Effects of Supplementation in Upper Yakima River Spring Chinook Salmon

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Supportive Breeding

- Multiple species of Pacific salmon with populations experiencing drastic declines
- Salmonid supplementation hatchery programs:
  - Rear and release hatchery supplementation (i.e., hatchery-origin) fish to increase abundance
- Concerns of supportive breeding programs:
  - Captive-born individuals released into the wild may exhibit lower survival and/or produce lower numbers of offspring[1].
- Integrating natural-origin fish into the supplementation broodstock may reduce negative effects associated with captivity[2].

1. Naish et al. 2007; Araki et al., 2008; Christie et al. 2014
2. Hess et al. 2012; Waters et al. 2015; Janowitz-Koch et al. 2019; Sahashi and Morita 2022

What are the effects of supplementation with broodstock comprised of mostly natural-origin fish?

Q1. Does supplementation provide a demographic boost to the natural population?

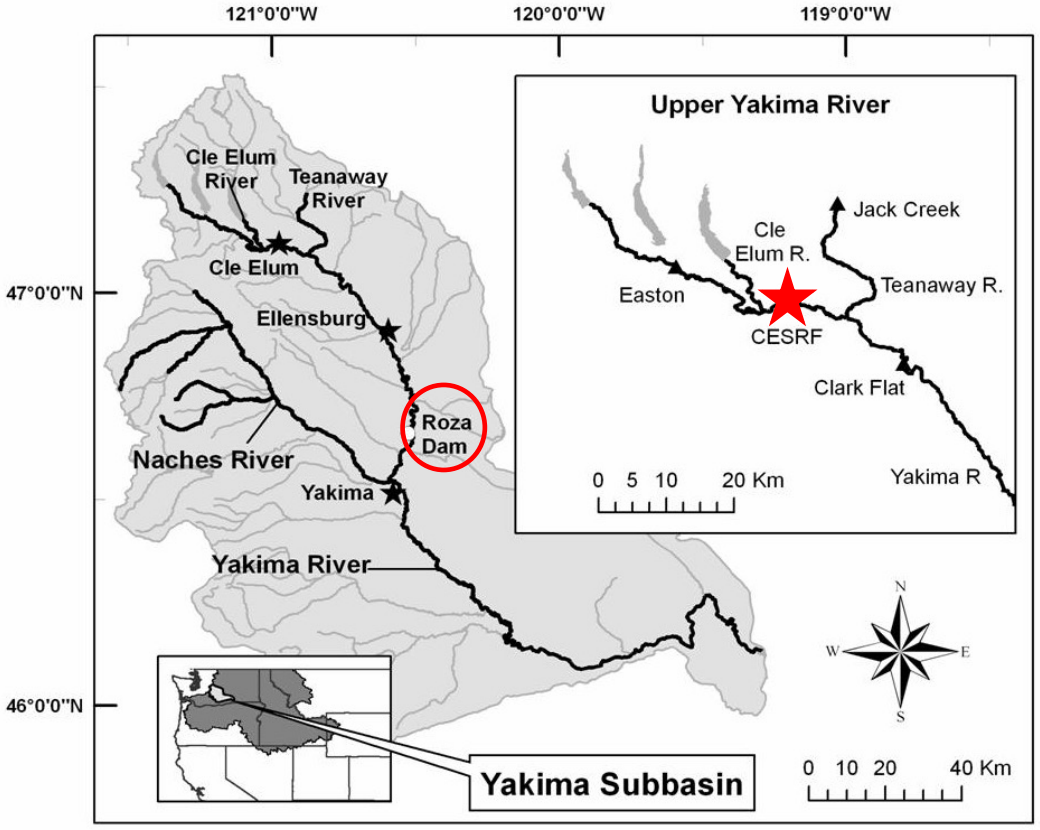
Q2. Do hatchery-origin (fish born in captivity) and natural-origin (fish born in nature) demonstrate differences in reproductive success (offspring number) when spawning in nature?

Q3. Is there a reduction in reproductive success when hatchery-origin and natural-origin fish naturally interbreed (crosses containing hatchery-origin parents compared to those containing natural-origin parents)?

Q4. Are there other potential factors that affect reproductive success of fish?

Cle Elum Supplementation and Research Facility (CESRF)

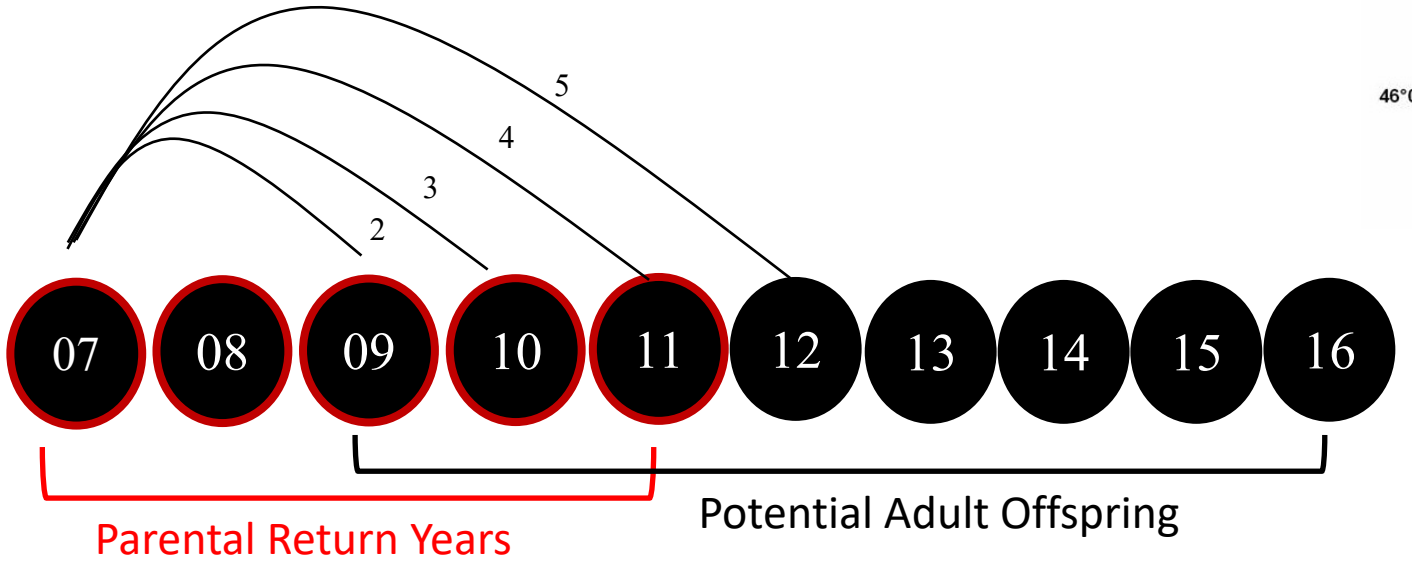
- Rear and release Upper Yakima River Spring Chinook Salmon (*Oncorhynchus tshawytscha*) in the Yakima River subbasin (WA)
- Integrated hatchery program: broodstock comprised exclusively of unmarked fish, presumed to be of natural-origin

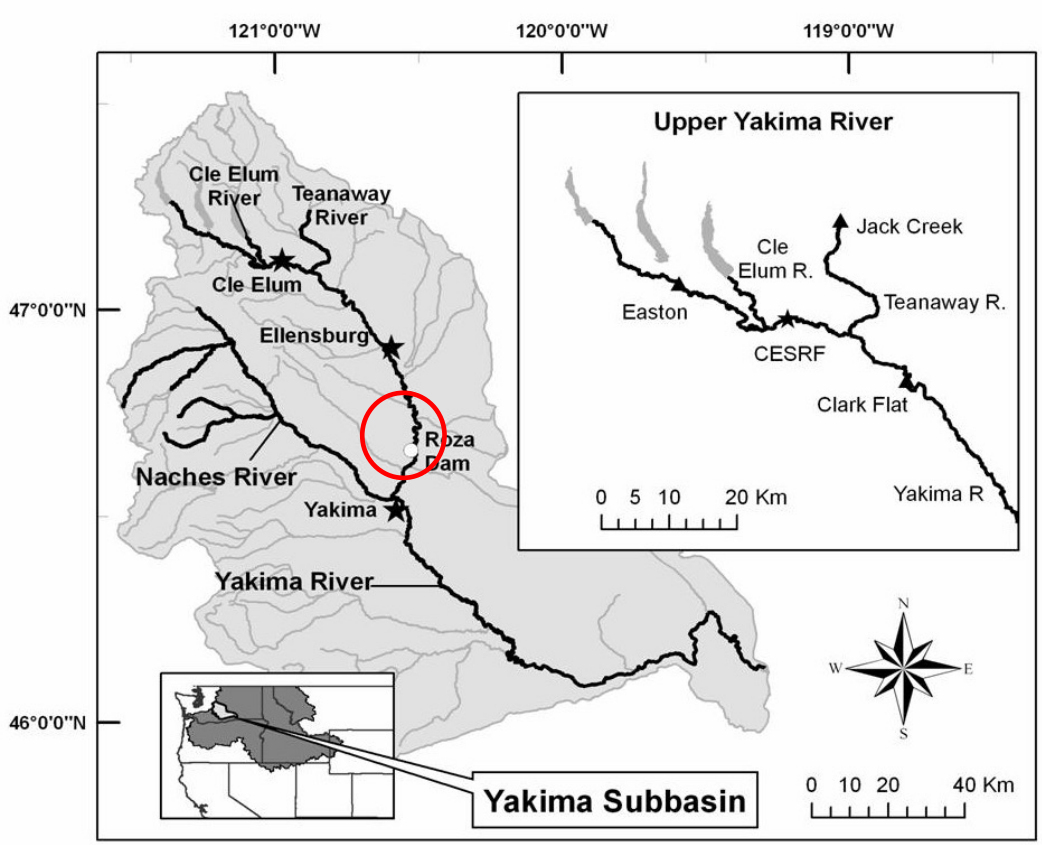


Sample Collection

Tissue samples were collected at the Roza Dam Adult Monitoring Facility on the Yakima River:

- ~32,000 potential parents from return years 2007 through 2011
- ~54,000 potential adult offspring from return years 2009 through 2016





Methods

- Genotyped samples at panel of 298 SNP markers via GTseq
- Parentage analysis in COLONY to generate single- and two-parent assignments

Q1. Demographic boost: comparison of the number of offspring produced by broodstock and natural spawners

$$\frac{\text{Avg \# offspring produced by broodstock fish}}{\text{Avg \# offspring produced by naturally spawning fish}}$$

Q2 & Q3. Relative reproductive success (RRS): comparison of the number of offspring produced by hatchery-origin and natural-origin fish spawning naturally

$$\frac{\text{Avg \# offspring produced by hatchery-origin fish}}{\text{Avg \# offspring produced by natural-origin fish}}$$

$$\frac{\text{Avg \# offspring produced by a spawned cross containing one or two hatchery-origin parents}}{\text{Avg \# offspring produced by a spawned cross containing two natural-origin parents}}$$

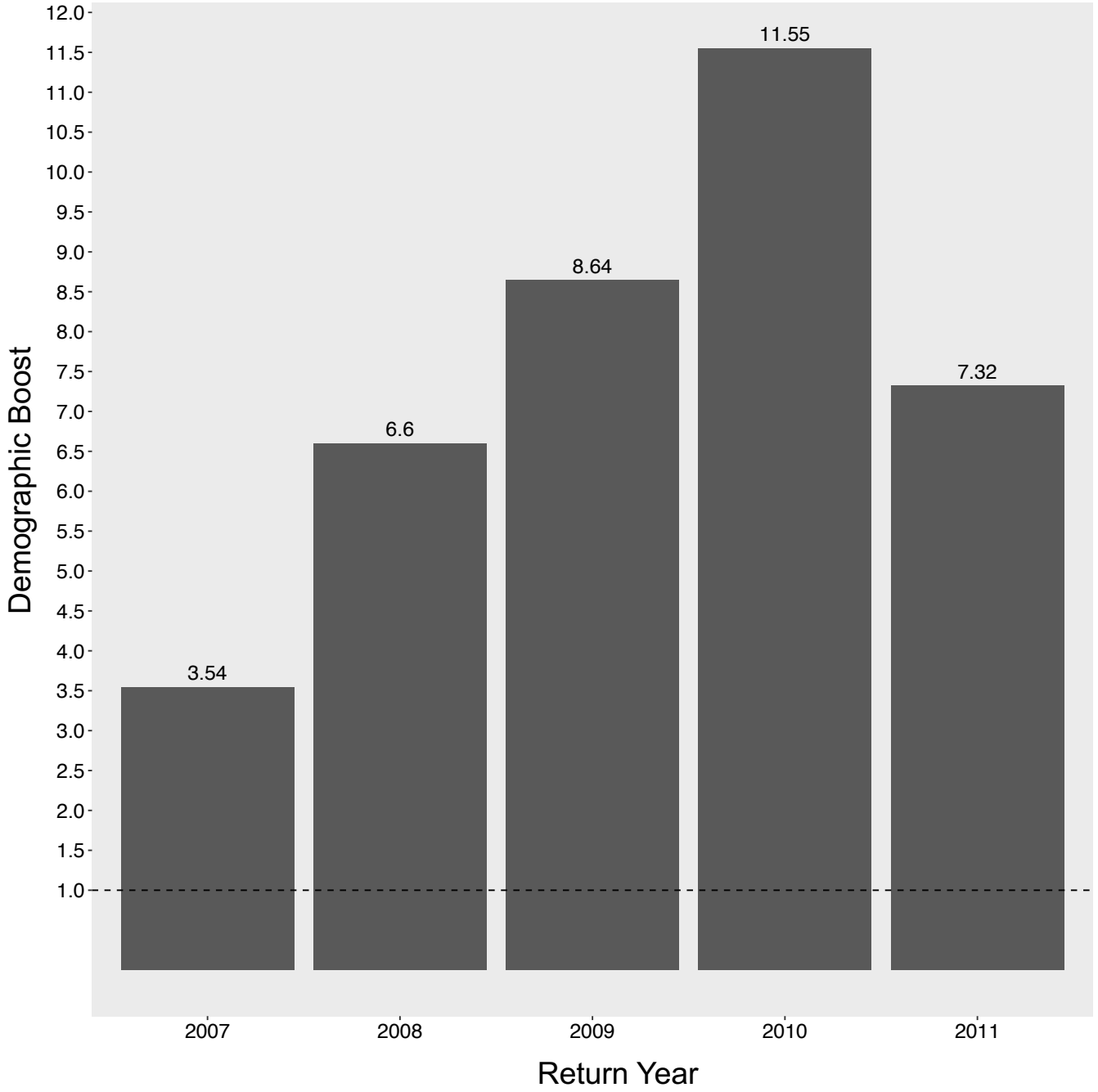
Q4. Potential factors affecting reproductive success:

- Return timing (day and year)
- Body size (fork length)

Demographic Boost

Broodstock fish produced 4 – 12 times the number of returning adult offspring than they would have had they spawned naturally (average = 7.53)

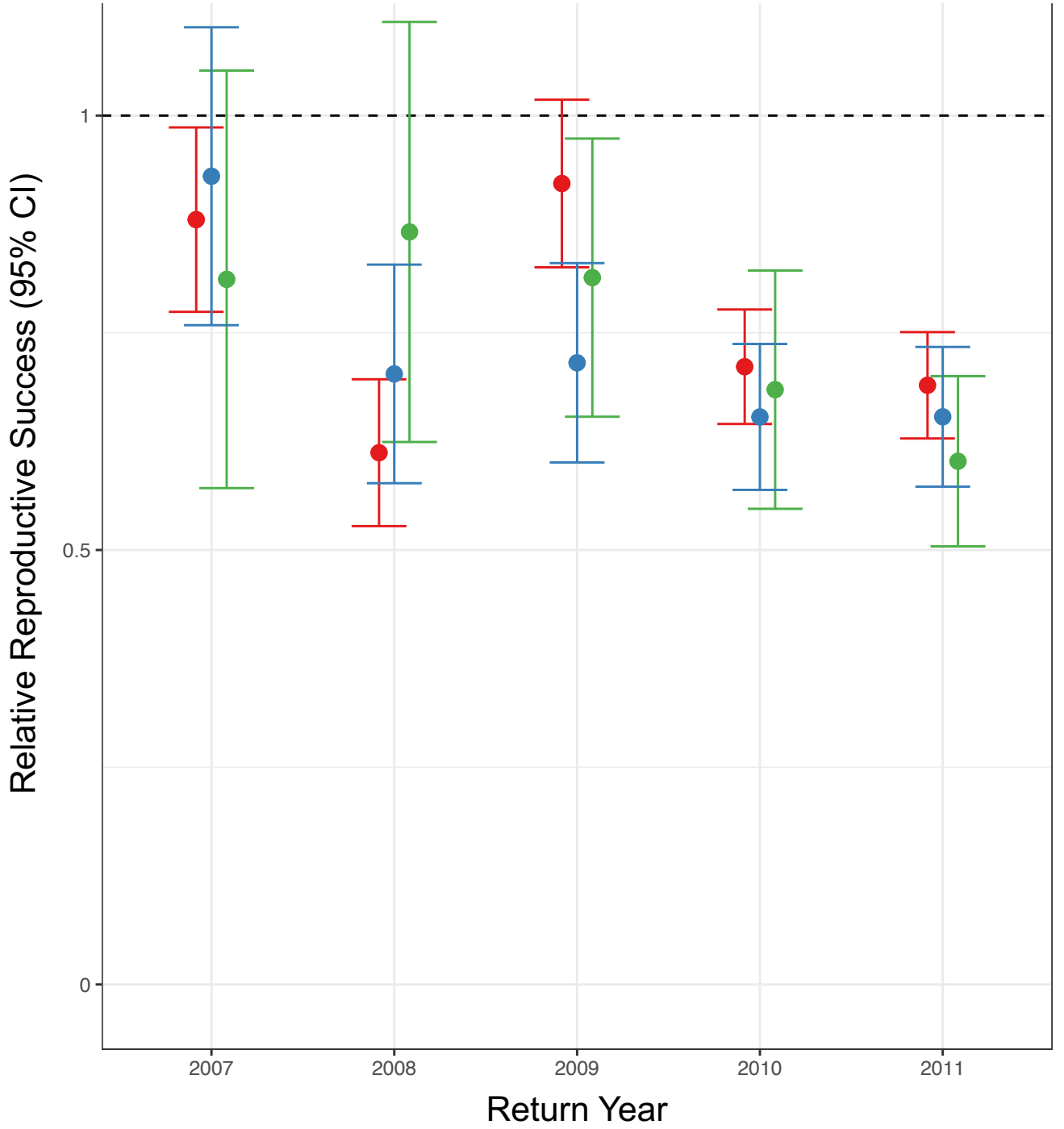
$$\frac{\text{Avg \# offspring produced by broodstock fish}}{\text{Avg \# offspring produced by naturally spawning fish}}$$



Relative Reproductive Success (RRS)

Average Female RRS: 0.76
Average Male RRS: 0.73
Average Jack RRS: 0.76

$$\text{RRS} = \frac{\text{Avg \# offspring produced by hatchery-origin fish}}{\text{Avg \# offspring produced by natural-origin fish}}$$



RRS of cross types

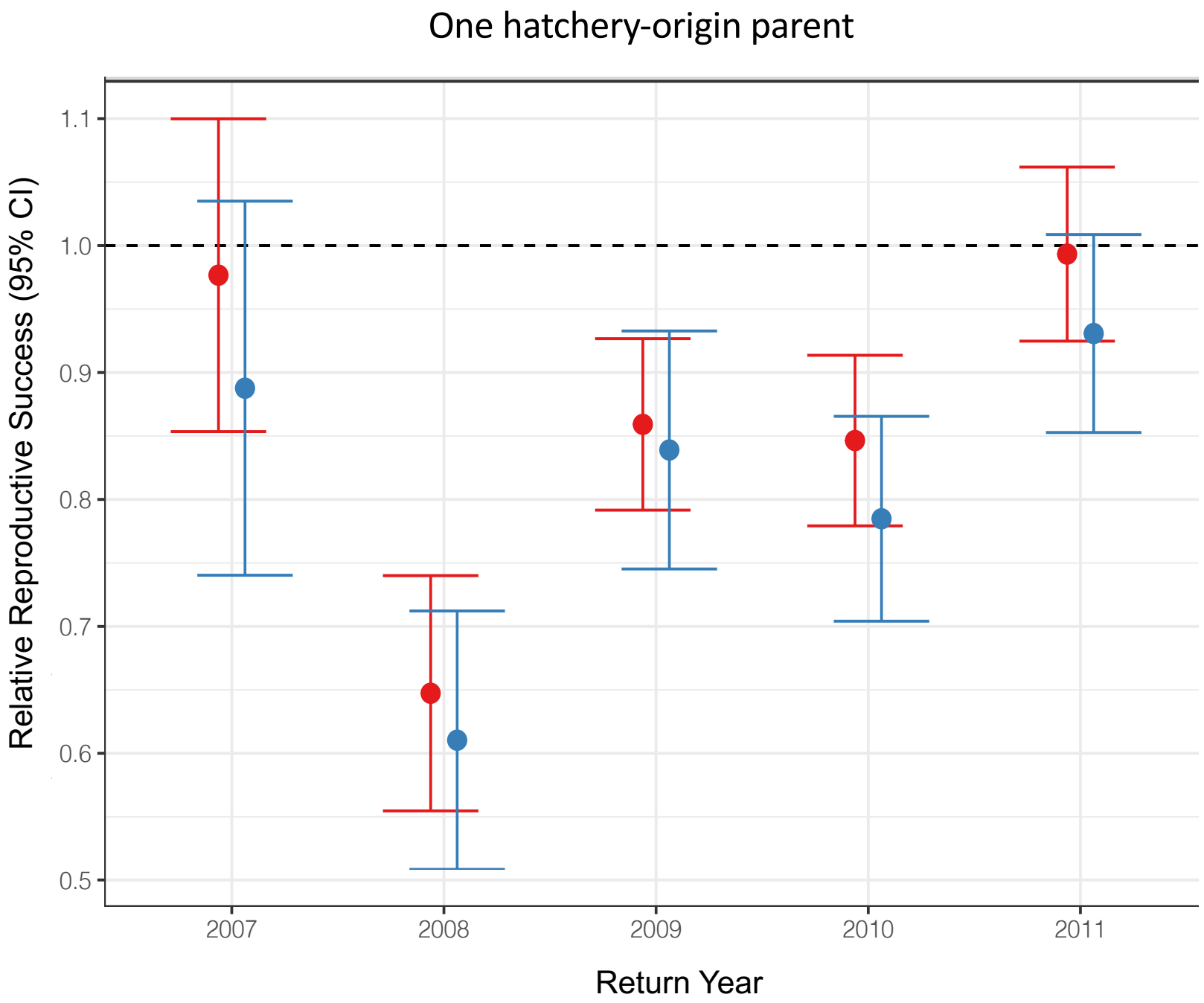
Average RRS for females in a NxH or HxN cross compared to a NxN cross = 0.86

$$\textbf{RRS} = \frac{N \times H \text{ or } H \times N}{N \times N}$$

Average RRS for males in a NxH or HxN compared to a NxN cross = 0.81

$$\textbf{RRS} = \frac{N \times N \text{ or } H \times N}{N \times N}$$

H= hatchery-origin N= natural-origin



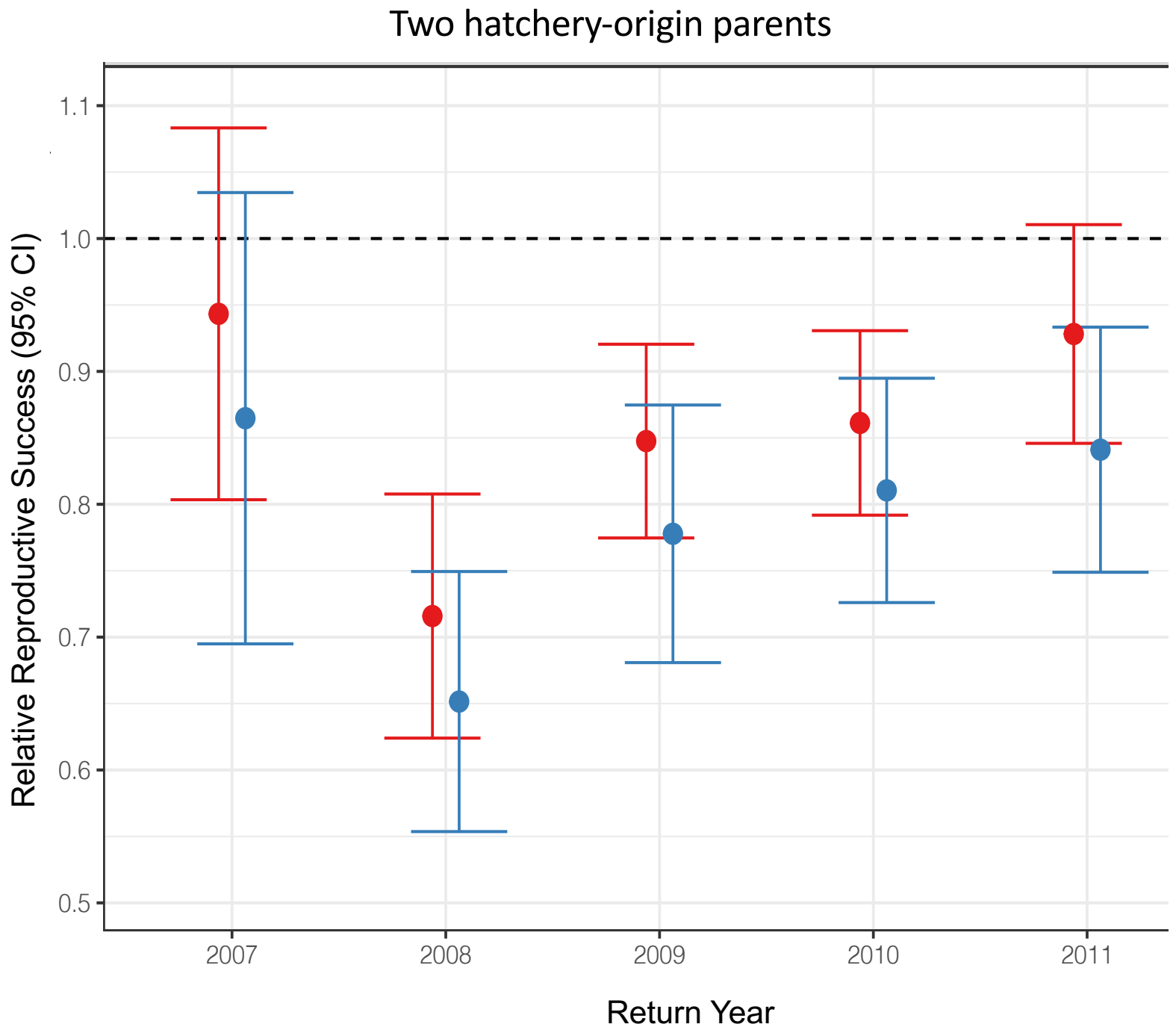
RRS of cross types

Average RRS for females in a HxH cross compared to a NxN cross = 0.86

RRS = $\frac{H \times H}{N \times N}$

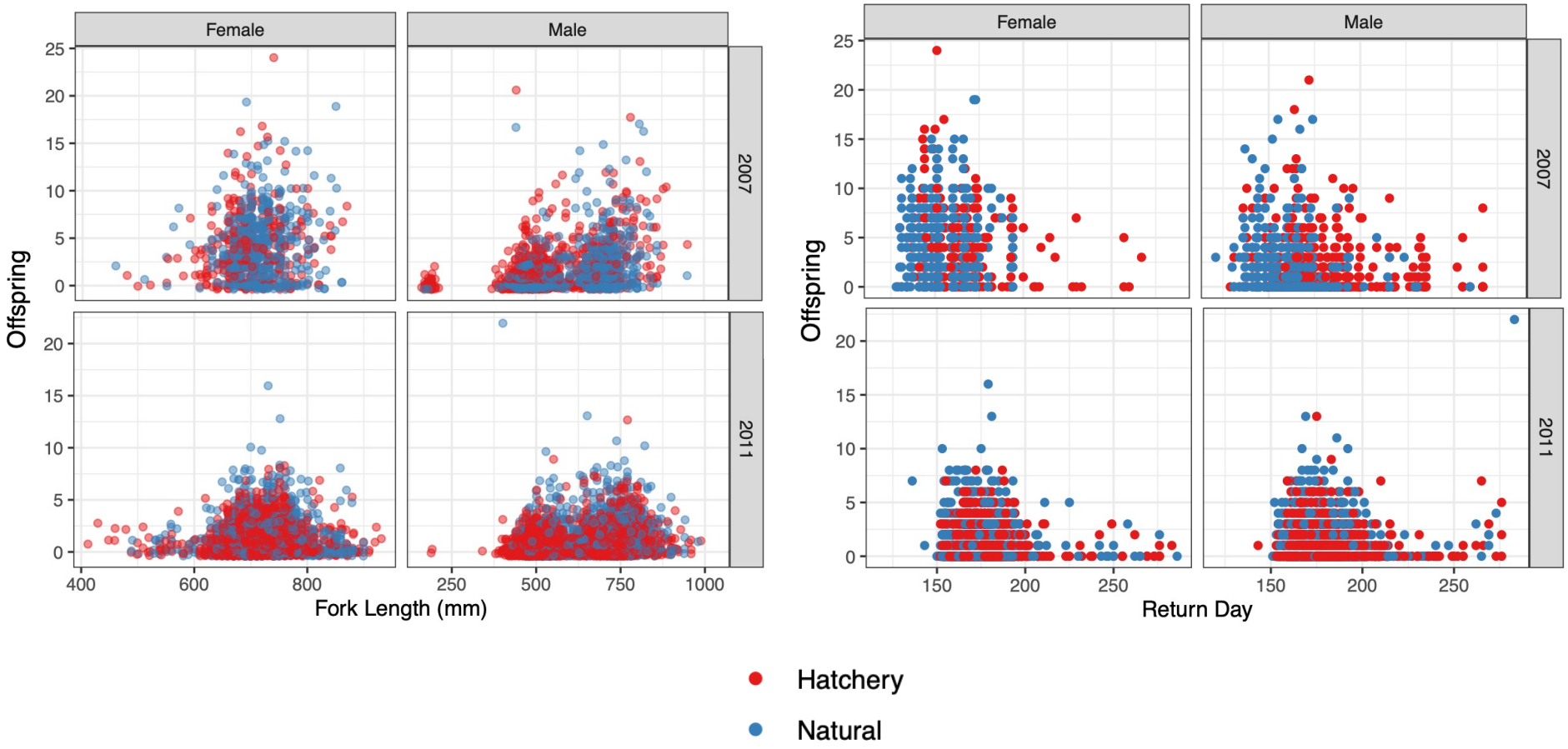
Average RRS for males in a HxH cross compared to a NxN cross = 0.79

RRS = $\frac{H \times H}{N \times N}$



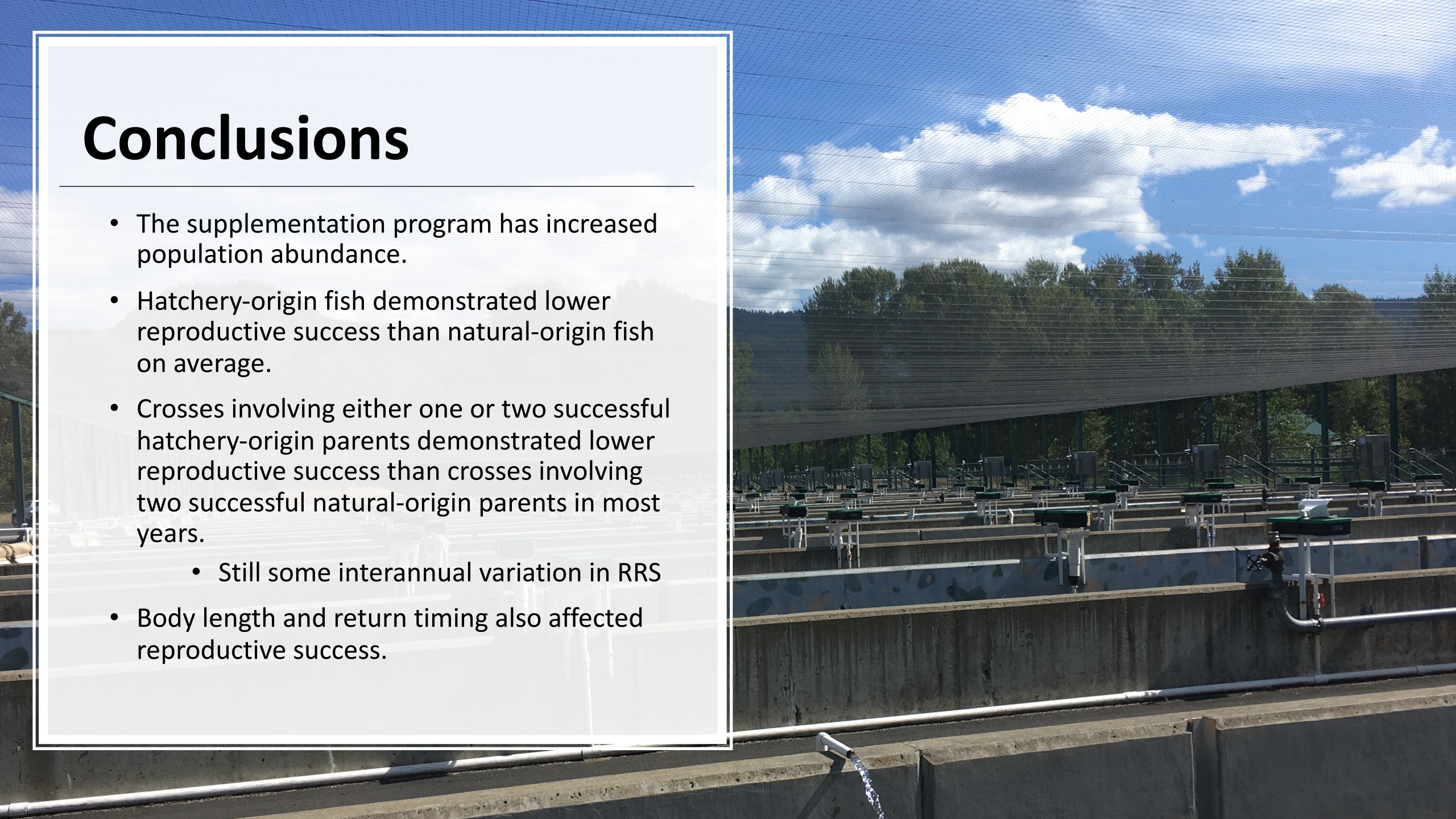
Factors Affecting Reproductive Success

- Fork Length
- Return day & year



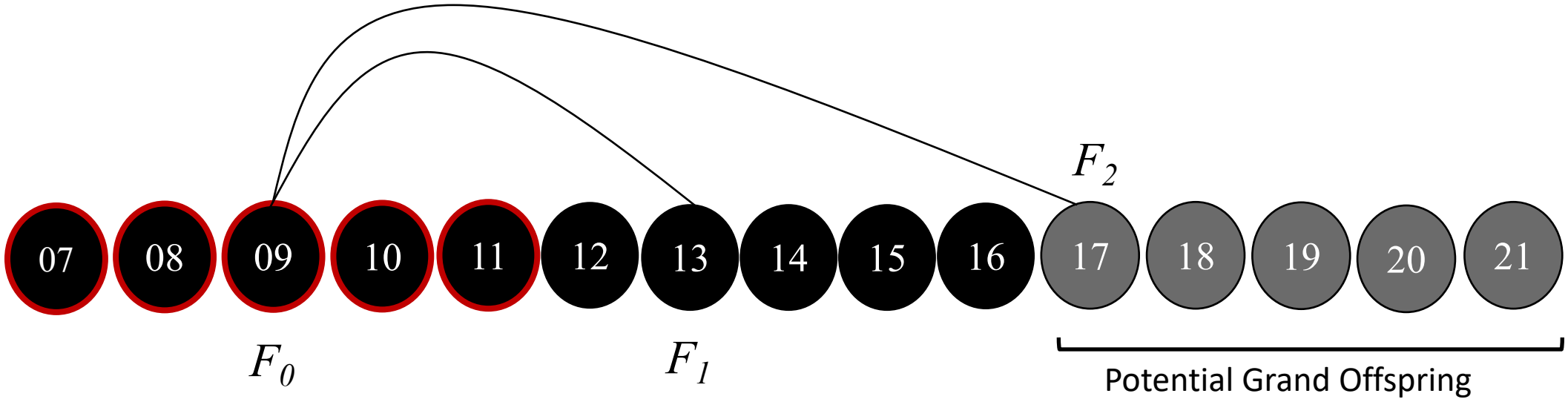
Conclusions

- The supplementation program has increased population abundance.
- Hatchery-origin fish demonstrated lower reproductive success than natural-origin fish on average.
- Crosses involving either one or two successful hatchery-origin parents demonstrated lower reproductive success than crosses involving two successful natural-origin parents in most years.
    - Still some interannual variation in RRS
- Body length and return timing also affected reproductive success.



Future Directions

- Does supplementation continue to boost natural production even after accounting for the lower reproductive success of hatchery-origin fish?
  - Second-generation (i.e., grandparental) RRS estimates from return years 2007-2011



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