Some notes on shorthand in the outline:

* I use the “RRS < 1” as shorthand throughout the outline to indicate that hatchery origin (HOR) spawners have lower reproductive success (adults or juveniles) than wild born spawners.
* F1 refers to wild born spawners with two HOR parents inferred from the pedigree
* NOR (following our conversation) does not refer to all wild born individuals. Instead it refers to only wild born spawners with no parentage assignment in our pedigree (i.e. NOR immigrants in the TAFS manuscript).

*Relative Reproductive Success*

* NOR vs HOR RRS
  + Two to three sentence overview of RRS literature, highlighting that RRS varies according to species and hatchery broodstock, following (Koch & Narum 2021).
  + We previously found that RRS < 1 in this system (Sard *et al.* 2016)(O’Malley *et al* 2023). However, in the McKenzie system wild born spawners include descendants of HOR salmon released above the dam in previous years, as well as salmon that do not assign to parents previously released above the dam.
  + When we exclude individuals descended from HORs previously released above the dam, RRS = 0.532.
  + Compare this RRS estimate to other Chinook salmon RRS estimates (Anderson *et al.* 2013; Hess *et al.* 2012; Koch *et al.* 2022; Nuetzel *et al.* 2022; Williamson *et al.* 2010)
* F1 vs HOR RRS
  + We found that the first generation offspring of HORxHOR crosses above the dam (F1s) produced significantly more adult offspring than HORs (RRS = 0.6).
  + This is the central result, only a single generation in the wild leads to strong, significant fitness increase.
  + However there are some important limitations that need to be considered before generalizing this result to other systems
    - Broodstock integration and history of sustained natural production in the McKenzie.
    - Similar results may not apply to other systems, particular in the case of segregated broodstock and/or strong hatchery influence on natural production (e.g. high pHOS)
* F1 vs NOR RRS
  + We also found no fitness differences between F1s and NORs
  + This means that not only is the single generation increase in fitness large and significant, it may be close to complete.
  + but there are also important caveats and limitations to this conclusion (just acknowledge each of these without diving into a lot of detail, maybe one or two sentences each)
    - Hatchery influence of on NORs: many NORs could be later generation descendants of HORs that spawned below the dam, reducing apparent fitness difference between HORs and NORs.
      * But if this is the case, it may be true for all NORs in the McKenzie (Willoughby & Christie 2019)
    - NORs released above the dam may not be representative of the broader McKenzie NOR population
      * Arrival time is later than F1s. Perhaps many NORs released above the dam are late season dispersers, or strays with lower fitness than NORs in the McKenzie river more generally.
      * But differentiation within McKenzie NORs is low, and stray rate into the McKenzie is low

*Age at Maturity / Size*

* Context: HORs tend to express lower size and age at maturity (citations), and increased frequency of precocial maturation (citations). RRS < 1 has been attributed in part to reduced size and AAM for hatchery fish (citations).
* AAM is not known for HORs in our dataset, but size is known and closely related to AAM (Pearson correlation = 0.57) and we include it in our final model of TLF. HORs are significantly smaller than both NORs and F1s. Both generation and size significantly explain variation in TLF in the model. Therefore RRS < 1 even after accounting for differences in size, and size alone cannot explain fitness differences between HORs, F1s and NORs.
* AAM of the **offspring** of F1s is greater than that of HORs.
  + In addition to the effect of AAM on the fitness of salmon released above the dam, we also examined the AAM of their offspring. We found that found that F1s produced significantly more age 5 vs age 4 offspring than HORs, and that the size at maturity of offspring of NORs is greater than that of HORs. This suggests despite spending their entire lives in the wild, the wild-born offspring of hatchery salmon tend to express lower AAM, than subsequent generations of wild-born salmon, pointing to heritable genetic or epigenetic effects hatchery rearing on life-history expression.

*Mechanisms*

* The rate of fitness increase (one generation) suggests that either (1) much of RRS < 1 is explained by plastic, rather than inherited genetic effects, or (2) that selection is very strong and genetic variance is very high. Theoretically we could discuss this and place our results in context with the research into size and age effects on RRS, but my preference is to avoid speculation here since we can’t parse these two mechanisms using our analysis, and simply recognize that RRS < 1 might be driven by either plasticity or genetic effects (or both) in the section below.

*Conservation and Management Consequences / Conclusion*

* Following ~two decades of research, there are many point estimates of RRS across species, hatchery programs (integrated vs segregated), and river basins. These studies have revealed important trends and suggested areas where more research is needed. However, the focus of this body of literature has primarily been documenting potential fitness differences between HOR and wild born salmon spawning in the wild, the pace at which these fitness differences (if present) accrue, and the underlying mechanisms.
* One important question that arises from the RRS literature has gone relatively unaddressed: Since reintroduction and supplementation relies (at least initially) on HOR salmon spawning in the wild, does the lower fitness of HOR salmon spawning in the wild persist among their wild born descendants?
* There is reason to be concerned this may be the case. If RRS < 1 is due to domestication selection, the pace of adaptation to natural conditions may be too slow to be material important on conservation relevant timescales, especially if domestication selection has severely reduced genetic variance in the wild. Alternatively, if RRS < 1 may be driven by plastic responses to the hatchery environment. Even in the case of plasticity, reduced genetic diversity among hatchery stocks might lead to canalization of reaction norms. Therefore hatchery associated, maladaptive phenotypes may continue to be expressed in the wild despite the absence of the environmental cues that initially produced them.
* To our knowledge, only a single study to date has explicitly addressed this question (Nuetzel *et al.* 2022), (although previously published pedigree studies could be used to address it).
* We found
  + both fitness and a fitness related trait (AAM of offspring) improve after just a single generation in the wild
  + these improvements make them indistinguishable from NORs that spawned above the dam with respect to , which may be representative of NOR salmon in the McKenzie basin more broadly.
* This is an encouraging result for the continued use of HOR salmon in re-establishing naturally spawning populations in habitats where they have been extirpated, as well as in supplementation programs intended to reduce short term extinction risk.
* However, RRS literature has made clear that RRS is highly variable between species and broodstocks and further work is needed to understand how generalizable this result is to other reintroduction/supplementation programs.

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