Title: Comparison of Upper Yakima Hatchery- and Wild- Origin Spring Chinook Demographics

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Abstract:
A major component of determining supplementation success in the Yakima Klickitat Fishery Project's spring chinook (*Oncorhynchus tshawytscha*) program is an increase in natural production. Within this context, comparing upper Yakima River hatchery and wild origin fish across traits such as sex ratio, age composition, size-at-age, fecundity, and run timing is important because these traits directly affect population productivity through individual fish fitness. In addition, comparisons of these traits across the three putative wild populations in the Yakima River basin: American River, Naches, and upper Yakima River, help us identify and understand how local adaptations have uniquely shaped each population.

Sex Ratio - The female:male (F:M) ratios of upper Yakima River wild (1.6) and hatchery (1.5) origin fish collected at Roza Adult Monitoring Facility (RAMF) were not significantly different. In contrast, the F:M ratios of wild and hatchery origin fish in the spawning ground carcass sample were 1.5 and 2.6, respectively, and were significantly different. The F:M ratios of American and Naches spawning ground carcass samples were 2.0 and 1.6, respectively.

Age Composition – The majority of upper Yakima hatchery and wild origin fish returned as 3-year olds (49-50%), indicating a strong cohort from broodyear 2000. Age-4 fish made up 42% of the total wild origin returns and 27% of the hatchery origin returns.

Age-5 fish made up 8 and 24% of the total wild and hatchery populations, respectively. Based on scale sampled carcass recoveries, age composition of the American River was 0, 8 and 92% age-3, -4 and –5, respectively. Naches system fish were 4, 21 and 75% age-3, -4 and –5, respectively.

Sexual Dimorphism – There were no significant Sex (Male vs. Female) effects in body size distributions of wild or hatchery age-4 American, Naches or upper Yakima River populations. American River, Naches and upper Yakima age-5 fish demonstrated significant sexual dimorphism with males being significantly larger than females.

Size-at-Age – As noted in both 2001 and 2002, returning age-3 and -4 hatchery fish in 2003 were significantly smaller than wild fish by just under 2 *cm* and 0.1 and 0.3 *kg*, respectively. There was no significant difference in size between age-5 hatchery and wild fish. Within hatchery returns there was no significant within-age difference in body size of age-3, -4 or -5 OCT and SNT returns. For wild populations, age-4 and –5 fish from the American River were larger than the Naches fish, which in turn were larger than upper Yakima fish of the same age. These wild origin populational differences in size-at-age, as well as age composition noted above, are likely local adaptations developed in response to population-specific selection pressure from factors such as migration difficulty (gradient and flow), water temperature, and intra-sexual competition. The observed reductions in hatchery fish size-at-age of approximately 0.5 standard deviation will result in reduced fitness of naturally spawning hatchery fish and diminished natural productivity relative to wild fish. Counter selection in the wild will likely reduce the impacts on heritable traits in future generations.

Run/Spawn Timing - Median passage timing of adult hatchery and wild fish at RAMF differed by 1 day with hatchery fish passing earlier than wild fish. As in previous years, age-5's passed RAMF earliest, followed by age-4's, age-3's (lagging adult median passage date by 20-21 days) and finally age-2's. Mean spawn timing of upper Yakima River hatchery fish was significantly earlier by 6 days than wild fish, based on maturation/spawn dates at CESRF. As in past years, neither wild nor hatchery origin males nor hatchery females exhibited a significant linear relationship between passage date at RAMF and date of spawning at CESRF. Hatchery females did show a weak, significant positive correlation with passage date at RAMF, but it explained only 3% of the total variation in spawning date. Mean and median spawn timing was August 15 and 18, respectively, for the American River and September 13 and 14, respectively, for the Naches population based on carcass recoveries.

Carcass Recovery Bias – For adult hatchery origin fish, the F:M ratio at RAMF was significantly lower than the F:M ratio of spawning ground carcass recoveries, indicating that sex ratios estimated from hatchery origin carcass recoveries were biased due to female carcasses being recovered at higher rates than male carcasses. This was not true of wild origin fish. A comparison of the proportion of hatchery origin age-3 fish in the RAMF sample and the carcasses recovery sample also indicated that older, larger

hatchery fish were recovered as carcasses at significantly higher rates than younger, smaller fish. This trend was not demonstrated in wild fish carcass recoveries. Within age classes, the mean POHP length of carcass recoveries did not differ significantly from fish sampled at RAMF. Thus, as in past years, carcass recovery length distributions accurately represent size-at-age.

Fecundity and Fecundity/Female Size Relationship - Age-4 hatchery females (3,907 eggs) were significantly less fecund than wild origin females (4,349 eggs). Age-5 wild (5,427 eggs) and hatchery (5,732 eggs) origin females did not differ significantly from each other, but were significantly more fecund than age-4 females. Fecundity and female body size showed similar significant strong, positive correlations in both hatchery and wild origin females. Age-5 females had stronger, positive correlations between female body size and fecundity not observed in previous years.

Egg Weight - There was no significant difference between mean egg weights of age-4 hatchery (0.184 g) and wild (0.188 g) or age-5 hatchery (0.200 g) and wild (0.208 g) origin females. Age-4 eggs were significantly lighter than age-5 eggs by approximately 10%, similar to results for 2001 and 2002 returns.

Gamete Weight and Reproductive Effort - Reflecting the results for fecundity, gamete weight was significantly greater for wild age-4 females (mean= 812 *g*) compared to age-4 hatchery females (mean= 732 *g*). Age-5 hatchery females (mean= 1150 *g*) had greater mean gamete weight than wild age-5 females (mean= 1115 *g*), but the difference was not significant. Female Reproductive Effort (RE), the ratio of the weight of gametes to total body weight, did not differ significantly between age-4 or 5 females regardless of origin in 2003 (age-4 hatchery mean=0.190; wild females mean=0.197; age-5 wild mean=0.190; hatchery mean=0.193). This mirrors results found in 2001 and 2002.

Egg-to-Fry Survival and Developmental Abnormalities - There was no significant difference in egg-to-fry viability of hatchery (median =92.5%) and wild (median =92.1%) origin females. Both hatchery (median=0.2%) and wild (median=0.4%) origin fish had low percentages of abnormally developing fry with no significant difference between groups. These results are consistent with those from 2001 and 2002.

Fry Size - Wild fry (35 *mm*, 0.3 *g*, and 1.4 KD) were not significantly different in size from hatchery fry (35 *mm*, 0.3 *g* and 1.4 KD). There were strong positive relationships between fry size and egg weight for both wild and hatchery origin females. ANCOVA indicated that hatchery and wild fry slopes were not significantly different. As in 2001 and 2002, there were either no or weak positive female body size/fry size relationships, explaining at most 15% of the total variation in fry size.

Fry Emergence Timing - This research effort was initiated in 2002 and repeated in 2003 at CESRF. In 2002, median emergence timing and the range of emergence timing were not significantly different between hatchery and wild fry. In 2003, there was a significant difference, wild origin median emergence was 3 days later than hatchery and the wild
range was days shorter.

Male Testes/Body Size Relationships - Wild and Hatchery origin age-3 males did not exhibit significant differences in either mean testes weight, log(testes weight)/log(body size) relationships, or Reproductive Effort (RE). Testes weight was positively correlated with body size across all ages and age-2, -3 and -4 males each had significantly different mean testes weights. Age-2 males had a mean RE of 13%, which was significantly higher than in age-3 (6%) and -4 (6%) males. Thus, age-2 males allocated approximately twice the proportion of their total body weight toward gamete production than older anadromous males in order to compensate for their inordinate size disadvantage relative to older anadromous males during spawning.