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

FEB 21 2014

Mr. Ron Milligan
Operations Manager, Central Valley Project
U.S. Bureau of Reclamation
3310 El Camino Avenue, Suite 300
Sacramento, California 95821

Dear Mr. Milligan:

This letter provides the U.S. Bureau of Reclamation (Reclamation) with the estimated number of juvenile Sacramento River winter-run Chinook salmon (winter-run, *Oncorhynchus tshawytscha*) expected to enter the Sacramento-San Joaquin Delta (Delta) during water year 2014. In order to provide incidental take for the combined operation of the Central Valley Project (CVP) and the State Water Project (SWP), NOAA's National Marine Fisheries Service (NMFS) calculates a juvenile production estimate (JPE), pursuant to the June 4, 2009, biological opinion on the long-term operations of the CVP and SWP (CVP/SWP Opinion). This estimate is used to determine the authorized level of incidental take, under section 7 of the Endangered Species Act (ESA), for winter-run while operating the CVP/SWP Delta pumping facilities in water year 2014.

The winter-run adult escapement estimate for 2013 was derived from carcass surveys conducted in the upper Sacramento River by the California Department of Fish and Wildlife (CDFW). This information was provided to NMFS via a letter dated January 7, 2014 (enclosure 1). The CDFW estimate of total winter- run escapement in 2013 was **6,075** spawners, which includes 117 collected for hatchery broodstock at the Keswick trap. The estimate is 227 percent higher than, or more than double, the estimated 2,674 adults that returned in 2012 and a change to a positive cohort replacement rate for the first time in 7 years (figures 1 and 2). The 2010 adult escapement that this year's return originated from was 1,596, resulted in a 3.81 increase in the population growth rate. The methodology (*i.e.*, Cormack-Jolly-Seber Model) used by CDFW to calculate winter-run escapement in 2013 was the same as in 2012. This method allows the calculation of confidence intervals. The 90 percent confidence interval for total estimate (6,075) is from 5,275 to 6,677 fish.

This year the Interagency Ecological Program's winter-run Project Work Team (WRPWT) conducted a technical review of the survival terms used to calculate the JPE based on the most recent acoustic tag studies in the Sacramento River. The WRPWT review found that the current JPE overestimates the number of juveniles entering the Delta on average by 400 percent (Table 1) based on four years of genetic studies at Chipps Island (Pyper *et al.* 2013). The positive identification of juvenile winter-run captured at Chipps Island allowed for comparisons between abundance estimates using actual observed data from 2008–2011instead of modeled data.

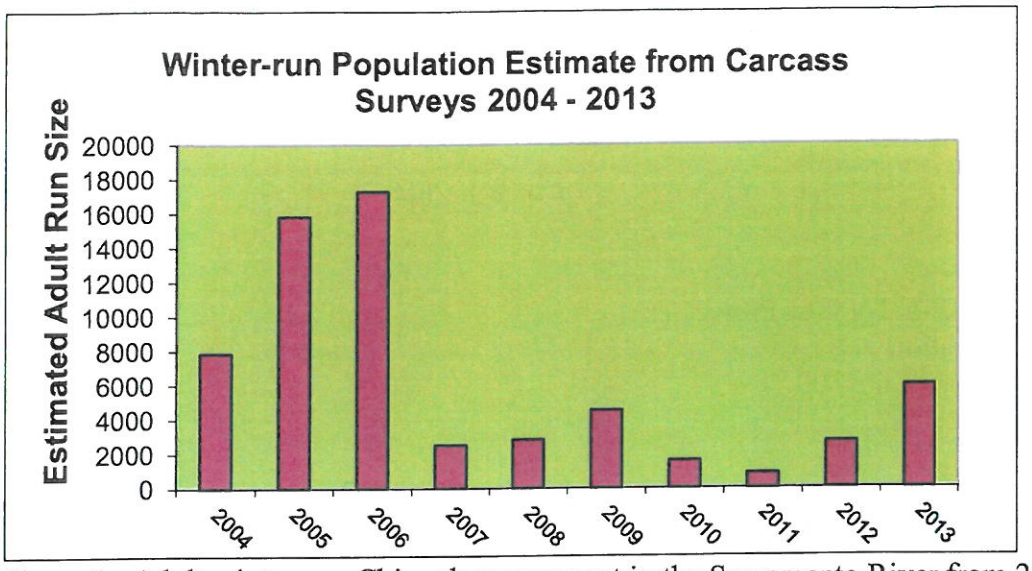


Figure 1. Adult winter-run Chinook escapement in the Sacramento River from 2004-2013.

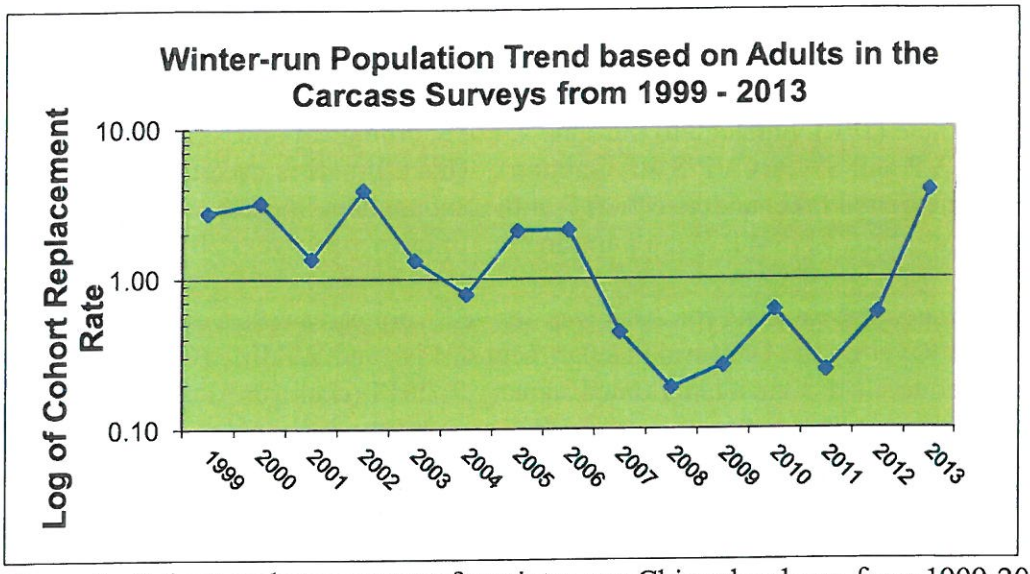


Figure 2. Cohort replacement rate for winter-run Chinook salmon from 1999-2013.

Table 1. Winter-run JPE comparison to Chipps Island Trawl data accounting for in Delta survival from Sacramento to Chipps Island.

	Year			
	2008	**2009**	**2010**	**2011**
JPE to Sacramento (NMFS)	589,911	617,783	1,179,633	332,012
JPE to Chipps w/ Delta survival added[1]	195,260	204,486	390,458	109,895
JPE to Chipps w/DNA (Pyper *et al.* 2013)	44,943	51,228	63,442	60,051
% overestimated at Chipps	400	400	600	180

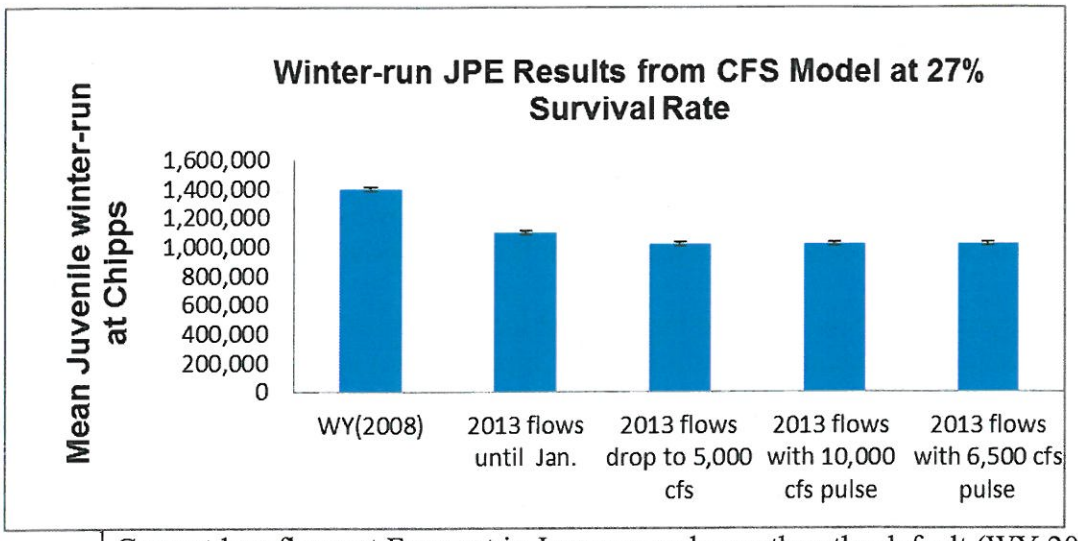
[1] JPE through Delta uses 33% survival for all years based on Perry *et al.* (2012).

In addition, 2013 was the first year that in-river survival was directly estimated for hatchery-released juvenile winter-run (using acoustic JSAT tags). This allowed for the comparison of survival rates from the 2013 data to those previously used in the calculation of the JPE. Direct estimates of survival are considered the best method of estimating natural juvenile winter-run survival and abundance between reaches on the Sacramento River. Previously, NMFS used survival rates indirectly by comparing the differences in ocean recovery rates of hatchery CWT coded wire tagged (CWT) late-fall run releases made at Battle Creek and in the Delta.

For the 2013 broodyear, NMFS has revised the survival terms in the JPE calculator based on the latest acoustic tag studies and abundance estimates at Chipps Island (Table 1). Smolt survival in from Red Bluff to the Delta was changed based on: (1) 2013 survival of acoustically-tagged hatchery winter-run (hydrologic conditions at release were similar to water year 2014); and (2) the average survival of 4 years (2007–2010) of acoustically-tagged late fall-run hatchery releases (excluding 2011 releases because it was a wet year with high survival). In 2013, the habitat and environmental conditions were considered to be similar to the dry year survival estimates from the acoustic tag data. Survival from Red Bluff to the Delta was derived by equally weighting the survival of both the winter-run and the average of the late fall-run releases (see enclosure 3). Various survival terms in the JPE calculator may be revised for the 2014 broodyear based on additional data from the 2014 release of acoustically-tagged winter-run.

Details of this year's calculation of the JPE are described in the NMFS JPE Estimator Program (enclosure 2). In most years, NMFS compares its modeled estimate to the U.S. Fish and Wildlife Service (USFWS) juvenile production index (JPI) at Red Bluff. The JPI is an independently-developed estimate based on real-time rotary screw trap catch data of juvenile winter-run passage at Red Bluff Diversion Dam (RBDD). However, due to the partial government shutdown, 17 days of catch data were missed from October 1–17 period, during the peak of winter-run juvenile outmigration from the upper Sacramento River. Although data were extrapolated to fill in the gap of missed catch days, NMFS does not consider the JPI as a good comparison for the JPE from the 2013 spawning season.

NMFS uses a model developed by Cramer Fish Sciences (CFS) in 2011 to estimate uncertainty in the JPE. Although, the end point for juveniles in the CFS model is Chipps Island in the Delta, and not the entrance into the Delta, it is still useful for purposes of estimating uncertainty. For the JPE from the 2013 spawning season, NMFS has defined entrance into the Delta as the Tower Bridge at Sacramento for purposes of comparing in-reach survival; consistent with how the JPE is defined in the CVP/SWP Opinion. Using the CFS model default critical water year hydrology (WY 2008) resulted in an estimate of 1,395,200 winter-run to Chipps Island, with a confidence interval of 14,776 (5 (Figure 3). Additional modeling, using a 10,000 cfs pulse flow in February, and 6,500 cfs March, only increasing the JPE by 2,640 fish (or <0.5%), compared to more significant increases found in del Rosario *et al.* (2013).



[1] Current low flows at Freeport in January are lower than the default (WY 2008) flows in model.

[2] Pulse flows 10,000 cfs in February and 6,500 cfs in March as cues for migration (Rosario *et al.* 2013).

Figure 3. Cramer Fish Sciences model summary of mean winter-run juvenile production under various critical water year scenarios.

Using the JPE as defined in the CVP/SWP Opinion (*i.e.*, survival to the Delta but not through the Delta), and based upon the best available information, NMFS estimates that 1,196,387 natural origin juvenile winter-run will enter the Delta during water year 2014 (enclosure 2). The NMFS JPE was within 100,000 of the CFS model results for the 2013 water year. The outmigration period for winter-run into the Delta typically runs from November through April, based upon CDFW historical monitoring data at Knights Landing rotary screw traps.

An additional 193,000 hatchery-reared juvenile winter-run propagated at Livingston Stone National Fish Hatchery (LSNFH) were released into the upper Sacramento River near Redding on February 10, 2014. All hatchery-produced winter-run are CWTed and marked with an adipose fin clip, so that they can be identified from other hatchery fish. NMFS has determined that the survival of these hatchery fish would be similar to the acoustic tag release in 2013 since they were released at the same time, location, and size. NMFS estimates that approximately 30,880 hatchery winter-run will survive to enter the Delta during water year 2014 (enclosure 2).

The authorized incidental take limit for the combined CVP/SWP Delta pumping facilities includes both the natural (wild) and hatchery-produced juvenile Sacramento River winter-run Chinook salmon, as both are considered necessary components of the population for survival and recovery of the species. The authorized incidental take for naturally-produced Sacramento River winter-run Chinook salmon has been established as 2 percent of the JPE [The incidental take limit is actually 1 percent of the JPE based on genetically determined winter-run, however, a 50 percent allowance is provided due to the uncertainties in the length-at-date criteria and difficulty in identifying juveniles of other races (*i.e.*, fall-run, late-fall run, and spring-run Chinook salmon)]. The incidental take for hatchery winter-run is set at one percent of the LSNFH release because the race is known and all are marked with CWTs. Therefore, the authorized level of

incidental take (*i.e.*, reported as loss) under the ESA for the combined CVP/SWP Delta pumping facilities from October 1, 2013, through June 30, 2014, is set at **23,928 natural (non-clipped or wild)**, and **309 hatchery-produced** Sacramento River winter-run Chinook salmon. If the incidental take exceeds 1 percent of the natural production entering the Delta (*i.e.*, 11,964) or 0.5 percent of the hatchery production (*i.e.*, 154), Reclamation and the California Department of Water Resources (DWR) must immediately convene the Water Operations Management Team (WOMT) to consider actions to minimize incidental take, pursuant to the CVP/SWP Opinion.

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 developed by the USFWS in cooperation with CDFW and DWR. As additional information becomes available through genetic analysis of tissue samples and other fisheries monitoring programs (*e.g.*, acoustical tag studies) in the Central Valley region, estimates of the incidental take at the Delta fish facilities may be adjusted, if deemed scientifically sound by NMFS.

NMFS will continue to monitor daily salvage and loss, and loss densities of Sacramento River winter-run Chinook salmon and other ESA-listed species at the Delta fish salvage facilities through participation in the Delta Operations for Salmonids and Sturgeon (DOSS) Technical Team and the WOMT. We appreciate the opportunity to provide Reclamation and DWR with information related to the juvenile production of Sacramento River winter-run Chinook salmon.

NMFS acknowledges that additional research using acoustically-tagged winter-run (both hatchery and wild) is necessary to provide a more robust estimate of in-reach survival of winter-run in the Sacramento River, and would provide direct calculation of survival, and greatly improve the accuracy of the JPE. We support the continuation of acoustic tag studies on winter-run to provide data on survival rates over a range of hydrologic conditions, and request that Reclamation provide funding to continue these studies. In addition, the calculation of the JPE, and specifically the use and application of data from the acoustically-tagged Chinook salmon releases, will be included as a topic in the 2014 annual review, as required in section 11.2.1.2 of the CVP/SWP Opinion (page 9 of the 2009 RPA with 2011 amendments, http://www.westcoast.fisheries.noaa.gov/publications/Central_Valley/Water%20Operations/Operations,%20Criteria%20and%20Plan/040711_ocap_opinion_2011_amendments.pdf).

If you have any questions regarding this correspondence, or if NMFS can provide further assistance, please contact Mr. Bruce Oppenheim at (916) 930-3603, or via email at bruce.oppenheim@noaa.gov.

Sincerely,

Maria Rea

Maria Rea
Assistant Regional Administrator
California Central Valley Area Office

References cited:

Michel, C. J., A. J. Ammann, S. T. Lindley, P. T. Sandstrom, E. D. Chapman, H. E. Fish, M. J. Thomas, G. P. Singer, P. Klimley, and B. MacFarlane. unpublished draft. Chinook Salmon (*Oncorhynchus Tshawytscha*) Outmigration Survival between Wet and Dry Years in California's Sacramento River.42.

Perry, R. W., P. L. Brandes, J. R. Burau, A. P. Klimley, B. MacFarlane, C. Michel, and J. R. Skalski. 2012. Sensitivity of Survival to Migration Routes Used by Juvenile Chinook Salmon to Negotiate the Sacramento-San Joaquin River Delta. Environmental Biology of Fishes 96(2-3):381-392.

Pyper, B., T. Garrison, S. Cramer, P. L. Brandes, D. P. Jacobson, and M. A. Banks. 2013. Absolute Abundance Estimates of Juvenile Spring-Run and Winter-Run Chinook Salmon at Chipps Island. Page 89. Delta Science of Delta Stewardship Council, Sacramento-San Joaquin Delta.

del Rosario, R. B. d., Y. J. Redler, K. Newman, P. L. Brandes, T. Sommer, K. Reece, and R. Vincik. 2013. Migration Patterns of Juvenile Winter-Run-Sized Chinook Salmon (*Oncorhynchus tshawytscha*) through the Sacramento–San Joaquin Delta. San Francisco Estuary & Watershed Science 11(1).

Enclosures:

1. CDFW letter to NMFS, dated January 7, 2014
2. NMFS winter-run juvenile production estimate from the 2013 spawning escapement
3. Supporting memorandum modifying survival.

cc: Copy to file: ARN 151422SWR2006SA00268
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EDMUND G. BROWN JR., Governor
CHARLTON H. BONHAM, Director

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January 7, 2013

Mr. Will Stelle
Regional Administrator, West Coast Region
National Marine Fisheries Service
7600 Sand Point Way Northeast
Seattle, WA 98115

Dear Mr. Stelle:

Winter-run Chinook Salmon Escapement Estimates for 2013

The California Department of Fish and Wildlife (Department) has developed Sacramento River winter-run Chinook salmon escapement estimates for 2013. These estimates were developed from data collected in the Upper Sacramento River Winter-run Chinook Salmon Escapement Survey (carcass survey) by Department and U.S. Fish and Wildlife Service (USFWS) personnel.

Escapement estimates based on the application of the Cormack-Jolly-Seber (CJS) mark-recapture population model to the upper Sacramento River winter-run carcass survey data for 2013 are shown below:

Estimated Total In-river Escapement (hatchery and natural origin)	**5,958**
Estimated In-river Escapement (hatchery origin)	**397**
Estimated Number of In-river Adult Females (hatchery and natural origin)	**3,613**

These estimates include naturally spawning winter-run Chinook in the upper Sacramento River. In addition, 117 winter-run Chinook were collected at the Keswick trap site upstream from RBDD for spawning at Livingston Stone National Fish Hatchery (LSNFH). These fish are not included in the above estimate of naturally spawning winter-run Chinook. The total winter-run spawning escapement estimate in 2013, including in-river spawners and fish collected for normal hatchery broodstock, is **6,075** fish. The 90% confidence interval on this total estimate is from **5,275 to 6,677** fish.

This year, the escapement estimate was again calculated from the carcass survey data using a different statistical model than used in some previous years. From 2003-2011, the escapement estimate had been based on application of the Jolly-Seber model. Based on the recommendations of the *Central Valley Chinook Salmon In-River Escapement Monitoring Plan* (DFG 2012), starting in 2012, the winter-run carcass survey used field and

analysis methods consistent with application of the CJS model. In simulation studies performed in the development of the Monitoring Plan, the CJS model was shown to more accurately estimate escapement based on mark-recapture data than any other available model. Due to its similarity to the Jolly-Seber model previously used to estimate winter-run escapement, we consider the data for 2013 to be directly comparable for trend analysis with escapement estimates from 2003 through 2012. The CJS model allows the calculation of confidence intervals; we began reporting confidence intervals on our total estimate for the first time in 2012 and continue doing so this year.

In the spring of 2013 the Department observed a number of Chinook salmon had strayed into the Colusa Basin Drain area and were trapped by irrigation diversions. Many of these fish were winter-run Chinook and were released back into the Sacramento River. These released fish are included in the in-river totals listed above because they were assumed to have reached the spawning grounds. Other salmon (spring-run and winter-run) were observed to have died in the Colusa Basin Drain and are not included in the above totals. In addition, another 47 known winter-run Chinook were rescued and taken into LSNFH on an emergency basis and are not included in any of the totals above.

We look forward to further discussion and collaboration with NOAA Fisheries staff regarding the application of this information. Inquiries regarding the methodology and development of the estimates in this letter should be directed to Mr. Michael Lacy, Michael.Lacy@wildlife.ca.gov or at the address and phone number above.

Sincerely,

Stafford Lehr, Chief
Fisheries Branch

cc: See next page.

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NMFS - Southwest Region **Enclosure 2**

WINTER RUN JPE ESTIMATOR PROGRAM

Version 5 2/10/2014

DATA ENTRY HERE

Year Pair	*Broodyear*
2013/2014	2010

actually observed: 3,309

Females unspawned: 1.00% 3/

CDFG Carcass Survey: 6,075 1/

Female Percent: 60.64% 2/

LSNFH *Hatchery Release*: 193,000 9/

Release Date: 02/01/14

WINTER RUN CHINOOK SALMON Juvenile Production Estimate	Factors	Carcass Survey Estimate
Total In-river Escapement - 1/		5958
Adult Female Estimate - 2/	0.61	3613
Prespawn mortality - 3/	0.01	3577
Average Fecundity - 4/	4596	16439295
Egg Loss Due To Temperature - 5/	0.0017	27947
Total Viable Eggs		16411348
Estimated Survival - egg to fry (at RBDD) -6/	0.27	4431064
Estimated Survival - fry-to-smolt - 7/ (RBDD to Tower Bridge at Sacramento)	0.27	1196387
Total Natural Production Entering Delta		1196387
Hatchery Release - 8/		193000
Total Hatchery Production Entering Delta - 9/	0.16	30880
Level of Concern for wild fish (1%)		11964
Level of Concern for hatchery fish (0.5%)		154
Incidental Take Level for Natural Production (2%)		23928
Incidental Take level for Hatchery Production (1%)		309

Footnotes -

1/ Total in-river escapement from Cormack-Jolly-Seber (CJS) model (90% CI), includes natural and hatchery origin, but not 117 collected at Keswick trap for LSNFH (CDFW letter 1/7/14).

2/ The number of females is derived from carcass survey and then the number of males is derived using sex ratio at Keswick trap.

3/ Pre-spawn mortality was estimated from carcass surveys of females (CDFW final estimate 12/15/13).

4/ Average # eggs/female, from 2013 returns to LSNFH (n=50), John Rueth, USFWS, email 12/13/13.

5/ 1 of 569 redds (569/1) observed below Airport Rd temperature compliance point (CDFW redd data).

6/ Egg-to-fry survival based on 15 year average at RBDD using JPI/female spawners in carcass survey, and fecundity data. Increased from 25% in 2013 (Bill Poytress, USFWS, subteam notes 12/6/13)

7/ Weighted average (50/50) of winter-run (2013) and late-fall run (2007-2010) acoustic tag data.

8/ LSNFH estimated 2014 release numbers from USFWS pre-release, 2/3/14 (100% tagged & clipped).

9/ Hatchery survival estimated from 2013 acoustic tag study (Hassrick, unpublished)

MEMORANDUM TO: File AR151422SWR2006SA00268 Enclosure 3

FROM: Bruce Oppenheim
Fishery Biologist, California Central Valley Area Office
West Coast Region, National Marine Fisheries Service

SUBJECT: 2013 Winter-run Juvenile Production Estimate

PROJECT BACKGROUND

Project Name: Biological Opinion on the Long-Term Operation of the Central Valley Project (CVP) and State Water Project (SWP)
Date: January 27, 2014

In order to provide the incidental take for the CVP/SWP operations at the export facilities in the south Delta, NMFS calculates the number of juvenile winter-run that will enter the Sacramento-San Joaquin Delta annually based on adult escapement. The California Department of Fish and Wildlife (CDFW) typically provides an official adult escapement estimate in late December, or early January (official letter to NMFS). The number of adults is determined from carcass surveys conducted during the summer (May–September) in the upper Sacramento River (upstream of above Red Bluff Diversion Dam). A simple spreadsheet model calculates the juvenile production estimate (JPE) to the Delta based on these data, and survival terms based on life history stages and river reaches. Each year, the Winter-run Project Work Team (WRPWT) part of the Interagency Ecological Program, reviews the data that feed into the calculations of the JPE. For the 2013 winter-run spawning escapement, the WRPWT, of which NMFS is a member, reviewed the latest studies using acoustic tags and recommended making changes to the survival terms used in the JPE.

This memorandum describes the modifications to the winter-run JPE for brood-year 2013. NMFS staff from the California Central Valley Area Office and the Southwest Fisheries Science Center participated in the review of the latest studies (both published and unpublished). This was the first year that direct measurements of juvenile winter-run survival were available using acoustic tags. Also, 4 years of absolute abundance estimates (2008–2011) using genetic identification of winter-run at Chipps Island (Pyper *et al.* 2013) were compared to the JPE to determine in-river survival. Acoustic tag data from other runs including late-fall run Chinook salmon (Table 2) were used to compare the cumulative survival rates from the upper Sacramento River spawning grounds (above Red Bluff Diversion Dam) to Sacramento (Tower Bridge). The changes made to the JPE for the 2013 spawning escapement reflect a more accurate abundance estimate that reduces uncertainty associated with assumptions used in previous indirect methods that were considered best available at the time. The survival estimates were revised based on both acoustically-tagged winter-run and late-fall run hatchery releases, rather than solely inferring survival from surrogates (*e.g.*, CWT fall-run and late-fall run hatchery releases). Table 1 summarizes the changes made to the survival terms in the JPE.

Table 1. Summary of Modifications to Survival Terms in the JPE

Survival Term (life-stage)	Old Term	Basis	New Term	Basis
Egg-to-Fry	.25	RBDD data (direct)	.27	Added 2 years data (direct)
Fry-to-Smolt	.59	Fall-run spawning, 1985 Tehama-Colusa Canal (indirect)	N/A	Deleted, overlaps with the following survival term
Smolt (Salt Creek to Delta)	.54	Difference in CWT ocean recoveries of paired late-fall between Battle Creek and Delta 1994–2004 (indirect)	.27	Weighted average of late-fall run (2007–2010) and winter-run (2013) acoustic tag data (direct)

RBDD = Red Bluff Diversion Dam, CWT = Coded Wire Tag, N/A = not applicable

A technical subteam of the WRPWT made two proposals to modify the survival (S) to the Delta term (S= .54) currently used in the JPE, based on the latest studies. These were to either use: (1) one year of winter-run 2013 acoustic data (S = .16; Hassrick and Hayes, unpublished data), or (2) combine the winter-run 2013 acoustic data with the average survival of five years (2007–2011) of late-fall run acoustic data (S = .39), from Michel *et al.* (unpublished draft). After reviewing both the pros and cons of each proposal, the WRPWT could not reach agreement on which proposal to from the JPE subteam to support (CDFW 2014).

To calculate the JPE for the 2013 spawning escapement, NMFS applied a weighted average to the acoustically-tagged winter-run and late fall-run data (Lindley 2014). To reflect this year's critically dry habitat conditions, data representing dry years was chosen: the 2013 winter-run data and the average of 4 dry years of late fall-run acoustic data (2007–2010[1], Table 2). The survival rates of the 2013 winter-run data and the average of the late fall-run data were then weighted equally (50/50) and added together, in consideration of using a single year of winter-run data from 2013, and multiple years of acoustic tag data from late fall-run that likely have different life history and habitat needs and migration patterns.

NMFS methodology to calculate the JPE for the 2013 winter-run spawning escapement:

(1) Average of late-fall run (dry year) survival (2007-2010) = .38 * .50 (weighting) =.19
(2) 2013 (dry year) winter-run survival = .16 * .50 (weighting) = .08
(3) Sum of weighted survivals = (.19 + .08) = .27

In the future, if and when more data on winter-run juvenile survival becomes available, this weighting method can change to reflect the variability in multiple years and differences in hydrologic conditions (*i.e.*, environmental/habitat conditions).

[1] 2011 was a wet year, therefore, acoustic data from that year were not included.

Table 2. Late fall-run cumulative survival rates from RBDD to Sacramento using acoustically-tagged hatchery releases (Michel *et al.* unpublished draft).

Year	WY	S	SE	CI	UCI	LCI	River Segment
2007	D	0.213	0.060	0.118	0.331	0.095	RBDD to I-80/50 bridge in Sacramento
2008	C	0.378	0.059	0.116	0.494	0.262	RBDD to I-80/50 bridge in Sacramento
2009	D	0.501	0.058	0.114	0.615	0.387	RBDD to I-80/50 bridge in Sacramento
2010	BN	0.419	0.053	0.104	0.523	0.315	RBDD to I-80/50 bridge in Sacramento
2011	W	0.672	0.039	0.076	0.748	0.596	Jelly's Ferry to I-80/50 bridge in Sacramento (survival from RBDD down was not available due to poor detection efficiency)

S = survival, SE = Standard Error, CI = Confidence Interval, UCI = upper confidence interval, LCI= lower confidence interval. WY=Water Year Type, based on unimpaired runoff (CDEC WSIHIST) where D=Dry, C=Critical, BN=Below Normal, W=Wet.

References:

Lindley, S. 2014. Electronic mail summarizing a conference call with Steve Lindley, Maria Rea, and Garwin Yip concerning winter-run survival estimates. January 22, 2014.

CDFW. 2014. Memorandum from the winter-run Project Work Team to the JPE sub-team concerning modifications to the 2013 winter-run juvenile production estimate. Interagency Ecological Program. February 4.

Hassrick, J. and Sean Hayes. Unpublished. Survival of Migratory Patterns of Juvenile Winter-run Chinook salmon in the Sacramento River, Delta, and San Francisco Bay. Results of first year acoustic tag study. Contributing agencies include the National Marine Fisheries Service, University of California at Davis, Cramer Fish Sciences, California Department of Water Resources, and the U.S. Fish and Wildlife Service.

Michel, C. J., A. J. Ammann, S. T. Lindley, P. T. Sandstrom, E. D. Chapman, H. E. Fish, M. J. Thomas, G. P. Singer, P. Klimley, and B. MacFarlane. unpublished draft. Chinook Salmon (*Oncorhynchus Tshawytscha*) Outmigration Survival between Wet and Dry Years in California's Sacramento River.42.

Pyper, B., T. Garrison, S. Cramer, P. L. Brandes, D. P. Jacobson, and M. A. Banks. 2013. Absolute Abundance Estimates of Juvenile Spring-Run and Winter-Run Chinook Salmon at Chipps Island. Page 89. Delta Science of Delta Stewardship Council, Sacramento-San Joaquin Delta.