Differences in smolt to adult survival rates between Willamette River sub-basins and implications for the recovery potential of spring Chinook salmon

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The Upper Willamette River population of spring Chinook salmon (*Oncorhynchus tshawytscha*) is listed as threatened under the Endangered Species Act. Life cycle models are being used in each sub-basin to evaluate population responses to alternative fish passage measures through high-head dams operated by the US Army Corps of Engineers (USACE). Survival through different events in the Chinook salmon life cycle influences the potential for population recovery in response to dam passage measures. Juvenile Chinook salmon must survive from emergence in natal streams to move into reservoirs, through dam passage, downstream migration and smolting into the marine environment, before returning as adults. Due to the challenges involved in estimating them, many of these survival rates are poorly understood.

Survival rates can be estimated by modelling data on detections of fish implanted with Passive Integrated Transponder (PIT) tags. The Cormack-Jolly-Seber (CJS) model estimates the survival rate between discrete release and detection locations by adjusting the numbers of PIT tag detections at each location for the probability of detection at each location. This study aimed to 1) estimate release to smolt survival rate (RSS) and smolt to adult survival rate (SAS) in different Willamette River sub-basins, 2) interpret differences in RSS and SAS within and between sub-basins, and 3) determine how the estimates of SAS influenced population responses to alternative dam passage measures when used as input parameters in life cycle models.

A Bayesian CJS model was used to estimate RSS and SAS of juvenile Chinook salmon released into reservoirs above and tailraces below USACE dams in 2011-2015, using detection locations at Willamette Falls (Sullivan Juvenile Bypass Facility for smolts, Willamette Falls Fishway for returning adults). Informative prior probability distributions were developed and used to reduce uncertainty in each of the survival rate and detection probability estimates.

Release to smolt survival rate showed differences between sub-basins that could be explained by factors including distance from release to SUJ, month of release and length at release. Water year type influenced differences in RSS estimates within sub-basins, where the general pattern was abundant > adequate > deficit. Depending upon release location (above or below dam), smolt to adult survival rate showed differences of up to an order of magnitude between sub-basins. Mean SAS estimates in the Middle Fork were the lowest at 0.5%, while North Santiam and McKenzie estimates were higher at 1.6% and 1.7%, respectively. While some of these differences can be explained by release month and length, there appears to be a sub-basin specific effect. Release

location affected SAS estimates within sub-basins, whereby juvenile release groups that had opportunity to grow in reservoirs prior to smolting showed higher marine survival.

When incorporated into life cycle models, the relative smolt to adult survival rates between sub-basins influenced the potential for passage measures to result in population recovery. Compared to baseline conditions, a structural passage alternative led to greater than ten-fold increases in projected numbers of natural-origin spawners (NOR) above dams in the North Santiam and McKenzie sub-basins, but only about a three-fold increase in NOR above dams in the Middle Fork. These findings highlight that although dam passage measures can improve the status of Chinook salmon, marine survival remains an important factor in their population dynamics that is much more difficult to mitigate for.