Agenda Item D.2.a
Supplemental SSC Report
November 2016

SCIENTIFIC AND STATISTICAL COMMITTEE REPORT ON SALMON METHODOLOGY REVIEW

The Scientific and Statistical Committee Salmon Subcommittee (SSCSS) and Salmon Technical Team (STT) held a joint methodology review meeting in Portland, Oregon on October 18, 2016 to review models that predict the preseason abundance of Sacramento River Winter run Chinook salmon (Agenda Item D.2, Attachment 1). Dr. Michael O'Farrell (Southwest Fisheries Science Center [SWFSC]) briefed the SSC on work that was completed after the methodology review to further evaluate these models based on recommendations made at that meeting. Dr. O'Farrell reported that some errors were discovered and corrected in calculations used for Table 7. An additional test of model performance using leave-one-out cross validation showed little difference in the performance of the models. Based on these results, the SSC agrees with Dr. O'Farrell that there is no basis for selecting a best-performing model using the small data set available at this time. As additional years of data become available, a more rigorous evaluation will be possible, especially as the effects of the drought on this stock are manifested. The addition of drought year data may allow us to better differentiate among the models.

Scientific and Statistical Committee Salmon Subcommittee Report on Preseason Abundance Forecasts for Sacramento River Winter Chinook Salmon

The Scientific and Statistical Committee's Salmon Subcommittee (SSCSS) met in Portland, OR, on 18 October 2016 for a joint methodology review with the Salmon Technical Team of the report, "An evaluation of preseason abundance forecasts for Sacramento River winter Chinook salmon". The report was presented by Dr. Michael O'Farrell (SWFSC), with co-author Mr. Michael Mohr (SWFSC) in attendance and co-author Dr. Noble Hendrix (QEDA Consulting) joining the discussion via telephone.

Sacramento River Winter Chinook (SRWC) have a life history that precludes the use of jack returns to predict adult abundance prior to ocean fisheries, given the standard sampling methods and timing of jack return estimation. Thus, the current harvest control rule (HCR) for SRWC uses the recent 3-year geometric mean number of spawners. The SRWC Workgroup developed a suite of models to forecast the age-3 escapement in the absence of fishing ($E_{t,3}^{0}$) with the goal of better capturing rapid changes in population than is possible by relying on a mean of previous years. The SRWC model development and testing had three main components: (1) the fitting of a population dynamics model to fry and/or spawner data to estimate population parameters, (2) use of the estimated parameters in three forecast models, and (3) comparison of the performance of the three forecast models. The formulation of the underlying population dynamics model was published in a peer-reviewed journal and is extensively documented (Winship et al. 2014). The Winship paper was not reviewed by the SSCSS. Compared to the Winship et al. model, the population dynamics model was updated by adding recent data, and modified by including year-specific fecundity estimates rather than a constant number of eggs per female spawner and by adding a temperature covariate to the egg-to-fry relationship to better capture low survival in drought years. Additionally, in one proposed model variant, the juvenile survival rate (fry to end of ocean age 2) was modeled as a function of the egg-to-fry survival rate in an attempt to capture apparent correlation between survivals of the two stages.

Three forecast models (Base, ETF, and No JPI) were explored. The Base forecast model takes a random draw for the number of fry based on an empirical estimate of the fry-equivalent Juvenile Production Index (JPI, the estimated number of juveniles passing Red Bluff Diversion Dam standardized to the fry stage) and its uncertainty, and takes a random draw of juvenile survival from a beta distribution fitted by the population dynamics model. These draws are multiplied together (yielding a forecast for fish alive at the end of age 2) and scaled by natural mortality and maturation rates to generate the distribution of $E_{t,3}^{0}$ for natural-origin fish. The second forecast model ("ETF") differs from the Base model in that the juvenile survival rate distribution is estimated using an egg-to fry survival covariate, with the covariate based on an empirical estimate of the egg-to-fry survival rate. A third forecast model ("No JPI") was also tested, because in some years the JPI is unavailable. In this case, a model-based distribution of fry numbers is used that is estimated based on the number of spawners, their fecundity, and temperature-dependent egg-to-fry survival. The juvenile survival rate is modeled as in the Base model. A forecasted distribution of the number of hatchery-origin fish was made in all three models by multiplying the known number of hatchery fish that were released by scaled versions of the juvenile survival rate draws used in each model. The natural and hatchery forecasts were summed to get the total $E_{t,3}^{0}$. The three forecast models were evaluated using a one-year-ahead cross-validation with post-season estimates of $E_{t,3}^{0}$, which was limited to four years (2012-2015) due to the small size of the data set relative to the number of parameters that need to be estimated.

The report authors recommended using the Base model to forecast $E_{t,3}^{0}$ when the JPI estimate is available, and the No JPI model in years where the JPI is unavailable. The SSCSS agrees that the Base model performed as well or better than the other two model scenarios given the metrics used to assess them and the No JPI option is acceptable to use in years without a JPI estimate. The SSCSS recommends assessing the model's performance for all years, leaving out one year of data each time. Another possible evaluation of the models is to generate forecasts for each year using each model fitted to the full dataset, and compare these forecasts to the post-season estimates of $E_{t,3}^{0}$ for those years. This is not a rigorous method of validation but gives some idea of how each model performs across a range of inputs, and provides values that should match figures in the document.

The report authors recommended using the mode of the forecasted escapement distribution from the Base model to estimate $E_{t,3}^{0}$. The SSCSS recommends that when choosing an $E_{t,3}^{0}$, the full distribution of the estimate should be considered as this allows an assessment of the uncertainty of the estimate and an analysis of risk when used with a HCR. Results from the mode were more conservative than the median, but were biased low providing forecasts that were less than half of the post-season estimates of escapement with forecasts in all but one year. The SSCSS suggests examination of the mode, mean, the median, or other quantiles from the escapement distribution as inputs for alternative HCRs in the upcoming management strategy evaluation.

The SSCSS notes that there is not a HCR in place that can use these forecasted $E_{t,3}^{0}$ estimates. The existing HCR is based on the recent 3 year geometric mean of the number of spawners, which is not directly comparable to the forecasted age 3 SRWC escapement without fishing.

The report authors noted that the ETF model performance increased as additional years of data were added. All four cross-validation cohorts had empirical egg-to-fry survival rates well above the average across the time series, whereas the next two returning cohorts (including those that spawned in summer 2016) experienced well below the average egg-to-fry survival. The SSCSS agrees that this model should be monitored for feasibility as more years of data become available. In addition, other environmental variables such as flow should be examined and model performance assessed.

Works Cited:

Winship, AJ, MR O'Farrell, and MS Mohr. 2014. Fishery and hatchery effects on an endangered salmon population with low productivity. Transactions of the American Fisheries Society 143:957-971.

PFMC
11/16/17