Review of relative fitness (RF) of hatchery- and natural-origin salmon and steelhead

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Previous reviews

- Berejikian, B.A., and M.J. Ford. 2004. Review of relative fitness of hatchery and natural salmon. U.S. Dept. Commer., NOAA Tech. Memo. NMFS-NWFSC-61, 28 p

- Araki, H., B. A. Berejikian, M. J. Ford, and M. S. Blouin. 2008. Fitness of hatchery-reared salmonids in the wild. Evolutionary Applications 1:342-355.

Objectives

- Provide an overview of RF from published and on-going studies
- Focus in on effects in supplementation programs
- Identify some important variables that may influence the outcome of RF studies
- Recommendations regarding future RF studies

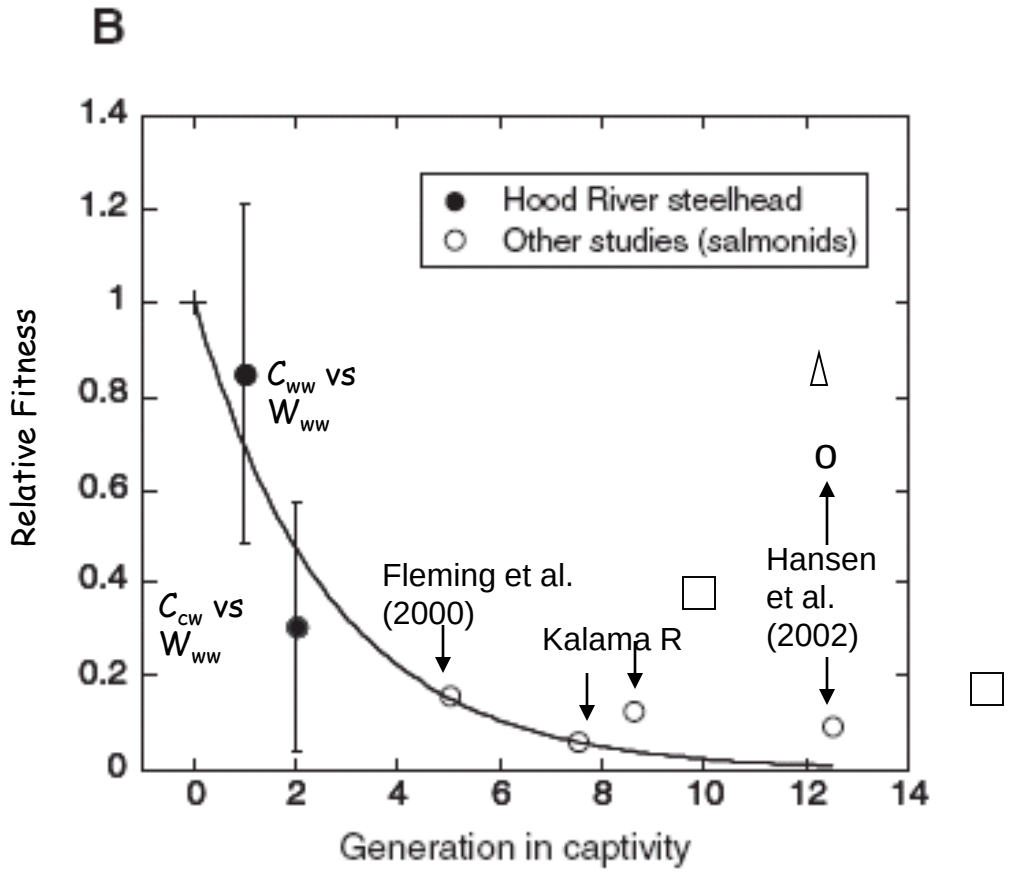
Definitions

- Relative fitness: $(R/S_h)/(R/S_w)$
- Hatchery fish: born in the hatchery
- Wild or natural-origin fish: born in the natural environment
- Hatchery generations: number of generations the hatchery had been operating

Potential causes of differential fitness of hatchery and wild salmon

- Environmental: Incubation and juvenile rearing environment
  - age-at-maturity
  - spawn timing
  - size-at-age
  - spawning location
- Genetic
  - Domestication selection (adaptation to the hatchery)
  - Intentional artificial selection
  - Other genetic mechanisms (inbreeding, founder effects, etc)

Re-visiting Araki et al. 2007: The Hood River Study

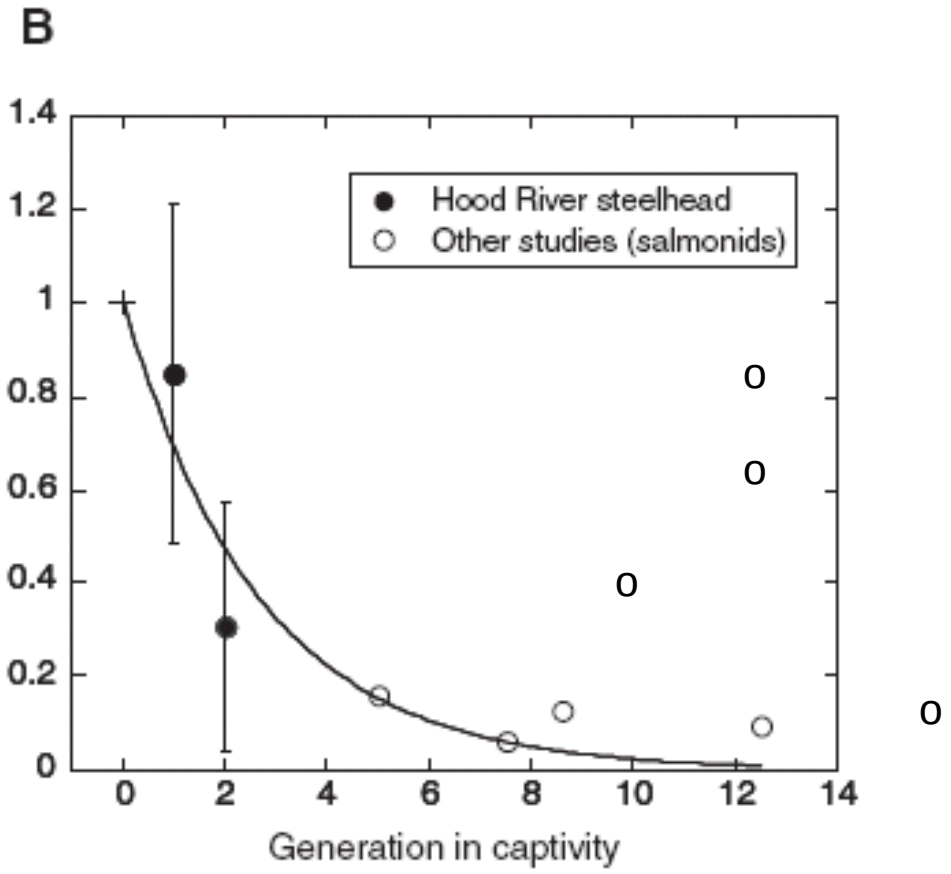


Ford et al. (2006)

Araki et al. (2006)

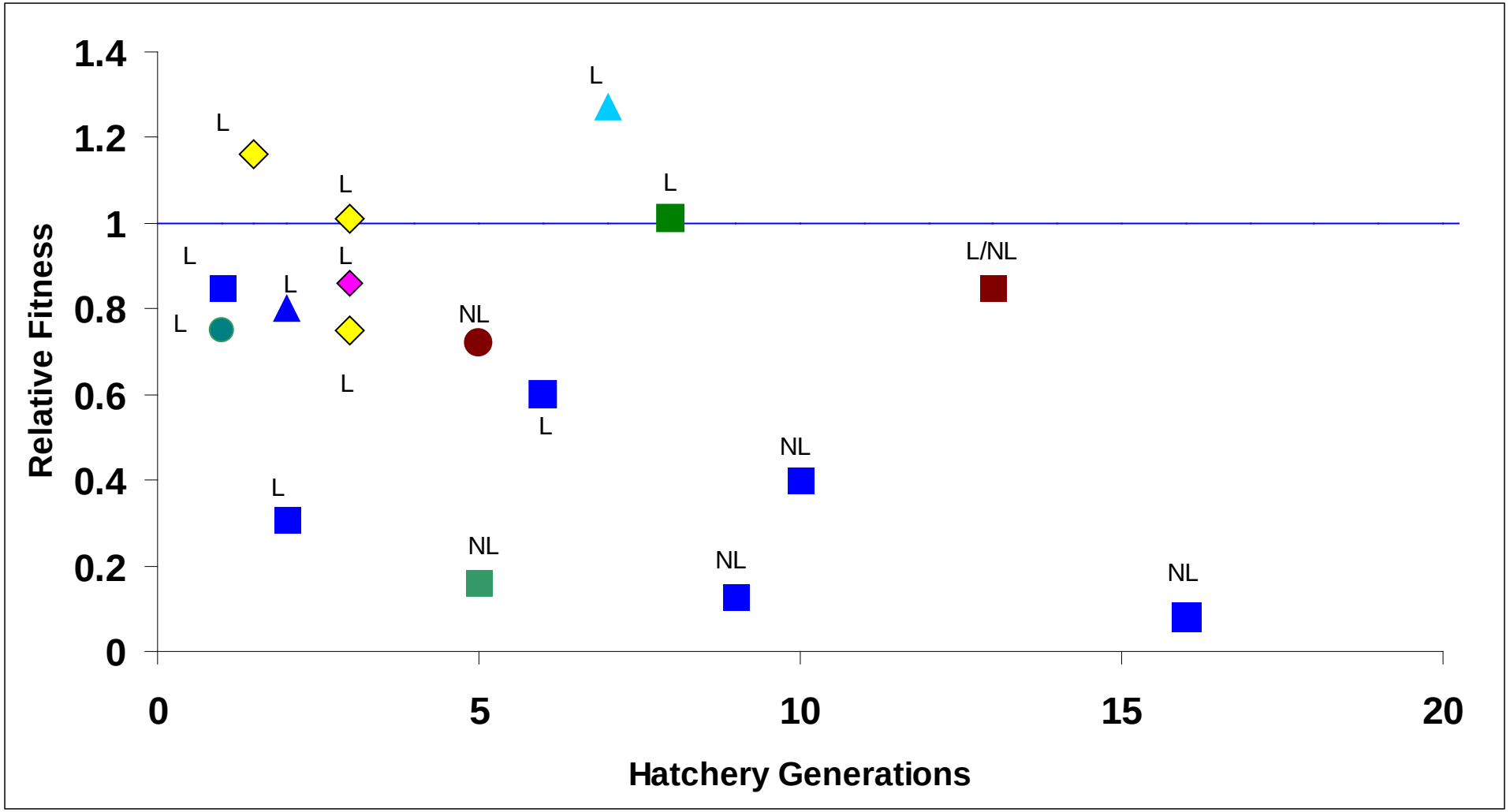
From Araki et al. 2007. Science 318:100-103 (Figure 2b)

Revisiting Araki et al. 2007



From Araki et al. 2007. Science 318:100-103 (Figure 2b)

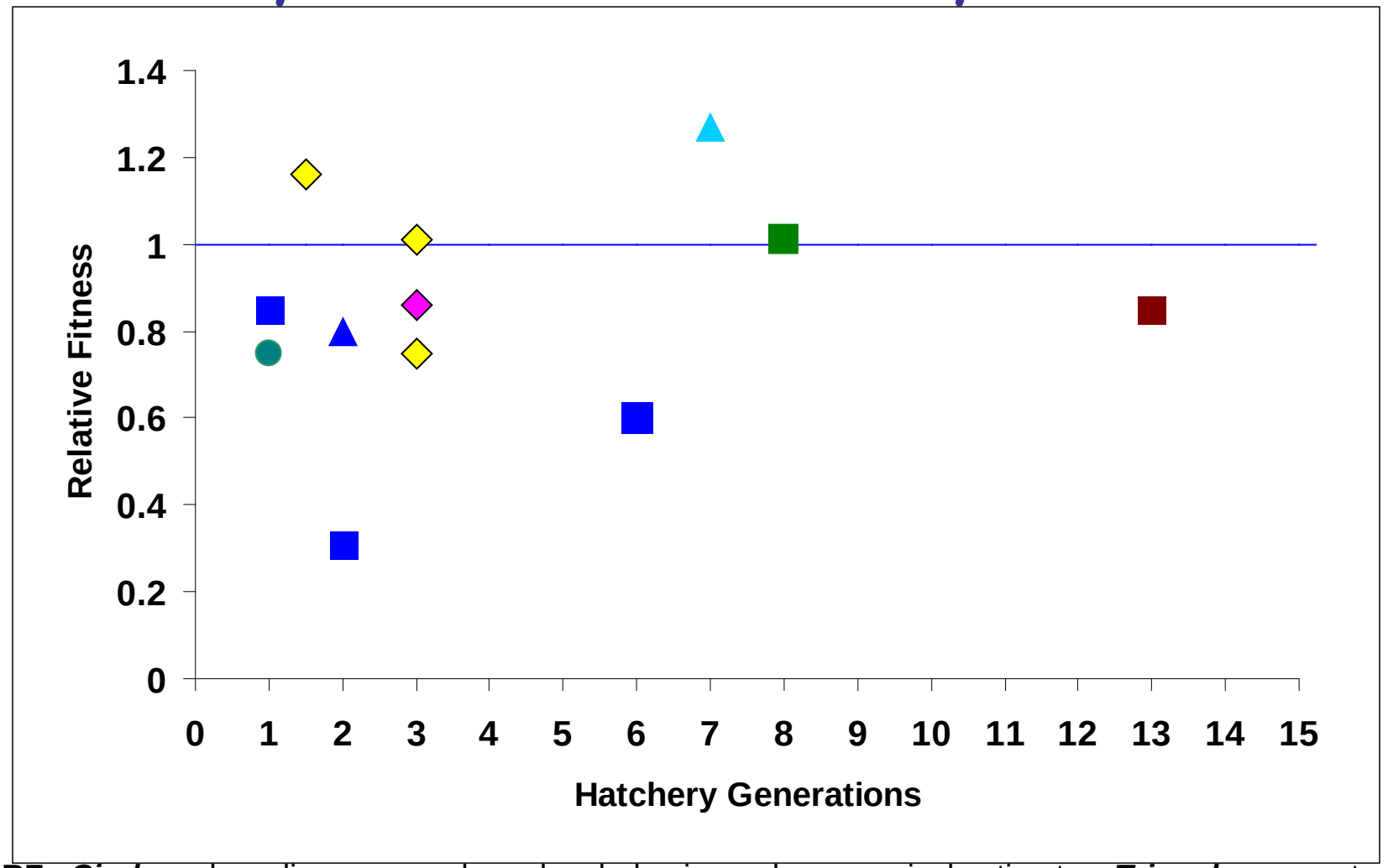
Relative fitness of anadromous salmonids



RF: ***Circles*** = breeding success based on behavior and egg survival estimates, ***Triangles*** = egg-to-parr, ***Diamonds*** = adult to parr/smolt, ***Squares*** = lifetime

Species: ***Dark blue*** = steelhead, ***green*** = Atlantic salmon, ***red*** = coho salmon, ***light blue*** = brown trout, ***yellow*** = Chinook, ***Pink*** = summer chum salmon

Locally-derived hatchery broodstocks



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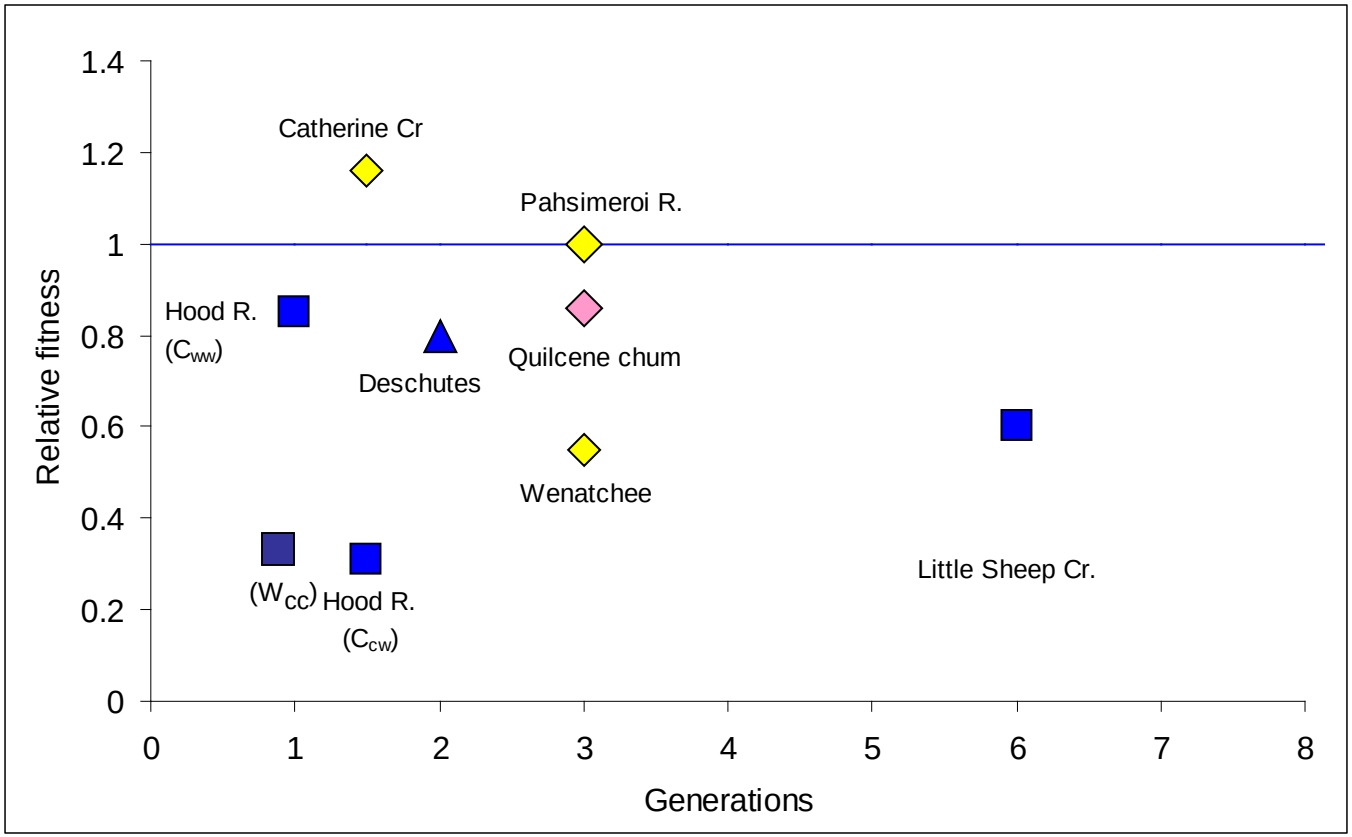
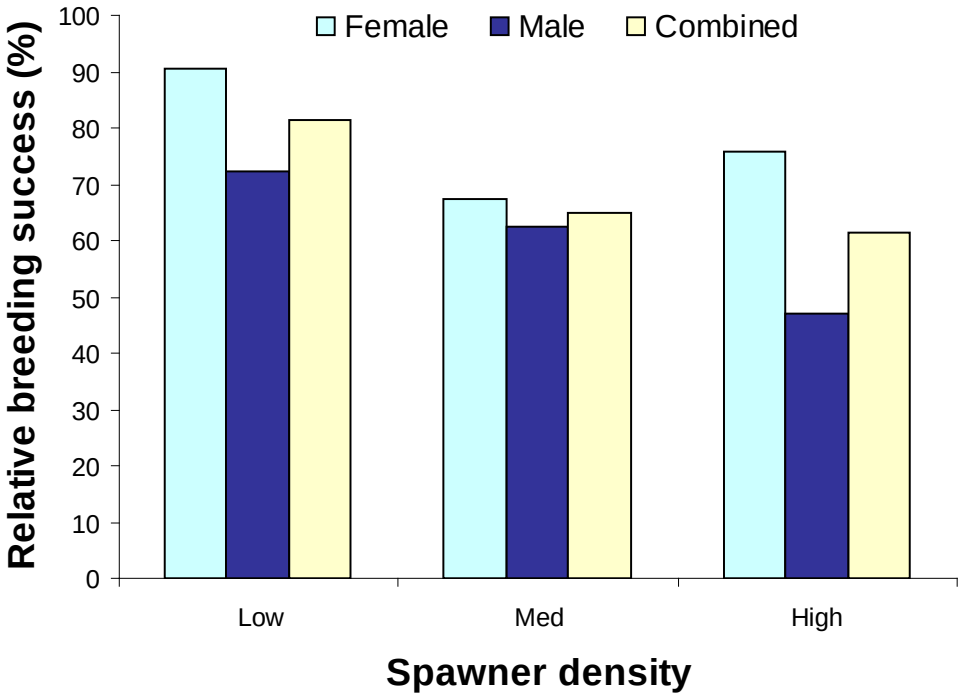
Supplementation programs



Triangles = egg-to-parr/smolt, **Diamonds** = adult-to-parr/smolt, **Squares** = lifetime

Density-dependent relative breeding success

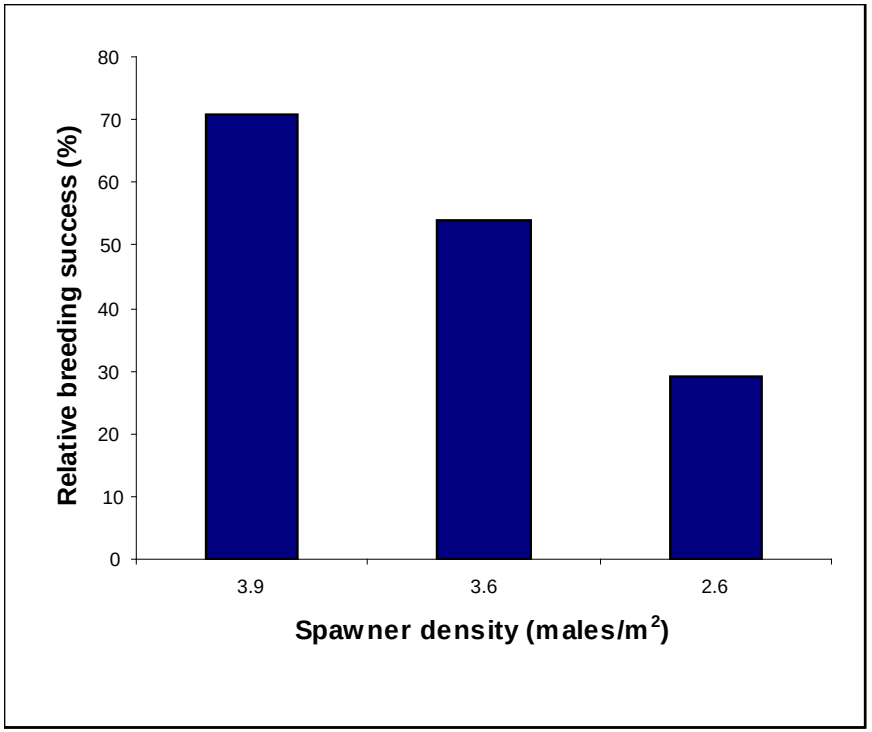
- Hatchery male coho salmon competitively inferior to wild males
- Hatchery females spawned later, but suffered higher levels of nest superimposition
- Relative breeding success lower at higher density



Source: Fleming et al. 1993. Ecol. Appl. Table 5.

Density dependent relative breeding success

- Male Atlantic salmon competitively inferior to wild males
- 1st generation hatchery fish (C_{ww} vs W_{ww})
- Relative breeding success lower at higher density



Source: Fleming et al. 1997. Behav. Ecol.

Gender effects?

Species	RF male		RF female	Comments	Reference
Coho salmon	0.97	>	0.74	Lifetime	Ford et al. 2006
Coho salmon	0.62	<	0.82	Breeding success	Fleming and Gross 1993
Chum salmon	0.99	>	0.73	Adult-to-fry	Berejikian et al. In press
Atlantic salmon	0.51	<	~1.0	Breeding success	Fleming et al. 1997
Steelhead	0.60	=	0.63	Lifetime C_{cw} v. C_{ww}	Araki et al. 2007

Conclusions

- Non-local stocks perform poorly
- Single generation effects on RF appear to be fairly small (except for Araki et al. 2007, 2009)
- Very little data on lifetime RF
- Varying intensity of competition may influence relative breeding success
- Gender effects are inconsistent
- Future studies should focus on genetic fitness (e.g., Schroder et al. in the Yakima R)

Supplementation programs