UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
West Coast Region
650 Capitol Mall, Suite 5-100
Sacramento, California 95814-4700

January 25, 2021

Kristin White, Operations Manager
U.S. Department of the Interior
Bureau of Reclamation
Central Valley Operations
2800 Cottage Way
Sacramento, California 95825-1898

Electronic transmittal only

Dear Ms. White:

This letter provides the U.S. Bureau of Reclamation (Reclamation) with the estimated number of juvenile Sacramento River winter-run Chinook salmon (*Oncorhynchus tshawytscha*) from brood year (BY) 2020 expected to enter the Sacramento-San Joaquin Delta (Delta) during water year (WY) 2021. This juvenile production estimate, or JPE, is provided by NOAA's National Marine Fisheries Service (NMFS) pursuant to the October 21, 2019, biological opinion for the reinitiation of consultation on the long-term operations of the Central Valley Project (CVP) and the State Water Project (SWP) (NMFS 2019). The JPE is calculated annually and is used to determine the authorized level of incidental take for winter-run Chinook salmon, under Section 7 of the Endangered Species Act (ESA), while operating the CVP/SWP Delta pumping facilities in a given water year (NMFS 2019).

The authorized incidental take limits for natural-origin winter-run Chinook salmon and hatchery winter-run Chinook salmon have been established in Table 140 in NMFS (2019) as follows:

- Loss of natural-origin winter-run Chinook salmon is 1.3% of the JPE on a three-year rolling average or 2.0% of the JPE in any single year.
- Loss of Sacramento River hatchery-origin winter-run Chinook salmon is 0.8% of the estimated hatchery JPE (fish surviving to the Delta) from Livingston Stone National Fish Hatchery (LSNFH) released into the upper Sacramento River on a three-year rolling average or 1.0% of the JPE in any single year.
- Loss of Battle Creek hatchery-origin winter-run Chinook salmon is 0.8% of the estimated hatchery JPE (fish surviving to the Delta) from LNSFH released into Battle Creek on a three-year rolling average or 1.0% of the JPE in any single year.

The winter-run Chinook salmon JPE for BY 2020 is **330,130 natural-origin juvenile winter-run Chinook salmon expected to enter the Delta during WY 2021**. The incidental take limits for natural-origin winter-run Chinook salmon are 4,292 (1.3% of 330,130) on a three-year rolling average loss and 6,603 (2% of 330,130) for single year loss during WY 2021. The JPE calculation is developed as a function of the estimated number of adult spawners (and estimated number of viable eggs) combined with estimated egg-to-fry and fry-to-smolt survival rates. There was a decrease in the JPE for BY 2020 compared to the JPE for BY 2019 due to a significant decrease in escapement from 7,852 in 2019 to 6,195 in 2020, and the estimated number of juveniles passing Red Bluff Diversion Dam (RBDD) from 3,950,314 in 2019[1] to 1,915,004 in 2020.

The incidental take limit for hatchery-origin winter-run Chinook salmon is set separately for each release (*i.e.,* Sacramento River and Battle Creek releases). Based on projected releases, the **JPE for BY 2020 hatchery-origin (adipose fin-clipped) winter-run Chinook salmon juveniles released from LSNFH into the Sacramento River is 97,888.** The incidental take limit for hatchery-origin winter-run Chinook salmon juveniles released from LSNFH into the Sacramento River is 783 (0.8% of 97,888) on a three-year rolling average loss and 979 (1% of 97,888) for single year loss during WY 2021. The **JPE for BY 2020 hatchery-origin (adipose fin clipped and left ventral fin clipped) winter-run Chinook salmon juveniles released from LSNFH into Battle Creek is 37,232**. The incidental take limit for hatchery-origin winter-run Chinook salmon juveniles released from LSNFH into Battle Creek is 298 (0.8% of 37,232) on a three-year rolling average loss and 372 (1% of 37,232) for single year loss during WY 2021**.**

Status of Winter-Run Chinook Salmon

Millions of wild salmon once returned to spawn in the cold water streams in the foothills and mountains of California's Central Valley. The endangered Sacramento River winter-run Chinook salmon are unique in that they spawn during the summer months when air temperatures are usually their warmest. The construction of dams eliminated access to important spawning and rearing habitat, effectively causing the extirpation of the winter-run Chinook salmon populations. Different populations were forced to mix and spawn as one population downstream of Keswick Dam on the Sacramento River. The one remaining population has persisted mainly due to agency-managed cold water releases during the summer and artificial propagation through hatchery releases. Winter-run Chinook salmon are dependent on sufficient cold water, and it has been recognized that a prolonged drought could have detrimental impacts, putting the species at risk of extinction.

Juvenile winter-run Chinook salmon experienced very low survival in 2014 and 2015 due to drought conditions causing unfavorable temperatures in the spawning grounds. The California Department of Fish and Wildlife (CDFW), NMFS and the U.S. Fish and Wildlife Service (USFWS) responded to this crisis in part by reinstating the winter-run Chinook salmon Captive Broodstock Program at LSNFH. The primary purpose of the Captive Broodstock Program is to maintain a refugial population of winter-run Chinook salmon in a safe and secure environment to be available for use as hatchery broodstock in the event of a catastrophic decline in abundance. A secondary purpose of the program is to provide fish, when possible, to fulfill multi-agency efforts to reintroduce winter-run Chinook salmon into the restored habitats of Battle Creek and above Shasta Dam. Approximately 1,000 juvenile winter-run Chinook salmon propagated at LSNFH have been retained annually for the Captive Broodstock Program since it was reinstated beginning with BY 2014 (with the exception of BY 2016, when approximately 534 juveniles were retained).

[1] BY 2019 JPE Letter.

In 2015, NMFS selected winter-run Chinook salmon as one of eight species highlighted in our "Species in the Spotlight" initiative[2]; an effort designed to focus attention and resources to manage our most critically endangered species.

The BY 2019 cohort benefitted from improved river conditions, as over 3.9 million juvenile winter-run Chinook salmon were estimated to pass RBDD, the largest number of juvenile winter-run Chinook salmon observed in a decade. Approximately 1.9 million BY 2020 juveniles were estimated to pass RBDD. This year's cohort appears to have been affected by a thiamine deficiency in returning adults, decreasing the number of successful fry upstream of RBDD. BY 2020 was also subject to low flows and low turbidity due to limited precipitation events this fall and winter. Outmigrating juveniles will also likely encounter challenging water conditions in certain areas where debris from last year's fires will travel into streams and rivers. Despite recent wet winters, drought conditions are expected to return in the near future.

JPE Development Process

The process for developing the JPE was similar to what was done for BY 2019. The Winter-Run Project Work Team (WRPWT), a technical team from the Interagency Ecological Program (IEP), met in December 2020 and provided recommendations to NMFS and CDFW (Enclosure 2) on January 15, 2021. The method used to calculate the BY 2020 JPE is derived from the USFWS' estimated number of juveniles passing RBDD. This estimate is known as the Juvenile Production Index, or JPI, and is based on fry-equivalents at RBDD.

NMFS (2019) defines the JPE as the estimated number of juvenile winter-run Chinook salmon to enter the Delta (*i.e.,* Tower Bridge in Sacramento), but not necessarily survive through the Delta. The calculation of the winter-run Chinook salmon JPE for BY 2020 begins with estimates of winter-run Chinook salmon adult escapement in 2020, which are derived from carcass surveys conducted in the upper Sacramento River by CDFW. Escapement information was provided to NMFS via a December 14, 2020, letter (Enclosure 1). The CDFW estimate for total winter-run Chinook salmon escapement in 2020 was 6,195 spawners[3]. Of this total number of spawners, 3,904 were estimated to be females.

The number of adult spawners in 2020 was higher than the 10-year average (*i.e.,* 3,539) for 2011–2020 (Figure 1). The cohort replacement rate (CRR), which is a measure of the population's growth rate, was positive again this year (*i.e.,* 6.35), meaning the population is currently replacing itself (Figure 2), and the trend is continuing in a positive growth rate for the second consecutive year.

Similar to BY 2019, genetic analyses were conducted on some length-at-date (LAD) juvenile spring-run Chinook salmon sampled from the RBDD RSTs, and the estimate of juvenile winter-run Chinook salmon emigration past RBDD was adjusted to include the LAD spring-run Chinook salmon that were determined to be genetic winter-run Chinook salmon.

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[2] Species in the Spotlight.

[3] The methodology used by CDFW (*i.e.*, Cormack-Jolly-Seber Model) to estimate escapement is the same model that has been used since 2012.

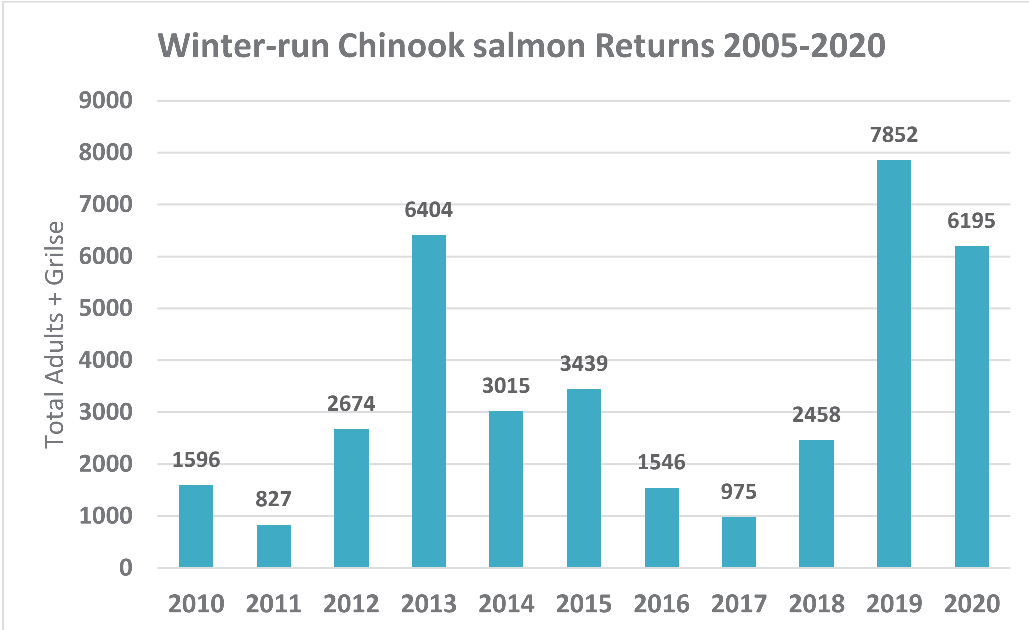

Figure 1. Winter-run Chinook Salmon Spawning Escapement 2005-2020 (CDFW 2020 and Enclosure 1).

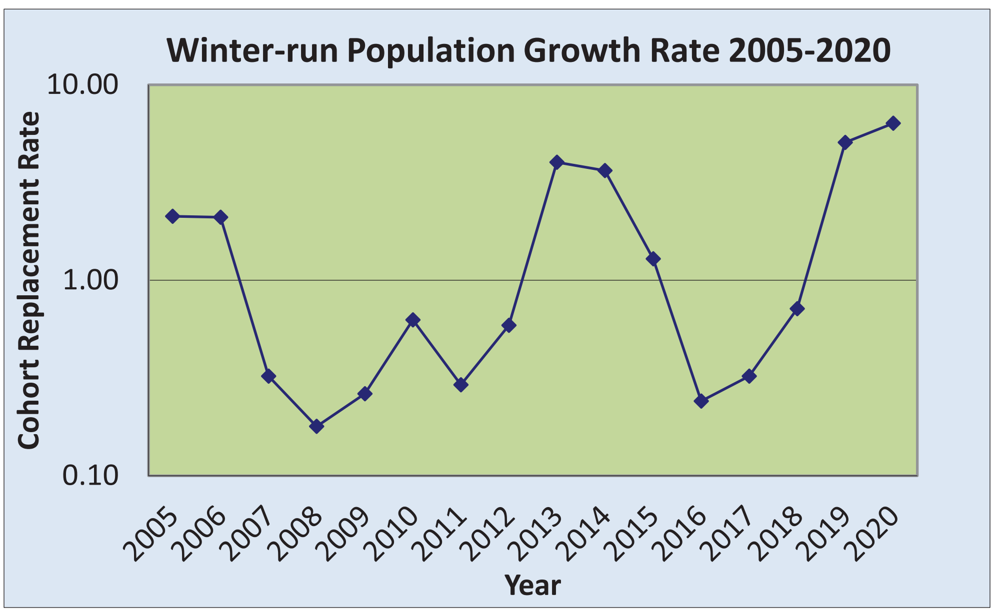

Figure 2. Cohort replacement rate for winter-run Chinook salmon 2005–2020 (CDFW 2020).

The JPE for BY 2020 incorporates the recommendations from the WRPWT (Enclosure 2). The WRPWT identified four factors in calculating the JPE similar to last year that it advises continuing for BY 2020:

1. Estimated number of fry passing the RBDD
2. Survival rate of natural-origin fry to smolts

3. Survival rate of smolts from RBDD to Delta entry (defined as Sacramento at the Tower Bridge)
4. Estimated survival rate of winter-run Chinook salmon hatchery fish to be released in February 2021

Estimates of egg-to-fry survival rate are based on the JPI estimate at RBDD. The JPI method is considered a more accurate estimate of the egg-to-fry survival rate because it is an annual estimate, which better represents the response of fish to the environmental conditions at the time of spawning (see recommendations from the WRPWT in Enclosure 2).

Another reason to use the JPI this year, rather than historical measures of egg-to-fry survival, is that the JPI approach may at least partially account for the potentially lower than average egg-to-fry survival that may be occurring in naturally spawned winter-run Chinook salmon due to issues related to thiamine deficiency in returning spawners. Any thiamine deficiency impacts manifested in egg viability or early fry stages, will lead to a reduced JPI compared to what would have been observed absent thiamine deficiency impacts. USFWS has had no observations of abnormal fry behavior at the RBDD rotary screw traps, suggesting that any mortality caused by thiamine deficiency occurred primarily upstream of RBDD, though there may be latent impacts to young-of-year winter-run Chinook salmon downstream of RBDD that are not estimable based on information available this year. The assumption that most mortality would occur prior to outmigration is consistent with observations at Central Valley hatcheries, where mortality and behavioral abnormalities associated with thiamine deficiency were documented soon after hatch.

The egg-to-fry survival rate has ranged from 4 percent to 49 percent from BY 2005 to BY 2020, with an average of 23 percent (see Figure 3). BY 2020 egg-to-fry survival rate is estimated at 11 percent.

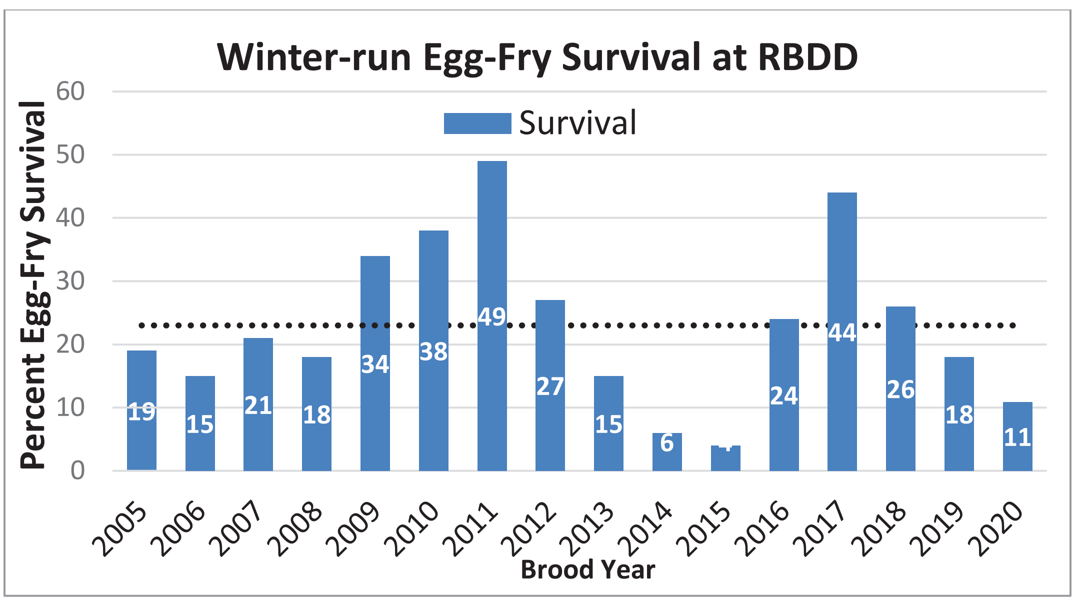

Figure 3. Winter-run egg-to-fry survival estimated at Red Bluff Diversion Dam 2005-2020 (Poytress et al. 2014, Poytress 2016, and Enclosure 2)

Until last year, a fry-to-smolt survival rate of 0.59, based on fall-run Chinook salmon, had been used since 1993 as a surrogate for winter-run Chinook salmon fry-to-smolt survival. This value was based on previous studies by Hallock (undated), and confirmed through a literature review in 1995 (B. Poytress, USFWS, personal communication). Without this factor, survival from fry to smolts is assumed to be 100 percent, which is unrealistic. The WRPWT has expressed reservations about the accuracy of the 0.59 term, and thus has recommended an alternative approach. The WRPWT reviewed a fry-to-smolt survival rate forecasting method developed by O'Farrell *et al*. (2018), which uses more recent winter-run Chinook salmon survival data and is updated with new survival data annually. The fry-to-smolt survival rate of 0.4475 was based on peer-reviewed methodologies and more recent winter-run Chinook salmon data, and therefore, improves the calculation of the JPE as compared to values used previously.

The calculation of the JPE is based on assumed environmental conditions (*e.g.,* temperature, flows, and turbidity) in the Sacramento River. However, actual environmental conditions, which may occur after the JPE is calculated, may be different than those assumed in the calculation of the JPE. Based on recommendations from the WRPWT, smolt survival to the Delta was calculated based on a weighted average of acoustically-tagged hatchery winter-run Chinook salmon releases from RBDD to the Tower Bridge (in Sacramento). NMFS considers the Tower Bridge as the point of Delta entry.

Using the JPI, and based upon the WRPWT recommendation, NMFS estimates a JPE of **330,130 natural-origin juvenile winter-run Chinook salmon entering the Delta during WY 2021** (Table 1 in Enclosure 2). Juvenile winter-run Chinook salmon are expected to emigrate into the Delta from November 2020 through April 2021, based upon CDFW historical monitoring data at Knights Landing rotary screw traps.

In early 2021, approximately 310,953 juvenile winter-run Chinook salmon propagated at LSNFH will be released into the upper Sacramento River near Redding (Caldwell Park). Depending on COVID-19 restrictions this year, a portion of the juvenile winter-run Chinook salmon from LSNFH may be acoustically-tagged (JSAT) to monitor their survival and movement downstream, some of which may be released up to 30 days prior to the production release. The objective of the early tag release is to use this information to parameterize the JPE equation of survival versus holding time upstream in the river. All hatchery-produced winter-run Chinook salmon will be coded-wire tagged and marked (100 percent) with an adipose fin-clip before release so that they can be identified from other hatchery fish. Since the hatchery winter-run Chinook salmon have not been released yet, their survival rate is unknown.

Based on the WRPWT advice (Enclosure 2), NMFS used a weighted average survival rate (*i.e.,* 0.1570) of the hatchery acoustic tag releases between Caldwell Park in Redding and the Tower Bridge in Sacramento to estimate how many hatchery fish released in the Sacramento River would enter the Delta. The survival rate for hatchery-origin fish is different than the natural-origin fish because it is measured over a longer distance (Caldwell Park vs RBDD). NMFS estimates that approximately **97,888 juvenile winter-run Chinook salmon from BY 2020 released into the Sacramento River from LSNFH will survive to enter the Delta during WY 2021**.

In 2017, the first group of winter-run Chinook salmon captive broodstock withheld and maintained at LSNFH reached maturity and became ready to spawn. Given the precarious status of winter-run Chinook salmon resulting from numerous years of drought, CDFW, NMFS, and USFWS determined that the progeny from captive broodstock could be used to “jump start” the Battle Creek Winter-Run Chinook Salmon Reintroduction Plan. The reintroduction of winter-run Chinook salmon to Battle Creek is an extremely important step in the conservation of this endangered species, highlighted by the fact that only a single population exists today. The progeny of the captive broodstock proposed for release into Battle Creek will be the third year that juvenile winter-run Chinook salmon will experience portions of Battle Creek that were recently restored, providing a unique opportunity to learn vital information about release strategies, marking and tagging regimes, habitat utilization, and survival.

Although data are lacking on survival rates from juvenile Chinook salmon released in Battle Creek, the size at release and the distance traveled to the Delta are comparable to the releases occurring in the Sacramento River. Therefore, for WY 2021, the weighted average survival rate described above (*i.e.*, 0.1570) was used to estimate how many hatchery winter-run Chinook salmon released into Battle Creek would enter the Delta. In spring of 2021, approximately 237,148 juvenile winter-run Chinook salmon will be released into Battle Creek. Depending on COVID-19 restrictions this year, a subset of the winter-run Chinook salmon released in Battle Creek during WY 2021 may receive acoustic tags, allowing for the estimation of survival rates specific to releases occurring in Battle Creek. As releases of acoustically-tagged winter-run Chinook salmon continue in Battle Creek during subsequent years, the data collected will allow for the refinement of the survival rates specific to Battle Creek and better estimates of the number of winter-run Chinook salmon released in Battle Creek that survive to the Delta. NMFS estimates that approximately **37,232 juvenile winter-run Chinook salmon from BY 2020 released into Battle Creek will survive to enter the Delta during WY 2021**.

Incidental Take Limits for Natural and Hatchery Juvenile Winter-Run Chinook Salmon

The authorized incidental take limit for the combined CVP/SWP Delta pumping facilities includes both the natural-origin (wild) and hatchery-origin juvenile winter-run Chinook salmon, as both are necessary components of the population for survival and recovery of the species. Incidental take limits are summarized below:

- For natural-origin winter-run Chinook salmon: 4,292 on a three-year rolling average loss and 6,603 for single year loss.
- For hatchery-origin winter-run Chinook salmon juveniles released into the Sacramento River: 783 on a three-year rolling average loss and 979 for single year loss.
- For hatchery-origin winter-run Chinook salmon juveniles released into Battle Creek: 298 on a three-year rolling average loss and 372 for single year loss.

The JPE-related incidental take limits allow for errors in fish identification due to use of LAD criteria to determine Chinook salmon race (i.e., differentiating from fall-run, late-fall run, and spring-run Chinook salmon). The authorized level of incidental take for natural-origin winter-run Chinook salmon (i.e., reported as loss at the CVP/SWP Delta fish facilities) under the ESA for the combined CVP/SWP Delta pumping facilities from October 1, 2020 through June 30, 2021, is for natural-origin winter-run-sized fish, based on LAD criteria.

The initial identification of natural-origin (non-clipped) winter-run Chinook salmon at the CVP/SWP Delta fish facilities shall be based on the length-at-date criteria for the Delta. NMFS will continue to monitor fish salvage and loss, and loss densities of winter-run Chinook salmon and other ESA-listed species at the CVP/SWP Delta fish facilities, through participation in the Salmonid Monitoring Team technical team and the Water Operations Management Team.

NMFS acknowledges that additional research using acoustically-tagged winter-run Chinook salmon (both hatchery and wild) is necessary to provide a more robust estimate of in-reach survival of winter-run Chinook salmon in the Sacramento River and would also provide direct calculation of survival, thereby greatly improving the accuracy of the JPE. We recommend that funding be continued for acoustic tag studies on winter-run Chinook salmon for BY 2021 and beyond to provide data on survival rates over a range of hydrologic conditions.

In closing, we look forward to continuing to work with Reclamation and the other State and Federal agencies to manage water resources in WY 2021 in a way that supports both water supply and fish and wildlife resources. If you have any questions regarding this correspondence, or if NMFS can provide further assistance, please contact Mr. Garwin Yip at (916) 930-3611, or via email at Garwin.Yip@noaa.gov.

Sincerely,

A. Catherine Marcinkevage

Cathy Marcinkevage
Assistant Regional Administrator
California Central Valley Office

Enclosures:
1. CDFW letter with winter-run escapement estimate for BY 2020, dated December 14, 2020
2. Winter-Run Project Work Team letter to NMFS, dated January 15, 2021

cc: Copy to file: ARN 151422SWR2006SA00268

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References Cited

California Department of Fish and Wildlife (CDFW). 2019. Unpublished data, GrandTab Spreadsheet of Adult Chinook Escapement in the Central Valley, 5/7/2019. CDFW Fisheries Branch Anadromous Resources Assessment

NMFS. 2019. Biological Opinion for the Re-initiation of Consultation on the Long-Term Operation of the Central Valley Project and State Water Project. U.S. Department of Commerce National Marine Fisheries Service. 900 pages plus appendices. 21 October 2019. Available at: NMFS 2019 Biological Opinion

O'Farrell M.R., W.H. Satterthwaite, A.N. Hendrix, and M.S. Mohr. Alternative Juvenile Production Estimate (JPE) Forecast Approaches for Sacramento River Winter-Run Chinook Salmon. San Francisco Estuary & Watershed Science. Volume 16, Issue 4 | Article 4. Alternative Juvenile Production Estimate

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Poytress, W. R., J. J. Gruber, F. D. Carrillo and S. D. Voss. 2014. Compendium Report of Red Bluff Diversion Dam Rotary Trap Juvenile Anadromous Fish Production Indices for Years 2002-2012. Report of U.S. Fish and Wildlife Service to California Department of Fish and Wildlife and US Bureau of Reclamation.

U.S. Fish and Wildlife Service (USFWS). 2020. Biweekly Report of Passage at Red Bluff Diversion Dam (December 17, 2020 - December 31, 2020). Red Bluff Fish and Wildlife Office. Available at Juvenile Salmonid Monitoring at RBDD

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GAVIN C. NEWSOM, Governor
CHARLTON H. BONHAM, Director

December 14, 2020

Mr. Barry Thom
Regional Administrator, West Coast Region
National Marine Fisheries Service
1201 NE Lloyd Blvd., Suite 1100
Portland, OR 97232

WINTER-RUN CHINOOK SALMON ESCAPEMENT ESTIMATES FOR 2020

Dear Mr. Thom:

The California Department of Fish and Wildlife (CDFW) has developed Sacramento River winter-run Chinook Salmon escapement estimates for 2020. These estimates were developed from data collected in the Upper Sacramento River winter-run Chinook Salmon Escapement Survey (carcass survey) conducted by CDFW and U.S. Fish and Wildlife Service (USFWS) personnel.

Escapement estimates shown below were calculated using the Cormack-Jolly-Seber (CJS) mark-recapture population model:

Estimated Total In-river Escapement (hatchery and natural origin)	**6,195**
Estimated In-river Escapement (hatchery origin)	**2,781**
Estimated Number of In-river Spawning Females (hatchery and natural origin)	**3,904**

These estimates include only naturally spawning winter-run Chinook Salmon in the upper Sacramento River. An additional **191** winter-run Chinook Salmon were collected at the Keswick Dam trap site for spawning at Livingston Stone National Fish Hatchery. The total 2020 Sacramento River winter-run spawning escapement estimate, including in-river spawners and fish collected for hatchery broodstock, is **6,390** fish. The 90% confidence interval on this total escapement estimate is **5,962 to 6,828** fish.

The total escapement estimate includes four female carcasses that were observed during the late-fall-run carcass survey earlier in the year. Not included in these estimates are winter-run returns to Battle Creek into and upstream of the Coleman National Fish Hatchery as part of the Battle Creek “jumpstart” reintroduction effort. Eight Battle Creek winter-run Chinook Salmon carcasses from were recovered during the Sacramento River carcass survey and are included in the escapement estimate.

The CDFW has used the CJS model to estimate winter-run Chinook Salmon escapement since 2012. Due to its similarity to the Jolly-Seber model used previously, we consider escapement estimates from 2012-2020 to be directly comparable to those from 2003-2011. Figure 1, below, shows the Sacramento River winter-run Chinook Salmon spawner escapement estimates from 2003 to present. The reported total escapement estimate for 2020 is considered final, subject to revision if additional data becomes available after the date of this letter. Updated estimates can be found in the GrandTab spreadsheet which is updated if and when new information is received (https://nrm.dfg.ca.gov/FileHandler.ashx?DocumentID=84381).

We look forward to further discussion and collaboration with National Marine Fisheries Service staff regarding the application of this information. Inquiries regarding the methodology and development of the estimates in this letter should be directed to Mr. Douglas Killam at Doug.Killam@wildlife.ca.gov or Ms. Erica Meyers at Erica.Meyers@wildlife.ca.gov.

Sincerely,

DocuSigned by:
Kevin Shaffer
D168439904AD42A...
Kevin Shaffer, Fisheries Branch Chief

cc: Ms. Cathy Marcinkevage
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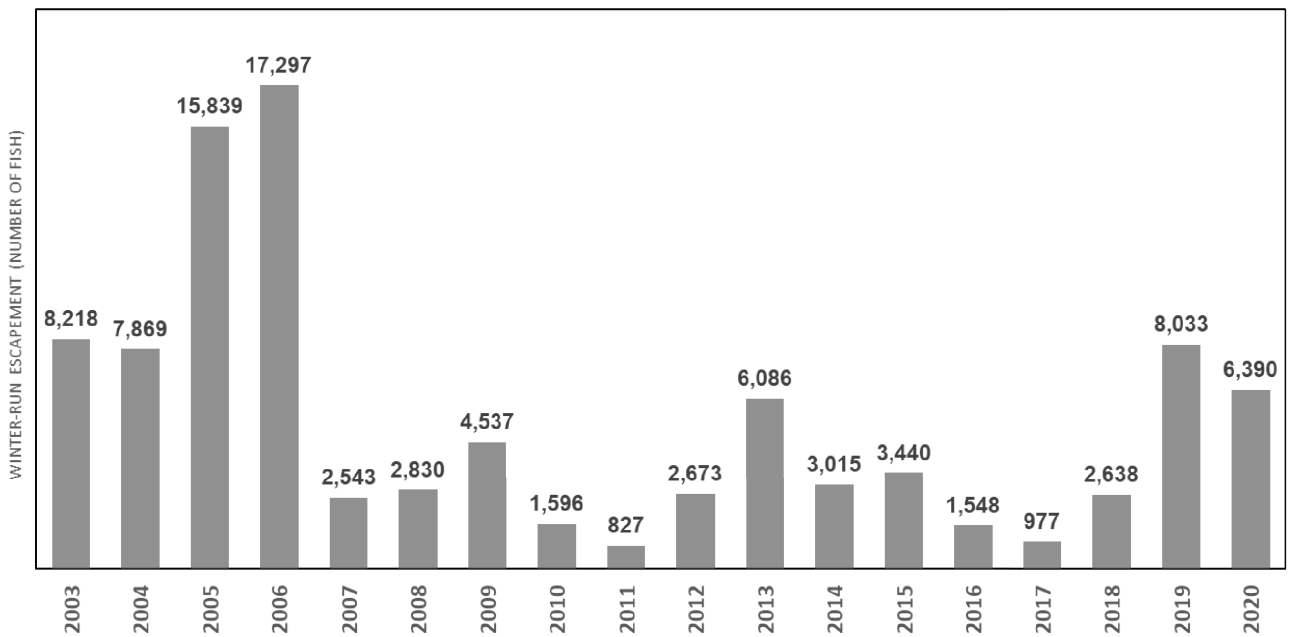

Figure 1. Estimated escapement of winter-run Chinook Salmon to the Upper Sacramento River Basin, 2003-2020. Data compiled from GrandTab (CDFW 2020; https://www.dfg.ca.gov/fish/Resources/Chinook/CValleyAssessment.asp). Data for 2009-2020 are preliminary and subject to change.

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January 15, 2021

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Sacramento, CA 95814

Dr. Brooke Jacobs
California Department of Fish and Wildlife
State Water Project Permitting Unit
1010 Riverside Parkway
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FINAL WINTER-RUN JUVENILE PRODUCTION ESTIMATE (JPE) FOR BROOD YEAR 2020

Dear Mr. Yip and Dr. Jacobs:

In 2013, the Interagency Ecological Program's Winter-Run Chinook Salmon Project Work Team (Winter-Run PWT) recommended that the Juvenile Production Estimate (JPE) be revisited annually and updated as needed with any new or improved information. The annual JPE is used to implement components of the National Marine Fisheries Service (NMFS) Biological Opinion on Long Term Operation of the Central Valley Project and the State Water Project, No. WRCO-2016-00069 (2019 NMFS BiOp) and California Department of Fish and Wildlife (CDFW) Incidental Take Permit No. 2081-2019-066-00 (2020 ITP). A subgroup of the Winter-Run PWT met in December 2020 to review and update the factors used to calculate the brood year (BY) 2020 JPE. The subgroup transmitted a recommended draft winter-run JPE for BY 2020 to NMFS and CDFW on December 29, 2020. This letter revises that recommendation based on recent data from juvenile trapping and genetic run assignment. The below recommendations for a final JPE were discussed and approved by the Winter-Run PWT at the group's January 15, 2021 meeting.

JPE Recommendations

The Winter-Run PWT identified several factors in calculating the JPE that we advise be continued or updated for BY 2020. We considered one method for forecasting natural-origin JPE—The "Method 2" approach used last year for the BY 2019 JPE and described in O'Farrell *et al.* (2018). The data inputs for the calculations include estimates of the following parameters for calculating JPE for natural-origin BY 2020 winter-run Chinook ($JPE_{Natural}$) (Figure 1):

1) Number of winter-run fry-equivalents passing Red Bluff Diversion Dam (RBDD)(JPI_{Fry})
2) Survival rate of natural origin fry to smolts ($Survival_{Fry\text{-}to\text{-}Smolt}$)
3) Survival rate of smolts from RBDD to Delta entry (defined as Sacramento at the I-80/I-50 Bridge) ($Survival_{Smolt}$)

Hatchery Release JPE Recommendations

Additionally, we used the number of winter-run hatchery smolts expected to be released from Livingston Stone National Fish Hatchery (LSNFH) in February 2021 ($N_{Hatchery}$) and their predicted survival rate ($Survival_{HatcherySmolt}$) to estimate a JPE of hatchery-origin winter-run juveniles in the Delta ($JPE_{Hatchery}$) (Figure 1). We present the data inputs used in the calculations in Table 1 and describe each in the sections below.

For the first time, we also include an estimate of hatchery-origin winter-run smolts released in Battle Creek as part of the "Jumpstart" reintroduction ($N_{BCJumpstart}$), their survival ($Survival_{BCJumpstart}$), and a forecast of the number entering the Delta ($JPE_{BCJumpstart}$). Although there was natural spawning in Battle Creek in 2020, we do not differentiate naturally produced juveniles from Battle Creek from Sacramento River juveniles, and they are included in the JPI_{Fry}.

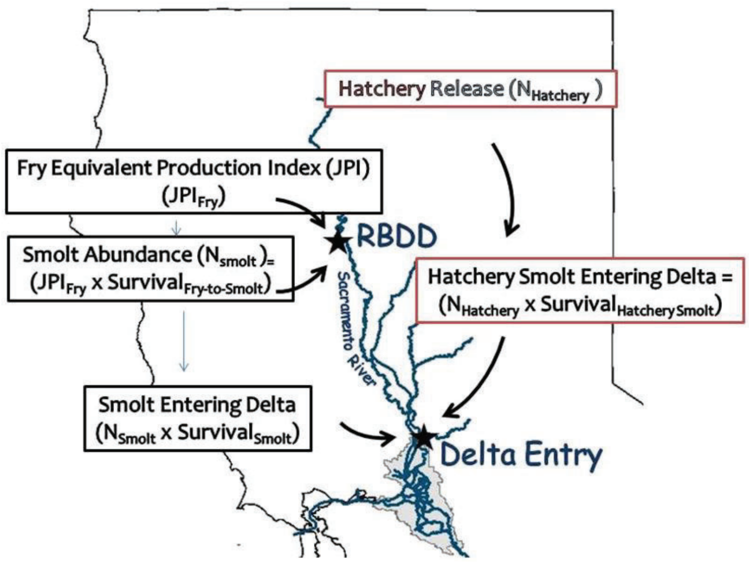

Figure 1. Location and formulas recommended for use in the JPE for the wild (black boxes) and hatchery (red boxes) components of the winter-run population estimated for BY 2020. Separate hatchery JPEs are estimated for hatchery releases from Livingston Stone Fish Hatchery into the Sacramento River ($N_{Hatchery}$) and for the Battle Creek Jumpstart into Battle Creek (not shown).

Winter-Run JPE Methods for 2020-2021

The Winter-Run PWT focused on a single method for forecasting the JPE for BY 2020. This method was recommended in O'Farrell *et al.* (2018) and was the chosen method for BY 2019. It is the opinion of the Winter-Run PWT that this method represents the best available science given currently available data.

Juvenile Production Index - For the BY 2020 JPE, the Winter-Run PWT continues to recommend using the Juvenile Production Index (JPI_{Fry} or JPI), which is based on an estimate of fry-equivalents at RBDD. The JPI has been used in the calculation since 2014 and better represents the response of fish to annual environmental conditions during spawning, egg incubation, and outmigration, as compared to the long-term average egg-to-fry survival rate used in the JPE prior to 2014.

Another reason to use the JPI this year, rather than historical measures of egg-to-fry survival, is that the JPI approach may at least partially account for the potentially lower than average egg-to-fry survival that may be occurring in naturally spawned winter-run Chinook Salmon due to issues related to thiamine deficiency in returning spawners. Any thiamine deficiency impacts manifested in egg viability or early fry stages will lead to a reduced JPI compared to what would have been observed absent thiamine deficiency impacts. USFWS has had no observations of abnormal fry behavior at the RBDD rotary screw traps, suggesting that any mortality caused by thiamine deficiency occurred primarily upstream of RBDD, though there may be latent impacts to young-of-year winter-run Chinook Salmon downstream of RBDD that are not estimable based on information available this year. The assumption that most mortality would occur prior to outmigration is consistent with observations at Central Valley hatcheries, where mortality and behavioral abnormalities associated with thiamine deficiency were documented soon after hatch.

In response to changes in channel geometry and juvenile trap configurations, USFWS is currently evaluating several new models for calculating JPI at RBDD, which use different assumptions of trap efficiency based on temporal differences in dam operation, run of Chinook Salmon, and additional predictor variables, including water temperature. It is unlikely that there will be a decision regarding the most accurate model for JPI prior to finalizing our recommendation for JPE, as new efficiency data collected during the fall of 2020 has not been added to any models under consideration. Therefore, we present three options for JPI model selection that are currently being considered by the USFWS, including two that are undergoing further biostatistical analyses.

The first model (Te99) is the traditional model based on naturally caught fish used in mark-recapture trials under “run of the river” conditions between 2002 and 2019 (Poytress et al. 2014, Voss and Poytress 2020). The second (Te42) and third (Nsom) are based on preliminary analyses that, coupled with direct observations, indicate an evolution in river channel geometry at RBDD since the dam ceased operations in 2011. These two models both use mark-recapture trials conducted since 2012 using naturally caught fall-run and winter-run Chinook Salmon. The primary difference between the third (Nsom) and the second model option (Te42) are that an additional explanatory variable, water temperature, has been added to the model structure of Nsom, creating a multi-variate model as opposed to a simple least-squares regression model.

Data from fall 2020 trap efficiency trials have not yet been incorporated, as models are typically updated annually in July. Preliminary analyses indicate observed trap efficiencies have been higher than modeled efficiencies using Te99, overpredicting JPI for the last three years. Nsom appears to best predict trap efficiencies observed in 2020; however, it relies on a relatively small number of winter-run Chinook trap efficiency trials. We therefore recommend additional data analyses and validation for the Nsom model. Model Te42 appears to represent best available data for the current JPE, providing a balance between Te99, which overpredicts juvenile passage, and Nsom, which needs more data. All three models’ results are described in Table 1.

Since 2017, the JPI has been adjusted based on the results of genetic run assignment of a representative sample of spring-run sized juveniles based on length-at-date. These data were not available prior to December 29, 2020, and the draft JPE assumed spring-run sized juveniles prior to November 18, 2020 were winter-run. This final recommendation includes the results from the genetic analysis and juvenile passage at RBDD through January 14, 2021. Genetic data assignments confirmed the vast majority of length-at-date spring run through November 17, 2020 were winter-run, and a small runoff event resulted in an influx of winter-run smolts passing RBDD on January 5, 2021, allowing greater confidence in the preliminary JPI estimate.

Table 1 – Factors in the Juvenile Production Estimate and the resulting estimates for BY 2020

	Method 2 (Te42)		Alternate JPI Models	
Component	Natural	Hatchery	Te99	Nsom
Total Sacramento River escapement[1]	6,195		-	-
Adult female estimate (AFE)[2]	4,023		-	-
AFE minus pre-spawn mortality[3] (2.96%)	3,904		-	-
Average fecundity[4]	4,991		-	-
Total viable eggs	19,484,864		-	-
Estimated egg-to-fry survival rate based on JPI at RBDD/Total viable eggs[5]	0.1146		0.1386	0.0973
Fry equivalents of juvenile production at RBDD (JPI or JPI_{Fry})[6]	2,232,811		2,700,503	1,896,376
Fry-to-smolt survival estimates from October (peak) to February at RBDD ($Survival_{Fry\text{-}to\text{-}Smolt}$)[7]	0.4475		-	-
Number of smolt equivalents at RBDD	999,183		1,208,475	848,628
Estimated smolt survival term: RBDD to Delta[8] ($Survival_{Smolt}$)	0.3304		-	-
Total natural production entering the Delta (JPE)	330,130			
JPE 95 percent confidence interval	145,088 – 515,172			
LSNFH Hatchery release ($N_{Hatchery}$)[9]		310,953		
Survival rate from release to Sacramento ($Survival_{HatcherySmolt}$)[10]		0.3148		
Total LSNFH production entering the Delta		97,888		
Battle Creek Hatchery release ($N_{BCJumpstart}$)[11]		237,148		
Survival rate from release to Sacramento ($Survival_{BCJumpstart}$)[12]		0.1570		
Total Jumpstart production entering the Delta		37,232		

1/ Total Sacramento River in-river escapement from CDFW Cormack-Jolly Seber (CJS) model includes natural and hatchery origin, but not hatchery fish retained for brood stock at LSNFH.
2/ The number of adult females is derived from carcass surveys on the Sacramento River. Naturally spawning winter-run in Battle Creek are not included.
3/ Pre-spawn mortality was estimated from carcass surveys of females (CDFW).
4/ Preliminary (subject to change) average number of eggs per female from 75 female fish spawned at LSNFH (Taylor Lipscomb, USFWS pers. comm.).
5/ Back-calculated estimated survival between eggs laid in-river and fry production estimates at RBDD based on numbers of fry equivalents (JPI) using the 0.4475 fry-to-smolt survival rate estimate method described in O'Farrell *et al*. (2018).
6/ Preliminary number of fry equivalents estimated on January 14, 2021 plus 2.11% interpolation to account for remainder of estimated passage for the 2020 brood year at RBDD; using 0.4475 fry-to-smolt survival rate estimate (Bill Poytress, USFWS, pers. comm.). This estimate includes and does not differentiate between the number of fry equivalents outmigrating from Battle Creek and the Sacramento River.
7/ Estimate of fry-to-smolt survival rate based on O'Farrell *et al*. (2018) applied to catch at RBDD.
8/ Variance-weighted mean survival rate of acoustically tagged hatchery winter-run from 2013 to 2020 between RBDD and I-80/Tower Bridge in Sacramento. Survival is estimated from the Salt Creek receiver site, located 3 miles downstream of RBDD, to estimate survival from RBDD for natural-origin smolts.
9/ Estimated LSNFH production release as of January 8, 2021 (100% tagged and adipose clipped).
10/ Variance-weighted mean survival rate of acoustically tagged hatchery winter-run from 2013 to 2020 between release location and I-80/Tower Bridge in Sacramento.
11/ Estimated Battle Creek Jumpstart release as of January 11, 2021 (100% tagged and marked)
12/ Variance-weighted mean survival rate of acoustically tagged hatchery winter-run from 2019 to 2020 between release location in North Fork Battle Creek and I-80/Tower Bridge in Sacramento.

Fry-to-Smolt Survival - The Winter-Run PWT recommends the continued inclusion of a fry-to-smolt survival factor ($Survival_{Fry\text{-}to\text{-}Smolt}$). This is necessary because the available survival estimates between RBDD and the Delta are based on releases of acoustically telemetered smolts, which have a higher survival rate than fry. Without this factor, the survival rate from fry to smolts is assumed to be 1.00, which is unrealistic. The same factor is used to adjust juvenile passage at RBDD to fry equivalents, based on the peak of fry catch at RBDD (generally in October) and the smolt life-stage at RBDD for naturally produced winter-run Chinook.

The Winter-Run PWT recommends the fry-to-smolt survival rate forecasting method developed by O'Farrell *et al*. (2018), which uses recent winter-run Chinook Salmon survival data and is updated with new survival data annually. Incorporating updated survival rate estimates, this method results in a winter-run Chinook Salmon fry-to-smolt survival rate of 0.4475 for BY 2020. The team recommends using this forecasting method to estimate fry-to-smolt-survival in calculations of JPE and updating the fry equivalent multiplier to 2.235 (the factor 2.235 is the inverse of 0.4475). It is the opinion of the Winter-Run PWT that these updated values, which are based on peer-reviewed methodologies and more recent winter-run Chinook data, improve the JPE forecast compared to values used prior to 2019.

Fry Production - The JPI seasonal fry-equivalent estimate using the 0.4475 fry-to-smolt survival rate was 2,185,699 as of January 14, 2021 (week 2; B. Poytress, USFWS, personal communication). The value through January 14 accounts for approximately 97.89 percent of annual winter-run passage at RBDD based on data collected from 2002 to 2019. Including an interpolation of the remaining 2.11 percent for the remainder of BY 2020, the total BY 2020 estimate is 2,232,811 fry equivalents (Table 1). This value incorporates results from in-season genetic analyses. With this estimate of fry production at RBDD, the estimated egg-to-fry survival is calculated to be 0.1146 (Table 1).

Natural-origin Smolt Survival - The next recommendation of the Winter-Run PWT is related to the smolt survival term for estimating survival of natural origin winter-run smolts from RBDD (*i.e.,* Salt Creek) to the Delta (*i.e.*, Sacramento at the I-80/I-50 Bridge)($Survival_{Smolt}$). For this term, we recommend using the variance-weighted mean of survival estimates from acoustically tagged LSNFH smolts released in 2013 through 2020. Method 2 uses the Cormack-Jolly-Seber model, which accounts for variation in detection probabilities, to estimate an annual survival rate of 0.3304.

Hatchery Smolt Survival – As an estimate of survival of hatchery-produced winter-run ($Survival_{HatcherySmolt}$) released in the Sacramento River near Redding, we recommend using 0.3148, the variance-weighted mean of 2013-2020 survival rates from the LSNFH release point to the Delta. For hatchery-produced winter-run released in North Fork Battle Creek ($Survival_{BCJumpstart}$), we recommend using 0.1570, the variance-weighted mean of 2019-2020 survival rates from the Battle Creek release point to the Delta. Because both release points of hatchery fish are upstream of RBDD, the overall survival to the Delta is lower compared to the survival applied to natural-origin smolts. As for natural-origin smolt survival, these estimates of hatchery smolt survival use the Cormack-Jolly-Seber model to account for variation in detection probabilities.

Winter-Run PWT Recommended Method for BY 2020

The Winter-Run PWT recommends that Method 2, using the JPI estimate from method Te42, be used for estimating the BY 2020 natural-origin (Equation 1) and hatchery-origin (Equations 2 and 3) JPE:

Equation 1:

$$\begin{aligned} JPE_{Natural} &= JPI_{Fry} \times Survival_{Fry-to-Smolt} \times Survival_{Smolt} \\ &= 2{,}232{,}811 \times 0.4475 \times 0.3304 = 330{,}130 \end{aligned}$$

Equation 2:

$$\begin{aligned} JPE_{Hatchery} &= N_{Hatchery} \times Survival_{HatcherySmolt} \\ &= 310{,}953 \times 0.3148 = 97{,}888 \end{aligned}$$

Equation 3:

$$\begin{aligned} JPE_{BCJumpstart} &= N_{BCJumpstart} \times Survival_{BCJumpstartSmolt} \\ &= 237{,}148 \times 0.1570 = 37{,}232 \end{aligned}$$

It is the opinion of the Winter-Run PWT that this method represents the best available science given currently available data. Method 2 accounts for detection probabilities and quantifies uncertainty associated with estimates of JPI_{Fry} and smolt survival rates, which are used to develop the 95 percent confidence intervals for the JPE forecast. Because Method 2 does not capture process error, or the variation in true survival rates from year to year, these confidence intervals likely underestimate the uncertainty in the JPE forecast. We acknowledge that Method 2 still has considerable uncertainty, and that confidence intervals may not have utility to water mangers under the current management setting. However, there is uncertainty with any forecast method for JPE, and we believe there is value in quantifying and reporting that uncertainty.

It is the opinion of the Winter-Run PWT that this recommendation is the best information currently available from which to derive a JPE. This is the Winter-Run PWTs final recommendation for the BY 2020 JPE, and includes new information from genetic analysis and juvenile passage that were not available prior to recommending a draft JPE in December. We conclude that this analysis and these technical recommendations from the Winter-Run PWT will establish the most accurate forecast of JPE for use in the 2021 water year at the Central Valley Project and State Water Project export facilities.

Sincerely,

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