DIMINISHED REPRODUCTIVE SUCCESS OF STEELHEAD FROM A HATCHERY SUPPLEMENTATION PROGRAM (LITTLE SHEEP CREEK, IMNAHA BASIN, OREGON)

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Introduction

Historical populations of steelhead (*O. mykiss*) in the Snake River basin were significantly impacted by hydropower development. Mitigation in the Imnaha River basin began in 1982, with a hatchery program on Little Sheep Creek. Continued population declines resulted in protection under the US Endangered Species Act in 1997. The Little Sheep hatchery program utilizes locally-derived brood stock and releases smolts back into the creek. The program has two current goals: mitigating hydropower losses and boosting natural production for conservation and recovery.

This ongoing study evaluates the relative reproductive success (RRS) of hatchery- vs. natural-origin steelhead by using microsatellite data to reconstruct pedigrees in nature. The results shown here include full adult-to-adult results, plus an analysis of factors involved in RRS in wild-spawning *O. mykiss*.

Methods

- Returning anadromous adults were sampled at the weir, and juveniles, smolts, and resident rainbow trout were sampled above the weir by electrofishing and smolt trap (Fig. 1).
- Microsatellite information was acquired for 15 loci.
- Pedigrees were reconstructed using exclusion.
- Generalized Linear Modeling was used to address the importance of various factors to reproductive success.

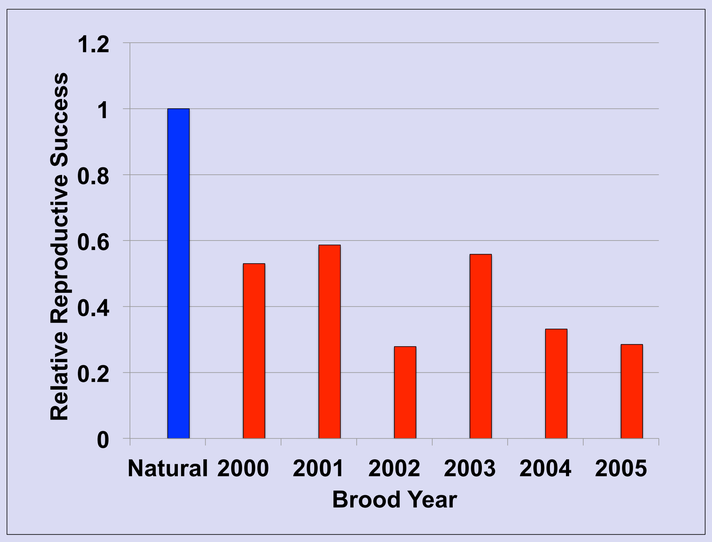

Figure 2. Adult-to-adult RRS by origin, normalized to wild spawners in each year.

Brood year	Ad-to-juv	Ad-to-ad
2000	0.39	0.53
2001	0.36	0.59
2002	0.26	0.28
2003	0.56	0.56
2004	0.25	0.33
2005	0.33	0.29

Table 1. Comparison of relative reproductive success rates calculated from adult-to-juvenile and adult-to-adult data.

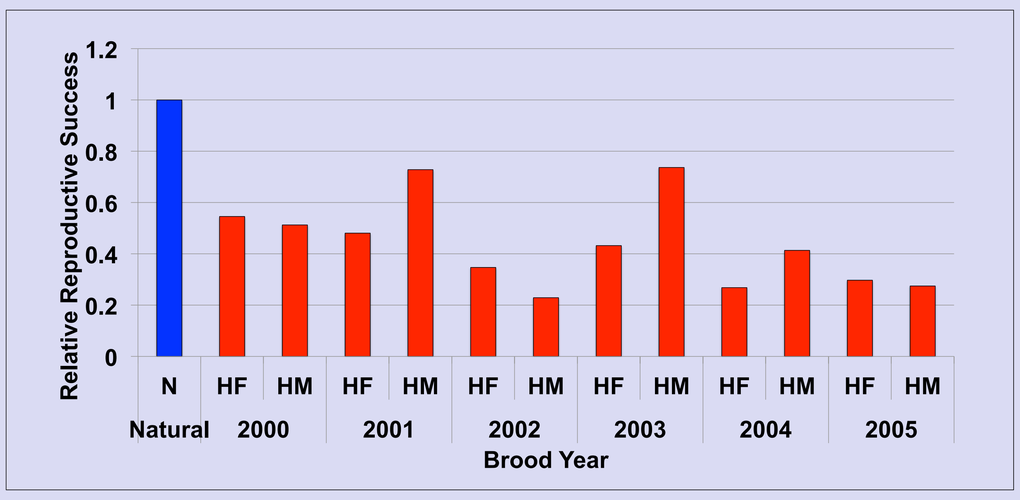

Figure 3. Adult-to-adult RRS by origin and sex, normalized to wild spawners of each sex in each year.

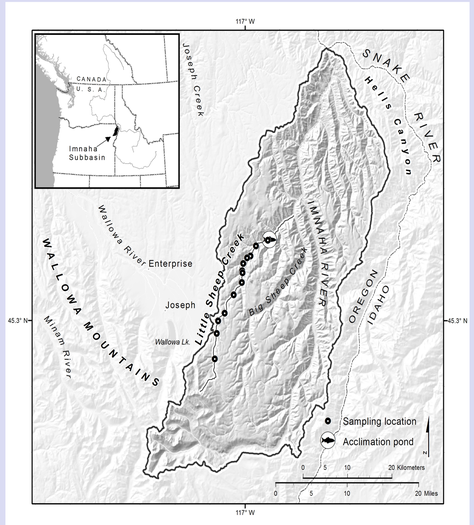

Fig. 1 Little Sheep Creek, Imnaha basin

Pedigree Results

- Across the study years, hatchery fish averaged 0.41 of the relative reproductive success of their natural counterparts measured from adult-to-adult (Fig. 2).
- The RRS of hatchery fish calculated from adult-to-juvenile results was very similar to that calculated from adult-to-adult results across comparable brood years (Table 1). Geometric mean of adult-to-juvenile results from brood years 1999-2008 was 0.49 (not shown).
- Hatchery males and females both do poorly relative to wild (Fig. 3).
- Hatchery-by-hatchery matings were the least successful of any of the mating classes across all years (not shown). Geometric means of WH matings RS =0.48, HW = 0.49, and HH = 0.2.
- In 1999 hatchery-origin fish had significantly higher RS than natural-origin, but only 5 out of 78 fish placed over the weir were of natural origin.
- One-third of all wild returning adults were typed to two parents, with an additional third typed only to a mother or father. Neither parent was identified for the remaining third.
- A greater percentage of natural-origin residents were not assigned to any parent (61%). Less than 1% of returning adults were offspring of resident parents.
- 86% of single-parent matches were known anadromous females with a missing male, consistent with resident "sneakers," and we document a small number of those matings.
- Only 15 matings were genetically confirmed to involve a resident male and anadromous female, and only 1 of those residents was a hatchery residual, despite hatchery residuals making up nearly 50% of the residents collected. No resident-by-resident crosses were observed.
- Because year-to-year site fidelity for recaptured juveniles was extremely high, we felt collection site of the juveniles might act as a proxy for redd location. Hatchery-origin females spawned significantly lower in the system than natural females. No pattern was seen for males (Fig. 5).

Figure 5. Inferred collection site of juveniles vs. parental cross. Dam is listed first and sire second.

General Linear Modeling Results

- GLM results indicate a negative binomial for best fit, and origin (hatchery vs. natural) is the largest factor in RRS.
- For both hatchery- and natural-origin adults, females have higher fitness than males (Fig. 4)
- The number of same-sex competitors also has a large effect, and natural-origin fish are better able to compete at higher densities (Fig. 4).
- Female fitness declines faster than male with increasing same-sex competitors (Fig. 4). This is consistent with competition for redd location.
- Larger fish also had higher RS.

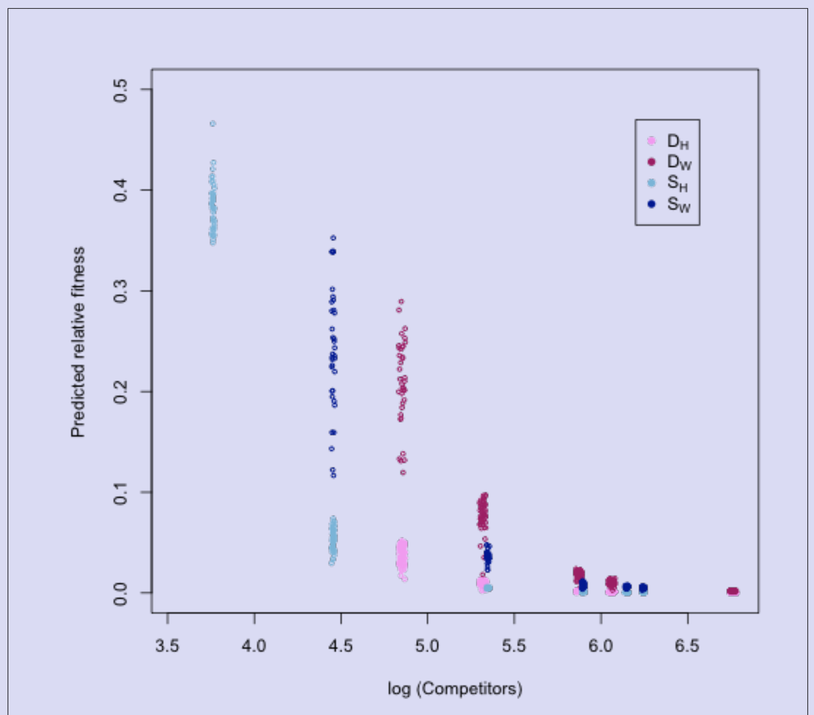

Figure 4. Relationship between estimated mean RRS and increasing density. The best model predicts a decay in fitness as a function of the number of same-sex competitors.

Conclusions

- Hatchery- and natural-origin steelhead in Little Sheep Creek interbreed widely, but hatchery-origin steelhead have significantly lower reproductive success relative to their natural counterparts.
- Diminished RRS of hatchery fish was detectable in the youngest fish we examined, age 0+ juveniles.
- Despite their diminished RRS, the numerical abundance of hatchery fish resulted in an overall genetic contribution that was twice that of the natural fish.
- Resident males appear to contribute significantly to overall reproduction.
- Residualized hatchery fish do not appear to contribute substantially to overall productivity.
- Hatchery males and females perform equally poorly.
- Same-sex competition has a large effect, and natural-origin fish compete better than hatchery.
- Same-sex competition is more acute for females than for males.

Acknowledgements

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