Hydraulic redd sampling and two-year smolt rearing to reduce domestication in steelhead supplementation programs

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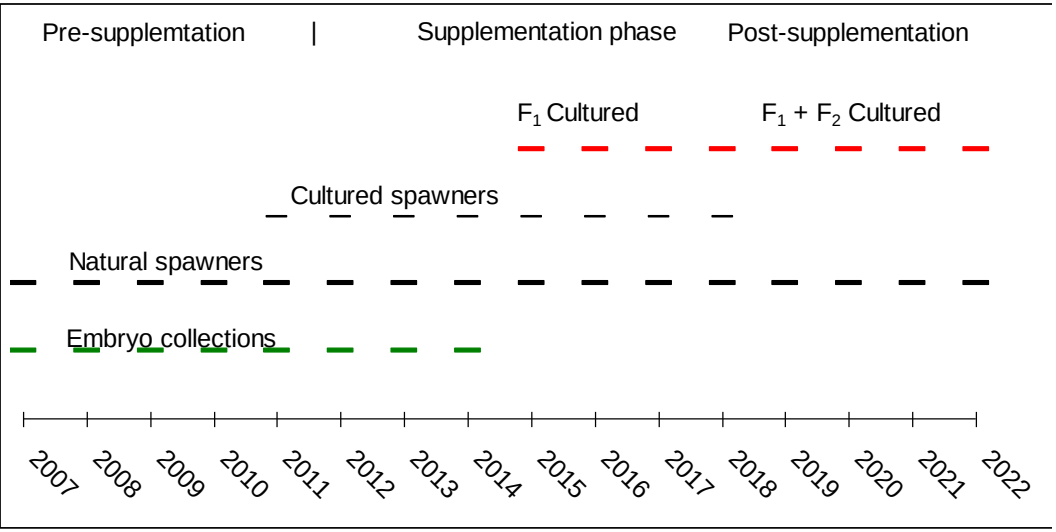
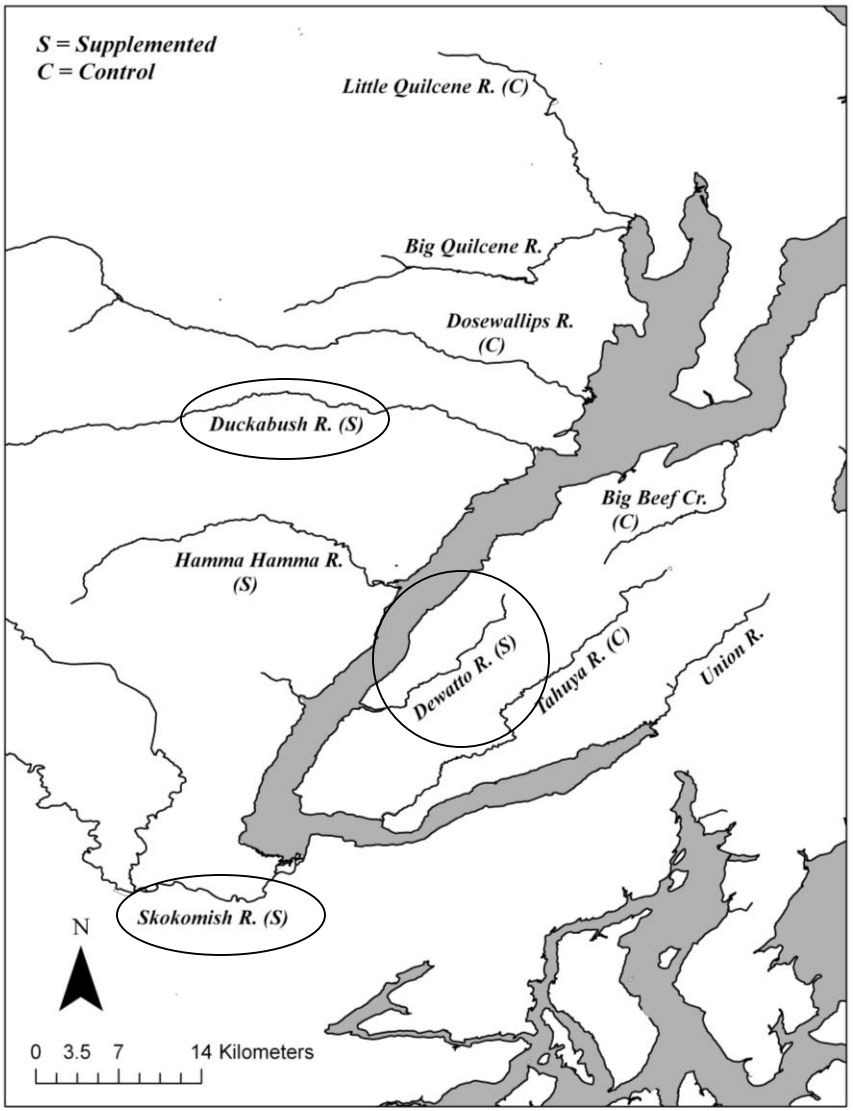
Steelhead hatchery effects

- Domestication selection may lower fitness of hatchery steelhead (Araki et al. 2008)
  - Artificial spawning and incubation
  - Emergence and freshwater rearing
  - Smolt migration
- Potential methods to reduce domestication
  - Eliminate artificial spawning
  - Release at a natural size and age (i.e. age-2)

Hatchery effects - experimental Design

- BACI with replication
- Compare supplemented to non-supplemented populations
- Before, during and after supplementation periods
- Response variables: abundance, productivity, life history, and genetic variation





Annual fish production goals

River	Embryo collection	Smolt release (age-2)	Adult release (age-4)
Duckabush	8,620	6,667	229
Dewatto	9,566	7,400	253
SF Skokomish	44,616	34,507	400

Obtaining eggs for culture

Artificial spawning

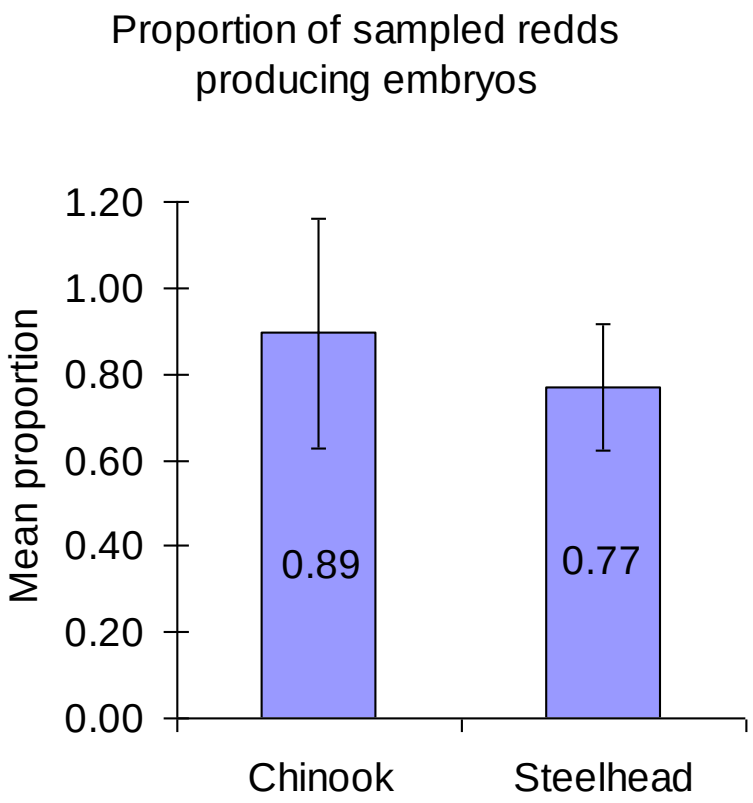
Hydraulic redd sampling

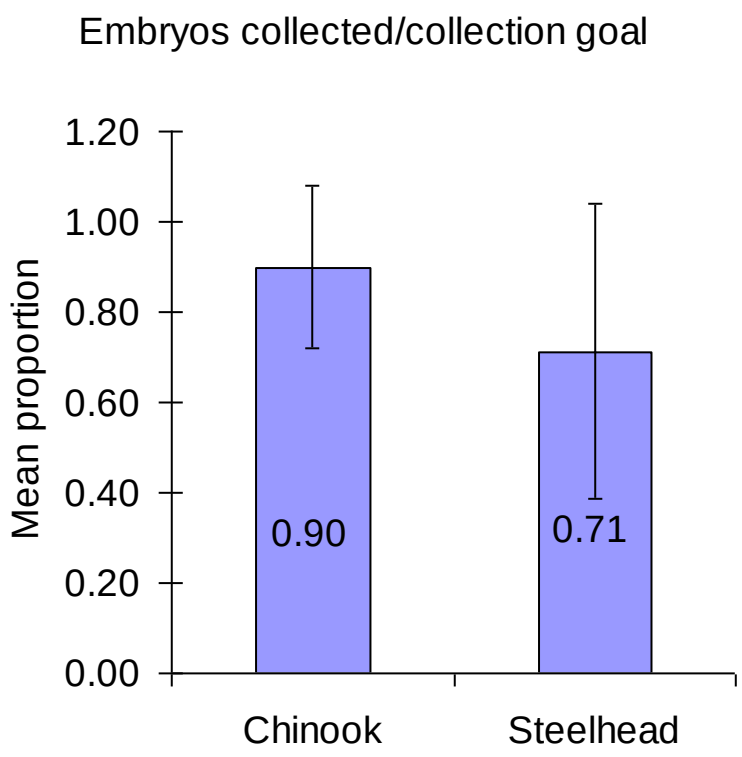
Hydraulic redd sampling



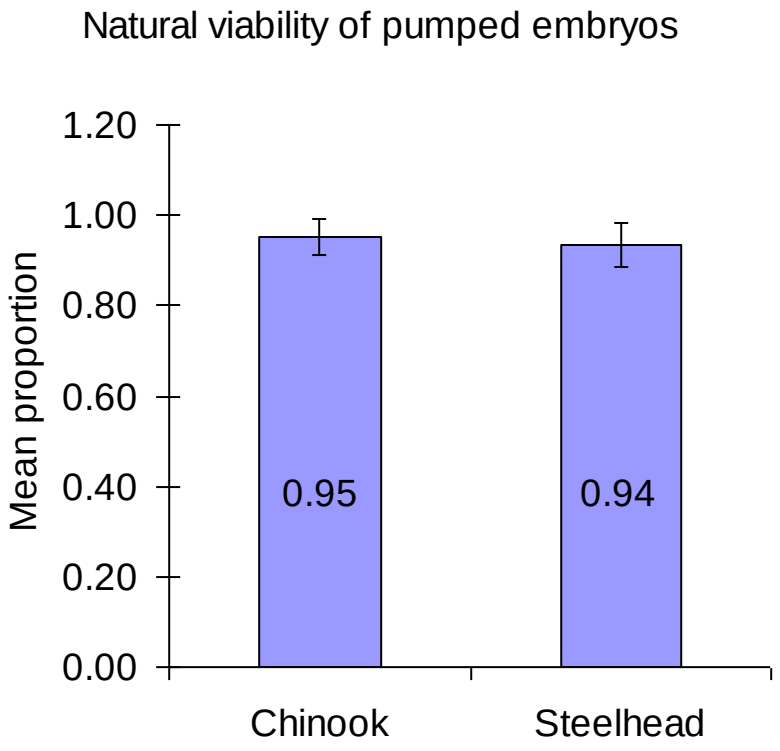


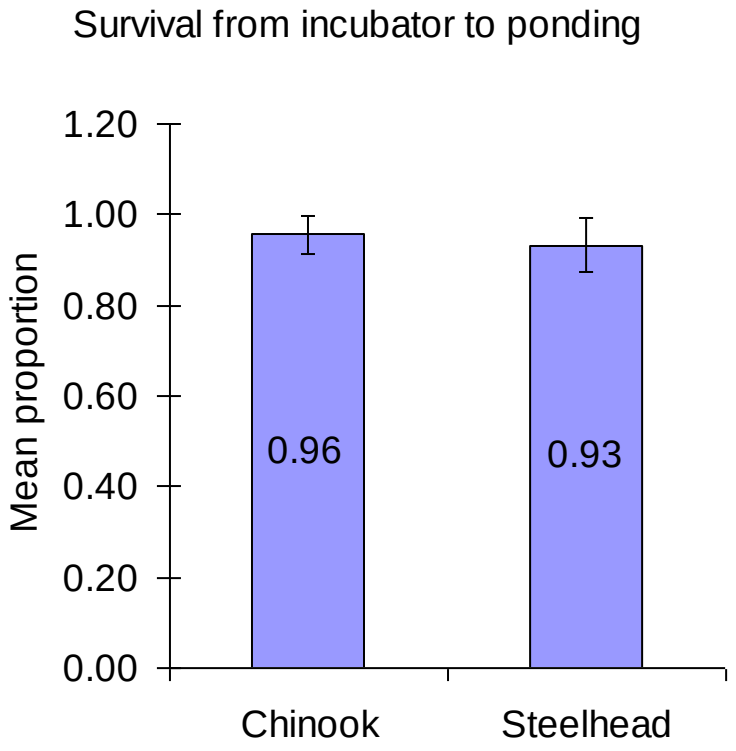

Embryo collection success





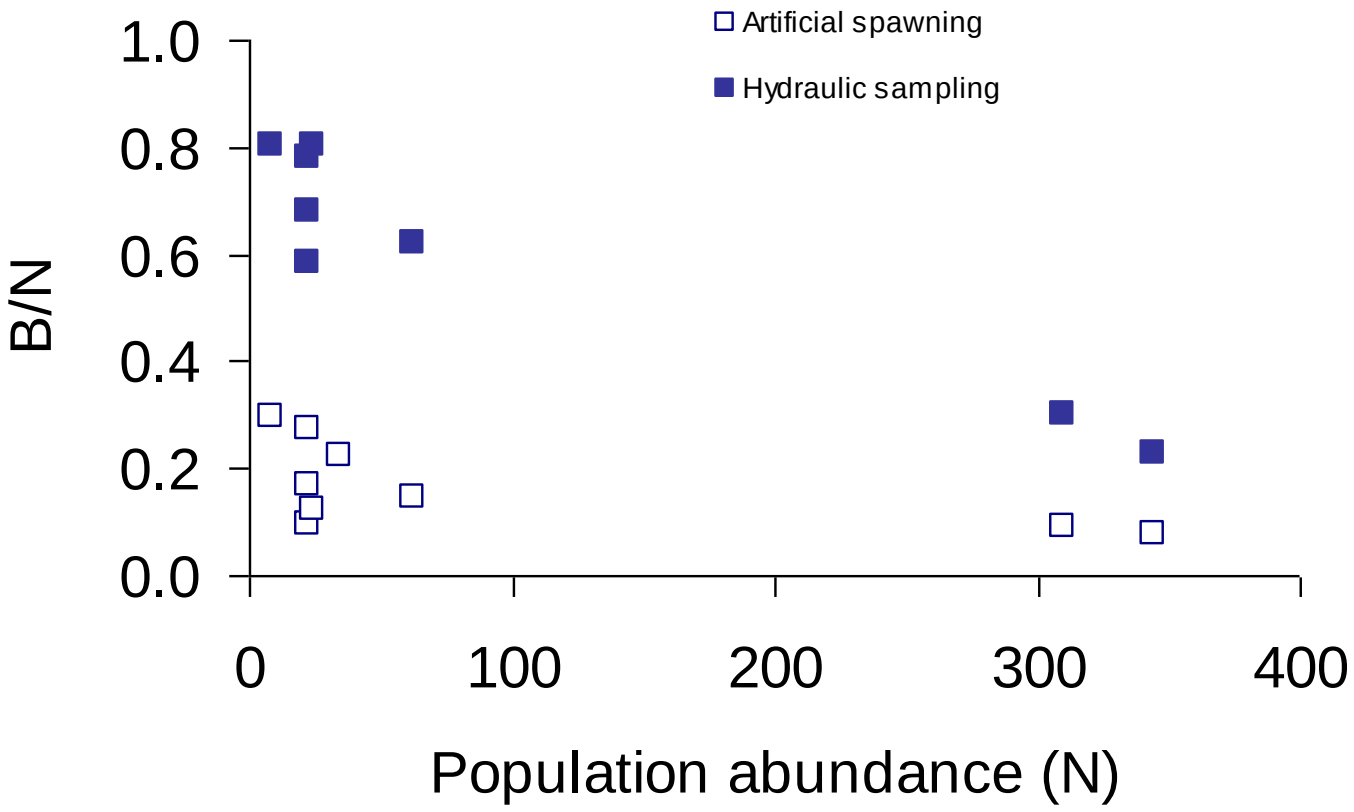
Viability and survival in culture





Targeting release numbers

Proportion of the natural spawners represented in the captive population



Selection in yearling smolt programs

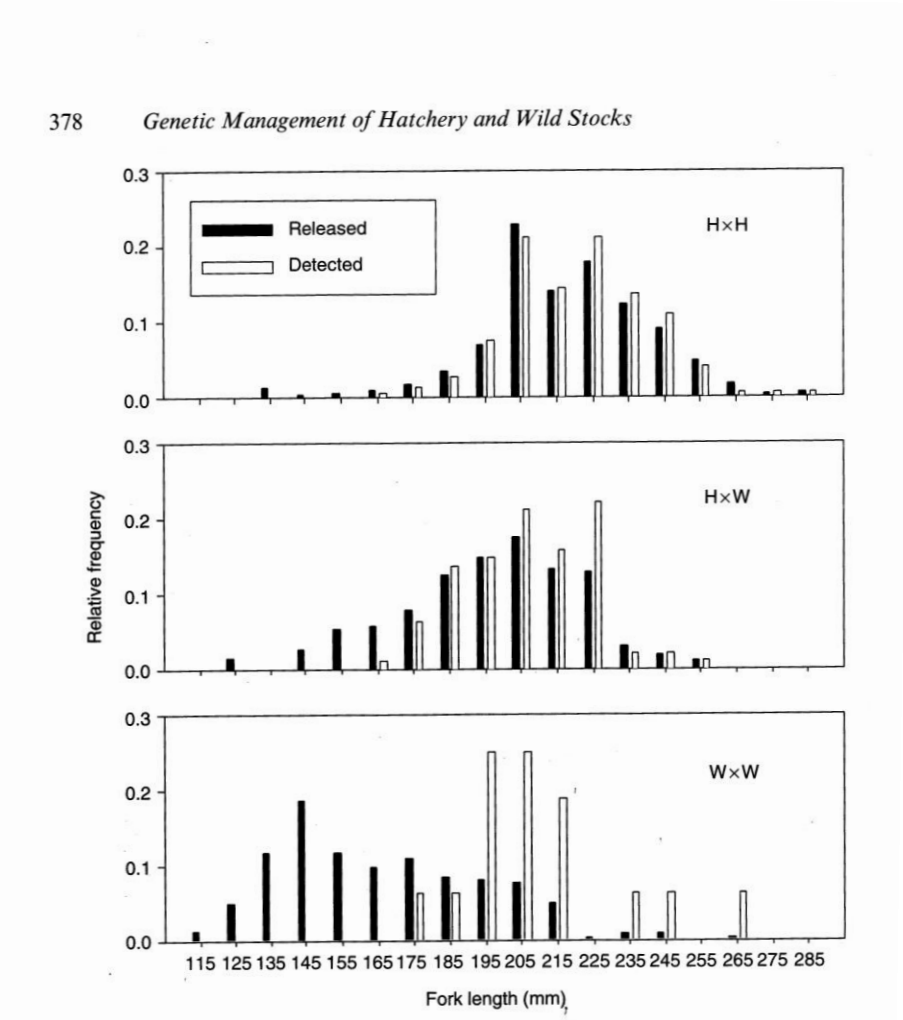


Fig. 27.2 Fork length of experimental fish when they were injected with PIT tags in March 1997. The fish were released into the Crooked River one month after being tagged. Relative frequencies for released fish in each cross sum to one; likewise for detected fish. Solid bars show the lengths at tagging for the fish released into Crooked River; open bars show the lengths at tagging for only those fish that were detected at downstream dams in the Snake or Columbia Rivers. H×H, H×W, and W×W denote the crosses among hatchery (H) and wild (W) fish.

Selection against slower growing hatchery fish

Domesticated age-1 smolts perform better than natural broodstock age-1 smolts

Source: Reisenbichler et al. (2004) in Leber et al. (editors), Stock Enhancement and Sea Ranching 2nd ed. pp 371-382

Mechanism

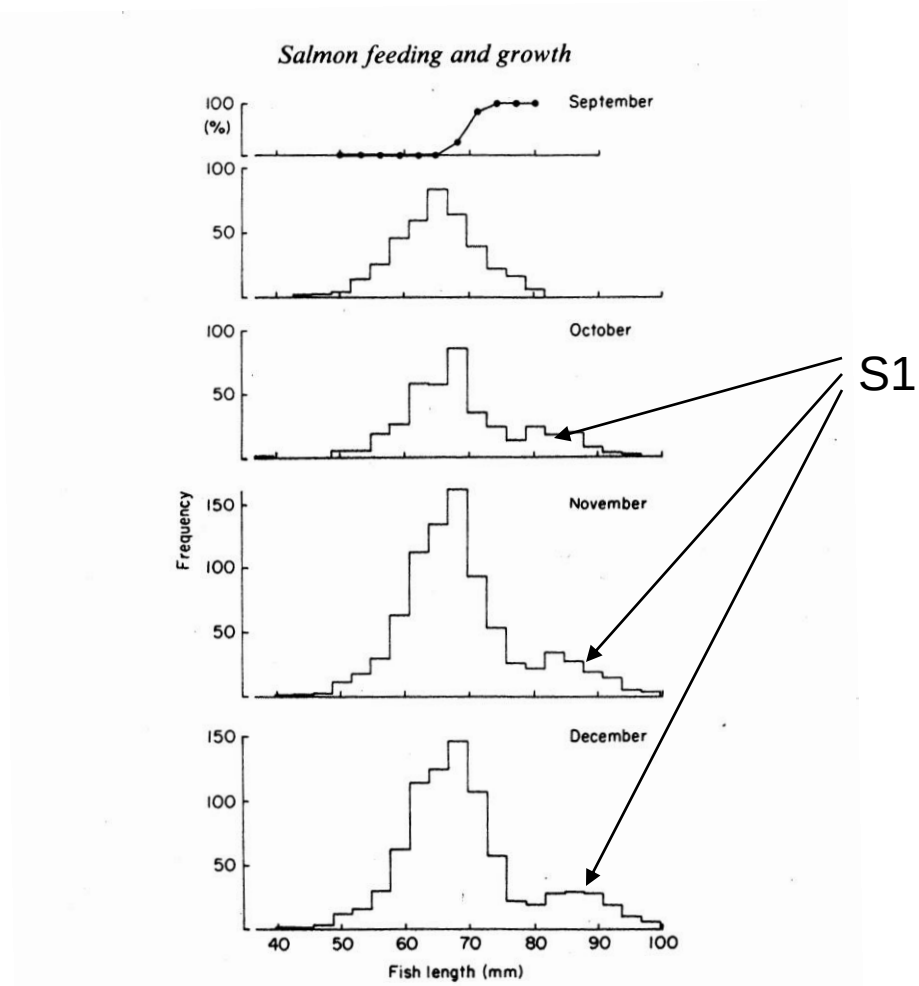


FIG. 1. Length–frequency distributions of the studied sibling population from September to December 1986. Sampling dates and sample sizes were as follows: 17 September ($n=378$), 1 October (405), 19 November (832) and 10 December (complete population, $n=835$). Also shown (top) is the estimated percentage of fish of a given size in September that subsequently became members of the UMG, based on the marked sample of fish.

Appetite increases in the upper modal (S1) group in late summer/fall

Internal control of developmental 'strategy' (i.e., slow or fast)

Potential selection against the slow development group in S1 programs

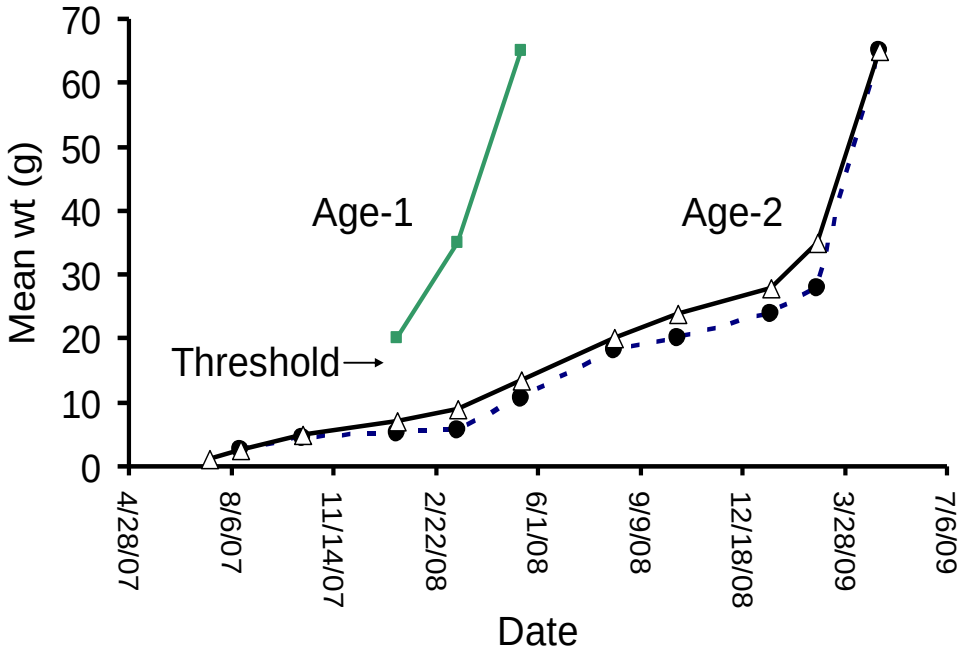
Source: Metcalfe et al. 1988. J. Anim. Ecol. 57:463-474

Hood Canal Steelhead Conservation Hatcheries

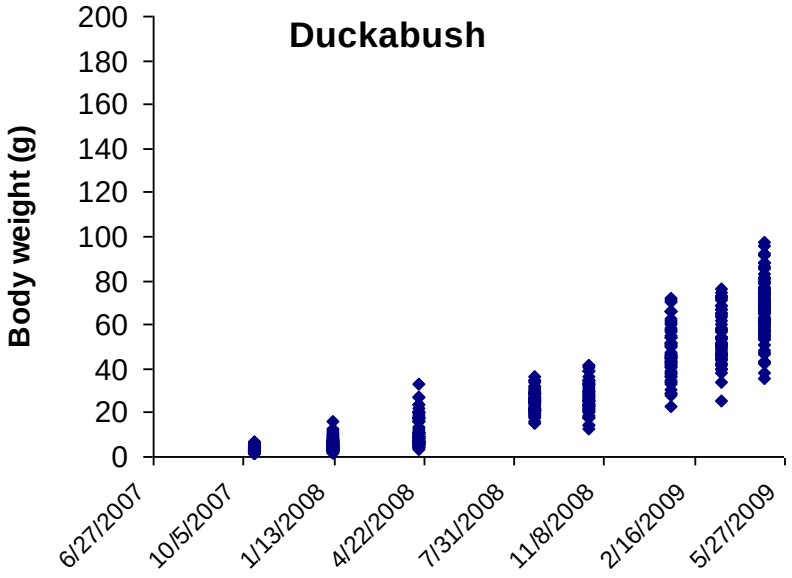
Long Live the Kings Lilliwaup Hatchery

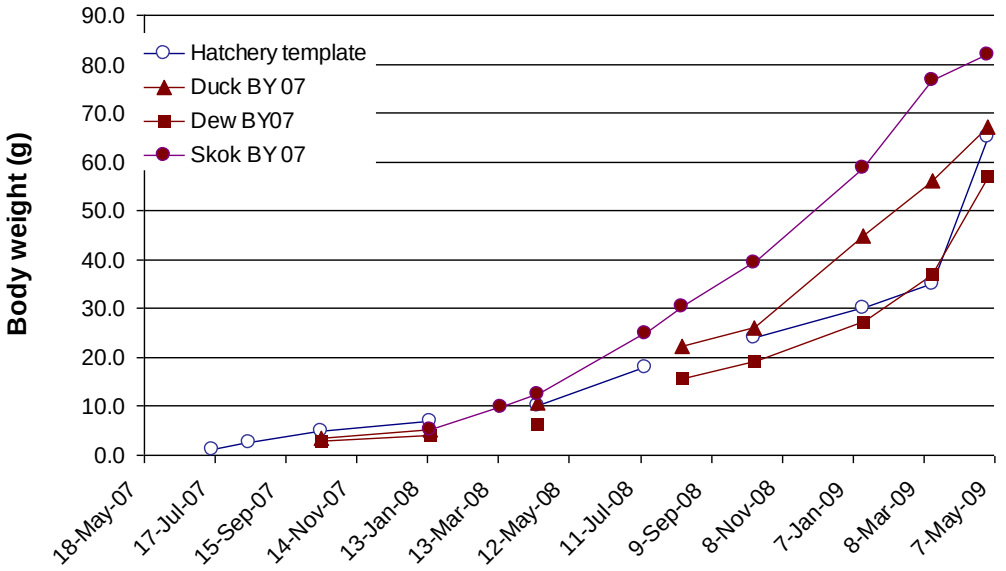
WDFW McKernan Hatchery

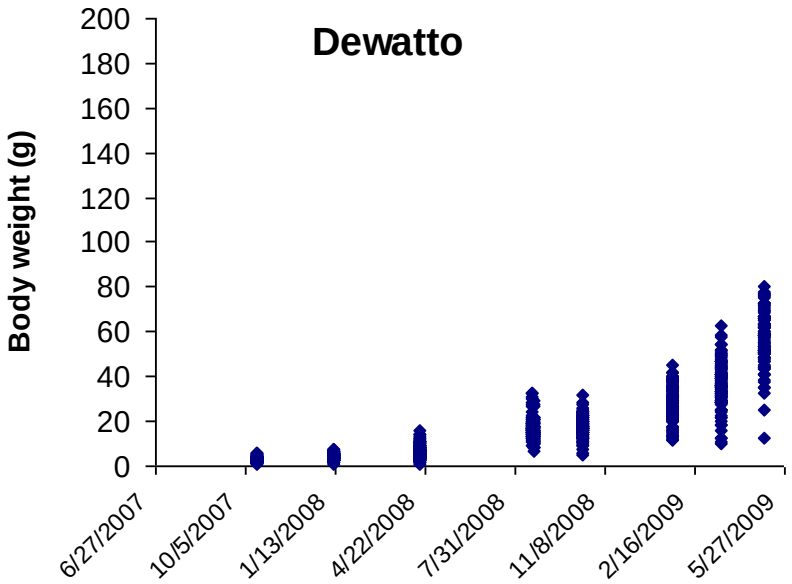
Age-1 and -2 smolt release

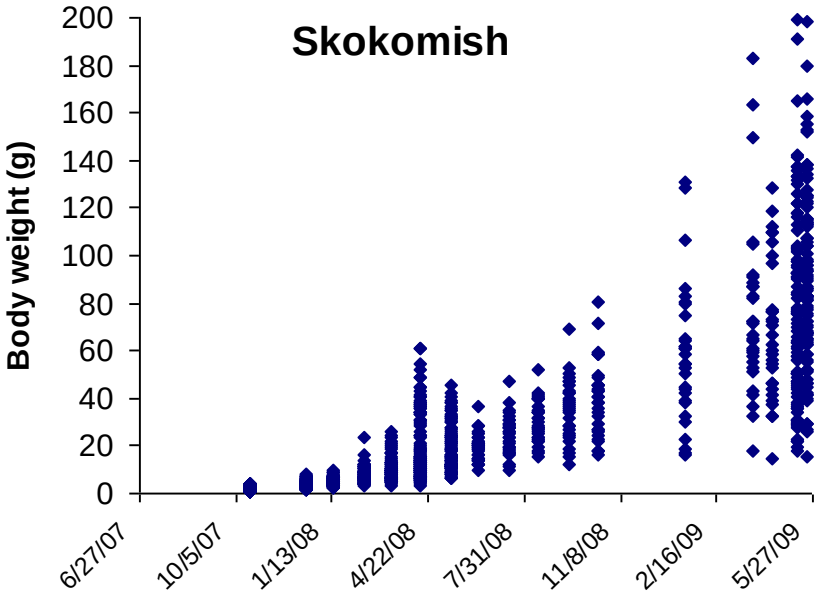


Among-population weight comparison

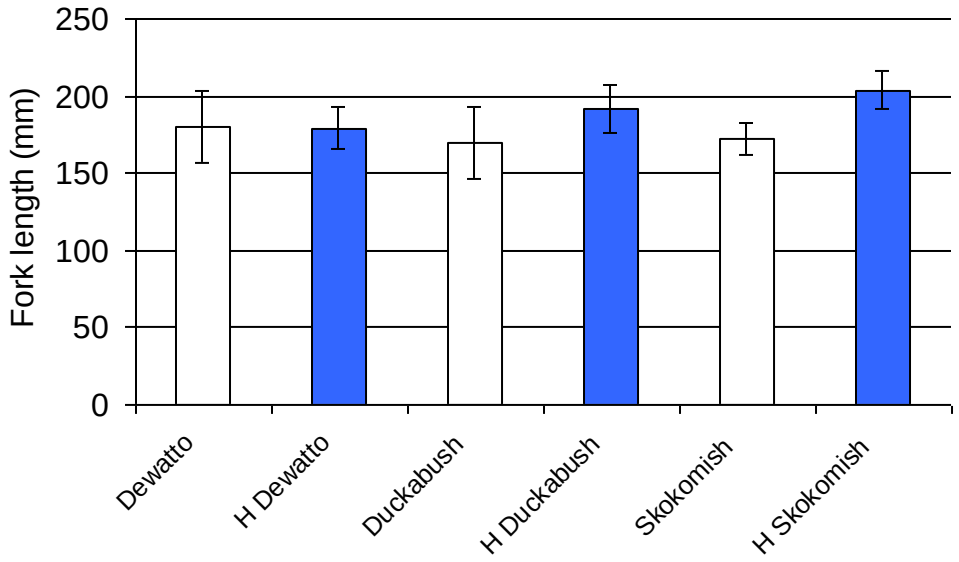


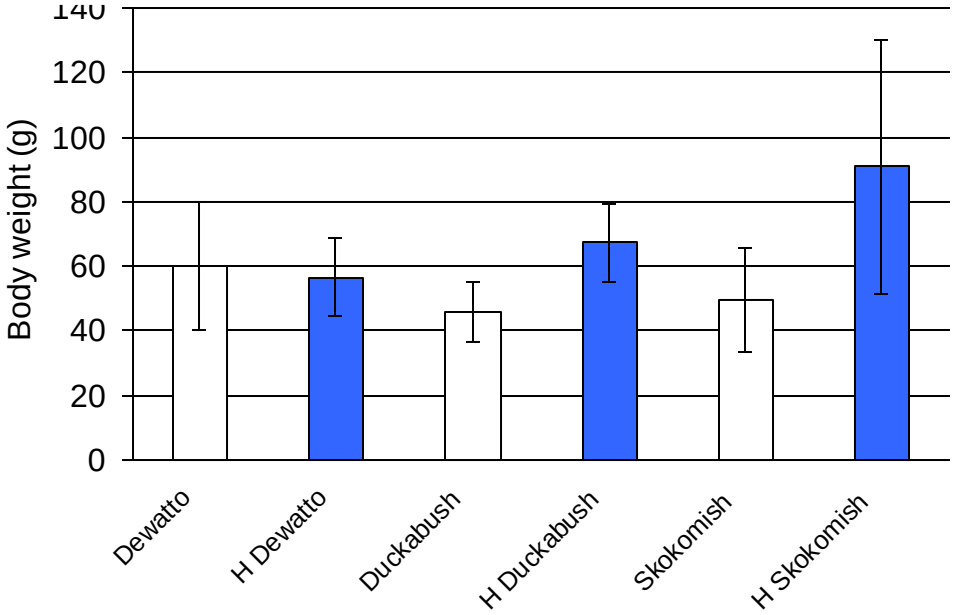




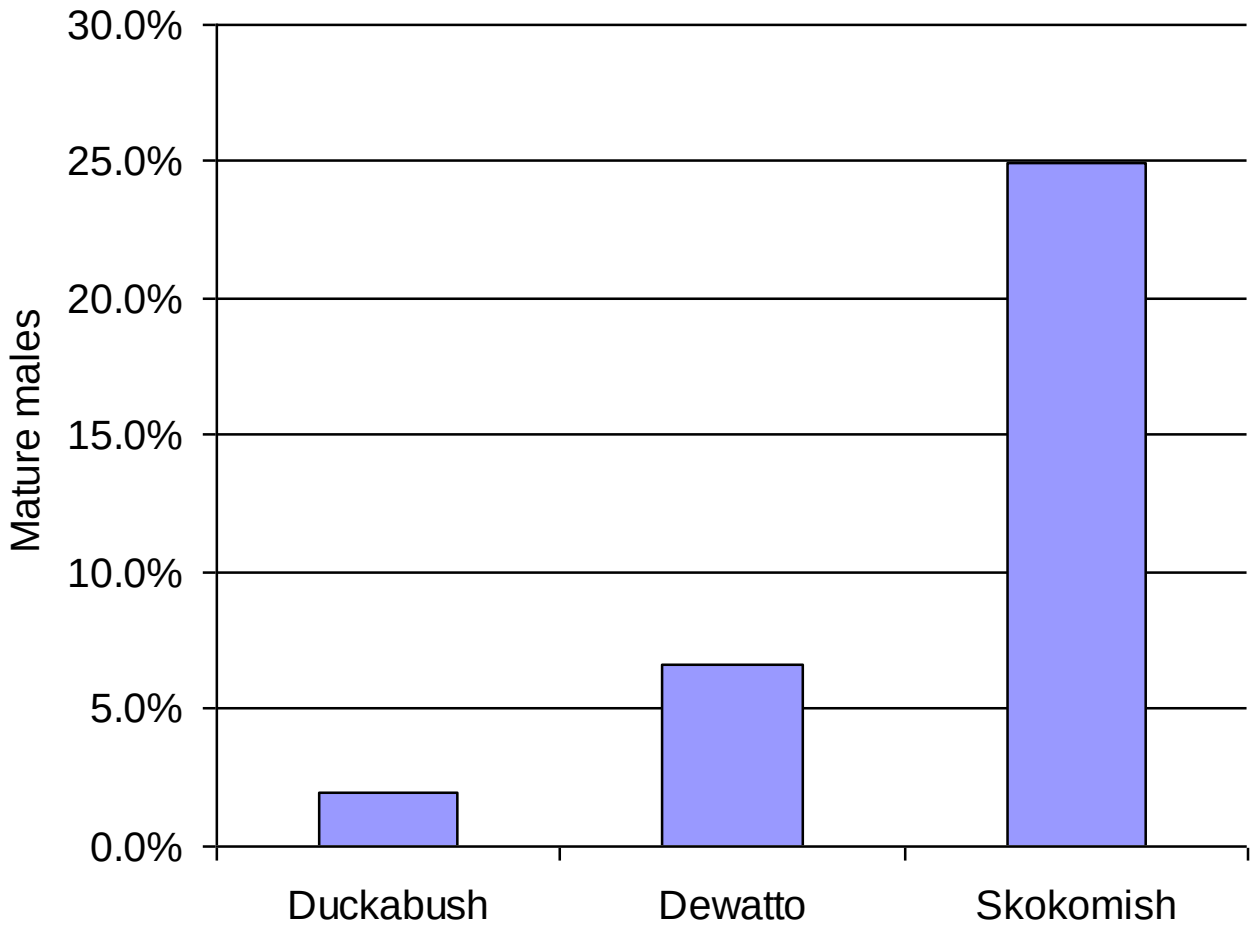


Age-2 smolt size (hatchery and natural)





Male maturation rates



Summary

- Egg collections are effective for obtaining broad genetic representation
  - may be limited to smaller programs
  - flow regime is important
- Two year smolt rearing is achievable if water temps permit
- Effects of these approaches on reducing domestication selection require targeted research

Hydraulic Redd Sampling

Benefits	Drawbacks
Can limit # eggs collected/female	Unknown damage to non-collected embryos
Broader genetic representation to reach a given release target	Requires frequent redd surveys and high effort to recovery embryos
Natural and sexual selection occurs in the wild	Limits on maximum number that can be collected
Requires no weirs or traps and no pre-spawning mortality	Most appropriate for smaller programs (<50,000 eggs)
High embryo survival in hatchery	Impossible in some rivers (e.g., steelhead rivers with high early spring flows)
Better chance at short-term maintenance of N_e	No pathology data on adults

Population size (N) and breeders represented in embryo collection (B)

Assumptions and estimates

- 0.67 females per redd (*Kuligowski et al. 2005, Berejikian et al. 2005*)

- N = # redds observed x 0.67 x 2
(i.e.,1:1 sex ratio)

- B = # redds represented in egg collection x 0.67 x 2
- 4,000 eggs per female

Targeting number of breeders

How many eggs would be spawned to obtain the genetic representation that was obtained by hydraulic sampling?