Juvenile Migrant History Diversity Above Dams in Willamette Spring Chinook Salmon Life Cycle Models

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Spring Chinook salmon (*Oncorhynchus tshawytscha*) in the Middle Fork of the Willamette River (MFW) were listed as threatened under the Endangered Species Act in 1999. A Biological Opinion provided by the National Marine Fisheries Service in 2008 prompted the Corps to conduct research, monitoring and evaluation to assess the feasibility and benefits of alternative approaches for dam passage in the MFW. Life cycle models (LCMs) of spring Chinook salmon in the Upper Willamette sub-basins have been previously developed for this purpose (COP 2015). To provide an independent assessment, a new LCM has recently been constructed by University of British Columbia (UBC) modelers.

Diversity in juvenile migrant history types has been recognized as one component of population viability as reflected in the formulation of the Viable Salmonid Population (VSP) performance metric and therefore needs to be explicitly included in LCMs (McElhany 2003, 2006). Schroeder et al. (2016) identified six juvenile migrant histories in the McKenzie sub-basin and hypothesized that maintaining this diversity would help to reduce variability in the total abundance of juvenile outmigrants. In contrast to a previously constructed LCM which considered three juvenile migrant history types, we developed, consistent with the findings of Schroeder et al. (2016), a LCM for above dam populations of Upper Willamette spring Chinook salmon which represents six juvenile migrant histories. We recognized two groups of reservoir entrants which correspond with the timing of movement of juveniles from their natal spawning streams; one group called movers migrates downstream and into the reservoir soon after fry emergence in the spring; a second group called stayers stays in the natal stream a least until after summer and migrates from the natal spawning stream into the reservoir autumn as sub-yearlings, or during the following spring as yearlings. Each of these two groups are further divided up in association with the timing of migration past the dam in either the first spring, autumn or the following spring. This gave rise to the following juvenile migrant groups:

1. Fry that pass the dam/smolt in spring = mover-subyearling
2. Subyearling that pass the dam in fall having spent summer in reservoir = mover-autumn
3. Subyearling that pass the dam in fall having spent summer in stream = stayer-fall migrant-autumn
4. Yearling that pass the dam the next spring having spent summer and winter in reservoir = mover-yearling
5. Yearling that pass the dam the next spring having spent only winter in reservoir = stayer-fall migrant-yearling
6. Yearling that pass the dam the next spring having spent nearly all of their life in stream = stayer-spring migrant-yearling

The precise causal determinants of juvenile migrant group variation in above-reservoir spring Chinook salmon populations remain poorly understood. However, the frequency distribution of migrant history types is quantifiable from a variety of field data. We used Rotary Screw Trap data collected by Romer (Romer 2011-2016) to parametrize the reservoir entry proportions of the six juvenile migrant history types. The hypothesized values for above dam survival rates of these juvenile migrant groups were obtained from the literature (Zabel 2015). The numbers of fish in each juvenile migrant group were computed in our LCM accounting for the effects of dam operations, reservoir survival, and the documented migration patterns of juvenile spring Chinook salmon.

Some preliminary LCM predictions of the relative frequencies of juvenile migrant groups under recent water year types and dam operations are reviewed for the McKenzie, Middle Fork, South Santiam and North Santiam sub-basins. Our LCM analyses show that deliberate modifications to dam passage structures and operations can potentially have large impacts on the relative frequencies of occurrence of juvenile migrant types; this is because lengthier delays in juvenile dam passage may lead to higher mortality rates from reservoir rearing, but also increased growth and associated changes in dam passage survival, depending on the dam passage routes taken.