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 20, 2023

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) 2022 expected to enter the Sacramento-San Joaquin Delta (Delta) during water year (WY) 2023. This juvenile production estimate (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 for natural origin winter-run Chinook salmon and hatchery winter-run Chinook salmon 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).

Incidental Take Limits

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 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 winter-run Chinook salmon is 0.8% of the estimated hatchery JPE 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 winter-run Chinook salmon is 0.8% of the estimated hatchery JPE from LSNFH released into Battle Creek on a three-year rolling average or 1.0% of the JPE in any single year.

JPE Estimates

A technical team from the Interagency Ecological Program (IEP), the Winter-run Project Work Team (WRPWT), met in December 2022 and January 2023, and provided recommendations to NMFS and the California Department of Fish and Wildlife (CDFW, Enclosure 1) on January 13, 2023. The process for developing the BY 2022 JPE was similar to what was done for BY 2021. The natural-origin JPE calculation is a function of the estimated number of fry-equivalents passing the Red Bluff Diversion Dam (RBDD), fry-to-smolt survival rates, and in-river smolt survival from RBDD to the Delta.

The hatchery-origin JPE calculations are a function of the estimated number of smolts that will be released into the river (either the Sacramento River near Redding or Battle Creek), and in-river smolt survival from the release point to the Delta. The method used by the WRPWT to calculate the BY 2022 JPE for natural-origin and hatchery winter-run Chinook salmon is detailed in Enclosure 1, and was adopted without modification by NMFS.

The **JPE for BY 2022 natural-origin winter-run Chinook salmon juveniles is 49,924.** The incidental take limit for natural origin winter-run Chinook salmon is 2,189, based on a three-year rolling average loss[1], or 998 (2% of 49,924) for single year loss during WY 2023, whichever is lower. Therefore, the incidental take limit for natural origin winter-run Chinook salmon is 998 (based on loss of length-at-date winter-run Chinook salmon).

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 2022 hatchery-produced (adipose fin-clipped) winter-run Chinook salmon juveniles released from LSNFH into the Sacramento River is 190,956** (estimated release of 741,000 juveniles). The incidental take limit for hatchery-produced winter-run Chinook salmon juveniles released from LSNFH into the Sacramento River is 1,174, based on a three-year rolling average loss[2] or 1,910 (1% of 190,956) for single year loss during WY 2023, whichever is lower. Therefore, the incidental take limit for LSNFH-produced winter-run Chinook salmon released into the Sacramento River is 1,174. The **JPE for BY 2022 hatchery-produced (adipose fin clipped and left ventral fin clipped) winter-run Chinook salmon juveniles released from LSNFH into Battle Creek is 3,976** (estimated release of 193,000 juveniles). The incidental take limit for hatchery-produced winter-run Chinook salmon juveniles released from LSNFH into Battle Creek is 129, based on a three-year rolling average annual loss[3] or 40 (1% of 3,976) for single year loss during WY 2023, whichever is lower. Therefore, the incidental take limit for LSNFH-produced winter-run Chinook salmon released into Battle Creek is 40.

Status of Winter-Run Chinook Salmon

Captive Broodstock Program: Juvenile winter-run Chinook salmon experienced very low survival in BY 2014 and BY 2015, and again in BY 2020 and BY 2021, due to drought

[1] 3-year rolling average loss of natural length-at-date winter-run Chinook salmon is 1.3% of the 3-year JPE average, so 1.3% * [(BY 2020 JPE 330,130+BY 2021 JPE 125,038+BY 2022 JPE 49,924)/3] = 2,189.
[2] 3-year rolling average loss of Sacramento River-released winter-run Chinook salmon is 0.8% of the 3-year JPE average, so 0.8% * [(BY 2020 JPE 97,888+BY 2021 JPE 151,544+BY 2022 JPE 190,956)/3] = 1,174.
[3] 3-year rolling average loss of Battle Creek-released winter-run Chinook salmon is 0.8% of the 3-year JPE average, so 0.8% * [(BY 2020 JPE 37,232+BY 2021 JPE 7,311+BY 2022 JPE 3,976)/3] = 129.

conditions causing unfavorable temperatures in the spawning grounds. CDFW, NMFS, and the U.S. Fish and Wildlife Service (USFWS) responded to the earlier drought 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).

Remote Broodstock Program: In addition to the broodstock at LSNFH, NMFS and USFWS established a new captive broodstock at a location separate from the hatchery this year. This was done to provide a backup population and ensure the survival of this year-class in the event of a catastrophic event at LSNFH. Eyed winter-run Chinook salmon eggs or fry from LSNFH were transferred to a facility at the University of California at Davis to rear until at least the end of March 2023, with the potential of extending that through August 2025. A total of 1,430 winter-run Chinook salmon eggs and fry were transferred to initiate this new captive broodstock.

Battle Creek Jumpstart: 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. These 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 use, and survival.

BY 2022 conditions: Similar to BY 2020 and BY 2021, BY 2022 was affected by a thiamine deficiency in returning adults. While the thiamine deficiency was addressed in the BY 2022 hatchery stock, it is expected that BY 2022 naturally-spawning winter-run Chinook salmon adults with low thiamine levels spawned eggs low in thiamine which likely resulted in a decreased number of successful fry upstream of RBDD. Collaborative efforts and reduced diversions allowed Sacramento River water temperatures to be managed more protectively for winter-run Chinook salmon eggs, resulting in more than 80 percent of eggs survival despite the warm and dry conditions this year. BY 2022 was also subject to low flows and low turbidity due to the overall dry hydrology and associated operational decisions in WY 2022. Approximately 214,667 BY 2022 juvenile winter-run Chinook salmon were estimated to pass RBDD from BY 2022, compared to 570,000 from BY 2021 and 2.1 million juveniles from BY 2020. Because of recent precipitation events occurring at the end of calendar year 2022 and beginning of calendar year 2023, outmigrating juveniles this water year are expected to have improved in-river conditions compared to previous recent years. Efforts such as reintroduction into historical habitat and ongoing research on thiamine deficiency and treatments will help improve the long-term security of the species.

BY 2022 Escapement: Escapement information was provided to NMFS via a December 13, 2022, letter (Enclosure 2). The CDFW estimate for total adult winter-run Chinook salmon escapement in 2022 was 5,927 spawners. Of this total number of spawners, 484 were collected at the Keswick Dam trap site for spawning at LSNFH, leaving an estimated 5,443 to spawn naturally in-river. The number of adult spawners in 2022 was lower than in the previous few years (Figure 1). The cohort replacement rate (CRR), which is a measure of the population's growth rate, was trending negative this year (*i.e.,* 0.74), meaning the population is not currently replacing itself (Figure 2).

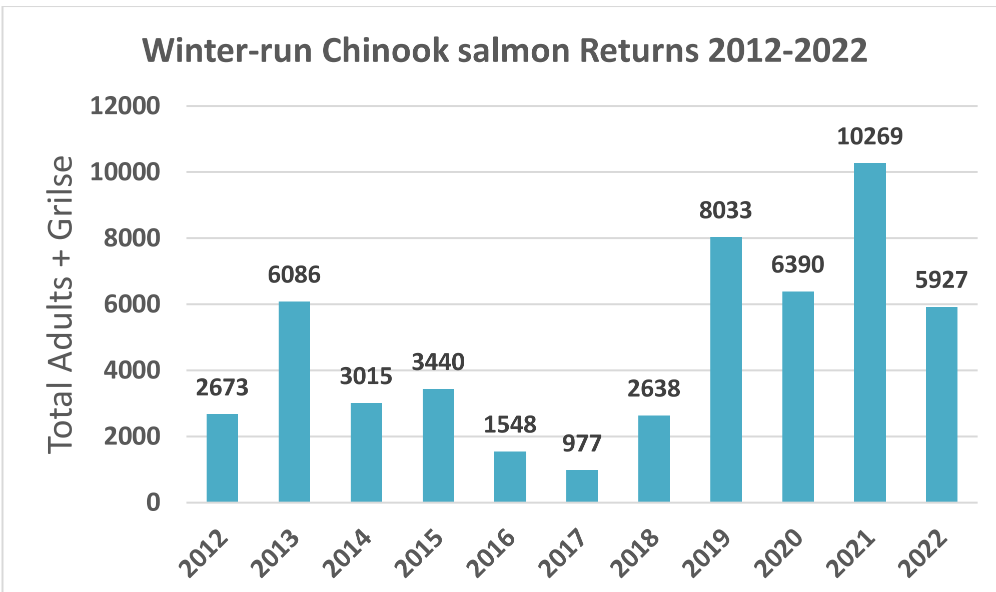

Figure 1. Winter-run Chinook Salmon Spawning Escapement 2012-2022 (CDFW 2022 and Enclosure 2).

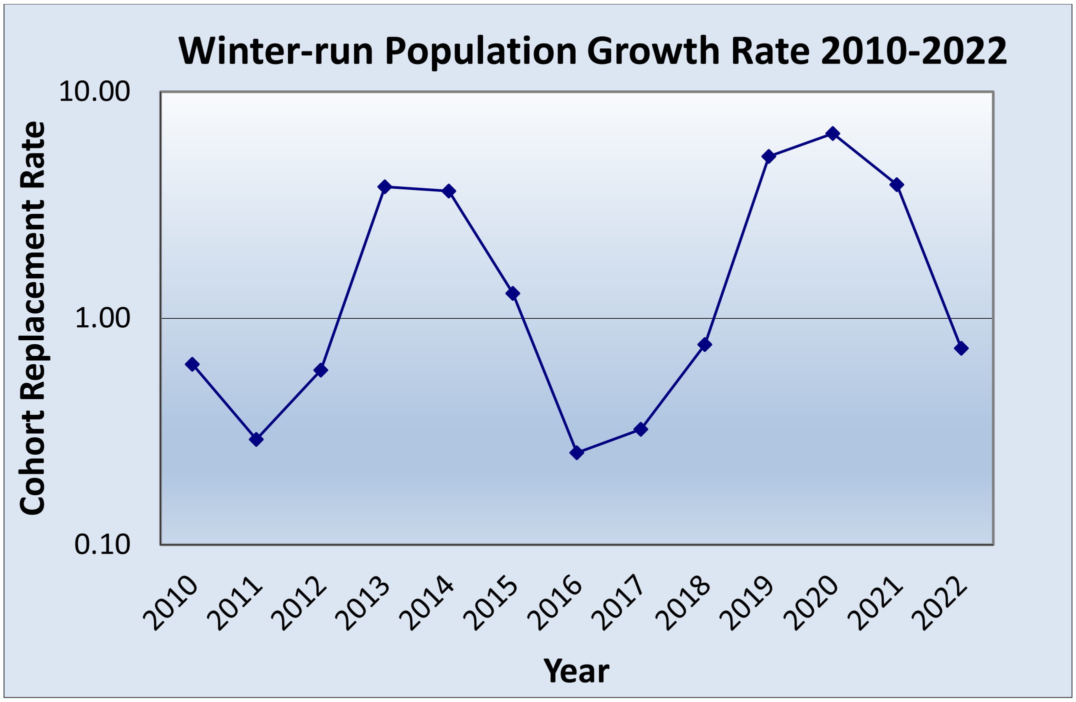

Figure 2. Cohort replacement rate for winter-run Chinook salmon 2010–2022 (CDFW 2022).

BY 2022 Egg-to-Fry Survival: The estimated egg-to-fry survival rate has ranged from 2.17 percent to 49 percent from BY 2005 to BY 2022, with an average of 21 percent (see Figure 3). BY 2022 egg-to-fry survival rate is estimated at 2.17 percent.

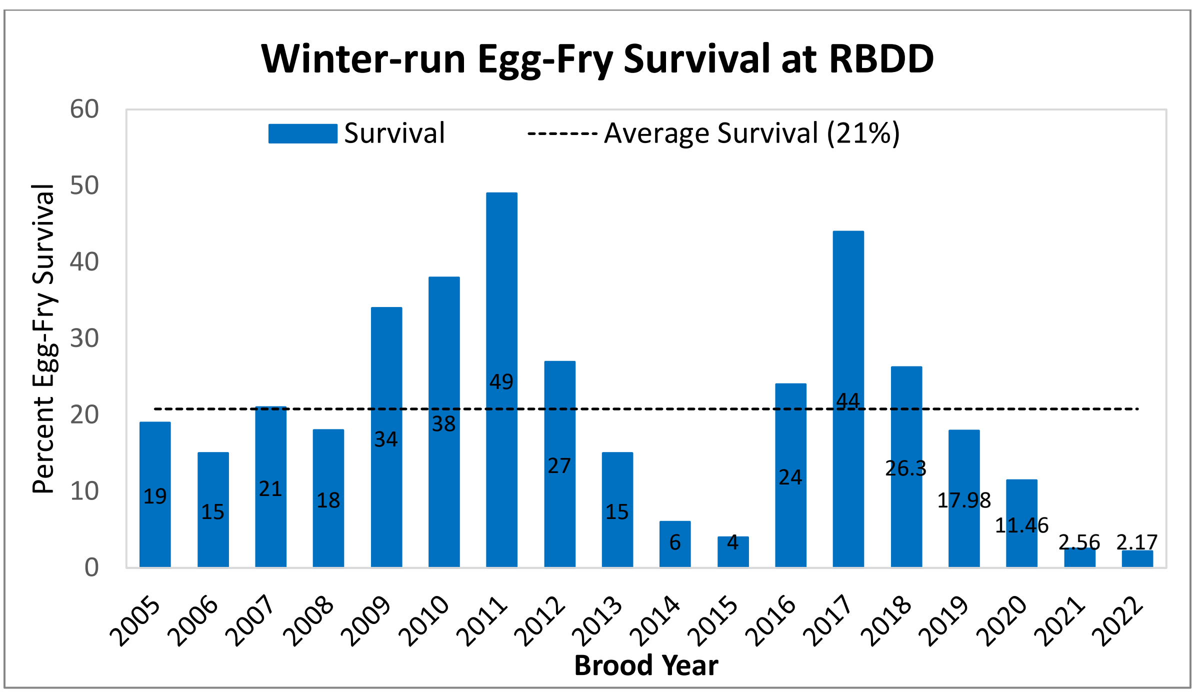

Figure 3. Winter-run egg-to-fry survival estimated at Red Bluff Diversion Dam 2005-2022 (Poytress et al. 2014, Voss and Poytress 2020, and Enclosure 1)

NMFS will continue to monitor loss of winter-run Chinook salmon and other ESA-listed species at the CVP/SWP Delta fish facilities, through participation in the Salmon Monitoring Team technical team and the Water Operations Management Team.

Ongoing research using acoustically-tagged winter-run Chinook salmon (both hatchery and wild) is necessary to provide updated estimates of in-reach survival of winter-run Chinook salmon in the Sacramento River. We recommend that funding continues for acoustic tag studies on winter-run Chinook salmon for BY 2023 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 2023 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. Winter-Run Project Work Team letter to NMFS, dated January 13, 2023
2. CDFW letter with winter-run escapement estimate for BY 2022, dated December 13, 2022

cc: Copy to file: ARN 151422SWR2006SA00268

Electronic copy only:

Bill Poytress, USFWS, bill_poytress@fws.gov
Kaylee Allen, USFWS, kaylee_allen@fws.gov
Brooke Jacobs, CDFW, brooke.jacobs@wildlife.ca.gov
Erica Meyers, CDFW, erica.meyers@wildlife.ca.gov
Doug Killam, CDFW, doug.killam@wildlife.ca.gov
Dan Kratville, CDFW, daniel.kratville@wildlife.ca.gov
Johnathan Nelson, CDFW, jonathan.nelson@wildlife.ca.gov
Kevin Reece, DWR, kevin.reece@water.ca.gov
Farida Islam, DWR, farida.islam@water.ca.gov
Molly White, DWR, molly.white@water.ca.gov
Nick Bertrand, Reclamation, nbertrand@usbr.gov

DocuSign Envelope ID: DBC992AE-431D-49E5-8338-1C52AB73027A

Salmon carcass identified by a coded wire tag was recovered during the Sacramento River carcass survey and was 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 2012-2022 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 2022 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. Tracy Grimes at Tracy.Grimes@wildlife.ca.gov.

Sincerely,

DocuSigned by:
Jay Rowan
2113A9B7822F42D...

Jay Rowan, Fisheries Branch Chief

cc: Ms. Cathy Marcinkevage
Assistant Regional Administrator
National Marine Fisheries Service
cathy.marcinkevage@noaa.gov

Mr. Paul Souza
Pacific SW Regional Director
U.S. Fish and Wildlife Service
paul_souza@fws.gov

Mr. Garwin Yip
National Marine Fisheries Service
garwin.yip@noaa.gov

Mr. Jeffrey McLain
U.S. Fish and Wildlife Service
jeffrey_mclain@fws.gov

Mr. Matt Brown
U.S. Fish and Wildlife Service
matt_brown@fws.gov

Mr. Jason Roberts
jason.roberts@wildlife.ca.gov

Mr. Jonathan Nelson
jonathan.nelson@wildlife.ca.gov

Mr. Michael Harris
michael.r.harris@wildlife.ca.gov

Mr. Peter McHugh
peter.mchugh@wildlife.ca.gov

Mr. Rob Titus
rob.titus@wildlife.ca.gov

Mr. Michael Lacy
michael.lacy@wildlife.ca.gov

Mr. Douglas Killam
doug.killam@wildlife.ca.gov

References Cited

California Department of Fish and Wildlife (CDFW). 2022. Unpublished data, GrandTab Spreadsheet of Adult Chinook Escapement in the Central Valley, 7/20/2022. 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. 2018. 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

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 U.S. Bureau of Reclamation.

U.S. Fish and Wildlife Service (USFWS). 2023. Biweekly Report of Passage at Red Bluff Diversion Dam (December 17, 2022 - December 31, 2022). Red Bluff Fish and Wildlife Office. Available at Juvenile Salmonid Monitoring at RBDD

Voss, S. D., and W. R. Poytress. 2020. Brood year 2018 juvenile salmonid production and passage indices at the Red Bluff Diversion Dam. Report of U.S. Fish and Wildlife Service to U.S. Bureau of Reclamation, Sacramento, California.

January 13, 2023

Mr. Garwin Yip
National Marine Fisheries Service
California Central Valley Office
650 Capitol Mall, Suite 5-100
Sacramento, CA 95814

Dr. Brooke Jacobs
California Department of Fish and Wildlife
Chief, Water Branch
P.O. Box 944209
Sacramento, CA 94244-2090

Final Winter-Run Juvenile Production Estimate Recommendation for Brood Year 2022

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 National Marine Fisheries Service (NMFS) Juvenile Production Estimate (JPE) be revisited annually and updated as needed with any new or improved information. The annual JPE is used to calculate loss thresholds for Long-Term Operation of the Central Valley Project and the State Water Project, as described in the U.S. Bureau of Reclamation's biological assessment (Reclamation 2019) and the NMFS Biological Opinion, No. WRCO-2016-00069 (2019 NMFS BiOp), and required by CDFW Incidental Take Permit No. 2081-2019-066-00. A subgroup of the Winter-Run PWT met three times in December 2022 to review and update the factors used to calculate the brood year (BY) 2022 JPE, and to develop a recommended draft winter-run JPE for BY 2022. The final JPE recommendation includes data through December 31, 2022 and was approved at the Winter-Run PWT meeting on January 12, 2023. 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 2022. We considered one method for forecasting natural-origin JPE—The "Method 2" approach used for the BY 2019, 2020, and 2021 JPEs and described in O'Farrell et al. (2018). The data inputs for the calculations include estimates of the following parameters for calculating the JPE for natural-origin BY 2022 winter-run Chinook Salmon ($JPE_{Natural}$) (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 2023 ($N_{Hatchery}$) 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 third year in a row, we also include estimates 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 some natural spawning in Battle Creek in 2022, we do not differentiate naturally produced juveniles from Battle Creek from Sacramento River juveniles, and both are included in the JPI_{Fry}. Similarly, approximately 1,638 unmarked juveniles from the McCloud River were transported and released below Keswick Dam and would have been sampled and estimated along with the naturally produced juveniles (JPI_{Fry}). The Winter-Run PWT recognizes that, as these new populations become established, differentiating production sources will become more relevant. At this time, these new populations represent a very small (estimated <1%) fraction of total production.

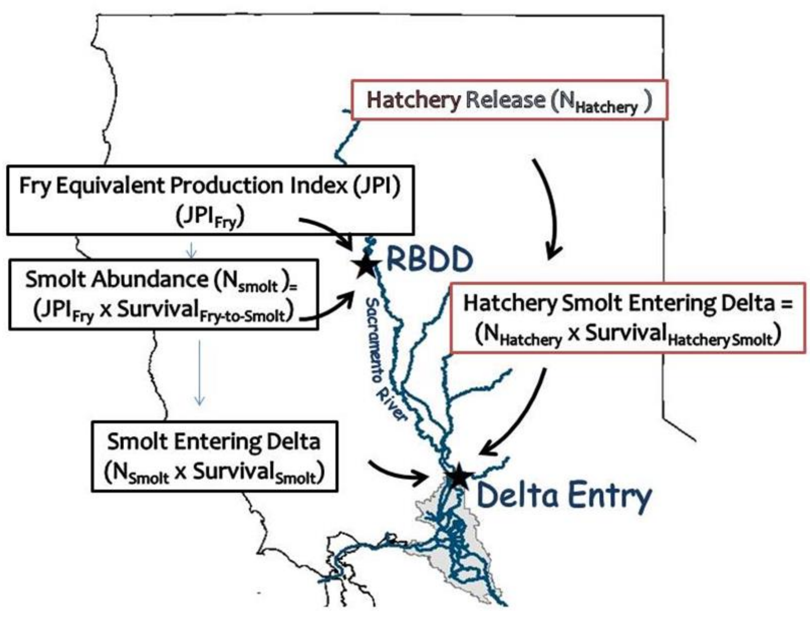

Figure 1. Location and formulas recommended for use in the JPE for the natural-origin (black boxes) and hatchery-origin (red boxes) components of the winter-run population estimated for BY 2022. Separate hatchery JPEs are estimated for hatchery releases from LSNFH into the Sacramento River ($N_{Hatchery}$) and for the Battle Creek Jumpstart hatchery releases into Battle Creek (not shown).

Winter-Run JPE Methods for 2022-2023

The Winter-Run PWT focused on a single method for forecasting the JPE for BY 2022. This method, recommended in O'Farrell et al. (2018), has been the method used since BY 2019 and has been the only method considered since BY 2020. It is the opinion of the Winter-Run PWT that this method represents the best available science for estimating an annual JPE given currently available data.

Juvenile Production Index - For the BY 2022 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. This is of particular importance this year, as the JPI approach at least partially accounts for lower than average egg-to-fry survival in naturally spawned winter-run Chinook Salmon expected for BY 2022 due to factors including thiamine deficiency and temperature-related mortality.

In July 2022, the USFWS updated the least-squares regression model used to estimate trap efficiency and expand rotary screw trap (RST) catch to estimate the JPI. The updated 39-trial model incorporated efficiency trials conducted in 2021 (n=1; winter-run) and 2022 (n=6; fall-run) to the previous year's model fitted to data from 2020 using the current trap configuration (four 5-ft and one 8-ft diameter RST). Additionally, trials (n=15) from 2018 and 2019 conducted with the prior four 8-ft trap configuration using primarily winter-run Chinook Salmon were included in this model. This dataset is considered the best available to estimate winter-run production from catch.

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 Salmon.

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 0.4946 for BY 2022. The team recommends using this forecasting method to estimate fry-to-smolt survival in calculations of JPE and updating the fry equivalent multiplier to 2.022 (the factor 2.022 is the inverse of 0.4946). 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 Salmon data, improve the JPE forecast compared to values used prior to 2019.

Fry Production - The JPI seasonal estimate of fry equivalents using the 0.4946 fry-to-smolt survival rate was 302,659 as of December 31, 2022 (week 52; B. Poytress, USFWS, pers. comm.). The value through December 31 accounts for approximately 97.30 percent of annual winter-run passage at RBDD based on mean passage from 2002 to 2021. Including an interpolation of the remaining 2.70 percent to account for the remainder of BY 2022, the total BY 2022 estimate is 311,058 fry equivalents (Table 1). This value accounts for in-season winter-run genetic corrections, which have a minimal effect on the estimate. With this estimate of fry production at RBDD, the estimated egg-to-fry survival is calculated to be 0.0217 (Table 1).

Natural-origin Smolt Survival - To estimate 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) ($Survival_{Smolt}$), the Winter-Run PWT recommends using the variance-weighted mean of survival estimates from acoustically tagged LSNFH smolts released in 2013–2022, as described in O'Farrell et al. (2018). This calculation is updated each year to incorporate survival and variance estimates from the previous year and uses the Cormack-Jolly-Seber model, which accounts for variation in detection probabilities. The estimated annual survival rate using this method is 0.3245. The filtering algorithm used to process receiver detection data is described in Danner and Ammann (2021).

Hatchery Smolt Survival – To estimate survival of hatchery-produced winter-run released in the Sacramento River near Redding ($Survival_{HatcherySmolt}$), we recommend using the variance-weighted mean of 2013–2022 survival rates from the LSNFH release point to the Delta. This survival rate is 0.2577. For hatchery-produced winter-run released in North Fork Battle Creek ($Survival_{BCJumpstart}$), we recommend using the variance-weighted mean of 2019–2022 survival rates from the Battle Creek release point to the Delta (excluding the May 2020 release because fish size and environmental conditions did not represent expected conditions during the BY 2022 winter release). This survival rate is 0.0206. 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 and are updated annually to incorporate survival and variance estimates from the previous year.

Table 1. Reported population estimates and survival factors for brood year 2022. Factors used in the JPE calculations and the resulting JPEs are noted.

Component	Natural	Hatchery
Total Sacramento River escapement[1]	5,443	N/A
Adult female estimate (AFE)[2]	2,663	N/A
AFE minus pre-spawn mortality[3] (2.1%) ($N_{Spawners}$)	2,607	N/A
Average fecundity[4] (AF)	5,505	N/A
Total eggs	14,351,535	N/A
Estimated egg-to-fry survival rate based on JPI at RBDD/Total eggs[5]	0.0217	N/A
Fry equivalents of juvenile production at RBDD (JPI or JPI_{Fry})[6] JPE	**311,058**	N/A
Fry-to-smolt survival ($Survival_{Fry-to-Smolt}$)[7] JPE	**0.4946**	N/A
Number of smolts at RBDD	153,849	N/A
Estimated smolt survival term: RBDD to Delta ($Survival_{Smolt}$)[8] JPE	0.3245	N/A
Total natural production entering the Delta (JPE) JPE	49,924	N/A
JPE 95 percent confidence interval	32,298 – 67,550	N/A
N/A	N/A	N/A
LSNFH Hatchery release ($N_{Hatchery}$)[9]	N/A	741,000
Survival rate from release to Sacramento ($Survival_{HatcherySmolt}$)[10] JPE	N/A	0.2577
Total LSNFH production entering the Delta JPE	N/A	190,956
N/A	N/A	N/A
Battle Creek Hatchery release ($N_{BCJumpstart}$)[11] JPE	N/A	193,000
Survival rate from release to Sacramento ($Survival_{BCJumpstart}$)[12] JPE	N/A	0.0206
Total Jumpstart production entering the Delta JPE	N/A	3,976

[1] Total Sacramento River in-river escapement from CDFW Cormack-Jolly Seber (CJS) model includes natural- and hatchery-origin winter-run Chinook Salmon, 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 Chinook Salmon in Battle Creek are not included.

[3] Pre-spawn mortality was estimated from carcass surveys of females (Doug Killam, CDFW, pers. comm.).

[4] Preliminary (subject to change) average number of eggs per female from fish spawned (n=169) at LSNFH (Kaitlin Dunham, 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 0.4946 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, 2022 plus 2.70% interpolation to account for remainder of estimated passage for the 2022 brood year at RBDD; using 0.4946 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), updated using data from BY 1998-2017.

[8] Variance-weighted mean survival rate of acoustically tagged hatchery winter-run Chinook Salmon from 2013 to 2022 between RBDD and I-80/Tower Bridge in Sacramento (based on O'Farrell et al. 2018). 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 12, 2023 (100% tagged and adipose clipped).

[10] Variance-weighted mean survival rate of acoustically tagged hatchery winter-run Chinook Salmon from 2013 to 2022 between release location and I-80/Tower Bridge in Sacramento (based on O'Farrell et al. 2018).

[11] Estimated Battle Creek Jumpstart release as of December 15, 2022 (100% tagged and marked).

[12] Variance-weighted mean survival rate of acoustically tagged hatchery winter-run Chinook Salmon from 2019 to 2022 between release location in North Fork Battle Creek and I-80/Tower Bridge in Sacramento (based on O'Farrell et al. 2018). The survival rate of 64 fish on released on May 18, 2020 was not included in this calculation because fish size and environmental conditions did not represent expected conditions during the BY 2022 winter release.

Discussion on low estimated egg-to-fry survival for BY 2022

The approach described above allows us to back-calculate egg-to-fry survival based on estimates of the number of successful female spawners ($N_{Spawners}$), average female fecundity (AF), and JPI, as described under "Fry Production" and in Equation 1. This calculation can be a useful metric to compare to average or expected survival in order to identify mortality occurring during egg incubation and fry emergence. Using this equation, estimated BY 2022 egg-to-fry survival for winter-run Chinook Salmon is 0.0217.

Equation 1:

$$Survival_{Egg-to-Fry} = \frac{JPI_{Fry}}{N_{Spawners} \times AF}$$

Although uncertainty exists in all three variables used to estimate egg-to-fry survival, uncertainty in female spawners and fecundity is not quantified during JPE development. Uncertainty in the JPI is quantified by 90 percent confidence intervals around the estimate of fry equivalent; based on these confidence intervals, egg-to-fry survival is estimated to be between 0.0135 and 0.0299.

Winter-run Chinook Salmon in 2022 spawned during one of the warmest and driest years on record. Average air temperatures in the Sacramento Drainage from July through September were the third highest in the last century (NOAA 2022), and streamflow was approximately one third of average flow since 1981. The NMFS model (Martin et al. 2017), estimates mean annual temperature dependent mortality of winter-run Chinook Salmon eggs at 17 percent (25–75% confidence interval of 13–29%), based on measured water temperatures and mapped winter-run Chinook Salmon spawning locations in the Sacramento River in 2022 (SWFSC 2022).

Additional early life stage mortality was likely due to thiamine deficiency complex syndrome, thought to be the result of shifts in marine forage fish species off the coast of California. Thiamine concentrations in egg samples from 28 females spawned at LSNFH in 2022 showed 93 percent of females with thiamine levels low enough (<4.9 nmol/g) that some fry mortality would be expected and 71% with critically low levels (<2.9 nmol/g) (SWFSC, pers. comm.).

These estimates of mortality related to temperature and thiamine deficiency do not completely account for the low egg-to-fry survival estimates calculated using Equation 1. There are likely other sources of mortality upstream of Red Bluff that are not accounted for in the models. Because the USFWS did not observe any abnormal fry behavior at the RBDD RSTs (B. Poytress, USFWS, pers. comm.) and pathology results of fish collected at the traps did not show abnormally high levels of pathogens (S. Foott, USFWS, pers. comm.), suggesting that any acute It is important to note that because the method used to calculate the JPE uses the JPI approach, any uncertainty due to the cause of mortality does not affect the JPE.

Winter-Run PWT Recommended Method for BY 2022

The Winter-Run PWT recommends the previously described inputs and the following equations be used for estimating the BY 2022 natural-origin (Equation 2) and hatchery-origin (Equations 3 and 4) JPE:

Equation 2:

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

$$= 311{,}058 \times 0.4946 \times 0.3245 = 49{,}924$$

Equation 3:

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

$$= 741{,}000 \times 0.2577 = 190{,}956$$

Equation 4:

$$JPE_{BCJumpstart} = N_{BCJumpstart} \times Survival_{BCJumpstartSmolt}$$

$$= 193{,}000 \times 0.0206 = 3{,}976$$

It is the opinion of the Winter-Run PWT that this method represents the best available science for estimating a JPE given currently available data. The JPE and confidence intervals account for detection probabilities and quantify uncertainty associated with estimates of JPI_{Fry}, fry-to-smolt, and smolt survival rates, which are used to develop the 95 percent confidence intervals for the JPE forecast. Because it 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 this method still has considerable uncertainty, and that confidence intervals may not have utility to water managers under the current management setting. However, there is uncertainty with any forecast method for a 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 and the best method for arriving at estimates. 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 2023 water year at the Central Valley Project and State Water Project export facilities.

Sincerely,

Winter-Run PWT

cc: Cathy Marcinkevage
Assistant Regional Administrator
National Marine Fisheries Service
cathy.marcinkevage@noaa.gov

Jay Rowan
Chief, Fisheries Branch
California Department of Fish and Wildlife
Jay.Rowan@wildlife.ca.gov

Joshua Grover
Deputy Director, Ecosystem Conservation Division
California Department of Fish and Wildlife
Joshua.Grover@wildlife.ca.gov

Bcc: Winter-Run JPE Subgroup Members

Winter-Run Project Work Team Email List

References

Danner, E. and A. J. Ammann. 2021. Annual technical report for enhanced acoustic tagging, analysis, and real-time monitoring of wild and hatchery salmonids in the Sacramento River Valley. Report from NOAA Southwest Fisheries Science Center to U.S. Bureau of Reclamation, Sacramento, CA.

Martin, B. T., A. Pike, S. N. John, N. Hamda, J. Roberts, S. T. Lindley, and E. M. Danner. 2017. Phenomenological vs. biophysical models of thermal stress in aquatic eggs. Ecology Letters 20(1):50–59.

NOAA National Centers for Environmental information, Climate at a Glance: Divisional Time Series, published December 2022, retrieved on December 29, 2022 from https://www.ncei.noaa.gov/access/monitoring/climate-at-a-glance/divisional/time-series

O'Farrell M. R., W. H. Satterthwaite, A. N. Hendrix, and M. S. Mohr. 2018. Alternative Juvenile Production Estimate (JPE) forecast approaches for Sacramento River winter-run Chinook Salmon. San Francisco Estuary & Watershed Science 16(4):4.

Southwest Fisheries Science Center (SWFSC). 2022. Hindcast of factors contributing to Winter-Run Egg TDM change as forecasted in April compared to as observed in October 2022. Prepared by the Southwest Fisheries Science Center. November.

U.S. Bureau of Reclamation. 2019. Reinitiation of Consultation on the Coordinated Long-Term Operation of the Central Valley Project and State Water Project, Final Biological Assessment. https://www.usbr.gov/mp/bdo/docs/ba-final-biological-assessment.pdf

State of California – Natural Resources Agency
DEPARTMENT OF FISH AND WILDLIFE
Fisheries Branch
1010 Riverside Parkway
West Sacramento, CA 95605
www.wildlife.ca.gov

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

December 13, 2022

Mr. Scott Rumsey
Acting 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 2022

Dear Mr. Rumsey:

The California Department of Fish and Wildlife (CDFW) has developed Sacramento River winter-run Chinook Salmon escapement estimates for 2022. 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)	**5,437**
Estimated In-river Escapement (hatchery origin)	**318**
Estimated Number of In-river Spawning Females (hatchery and natural origin)	**2,607**

These estimates include only naturally spawning winter-run Chinook Salmon in the upper Sacramento River. An additional **484** winter-run Chinook Salmon were collected at the Keswick Dam trap site for spawning at Livingston Stone National Fish Hatchery. The total 2022 Sacramento River winter-run spawning escapement estimate, including in-river spawners and fish collected for hatchery broodstock, is **5,927** fish. The 90% confidence interval on this total escapement estimate is **5,009 to 6,889** fish.

The total escapement estimate includes spawned and unspawned carcasses from the winter-run carcass survey, and six 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. One Battle Creek winter-run Chinook

DocuSign Envelope ID: DBC992AE-431D-49E5-8338-1C52AB73027A

Salmon carcass identified by a coded wire tag was recovered during the Sacramento River carcass survey and was 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 2012-2022 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 2022 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. Tracy Grimes at Tracy.Grimes@wildlife.ca.gov.

Sincerely,

DocuSigned by:
Jay Rowan
2113A9B7822F42D...
Jay Rowan, Fisheries Branch Chief

cc: Ms. Cathy Marcinkevage
Assistant Regional Administrator
National Marine Fisheries Service
cathy.marcinkevage@noaa.gov

Mr. Paul Souza
Pacific SW Regional Director
U.S. Fish and Wildlife Service
paul_souza@fws.gov

Mr. Garwin Yip
National Marine Fisheries Service
garwin.yip@noaa.gov

Mr. Jeffrey McLain
U.S. Fish and Wildlife Service
jeffrey_mclain@fws.gov

Mr. Matt Brown
U.S. Fish and Wildlife Service
matt_brown@fws.gov

Mr. Jason Roberts
jason.roberts@wildlife.ca.gov

Mr. Jonathan Nelson
jonathan.nelson@wildlife.ca.gov

Mr. Michael Harris
michael.r.harris@wildlife.ca.gov

Mr. Peter McHugh
peter.mchugh@wildlife.ca.gov

Mr. Rob Titus
rob.titus@wildlife.ca.gov

Mr. Michael Lacy
michael.lacy@wildlife.ca.gov

Mr. Douglas Killam
doug.killam@wildlife.ca.gov

DocuSign Envelope ID: DBC992AE-431D-49E5-8338-1C52AB73027A

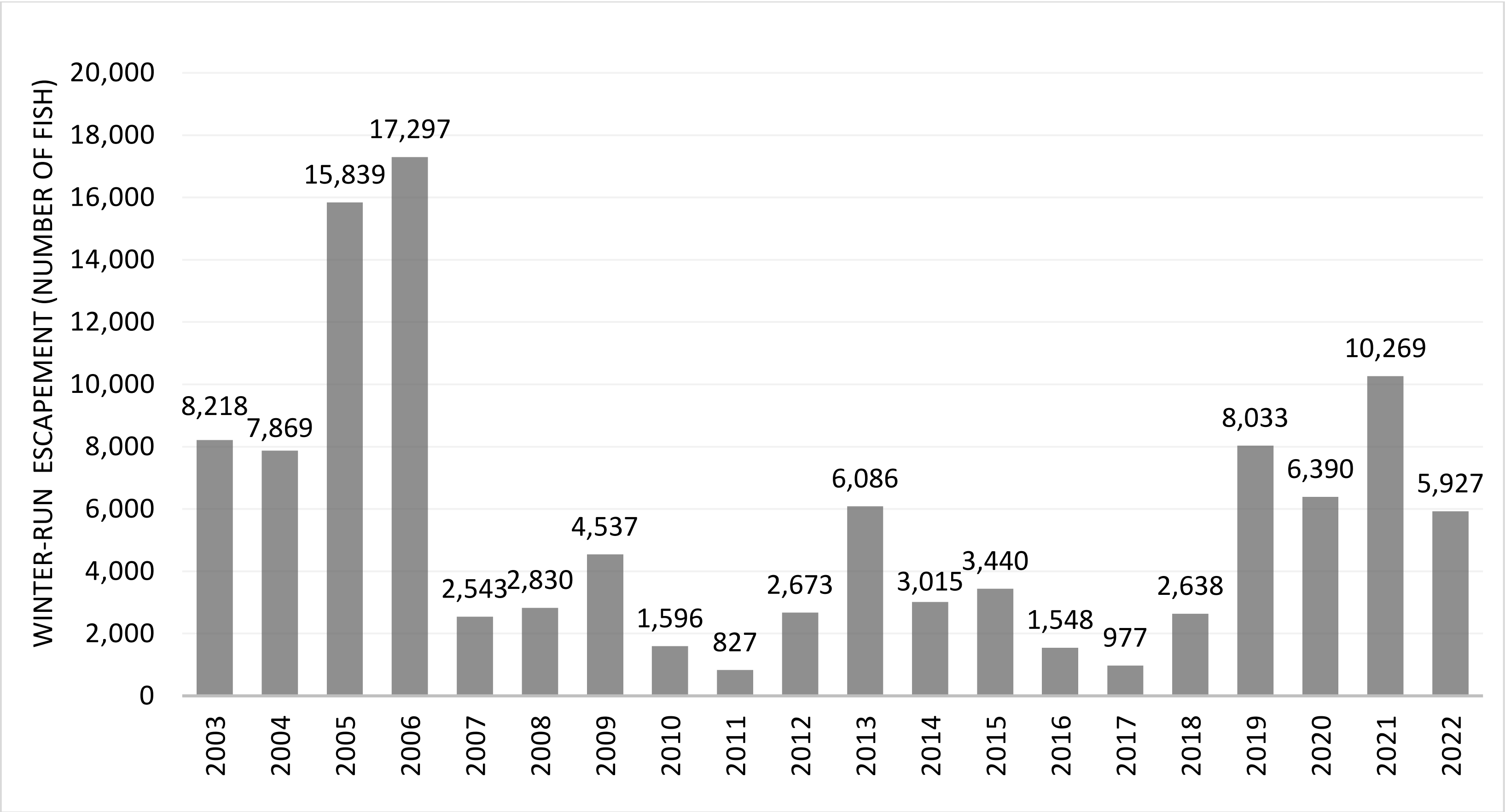

Figure 1. Estimated escapement of winter-run Chinook Salmon to the Upper Sacramento River Basin, 2003-2022. Data compiled from GrandTab (CDFW 2022; https://nrm.dfg.ca.gov/FileHandler.ashx?DocumentID=84381). Data for 2022 is preliminary and subject to change.