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

February 3, 2020

Ms. Kristin White
Operations Manager, Central Valley Project
U.S. Bureau of Reclamation
3310 El Camino Avenue, Suite 300
Sacramento, California 95821

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) 2019 expected to enter the Sacramento-San Joaquin Delta (Delta) during water year (WY) 2020. This juvenile production estimate, or JPE, is provided by NOAA's National Marine Fisheries Service (NMFS) pursuant to the June 4, 2009, biological opinion on the long-term operations of the Central Valley Project (CVP) and the State Water Project (SWP, CVP/SWP operations Opinion). 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 2009).

NMFS acknowledges that should the Record of Decision to execute NMFS' October 21, 2019, Biological Opinion for the Re-initiation of Consultation on the Long-Term Operation of the CVP and SWP (NMFS 2019 Biological Opinion) be signed during WY 2020, Reclamation would apply these genetic monitoring procedures in a manner consistent with the NMFS (2019) Biological Opinion.

The winter-run Chinook salmon JPE for BY 2019 is **854,941 natural-origin juvenile winter-run Chinook salmon entering the Delta during WY 2020**. 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 an increase in the JPE for BY 2019 compared to the JPE for BY 2018 due to a significant increase in escapement from 2,458 in 2018 to 7,852 in 2019, and the estimated number of juveniles passing Red Bluff Diversion Dam (RBDD) from 1,429,551 in 2018[1] to 4,762,142 in 2019.

The authorized incidental take limit for naturally-produced winter-run Chinook salmon has been established in the CVP/SWP operations Opinion as 2 percent of the JPE to allow for errors in fish identification due to use of length-at-date (LAD) criteria to determine Chinook salmon race (i.e., differentiating from fall-run, late-fall run, and spring-run Chinook salmon). In WY 2020, as in WYs 2016-2019, genetic race identification will be used. The use of genetic data to determine race of juvenile Chinook salmon observed at the CVP/SWP Delta fish facilities eliminates the

[1] BY 2018 JPE Letter.

uncertainty that was included in previous (2015 and earlier) annual incidental take limits for winter-run Chinook salmon. Therefore, the authorized level of incidental take (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, 2019, through June 30, 2020, or until the NMFS 2019 Biological Opinion supersedes the current 2009 CVP/SWP operations Opinion, is set at 1 percent of the JPE, or **8,549 natural-origin (non-clipped)** genetic winter-run Chinook salmon.

The incidental take limit for hatchery-origin winter-run Chinook salmon is set at 1 percent of each release (i.e., Sacramento River and Battle Creek releases) expected to enter the Delta. Therefore, the incidental take limit for juveniles released from Livingston Stone National Fish Hatchery (LSNFH) into the Sacramento River is **945 (1% of 94,528) hatchery-produced (adipose fin clipped)** winter-run Chinook salmon for WY 2020. The incidental take limit of juveniles released from LSNFH into Battle Creek is **673 (1% of 67,257) hatchery produced (adipose fin clipped and left ventral fin clipped)** winter-run Chinook salmon for WY 2020**.**

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).

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 nine most critically endangered species.

BY 2019 was primarily comprised of 2016 returns, the first year after the drought ended. This cohort benefitted from improved river conditions, as almost 3.8 million juvenile winter-run Chinook salmon have been estimated to pass Red Bluff Diversion Dam and are currently outmigrating toward the ocean. This is the largest number of juvenile winter-run Chinook salmon observed in a decade. BY 2019 is proving to be a strong year class, however, outmigrating juveniles are likely to encounter challenging water conditions in certain areas where debris from last year's fires will travel into streams and rivers. Despite the last two wet winters, drought conditions are expected to return in the future.

JPE Development Process

The process for developing the JPE was similar to what was done for BY 2018. A technical team from the Interagency Ecological Program (IEP), the Winter-run Project Work Team (WRPWT), met at the end of 2019 and provided recommendations to NMFS (Enclosure 2) on January 23, 2020. The method used to calculate the 2019 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.

The 2009 CVP/SWP operations Opinion 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 through the Delta. The calculation of the winter-run Chinook salmon JPE for BY 2019 begins with estimates of winter-run Chinook salmon adult escapement in 2019, which are derived from carcass surveys conducted in the upper Sacramento River by CDFW. Escapement information was provided to NMFS via a December 2, 2019, letter (Enclosure 1). The CDFW estimate for total winter-run Chinook salmon escapement in 2019 was **7,852 spawners**[3]. Of this total number of spawners, 4,947 were estimated to be females.

The number of adult spawners in 2019 was higher than the 10-year average (*i.e.,* 3,079) for 2010–2019 (Figure 1). The cohort replacement rate (CRR), which is a measure of the population's growth rate, was positive for the first time since 2015 (*i.e.* 5.01), meaning the population is currently replacing itself) (Figure 2), and the trend is increasing towards a positive growth rate. With more adults returning in 2019, the estimated number of juvenile winter-run Chinook salmon emigrating past RBDD is higher than in previous years, and estimates of the JPI, which account for the revised winter-run Chinook salmon estimates due to misclassification of spring-run Chinook salmon using the river LAD criteria (as described above) and also revised based on rotary screw trap efficiency studies.

Similar to BY 2018, genetic analyses were conducted on some LAD juvenile spring-run Chinook salmon sampled from the RBDD RSTs, and the estimate of juvenile winter-run Chinook salmon

[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.

emigration past RBDD was adjusted to include the LAD spring-run Chinook salmon that were determined to be genetic winter-run Chinook salmon.

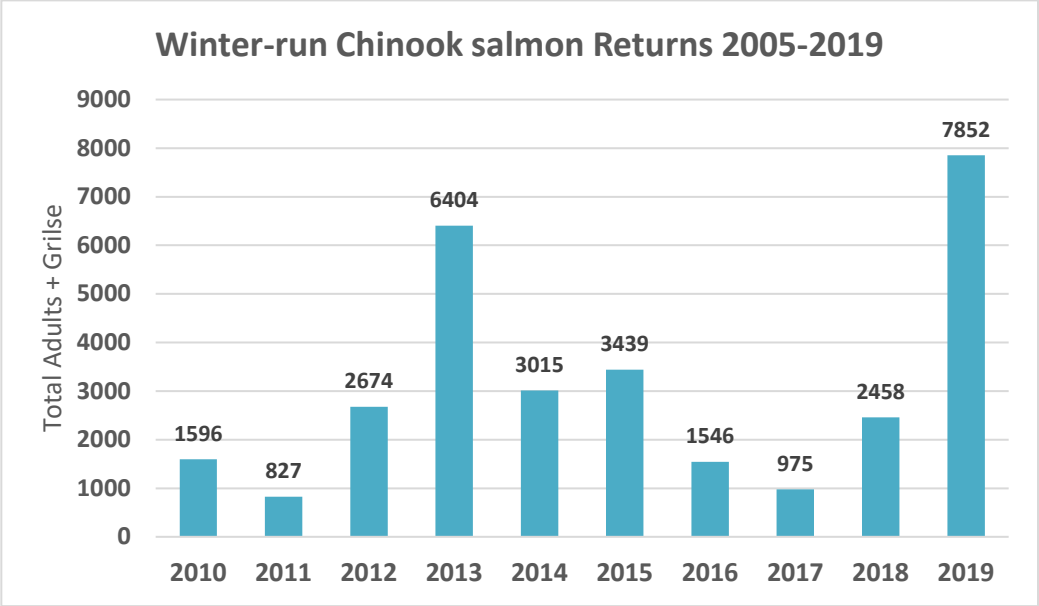

Figure 1. Winter-run Chinook Salmon Spawning Escapement 2010-2019 (CDFW 2019 and Enclosure 1).

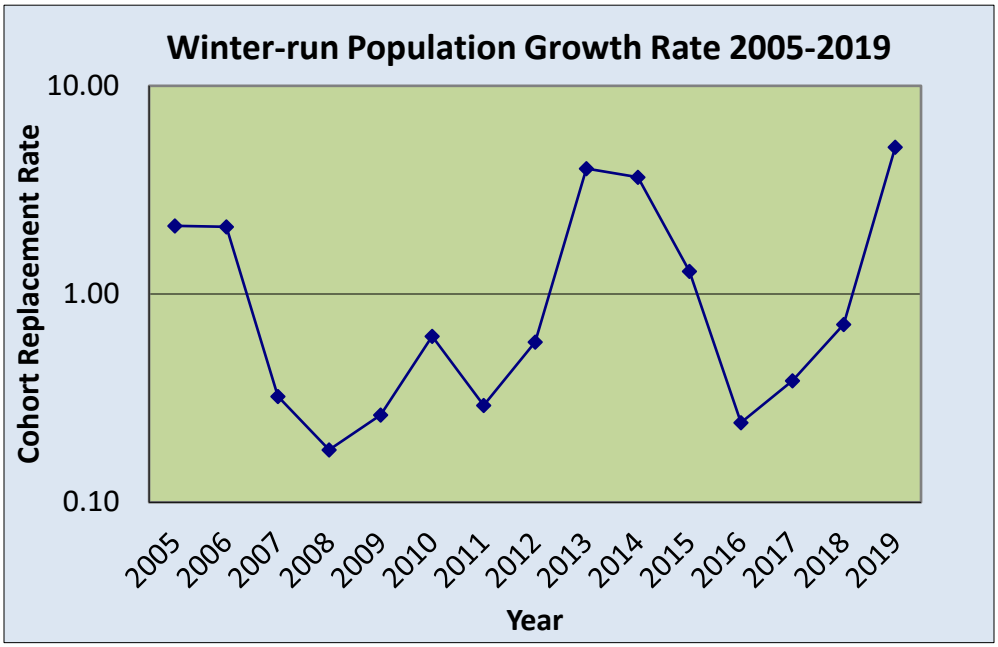

Figure 2. Cohort replacement rate for winter-run Chinook salmon 2005–2019 (CDFW 2019).

The JPE for BY 2019 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 2019:

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 2020

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). The egg-to-fry survival rate has ranged from 4 percent to 49 percent from BY 2002 to BY 2019, with an average of 24 percent (see Figure 3).

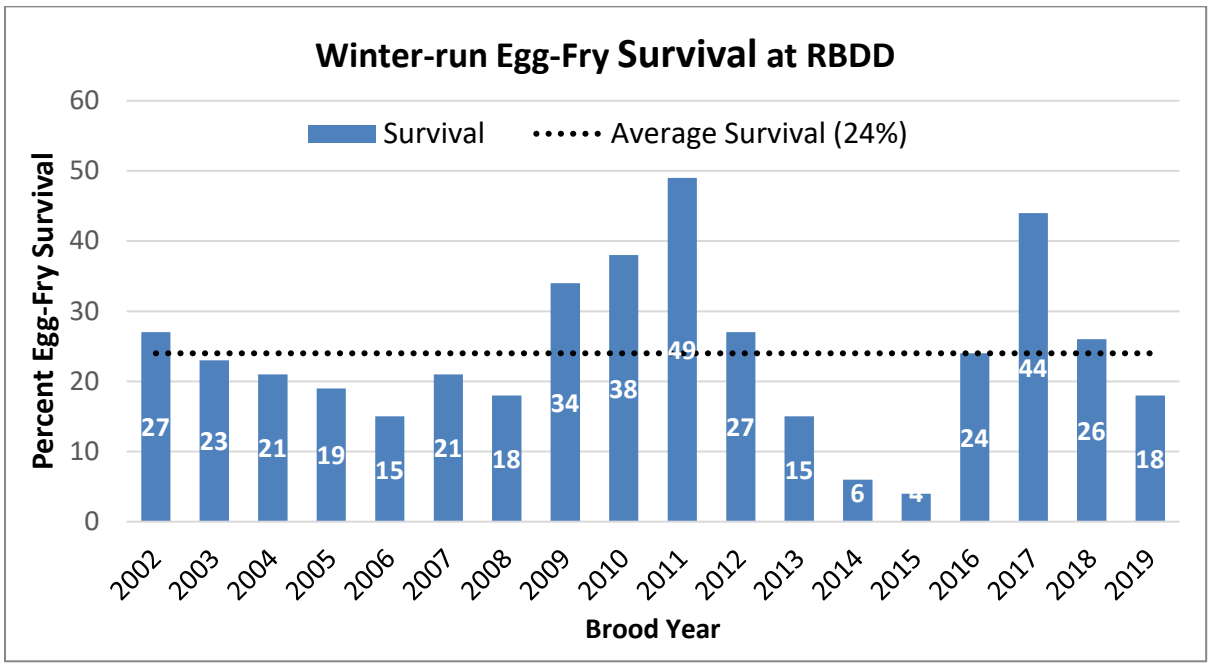

Figure 3. Winter-run egg-to-fry survival estimated at Red Bluff Diversion Dam 2002-2019 (Poytress et al. 2014, Poytress 2016, and Enclosure 2)

Until this year, a fry-to-smolt survival rate of 0.59, based on fall-run Chinook salmon, has been used since 1993 as a surrogate for winter-run Chinook salmon fry-to-smolt survival. This value is 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 0.4651 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 survival of juvenile winter-run Chinook salmon to the Delta 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 (at 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 **854,941 natural-origin juvenile winter-run Chinook salmon entering the Delta during WY 2020** (Table 1 in Enclosure 2). Juvenile winter-run Chinook salmon are expected to emigrate into the Delta from November 2019 through April 2020, based upon CDFW historical monitoring data at Knights Landing rotary screw traps.

In early 2020, approximately 256,381 juvenile winter-run Chinook salmon propagated at LSNFH will be released into the upper Sacramento River near Redding (Caldwell Park). A portion of the juvenile winter-run Chinook salmon from LSNFH will 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.,* 0.3687) 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 **94,528 juvenile winter-run Chinook salmon from BY 2019 released into the Sacramento River from LSNFH will survive to enter the Delta during WY 2020**.

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 2020, the weighted average survival rate described above (*i.e.*, 0.3687) was used to estimate how many hatchery winter-run Chinook salmon released into Battle Creek would enter the Delta. In spring of 2020, approximately 182,415 juvenile winter-run Chinook salmon will be released into Battle Creek. A subset of the winter-run Chinook salmon released in Battle Creek during WY 2020 will 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 **67,257 juvenile winter-run Chinook salmon from BY 2019 released into Battle Creek will survive to enter the Delta during WY 2020**.

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-produced juvenile winter-run Chinook salmon, as both are necessary components of the population for survival and recovery of the species. The authorized incidental take for naturally-produced winter-run Chinook salmon has been established in the CVP/SWP operations Opinion as 2 percent of the JPE to allow for errors in fish identification due to use of the LAD criteria to determine Chinook salmon race (*i.e.*, differentiating from fall-run, late-fall run, and spring-run Chinook salmon). As in WY 2019, genetic race identification will be used in WY 2020. The use of genetic data to determine race of juvenile Chinook salmon observed at the CVP/SWP Delta fish facilities eliminates the uncertainty that was included in previous annual incidental take limits for winter-run Chinook salmon. Therefore, the authorized level of incidental take (*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, 2019, through June 30, 2020, is set at 1 percent of the JPE, or **8,549 natural-origin (non-clipped)** winter-run Chinook salmon. In addition, the incidental take for hatchery-origin winter-run Chinook salmon is set at 1 percent of each hatchery JPE (*i.e.*, Sacramento River and Battle Creek releases). Therefore the incidental take for juveniles released from LSNFH into the Sacramento River is **945 hatchery-produced (adipose fin clipped)** winter-run Chinook salmon, and the incidental take of juveniles released into Battle Creek is **673 hatchery produced (adipose fin clipped and left ventral fin clipped)** winter-run Chinook salmon.

The JPE is high enough that the older juvenile Chinook salmon loss density based triggers used for Old and Middle River flow management Reasonable and Prudent Alternative Action IV.2.3 established in the CVP/SWP operations Opinion would be above the maximum of **8 older juvenile Chinook salmon per thousand acre-feet (TAF) of water exported for the first stage trigger and 12 older juvenile Chinook salmon per TAF of water exported for the second stage trigger.** If the first and second stage triggers were calculated based on the BY 2019 JPE, the first stage trigger would be 8.55 [(854,941 x 2 percent)/ 2,000 = 8.55] fish per TAF and the second stage trigger 17.10 [(854,941 x 2 percent)/1,000] fish per TAF. When applying rapid

genetic analysis protocol, the JPE-based triggers are calculated based on 1 percent of the winter-run JPE. For genetic winter-run Chinook salmon, the first stage trigger would be exceeded at 4.27 fish per TAF and the second stage trigger would be exceeded at 8.55 fish per TAF.

The initial identification of naturally-produced (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. As additional information becomes available through genetic analysis of tissue samples and other fisheries monitoring programs (*e.g.*, continued acoustical tag studies) in the Central Valley, estimates of the incidental take at the CVP/SWP Delta fish facilities may be adjusted, if deemed scientifically sound by NMFS. NMFS will continue to monitor daily 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 Delta Operations for Salmonids and Sturgeon technical team, the Water Operations Management Team, and fish agency coordination.

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 2020 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 2020 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,

Maria Rea
Assistant Regional Administrator
California Central Valley Office

Enclosures:

1. CDFW letter with winter-run escapement estimate for BY 2019, dated December 2, 2019
2. Winter-Run Project Work Team letter to NMFS, dated January 23, 2020

cc: Copy to file: ARN 151422SWR2006SA00268

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References Cited

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U.S. Fish and Wildlife Service (USFWS). 2020. Biweekly Report of Passage at Red Bluff Diversion Dam (January 1, 2020 - January 14, 2020). Red Bluff Fish and Wildlife Office. Available at https://www.fws.gov/redbluff/RBDD%20JSM%20Biweekly/2020/Biweekly20200101-20200114.pdf.

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CHARLTON H. BONHAM, Director

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December 2, 2019

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 2019

Dear Mr. Thom:

The California Department of Fish and Wildlife (CDFW) has developed Sacramento River winter-run Chinook Salmon escapement estimates for 2019. 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)	**7,852**
Estimated In-river Escapement (hatchery origin)	**2,873**
Estimated Number of In-river Spawning Females (hatchery and natural origin)	**4,947**

These estimates include only naturally spawning winter-run Chinook Salmon in the upper Sacramento River. An additional **180** winter-run Chinook Salmon were collected at the Keswick Dam trap site for spawning at Livingston Stone National Fish Hatchery. The total 2019 Sacramento River winter-run spawning escapement estimate, including in-river spawners and fish collected for hatchery broodstock, is **8,033** fish. The 90% confidence interval on this total escapement estimate is **7,213 to 8,852** fish.

The total escapement estimate includes one female carcass that was 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. No winter-run Chinook Salmon carcasses from Battle Creek were recovered during the carcass survey.

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 2012-2019 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 2019 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,

Kevin Shaffer, Fisheries Branch Chief

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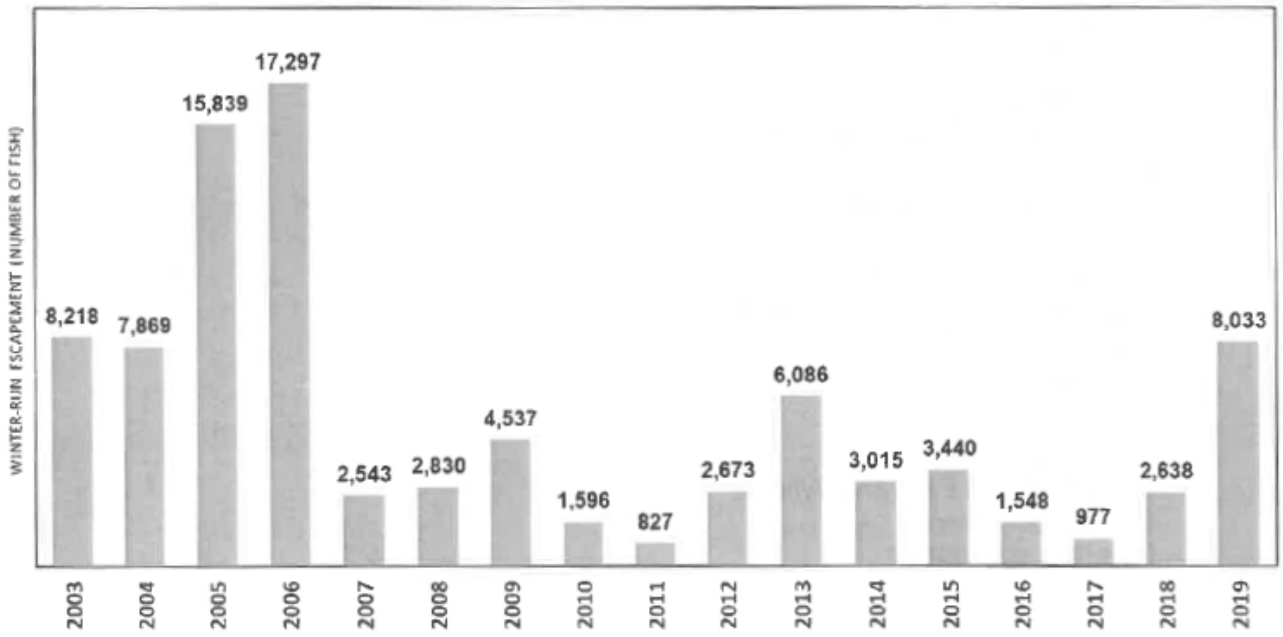

Figure 1. Estimated escapement of Winter-run Chinook Salmon to the Upper Sacramento River Basin, 2003-2019. Data compiled from GrandTab (CDFW 2019; https://www.dfg.ca.gov/fish/Resources/Chinook/CValleyAssessment.asp). Data for 2009-2019 are preliminary and subject to change.

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January 23, 2020

Mr. Garwin Yip
National Marine Fisheries Service
California Central Valley Office
650 Capital Mall, Suite 5-100
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WINTER-RUN JUVENILE PRODUCTION ESTIMATES (JPE) FOR 2020

Dear Mr. Yip:

In 2013, the Interagency Ecological Program's Winter-Run Project Work Team (Winter-Run PWT) recommended that the National Marine Fisheries Service (NMFS) Juvenile Production Estimate (JPE), which is used to calculate the incidental take limit of winter-run Chinook Salmon in the Delta at the State Water Project and Central Valley Project export facilities, be revisited annually and updated as needed with any new or improved information. A subgroup of the Winter-Run PWT met in December 2019 to review the factors used to calculate the brood year (BY) 2019 JPE. The Winter-Run PWT's recommendations resulting from this review are described below.

JPE Recommendations

The Winter-Run PWT identified several factors in calculating the JPE that we advise be continued or updated for BY 2019. We considered two methods for forecasting natural-origin JPE, consistent with the approaches used in the past as well as those described in O'Farrell *et al.* (2018). Both methods use the same general form and data inputs, but they differ in complexity and whether and how they quantify uncertainty. The need to demonstrate uncertainty was recommended during science reviews, but the utilization of uncertainty by water managers has been regarded as too complex for day-to-day operations. Although both methods are described in this letter, a single methodology (Method 2) is being recommended by the Winter Run PWT.

The data inputs for the calculations include estimates of the following parameters for calculating JPE for natural-origin BY 2019 winter-run Chinook ($JPE_{Natural}$)(Figure 1):

1) Number of winter-run fry 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)($Survival_{Smolt}$)

Additionally, we used the number of winter-run hatchery smolts expected to be released in February 2020 ($N_{Hatchery}$) and their predicted survival rate ($Survival_{HatcherySmolt}$) to estimate a JPE of hatchery-origin winter-run juveniles in the Delta ($JPE_{Hatchery}$) using both methods (Figure 1). We present the data inputs used in the calculations in Table 1 and describe each in the sections below.

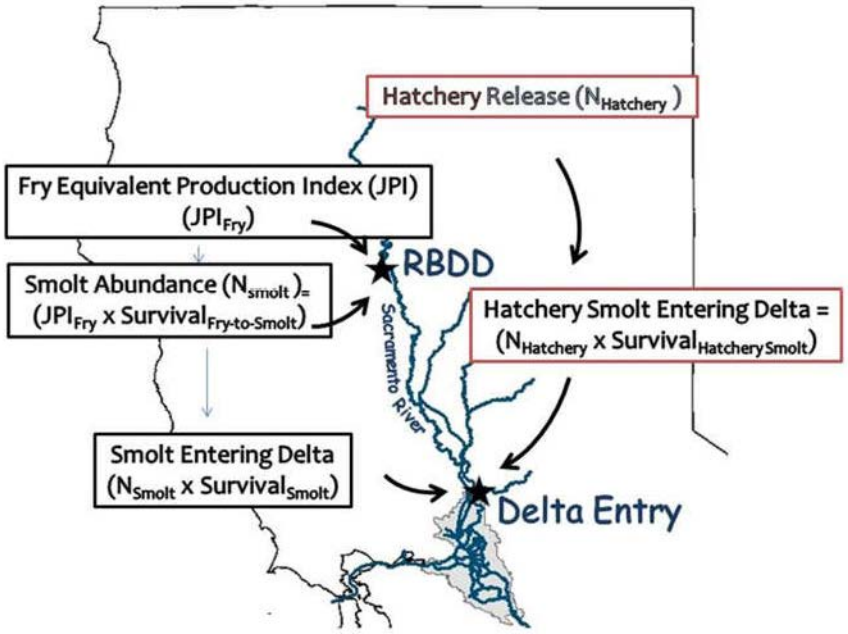

Figure 1 - Location and formulas recommended for use in the JPE for the wild (black boxes) and hatchery (red boxes) components of the winter-run population estimated for 2019-2020

Winter Run JPE Methodologies Considered for 2019-2020

The Winter-Run PWT considered two similar methodologies for estimating the JPE for 2019-2020. Method 1 is the method that has been used in recent years, and we recommend updating several terms if this method is used for the 2019-2020 estimate. Method 2 has similar structure, but it forecasts the smolt survival rate differently than Method 1 and accounts for observation error when making the JPE forecast (see O'Farrell *et al.* 2018). After review of both methods, the Winter-Run PWT recommends using Method 2 to forecast the JPE for 2019-2020. Both methods and their inputs are described below.

Juvenile Production Index - For the BY 2019 JPE, the Winter-Run PWT continues to recommend using the Juvenile Production Index (JPI_{Fry} or JPI), which is based on 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.

Table 1 – Factors in the Juvenile Production Estimate and the resulting estimates for 2019-2020 using two alternative methods

	Method 1		Method 2	
Component	Natural	Hatchery	Natural	Hatchery
Total in-river escapement[1]	7,852		7,852	
Adult female estimate (AFE)[2]	4,947		4,947	
AFE minus pre-spawn mortality[3] (1.3%)	4,883		4,883	
Average fecundity[4]	5,424		5,424	
Total viable eggs	26,485,392		26,485,392	
Estimated egg-to-fry survival based on JPI at RBDD/Total viable eggs[5]	0.1798		0.1798	
Fry equivalents of juvenile production at RBDD (JPI or JPI_{Fry})[6]	4,762,142		4,762,142	
Fry-to-smolt survival estimates from October (peak) to February at RBDD ($Survival_{Fry\text{-}to\text{-}Smolt}$)[7]	0.4651		0.4651	
Number of smolts at RBDD	2,214,872		2,214,872	
Estimated smolt survival term: RBDD to Delta[8] ($Survival_{Smolt}$)	0.4762		0.3860	
Total natural production entering the Delta (JPE)	1,054,722		854,941	
JPE 95 percent confidence interval	NA		301,002 – 1,408,880	
LSNFH Hatchery release ($N_{Hatchery}$)[9]		256,381		256,381
Survival rate from release to Sacramento ($Survival_{Hatchery}$)		0.3861		0.3687
Total hatchery production entering the Delta[10]		98,989		94,528

1/ Total 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, and the number of males is derived using sex ratio at Keswick trap.

3/ Pre-spawn mortality was estimated from carcass surveys of females (CDFW).

4/ Preliminary (subject to change) average number of eggs per female from 56 female fish spawned at LSNFH (unpublished data).

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 0.4651 fry-to-smolt survival rate estimate based on method described in O'Farrell *et al.* (2018).

6/ Preliminary number of fry equivalents estimated on December 31, 2019 plus 3.1% interpolation to account for remainder of estimated passage for the 2019 brood year at RBDD; using 0.4651 fry-to-smolt survival rate estimate (Bill Poytress, USFWS, pers. comm.).

7/ Estimate of fry-to-smolt survival rate based on O'Farrell *et al.* (2018).

8/ Variance-weighted mean survival rate of acoustically tagged winter-run from 2013 to 2019 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 acoustic tag studies. See Smolt Survival section for an explanation of the different values displayed here.

9/ Estimated LSNFH production release as of December 31, 2019 (100% tagged and adipose clipped). Up to 1,500 juveniles may be retained as broodstock or to conduct fish health assessments.

10/ Variance-weighted mean survival rate of acoustically tagged winter-run from 2013 to 2019 between release location 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 ($Survival_{Fry\text{-}to\text{-}Smolt}$) based on the peak of fry catch at RBDD (generally in October) and the smolt life-stage at RBDD for naturally produced winter-run. 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, survival from fry to smolts is assumed to be 100 percent, which is unrealistic

The Winter-Run PWT continues to have reservations about the fry-to-smolt survival rate value of 0.59 that has been used since 1993 as a surrogate for winter-run fry-to-smolt survival. This value was based on previous studies of fall-run Chinook salmon by Hallock (undated) and confirmed through a literature review in 1995 (B. Poytress, USFWS, personal communication). As an alternative, we reviewed a fry-to-smolt survival rate forecasting method developed by O'Farrell *et al*. (2018), which uses more recent winter-run Chinook survival data and is updated with new survival data annually. Using updated survival rate estimates, this method results in a winter run fry-to-smolt survival rate of 0.4651 for BY 2019. The team recommends using this forecasting method to estimate fry-to-smolt-survival in calculations of JPE and updating the fry equivalent multiplier to 2.150. (The factor 2.150 is the inverse of 0.4651; the previous multiplier of 1.7 was calculated as the inverse of 0.59.) This represents an important change from the fry-to-smolt survival rate previously recommended by the PWT and used in Method 1 in O'Farrell *et al*. (2018). These new values are reflected in the data presented in Table 1 and used for both Methods 1 and 2. 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 previously.

Fry Production - The JPI seasonal fry-equivalent estimate using the updated 0.4651 fry-to-smolt survival rate was 4,614,516 as of December 31, 2019 (week 52; B. Poytress, USFWS, personal communication). The value through December 31 accounts for approximately 96.9 percent of annual winter-run passage at RBDD based on data collected from 2002 to 2018. Including an interpolation of the remaining 3.1 percent for the remainder of BY 2019, the total BY 2019 estimate is 4,762,142 fry equivalents (Table 1). This value accounts for in-season winter-run genetic and trap efficiency corrections, which have a modest effect on the estimate. With this estimate of fry production at RBDD, the estimated egg-to-fry survival is calculated to be 0.1798 (Table 1).

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 2019.

Method 1 and Method 2 use different methods for forecasting the smolt survival rate (see O'Farrell et. al 2018). Method 1 uses a binomial model to estimate annual survival rates

and variances. Because Method 1 does not account for detection probabilities, it can underestimate the number of fish arriving to RBDD and thus overestimate smolt survival. Method 1 also understates the uncertainty associated with each estimate because the variance calculations do not directly account for detection probabilities. Method 2 uses the Cormack-Jolly-Seber model to estimate annual survival rates, which accounts for variation in detection probabilities. To estimate survival of naturally produced winter-run smolts in 2020, application of Method 1 and Method 2 results in mean survival rates of 0.4762 and 0.3860, respectively.

Hatchery Smolt Survival - The Winter-Run PWT recommends updating the term used to estimate survival of hatchery-produced winter-run ($Survival_{HatcherySmolt}$) for both methods (Table 1). For Methods 1 and 2, the variance-weighted mean of survival rates is 0.3861 and 0.3687, respectively. This survival rate is the full migration survival for acoustically tagged hatchery smolts from the release point (approximately 60 miles upstream of the RBDD) to the Delta from 2013-2019 and is therefore lower than the one used for naturally produced smolts at RBDD.

Winter Run PWT Recommended Method for 2019-2020

The Winter Run PWT recommends that Method 2 be used for estimating the BY 2019 natural-origin (Equation 1) and hatchery-origin (Equation 2) JPE:

Equation 1:

$$JPE_{Natural} = JPI_{Fry} \times Survival_{Fry-to-Smolt} \times Survival_{Smolt}$$

$$= 4{,}762{,}142 \times 0.4651 \times 0.3860 = 854{,}941$$

Equation 2:

$$JPE_{Hatchery} = N_{Hatchery} \times Survival_{HatcherySmolt}$$

$$= 256{,}381 \times 0.3687 = 94{,}528$$

It is the opinion of the Winter Run PWT that Method 2 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 (Table 1). 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. This is an advantage of Method 2 over Method 1 and methods recommended in previous years.

The Winter Run PWT believes this recommendation to be the best information currently available from which to derive a JPE. We hope this analysis and these technical recommendations from the Winter-Run PWT will help improve the JPE and the accuracy of the incidental take limit for water year 2019-2020 at the Central Valley Project and State Water Project export facilities.

Sincerely,

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References

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