A LIFE CYCLE MODEL TO EVALUATE SCALING-DOWN HATCHERY PRACTICES IN RESPONSE TO FUTURE ABOVE-DAM RECOVERY SIGNALS IN SPRING CHINOOK SALMON (*ONCORHYNCHUS TSHAWYTSCHA*)

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Congress has authorized the US Army Corps of Engineers to mitigate for blocked habitat access caused by the construction and continued operation of dams in the Willamette River Basin—historically, this mitigation has taken the form of hatchery production, release, and outplanting of hatchery salmonids. As EIS measures are implemented to improve dam passage of juvenile fish, it is expected that the need to mitigate for the loss of above-dam habitat will lessen. Current hatchery operations are guided by Hatchery and Genetic Management Plans (HGMPs) created by USACE in collaboration with ODFW for rainbow trout, summer steelhead, and spring Chinook. However, given expected improvements to downstream dam passage and survival of juvenile fish following implementation of EIS alternatives, practices defined in the 2019 HGMPs may be updated to reduce hatchery activity. For example, hatchery outplanting programs may be reduced in future years in response to signs of population recovery above dams.

Measures to reduce outplanting are, in part, motivated by the risks associated with interactions and interbreeding between natural- and hatchery-origin (NO and HO) conspecifics. These include ecological interactions like competition and predation as well as genetic risks like the reduction of genetic diversity in the wild-spawning population and lower prevalence of adaptive traits as a result of domestication within hatcheries (Ryman and Laikre 1991; Naish et al. 2007; Hayes et al. 2013; HSRG 2014; Hagen et al. 2021). Even in first-generation hatchery fish (i.e., those from natural broodstock parents), relative reproductive success can be lower than that of natural conspecifics (Schroder et al. 2008; Chilcote et al. 2011; Christie et al. 2014). Importantly, hatchery practices like broodstock composition and outplanting rules can be designed to minimize these risks.

Following improvements to juvenile downstream passage and survival, USACE is considering approaches to reduce the influence of HO fish on wild conspecifics. To help inform approaches to scaling-down hatchery activity in response to dam passage improvements, we built a life cycle model for spring run Chinook salmon (*Oncorhynchus tshawytscha*) able to project the consequences of alternative hatchery practices. Unlike the Chinook life cycle model in McAllister et al. (2022)—which describes only the progeny of above-dam naturally spawning populations comprised of NO and HO outplants—our hatchery mitigation model also projects the production and release of hatchery origin fish and separately tracks each of the NO and HO subpopulations as they emigrate to the ocean and return to freshwater at adults of multiple ages (Figure 1). The model allows for exploration of alternative hatchery mitigation measures and their potential effects on natural populations.

Despite the necessity of building a life cycle model (LCM) that can report these performance metrics, to date no LCM has been developed for the Upper Willamette basin that can assist in decision-making regarding these outplanting decisions. While the model is still a work in progress, it has been applied to assess these alternative decision rules that use signals of recovering NO populations to reduce hatchery activity. We show that explicit inclusion of plausible fitness consequences of hatchery origin adults in natural spawning grounds can have long-term consequences on Chinook salmon population recovery. The objectives of this talk are to explain (1) the current abilities of the hatchery mitigation model, including preliminary exploratory model projections, and (2) limits and planned expansion of the hatchery LCM.

Objective 1: Overview of the hatchery assessment model and preliminary results

Expanding tools developed by the Hatchery Science Review Group's All-H Analyzer (HSRG 2009), we have built a hatchery assessment model which can assess plausible genetic consequences of hatchery supplementation on wild populations. Compared to the All-H Analyzer, we have built a more realistic and adaptable model by (1) allowing for complex life history strategies (e.g., including multiple juvenile migrant types and multiple ages of adult return), and (2) allowing for multiple genetically distinct sub-populations of spawners within a river basin, including multiple naturally spawning and hatchery spawning components (Figure 1). The hatchery analysis model also allows for a suite of hatchery-related performance metrics useful for tracking long-term population outcomes, including cohort return rate, fitness, mean phenotype, and harvest of returning HO adults in mark-selective freshwater fisheries.

Objective 2: Future development of the model

The LCM is currently preliminary, and requires parameterization and validation (e.g., using pedigree and genetic analyses of adult populations and their fitness, c.f. Evans et al. 2019). We have not yet been able to estimate model parameters for hatchery components, instead using parameters from previous modelling efforts or from generalizable fitness and heritability parameters based on expert opinion (e.g. HSRG 2020). Given adequate time and data, it would be useful to calibrate HO components of the model to observed data to ensure that modelled processes can recreate observed patterns. This could include, for example, early marine survival of HO releases, proportions returning at age, and possibly fitness loss. In our talk, we will also briefly highlight avenues for future development of the LCM.

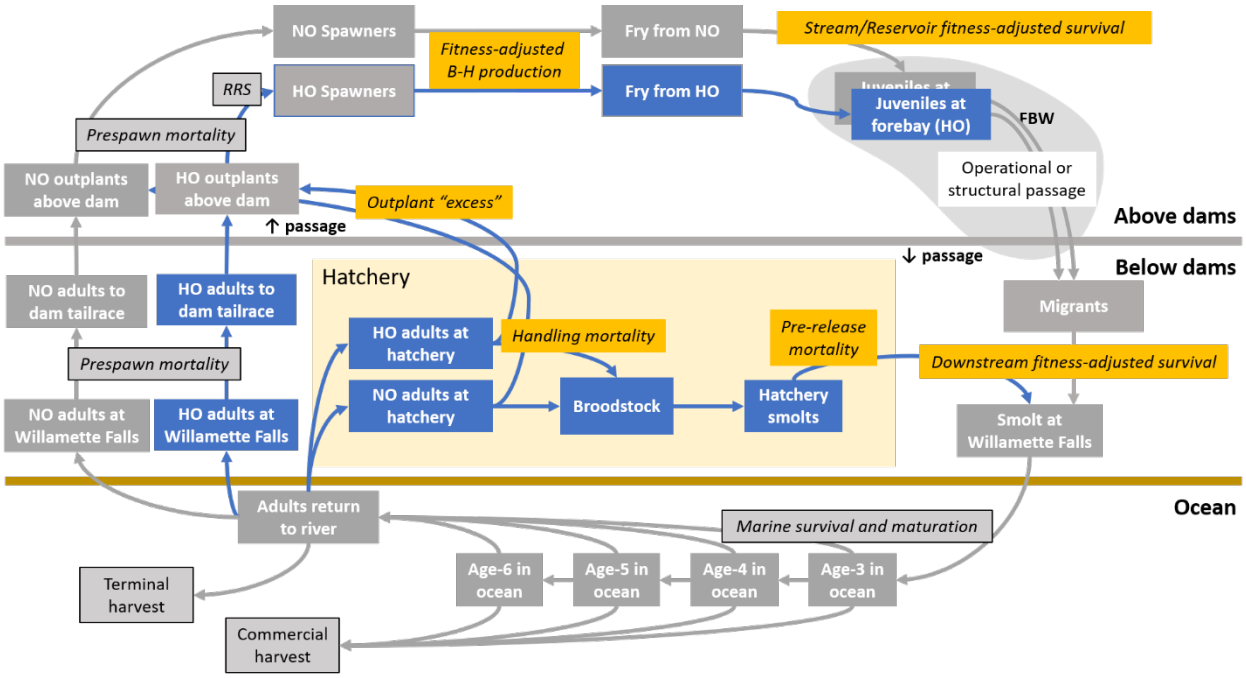

Figure 1. Flow-chart diagram of the hatchery assessment life cycle model for spring Chinook salmon (*O. tshawytscha*) in the Willamette River. Model components highlighted in blue and yellow represent new sub-populations and processes, respectively, that are additions to a previous version of the LCM published in McAllister et al. (2022), in grey. These include fitness-adjusted Beverton-Holt (BH) production of smolts, tracking of the natural- and hatchery-origin components (NO and HO, respectively) of the population and their phenotypes separately, as well as in-hatchery practices. RRS: Relative reproductive success; NO: natural origin; HO: hatchery origin, FBW: Fish Benefits Workbook.

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