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SUBJECT: Pacific Fishery Management Council’s Review of 2015 Ocean Salmon Fisheries

The Pacific Fishery Management Council (PFMC) manages fisheries for about 119 species of salmon, groundfish, coastal pelagic species (sardines, anchovies, and mackerel), and highly migratory species (tunas, sharks, and swordfish) off the coasts of Washington, Oregon, and California. The PFMC Salmon Technical Team is responsible for reviewing and preparing information on ocean salmon fisheries. The data collected is used to forecast stock abundances to set future limits on commercial and recreational fisheries in an effort to maintain sustainable populations. For the Sacramento River Fall-run Chinook salmon (SRFC) population, the Sacramento Index (SI) is the number of adult fish (ages 3-5) projected to be available in the ocean that will either be harvested or will escape to natural areas and hatcheries in the Central Valley. The total number of jacks (2-year old fish) that escaped to hatcheries and natural areas from the previous year is used in a logarithmic regression model to forecast the SI. The forecasted SI is used to set fishing regulations and harvest quotas.

This memorandum reviews PFMC’s 2015 forecast and how it compared to actual abundance and harvest, trends in forecast accuracy, and the 2016 forecast. Key findings from this review include the following:

- PFMC continues to overestimate the SI. On average, actual values are only 70% of forecasted values over the past decade.
- PFMC continues to overestimate escapement of SRFC.
- PFMC continues to underestimate exploitation (harvest) rates.
- Escapement in 2015 was below maximum yield minimum of 122,000 salmon.
- Although 2015 escapement fell short of the maximum yield objective, SRFC are not considered by PFMC’s criteria to be overfished because the geometric mean escapement exceeds the minimum stock size threshold and did not exceed the maximum fishing mortality threshold.
- The SI and SRFC escapement are both expected to be higher in 2016 than in 2015, which is illogical considering the record of overestimating both, an obvious recent declining trend in abundance and escapement, and the ongoing drought.
- We suggest that the PFMC consider an alternate method of estimating SI and escapement in 2016 for the protection of SRFC and the endangered Sacramento River Winter-run Chinook salmon.

How did forecasted Chinook salmon abundance compare to actual abundance in 2015?

Last year, PFMC forecasted the SI to be 650,000 Chinook salmon. It was estimated that 341,000 of those would escape harvest to spawn in hatchery or natural areas in the Sacramento River basin during 2015, exceeding the minimum required prediction of at least 122,000. In February 2016, PFMC completed their review of the 2015 season and reported that the actual SI was 255,287¹ (Figure 1), which was only 39% of the forecast. Actual SRFC escapement of 112,434 was only 33% of the 341,000 forecast.

How does the accuracy of the 2015 forecast compare to other years?

Since 2005, PFMC has overestimated the SI in 9 out of 11 years (Figure 2). During that time several attempts were made to improve forecast accuracy by adjusting the forecast model, including truncating the dataset upon which the model was based to reflect current trends. With ongoing challenges with forecast accuracy, the PFMC evaluated thirteen different models during 2013 for forecasting SI². Based on recommendations from the 2013 review, PFMC abandoned the traditional linear model in 2014 for a new logarithmic regression. Unfortunately, the new model continues to overestimate the SI as evidenced by the 2014 and 2015 SIs which were 87% and 39% of the respective forecasts.

What is PFMC's forecast for 2016 and is it logical?

PFMC forecasts a 2016 SI of 299,609 SRFC³. While the 2016 forecast for SRFC was adjusted down by approximately one-third due to the overestimation of SI in 2015, forecasted abundance for 2016 represents an increase over the observed SI of 255,287 during 2015 (Figure 1). It does not seem logical to expect that SI in 2016 will be greater than during 2015 given relatively consistent hatchery production, the ongoing drought, and declining trends in abundance and escapement. During the 1987-1992 drought, abundance declined over four consecutive years (Figure 1). A sharp decline in abundance also occurred over a six year period between 2003 and 2009. The current drought began in 2012 and 2015 was only the second year of decline, so caution is warranted when abundance is already low and should be expected to decline further over at least the next year if not beyond. Warm ocean temperatures off the west coast have also been unfavorable for salmon.

¹ PFMC 2015 Review

http://www.pcouncil.org/wp-content/uploads/2016/02/Review_of_2015_Salmon_Fisheries_FullDocument.pdf

² Winship, A.J., M.R. O'Farrell, W.H. Satterthwaite, B.K. Wells, and M.S. Mohr. 2013. Expected future performance of abundance forecast models with application to Sacramento River fall Chinook salmon. Pacific Fishery Management Council November 2013 Briefing Book, Agenda Item C.2.a, Attachment 5. September 13, 2013.

³ PFMC 2016 Preseason Report

http://www.pcouncil.org/wp-content/uploads/2016/03/Preseason_Report_I_2016_FINAL03012016.pdf

What is PFMC’s view of the status of SRFC?

In December 2011, PFMC adopted status determination criteria for SRFC (Table 1) under Salmon Fishery Management Plan Amendment 16. Although 2015 escapement fell short of the maximum sustainable yield objective of 122,000, SRFC are not considered by PFMC’s criteria to be overfished. SRFC are not considered overfished because the 3-yr geometric mean of escapement during 2013-2015 was 213,293 which exceeds the minimum stock size threshold of 91,500. SRFC also were not considered overfished because the harvest rate of 56% during 2015 did not exceed the maximum fishing mortality threshold of 78%.

SRFC are also not considered to be approaching an overfished condition because the geometric mean of the last two years and forecasted escapement for 2016 are greater than 91,500. Based on the 2016 forecast, the geometric mean is expected to be 157,000.

Looking towards the future, PFMC will not consider SRFC to be overfished in 2016 unless escapement is less than approximately 32,500, or the harvest rate exceeds 78%. SRFC were considered overfished in 2012, the first year that the status determination criteria were used, when the 2009-2011 geometric mean was only 83,530. This followed on the heels of the fishery closure in 2008 and 2009, and required that a rebuilding plan be developed and approved within two years. Since assessment of the role of fishing, marine, and freshwater survival in the overfished determination identified poor marine survival as the primary factor leading to the overfished determination and that SRFC were not subject to overfishing, no action was taken. The following year, in 2013, SRFC were considered to be rebuilt when the 3-year geometric mean spawning escapement of approximately 161,000 exceeded the rebuilding criteria of 122,000.

Table 1. PFMC status determination criteria for SRFC.

<i>Status</i>	<i>Definition</i>
Overfishing	SRFC are considered to have been subject to overfishing if the estimated exploitation rate exceeds their maximum fishing mortality threshold of 0.78.
Approaching overfished condition	SRFC are considered to be approaching overfished condition when the geometric mean of the two most recent postseason estimates of spawning escapement, and the current preseason forecast of spawning escapement, is less than the minimum stock size threshold of 91,500.
Overfished	SRFC are considered overfished when the 3-year geometric mean spawning escapement falls below the minimum stock size threshold of 91,500.
Not overfished/rebuilding	SRFC are considered not overfished/rebuilding if the stock has been classified as overfished and has not yet been rebuilt, and the most recent 3-year geometric mean spawning escapement is greater than 91,500 but less than 122,000.
Rebuilt	SRFC are considered rebuilt when the most recent 3-year geometric mean spawning escapement exceeds the minimum of the maximum sustainable yield of 122,000.

Are there potential alternatives to reduce risk of overestimation in the 2016 forecast?

The PFMC seems to be missing a potential solution to adjust the illogical forecast for 2016, and to reduce the risk of overestimation resulting in escapement well below the conservation objective. The data clearly show an abrupt shift approximately 10 years ago in the relationship between jack returns and SI the following year, resulting in overestimation of the SI in 9 out of the past 11 years. Yet the PFMC continues to use data back to 1985 in their forecast model. The data prior to 2005 represent about two-thirds of the data used to construct the PFMC forecast model and do not reflect contemporary trends. Using only data after the shift may reduce the risk of overestimating the 2016 SI.

We attempted to replicate the regression model used by PFMC, but using a truncated data series of jack returns since 2005 and SI since 2006. There is some uncertainty as to whether our adjustment for autocorrelation is exactly the same as that used by PFMC, but we are confident that the approach is reasonably consistent. We explored how well this model would have performed if it had been adopted during the 2013 review and implemented in 2014 and 2015, and also used the model to generate a forecast for 2016 (Table 2). While the model would have greatly underestimated abundance in 2014, it performed well in 2015. The model also provides a more realistic forecast for 2016 than the existing PFMC forecast in that it is slightly lower than the actual SI in 2015 rather than higher. In our opinion the overestimation in 2014 is not an issue that should preclude use of a model based on a truncated data set. This is an indication that the model performs more conservatively than the current model used by PFMC, which is warranted given the ongoing drought and recent trend of declining abundance.

Table 2. Predicted SI based on a logarithmic regression model of a truncated data series adjusted for autocorrelation, and comparison to the actual SI.

Year	Predicted	Actual	Actual/Predicted
2014	248,000	553,000	223%
2015	309,000	255,000	83%
2016	249,000	TBD	TBD

A more conservative forecast is also desirable due to the current status of Sacramento River Winter-run Chinook salmon (SRWC). During 2015 it is estimated that 17.5% of Age 3 SRWC were harvested in the ocean, a by-catch of the SRFC fishery¹. According to PFMC³ the acceptable mortality threshold for winter run in 2016 is 19.9% based on the geometric mean of SRWC escapement, which is 3,981 for 2013-2015. The report and forecast do not consider the extremely low survival of juvenile winter-run Chinook salmon over the past two years due to ongoing drought conditions and water temperature impacts from depletion of coldwater storage in Shasta Reservoir. How can harvest of nearly 1 out of every 5 of these endangered salmon be justified when only 4-5%⁴ of the

⁴ Letters from NOAA Fisheries to the U.S. Bureau of Reclamation regarding SRWC juvenile production. http://www.westcoast.fisheries.noaa.gov/publications/Central_Valley/Water%20Operations/winter-run_juvenile_production_estimate_jpe_-_january_28_2016.pdf

juveniles produced during the past two consecutive years survived to make it to the Bay? Clearly, harvest regulations adopted for 2016 should be more protective for SRWC.

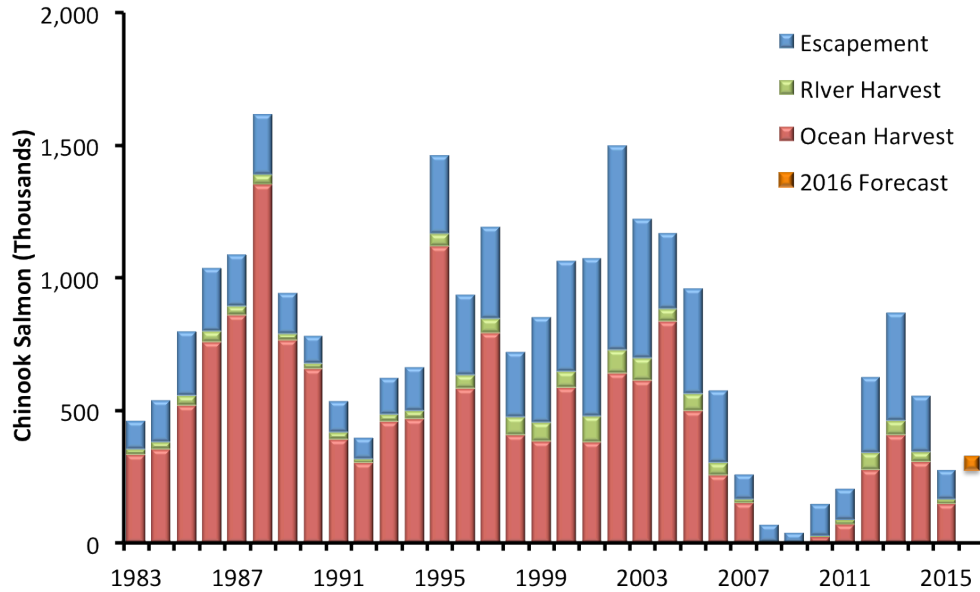


Figure 1. Sacramento River Fall-run Chinook salmon ocean harvest, river harvest and escapement, 1983-2015.

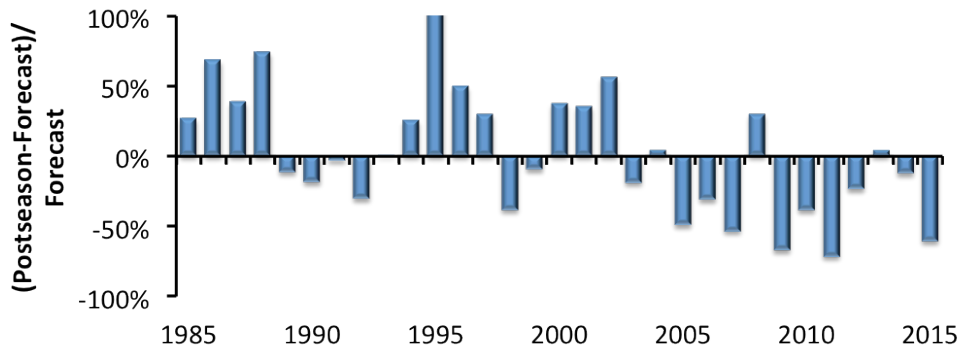


Figure 2. Percent difference from PFMC average annual preseason forecast relative to the actual SI observed, 1985-2015.