SCIENTIFIC AND STATISTICAL COMMITTEE REPORT ON FINAL METHODOLOGY REVIEW

The Scientific and Statistical Committee (SSC) received a report summarizing reviews of salmon topics conducted by the SSC's Salmon Subcommittee (SSCSS) via webinar October 12-13, 2022 (appended below). The SSC received summaries concerning five topics:

1. **Sacramento Index Forecast Calculations**
2. **Sacramento River Fall Chinook Conservation Objective**
3. **FRAM Technical Detail Documentation**
4. **Review Fishery Regulation Assessment Model – Round 7.1.1**
5. **Review Updates to Chinook Salmon Ocean Distribution Models**

Sacramento Index Forecast Calculations

The SSCSS received a presentation from Dr. Will Satterthwaite (SWFSC) on "Use of Mean Versus Median in Converting Sacramento Index Forecast from Logarithmic to Arithmetic Scale" and reviewed a document by the same name. The Sacramento Index (SI) is an index of the ocean abundance of adult (age-3 and older) Sacramento River Fall Chinook (SRFC) salmon. Each year a preseason forecast of the SI is generated using a log-scale regression of the previous year's return of jacks (age-2) and is used to set harvest limits for the fishing season. Current management uses the predicted mean from the forecasted lognormal distribution. Using the median value of the forecast lognormal distribution will always produce a smaller forecast than the mean forecast; however, the use of the median forecast should provide equal likelihood of over- and under-forecasting. The SSC recommends that the pre-season SI forecast use the median value when converting from logarithmic to arithmetic scale to improve forecast accuracy beginning in 2023. Use of the median forecast should not preclude the investigation of alternative analyses and measures of forecast accuracy.

Sacramento River Fall Chinook Conservation Objective

The SSC reviewed the basis for the current SRFC conservation objective by examining the literature cited within the Salmon FMP. The SSC identified several places where the language and numbers in the Salmon FMP could not be recreated from the cited source material, such as the mean escapements reported for the 1953-1960 period. The SSC supports the specific language appended to the end of this report to make the FMP consistent with the source material.

The SSC recommends a comprehensive review (as specified in section 3.2.2 of the FMP) of the current SRFC conservation objective, based on three main concerns:

1. The conservation objective applies to both natural and hatchery spawners and reflects hatchery goals at the time of implementation. Assumptions about the lack of distinction between natural and hatchery fish in the Sacramento River may need revisiting based on

recent tagging and genetic studies. The conservation objectives for many other stocks, including the Klamath River Fall Chinook, were established for natural spawners.

2. The current proxy for MSY is derived from the SRFC runs observed during a few years. The use of select years of historical data to define a MSY proxy is not compelling without additional scientific justification.
3. There have been changes to habitat, climate, and other factors since the 1950s (when some of the data used to calculate the MSY proxy were gathered) and 1984 (when the current conservation objective was adopted). The lower bound of the conservation objective (122,000 adults) was an interim goal until fish passage problems with the Red Bluff Diversion Dam were rectified; the gates of the dam have been fully open since 2011. The SRFC conservation objective should be assessed with newer data that captures current conditions.

There are several reference points and conservation objectives for other stocks that could be similarly reviewed, some of which are similarly dated (see FMP, Table 3-1). The SSC reiterates its recommendation from October of 2021 that a process be established to periodically review and, if needed, update reference points and conservation objectives for all salmon stocks in the FMP.

FRAM Technical Detail Documentation

The SSC appreciates the work done by the analysts to update and expand the online Fishery Regulation Assessment Model (FRAM) documentation. The online FRAM user's manual and overview are well organized and do not require further review. The SSC recommends that documentation of existing methodologies be completed as soon as possible and updated regularly. Future reviews of changes to FRAM algorithms or portions of FRAM that have not been previously reviewed (e.g., Backward FRAM) will require completed documentation of all the underlying concepts and algorithms.

Review Fishery Regulation Assessment Model – Round 7.1.1
and
Review Updates to Chinook Salmon Ocean Distribution Models

The SSC reviewed two short summary documents informing Southern Resident Killer Whale (SRKW) management measures (Section 6.6.8 of the FMP): Chinook salmon abundance (FRAM version 6.2 versus 7.1.1) and ocean distribution (Shelton et al. 2019, 2021). The SSC appreciated the updates on both topics. The description of data changes to FRAM are reasonable and since Round 7.1.1 is used for pre-season planning purposes, using the same FRAM base period for the SRKW threshold calculations would provide consistency with its use in other areas of Chinook management. Shelton et al. (2021) used 20 more years of data and provided estimated ocean distributions for more stocks than Shelton et al. (2019). The SSCSS did not review how the two model components were combined to produce area-specific abundances.

The FMP states (Section 6.6.8) that the determination of the Chinook abundance threshold is based on the best scientific information available (BSIA). However, it is the SSC's understanding that the adoption of the Chinook abundance threshold was a Council policy decision. The SSC has never fully reviewed the information contributing to the SRKW thresholds nor identified the inputs as BSIA for use in determining the Chinook salmon abundance threshold. The SSC did review the

risk analysis from the Ad Hoc SRKW Workgroup, which used FRAM estimates of abundance combined with Shelton et. al (2019) distributions as components, in November 2019. At that time, the SSC found "the data sets used and the analyses performed to be reasonable and appropriate for the questions at hand", where the questions at hand were examining relationships between indices of abundance and SRKW life history and body condition parameters. The SSC did not review the area-specific abundances for the purposes of management (https://www.pcouncil.org/documents/2019/11/agenda-item-e-4-a-supplemental-ssc-report-1.pdf/). Thus, the SSC requests clarification from the Council about what scientific information requires a BSIA determination.

The SSC recommends that the analyses that motivate and produce the Chinook salmon abundance threshold be compiled into a single document for transparency. Currently the analyses contributing to the SRKW threshold are spread across STT and SRKW Ad Hoc Working Group documents produced over a number of years.

The SSC suggests clarifying section 6.6.8 of the FMP. For example, after updating the abundance and distribution parameters, the seven lowest years of Chinook salmon abundance in the north of Falcon area may not be the specific years listed in the FMP. Should the calculated abundance be derived from years listed or the seven lowest abundances?

Additional Remarks

The SSC identified language in additional places within the FMP that does not conform to current management practices. For example, salmon fisheries in California are not managed with the goal of maximizing natural production (contrary to p. 51 of the FMP), and some ESA-listed evolutionarily significant units (ESUs) have gone more than five years without stock-specific management for at least one stock in each ESU (contrary to p. 39). The SSC is willing to work with the Salmon Technical Team (STT) to identify areas within the FMP that do not accurately characterize current management practices and recommend updates.

APPENDIX:

Proposed Edits to SRFC Conservation Objective (deletions in ~~strikethrough~~, additions in underline):

> 122,000-180,000 natural and hatchery adult spawners (122,000 is the MSY proxy adopted 1984). ~~This~~ The upper end of this objective is intended to provide adequate escapement of natural and hatchery production based on the sum of previous hatchery goals and reports of average fall Chinook escapements for various parts of the Sacramento Basin (which are inconsistent with current estimates for those years) during various reference periods (PFMC 1984). The lower end of the objective and S_{MSY} are based on a reduction from the average Upper Sacramento escapement, meant to be used until "problems caused by the Red Bluff Diversion Dam are rectified"(p. 3-19, PFMC 1984). ~~for Sacramento and San Joaquin fall and late-fall stocks based on habitat conditions and average run-sizes as follows: Sacramento River 1953-1960; San Joaquin River 1972-1977 (ASETF 1979; PFMC 1984; SRFCRT 1994).~~ The objective is less than ~~the~~ an estimated basin capacity of 240~~0~~5,000 fall-run spawners (Hallock 1977), but greater than the 118,000 spawners for maximum ~~production~~ yield estimated for natural areas in the Upper Sacramento alone, based on data from 1954-1963 ~~on a basin by basin basis before Oroville and Nimbus Dams~~ (Reisenbichler 1986).

SCIENTIFIC AND STATISTICAL COMMITTEE'S
SALMON SUBCOMMITTEE REPORT ON
SALMON METHODOLOGY REVIEW

Pacific Fishery Management Council
Via Webinar

October 12 – 13, 2022

The Scientific and Statistical Committee's Salmon Subcommittee (SSCSS) held an online meeting on October 12 and 13, 2022 with the Model Evaluation Workgroup (MEW) and the Salmon Technical Team (STT) in attendance. The salmon methodology agenda items that were discussed and reviewed at this meeting were: (1) Review Fishery Regulation Assessment Model Round 7.1.1; (2) Review Updates to Chinook Salmon Ocean Distribution Models; (3) FRAM Technical Detail Documentation; (4) Sacramento Index Forecast Calculations and; (5) Sacramento River Fall Chinook Conservation Objective.

1. Review Fishery Regulation Assessment Model – Round 7.1.1

Mr. Jon Carey (NOAA) presented the Fishery Regulation Assessment Model (FRAM) changes that occurred when base period Round 6.2 (Round 6.2) was updated to base period Round 7.1.1 (Round 7.1.1). These changes fall into four categories:

1) Updated coded wire tag recovery information, auxiliary recoveries, and fishery mapping.
2) Escapement expansions to account for inter-dam loss of Columbia River stocks that originate upstream of Bonneville Dam.
3) Updated stock-specific terminal run size inputs.
4) Updated estimates of catches in Canadian sport fisheries.

FRAM algorithms were not modified between Round 6.2 and Round 7.1.1. Twenty five years (1992-2016) were evaluated to assess the differences in the estimates of stock abundance using the two base periods. Using Round 7.1.1 resulted in little change of the estimated mean starting cohort age-3+ Chinook salmon abundance of most FRAM stocks (see Table 1). The total Chinook salmon October 1 pre-fishing abundance assumed to be in the North of Falcon region increased in all but two years (1997 and 2010, see Table 2) using Round 7.1.1 however, the increase was less than 81,000 fish in all years except 2015 (increase of 120,875). The percent change in the total Chinook salmon abundance ranged from -1% to 6% when using Round 7.1.1.

The Ad-hoc Southern Resident Killer Whale (SRKW) Workgroup identified a group of seven years (1994-1996, 1998-2000, and 2007) that had the lowest modeled pre-fishing October 1 total Chinook abundance in the North of Falcon region using FRAM Round 6.2 (out of candidate years 1993-2016, although the Salmon Fishery Management Plan (FMP) incorrectly states the range as 1992-2016, in which case 1992 would have qualified as one of the seven lowest). These seven years were reflected in the Salmon FMP but it is unclear whether the years would change when inputs to the threshold calculations are updated, or if they are fixed regardless of whether they

remain the lowest years with current and future updates. The update from Round 6.2 to Round 7.1.1 results in a change of the seven lowest pre-fishing abundance years and their modeled abundances in the North of Falcon region. However, there were no measures of uncertainty in the modeled total abundance estimates to evaluate whether the abundance differences between Round 6.2 and Round 7.1.1 were statistically significant.

The description of data changes to FRAM are reasonable and the SSCSS agrees that an improvement in model performance would be expected from these data changes. Further, since Round 7.1.1 is used for pre-season planning purposes, using the same FRAM base period for the SRKW threshold calculations is practical.

2. Review Updates to Chinook Salmon Ocean Distribution Models

The SSCSS reviewed a summary of the differences between two peer reviewed papers by Shelton et al. (2019 and 2021) that describe the abundance and distribution of Fall Chinook Salmon stocks using CWT recoveries. Both papers use a Bayesian state-space model to describe the abundance and distribution of Fall Chinook Salmon stocks since 1978 (release years 1978-1990 in Shelton et al. 2019; release years 1978-2010 in Shelton et al. 2021). The 2021 paper included CWT recovery data from five fishing fleets including two hake fisheries whereas the 2019 model excluded the hake fleets. The 2019 paper included 12 Fall Chinook Salmon stocks and the 2021 paper included 16 Fall Chinook Salmon stocks. A notable change in the stock structure between the two papers was splitting the Upper Columbia stock (UPCOL) into Snake River (SNAK) and upriver bright (URB) components in the 2021 paper. In addition to the data changes, there are two major differences in the statistical models used in the two papers. First, Shelton et al. (2021) derived and used a new likelihood function for connecting the observed data with the parameters of the biological model. This new likelihood improved both the biological interpretability of model parameters and the computational speed of model fitting. Second, Shelton et al. (2021) allowed the ocean distribution of salmon stocks to vary year-to-year as a function of localized sea surface temperature (SST). The 2021 model provides an estimate of the long-term average ocean distribution corresponding to the long-term average SST pattern for each season (1981-2015) as well as estimated distributions for each year. The 2019 model provided a single estimate of ocean distribution for each stock in each season.

The SSC did not receive any material to assess how the stocks and distribution parameters in Shelton's 2019 paper were used in section 6.6.8 of the Salmon FMP and hence can't comment on whether the distribution parameters in Shelton's 2021 model are an improvement from what is currently used.

3. FRAM Technical Detail Documentation

Ms. Angelika Hagen-Breaux (MEW) provided an overview of updates and additions to the FRAM documentation since the 2021 Salmon Methodology review. The FRAM online material documents parts of FRAM, including structural and design changes since 2007, and provides a more detailed description of its procedures and algorithms than previous iterations of the FRAM documentation. The FRAM website now provides equation formatting and descriptions of the terms, expanded descriptions of non-retention calculations for Chinook salmon to reflect length

restrictions, expanded descriptions of mark selective bias calculations for Coho salmon, and describes updates to the Chinook FRAM base period.

The SSCSS strongly recommends that documentation of existing methodologies be completed as soon as possible. As a living document, the documentation on the FRAM website can be updated regularly and new topics added. The SSCSS finds the online FRAM user's manual and overview portion of the documentation to be well organized and user friendly and do not require further review. However, future review of changes to FRAM algorithms or portions of FRAM that have not been previously reviewed (e.g., Backward FRAM) will require completed documentation of all the underlying concepts and algorithms.

4. Sacramento Index Forecast Calculations

The SSCSS received a presentation from Dr. Will Satterthwaite of the SWFSC on "Use of Mean Versus Median in Converting Sacramento Index Forecast from Logarithmic to Arithmetic Scale" and reviewed a document by the same name. The Sacramento Index (SI) is an index of the ocean abundance of adult (age-3 and older) Sacramento River Fall Chinook Salmon. Each year a preseason forecast of SI is generated using the previous year's return of jacks (age-2) and is used to set harvest limits for the fishing season. Since 2014, the SI forecast is generated from the results of a log-log regression with an autocorrelated error term, using inputs starting from adult return year 1983. The log-scale mean SI for year t $\log(SI_t)$ is the sum of an intercept term (β_0), a slope term (β_1) times the estimated logged jack escapement the previous year (J_{t-1}), and the estimated autocorrelation of past deviations from the fitted line (ρ) times the deviation of the previous year's postseason SI estimate from the fitted line prediction (ϵ_{t-1}):

$$\log(SI_t) = \beta_0 + \beta_1 \log(J_{t-1}) + \rho\varepsilon_{t-1}$$

Using this equation generates an SI forecast on the logarithmic scale that is distributed according to the normal distribution (assuming all statistical assumptions are met). However, management is based on the number of fish on the arithmetic scale. Transforming the SI forecast from the logarithmic to arithmetic scale results in a lognormal distribution for the SI forecast. The mean, median, and mode of a lognormal distribution are not equal on the arithmetic scale. Since 2014, the SI forecast has used the mean value when converting from the logarithmic to arithmetic scale.

The median value of a lognormal distribution will always be smaller than the mean. This means that using the median for the SI forecast value will result in smaller pre-season abundance estimates than the current method. Also, use of the median would be expected to be equally likely to produce an over-forecast or an under-forecast. By contrast, use of the mean value would be more likely to produce an over-forecast which seems to be occurring in recent years.

A retrospective analysis was done that compared use of the mean (i.e., the current method) to using the median when deriving a point estimate on the arithmetic scale. The results of all performance metrics considered for the years 1995 – 2021 (see Table 2) found that using the median produces forecasts closer to the postseason estimates than forecasts using the mean. The difference in the average forecast error is small relative to the typical level of forecast error overall. During the 2014-2021 period, using the median forecast would be expected to result in fewer years in overfished status (2 versus 3) and higher average escapement. The median forecast also results in

lower average harvest (by about 4,500 fish). However, the analysis did not take into account the impact of higher escapement on future production, which would be expected to increase the average escapement further and reduce the impact on average harvest.

The SSCSS recommends that the pre-season SI forecast use the median value when converting from logarithmic to arithmetic scale to improve forecast accuracy beginning in 2023.

5. Sacramento River Fall Chinook Conservation Objective

Dr. Will Satterthwaite (SWFSC, SSC) gave a presentation of his work documenting the basis for the current Sacramento River Fall Chinook conservation objective in the current Salmon FMP and an overview of two recent analyses relevant to this topic. In addition to his presentation, the SSCSS discussed the literature review that Dr. Satterthwaite conducted on the topic, relevant excerpts from the FMP, and excerpts from the Final Framework Amendment for Managing the Ocean Salmon Fisheries off the Coasts of Washington, Oregon, and California Commencing in 1985 that established the current conservation objective. The SSCSS appreciates the amount of work and careful documentation that Dr. Satterthwaite put into this literature review. The SSCSS notes that there are reference points and conservation objectives for other stocks that could be similarly reviewed, some of which are similarly dated (see FMP, Table 3-1).

The SSCSS recommends a comprehensive technical review (as specified in section 3.2.2 of the Salmon FMP) of the current SRFC conservation objective, based on three main concerns:

1. The conservation objective applies to both natural and hatchery spawners and reflects hatchery goals (since changed) at the time of implementation. Assumptions about the lack of distinction between natural and hatchery fish in the Sacramento River may need revisiting based in part on recent genetic studies. The conservation objectives for many other stocks, including the Klamath River Fall Chinook, were established for natural spawners.
2. The current proxy for MSY is derived from the SFRC runs observed during a few years. Without a compelling scientific justification, the SSCSS does not find the use of select years of historical data to define a MSY proxy to be compelling.
3. There have been changes to habitat, climate, and other factors since the 1950s (when some of the data used to calculate the MSY proxy was gathered) and 1984 (when the current conservation objective was approved). The SRFC conservation objective should be assessed with newer data that captures these changes.

In addition to these scientific concerns, the mean escapements reported for the 1953-1960 period could not be reproduced based on available data sources, and the lower bound of the conservation objective (which also serves as the S_{MSY} reference point needed for status determinations) is described as an "interim" goal meant to be used until passage problems at Red Bluff Diversion Dam are rectified. The gates of Red Bluff Diversion Dam have been fully open since 2011.
The literature review uncovered a number of factual errors in the FMP language, and the SSCSS strongly recommends resolving those errors. The literature review contains recommended edits on page 13, lines 443-462, which the SSCSS supports.

The SSCSS reiterates its recommendation from October of 2021 that a process be established for the periodic review and, if needed, updating reference points and conservation objectives for all salmon stocks in the FMP.

PFMC
11/03/22