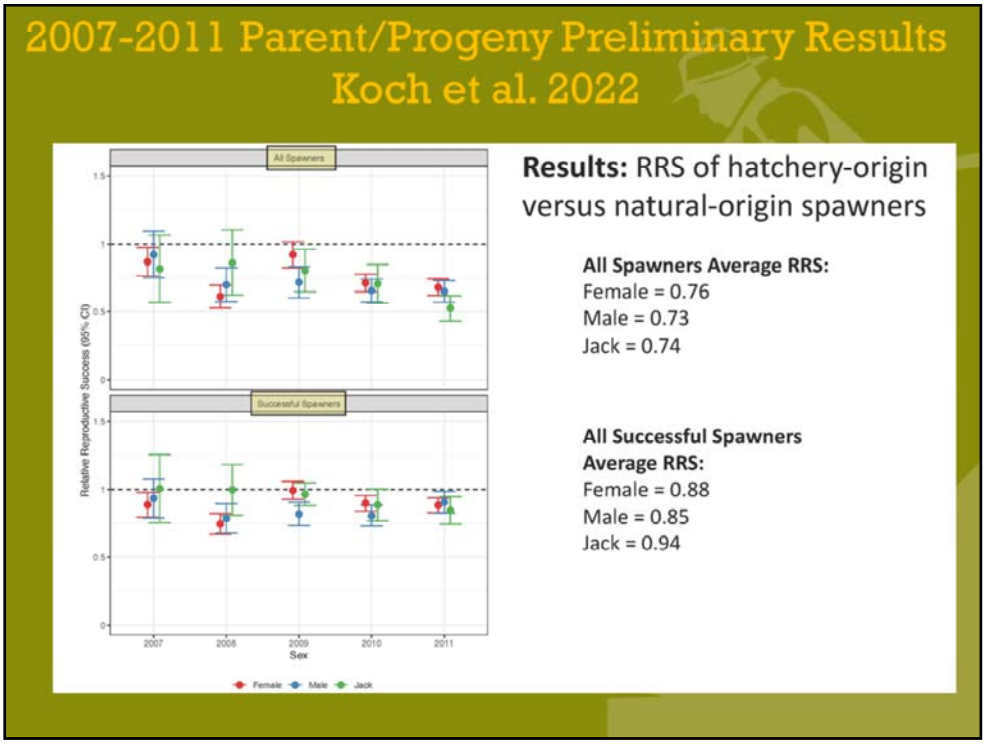

Other Ecological Risks
Proportions of mini-jacks and jacks concerning
Ecological interactions within adopted guidelines
Stray rates < 5%
Pathogen and BKD risk profiles very low
References: Fritts and Pearsons 2004, 2006, 2008; Fritts et al. 2007; Galbreath et al. 2021; Larsen et al. 2004, 2010, 2019; Pearsons and Hopley 1999; Pearsons 2008; Pearsons et al. 2007, 2009; Pearsons and Temple 2007, 2010; Pierce et al. 2021; Temple and Pearsons 2012; Temple et al. 2017.



This spawning channel was constructed for the specific purpose of studying relative reproductive success. From 2001 to 2005, we DNA-sampled and placed returning wild and hatchery-origin adults into the channel, let them spawn on their own, then collected DNA from a sub-sample of juvenile offspring and conducted a parent/progeny pedigree analysis to determine the number of progeny sired by hatchery- and wild-origin parents. Results were published in 2008 and 2010.



Since 2007 we have also been taking DNA samples from every spring Chinook returning through the Roza Dam adult monitoring facility for the purpose of doing a parent/progeny pedigree analysis for all fish destined to spawn in the Upper Yakima River over several years. In the illustration the circles represent the brood year with red lines corresponding to the year that aged 3 through 5 adults return to Roza Dam and are sampled prior to being released to spawn naturally upstream. This example shows fish from BY 2007, which return to spawn alongside their natural-origin counterparts in 2010 (age 3, “jacks”), 2011 (age 4), and 2012 (age 5). Mating among hatchery-reared and natural-origin fish occurred in every subsequent year to create wild-born F_2s, which return 3 to 5 years later. The example follows fish (returning to Roza in 2007) that spawned in the wild and whose progeny returned as adults in year 2010-12, and produced naturally-spawned fish (F_2s) that returned in years 2015 through 2017.



These are the results of the Roza / whole river pedigree evaluation for the first brood cycle (brood year 2007-2011 fish returning to spawn in 2010-2016). The study is expected to be completed in the next two years with updated data from fish returning through 2021 to include grandparentage analysis.

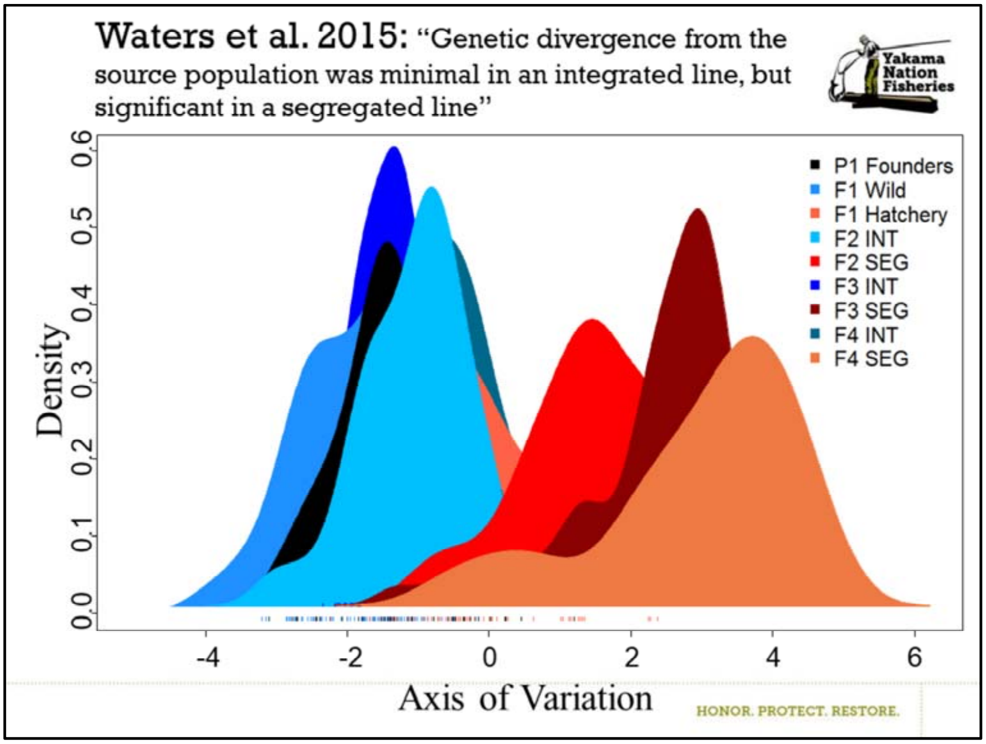
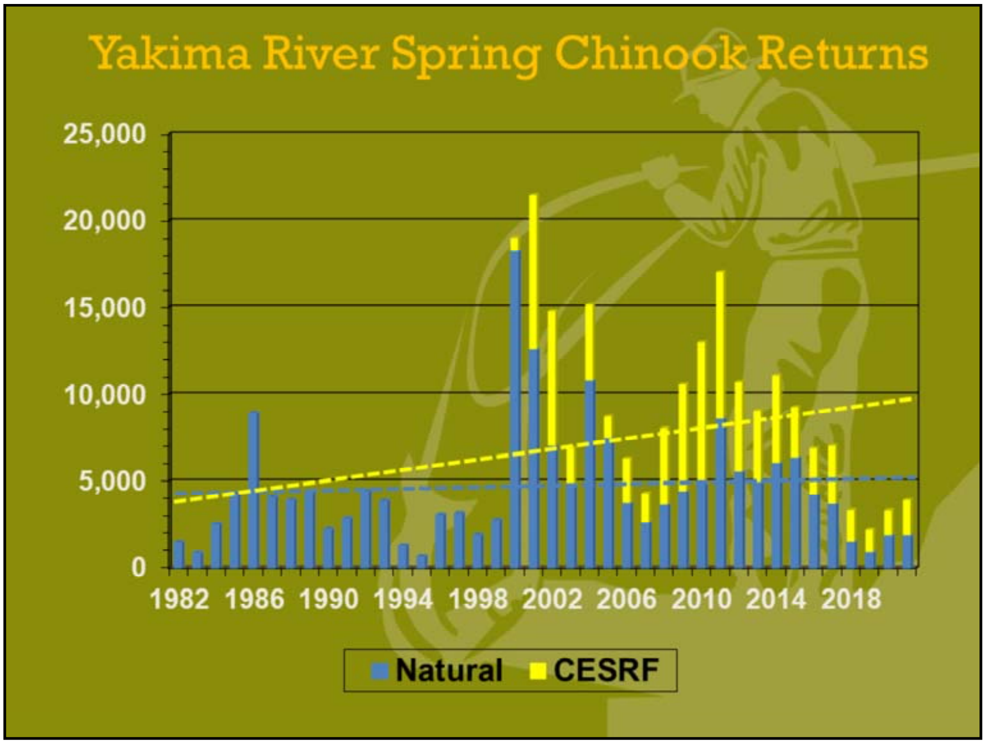
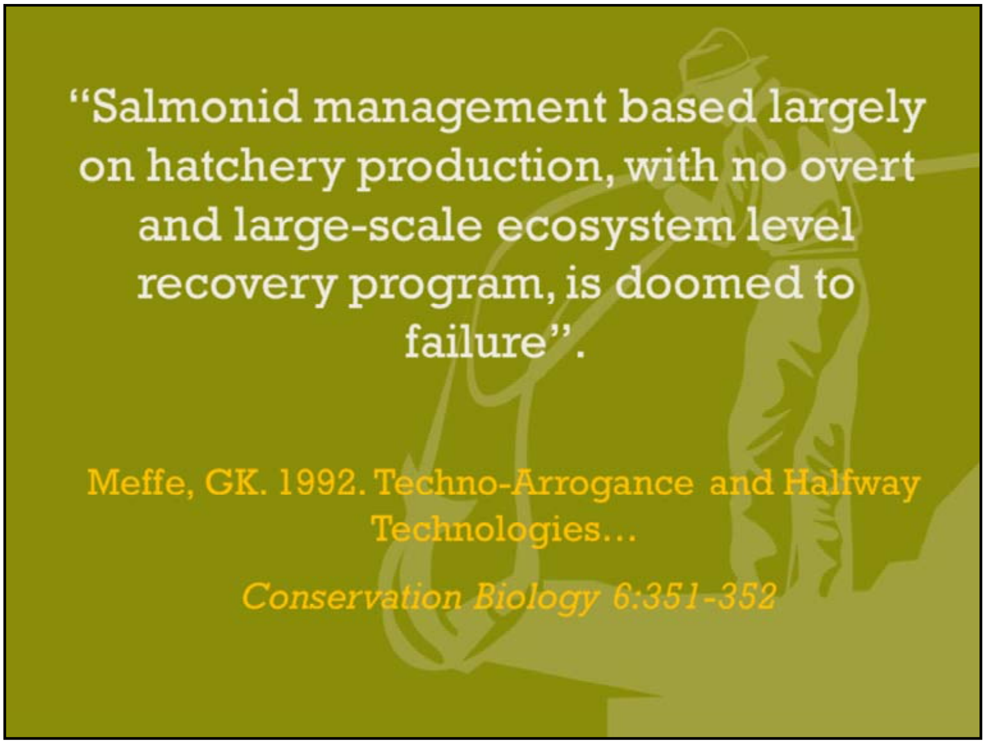


Figure 4 from paper updated to include fourth generation (BY2014) fish. Density plot of individuals from the wild founders (P_1 Founders, black) and three generations of the integrated (INT, blue colors) and segregated (SEG, red colors) hatchery lines along the first discriminant function from the discriminant analysis of principal components (DAPC). Population genetic differentiation, F_{ST}, for each of the generations compared to the P_1 founders was low in all pairwise comparisons, ranging from 0 to 0.0108 (Table S3). The F_1 hatchery fish and segregated line steadily diverged from the P_1 founders over time; the F_2 and F_3 SEG populations were significantly differentiated from the founders (F_{ST} = 0.0049 and 0.0108 respectively, $P < 0.001$). In contrast, the integrated line did not exhibit the same temporal trend of increasing genetic divergence.

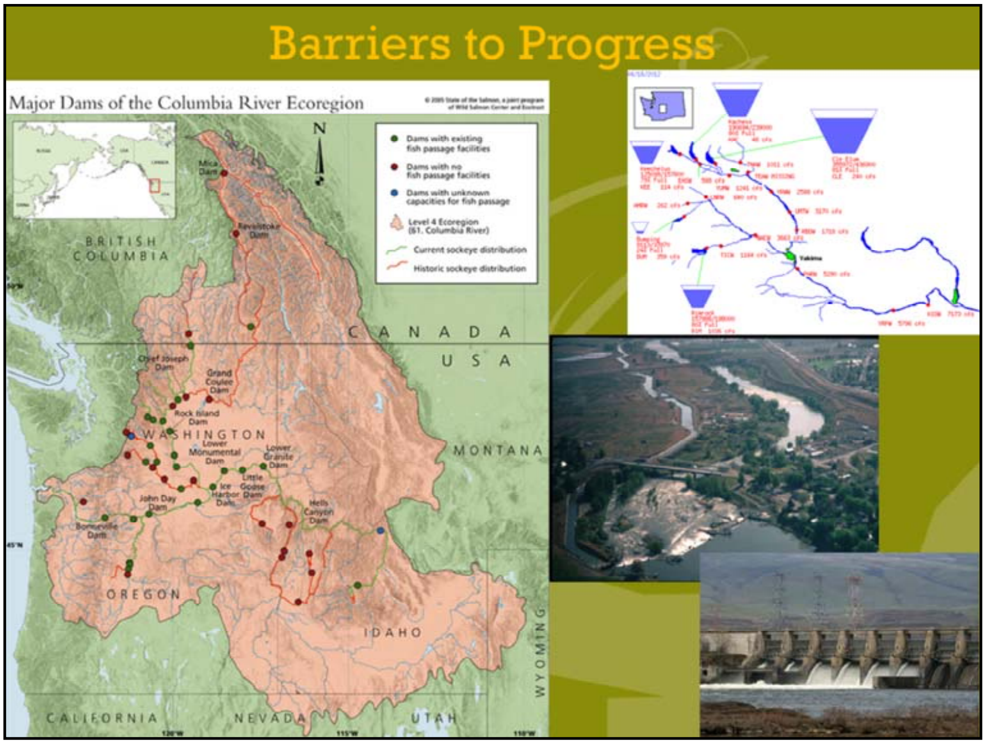


Supplementation has resulted in an increasing long-term trend in overall spring Chinook returns to the Yakima River Basin; however, the long-term trend in natural-origin returns is virtually flat.

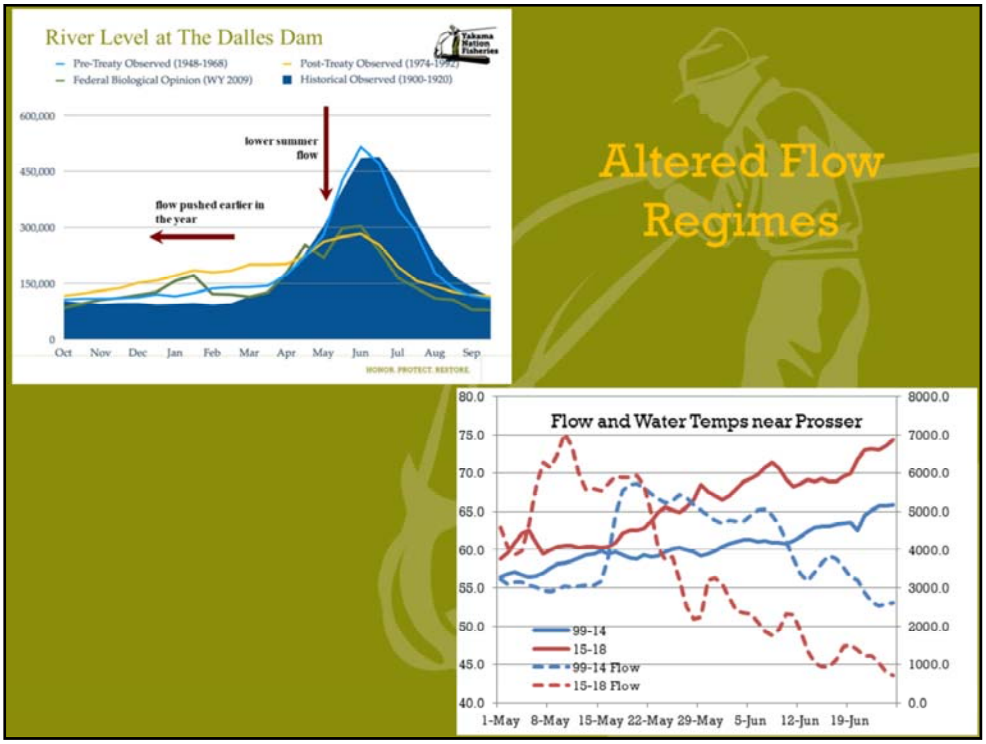


Conservation and fisheries professionals have made statements to regional and national policy makers very similar to this for over 150 years as European immigrants proceeded to occupy and transform the Columbia Basin to better serve their worldview which prioritized material wealth over ecosystem health. As Lisa Wilson of the Lummi Nation stated in a recent Op-ed, "re-establishing properly functioning ecosystems that support natural salmon production to meet these needs is preferable [to hatchery production] from a tribal perspective". That is why we are working hard throughout the Columbia Basin to restore habitats. In the Yakima Basin…

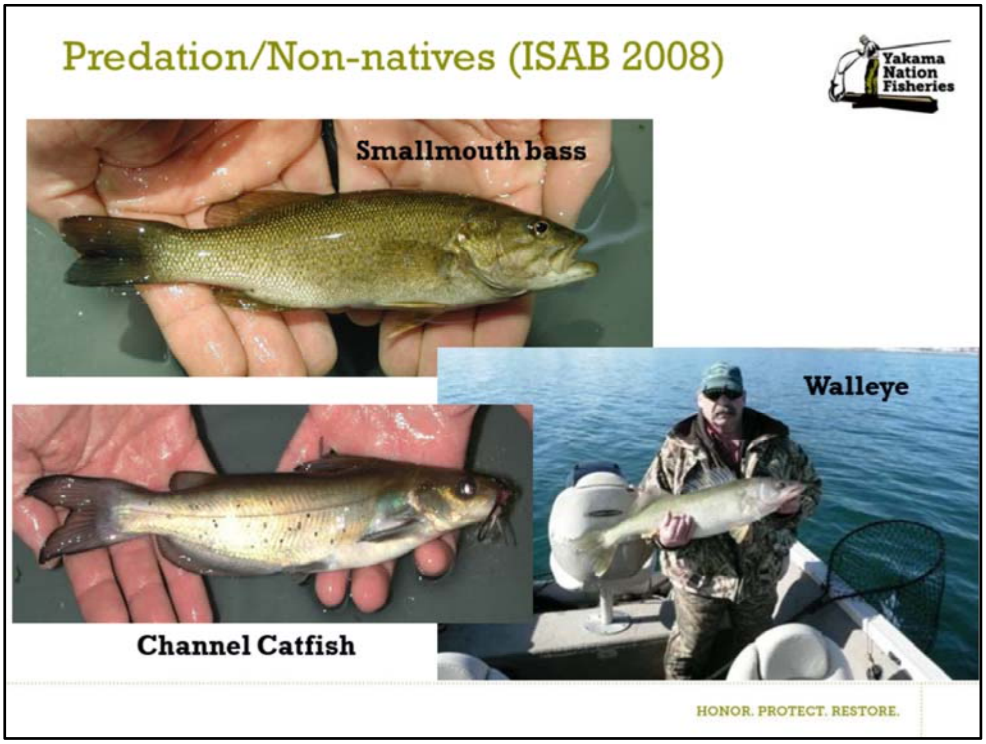
A lot of investment in terms of human and economic resources is occurring through the Yakima Basin Integrated Plan, a collaborative effort of tribal, city, county, irrigation, non-governmental, and other agencies and interests. But is this work sufficient to qualify as a “large-scale ecosystem level recovery program”? Or are there other factors still needing improvement…



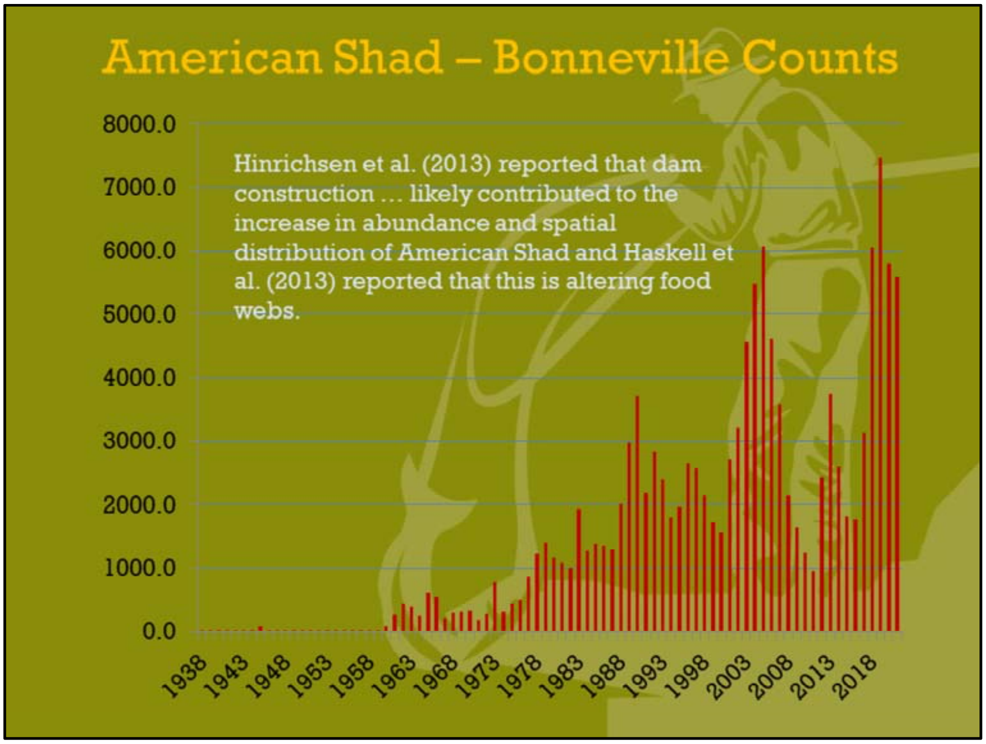
And it is not just large barriers that are sources of mortality for juvenile and adult salmon. In the Yakima R. Basin there are still over 30 water use diversions to serve irrigation districts, source: BOR Yakima River Basin Study 2011, pp. 5-7. https://www.usbr.gov/pn/programs/yrbwep/reports/tm/6modreliabtyflow.pdf



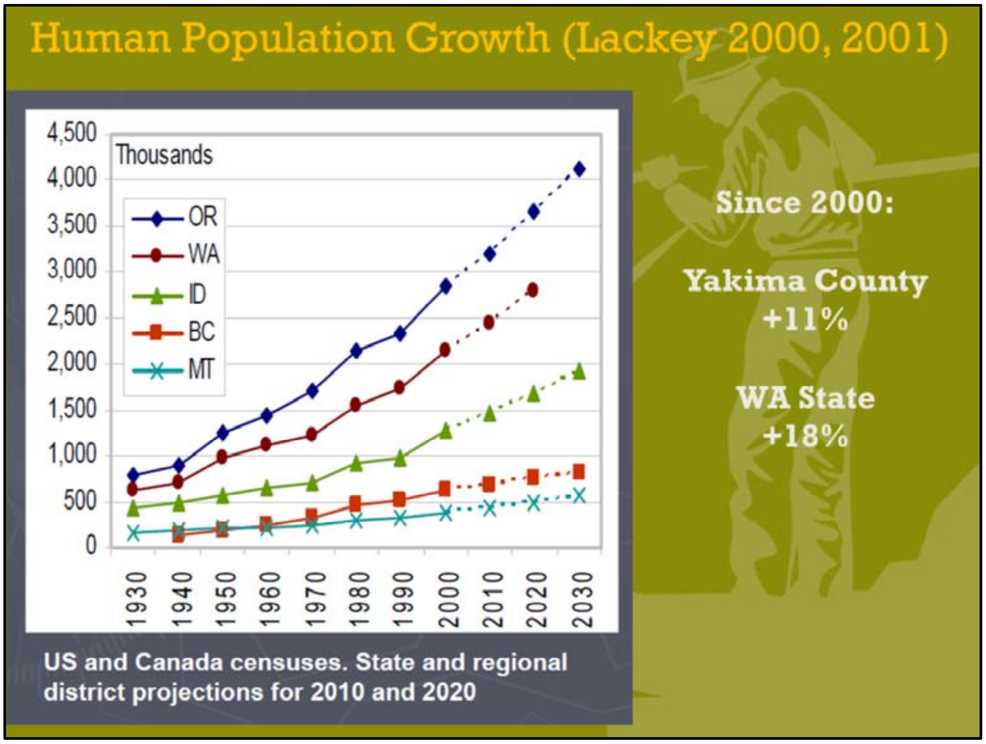
Managed rivers and climate change are reducing flows and increasing temperatures during critical juvenile and adult migration periods.



Highly altered river systems have created conditions that favor species such as these and …



Hinrichsen et al. (2013) reported that dam construction and alterations to the temperature and discharge regimes of the Columbia River have likely contributed to the increase in abundance and spatial distribution of American Shad *Alosa sapidissima* and Haskell et al. (2013) reported that this is altering food webs potentially affecting Pacific salmon.



I think we're all generally familiar with these human population trends (note OR and WA are reversed). More humans = more pressure to serve the needs and economic interests of those humans which historically has resulted in further alteration or elimination of habitats available to fish and wildlife.

Western science: what can we learn about organisms; traditional ecological knowledge: what can we learn from organisms. Both ways of learning are communicating the same message: if we want thriving, wild salmon populations we need healthy, wild ecosystems. If we are unable or unwilling to "re-wild" the ecosystems, we cannot and should not expect hatcheries to replace the wild productivity we willingly sacrifice to serve the needs of an ever-growing human economy.

Until we transition from a society that asks, "How can we continue to manage resources to maximize benefits to humans and the economy while minimizing risks to fish and wildlife" to a society that asks, "How can we restore healthy and whole ecosystems while minimizing sacrifices to humans and the economy" we will need hatchery programs to provide some fishery benefits and meet minimal obligations. Therefore we need to be looking at modifying hatchery operations in all ways possible to optimize their performance in terms of returning adults to fisheries and the spawning grounds.

Yakima Basin Levi George / Cle Elum Supplementation and Research
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