SALMON TECHNICAL TEAM EVALUATION OF RECOMMENDED CHANGES TO SACRAMENTO RIVER FALL CHINOOK ASSESSMENT AND MANAGEMENT

Introduction

At their June 2019 meeting, the Pacific Fishery Management Council (Council) adopted the Sacramento River fall Chinook (SRFC) rebuilding plan, recommending the rebuilt criterion and preferred rebuilding management strategy. In addition, Council member Brett Kormos requested the Salmon Technical Team (STT) to provide an assessment of what would be necessary to implement four recommendations listed in the section titled "Further recommendations". Below is a summarized version of these recommendations:

1. Reconsider the current conservation objective for SRFC,
2. Develop an age-structured stock assessment for the SRFC stock using cohort reconstruction methods,
3. Develop age-structured abundance forecasts, and
4. Develop an age-structured SRFC harvest model similar in structure to the Klamath Ocean Harvest Model (KOHM).

For complete versions of these four recommendations, see page 64 of the Sacramento River fall Chinook rebuilding plan, draft 12[1].

In this report, the STT provides their assessment of what would be needed to implement these four recommendations. We describe the data needs and analytical work that would need to be performed. We also assess potential timelines and workload issues for each recommendation.

Recommendation 1: SRFC conservation objective

This recommendation notes alternative potential forms of the conservation objective, including specifying it in terms of natural-area spawners and sub-basin specific escapement goals. In the absence of a clear cut form of the new conservation objective, there could be value in exploring alternative forms and allowing the Council to evaluate the merits of different alternatives.

It is likely that these analyses would entail fitting stock-recruitment relationships, as was done for Klamath River fall Chinook (KRFC) in 2005[2]. For that effort, three separate stock-recruitment relationships were considered, and results from one of those three models now forms the basis of the current KRFC conservation objective. That effort was completed between June 2005 (when the Council directed the STT to conduct the analysis) and September 2005. For the KRFC case, the recruitment data were available as cohort reconstructions for KRFC are performed annually. This is currently not the case for SRFC and thus cohort reconstructions would need to be performed prior to fitting of stock-recruitment relationships.

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[1] https://www.pcouncil.org/wp-content/uploads/2019/05/G1_ATT2_SRFC_Electric_Only_JUN2019BB.pdf
[2] Salmon Technical Team. 2005. Klamath River fall Chinook Stock-Recruitment Analysis. Available at: https://www.pcouncil.org/bb/2005/0905/G.1.b_STT_Sept2005BB.pdf

Recommendation 2: Cohort reconstruction

Recommendation 2 in the SRFC rebuilding plan notes that the data needed to perform cohort reconstructions largely exists. The core data needed for such an assessment includes hatchery release data as well as coded wire tag (CWT) recoveries (and associated sample and production expansion factors) from ocean fisheries, river fisheries, and spawner escapement. These data currently exist but would need to be formatted for use within particular models. While this would allow for reconstruction of hatchery cohorts, to perform cohort reconstructions on the natural-origin component of SRFC, age-specific escapement and river harvest estimates are also needed. This will require a significant investment from interested parties, as these are new tasks that would need to be completed in an expedited manner. From the end of the SRFC spawning period, interagency staff would have until late January to age scale samples and finalize total escapement and river harvest estimates, which together would then be used to produce the age-structured river return estimates needed for cohort reconstruction. Since there will likely be a substantial number of scales to age annually during this short window, due to the large geographic extent and sometimes high abundance of SRFC, it may be prudent to divide the scale aging work among agencies and/or sub-basins. The CWT recovery data would need to be available by late January as well. To ensure these data are available annually for use during preseason planning, this will need to be made a high priority for all involved agencies, particularly during December and January.

The Pacific States Marine Fisheries Commission (PSMFC), with the California Department of Fish and Wildlife (CDFW) and funding from mitigating agencies, is in the process of aging scales from past SRFC escapements, which is necessary before cohort reconstruction can begin. To date, aging is complete for escapement years 2006 through 2016, with 2017 in progress. It is possible that staff will be caught up to present time in approximately one year, but there are numerous factors that could delay that timeline. CDFW inland staff are also currently aging scales from past SRFC river fisheries and are approximately one year behind the escapement scale aging. In total, it will probably take at least two years before the river harvest scales are aged up to present time.

A preliminary cohort reconstruction model has been implemented in the R software environment. This implementation of a salmon cohort reconstruction will require additional coding before the SRFC cohort reconstruction could be completed. A SRFC-specific size-at-age model must also be developed to enable cohort reconstructions. Estimated distributions of size-at-age are needed to assess the proportion of a cohort of legal size for retention at each month, age, and fishery sector. Substantial work remains on the size-at-age model.

Recommendation 3: Abundance forecasts

Age-specific abundance forecasts currently made for KRFC require age-specific river return estimates from the most recent year and reconstructed age-specific ocean abundance estimates. To implement sibling regression age-specific abundance forecasts for SRFC in the same manner as KRFC, the age-structured river return and ocean abundance estimates would be needed by mid-February each year. Thus, there would need to be efficient data processing and timely implementation of annual cohort reconstructions in order to make abundance forecasts in time for the Council's preseason planning process. As mentioned in the previous section, the timeline will

require relevant agencies to make this work a high priority. Producing age-specific river run sizes and running the cohort reconstruction would require substantially more effort than the current SRFC assessment comprised of estimating and forecasting the Sacramento Index.

If appropriate data are available, simple sibling regression-based forecasts can be developed rapidly. However, recommendation 3 suggests exploring the inclusion of environmental variables or non-stationary methods, presumably to improve forecast skill. Model evaluation would require an evaluation of performance based on cross validation (e.g., Winship et al. 2015[3]). However, the time series of age-specific abundance estimates may not be long enough at the current time to adequately assess model performance. Forecasting methods can be modified and improved over time as more years become incorporated into the time series, but simple sibling regressions would likely be an appropriate starting point.

Recommendation 4: Harvest model
Development of a harvest model with a structure similar to the KOHM depends on the timely availability of cohort reconstruction results and abundance forecasts. There are likely to be differences between the KOHM and a SRFC age-structured harvest model based on differences in the conservation objective and the structure of inriver fisheries.

While the KOHM can serve as a template for the SRFC harvest model, there will need to be a substantial model development effort. The model will need to be programmed, de-bugged, and tested. New analyses will likely need to be performed as well. Development of the winter run harvest model (WRHM) took over six months. The WRHM is a much simpler harvest model than the KOHM and what will be a SRFC harvest model because it only makes projections for ocean fisheries and for one age class.

Prioritizing items to be completed
- First priorities
  - Complete aging of historical SRFC escapement and river harvest
    - In progress by PSMFC and CDFW
    - Estimate of 1+ years until caught up to present time for escapement, and probably an additional year until caught up to present time for river harvest
  - Develop SRFC-specific size-at-age model
    - Preliminary work performed by National Marine Fisheries Service, but work remains
    - Could take 1+ years to complete
  - Begin providing age-structured SRFC escapement and river harvest estimates annually

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[3] Winship, A.J., O'Farrell, M.R., Satterthwaite, W.H., Wells, B.K., and Mohr, M.S. 2015. Expected future performance of salmon abundance forecast models with varying complexity. Canadian Journal of Fisheries and Aquatic Sciences 72:1-13.

- As it will likely take several years to phase-in this type of work, relevant agencies should begin the scoping and planning process as soon as is feasible
- Next steps
    - Once all of the first priorities listed above are in place, begin development of the cohort reconstruction
        - Could take 2+ years to complete
    - After the cohort reconstruction is complete, implement sibling models across ages and produce age-structured abundance forecasts
        - Sibling regression-based forecasts can be developed rather quickly
    - Create a harvest model specific to SRFC once the cohort reconstruction is completed
        - Likely to take 1+ years
- Final steps
    - Assess the current conservation objective in light of the new cohort reconstruction results, and if warranted, modify the current objective and/or explore alternative forms
        - Likely to take 1+ years
    - Once the time series of age-specific abundance estimates is deemed long enough, explore ways to improve forecast skill

Needs on an annual basis
- Cohort reconstruction
    - Needed by late January/early February, year t (the management year), at least two weeks prior to the STT February work session
        - Age- and sector-specific escapement and river harvest from year t-1
        - Summarized CWT recovery data from ocean fisheries, river fisheries, and escapement surveys
- Abundance forecast
    - Needed by early February, year t (the management year), at least one week prior to the STT February work session
        - Completed cohort reconstructions
        - Age-specific river run estimates for run year t-1
- Harvest model
    - Needed by the STT work session in mid- to late-February, year t (the management year)
        - Completed cohort reconstructions
        - Completed abundance forecasts
        - Input files derived from cohort reconstruction results

Workload

- A team effort will be needed to conduct the necessary analyses.
- This will need to be made a priority for members of the STT and relevant state and Federal agency employees. Extensive interagency coordination will be necessary.
- There are workload issues for the STT, including involvement in rebuilding plans, ad hoc committees, and methodology reviews.
- There will also be workload and prioritization issues for agency employees.

PFMC
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