ABOVE-DAM LIFE HISTORY DIVERSITY OF JUVENILE SPRING CHINOOK SALMON (*ONCORHYNCHUS TSHAWYTSCHA*): IMPLICATIONS FOR LIFE CYCLE MODELLING AND POPULATION RECOVERY

Mairin Deith, Tom Porteus, Roberto Licandeo, Eric Parkinson, Aaron Greenberg, and Murdoch McAllister
University of British Columbia, Vancouver, BC, Canada
m.deith@oceans.ubc.ca

In species with multiple life history pathways (i.e., temporally and spatially distinct patterns of rearing, maturity, and reproduction), maintaining diversity in life history types has been hypothesized to be vital for the long-term stability and resilience of wild populations. Diversity in juvenile migratory types (JMTs) has been considered to be a vital component of population viability, with diversity in life history types included as a core component of the Viable Salmonid Population scoring system (McElhany et al. 2000). As such, it is appropriate to explicitly represent life history diversity of juvenile salmon in life cycle models (LCMs) seeking to predict how well the diversity of JMTs is maintained by different dam passage measures.

Schroeder et al. (2016) identified six juvenile life histories for spring Chinook salmon (*Oncorhynchus tshawytscha*) below dams in the McKenzie sub-basin and hypothesized that maintaining this diversity would help to reduce inter-annual variability in the total abundance of juvenile outmigrants. In contrast to a previously constructed LCM which considered three juvenile life history types (e.g., Zabel et al. 2015), we developed a LCM for above-dam populations of Upper Willamette spring Chinook salmon which represents the six juvenile life histories defined by Schroeder et al. (2016). The reservoirs created by dams present a novel rearing habitat that may result in different life history types to those below dams. The influence of dams on life history diversity is unknown as it is difficult to determine volitional reservoir residence from impeded downstream movement. Therefore we define diversity in terms of JMTs, rather than juvenile life history types. The objectives of this talk are two-fold: (1) we seek to describe the JMT diversity observed in the Upper Willamette sub-basins; (2), we will show results that highlight the relative productivity of each JMT according to simulated outcomes from the UBC LCM for spring Chinook (from McAllister et al. 2022).

Objective 1: Describing the diversity of life history types in the Upper Willamette sub-basins

There are three groups of reservoir entrants (defined by timing of reservoir entry; Figure 1). First, individuals of the fry JMT enter the reservoir soon after emergence in early spring. Next, sub-yearling JMTs enter the reservoir during summer and autumn, and yearlings during the following spring. Fry and subyearlings can, depending on reservoir operations and/or the availability of dam passage structures, continue to rear in the reservoir to an older life stage before attempting to pass (Figure 1). For example, depending on dam passage opportunities, fry that enter a reservoir can pass the dam soon after entry as fry migrants, or they may rear in reservoir and attempt passage in the fall as sub-yearlings or in the following spring as yearlings.

While the precise causal determinants of juvenile JMT diversity in above-reservoir spring Chinook salmon populations remain poorly understood, the frequency distribution of life history types is quantifiable from a variety of data sources collected in the field, e.g., rotary screw trap data. We used hypothesized values for above dam survival rates of each juvenile JMT from the literature. The numbers of fish in each juvenile life history were computed in our LCM accounting for the effects of dam operations, reservoir survival, and the documented migration patterns of juvenile spring Chinook salmon.

Objective 2: Life cycle model predictions of the relative performance of different JMTs

Following LCM simulations, we found that predicted proportions of juvenile JMTs varies under the different dam operation alternatives proposed in the EIS. We found that in each of the four focal subbasins—North Santiam, South Santiam, McKenzie, and Middle Fork—deliberate modifications to dam passage structures and operations can potentially impact the relative frequencies of occurrence of juvenile migrant types. Subyearling in-reservoir migrants were consistently the most frequent life history type across all alternatives, with the exception of South Santiam (where the majority of fry entering Foster reservoir move directly to the forebay). Yearlings who entered as fry and reared in the reservoir over both spring and winter were the next most frequent across all of the alternatives. However, the relative frequency of yearlings who entered as subyearlings and reared over winter varied more substantially between the different Alternatives (Figure 2). These differences in relative frequency of JMTs between the Alternatives and NAA are largely due to differences in assumed values for in-reservoir movement and juvenile dam passage survival. Higher mortality rates may result from prolonged reservoir rearing or high dam passage mortality, depending on the availability and effectiveness of mechanisms for dam passage during preferred juvenile migration windows within the year. On the other hand, in-reservoir rearing results in larger-sized and older fish attempting to pass the dam, and size-related declines in dam passage survival (depending on the dam passage routes taken and available fish passage structures; Figure 2).

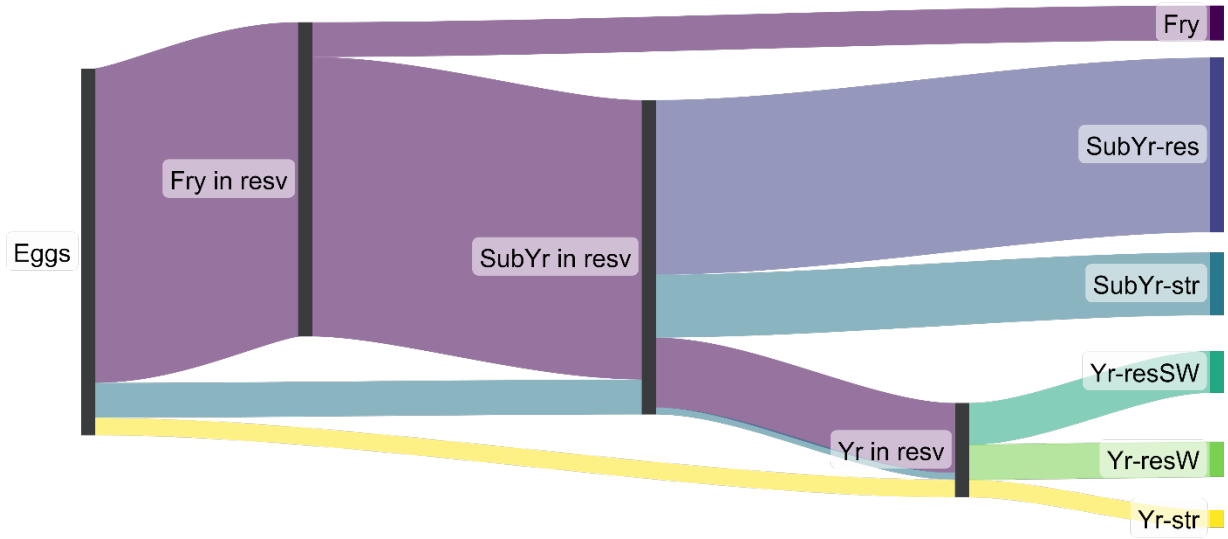

Figure 1. Schematic representation of an example of how juvenile migratory types are distinguished for spring Chinook spawned above high-head dams. There are multiple stages at which juvenile fish are observed to enter reservoirs before attempting to pass a given dam. First, as fry soon after emergence (Fry in resv); second, as subyearlings (SubYr in resv) in the late spring and summer following emergence; or as yearlings (Yr in resv) in the spring after their first year of life. After entering the reservoir as a fry or subyearling, a juvenile fish may additionally rear in the reservoir before passing the dam before passing, leading to six life history types: fry, subyearlings who reared in the reservoir (SubYr-res), subyearlings who reared in the stream (SubYr-str), yearlings who entered as fry and reared in the reservoir over both spring and winter (Yr-resSW), yearlings who entered as subyearlings and reared over winter (Yr-resW), and yearlings who reared in stream (Yr-str).

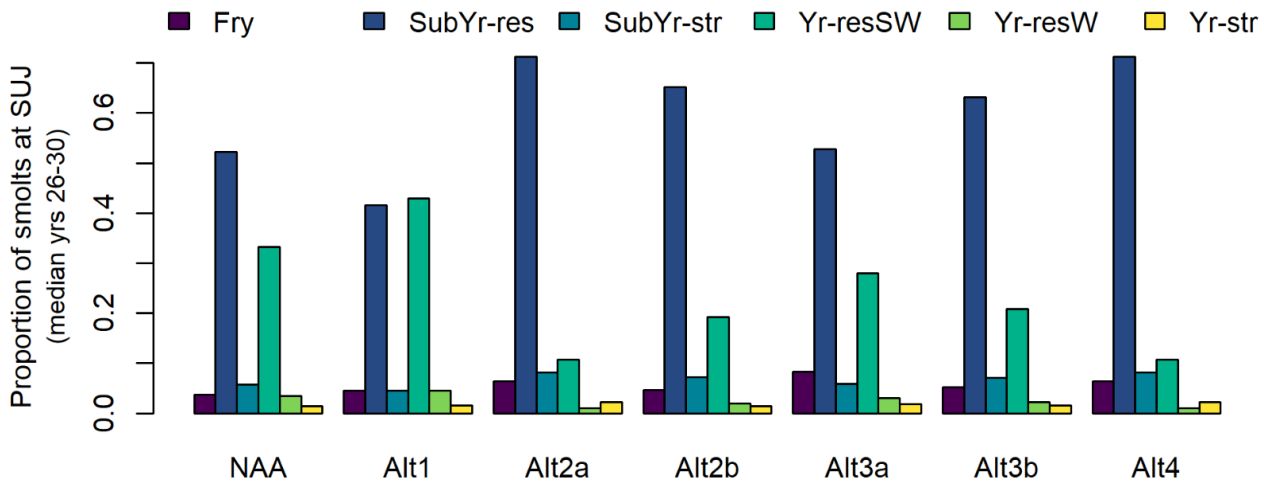

Figure 2. Life cycle model predictions of the relative proportions of different juvenile JMTJMTs—counted as smolts passing Sullivan Juvenile Facility (SUJ)—after passing Cougar dam in the McKenzie subbasin. Results are shown after a burn-in period of 25 years, so these results should be considered long-term expected outcomes of implementing dam passage alternatives. See caption of Figure 1 for abbreviation definitions.

Literature cited

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