A Modeling Analysis of the Potential for Restoration of South Santiam River Winter Steelhead using Dam Passage Mitigation

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Our modeling team developed a multi-stage life cycle model for winter steelhead (*Oncorhynchus mykiss*) to evaluate the potential of alternative dam passage measures in restoring the Winter Steelhead (WS) Distinct Population Segment (DPSG) in the Upper Willamette River (UWR). The demography of female recruits versus spawners was modeled by breaking the life cycle into 3 phases: a density-dependent egg-smolt phase, and two density independent phases, (dam passage, smolt to adult survival). Downstream passage parameters were dam passage efficiency (DPE) and dam passage survival (DPSV) values from USACE runs of the Fish Benefits Workbook, which only varied by $\pm$0.5% among water years. Smolt to adult survival was derived from several studies of smolt (Columbia Estuary) to adult (Bonneville) summarized in McCann et al. (2021). Recruit cohorts were linked to a spawner year using age structure and repeat spawning incidence from various UWR locations. Information from surrogate smolts, released into Foster Reservoir, as well as data from other Columbia River populations, indicate that both the timing and size of unclipped steelhead smolts have unimodal distributions (April-June, 150-220 mm).

Above dam freshwater survival (FS) was estimated by fitting the demographic model to counts of female WS adults that returned to Foster Dam and were out-planted above to the dam into the South Santiam River between 2006 and 2020. The estimated value, 2.50% egg-smolt survival, is comparable to low density FS measured for steelhead in other systems. If FS, DPS, DPE are constant across all years, then the among year variation is driven entirely by variation in Marine Survival (MS), which accounted for most of the variation among years (Fig 1). Average 2010-2020 spawner abundance under Current Operations and Perfect Passage were 52% and 327% of Historic Operations, respectively. Revisions to operations that are under consideration have the potential to increase abundance by up to 210% of historic abundance.

The current model represents a small fraction of the juvenile steelhead habitat in the UWR and needs to be extrapolated to reaches above and below dams. Steelhead of the UWR DPSG spawn and rear in the Molalla, North Santiam, South Santiam, and Calapooia sub-basins but dams are present on the North Santiam and South Santiam only and many WS spawn in the mainstems and tributaries below these dams. As a result, most of the Critical Habitat designated in the WS UWR DPSG in the 2011 Recovery Plan (ODFW and NMFS 2011) is below dams and therefore unaffected by dam passage mitigation. In the South Santiam sub-basin, however, reaches above Foster and Green Peter dams account for between 65-80% of potential juvenile steelhead habitat, depending on the estimation method (Bond et al 2017). The above dam habitat here therefore plays three key roles in the recovery plan: (1) access to high quality habitat, (2) breeding isolation from summer steelhead, and (3) an effective monitoring opportunity for returning adults at dam collection facilities.

Bond, MH, et al. 2017. Estimates of UWR Chinook and Steelhead spawning and rearing capacity above and below Willamette Project (WP) Dams. NOAA Fisheries / NWFSC Fish Ecology Division.

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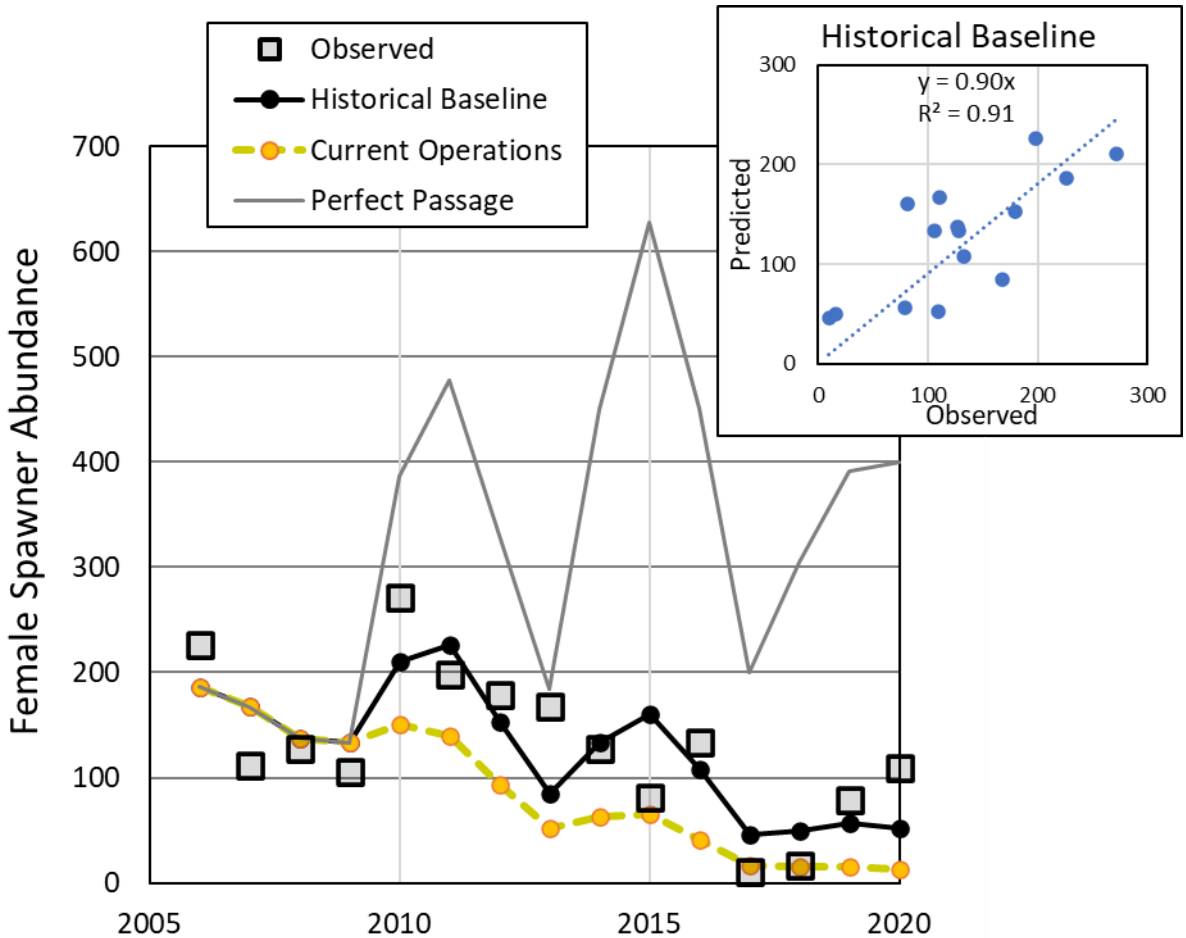

Figure 1. Observed and modeled abundance of female steelhead returning to the Foster Dam Fishway. "Historical Baseline" estimates reflect passage parameter that were in place prior to a 2018 change in operations. Passage is thought to be lower under the current operational regime and the 2010-2020 "Current Operations" abundance estimates are retrospective predictions of the effect of this change. A "Perfect Passage" scenario is included as a prediction of the effect of restoring 100% passage. All scenarios are the same until 2009 because identical initial conditions and the time lag between changes in passage and adult returns.