Status of Species

Winter-run Chinook salmon

A small number of winter-run Chinook salmon (*Oncorhynchus tshawytscha*) (n=3,015; 90% CI= 2,741-3,290) returned to spawn in the upper Sacramento River in 2014. Of these 3,105 winter-run Chinook, 388 were collected for broodstock at the Keswick trap. Assuming that 3-year old fish make up the majority of each spawning cohort, returning adults in 2014 were produced by a much smaller spawning escapement in 2011 (i.e., 827 adult spawners). The effects of limited cold water storage and loss of temperature control out of Keswick Dam from early September through the fall of 2014 led to substantial egg and fry mortality (Figure 1). Typically, the peak of fry outmigration from the upper Sacramento River has occurred in early-to-mid October, with fish rearing in the middle reaches of the Sacramento River downstream of Red Bluff Diversion Dam (RBDD). However, in 2014, the winter-run Chinook salmon fry population appeared to start moving downstream past RBDD in September and no noticeable peaks in passage have been observed through the current period (Figures 2 and 3). A one-day emigration pulse event occurred in late October, which was associated with a spike in turbidity; but observation of migrating fry passed RBDD have so far remained extremely low even with large precipitation events in early and mid-December and their associated increases in turbidity and river flows.

Because of staffing issues and concerns about debris during the high flows in December, the rotary screw traps at RBDD were operated for just 8 of 31 days during December 2014[1]. While this adds some uncertainty to the 2014 brood year passage estimates, historical patterns suggest that most winter-run Chinook salmon juveniles would have passed RBDD before December. Also, the seasonal passage estimates RBDD do include estimates of passage on non-sampled days based on interpolation. So, while it is possible that some of the higher passage days might not have been sampled and the estimated seasonal passage may be somewhat underestimating actual passage, the current RBDD passage estimate is less than half of the estimated passage for brood year 2011 juveniles, despite an adult escapement nearly four times the escapement observed in 2011.

Few winter-run Chinook salmon juveniles are currently being observed in the upper Sacramento River and the annual population estimates remain lower than expected. As of January 14, 2015, an estimated 402,000 winter-run Chinook salmon juveniles have migrated past RBDD (Gruber 2015). Flows from Keswick Dam were reduced during November for cold water pool conservation (Figure 4), and of 89 potential stranding sites along the Sacramento River from Tehama (Los Molinos) to Keswick Dam (about 70 river miles), only nine completely isolated sites were identified to have winter-run salmon trapped in them (Doug Killam, California

[1] Biweekly reports from RBDD are available at: http://www.fws.gov/redbluff/RBDD%20JSM%20Biweekly/2014/rbdd_jsmp_2014.html

Department of Fish and Wildlife [CDFW], pers. comm. January 20, 2015). Field biologists attribute the rarity of stranded juveniles in potential stranding locations to rarity of juveniles, not to improved avoidance of stranding relative to previous years.

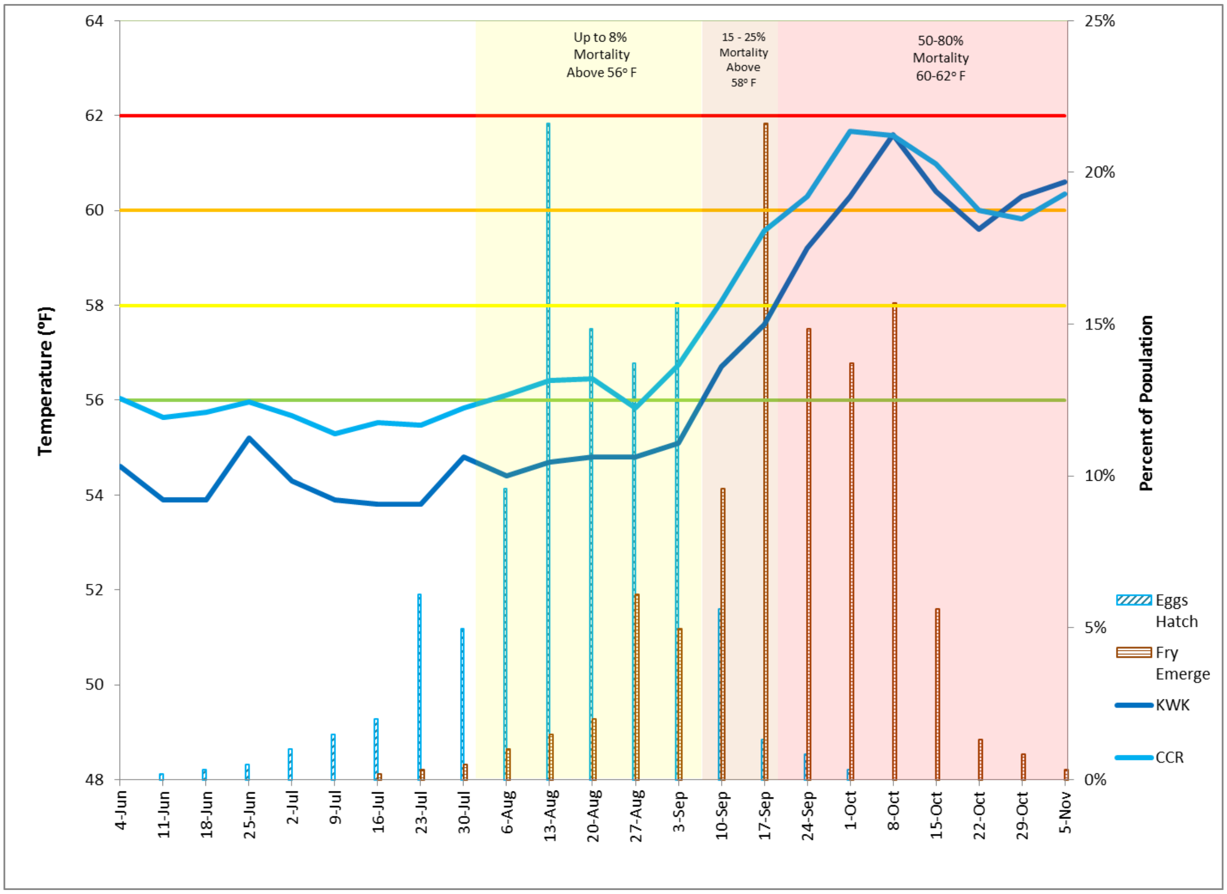


Figure 1. Water temperatures at Keswick Dam (KWK) and Clear Creek Confluence (CCR, WY14 temperature compliance point) and winter-run Chinook salmon early life history between May 1 and November 6, 2014. [2]

[2] Figure supplied by CDFW on January 20, 2015.

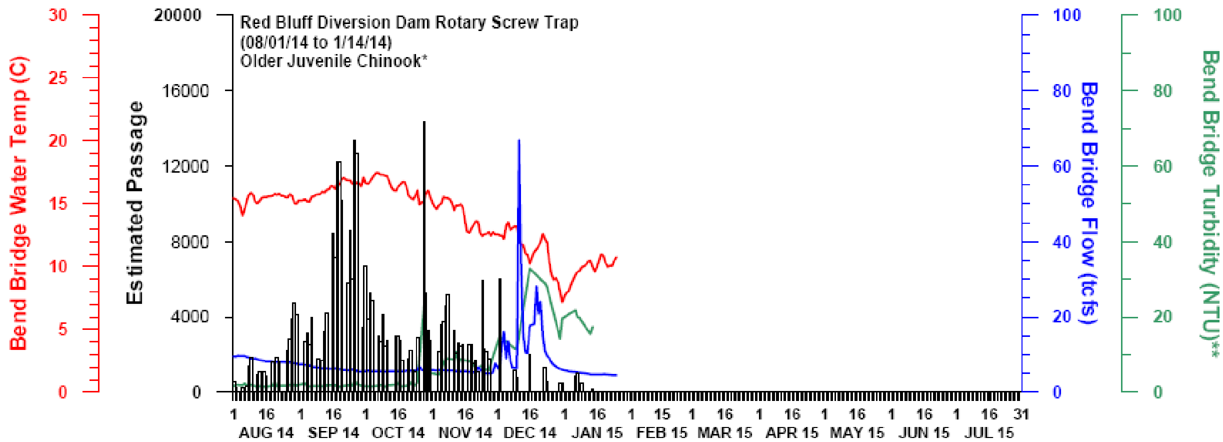


Figure 2. Daily estimated passage of Older Juvenile Chinook Salmon at Red Bluff Diversion Dam (RK 391) and associated environmental data at Bend Bridge (RK 415), BY2014. [3]

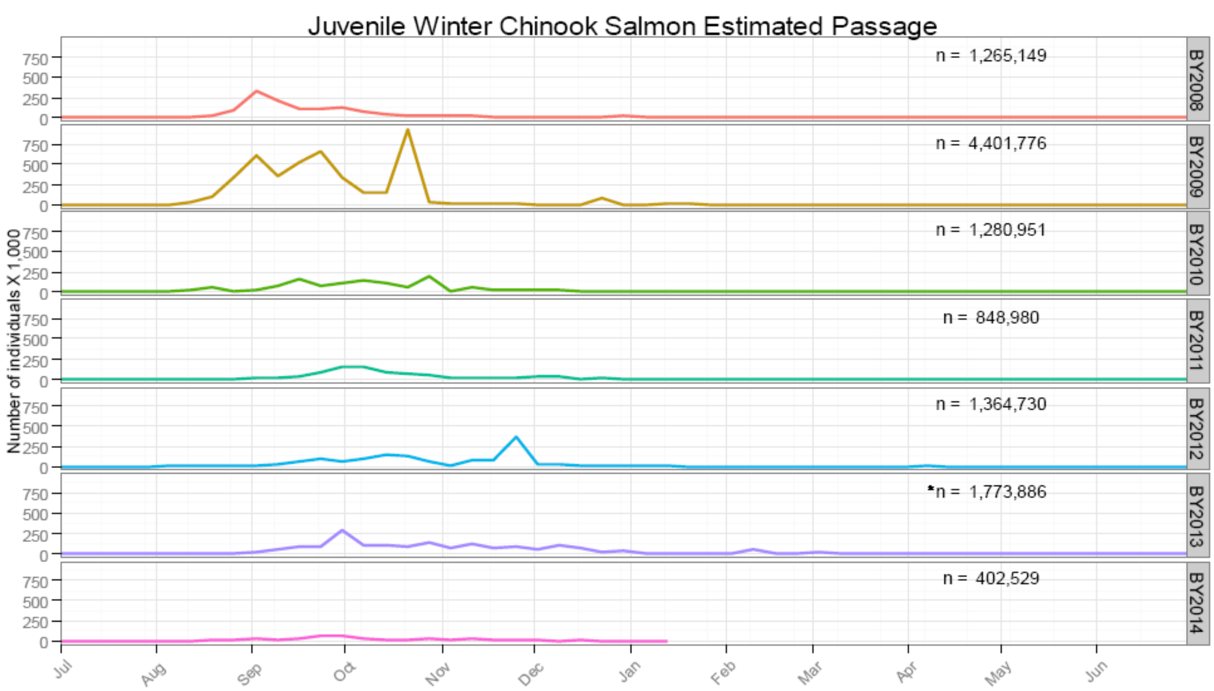


Figure 1. Weekly estimated passage of juvenile winter Chinook Salmon at Red Bluff Diversion Dam (RK391) by brood-year (BY). Fish were sampled using rotary-screw traps for the period July 1, 2008 to present.

Figure 3. Weekly estimated passage of Juvenile Winter-run Chinook Salmon at Red Bluff Diversion Dam (RK 391) by brood year (BY), BY2008-BY2014. [4]

[3] Figure supplied by DWR to DOSS on January 27, 2015.

[4] Fish were sampled using rotary-screw traps for the period July 1, 2008 to present. Winter-run passage value interpolated using a monthly mean for the period of October 1 through October 17, 2013, due to government shutdown. Figure supplied by USFWS on January 15, 2015.

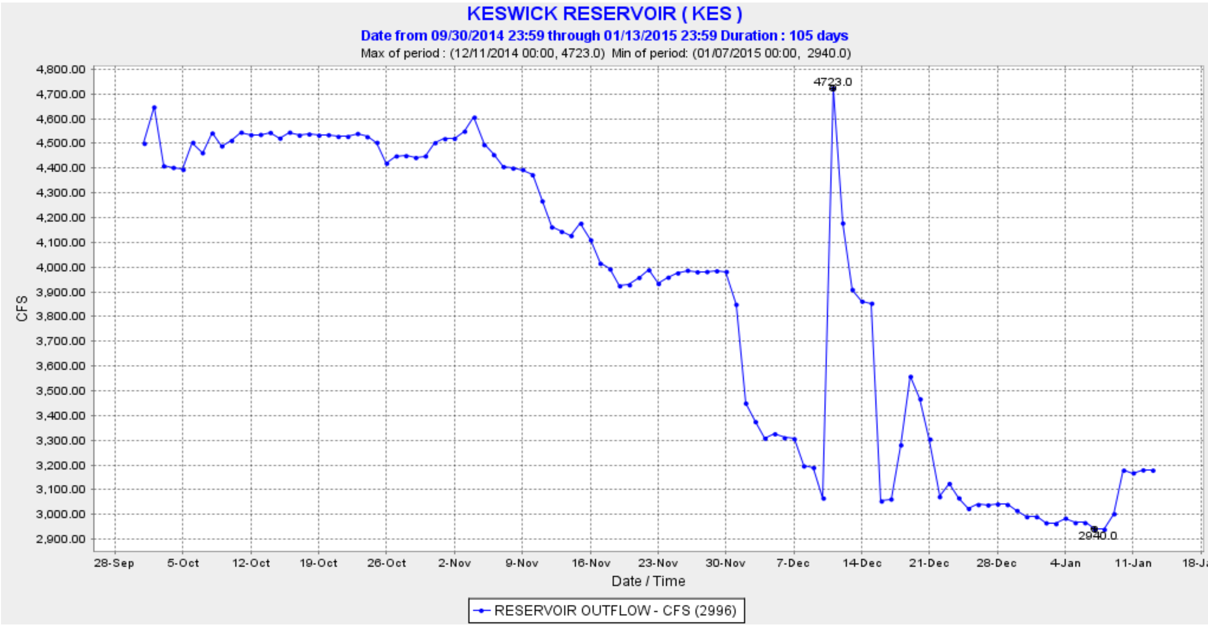


Figure 4. Keswick Reservoir outflow measured at Keswick Reservoir (KES) for water year (WY) 2015.[5]

These observations suggest that brood year (BY) 2014 winter-run Chinook salmon experienced substantial negative effects associated with drought-related environmental conditions. These effects are predicted to include significantly greater temperature mortality during the incubation of eggs and juvenile rearing stages than has previously been observed, truncation of the migration period from natal habitats due to the loss of a substantial proportion of the later portion of the incubating eggs and rearing juveniles, and significant reductions in the expression of a diversity of juvenile life history traits (parr and smolt migrants).

Del Rosario et al. (2013) described multiple pulses of distinctly different-sized juvenile winter-run Chinook salmon typically moving through the Lower Sacramento River past Knights Landing from November to January. These pulses of fish are associated with flow pulses greater than 400m^3/s (approximately 14,000 cfs) as measured at Wilkins Slough. For juvenile winter-run Chinook salmon BY2014 (through January 20, 2015), observations at Knights Landing and Tisdale Weir rotary screw traps (RST) indicate two migration pulses of juveniles have moved downstream into the Delta. The initial pulse emigrated during a storm event in late October that did not increase river flows on the Sacramento River substantially, but did increase turbidity in the mainstem Sacramento River. The second pulse emigrated during a large storm event in mid-December (Figure 3, Table 1). As a result, it appears that winter-run Chinook salmon juveniles

[5] Downloaded from CDEC on January 14, 2015.

emigrated from the upper Sacramento River between mid-October and mid-December, and the majority of the population (>95%) has moved out of the riverine system and entered the Delta.

Based on the 2014 adult winter-run Chinook salmon escapement (3,015 spawners, including 388 collected as hatchery broodstock), NMFS recently estimated a juvenile production estimate (JPE)[6] for both natural-origin (124,251) and hatchery-produced (188,500) winter-run Chinook salmon entering the Delta during WY 2015. This year's JPE reflects a number of significant changes as a result of recommendations by the (1) Long Term Biological Opinion Independent Review Panel, (2) Interagency Ecological Program Winter-Run Project Work Team, and (3) internal discussions by NMFS with the NMFS-Southwest Fisheries Science Center. While NMFS presented three methods of calculating the JPE—historical NMFS JPE method, Cramer Fish Science (CFS) Model, and the Juvenile Production Index (JPI) from USFWS—NMFS decided that the JPI method was a better fit because both the NMFS JPE and CFS models inaccurately represented the extreme drought conditions and associated early life stage losses due to high temperatures that occurred in 2014 as described previously (Figure 1). On the basis of the JPE, the authorized level of incidental take under the 2009 biological opinion for the Long Term Operations for the combined CVP/SWP Delta pumping facilities from October 1, 2014 through June 30 2015 was set at 2,490 natural (non-clipped, i.e., wild) winter-run Chinook salmon juveniles. The incidental take for hatchery-produced winter-run Chinook salmon juveniles was set at 1,885.

Due to the very low estimated abundances of juvenile winter-run Chinook salmon entering the Delta, observational data from sampling programs could be negatively biased due to rarity of observing winter-run Chinook salmon in the monitoring efforts. Nonetheless, observations from the Delta Juvenile Fish Monitoring Program's beach seining and trawling surveys, and special drought monitoring surveys (i.e., trawling efforts at Jersey and Prisoners Point) to date support the conclusion that winter-run Chinook salmon have migrated downstream and are currently rearing extensively in the Lower Sacramento and Delta survey regions (Table 2). Natural origin winter-run Chinook salmon have been observed weekly in very low densities at the CVP and SWP facilities since December 14, 2014 (combined loss =110, as of January 26, 2015); this also suggests that some juveniles are also present in the south Delta waterways. Finally, few winter-run Chinook salmon juveniles have been observed at Chipps Island suggesting that the majority of the population has not yet migrated to the ocean and is currently rearing in the Delta (Table 2). This broad distribution of juvenile winter-run Chinook salmon across the Delta during the winter

[6] http://www.westcoast.fisheries.noaa.gov/publications/Central_Valley/Water%20Operations/20150116_nmfs_winter-run_juvenile_production_estimate_nr.pdf

Table 1. Raw weekly fish observation data from Tisdale and Knights Landing rotary screw traps in WY2015.[7]

	Tisdale								Knights Landing							
	Wild Juveniles					Ad clipped			Wild juveniles					Ad clipped		
	Fall	Spring	Winter	Late fall	Steelhead	Salmon	Steelhead	Weekly total	Fall	Spring	Winter	Late fall	Steelhead	Salmon	Steelhead	Weekly total
10/4/2014 - 10/10/2014	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1
10/11/2014 - 10/17/2014	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10/18/2014 - 10/24/2014	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1
10/25/2014 - 10/31/2014	0	2	117	2	0	0	0	121	0	1	95	4	0	0	0	100
11/1/2014 - 11/7/2014	0	1	2	0	0	0	0	3	0	0	2	0	0	0	0	2
11/8/2014 - 11/14/2014	0	0	1	0	0	0	1	2	0	0	2	0	0	0	0	2
11/15/2014 - 11/21/2014	0	0	3	1	0	0	0	4	0	0	3	0	0	0	0	3
11/22/2014 - 11/28/2014	0	0	3	0	0	0	0	3	0	0	2	0	0	0	0	2
11/29/2014 - 12/5/2014	0	0	7	0	0	2	0	9	0	0	2	0	0	0	0	2
12/6/2014 - 12/12/2014	10	14	10	2	0	5	0	41	17	50	32	8	0	24	0	131
12/13/2014 - 12/19/2014	169	9	0	2	0	2	0	182	148	88	5	1	0	4	0	246
12/20/2014 - 12/26/2014	654	35	24	5	1	6	0	725	411	112	14	4	0	8	0	549
12/27/2014 - 1/2/2015	148	22	1	1	0	0	0	172	13	6	0	1	0	0	0	20
1/3/2015 - 1/9/2015	91	61	6	0	2	0	0	160	15	13	0	2	0	2	0	32
Species Totals	1072	144	174	13	3	15	1		604	278	158	21	0	38	0	

[7] Data updated through January 9, 2015. These raw catch numbers have not been expanded to account from inoperable traps, sampling period variation, and sampling cone variation.

is common and was described initially by Erkkila *et al*. (1951) prior to the initiation of CVP operations in the early 1950's.

Table 2. Weekly Fish Observation Data from the Delta Juvenile Fish Monitoring Program in WY2015.[8]

	Wild juveniles					Ad clipped		
Beach Seine Region	**Fall**	**LateFall**	**Spring**	**Winter**	**Steelhead**	**Chinook**	**Steelhead**	**Weekly Total**
Bay East	0	0	0	0	0	0	0	0
Bay West	0	0	0	0	0	0	0	0
Central Delta	3	0	1	0	0	0	0	4
Lower Sacramento	22	0	3	6	0	0	0	31
North Delta	23	0	8	0	0	1	0	32
Sacramento	263	8	177	54	1	13	0	516
South Delta	0	0	0	0	0	0	0	0
San Joaquin	0	0	0	0	0	0	0	0
Trawl								
Sacramento	103	5	21	15	0	16	0	160
Chipps	2	20	0	5	0	62	0	89
Jersey Point	22	1	3		0	0	0	26
Prisoners Pt	5	1	3	1	0	0	0	10
Species Total	443	35	216	81	1	92	0	

The observations described herein (i.e., RBDD, Tisdale, and Knights Landing RSTs; Delta Juvenile Fish Monitoring Program's beach seining and trawling surveys, and special drought monitoring [i.e., trawling surveys at Jersey and Prisoner's Point]), have been reviewed by the Delta Operation for Salmon and Sturgeon (DOSS) work team to evaluate the distribution of winter-run Chinook salmon juveniles in the Central Valley. Based on the currently available data, DOSS estimates that the majority (>95%) of winter-run Chinook salmon are in the Delta, while <5% either remain upstream of Knights Landing or have already exited the Delta past Chipps Island. This estimate is based on the best professional judgment of the biologists participating on the DOSS work team.

At this time, adult winter-run Chinook salmon are starting to enter the Sacramento River system and have begun to migrate to the upper reaches of the river. These adult winter-run Chinook salmon must hold in the upper Sacramento River between the RBDD and the impassable Keswick Dam until they are ready to spawn during the summer. These fish require cold water holding habitat for several months prior to spawning to allow for maturation of their gonads, and then subsequently require cold water to ensure the proper development of their fertilized eggs, which are highly sensitive to thermal conditions during this embryo development period (*i.e.*, embryogenesis). Adults returning to the river in 2015 are predominantly members of the cohort

[8] Data updated through January 13, 2015.

from BY2012 (assuming a 3-year cohort cycle). Based on cohort replacement rate (CRR) estimates, BY2012 had the fifth lowest CRR since 1992.

Spring-run Chinook Salmon

The 2014 spawning run of spring-run Chinook returning to the upper Sacramento River was lower in four of seven locations compared to the 2013 escapement, with considerably lower escapement observed in Butte Creek and Feather River Hatchery (Table 3).

Table 3. Spring run Chinook escapement in 2013 and 2014.

Location	2013	2014	Source
Battle Creek	608	429	Laurie Earley, USFWS
Clear Creek	659	95	
Antelope Creek	0	7	Matt Johnson, DFW
Mill Creek	644	679	
Deer Creek	708	830	
Butte Creek	16783	4815	Clint Garman, DFW
Feather River Hatchery	4294	2825	Penny Crenshaw, DWR

Spring-run Chinook salmon eggs in the Sacramento River underwent significant, and potentially complete, mortality due to high water temperature downstream of Keswick Dam starting in early September when water temperatures downstream of Keswick Dam exceeded 56^{o}Fahrenheit (F) (see water temperatures during September and October in Figure 1). Spawning of spring-run Chinook salmon in the Sacramento River Basin occurs approximately from mid-August through mid-October, peaking in September. This peak in spawning activity corresponded with the high Sacramento River temperatures downstream of Keswick Dam throughout the fall of 2014, and illustrates the potential for high egg and alevin mortality. Spring-run Chinook salmon eggs spawned in the tributaries to the Sacramento River may also have experienced warmer temperatures this year due to low flows through late October, as well as scouring or sedimentation during rain events from late October through December. Extremely few juvenile spring-run Chinook salmon have been observed this year migrating downstream past RBDD (Figure 5) during high winter flows, when spring-run Chinook salmon originating from the upper Sacramento River, Clear Creek, and other northern tributaries are typically observed to outmigrate. While, as noted for winter-run Chinook, the rotary screw traps at RBDD were operated for just 8 of 31 days during December 2014[9], the low RBDD passage estimates are a concern. A second pulse of juvenile spring-run Chinook salmon typically migrate past RBDD in the springtime (Poytress et al. 2014). However, this second pulse appears to positively bias

[9] Biweekly reports from RBDD are available at: http://www.fws.gov/redbluff/RBDD%20JSM%20Biweekly/2014/rbdd_jsmp_2014.html

estimates of spring Chinook passage due to the millions of unmarked fall-run Chinook salmon hatchery production fish falling into the spring-run Chinook salmon category based on the length-at-date run assignments (Poytress et al. 2014).

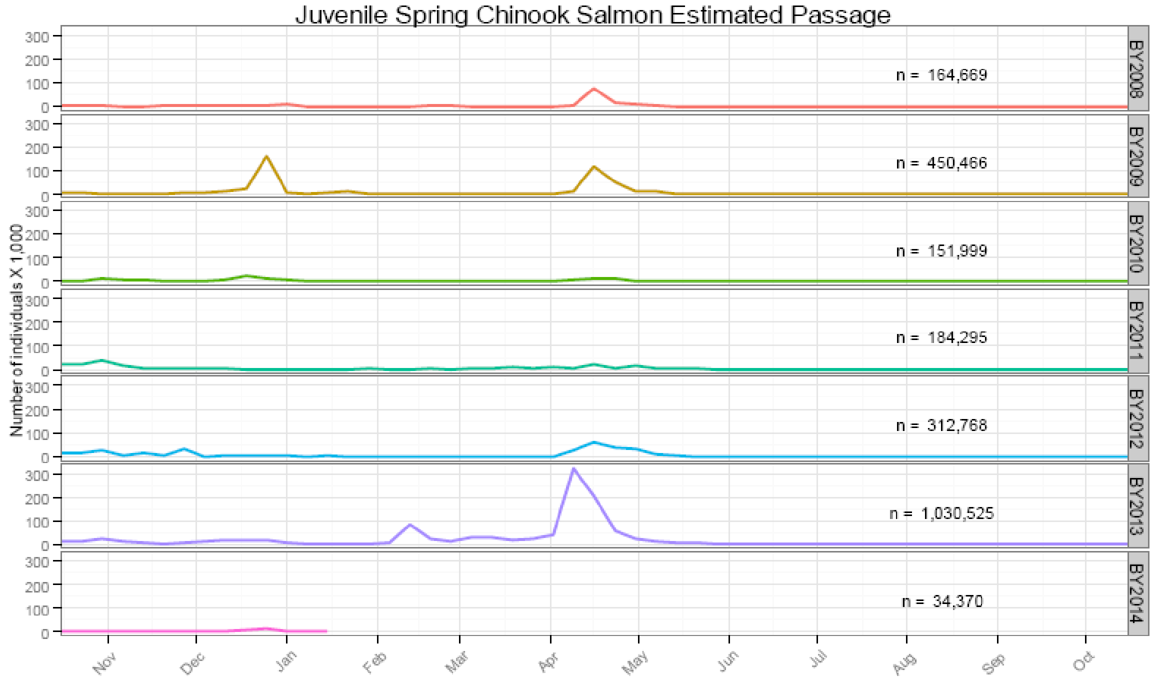


Figure 5. Weekly estimated passage of Juvenile Spring-Run Chinook Salmon at Red Bluff Diversion Dam (RK 391) by brood year (BY).[10]

In fall 2014, yearling spring-run Chinook salmon from Mill and Deer creeks experienced flow and temperature conditions typically associated with the outmigration of this life history expression from these tributaries. Although not currently monitored with RSTs, these tributaries have experienced flows (Figure 6-7) exceeding "First Alert" thresholds identified in the NMFS BiOp Action IV.1.2. Recent analyses of multiple years of RST data have determined that 99% of outmigrating yearlings are captured at flows greater than 95 cfs (Kevin Reece, DWR, pers. comm.). Based on the currently available data, DOSS estimates that the majority (80-90%) of yearling spring-run Chinook salmon are in the Delta, while <5% remain upstream of Knights Landing and <15% have already exited the Delta past Chipps Island. This estimate is based on the best professional judgment of the biologists participating on the DOSS work team.

Spring-run young-of-the-year (YOY) sized Chinook salmon juveniles have been observed at the Tisdale Weir and Knights Landing RSTs since early December, 2014 (Table 1). Likewise,

[10] Fish were sampled using rotary-screw traps for the period July 1, 2008 to present. Figure supplied by USFWS on January 15, 2015.

juvenile YOY spring-run Chinook have been observed in the catch from multiple Delta beach seine regions, and in the standard trawling and special drought monitoring trawling surveys, including those in the Central Delta. However, as of January 18, 2015, neither yearling nor YOY spring-run Chinook salmon have been observed at the state and federal fish collection facilities in the South Delta. Based on the currently available data, DOSS estimates up to half (25-50%) of YOY spring-run Chinook salmon are in the Delta, while 50-75% remain upstream of Knights Landing and <5% have already exited the Delta past Chipps Island. This estimate is based on the best professional judgment of the biologists participating on the DOSS work team.

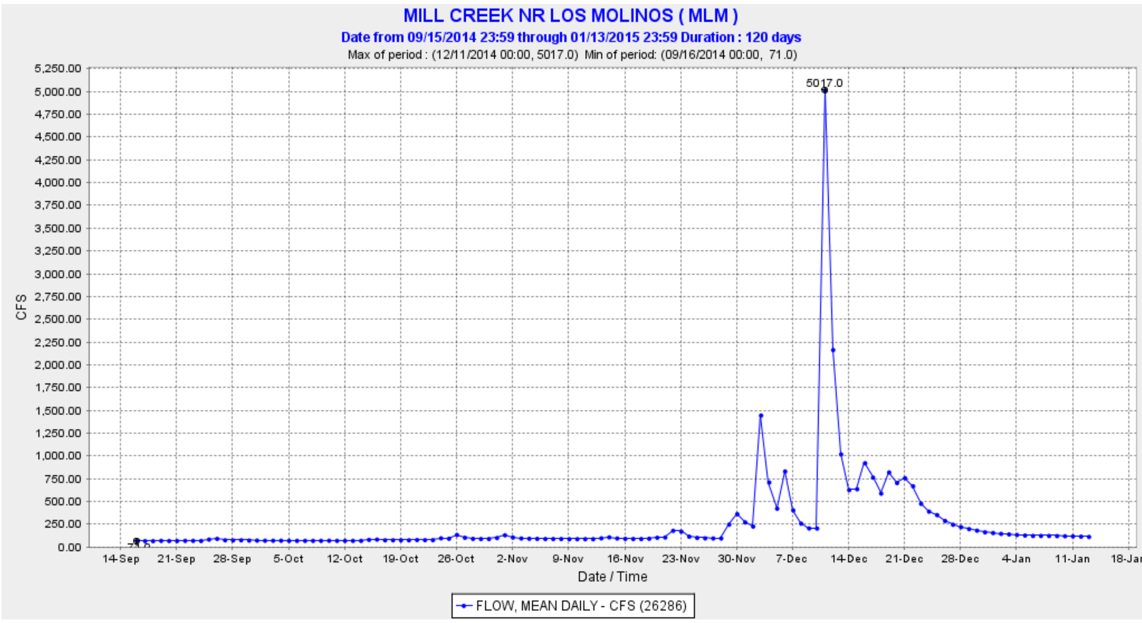


Figure 6. Mill Creek mean daily flow (cubic feet per second) measured near Los Molinos (MLM) during WY2015.[11]

[11] Downloaded from CDEC on January 14, 2015.

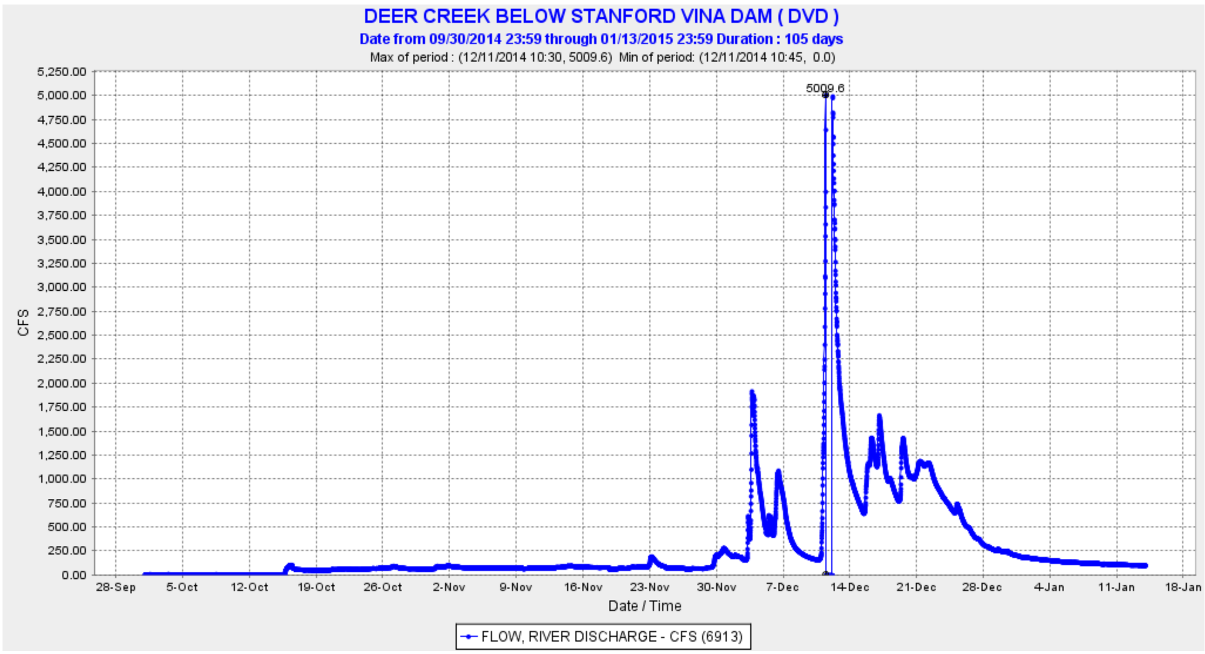


Figure 7. Deer Creek discharge (cubic feet per second) measured downstream of Stanford Vina Dam (DVD) during WY2015.[12]

Steelhead

California Central Valley steelhead (*Oncorhynchus mykiss*) smolts are seldom recovered in Sacramento River and Delta fish monitoring efforts due to sampling biases related to their larger size and enhanced swimming ability. False negatives (*i.e.*, zero catches when the target species is present) are more likely with steelhead smolts than smaller older juvenile Chinook salmon, but historic data can be assessed to consider their typical periodicity in Delta monitoring efforts. Between 1998 and 2011, temporal observations of wild steelhead juveniles (n=2,137) collected in Delta monitoring efforts occurred less than 10% of the time in January, >30% of the time during February, and >20% of the time during March.

Observed patterns of outmigrating *O. mykiss* from BY2014 at RBDD appear most similar to that of BY2011 (Figure 8); however, there was no peak migration observed in the typical August/September period. For WY2015 (as of January 12, 2015), five unmarked (two on 10/15/2014; and three between 1/7/2015 and 1/11/2015) and 828 marked steelhead (1/7/2015 to 1/12/2015) were captured at the GCID RST. The latter marked fish likely originated from a Coleman release of 688,000 brood year 2014 steelhead (100% marked with adipose clip only) in the Sacramento River at Bend Bridge (fish released in two groups: 144,700 on January 2, 2015, and 543,300 on January 5-9, 2015). For WY2015 (as of January 23, 2015), three unmarked (two captured between 1/5/2015 and 1/8/2015, and one on 12/22/2014) and 11 marked steelhead (first on 11/8/2014, 10 since 1/12/2015) were observed at the Tisdale Weir RST; and 12 clipped steelhead were captured at Knights Landing RST as of 1/22/2015.

[12] Downloaded from CDEC on January 14, 2015.

For WY2015 (as of January 23, 2015), one steelhead (acoustic tagged) was observed in the Sacramento beach seine monitoring at Miller Park (300mm fish on 12/8/2014); one clipped steelhead was observed at Sherwood Harbor on 1/23/2015, but not at any of the other trawl locations (i.e, Chipps Island Trawl, Mossdale Trawl, or Jersey Point/Prisoner's Point Trawl); and three steelhead were observed at the SWP (one unmarked on 11/16/2014 for a total salvage of 4, two clipped: one each on 1/23/15 and 1/25/15 for a total salvage of 8) and none at the CVP fish collection facilities at the South Delta CVP/SWP export pumps.

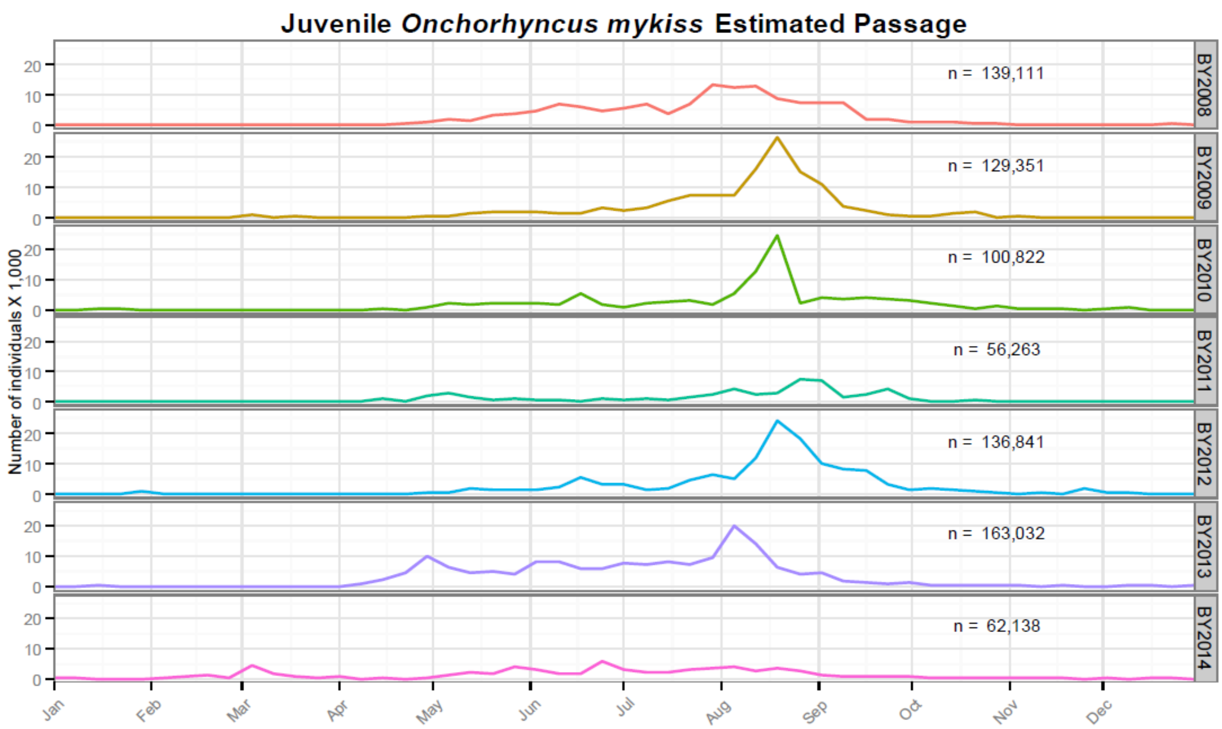


Figure 8. Weekly estimated passage of *O. mykiss* at Red Bluff Diversion Dam (RK 391) by brood year (BY).[13]

Green Sturgeon

Information on green sturgeon is extremely limited. Adult green sturgeon will migrate into the upper Sacramento River through the Delta between March and June. Spawning in the upper Sacramento River was documented during 2014. A review of telemetric data found 26 tagged green sturgeon entered the San Francisco Bay with only half migrating upstream of RBDD (M. Thomas, UC Davis, pers. comm.). Adult green sturgeon have been observed to overwinter in the Sacramento River, and a number of the tagged 2014 adults still appear to be present in the upper Sacramento River as of January 14, 2015 (R. Chase, Reclamation, pers. comm.). Larval green

[13] Fish were sampled using rotary-screw traps for the period July 1, 2008 to present. Figure supplied by USFWS on January 15, 2015.

sturgeon were observed at RBDD (n=319). This was greater than the long-term average of 186 fishes (Figure 9). At RBDD, two juvenile green sturgeon were also observed in the fall of 2014.

At GCID, ten juvenile green sturgeon (TL= 110-285) were observed from September 2014 to January 19, 2015. Green sturgeon observations are extremely rare in the Delta primarily related to the use of monitoring gear types that are not designed to sample the benthic habitats where green sturgeon are most likely to be found if they are present. Although the lower Sacramento and Delta fish monitoring surveys do not target benthic environments they have captured juvenile green sturgeon in the past, but no sturgeon have been observed in those surveys in recent years. Likewise, green sturgeon have not been observed at the state and federal fish collection facilities in the South Delta in recent years. In 2011 more than 3,000 juvenile green sturgeons were captured in the RSTs at RBDD, however no green sturgeon were observed in any of this years' river, Delta, or Bay fish monitoring surveys.

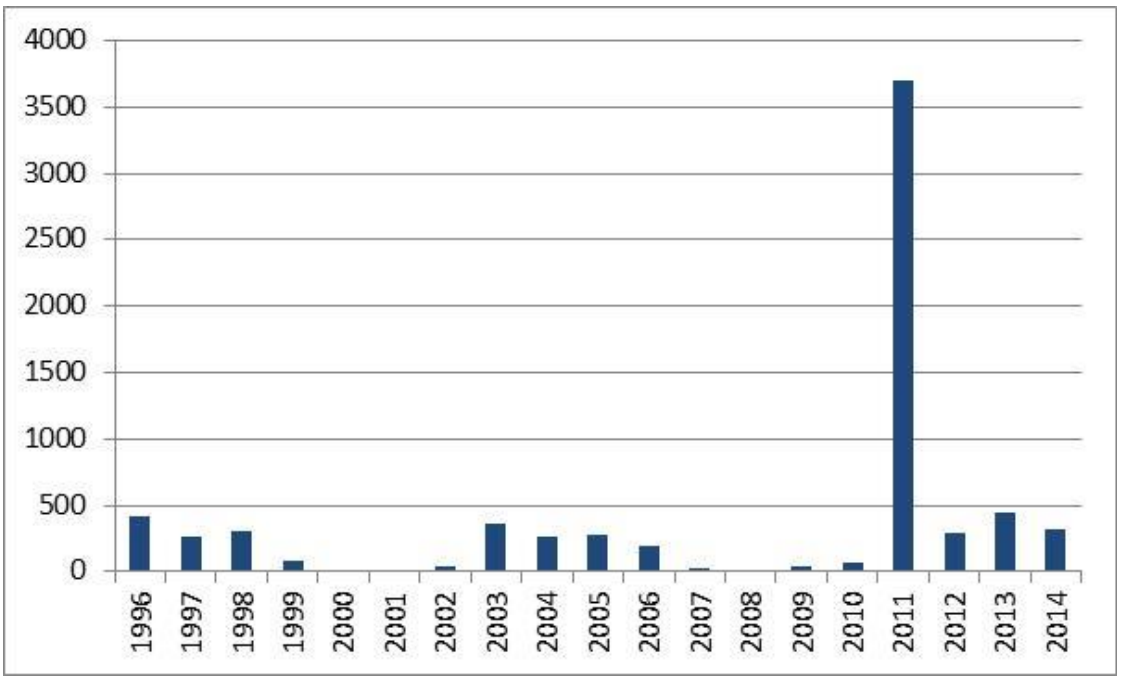


Figure 9. Larval Green sturgeon counted at Red Bluff Diversion Dam rotary screw traps.[14]

[14] The annual average catch is 426 fish. In 2011, an egg was observed directly upstream of the rotary traps; thus, the large number of fish in 2011 represents a unique sampling of a spawning event (Josh Gruber, USFWS, pers comm.). If 2011 data is removed, the annual average of juvenile green sturgeon counted is 183 fishes.

Proposed Action

See Project Description for February – March 2015 Drought Response Actions provided to support Endangered Species Act consultation (Reclamation 2015).

Analytical Framework

Methods and Metrics

A conceptual model for impacts from drought management actions was developed as part of an interagency assessment of the WY2014 drought on winter-run Chinook salmon. The conceptual model describes freshwater behavioral responses to indicators of environmental conditions (e.g., outflow, inflow, Delta Cross Channel [DCC] gates, and exports) that are expected to be affected by the Petition's Project Description. The NMFS BiOp (2009) was reviewed regarding biological linkage to these various actions.

This conceptual model was modified to provide a qualitative assessment of effects predicted to be linked to the four elements of this WY 2015 February and March Project Description: (1) modification to D-1641 Net Delta Outflow Index (NDOI), (2) modification to D-1641 export limits, (3) modification to the D-1641 DCC gate operation, and (4) modification of D-1641 San Joaquin River flow standard. This model highlights the biological linkages between drought management actions in the project description with predictions that can be assessed from the literature and modeling completed (Figure 10). Although OMR modifications are not proposed in the Project Description, they may be incorporated into a Temporary Urgency Change Petition (TUCP) request at a later date.

MANAGEMENT	DCC Gate Operation (Interior delta salinity)	Outflow (NDOI) (Change in Location)	Inflow (Storage impacted by DOP, seasonal depletions)	OMR (change in BiOp criteria)	Exports (E/I calculation)
LINKAGE	• Route entrainment	• Tidal influence • Migration rate • Rearing period • Survival rate	• Migration rate • Rearing period • Survival rate	• Route entrainment • Migration rate • Rearing period • Survival rate	• Route entrainment • Migration rate • Facility survival
ASSESSMENT	• DJFMP periodicity • Changes in DSM2 proportion daily flow • Delta survival information	• Changes in DSM2 velocity characteristics • Changes in DSM2 proportion daily flow • Delta survival information	• Changes in DSM2 velocity characteristics • Changes in DSM2 proportion daily flow • Delta survival information	• SD/CD DJFMP presence/absence • Facility salvage (Density, total, timing) • Delta survival information	• SD/CD DJFMP presence/absence • Facility salvage (Density,total, timing) • Delta survival information

Figure 10. Conceptual model of drought contingency plan elements and their biological linkage to salmonids and assessment information available for evaluation.

To evaluate February and March impacts to listed species due to Delta hydrodynamics caused by the proposed action's changes in outflow and exports, Delta Simulation Model II (DSM2) simulations were performed and evaluated for three different regulatory and operational management decision scenarios (Table 4). It is likely that actual conditions will differ somewhat from the modeled scenarios. Recent meteorological patterns appear to show a decoupled Sacramento and San Joaquin Valley storm pattern (with more rain falling in the Sacramento River basin), and if this continues, it is possible that actual Sacramento River outflow at Freeport could reach the modeled quantities, while actual San Joaquin outflow would not. In particular, if San Joaquin River flows at Vernalis remain low (<850 cfs) and pumping is increased as outflow is greater than 7,100 cfs, there may be a greater impact to San Joaquin fish than indicated in the results of the modeled scenarios. This increases the uncertainty of assessments of impacts to San Joaquin River steelhead.

Table 4. DSM2 regulatory and operational scenarios for February and March 2015 developed for biological review.

Scenario Name	Outflow (cfs)	Freeport flow (cfs)	Vernalis flow (cfs)	Combined Exports (cfs)	OMR (cfs)
4,000 Outflow	4,000	5,600	500	1,500	-1,400
5,500 Outflow	5,500	9,100	500	3,500	-3,200
99% Mod	7,100	11,700	850	6,000	-5,000
90% Least	11,400	15,300	1,400	6,400	-5,000

DSM2 modeling outputs for each scenario were used to evaluate the distribution of 15-minute flow and velocity values for multiple channels including:

- Upstream of Head of Old River (Channel 6)
- Downstream of Head of Old River (Channel 9)
- Upstream of Stockton Deepwater Shipping Channel (Channel 12)
- Downstream of Stockton Deepwater Shipping Channel (Channel 21)
- Turner Cut (Channel 173)
- Columbia Cut (Channel 160)
- Downstream of Head of Old River (Channel 54)
- Grant Line Canal (Channel 81)
- Old River at San Joaquin River (Channel 124)
- Jersey Point on San Joaquin River (Channel 49)
- Sherman Island on Sacramento River (Channel 434)
- Three Mile Slough near San Joaquin River (Channel 310)
- Sherman Island on San Joaquin River (Channel 50)

- Sacramento River upstream of Delta Cross Channel (Channel 421)
- Sacramento River upstream of Georgiana Slough (Channel 422)
- Sacramento river downstream of Georgiana Slough (Channel 423)
- Sacramento River near Cache Slough (Channel 429)

Hydrodynamic metrics, such as daily proportion positive velocity and daily mean velocity, were used to assess changes in the Delta at these locations. Daily proportion positive velocity is the percentage of the day that river flows have a positive velocity value (flows in downstream direction). Daily mean velocity is the average of all velocities values summed over the 24 hour period which takes into account the effects of tidal stage on velocity magnitudes. Distributions of these hydrodynamic metrics under the different outflow and export ranges for each scenario were also examined to qualitatively describe comparisons between different operational conditions likely to occur under the Project Description.

We discuss effects within the Delta during February and March using currently available species distribution and abundance data along with expected upcoming life stage periodicity information. To evaluate impacts to listed species due to Delta outflow changes, DCC gate configuration, and Delta hydrodynamics caused by the proposed February – March 2015 drought response actions, relevant peer-reviewed literature on these factors and fish biology, behavior, and survival are reported. Results from these sources were used to describe modified operation of the DCC gates on reach-specific and through Delta survival.

Effects Analysis

January Forecasts

Current storage in Shasta and Folsom reservoirs is greater than in January 2014, yet remains low compared to long term historical conditions. Storage in Trinity, Oroville, and New Melones reservoirs remains lower than January 2014 storage levels in these reservoirs. CVP/SWP operators and fishery agencies have been attempting since fall 2014 to conserve cold water pools system-wide in these reservoirs for listed species' summer temperature and habitat requirements. The January 50%, 90%, and 99% exceedance forecasts for WY 2015 projects reservoir volumes throughout spring and summer operations that are below their historic averages for those months (Tables 5 -7). Actual January 2014 Delta conditions are between the 90% and 99% exceedance forecasts (Table 8).

End-of-April (EOA) storages, representing the end of the reservoir storage conservation period, are projected to be between approximately 3,030 TAF (90% forecast) and 4,140 TAF (50% forecast) in Shasta Reservoir. Although there remains a significant range of possible temperature management outcomes for the Sacramento River, neither forecast allows for targeting the furthest downstream temperature compliance point target of 56°F between April and September at Bend Bridge. Additionally, if the 90% forecast is realized, maximum Shasta Reservoir elevation would limit the flexibility of the Shasta Temperature Compliance Device to only the Middle, Lower, and Side gates, which is similar to temperature control condition in WY2014. Furthermore, the considerable precipitation that would be necessary to attain a 50% forecasted EOA Shasta Reservoir storage appears highly unlikely since recent meteorology has reflected less precipitation than was anticipated under even the 90% forecast.

These factors are reasonably likely to result in extremely high egg mortality or even complete failure of natural brood year 2015 spring-run Chinook and winter-run Chinook below Keswick due to water temperature exceedances above critical thresholds. Relaxation of Delta outflow standards and Vernalis flow standards, while still continuing to meet required tributary releases from Oroville, Folsom, and New Melones (Reclamation 2015), will enhance the opportunities for summertime cold water management across CVP/SWP operated reservoirs in WY2015.

Table 5. 50% Exceedance Forecast

January 1 - 50% HYDROLOGIC EXCEEDENCE

END OF MONTH STORAGES (TAF)

RESERVOIRS	2015								
	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER
Trinity	917	1019	1172	1287	1199	1080	958	867	783
Shasta	2188	2843	3498	3835	3898	3611	3195	2856	2733
Folsom	491	486	587	646	878	935	825	694	642
Oroville	1463	1933	2431	2742	2900	2910	2374	1883	1523
New Melones	583	635	684	675	655	597	502	397	322

MONTHLY AVERAGE RELEASES (CFS)

RESERVOIRS	2015								
	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER
Trinity	300	300	300	550	4200	2100	1100	450	450
Sacramento	3250	3250	3250	5000	7000	10700	11050	9500	6200
American	900	5000	4700	4550	2100	2300	3400	3700	2250
Feather	950	950	800	1800	1050	1050	8600	8050	6950
Stanislaus	200	200	200	650	750	500	350	350	250

DELTA SUMMARY (CFS)

	2015								
	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER
Rio Vista Flows	11150	27100	22300	13950	8200	6250	10600	10100	8850
Sac River at Freeport	13250	31750	26350	17250	11450	11700	19800	18950	16600
SJ River at Vernalis	1450	3150	3000	2650	3100	1400	1100	1050	950
Computed Outflow	13000	31900	27150	17950	11400	7500	6500	5450	4450
Combined Project Pumping	3550	5100	3300	1550	1600	2400	10500	11250	11200

Table 6. 90% Exceedance Forecast.

January 1 - 90% HYDROLOGIC EXCEEDENCE

END OF MONTH STORAGES (TAF)

RESERVOIRS	2015								
	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER
Trinity	888	926	1007	1075	967	862	761	658	599
Shasta	2036	2389	2751	2889	2815	2566	2261	1994	1875
Folsom	465	537	640	642	646	488	316	229	210
Oroville	1403	1641	1926	2067	2037	1874	1682	1523	1485
New Melones	543	544	537	492	411	333	255	180	123

MONTHLY AVERAGE RELEASES (CFS)

RESERVOIRS	2015								
	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER
Trinity	300	300	300	550	2900	800	450	450	450
Sacramento	3250	3250	3250	4500	6400	8750	8500	7750	4900
American	900	1700	1900	3150	2500	4000	3800	2550	1350
Feather	950	950	800	1050	1300	1950	1400	1300	1200
Stanislaus	200	200	300	550	500	550	400	350	250

DELTA SUMMARY (CFS)

	2015								
	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER
Rio Vista Flows	9450	12200	9800	7400	5800	5300	2650	2600	2600
Sac River at Freeport	11300	14550	12000	9700	8600	10450	8550	8350	7800
SJ River at Vernalis	1050	1400	1600	1450	1450	1050	900	750	750
Computed Outflow	9650	12750	12250	9250	7100	7100	4250	4350	4200
Combined Project Pumping	3550	4350	1800	1150	1150	1200	1250	1400	2300

Table 7. 99% Exceedance Forecast.

January 1 - 99% HYDROLOGIC EXCEEDENCE

END OF MONTH STORAGES (TAF)

RESERVOIRS	2015								
	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER
Trinity	860	894	920	929	843	769	704	637	576
Shasta	1966	2173	2393	2424	2242	1843	1397	1070	936
Folsom	440	499	523	520	484	347	251	217	182
Oroville	1374	1516	1704	1762	1681	1468	1250	1027	1023
New Melones	543	544	537	491	409	331	254	178	122

MONTHLY AVERAGE RELEASES (CFS)

RESERVOIRS	2015								
	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER
Trinity	300	300	300	600	1500	800	450	450	450
Sacramento	3250	3250	3250	4500	7000	10000	9850	7800	4900
American	900	800	1950	2000	1750	3050	2200	1200	1100
Feather	950	950	800	1650	1700	2700	2400	3100	950
Stanislaus	200	200	300	550	550	550	400	350	250

DELTA SUMMARY (CFS)

	2015								
	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER
Rio Vista Flows	7800	7550	7050	6100	5750	5850	2900	2600	2000
Sac River at Freeport	9350	9200	8800	8200	8550	11200	8950	8400	6950
SJ River at Vernalis	1050	850	850	1750	1550	300	250	350	350
Computed Outflow	7050	7100	8050	7800	7100	7100	4200	4300	4050
Combined Project Pumping	3550	3350	1300	900	850	900	900	900	900

Footnote: These forecast numbers include adjustments to January inflows based upon observed conditions through mid-January.

Table 8. January to September 2014 Actual Reservoir Storage, Releases, and Delta Conditions[15].

Actual 2014 (January - September)

EOM Storages (TAF)

Reservoirs	2014								
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Trinity (Trinity Lake) CLE	1187	1306	1281	1196	1062	865	697	606	561
Shasta (Shasta Dam) SHA	1773	2198	2408	2177	1851	1575	1342	1157	1108
Folsom (Folsom Lake) FOL	304	436	546	547	470	406	381	344	304
Oroville (Oroville Dam) ORO	1406	1716	1876	1734	1511	1252	1100	1075	953
New Melones (New Melones Reservoir) NML	1060	1036	917	799	712	625	553	519	513

Monthly Average Releases (CFS)

Reservoirs	2014								
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Trinity (Trinity Lake) CLE	534	392	499	1669	1813	2366	3244	2668	1547
Sacramento (Keswick) KES	3084	3060	2766	3096	6839	8972	9203	7665	5558
American (Nimbus) NAT	745	650	614	718	1387	2107	1997	1505	1398
Feather (Oroville Dam) ORO	1624	729	641	881	3678	4930	5419	3387	1919
Stanislaus (Goodwin) GDW	295	255	403	1553	1259	270	316	232	184

Delta Summary (CFS)

	2014								
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Rio vista	4214	8144	11814	7212	3542	4524	3828	3389	3366
Sac River at Freeport	6511	10811	14815	9595	5645	8854	8853	8461	8249
SJ river at Vernalis	856	822	844	1770	1528	319	254	307	410
NDOI (outflow)	4780	11145	12721	7912	4174	5407	4085	3419	3202

[15] Data from http://cdec.water.ca.gov/reservoir.html. Table supplied by CDFW on January 26, 2015.

During February and March a continuation of Keswick minimal releases at the levels identified in the TUC Petition is hypothesized to increase the time needed for Chinook and steelhead smolts to emigrate down the Sacramento River, which will result in reduced outmigration survival (Singer et al 2013) and a reduced smoltification window (McCormick et al 1998). In contrast, any predicted increases in reservoir storage that may be realized by operating to the TUC Petition's outflow range will be critical to any measures to maintain water temperatures necessary for the biological needs of winter-run Chinook, spring-run Chinook, steelhead, and green sturgeon downstream of these reservoirs over the summer and fall of 2015. It should be noted that these January forecasts include later upstream impacts to BY 2015 fishes, including redd dewatering. Thus, this reduced outflow range in February and March is a proactive approach by Reclamation and DWR to immediately implement appropriate contingency measures that may benefit BY 2015 cold water listed species, as required in NMFS BiOp Action I.2.3.C.

Net Delta Outflow Index Modification

Although the NMFS BiOp (2009) does not contain NDOI standards, it did assume NDOI standards would be met. Based on the conceptual model, the reduction in outflow, as identified in the Petition's Project Description, may impact juvenile salmonids migrating through the North Delta between Sacramento and Rio Vista, where Sacramento River flows meet the tidally dominated western Delta. Currently, the greatest presence of salmonids in the Delta has been detected in the Lower Sacramento River and North Delta regions (DOSS 2015). The proposed reduction in minimum Delta outflow from a monthly average of 7,100 cfs to 4,000 cfs is lower than those under minimum standards to meet the D-1641 NDOI standards in February and March. This proposed reduction may reduce survival of juvenile salmonids migrating through the Lower Sacramento River and North Delta by increasing rates of predation mediated by hydrodynamic mechanisms (i.e. transit times, turbidity). However, once migrating fish reach the tidally-dominated regions in the western Delta (i.e. Rio Vista towards Chipps Island), South Delta, or Central Delta under the Petition's NDOI outflow threshold (4,000 cfs), they are likely to encounter a daily proportion of positive velocities and a mean velocity that are not substantially different from outflow conditions observed when a 7,100 cfs NDOI standard is being achieved (Table 9, Figures 11-12). This is due to the greater influence tides have in these

Table 9. DSM2 Results for Daily Proportion Positive Flows at Each Channel Node[16]. Note that Freeport and Vernalis flows are different between scenarios; see Table 4 for details. The DJFMP Seine Region Containing the Channel Node was identified from USFWS metadata.

Modeled NDOI	**4000**	**5500**	**7100**	**Difference between NDOI 7100 and 4000**	**Difference between NDOI 7100 and 5500**	**DJFMP Seine Region**
Modeled OMR	**-1400**	**-3200**	**-5000**			
Modeled Export	**1500**	**3500**	**6400**			
Channel Node						
6	0.76	0.76	0.88	-0.12	-0.12	San Joaquin
9	0.56	0.56	0.56	0.01	0.00	San Joaquin
12	0.54	0.54	0.54	0.01	0.00	South Delta
21	0.53	0.53	0.53	0.00	0.00	South Delta
49	0.52	0.52	0.52	0.00	0.00	Central Delta
50	0.52	0.52	0.51	0.00	0.00	Central Delta
54	0.79	0.83	0.90	-0.11	-0.07	San Joaquin
81	0.43	0.37	0.42	0.01	-0.05	South Delta
124	0.45	0.44	0.43	0.02	0.01	South Delta
160	0.52	0.51	0.50	0.01	0.00	South Delta
173	0.50	0.49	0.48	0.01	0.00	South Delta
310	0.51	0.50	0.50	0.01	0.01	Central Delta
421	0.73	0.84	0.94	-0.21	-0.10	North Delta
422	0.72	0.82	0.91	-0.19	-0.10	North Delta
423	0.64	0.68	0.73	-0.08	-0.04	North Delta
429	0.60	0.64	0.67	-0.06	-0.03	North Delta
434	0.53	0.53	0.53	-0.01	0.00	Central Delta

[16] A map of DSM2 node locations is available at: http://baydeltaoffice.water.ca.gov/modeling/deltamodeling/models/dsm2v6/DSM2_Grid2.0.pdf

Figure 11. Maps of the Delta with Key Channels Color-Coded for Daily Proportion Positive Velocity.

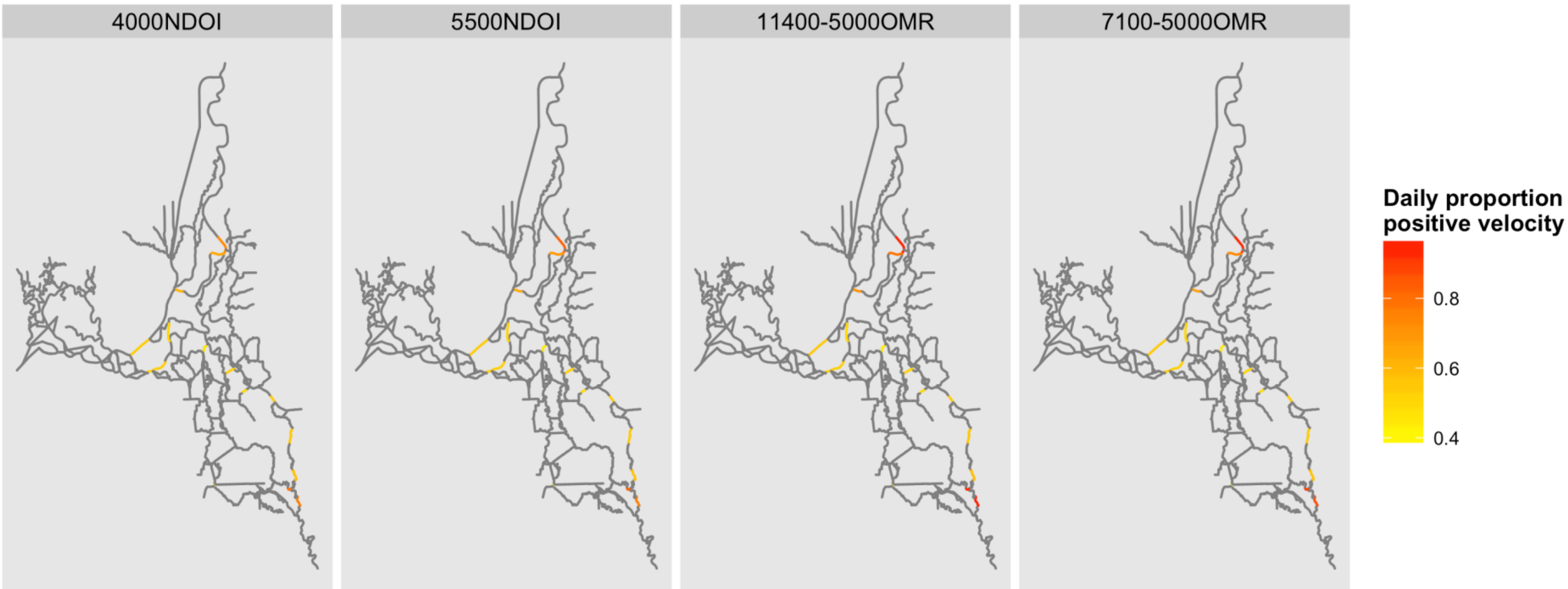
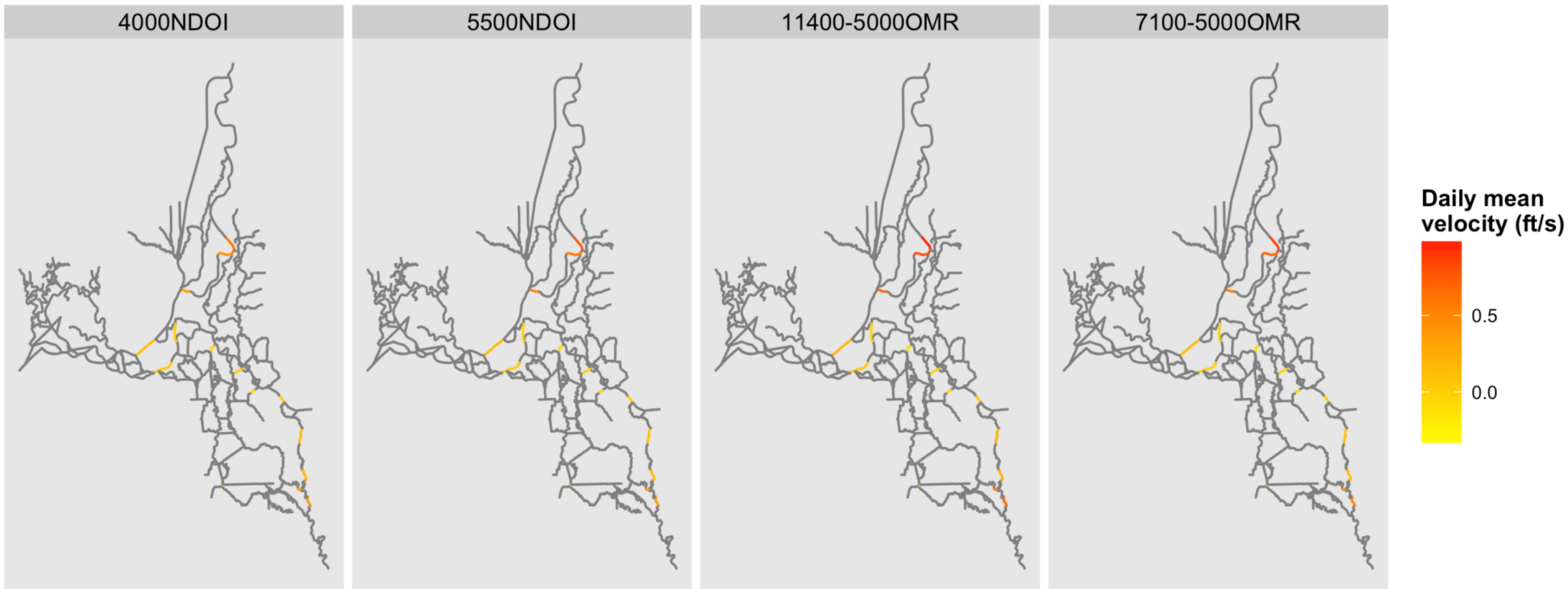


Figure 12. Maps of the Delta with Key Channels Color-Coded for Daily Mean Velocity Generated from DSM2.



regions under low Delta inflows. There is high certainty in our understanding of how hydrodynamics are affected in these regions by the Petition's Project Description.

In the North Delta, DSM2 modeling between 7,100 and 4,000 NDOI levels demonstrate a decrease in outflow, which will impact the Delta hydrodynamics in two ways that will influence Salmonid migration speed and patterns. These hydrodynamic processes influence survival by changing juvenile salmonids exposure to predators in the Lower Sacramento River and other relevant reaches (i.e. Georgiana Slough, Delta Cross Channel, Sutter and Steamboat sloughs). First, reduced outflow may increase tidal excursion in the upstream direction over a greater spatial range (reduced daily proportion of positive velocities) into the Lower Sacramento River region. These increased upstream tidal excursions appear to increase the duration of reverse flows into Georgiana Slough and/or an open DCC gates (Table 9), which likely increases entrainment into these waterways. Survival rate in the main stem Sacramento River or in one of the multiple distributary channels is decreased due to the longer duration of the downstream emigration phase resulting from reduced flows as compared to periods of greater downstream flows (greater NDOI). Also, the increased tidal excursion may increase entrainment into Sutter and Steamboat sloughs by creating greater probability of flow convergence at these junctions. However, due to the lower flows the time needed to migrate downstream through these two migratory corridors is also expected to increase, resulting in diminished survival compared to higher flows. There is high certainty in our understanding of the biological processes affected by reduced outflow along the Sacramento River salmonid migration corridor.

Second, DSM2 results show reduced NDOI will cause the daily mean channel velocity along the Sacramento River and North Delta to be less positive even at channels along the Sacramento River at Sherman Island and near Cache Slough (Figure 12). When the DCC gates are open, the daily mean channel velocity becomes even less positive in these reaches. Reducing outflow likely causes a decrease in the daily proportion of positive velocities through the Sacramento River downstream of Sutter and Steamboat sloughs confluences with the Sacramento River. A review of a similar NDOI modification (Reclamation 2014a) indicated that the impacts of reduced NDOI on the proportion of daily positive flows and mean daily velocities propagate up to Sutter and Steamboat Sloughs, although this effect was not modeled for this Petition. Additionally, Georgiana Slough flows become less positive as tidal excursion causes flow reversals in this channel when outflow is reduced. When the DCC gates are open, the daily proportion of positive velocities further decreases in the Sacramento River upstream of the DCC gates and more noticeably between the DCC gate and Georgiana slough. When the DCC is open, there is a reduction in the daily proportion of positive flows through Georgiana Slough. There is high certainty in our understanding of how hydrodynamics is affected in these regions by the Petition's Project Description.

Decreased daily proportion of positive velocities and daily mean channel velocities, due to the Petition's reduced outflow range, will increase migrating salmonids' residence time in the North

Delta, which likely exposes them to increased predation and mortality rates. There are no models to quantify the increase in mortality rates due to reduced flows in this reach, however comparisons may be made. The DCC's capacity is 3500cfs, which is in range of the Petition's change to the outflow standard. Two telemetry studies reported on changes in reach-specific survival when the DCC was open and closed, which provide a comparison for survival through the North Delta reach and downstream when this quantity of daily flow is removed from the channel. The average difference in survival rates for salmonids through the North Delta from Sutter and Steamboat sloughs to Rio Vista when the DCC was open (n=7, survival ranged from 0.012-0.306) versus closed (n=3, survival ranged from 0.099-0.233) was 3.4% (Table 2 in Romine et al. 2013). Perry et al. (2010) had a single measurement of survival in this reach when the DCC gates were open vs. closed and the difference was 12.1%. Reach-specific survival showed large variations within and between studies, and factors other than travel time and flow are suggested to have contributed to variations in survival estimates including environmental conditions and temporal shifts in predators (Perry et al. 2010) and tag failure (Romine et al. 2013). A previous study of steelhead (Singer et al. 2013) did not demonstrate interior routes to have the lowest survival. In that study, steelhead smolt survival was estimated to be higher through the eastern Delta route (i.e. Georgiana Slough, Mokelumne River, and San Joaquin River routes) than the western Delta route (Sutter and Steamboat sloughs) in one of two years studied, although survival was highest along the Sacramento River mainstem route in both years. There is moderate certainty in our understanding of the survival processes affected by flow associated with the DCC and Georgiana Slough migration routes.

BY2015 adult winter-run Chinook salmon may be affected by the Petition's proposed reduction in outflow, which would reduce detectable flow signal for upriver migration and may lead to longer transit times and increased predation mortality. Juveniles and sub-adult green sturgeon rearing and utilizing the Delta are not expected to be affected by the change in inflows to the Delta during February and March. Adult green sturgeon will be present in the Delta during the month of February, and are expected to migrate through the North Delta starting in March. Over the course of juvenile rearing in the Delta (1 to 3 years) the fish are exposed to a wide variety of flows, depending on where they happen to be at a particular moment. In most of the Delta where green sturgeon are expected to be rearing, flows are tidally dominated. There is low certainty in our understanding of the adult salmonid and green sturgeon biological processes affected by flow in the Delta.

Modification of Export Limits

Action IV.2.3 in the 2009 NMFS BiOp specifies fish loss density, daily older juvenile Chinook salmon and wild steelhead loss, and loss of surrogate hatchery releases of winter-run and late-fall run Chinook salmon as triggers to reduce the vulnerability of emigrating ESA-listed salmon and steelhead to entrainment into South Delta channels and at the pumps between January 1 and June 15. A calendar-based requirement, starting on January 1, is for the 14-day OMR average flow to be no more negative than -5,000cfs. Under the Petition's Project Description, these triggers will continue to be used to manage such that the 5-day net average OMR flow is not more negative than a calculated -3,500 or -2,500cfs OMR flow until fish densities return below levels of concern.

During February and March, juvenile and adult salmonids may experience South Delta hydrodynamic conditions under the Petition's Project Description that could result in greater export rates than were observed with modified NDOI targets during similar periods in WY2014. These modified export limits (subject to a 35% Export/Inflow standard per D-1641[17]) may occur when NDOI is less than 7,100 cfs but greater than 5,500 cfs. These export limits allow for combined pumping of 1,500 cfs when NDOI is less than 5,500 cfs. Old and Middle River conditions under these inflow and export management scenarios are predicted to be approximately -3,200 to -1,400 cfs. If precipitation events occur that enable Reclamation to comply with D-1641 standards and DCC gate closure requirements, then export levels may increase at the CVP/SWP. OMR management per NMFS BiOp Action IV.2.3 will continue to use fish loss density, daily loss, and loss of specific hatchery releases of late-fall and Winter-run Chinook salmon as triggers to reduce the vulnerability of emigrating ESA-listed salmon, steelhead, and green sturgeon to entrainment into South Delta channels and at the pumps between February 1 and March 30. Daily flows in Old and Middle River averaged approximately -4,885 cfs in December, 2014 and approximately -4140 cfs in January 2015 (through January 22) (Figure 13).

When comparing the Petition's Project Description's modeled conditions when NDOI is 4,000 cfs and OMR is -1,400 cfs to conditions when NDOI is 7,100 and OMR is -5,000 cfs, the majority of modeled channels in the South and Central Delta regions show no change in the mean daily proportion positive velocities under the lower NDOI. The only observed change in the metrics evaluated between these runs occurred at Columbia Cut, where with the NDOI of 4,000 cfs and OMR at -1,400 cfs, the daily average velocity becomes positive (0.01), instead of remaining negative (-0.01) similar to observed when NDOI is modeled at 7,100 cfs (0.02). The intermediate modeling with NDOI of 5,500 cfs and exports of 3,500 predicted similar conditions in the South and Central Delta regions compared to the model run with NDOI of 7,100 cfs and an OMR value of -5,000 cfs. These modeling results suggest that daily proportion of positive velocities may be quite balanced (i.e. similar frequencies of positive and negative velocities) rather than more riverine (i.e. predominantly positive velocities) at the intermediate or low NDOI condition in these regions and achieve similar tidal hydrodynamics throughout the San Joaquin River and South Delta.

[17] As in WY 2014, the E/I standard will be implemented using the inflow averaging period (3-day or 14-day) that allows the greatest exports.

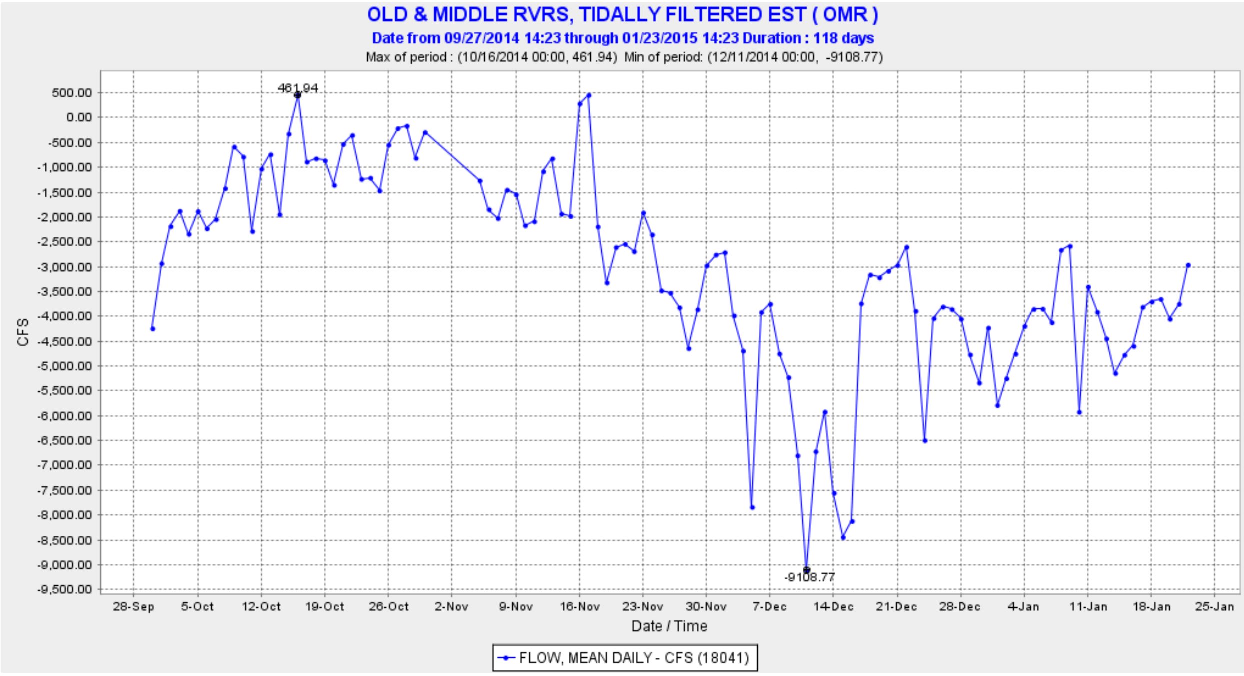


Figure 13. Old and Middle Rivers tidally-filtered daily flows (cubic feet per second) measured at Old & Middle Rivers (OMR) for WY 2015.[18]

The conditions may increase transit rates for salmonids, reduce dispersion of tributary turbidity input, and provide stable conditions for non-native vegetation supporting predaceous fish species, which cumulatively reduces survival rates of juvenile salmonids along the San Joaquin River migration corridor and in the South Delta region. There is low certainty in our understanding of the biological and environmental processes affected by NDOI and exports along the San Joaquin River salmonid migration corridor.

The mean daily proportion positive velocities become less frequently positive in the NDOI 5,500 cfs model than in the NDOI 4,000 cfs model run in Grant Line Canal due to higher pumping and increased San Joaquin flow reaching the facilities without increased San Joaquin River flow at Vernalis. Reduced Vernalis flows in the NDOI 4,000 cfs and NDOI 5,100 cfs models shows the same reduction in mean daily proportion positive velocities upstream of Head of Old River due to similarly modeled San Joaquin River flows at Vernalis. Under greater exports when the NDOI is 7,100 cfs and OMRs are -5,000 cfs, South Delta locations proximal to the facilities (Grant Line Canal) show greater proportions of mean daily proportion positive velocities than when NDOI was modeled at 4,000 cfs and OMRs are 1,400 cfs. This would indicate that the effect of greater exports increases the mean daily proportion of positive velocities towards the facilities in these channels. Greater positive velocities may support outmigration through the Delta; however it may increase salvage and loss of salmonids in the South Delta region if these flows are towards the facilities it may increase facility salvage and loss of salmonids. This is particularly

[18] Downloaded from CDEC on January 23, 2015.

the case for San Joaquin River steelhead entering the South Delta through Old River. There is moderate certainty in our understanding of the biological processes affected by exports in South Delta salmonid migration corridors and fish collection facilities at the CVP/SWP pumps.

Impacts to juvenile and subadult life stages of green sturgeon are anticipated to remain minimal. Age 1 to 3 green sturgeon are expected to be rearing in the Delta, and are typically exposed to a broad spectrum of flows over the course of the year during this life history phase and freely move throughout the Delta to find suitable conditions for their needs. There is low certainty in our understanding of the biological processes in green sturgeon affected by exports in the South Delta region and fish collection facilities at the CVP/SWP pumps.

Delta Cross Channel Gate Modification

The 2009 BiOp (NMFS 2009) and D-1641 include a calendar-based closure of the DCC Gates between February 1 and May 20 to protect winter-run, spring-run, and fall-run Chinook salmon and steelhead from entrainment into the Interior Delta. Studies have shown that the mortality rate of the fish entrained into the DCC and subsequently into the Mokelumne River system is higher than for fish that remain in the mainstem corridor (Perry and Skalski 2008; Vogel 2004, 2008). Closure of the DCC gates during periods of salmon emigration eliminates the potential for entrainment into the DCC and the Mokelumne River system with its high mortality rates. In addition, closure of the gates appears to redirect the migratory paths of emigrating fish into channels with relatively less mortality (*e.g.*, Sutter and Steamboat sloughs), due to a redistribution of river flows among the channels. The overall effect is an increase in the apparent survival rate of these salmon populations as they move through the Delta. There is high certainty in our understanding of the biological processes in salmonids affected by DCC gate operations.

A series of studies conducted by Reclamation and U.S. Geological Survey (USGS, Horn and Blake 2004) used acoustic tracking of released juvenile Chinook salmon to follow their movements in the vicinity of the DCC under different flows and tidal conditions. The study results indicate that the behavior of the Chinook salmon juveniles increased their exposure to entrainment through both the DCC and Georgiana Slough. Horizontal positioning along the east bank of the Sacramento River during both the flood and ebb tidal conditions enhanced the probability of entrainment into the two channels. Upstream movement of fish with the flood tide demonstrated that fish could pass the channel mouths on an ebb tide and still be entrained on the subsequent flood tide cycle. In addition, diel movement of fish vertically in the water column exposed more fish at night (~70%) to entrainment into the DCC than during the day (~30%; Jon Burau, pers. comm.). Perry et al. (2010) included two releases of acoustically-tagged late fall-run Chinook salmon to evaluate the impact of DCC gate opening of reach specific and total Delta survival. Mainstem survival downstream of the DCC gate was lower when they were open (0.443) than when the closed (0.564). During 2008-2009, ten releases of juvenile late fall run Chinook salmon were made by USGS (Romine et al. 2013, Table 10) and through Delta survival was greater when the DCC gates were closed (0.170) than when they were open (0.123). These values are negatively biased due to tag failure (Romine et al. 2013). Perry et al. (2010) observed through-Delta survival to be greater with the DCC closed (0.543) than open (0.351), principally due to increased survival through the Sutter and Steamboat sloughs route from 0.263 to 0.561. In addition to the Petition's effects on emigrating juvenile salmonids, the Petition's opening of the DCC may increase straying of returning winter-run Chinook adult salmon on the Sacramento River mainstem by diverting a portion of the Sacramento River flows through the forks of the Mokelumne River and Central Delta. This will lead to false attraction and hence straying into these waterways.

Table 10. Average Values for Releases Described in Romine et al. (2013). Seven releases occurred with DCC open and three releases occurred with it closed.[19]

DCC Position	S_A	S_B	S_C	S_D	Ψ_A	Ψ_B	Ψ_C	Ψ_D	S_{TOTAL}
Open	0.143	0.1	0.098	0.159	0.486	0.267	0.064	0.182	0.123
Closed	0.177	0.205	-	0.102	0.521	0.276	-	0.202	0.17

During the fall and early winter when juvenile listed salmonids are not typically present in the Lower Sacramento River and Delta, action triggers in the Chinook salmon Decision Tree use fish monitoring catch indices from Knights Landing and Sacramento River to detect substantial winter-run Chinook migration into the lower Sacramento River. Catch index exceedance values were based on analyses of historic screw trap, beach seine, and trawl data (Chappell 2004). Historic analyses (Chappell 2004) modified the "critical trigger" and duration of DCC gate closure in the Chinook Salmon Decision Tree. Multiple exceedance levels were identified to modify DCC operations in a manner that reduces risks due to the elevated presence of spring-run and winter-run Chinook salmon upstream of the Delta. The Knights Landing Catch Index Catch Index of 23.2 on October 31, 2014 triggered closure of the DCC gates on November 2, 2014.

Currently, the greatest presence of winter-run Chinook salmon in Delta monitoring efforts appears to be in the Lower Sacramento River and the North Delta regions, and a majority of spring-run Chinook are also in these areas (DOSS 2015), which are proximal to the DCC. When emigrating salmonids are in proximity of the DCC gates they are vulnerable to entrainment through the DCC when the gates are open. Based on the conceptual model, greater percentages of ESA-listed salmonids, including hatchery winter-run Chinook, continue to enter the Delta through February and March, there is an increasing risk of exposure as greater proportions of these populations enter the Delta through the winter and spring.

[19] *S*= survival and Ψ=route entrainment; Routes: A=Sacramento, B=Sutter and Steamboat, C= DCC route, D= Georgiana Slough route

Vernalis Flows Modification

Under D-1641, the minimum monthly average flow objective in the lower San Joaquin River (measured at Airport Way Bridge, Vernalis) during February and March is 710 cfs or 1,140 cfs[20] during critically dry years such as WY 2015. The Project Description reduces the Vernalis monthly average base flows to 500 cfs for February and March.

Based on the conceptual model, the Petition's Project Description to reduce flows at Vernalis to less than the Critical WY D-1641 flow objective may reduce survival of juvenile salmonids migrating through the lower San Joaquin River. This change will increase their migration travel time, which increases their exposure to degraded habitats and predators. Reduced Vernalis flows, in combination with reduced NDOI, results in a reduction in the daily proportion of positive flows along the lower San Joaquin River downstream of the Head of Old River (Table 9). Although only a limited number of Lower San Joaquin River channels were assessed there did not appear to be an increase in the daily proportion of negative flows in these channels downstream of the Stockton Deepwater Ship Channel. Along Grant Line Canal, the DSM2 run with the more negative OMR flows (NDOI 7,100, OMR -5,000) had greater positive flows towards the facilities than compared to the run with very low NDOI and OMR flows of 4,000 cfs and -1,400 cfs, respectively. This suggests that a more positive OMR leads to greater tidal conditions (i.e. more balanced daily proportion of positive velocities and daily mean channel velocities) in local waterways such as Grant Line Canal, which will likely increase migrating salmonids' residence time in these waterways, and increase their exposure to predation and mortality. Effects of increasing exports and creating more negative OMR conditions in South Delta waterways north of the CVP/SWP export facilities would likely show an increase in the magnitude of negative velocities and a reduction in the daily average magnitude of flow velocities, indicating that less water was moving downstream to the ocean (positive direction) and more water was moving towards the export facilities. This would also lead to increasing the residence time of salmonids in these waterways, with a corresponding reduction in survival. The modeling conducted for the Project Description did not include these additional waterways.

There are no models to quantify the increase in mortality due to reduced flows in this reach; however, comparisons may be made using results from recent acoustic tagging studies of juvenile San Joaquin steelhead migration and survival through the South Delta (Buchanan et al. 2014). Although there are only two years of data and these studies were conducted during the spring (late March through June) under higher flow conditions (>3,000 cfs) and variable Head of Old River Barrier (HORB) status (in or out), they provide an indication of possible relative survival and travel time differences. Average survival rates of tagged steelhead released at Durham Ferry from the lower San Joaquin River through the Delta ranged from 0.38 to 0.69

[20] The higher flow objective applies when the 2-ppt isohaline (measured as 2.64 mmhos/cm surface salinity) is required to be at or west of Chipps Island.

(SE≤0.05) in 2011 when San Joaquin River flows were high (>15,000 cfs at Vernalis) and no HORB was installed. Average survival rates through the Delta ranged from 0.24 to 0.32 (SE≤0.03) in 2012 when river flows were considerably lower (about 3,000 cfs) and the HORB was installed. The median travel time of tagged steelhead from Durham Ferry to the Head of Old River was 5–6 days in both years, and ranged up to 28 days in 2011 and 35 days in 2012. These results, albeit not directly comparable due to timeframes and HORB conditions, provide limited evidence that steelhead survival may be reduced by proposed Vernalis flow requirements. Additionally, it appears that median travel times of surviving migrants are generally independent of flow level; however, travel times took up to an additional seven days for some migrants under lower flow conditions. This hints at the possibility that lower survival in 2012 may be associated with increased travel times of those fish not surviving. There is low certainty in our understanding of the hydrodynamic and biological processes in steelhead affected by exports along the San Joaquin River and in the South Delta.

Although travel times may increase and survival be reduced under lower flows, only about 5% of the total number of steelhead captured in the lower San Joaquin River during Mossdale trawling surveys (1997-2003) have been collected in February and March, and most were greater than 200 mm (one 115 mm). These surveys indicate that few, if any, juvenile steelhead can be expected to migrate in the lower San Joaquin River during February and March and, those that do migrate during this period will be less susceptible to predation due to their larger size. Given the low likelihood that steelhead will be migrating during this period, but the moderate to high potential for lower flows to effect migration travel times and survival for any juvenile steelhead migrating during February and March, changes in hydrodynamic conditions under the Project Description may have a moderate effect on juvenile steelhead in the lower San Joaquin River. There is moderate uncertainty in this prediction based on the unknown number and size of juvenile steelhead attempting to migrate through the lower San Joaquin River during February and March this year, and their behavioral response to flows as low as 500 cfs in the lower San Joaquin River.

Cumulative Effects of Action

The Petition's action to: 1) Reduce the D-1641 Delta outflow standard for February and March from at least 7,100 cfs to 4,000 cfs, 2) Allow exports of up to 3,500 cfs when NDOI is between 7,100 cfs and 5,500 cfs, exports of 1,500 cfs when NDOI is below 5,500 cfs, and exports up to those achieving OMR flows no more negative than -5,000 cfs when NDOI is greater than 7,100 cfs, 3) Modify the D-1641 and NMFS BiOp DCC gate operations using the triggers matrix in Attachment G of Reclamation 2014b, and 4) Reduce the D-1641 Vernalis flow to 500 cfs, will affect the abundance and spatial distribution of juvenile winter-run and spring-run Chinook salmon, steelhead, and green sturgeon. The modifications to outflow and DCC gate operations as part of the proposed action may affect the spatial distribution and abundance of adult winter-run Chinook salmon and green sturgeon. Life history diversity of steelhead may be affected due to reduced survival through the San Joaquin River migration corridor. There is moderate certainty in these analyses due to the limited variability in the modeling and potential for actual hydrodynamic conditions to vary from modeled conditions, especially on the San Joaquin River.

The proposed Project Description's modification of outflow, exports, and Vernalis flows may reduce survival of juvenile listed salmonids, steelhead and green sturgeon, and may modify their designated critical habitat. The modification of juvenile winter-run and spring-run Chinook salmon and steelhead survival due to changes in outflow would occur primarily in migratory corridors in the North Delta due to increased entrainment into the Interior Delta. Steelhead survival may also be reduced along the mainstem San Joaquin River downstream of the Stanislaus River until tidal hydrodynamics dominate this channel upstream of the Stockton Deepwater Ship Channel. The location where tides influence outflow will move upstream of the Head of Old River, thus leading to increased entrainment of steelhead toward the CVP/SWP facilities. The Petition's action to reduce Delta outflow keeps the CVP/SWP operation proactively compliant with implementation of NMFS RPA I.2.2C and I.2.3C. The Petition's outflow action will enhance the potential to operate summer reservoir releases by potentially increasing the ability to control in-river water temperatures. This may decrease the endangerment to brood year 2015 by reducing mortality to incubating winter-run and spring-run Chinook eggs and holding adults during the summer of 2015.

Modeling of the Petition's intermediate export limits when NDOI is between 5500 and 7,100 cfs suggests that exports at intermediate values (3500 cfs) lead to greater mean daily proportion of positive velocities in the South Delta proximal to the facilities from the San Joaquin River (i.e Grant Line Canal) but not along the San Joaquin River migration route's channels. This modeling suggests hydrodynamics in this South Delta region proximal to the facilities may reduce local salmonid travel times towards the facility, while San Joaquin River hydrodynamics do not change and travel times remain similar. Although not modeled, the South Delta waterways north of the CVP/SWP export facilities are likely to have decreased daily proportion of positive velocities when exports are increased, which may increase residence time of rearing salmonids. These effects may increase unmeasured mortality in the South Delta region by increasing entrainment towards the facilities where pre-screen mortality is likely very high due to unprecedented nonnative vegetation problems and also maintain long transit times on the San Joaquin River where exposure to degraded habitat and predaceous species is constant.

Under the driest conditions, if NDOI reaches 5,500 cfs, the CVP/SWP will reduce exports to 1,500 cfs, which increases positive flows in the South and Central Delta relative to the baseline condition of NDOI 7,100 cfs and OMR no more negative than -5,000 cfs. Under these driest conditions, there will be reduced entrainment and salvage of listed species at the CVP/SWP fish collection facilities adjacent to the South Delta export facilities.

The Petition's DCC gate operation will minimize the additional mortality risk to juvenile outmigrating and rearing winter-run and spring-run Chinook and juvenile steelhead, since the DCC gate operations matric limits DCC flexibilities when migrating ESA-listed salmonids are present in the Lower Sacramento River region. During the period the gates are open, exports will be limited to 1,500 cfs. This export limit along with the implementation of the DCC gate operations matrix will minimize entrainment of existing rearing fish in the Interior and South Delta. The Petition's DCC gate operations may also cause straying of adult winter-run Chinook and green sturgeon.

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