Lower fitness of hatchery and hybrid rainbow trout compared to naturalized populations in Lake Superior tributaries.
Miller, L.M., T. Close and A.R. Kapuscinski. 2004. Molecular Ecology 13:3779-3388.

Objective: To compare the survival of stocked fry with Steelhead vs. Kamloops parents

Approach: For two years at the French River hatchery, we made crosses between Steelhead pairs, Kamloops pairs, and a mother and father of each type. Approximately equal numbers of fry from each cross type were stocked simultaneously into two streams. We electrofished to sample survivors at the end of the first and second summers following stocking.

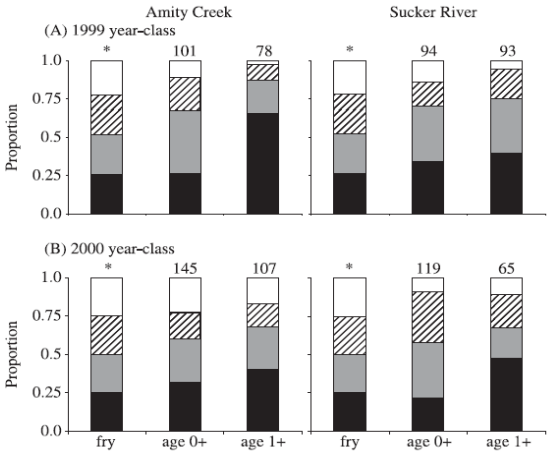

Figure 1. Proportion of each cross type at time of stocking (fry) and at the end of the first (age 0+) and second (age 1+) summers in two streams. White = Kamloops; Black = Steelhead; hatched = Kamloops female x Steelhead male; gray = Steelhead female x Kamloops male.

Table 1. Relative survival of cross types combining hatch rates and juvenile survival. N = naturalized Steelhead; H = hatchery Kamloops

Cross type	Survival to hatch	Average survival from fry to age 1+ (range)	Cumulative relative survival (female first)
N × N	1.0	1.0	1.0
N × H	0.99	0.59 (0.33–0.89)	0.58
H × N	0.80	0.37 (0.16–0.49)	0.30
H × H	0.67	0.21 (0.05–0.42)	0.14

Results: Pure Kamloops offspring had consistently poor survival in the wild while pure Steelhead had the greatest survival (Figure 1: H = Kamloops; N = naturalized Steelhead). Crossing a Kamloops with a Steelhead reduced survival compared with pure Steelhead. An earlier study of hatch rates found similar reduced performance by Kamloops crosses. Combined, we estimated that Kamloops pairs would produce only 14 offspring for every 100 produced by Steelhead pairs, while mixed crosses would average about 50 offspring.

Implications: These results indicate that if Kamloops spawn in the wild their offspring will likely have poor survival, at least if they have to compete with Steelhead offspring. If Kamloops spawn with Steelhead, they can reduce the reproductive potential of the Steelhead parent. Selection may be able to "weed out" the Kamloops genes but at the expense of the contribution the Steelhead parent could have made (called gamete wastage).

Stocking success of local-origin fry and impact of hatchery ancestry: monitoring a new steelhead stocking program in a Minnesota tributary to Lake Superior.
Caroffino, D.C., L.M. Miller, A.R. Kapuscinski and J. Ostazeski. 2008. Can. J. Fish. Aquat. Sci. 65:309-318

Objective 1: To compare juvenile production by hatchery and wild Steelhead.
Approach: Hatchery fry from Knife River adults were stocked into the Knife River. All parents were sampled for genetics. Outmigrating juveniles at age 1 and age 2 were sampled at the trap and assigned parentage. If they did not assign to our known hatchery parents, they were from natural spawners.

Table 2. Number of juvenile emigrants from different parent types of Knife River steelhead, naturally spawning females (NS) and hatchery females with one (H_1) or two (H_2) generations of artificial spawning.

		Age 1		Age 2	
Type	Number of females	Number of offspring	Offspring per female	Number of offspring	Offspring per female
2002 Year Class					
NS*	104	47	0.45	63	0.61
H_2	20	37	1.85	75	3.75
2003 Year Class					
NS*	178	167	0.94	806	4.53
H_1*	14	32	2.29	132	9.42
H_2	19	26	1.37	110	5.79

Results: Hatchery spawning successfully increased the number of offspring per female (1.3-6.1X more) (Table 2). In 2003, second-generation hatchery fish (clipped returns from previous stocking) did not perform as well as first-generation hatchery fish (unclipped wild parents spawned in the hatchery).

Objective 2: To compare survival by offspring of adults with 1 or 2 generations of hatchery spawning.
Approach: We stocked equal numbers of fry from crosses between clipped and between unclipped Knife River parents into six streams. We sampled survivors at the end of the first summer.

Table 3. Age-0 steelhead whose parents had one generation (H_1) or two generations (H_2) of artificial spawning.

		Number Captured	
Location	Year	H_1	H_2
Little Knife River	2003	39	27
McCarthy Creek	2003	22	23
Stewart River	2004	45	33
Budd Creek	2004	24	14
Stewart River	2005	13	7
West Branch Split Rock	2005	44	27
All streams/years	2003 - 2005	187	131

Results: In 5 of 6 streams, adults with one generation of hatchery spawning produced more juveniles than adults with two generations of hatchery spawning (Table 3). When combined across streams, the results were statistically significant (the probability this was due to chance was 0.002).

Implications: Fry stocking can clearly produce more offspring per female than what occurs in the wild because of the hatching and early-life survival advantage in the hatchery. However, even one additional generation of hatchery spawning can produce offspring less able to compete in the wild, possibly because the hatchery allowed many young to survive that would have been selected out if born in the wild. Long-term hatchery programs may continuously erode the competiveness of stocked fish.

Reduced reproductive success of hatchery fish from a supplementation program for naturalized steelhead in a Minnesota tributary to Lake Superior.
Miller, L.M., M.C. Ward and D.R. Schreiner. 2014. Journal of Great Lakes Research 40:994-1001.

Objective: To compare the reproductive success of returning hatchery steelhead to that of wild steelhead when passed above the trap to spawn in the Knife River.

Approach: Clipped hatchery adults (returns from smolt stocking) and unclipped wild adults were counted, measured, sexed and sampled for tissue before being passed above the Knife River trap to spawn. Two years later, age-2 smolts were sampled and assigned to parents using genetic parentage analysis.

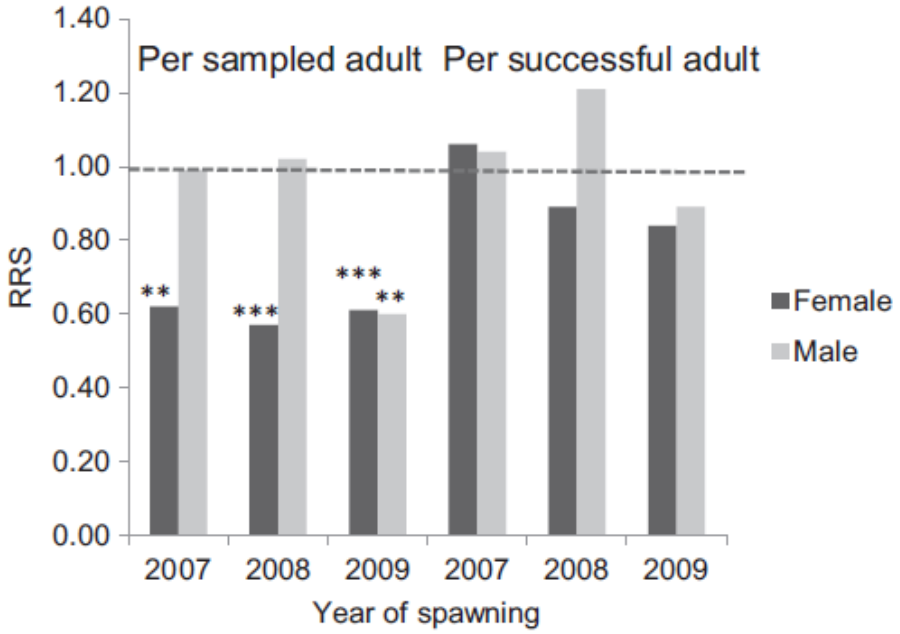

Figure 2. Relative reproductive success of hatchery Steelhead compared with wild fish spawning in the Knife River. Bars below the dashed line at 1.00 indicate that hatchery fish had fewer offspring per adult than wild fish. Statistically significant differences are marked with asterisks.

Results: Returning hatchery adults, especially females, produced fewer offspring per fish passed above the Knife trap to spawn in the wild (Figure 2, left side). The number of offspring per successful adult (those that had at least one offspring) was similar for hatchery and wild fish (Figure 2, right side).

Implications: Together, these results indicated that hatchery fish were less likely to spawn successfully in the wild, but their offspring survived similarly if they did spawn in suitable habitat. Hatchery fish may have chosen or been forced by competition into less favorable spawning habitat. The poorer performance by hatchery fish may have been due to genetics (less fit fish survive in the protected hatchery environment) or environment (something during their hatchery rearing that later affects their development, physiology and reproductive performance). Managers may minimize potential environmental and genetic contributors to reduced performance by hatchery fish, but continuous reliance on hatchery supplementation may hinder achievement of a long-term goal of a fishery supported largely by naturally reproducing populations.