Supportive breeding boosts population abundance with minimal negative impacts on fitness of natural-origin Chinook salmon in Johnson Creek

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Hess et al. 2012, Molecular Ecology, with updated BY 2006 and 2007 data - August 2015

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Introduction

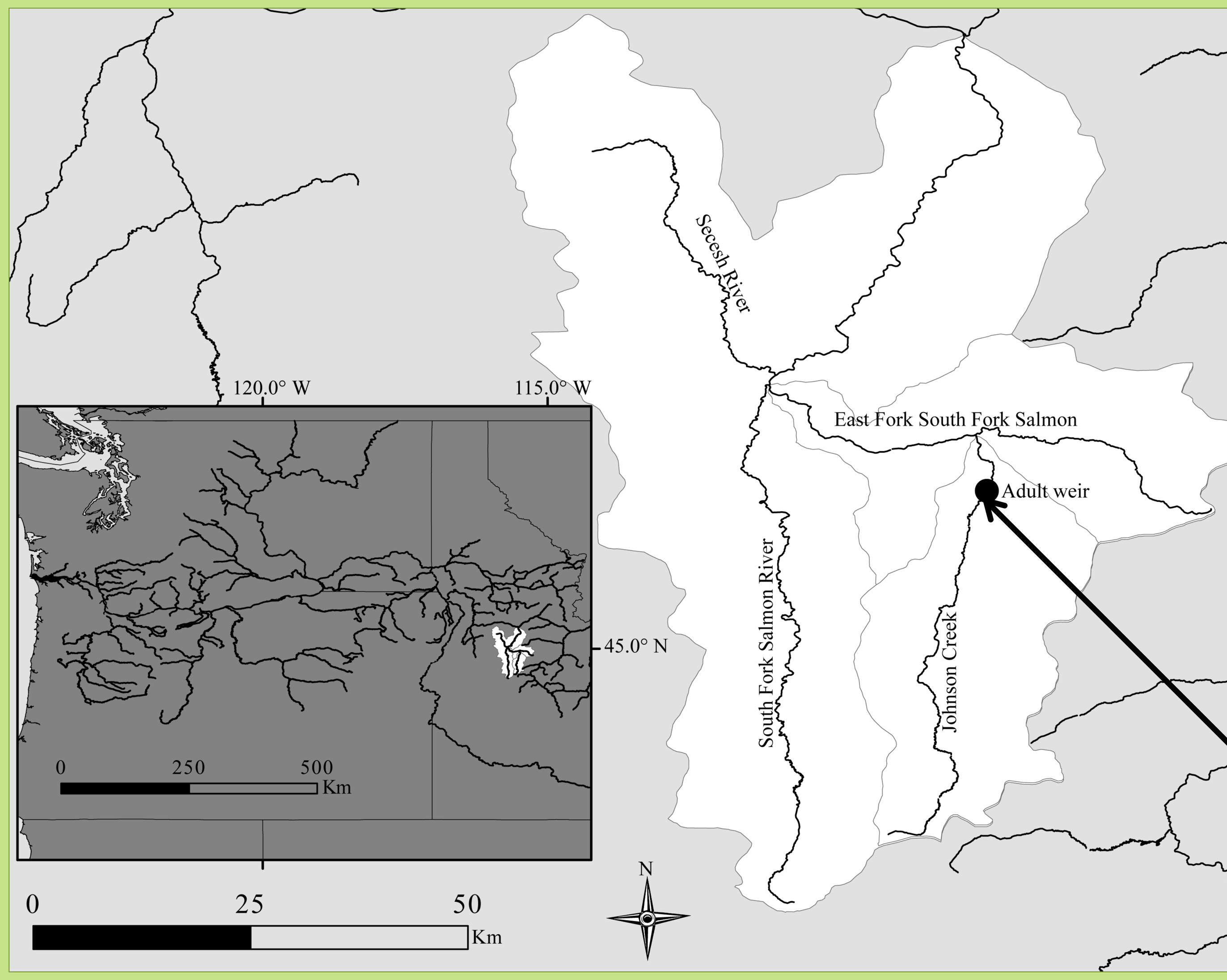
- Due to low returns, Snake River spring/summer Chinook salmon are listed as threatened under the Endangered Species Act.
- A supplementation program, using 100% natural-origin fish for broodstock, for summer Chinook was initiated in Johnson Creek in 1998 to prevent extirpation and enhance natural production.

Objectives

- i) Demographic boost provided by hatchery?
- ii) Fitness differences between successful natural and hatchery fish (H) spawning in nature?
- iii) Do hatchery fish spawning in nature reduce the fitness of the natural (N) population?

Methods

- Genetic data for ~9,000 returning adults to Johnson Creek (Figure 1) over 15 return years (1998-2012).
- Reconstructed genetic pedigrees to quantify reproductive success (RS).



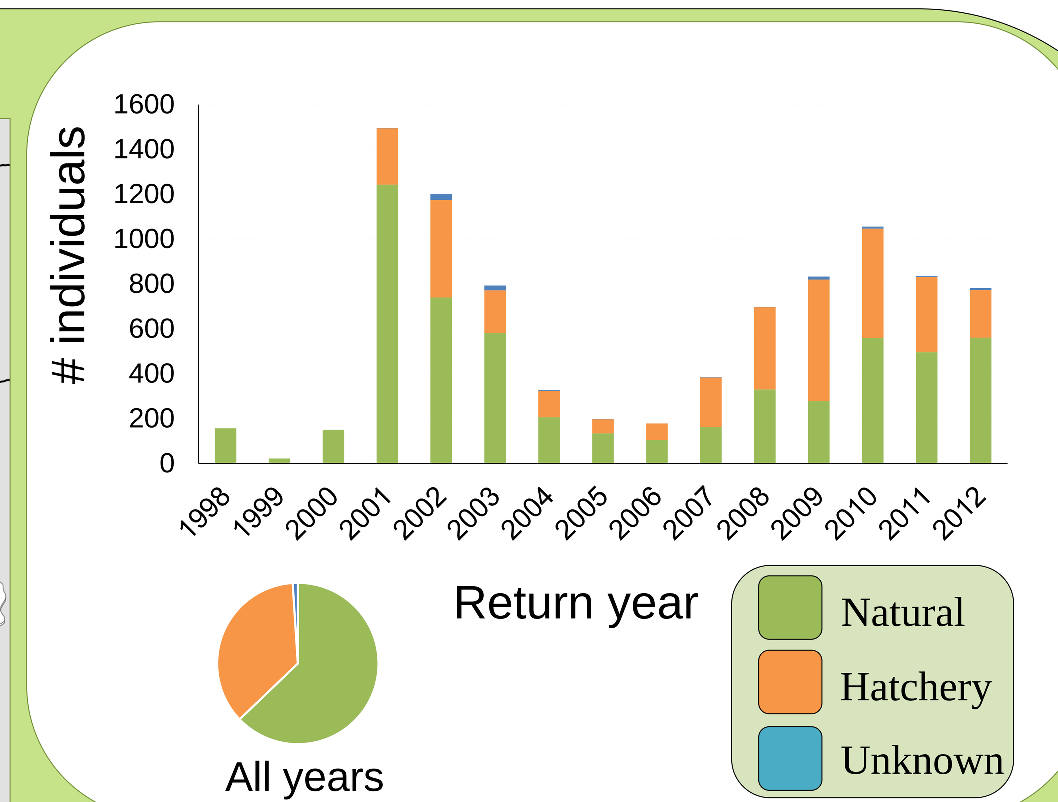


Figure 1. Inset map showing the location of Johnson Creek in the East Fork South Fork Salmon River within the Columbia River Basin. Graph: number of fish sampled by origin and return year. Photo: the adult weir; location of the adult weir in the Johnson Creek subbasin is indicated by the black point.

Brood year (BY)	Adult offspring produced relative to NAT	Adult grand-offspring produced relative to NAT
1998	2.79	1.25
1999	n/a	n/a
2000	1.20	0.85
2001	5.22	3.93
2002	5.40	4.78
2003	7.94	10.02*
2004	5.25	tbd
2005	4.41	tbd
2006	3.40	tbd
2007	4.70	tbd
Mean	4.48	2.70

Table 1. Comparison of the number of returning adult offspring and grand-offspring (including jacks) produced by fish removed at the weir for hatchery brood stock and the number of returning adult offspring produced by fish allowed to spawn in the natural environment.

*Does not yet include F2 offspring from 2013 return, and BY is not included in mean

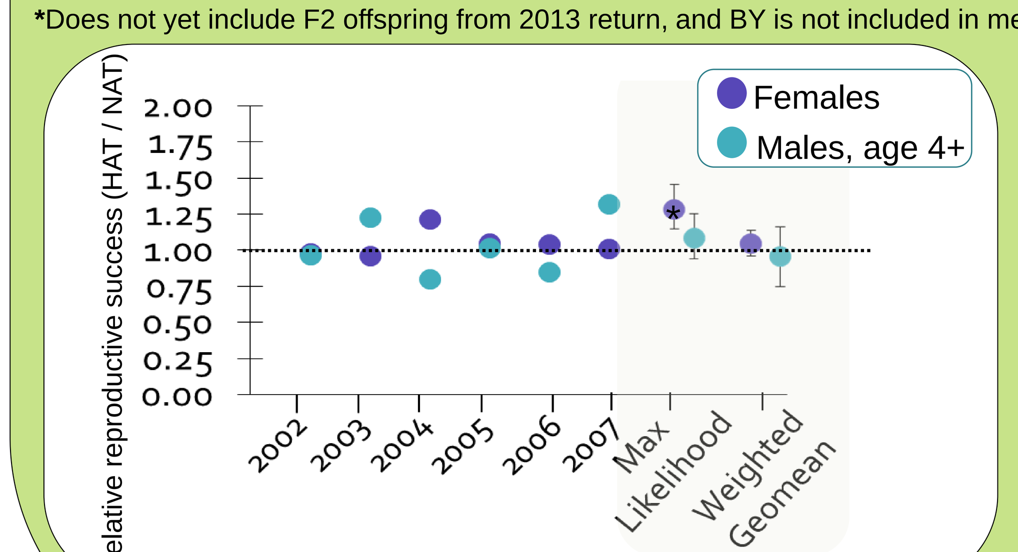


Figure 2. Relative RS (to N, RRS = 1.0, by definition) of **successfully reproducing*** hatchery female, male and jack F_1 fish from BY 1998 and 2000.

*RS also calculated to include all potential parents, see supplementary in Hess et al. 2012

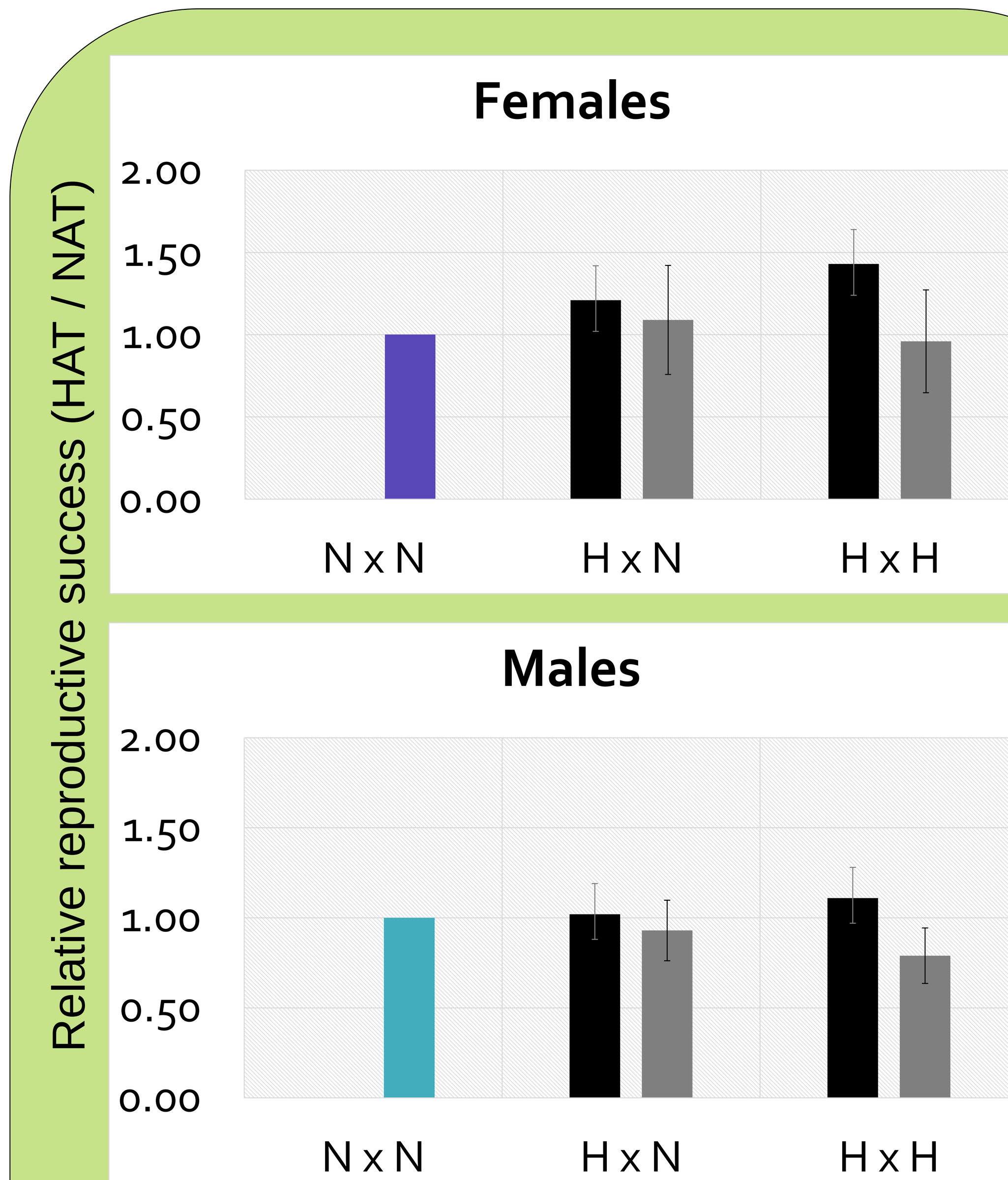


Figure 3. RRS of each F_1 mating type in the wild, relative to N x N. (*a*) Female F_1s, (*b*) Male F_1s. Combined year estimates - maximum likelihood (black bar) and weighted geometric mean (gray bar) RRS among return years 2003 to 2008 is plotted for H x N and H x H relative to N x N. Error bar represents 1 s.d. for geomean and 95% confidence interval for maximum likelihood method.

Results

- On average, fish taken into the hatchery produced ~4.5x more adult offspring, and boost continues in second generation (Table 1).
- Overall RRS for successful hatchery F_1 females and males was $1.05_{geomean}$, 1.26_{ML} and $0.96_{geomean}$, 1.06_{ML} respectively (Figure 2).
- Overall RRS of mating types (Figure 3):

Female – HxN $1.09_{geomean}$, 1.21_{ML}
HxH $0.96_{geomean}$, 1.43_{ML}

Male – HxN $0.93_{geomean}$, 1.02_{ML}
HxH $0.79_{geomean}$, 1.25_{ML}

Conclusions

- Demographic Boost: Supplementation program provides a boost to the natural population
- Fitness Differences: Generally, equal reproductive success of H and N fish that contribute offspring to the next generation
- Fitness Effects: No significant difference in RS of mating types (but possible interaction effect of HxH males), suggests Chinook salmon reared for a single generation in the hatchery had a limited and undetectable effect on the fitness of natural-origin fish