Attachment 1
List of Acronyms and Terms

°C	degrees Celsius
°F	degrees Fahrenheit
2018 COA Addendum	2018 amended Coordinated Operations Agreement between the federal government and the State of California
2019 NMFS BO	National Marine Fisheries Service Biological Opinion on Long-term Operations of the Central Valley Project and State Water Project (Biological Opinion No. WCRO-2016-0069)
2019 USFWS BO	United States Fish and Wildlife Service Biological Opinion for the Reinitiation of Consultation on Long-term Operations of the Central Valley Project and State Water Project (Biological Opinion No. 08FBTD00-2019-F-0164)
a.m.	ante meridiem, before noon
AF	acre-feet
Agencies	Collectively DWR, CDFW, Reclamation, USFWS, and NMFS in terms of implementing SWP and CVP Governance
AMP	Adaptive Management Program
AMSC	Adaptive Management Steering Committee
ASR	Annual Status Report
Banks Pumping Plant	Harvey O. Banks Pumping Plant
Bay-Delta Plan	Bay-Delta Water Quality Control Plan
BSPP	Barker Slough Pumping Plant
Cal. Code Regs.	California Code of Regulations
CASS SC	Culture and Supplementation of Smelt Steering Committee
CCF	Clifton Court Forebay
CD	Consistency Determination
CDEC	California Data Exchange Center
CDFW	California Department of Fish and Wildlife
CEQA	California Environmental Quality Act
CESA	California Endangered Species Act
cfs	cubic feet per second
CHNSR	spring-run Chinook Salmon
CHNSR JPE	spring-run Chinook Salmon juvenile production estimate

Attachment 1
List of Acronyms and Terms

CHNSR LCM	spring-run Chinook Salmon Life Cycle Model
CHNSR LCM Management Team	spring-run Chinook Salmon Life Cycle Model interagency management team
CHNWR	winter-run Chinook Salmon
CLC	Clifton Court Forebay CDEC station
cm	centimeter(s)
cm/sec	centimeter(s) per second
CNDDB	California Natural Diversity Database
COA	Coordinated Operation Agreement between the Federal Government and the State of California
CVP	Central Valley Project
CVP Contractors	Entities holding water supply contracts with the U.S. Bureau of Reclamation
Covered Activities	activities expected to result in incidental take of individuals of the Covered Species
Covered Species	species subject to take authorization by the Incidental Take Permit
CVPIA	Central Valley Project Improvement Act
CWT	coded-wire tag
D-1641	State Water Resources Control Board Water Rights Decision 1641
DCG	Delta Coordination Group
DCI	Delta-Mendota Canal/California Aqueduct Intertie
Delta	Sacramento-San Joaquin Delta
DGL	Doughty Cut above Grant Line Canal CDEC station
DJFMP	Juvenile Salmon Emigration Real Time Monitoring Program
DMC	Delta-Mendota Canal
DMW	Delta Monitoring Working Group
DRY Team	Drought Relief Year Team
DS	Delta Smelt
ECO-PTM	Ecological Particle Tracking Model
EDI	Environmental Data Initiative

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List of Acronyms and Terms

Endowment	long-term management fund for mitigation property
ESA	Endangered Species Act
FLaSH	Synthesis of Studies in the Fall Low-Salinity Zone of theSan Francisco Estuary, September-December 2011
FNU	Formazin Nephelometric Units
FPT	Freeport CDEC station
ft/sec	foot (feet) per second
GIS	Geographic Information Systems
GYSO	Goodyear Slough Outfall
HM	Habitat Management
HOL	Holland Cut CDEC station
HRL	Healthy Rivers and Landscapes Program
IEP	Interagency Ecological Program
Implementing Entities	Collectively DWR, CDFW, Reclamation, USFWS, NMFS in terms of implementing Adaptive Management
ITAG	Interagency Telemetry Advisory Group
ITP	Incidental Take Permit
Jones Pumping Plant	C.W. Bill Jones Pumping Plant
JPE	juvenile production estimate
JPOD	Joint Point of Diversion
km	kilometer(s)
LFS	Longfin Smelt
LFSSP	2020 Longfin Smelt Science Plan
LSNFH	Livingston Stone National Fish Hatchery
m	meter(s)
M&I	municipal and industrial
MAF	million acre-feet
MHR	Middle River near the Howard Road Bridge CDEC station
MIDS	Morrow Island Distribution System
mm	millimeter(s)

MMRP	Mitigation Monitoring and Reporting Program
mph	miles per hour
MSD	Mossdale CDEC station
NAVD88	North American Vertical Datum of 1988
NBA	North Bay Aqueduct
NMFS	National Marine Fisheries Service
NOAA ERDDAP	National Oceanic Atmosphere Administration Environmental Research Division Data Access Program
NPDES	National Pollutant Discharge Elimination System
OBI	Old River at Bacon Island CDEC station
OLD	Old River near Tracy CDEC station
OMR	Old and Middle River
OSJ	Old River at Franks Tract near Terminous CDEC station
PAR	Property Analysis Record
Permittee	California Department of Water Resources
PIT	passive integrated transponder
ppm	parts per million
PPT	Prisoner's Point CDEC station
ppt	parts per thousand
Project	Long-term Operation of the State Water Project in the Sacramento-San Joaquin Delta
Proposed Action	Reclamation's proposal for Long-term Operation of the Central Valley Project and State Water Project
psu	practical salinity units
Reclamation	United States Bureau of Reclamation
ROD	Record of Decision
RRDS	Roaring River Distribution System
SaMT	Salmon Monitoring Team
SCH No.	State Clearinghouse Number
SDM	structured decision-making

Attachment 1
List of Acronyms and Terms

sDPS	Southern Distinct Population Segment
SHOT	Shasta Operations Team
Skinner Fish Facility	John E. Skinner Delta Fish Protective Facility
SLS	Smelt Larval Survey
SMPA	Suisun Marsh Preservation Agreement
SMSCG	Suisun Marsh Salinity Control Gates
SMT	Smelt Monitoring Team
SPK	USACE Sacramento District
State Water Board	State Water Resources Control Board
Summer-Fall Action Plan	plan to achieve Summer-Fall Habitat Action operational requirements
SWP	State Water Project
SWP Contractors	Public water agencies that hold long-term water service contracts with the California Department of Water Resources
TAF	thousand acre-feet
USACE	United States Army Corp of Engineers
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Survey
WOMT	Water Operations Management Team
WS	White Sturgeon
WSMT	White Sturgeon Monitoring Team
X2	Distance (km) up the axis of the estuary measured from the Golden Gate Bridge where the near-bottom daily average salinity is 2 practical salinity units (psu)
YBFMP	Yolo Bypass Fish Monitoring Program

Appendix F
Winter-run Chinook Salmon Juvenile Production Estimates

This document provides background information about the winter-run Chinook Salmon Juvenile Production Estimate (JPE) and describes how it is calculated, the process for producing an annual JPE, and how it will be utilized to manage Long-term Operations of the State Water Project (SWP) and Central Valley Project (CVP).

F.1 Background

The winter-run JPE is a forecast of the number of winter-run Chinook Salmon (winter-run) juveniles expected to reach the Sacramento–San Joaquin Delta (Delta) each year. It is used to set loss thresholds that will adjust flow management in Old and Middle River (OMR) to minimize impacts of the State and Federal water project pumping facilities on outmigrating winter-run.

Using a JPE to scale allowable take was first introduced in the 1993 National Marine Fisheries Service (NMFS) Biological Opinion for Long-term Operations of the CVP and SWP, and was used to reduce take. JPE letters are available on the NMFS website.

F.1.1 Early JPE Methods

The winter-run JPE has been calculated several different ways since its inception, based on the best information available to make an estimate at that time. When new or better information was available to calculate a JPE, the method and/or inputs were updated. Early JPE methods all had a similar structure, starting with estimates of female spawners and fecundity and including various survival factors to account for mortality between the egg and smolt stages. Below is a timeline of changes made to the JPE inputs and calculations since 1993 (years shown are BYs), summarized from annual JPE letters:

- 1993: The first JPE was issued. Escapement was estimated based on counts at the fish ladder at Red Bluff Diversion Dam (RBDD). Pre-spawn mortality (5%), sex ratio (50:50), and fecundity (3,353–3,859) were estimated from literature or best professional judgement. Egg mortality due to temperature and dewatering were estimated using a linear regression temperature model and aerial redd surveys. Egg-to-fry survival (25%) was assumed based on U.S. Fish and Wildlife Service (USFWS) studies in the Tehama–Colusa spawning channel from 1975–1980, and fry-to smolt survival (59%) was assumed based on Hallock (undated). The number of smolts released from the Livingston Stone National Fish Hatchery (LSNFH) was added to the JPE without differentiation from natural production. There was not a separate factor for survival to the Delta.
- **2000:** Fecundity was estimated from winter-run females spawned at LSNFH. No other factors changed.

- **2001:** Escapement, number of females, and pre-spawn mortality were estimated by carcass surveys, using the Jolly-Seber model. A factor was added to estimate smolt survival between RBDD and the Delta (52–56%) for natural-origin juveniles; this factor is based on average differential ocean recovery rates of paired releases of coded-wire-tagged late-fall-run Chinook Salmon in Battle Creek and the Delta and was updated with new data when available.
- **2002:** NMFS began developing separate JPE forecasts for hatchery-origin and natural-origin winter-run. The same smolt survival term (52-56%) was applied to releases of winter-run smolts from LSNFH to account for survival between release and the Delta.
- **2010:** Egg-to-fry survival was based on the long term average juvenile passage estimate, calculated at the juvenile monitoring stations at RBDD, divided by female spawners, calculated from carcass surveys.
- **2013:** Smolt survival rates were estimated using the weighted average of late-fall-run and winter-run acoustic tag studies for natural-origin smolts, and winter-run acoustic tag studies for hatchery-origin smolts.
- **2014:** Shift to the JPI Method, which calculated the JPE from estimates of juvenile production from monitoring at RBDD, rather than carcass surveys (see section below).

F.1.2 JPI-based JPE Method (BY 2014-2018)

The method for calculating the JPE shifted in BY 2014, after a review by the Interagency Ecological Program's winter-run Chinook Salmon Project Work Team (Winter-run PWT) found that the previous method overestimated the number of juveniles entering the Delta on average by 400 percent (National Marine Fisheries Service 2014). The Winter-run PWT also recommended that the JPE be revisited annually and updated as needed with any new or improved information. The equation for calculating the JPE using the JPI-based method is shown in Equation 2C-1.

From BY 2014–2019, the JPE calculation was calculated using estimates of the number of "fry equivalents" passing RBDD (Juvenile Production Index or JPI_{Fry}), an estimated fry-to-smolt survival rate of 0.59 (Hallock, undated), and an estimated smolt migration survival rate based on average survival from acoustic tagged smolts from LSNFH (Figure 2C-1). By starting with an estimate of fry production rather than female spawners, this method reduced uncertainty related to the large number of survival factors that need to be estimated. It also better represented survival differences due to environmental conditions during spawning, egg incubation, and rearing upstream of RBDD.

F.1.3 Current "Method 2" JPI-based JPE Calculation Method (BY 2019-present)

Since BY 2019 (JPE applied in water year 2020), the winter-run JPE has consistently been calculated using the same method, although the factors used to calculate it are updated each year to include new available data. Described in O'Farrell et al. (2018) as "Method 2," this JPE method (Equation 2C-1) has a similar structure to the method used from 2014-2018, but it uses different methods to estimate survival rates for fry-to-smolt ($Survival_{Fry\text{-}to\text{-}Smolt}$) and smolt migration ($Survival_{Smolt}$).

Equation 2C-1:

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

The Juvenile Production Index (JPI_{Fry}) is an estimate of the number of juveniles passing the monitoring stations at RBDD, extrapolated for the remainder of the season and converted to "fry equivalents" to account for mortality between the fry and smolt stage. The fry-to-smolt survival rate ($Survival_{Fry\text{-}to\text{-}Smolt}$) is the estimated slope of a zero-intercept linear model fitted to estimates of hatchery-origin juvenile survival rates and natural-origin juvenile survival rates (O'Farrell et al. 2018). $Survival_{Fry\text{-}to\text{-}Smolt}$ is also the factor used to convert juvenile passage estimates at RBDD to "fry equivalents" for JPI_{Fry}, based on the peak of fry catch (generally in October) and the smolt life-stage for natural-origin winter-run at RBDD. The survival rate for smolt migration ($Survival_{Smolt}$) from RBDD to the Delta (i.e., Sacramento at the I-80/I-50 Bridge) is estimated using the variance-weighted mean of survival estimates from acoustic tagged LSNFH smolts released (2013-present) and uses the Cormack-Jolly-Seber model which accounts for variation in detection probabilities. Both survival parameters ($Survival_{Fry\text{-}to\text{-}Smolt}$ and $Survival_{Smolt}$) are updated annually to incorporate new data collected since the previous year (Table 2C-1).

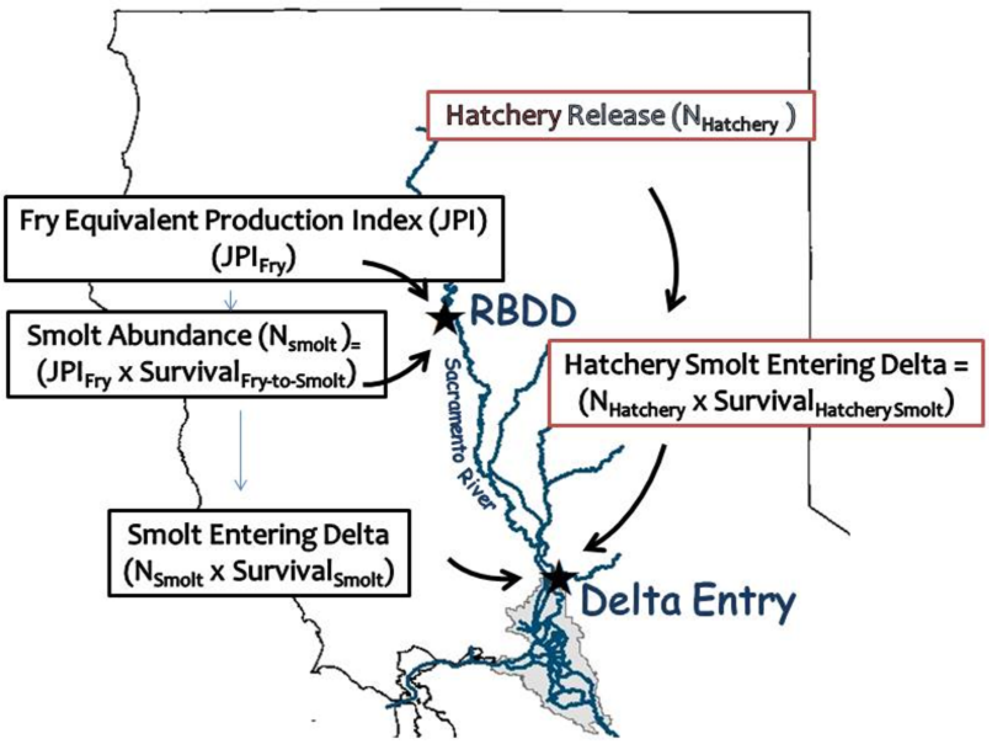

Figure 2C-1. Location and formulas used to calculate the Juvenile Production Estimate from 2014-present

A similar calculation is used to forecast the number of hatchery-origin winter-run Chinook Salmon entering the Delta each year, although it requires fewer parameters because the release numbers are known ($N_{Hatchery}$) and fish are released as smolts. Survival of hatchery smolts from release to the Delta ($Survival_{HatcherySmolt}$) is estimated by the variance-weighted mean of survival rates from LSNFH release to the Delta (2013-present). Separate JPEs are calculated for different release groups and accounted for separately in tracking.

Equation 2C-2:

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

Beginning in 2019, the Winter-run PWT has also calculated a JPE for hatchery-origin winter-run smolts released in Battle Creek as part of the "Jumpstart" reintroduction. Although there was also natural spawning in Battle Creek, the JPE has not differentiated natural-origin juveniles from Battle Creek from Sacramento River juveniles. As reintroduction efforts continue in Battle Creek and the McCloud River and populations become established, differentiating production sources is expected to become more relevant. Under the current method, unmarked winter-run Chinook Salmon from Battle Creek and the McCloud River are included in JPI estimates and therefore in $JPE_{Natural}$.

Table 2C-1. Parameters used in calculating the winter-run JPEs for brood years 2019-2022. Survival parameters were generated as described in in O'Farrell et al. (2018), Method 2, and updated annually to include the previous year of monitoring data.

Estimate	Parameter	BY 2019	BY 2020	BY 2021	BY 2022
Fry Production [a]	JPI_{Fry}	4,762,142	2,232,811	796,403	311,058
Fry-to-Smolt Survival [b]	$Survival_{Fry\text{-}to\text{-}Smolt}$	0.4651	0.4475	0.4429	0.4946
	Data for Fry-to-Smolt Survival	1998–2014	1998–2015	1998–2016	1998–2017
Natural Smolt Survival, RBDD to Delta [c]	$Survival_{Smolt}$	0.3860	0.3304	0.3537	0.3245
	Data for Smolt Survival	2013–2019	2013–2020	2013–2021	2013–2022
Hatchery Smolt Survival, LSNFH release to Delta [c]	$Survival_{HatcherySmolt}$	0.3687	0.3148	0.2818	0.2577
Hatchery Smolt Survival, Battle Creek to Delta [d]	$Survival_{BCJumpstart}$	NA	0.1570	0.0519	0.0206
Juvenile Production Estimate	$JPE_{Natural}$	854,941	330,130	124,760	49,924
JPE Confidence Interval (C.I.)2	95% C.I.	301,002–1,408,880	145,088–515,172	58,840–190,679	32,298–67,550

[a] Estimated juvenile passage at juvenile monitoring stations at Red Bluff Diversion Dam (RBDD), converted to "fry equivalents" using the fry-to-smolt survival factor for smolt-sized juveniles. This estimate includes an interpolation to account for the remainder of passage for the brood year.

[b] Estimate of fry-to-smolt survival is calculated using estimated slope of a zero-intercept linear model fitted to estimates of hatchery-origin juvenile survival rates and natural-origin juvenile survival rates (O'Farrell et al. 2018).

[c] Variance-weighted mean survival rate of acoustically tagged hatchery winter-run Chinook Salmon between RBDD and I-80/Tower Bridge in Sacramento (based on O'Farrell et al. 2018). Survival is estimated from the release location for hatchery-origin smolts, and from the Salt Creek receiver site, located 3 miles downstream of RBDD, to estimate survival from RBDD for natural-origin smolts.

[d] Variance-weighted mean survival rate of acoustically tagged hatchery winter-run Chinook Salmon between the 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 because fish size and environmental conditions were not consistent with expected conditions during planned releases.

F.2 Annual JPE Development Process

After the Record of Decision is finalized, the JPE will be developed by the JPE Subteam, consisting of technical representatives from the U.S. Bureau of Reclamation, California Department of Water Resources, NMFS, USFWS, and California Department of Fish and Wildlife. Annual JPE Development will begin in November, and the JPE Subteam will issue the JPE Memo to the Shasta Operations Team (SHOT) by December 31 of the same year. The objective of the JPE Subteam will be to use best available science and work collaboratively to produce JPE forecasts that are transparent, defensible, and unbiased.

F.2.1 Annual JPE Parameter Updates

During annual JPE development, the JPE Subteam will evaluate and incorporate any new data they agree will improve estimates of JPI_{Fry}, $Survival_{Fry\text{-}to\text{-}Smolt}$, $Survival_{Smolt}$, and $Survival_{HatcherySmolt}$ for the purposes of generating JPEs for natural-origin and hatchery-origin winter-run Chinook Salmon. This has occurred annually since the current JPE method was adopted in 2019, and is consistent with O'Farrell et al. (2018).

F.2.2 Potential JPE Calculation Method Updates

Since 2014, the JPE development process has included an annual technical review to determine if there is new or improved information that should be incorporated. Additional years of monitoring data, additional data on fry and smolt survival, and better statistical models could increase accuracy and/or better capture uncertainty, resulting in better JPE forecasts (O'Farrell et al. 2018). If, after evaluation of the alternatives, the JPE Subteam determines that adjusting the method beyond updating parameter estimates for "Method 2" and Equation 2C-1 would improve the JPE forecast, the JPE Subteam will provide a technical memorandum to SHOT for consideration.

F.3 Winter-run JPE Application

The Proposed Action for Long-term Operations of the SWP and CVP includes loss thresholds for natural- and hatchery-origin winter-run that are scaled to the Winter-run JPE. When triggered by winter-run loss observed in salvage, the loss thresholds require prescribed adjustments to OMR flow management through SWP and CVP exports in the Delta to protect outmigrating winter-run. The Proposed Action includes an annual loss threshold and weekly distributed loss thresholds for natural-origin winter-run and an annual loss threshold for hatchery-origin winter-run. The weekly distributed loss thresholds are calculated separately for early season (November through December) migrating juveniles and for mid- and late-season (January through June) migrating juveniles. The equations for calculating each loss threshold are provided in the Proposed Action and are explained further below.

F.3.1 Annual Loss and Mid- and Late-Season Weekly Distributed Loss Thresholds

The winter-run JPE will be used as a factor in the equations to calculate thresholds for mid- and late-season weekly distributed loss and annual loss at the SWP and CVP during the OMR Management Season, as described in the Proposed Action. The JPE Subteam will coordinate with the Salmon Monitoring Team (SaMT) to ensure that SaMT is able to calculate thresholds using the JPE forecasts prior to the start of OMR Management Season for winter-run on January 1 each year.

F.3.2 Early Season Migration Loss Threshold Multiplier (before a JPE is available)

The early season migration loss threshold is in effect in November and December, prior to development of $JPE_{Natural}$ for the BY. Weekly thresholds are calculated separately for November and December as the product of the cumulative biweekly winter-run passage estimates at RBDD and a Multiplier.[1] The Multiplier, applied to both November and December thresholds ($Multiplier_{Nov}$ and $Multiplier_{Dec}$, is the product of the estimated percent of winter-run juveniles present in the Delta for the given month[2] scaled to week (multiplied by 0.25), fry-to-smolt survival ($Survival_{Fry\text{-}to\text{-}Smolt}$), and smolt survival from RBDD to the Delta ($Survival_{Smolt}$).

Similarly to the JPE, $Survival_{Fry\text{-}to\text{-}Smolt}$ and $Survival_{Smolt}$ will be updated each year to include any new data that are available. If data are not yet available to update the parameters, the JPE Subteam will use the $Survival_{Fry\text{-}to\text{-}Smolt}$ and/or $Survival_{Smolt}$ estimates from the previous BY JPE calculation. Equations 2C-3 and 2C-4 show the calculations for the $Multiplier_{Nov}$ and $Multiplier_{Dec}$, and an example calculation for BY 2023 (as would be applied to water year 2024), which uses survival estimates from the BY 2022 JPE.

Equation 2C-3:

$$Multiplier_{Nov} = 0.0011 \times 0.25 \times Survival_{Fry-to-Smolt} \times Survival_{Smolt}$$

Example for BY 2023: $0.0044\% = 0.0011 \times 0.25 \times 0.4946 \times 0.3245$

Equation 2C-4:

$$Multiplier_{Dec} = 0.0021 \times 0.25 \times Survival_{Fry-to-Smolt} \times Survival_{Smolt}$$

Example for BY 2023: $0.0084\% = 0.0021 \times 0.25 \times 0.4946 \times 0.3245$

F.4 Cited

National Marine Fisheries Service. 2014. Winter-run Chinook Salmon Juvenile Production Estimate for Water Year 2014. Letter to Mr. Ron Milligan, Operations Manager, Central Valley Project, U.S. Bureau of Reclamation from Marian Rea, Assistant Regional Administrator, California Central Valley Area Office.

[1] The November threshold is calculated using the seasonal passage to date from the second biweekly RBDD winter-run passage estimate in October. The December threshold is calculated using the seasonal passage to date from the second biweekly RBDD winter-run passage estimate in November.

[2] The November and December estimated percent of winter-run juveniles present in the Delta are based on Table 15 of the Proposed Action, which includes calculated values for the percent of winter-run present in the Sacramento Trawl (Sherwood Harbor; Delta entry) and the percent of winter-run present in Chipps Island Trawl (Delta exit), as determined by genetic analyses for water years 2017-2022. For the first week of January (January 1-7), Table 15 indicates that 0.32% of winter-run are historically present in the Delta (scaled to 100%; Column E). The November Multiplier assumes that one third of winter-run presence in the Delta by the first week of January occurred as early as November (one third of 0.32% = 0.0011). The December Multiplier assumes that two thirds of winter-run presence in the Delta by the first week of January occurred as early as December (two thirds of 0.32% = 0.0021).

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.

Chinook Salmon Loss Estimation
for
Skinner Delta Fish Protective Facility and Tracy Fish Collection Facility

7/9/2018

I. Introduction

Estimates of salmon loss are based on fish salvage and operational data collected at the John E. Skinner Delta Fish Protective Facility (Skinner) and the Tracy Fish Collection Facility (Tracy). Loss calculations utilize estimates based on DFG studies of screening efficiency, handling and trucking mortality due to operation of the Skinner facility, and pre-screening losses occurring in Clifton Court Forebay (CCF) and the intake channel.

II. Loss Estimation

There are 4 essential components of loss estimation: salvage, pre-screen loss (predation), screen (louver) efficiency, and handling and trucking loss. Losses are estimated from the time salmon enter Clifton Court Forebay (at Skinner) or across the trash racks (at Tracy) to the time they are released back into the Delta. Salmon are lost in two ways before they are collected in the facility: 1) they might be eaten by predatory fish, or 2) they might pass through the louvers and then exported along with Delta water. Once collected, fish loss occurs when some fish die in the process of being handled or trucked.

A. Salvage Estimation

The first step in estimating loss is to estimate fish salvage. Salvage is estimated from samples (counts) of fish collected at least every two hours while water is being pumped.

SALVAGE = Observed number of fish x (Total minutes pumping ÷ Count length)

<u>Exceptions</u>: If the fish is observed in a predator removal, then SALVAGE = Observed number of fish x 1. Count length is also adjusted for time that the secondary is shut down and no salvage took place
If the fish is observed during a special study, then SALVAGE = 0.

<u>Example</u>: 1 salmon in count * (120 min. pumping / 10 min. count length) →
SALVAGE = 12

B. Entrainment Estimation

The number of fish that are entrained into the facilities is estimated in two steps. First we estimate how many fish encountered the screens, the second step is to estimate how many fish entered the facility.

1. Encounter Estimation

We have already estimated how many salmon were collected (salvage), but since the screens are not 100% efficient, we know some fish passed through and were lost. Estimating the number of fish encountering the screens depends on fish size. Efficiency is generally higher for fish < 100 mm than for fish > 100 mm. The fish's ability to avoid the louvers and enter the bypass also depends on the water velocity through the louvers. For small fish, higher velocities will make it more difficult for them to avoid the louvers and will increase the likelihood that they will pass through the louvers and will be lost. The number of fish encountering the screens (ENCOUNT) is calculated by dividing the salvage (SALVAGE) by the screen efficiency (EFF).

If Length < 101 mm → ENCOUNT = SALVAGE/EFF1;
If Length > 100 mm → ENCOUNT = SALVAGE/EFF2;

EFF1 = 0.630 + (0.0494 * (Primary Channel Flow /(Primary Channel Depth * Width)))
EFF2 = 0.568 + (0.0579 * (Primary Channel Flow /(Primary Channel Depth * Width)))

Note: Channel width at Skinner depends on the number of bays open. As the pumping rate changes, bays are opened and closed to maintain primary channel approach velocities and bypass ratios within established criteria. Channel width at Tracy is fixed (84 ft).

2. Entrainment Estimation

The number of fish entrained (ENTRAIN) is calculated by dividing the number of fish encountering the screens (ENCOUNT) by the proportion of fish assumed to survive the journey to the louvers (1 – P). The pre-screen loss rate (P) is the rate of loss to entrained salmon during movement from the radial gates (Skinner) or trash racks (Tracy) to the louvers. The pre-screen loss at Skinner is based on an average of measured pre-screen loss rates in CCF for chinook salmon (75%). The pre-screen loss rate at Tracy is an agreed-upon value (15%).

ENTRAIN = ENCOUNT / (1 – P)

For Skinner: P = 0.75
For Tracy: P = 0.15

C. Live Release Estimation

We then estimate the number of salvaged fish that will survive the process of being transferred from the holding tanks to the truck and transported back to the Delta. This estimate is based on studies with salmon at the Skinner facility and depends on salmon length. Mortality during the transport process has been referred to as handling and trucking loss. For salmon less than or equal to 100 mm, mortality is assumed to be 2% and for salmon larger than 100 mm, mortality is assumed to be 0.

If length < 101 mm → RELEASE = SALVAGE x (1 – 0.02)
If length > 100 mm → RELEASE = SALVAGE

Note: Trucking and handling loss is combined into a single rate (2% for smaller fish).

D. System Loss Estimation

The final step in loss estimation is to subtract the estimated number of fish released alive from the estimated number of fish entrained.

LOSS = ENTRAIN – RELEASE

Exceptions:
If the fish is observed in a Skinner predator removal, then LOSS = SALVAGE x 4.33
If the fish is observed in a Tracy predator removal, then LOSS = SALVAGE x 0.569
If the fish is observed in a special study, then LOSS = 0
If a Non Clipped salmon is accidentally killed and not released, then 1 is added to the loss number to account for the lost salmon

III. Loss Calculation Examples:

A. Skinner:

1 salmon observed in count * (120 min. pumping / 10 count length) → Salvage = 12, but some fish went through louvers and were not salvaged, so...

If < 101 mm, # fish encountering screens = 12 / (0.63 + (0.0494 * (2260 cfs / 20 ft.* 106 ft))) = 17.6

But, most of the salmon were eaten before they got to the louvers, so... # fish entrained = 17.6 / (1-.75) = 70.4

But, we were able to release some of these fish back into the delta alive, so if fish < 100 mm... # fish released = 12 * (1 – .02) = 11.8

So, loss is the number of fish entrained minus the number of fish released alive... # fish lost = 70.4 - 11.8 = 58.6

B. Tracy:

1 salmon observed in count * (120 min. pumping / 10 count length) ⟶ Salvage = 12, but some fish went through louvers and were not salvaged, so...

> If < 101 mm, # fish encountering screens = 12 / (0.63 + (0.0494 * 2806 cfs / (16.7 ft.* 84 ft))) = 16.4

But, most of the salmon were eaten before they got to the louvers, so... # fish entrained = 16.4 / (1-.15) = 19.3

But, we were able to release some of these fish back into the delta alive, so if fish < 100 mm... # fish released = 12 * (1 – .02) = 11.8

So, loss is the number of fish entrained minus the number of fish released alive... # fish lost = 19.3 - 11.8 = 7.5