Status of Species

Winter-run Chinook salmon

A modest spawning run of Winter-run Chinook salmon (n=6,075) returned to the upper Sacramento River in 2013, which was larger than the spawning run that produced these fish in the Sacramento River during the summer of 2010. Redd surveys detected <0.5% of the Winter-run Chinook salmon redds built in 2013 to be downstream of the 2013 temperature compliance point at Airport Bridge. Typically a pulse of fry outmigrates from the upper Sacramento River in early October and rear in the middle Sacramento River. In fact, a pulse of Winter-run Chinook fry appeared to have moved downstream of Red Bluff Diversion Dam (RBDD) during early October, although monitoring of this pattern is uncertain due to the federal furloughs that kept biologists from monitoring this site (Figure 1 and 2). If flows remain high in the fall, a substantial proportion of Winter-run Chinook can be transported downstream of Red Bluff Diversion Dam. However, thousands of larger-sized Winter-run Chinook continue to be observed weekly in fish monitoring at Red Bluff Diversion Dam in larger numbers than previous years (Figure 2). However it should be noted that emigrating winter-run juveniles detected in the daily monitoring efforts have declined to numbers that are less than those seen in the early portion of the emigration season (low thousands compared to 5,000 to approximately 20,000 fish daily during September 2013). Of the estimated 4.3 million juvenile Winter-run Chinook expected to migrate past RBDD (based on the 2013 spawner escapement and JPE survival values), approximately 1.6 million fish have migrated past RBDD by January 14, 2014 [United States Fish and Wildlife Service (USFWS), Red Bluff, biweekly data]. While the absence of the majority of Winter-run Chinook moving past RBDD this late in the winter in RBDD screw trap monitoring records has not previously been observed, such a protracted and significant daily passage of Winter-run Chinook salmon past this location in January has also not been observed (Bill Poytress, USFWS, pers. comm.). Of 179 stranding sites along the Sacramento River from Tehama (Los Molinos) to Keswick Dam (about RM70), 21 completely isolated sites have been identified to have winter-run salmon trapped in them [Doug Killam, California Department of Fish and Wildlife (CDFW), pers. comm.].

Based on these current estimates of passage and juvenile abundance, there is a fair likelihood that a substantial proportion of the Winter-run Chinook population remains above RBDD. On recent weekly DOSS calls, the topic of the position of Winter-run Chinook salmon has been discussed. There has been agreement that a broad distribution of Winter-run Chinook lies between Red Bluff and Knights Landing with fish going from above Red Bluff downstream into the Delta.

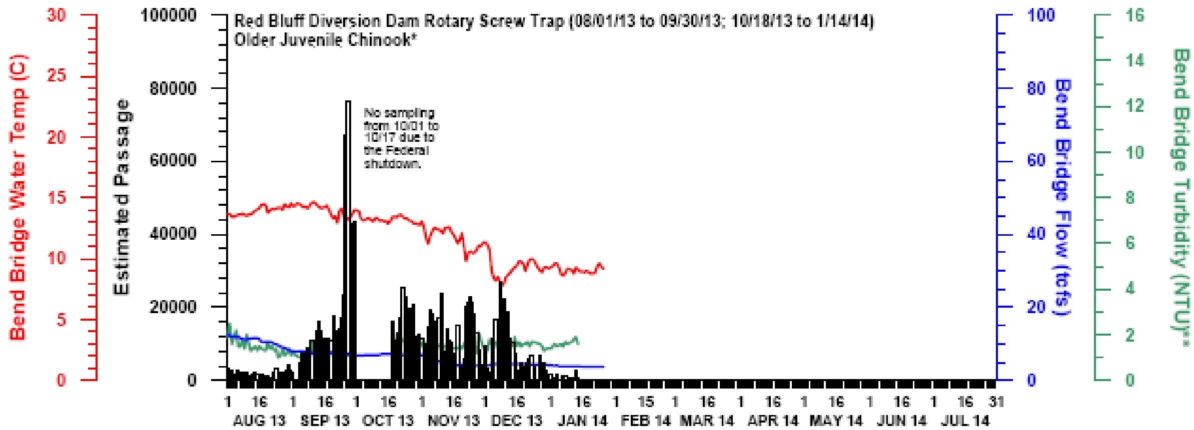

Figure 1. Red Bluff Diversion Dam Passage of Juvenile Older Chinook Salmon and Associated Environmental Data. [1]

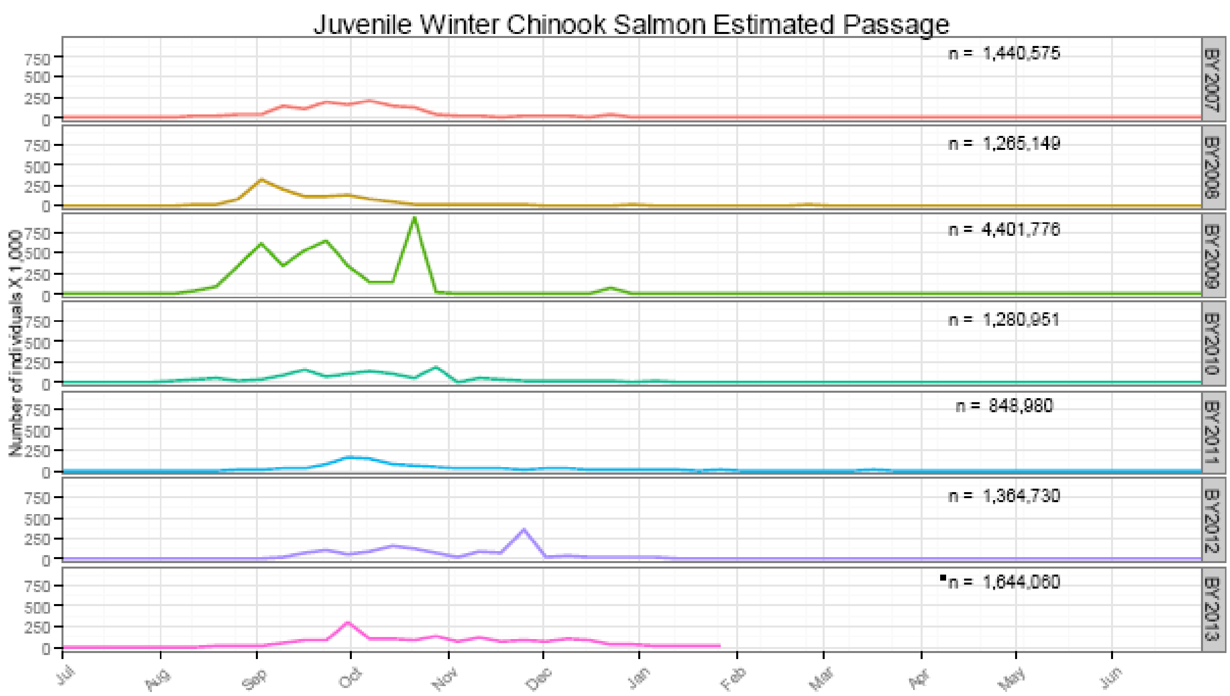

Figure 2. Weekly Estimated Passage of Juvenile Winter-run Chinook Salmon at Red Bluff Diversion Dam (RK 391) by Brood-Year (BY). [2]

[1] Figure supplied by DWR to DOSS on January 27, 2014.

[2] Fish were sampled using rotary-screw traps for the period July 1, 2007 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 29, 2014.

Winter-run Chinook juveniles have been passing the location of the monitoring station at the Glen-Colusa Irrigation District intake canal in the middle section of the Sacramento River since October 2013 (Figure 4). As of January 27 2014, 13 Winter-run Chinook salmon smolts and 18 Winter-run juvenile, have been observed in GCID fish monitoring in January 2014. The declining recovery trend of outmigrating Winter-run Chinook past GCID's screw traps in January may suggest that Winter-run Chinook, which past RBDD earlier in the fall and winter as fry and parr, have abandoned outmigration to rear between RBDD and GCID or conversely, a majority of the fish observed past RBDD have also past GCID. The pulses in the GCID data reflect the pulses seen in the RBDD data for the corresponding time points in the emigration season. Typically, fry and parr that cannot sustain territories in river flows maintain outmigration past Knights Landing and into the Lower Sacramento River with late fall/early winter Sacramento Valley rainstorms increase flows to greater than 7,500 cfs. Juvenile Winter-run Chinook were infrequently observed in October and December 2013 at the Tisdale Weir fish monitoring station on the Middle Sacramento River and in October at the Knights Landing fish monitoring station on the Lower Sacramento River (Table 1). Rosario et al (2013) described multiple pulses of distinctly different sized Winter-run Chinook salmon typically moving through the Lower Sacramento River at Knights Landing between November and January. There seems to have been almost a complete lack of smaller Winter-run Chinook fry outmigration during Water Year (WY) 2014 through the Lower Sacramento River and Delta (Table 1). Also, in WY 2014, there have not been pulses of multiple size classes collected in the rotary screw traps at the same time, and fish the length of fish has recovered over time as the emigration season progresses. Rosario et al (2013) did not report on any uniquely dry water years similar to WY2014, thus direct comparisons between WY 2014 and their findings raise uncertainties. Unlike the typical pattern of substantial proportions of Winter-run salmonid population rearing in the Delta, in WY 2014 a substantial proportion of Winter-run Chinook parr are apparently undergoing smoltification while still in the middle and upper Sacramento River waiting for physiological or environmental cues to emigrate into the Delta.

Based on 2013 adult Winter-run Chinook salmon escapement, the juvenile production estimate for Winter-run Chinook salmon juveniles entering the Delta ranges from approximately 1.32 million fish (using the JPE method from WY2013) to approximately 400,000 fish (using limited Winter-run Chinook specific riverine survival estimates of 0.16). No juvenile Winter-run Chinook salmon have been observed in lower Sacramento River and Delta beach seine and trawl fish monitoring surveys or at the state and federal fish collection facilities at the South Delta CVP/SWP export pumps. On recent weekly DOSS calls, the topic of the proportion of the population of Winter-run Chinook salmon that has entered the lower Sacramento River or Delta has been discussed. There are a diversity of opinions, and estimates of <5%, based on the information in this assessment, to as much as >30%, based on expert opinion, of the Winter-run Chinook salmon are downstream of Knights Landing and in the Delta.

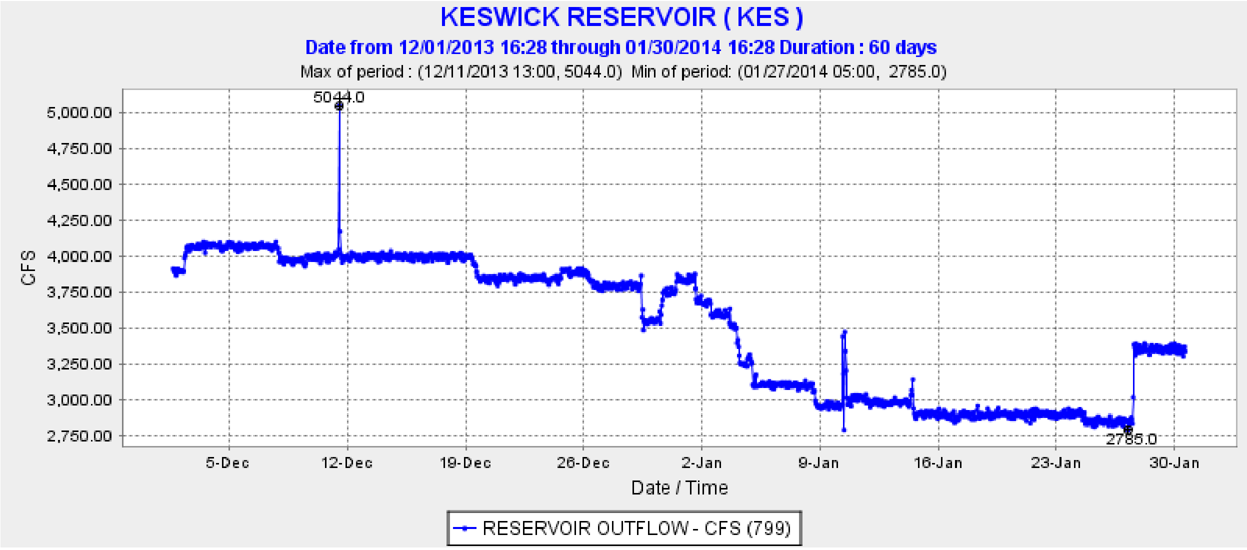

Figure 3. Keswick Reservoir Outflow for WY 2014.[3]

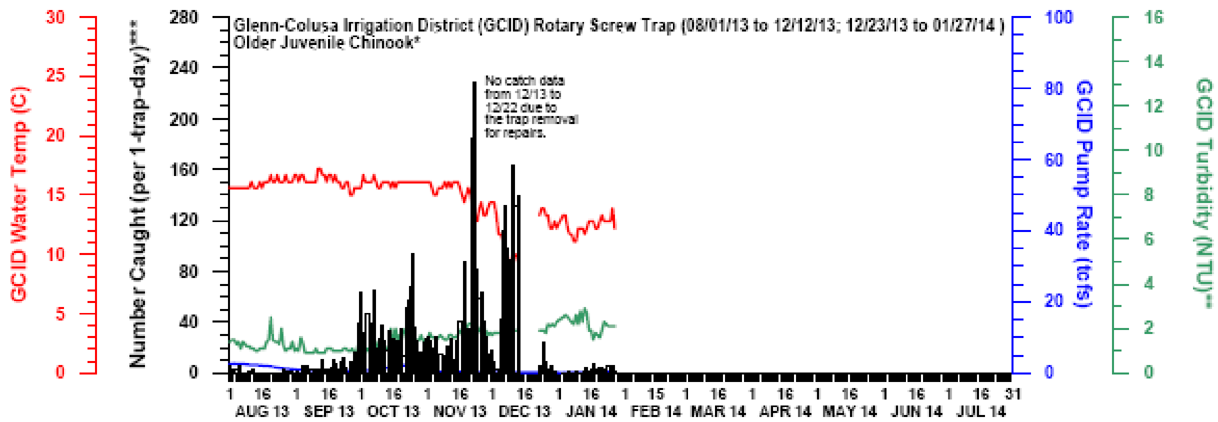

Figure 4. Glen-Colusa Irrigation District Rotary Screw Trap older juvenile Chinook salmon catch data and associated environmental data.[4]

Adult winter-run Chinook salmon are currently entering the Sacramento River and migrating to the upper reaches of the river in preparation for spawning during the summer of 2014. These adult Winter-run Chinook will hold in the upper Sacramento River between Red Bluff Diversion Dam and Keswick Dam until they are ready to spawn during the summer. These

[3] Downloaded from CDEC on January 30, 2014.
[4] Figure supplied by DWR to DOSS on January 27, 2014.

fish require coldwater holding habitat for several months prior to spawning as their gonads mature, and then require cold water to ensure the proper development of their fertilized eggs, which are highly sensitive to thermal conditions during this embryo development period. Adults returning to the river in 2014 are predominantly members of the cohort from brood year 2011. Based on cohort replacement rate (CRR) estimates, the 2011 brood year was the third lowest CRR since 1992. It is likely that the escapement of Winter-run Chinook in 2014 will be approximately half the number of adults that spawned in 2013, based on the smaller number of adults that returned in 2011 compared to 2010. Fewer returning adults will typically result in lower juvenile production for that year, thus the juvenile production for 2014 is expected to be lower than 2013.

Table 1. Fish Observation Data from Tisdale and Knights Landing Rotary Screw Traps in WY 2014.[5]

Location	Gear	Start Date	Stop Date	Num. of Hours During Sampling Period	Flow cfs (@ WLK)	Cone RPM (8.3)	Cone RPM (8.4)	Total Cone Rev. (8.3)	Total Cone Rev. (8.4)	Total Hrs. Fished	Water T (F)	Secchi (ft)	Turbidity (FTU)	Unmarked Chinook CATCH	Min FL	Max FL	# Fall	# Spring	# Winter	# Late fall	# Ad-clip CS	# Ad-clip SH	# Unclip SH	Fall+Spring CPUE (catch per hour)	Winter+Late fall CPUE (catch per hour)	Unclip SH CPUE (catch per hour)
TIS	2 x 8' Cone	9/30/2013	10/1/2013	25.00	6,405	2.5	2.6	2,926	4,106	46.14	62	NA	4.5	1	34	34	0	0	1	0	0	0	0	0.000	0.022	0
TIS	2 x 8' Cone	10/2/2013	10/3/2013	23.50	5,987	2.6	2.6	3,323	3,816	46.06	61	NA	4.6	1	38	38	0	0	1	0	0	0	0	0.000	0.022	0
KL	2 x 8' Cone	10/4/2013	10/5/2013	21.00	5902	1.9	2.0	2488	2696	44.9	61	5.6	1.5	2	36	39	0	0	2	0	0	0	0	0.000	0.045	0
KL	2 x 8' Cone	10/4/2013	10/5/2013	21.00	5902	1.9	2.0	2488	2696	44.9	61	5.6	1.5	2	36	39	0	0	2	0	0	0	0	0.000	0.045	0
KL	2 x 8' Cone	10/8/2013	10/10/2013	44.00	5640	1.7	1.7	5099	5521	104.1	60	5.9	1.1	1	38	38	0	0	1	0	0	0	0	0.000	0.010	0
TIS	2 x 8' Cone	10/9/2013	10/10/2013	21.75	5,458	1.7	2.2	2,198	3,080	44.76	57	NA	5.5	1	37	37	0	0	1	0	0	0	0	0.000	0.022	0
KL	2 x 8' Cone	10/10/2013	10/11/2013	23.75	5269	1.9	1.8	2596	2842	49.7	60	6.0	2.8	1	41	41	0	0	1	0	0	0	0	0.000	0.020	0
TIS	2 x 8' Cone	10/22/2013	10/23/2013	23.50	3,845	0.0	1.9	0	1,014	9.09	59	NA	11.4	1	36	36	0	0	1	0	0	0	0	0.000	0.110	0
TIS	2 x 8' Cone	10/23/2013	10/24/2013	22.00	4,008	1.1	2.1	1,784	3,032	51.09	58	NA	6.7	1	39	39	0	0	1	0	0	0	0	0.000	0.020	0
KL	2 x 8' Cone	11/8/2013	11/8/2013	7.25	5310	1.3	1.6	590	759	15.7	57	3.9	3.9	1	38	38	0	1	0	0	0	0	0	0.064	0.000	0
TIS	2 x 8' Cone	11/10/2013	11/11/2013	16.25	5,057	1.3	2.1	829	1,214	20.13	54	NA	5.9	1	35	35	0	1	0	0	0	0	0	0.050	0.000	0
TIS	2 x 8' Cone	12/16/2013	12/16/2013	8.75	4,586	1.0	1.8	497	945	17.03	45	NA	8.0	1	79	79	0	0	1	0	0	0	0	0.000	0.059	0
TIS	2 x 8' Cone	12/21/2013	12/21/2013	8.25	4,633	1.3	1.7	493	878	14.93	45	NA	7.1	1	75	75	0	0	1	0	0	0	0	0.000	0.067	0
TIS	2 x 8' Cone	12/23/2013	12/24/2013	15.00	4,650	1.2	1.7	818	1,623	28.05	46	NA	8.9	1	94	94	0	0	1	0	0	0	0	0.000	0.036	0
TIS	2 x 8' Cone	12/30/2013	12/31/2013	15.25	4,689	1.2	2.0	886	1,597	25.61	45	NA	5.6	1	34	34	1	0	0	0	0	0	0	0.039	0.000	0
TIS	2 x 8' Cone	1/3/2014	1/4/2014	15.00	4,536	0.8	1.8	720	1,540	29.42	46	NA	8.6	1	37	37	1	0	0	0	0	0	0	0.034	0.000	0
TIS	2 x 8' Cone	1/4/2014	1/4/2014	8.25	4,458	1.3	1.8	625	936	16.68	46	NA	6.3	1	39	39	1	0	0	0	0	0	0	0.060	0.000	0
TIS	2 x 8' Cone	1/4/2014	1/5/2014	15.25	4,458	1.3	1.9	1,060	1,619	27.79	46	NA	7.8	1	39	39	1	0	0	0	0	0	0	0.036	0.000	0
TIS	2 x 8' Cone	1/5/2014	1/6/2014	15.50	4,416	0.9	1.6	914	1,457	33.18	48	NA	7.2	3	35	37	3	0	0	0	0	0	0	0.090	0.000	0
TIS	2 x 8' Cone	1/6/2014	1/6/2014	8.50	4,425	0.9	1.8	513	834	17.40	46	NA		1	38	38	1	0	0	0	0	0	0	0.057	0.000	0
TIS	2 x 8' Cone	1/8/2014	1/8/2014	8.50	3,917	0.3	1.2	287	760	24.96	46	NA	6.1	1	33	33	1	0	0	0	0	0	0	0.040	0.000	0
TIS	2 x 8' Cone	1/8/2014	1/9/2014	14.75	3,917	0.7	1.4	311	1,106	21.05	43	NA	7.7	2	40	40	2	0	0	0	0	0	0	0.095	0.000	0
KL	2 x 8' Cone	1/10/2014	1/11/2014	13.75	3757	1.1	1.1	972	857	27.7	48	6.2	2.9	1	39	39	1	0	0	0	0	0	0	0.036	0.000	0
TIS	2 x 8' Cone	1/12/2014	1/13/2014	15.00	3,730	0.8	1.6	885	1,632	34.46	47	NA	6.0	3	36	41	3	0	0	0	0	0	0	0.087	0.000	0
KL	2 x 8' Cone	1/13/2014	1/14/2014	14.75	3880	1.3	1.3	1094	1053	27.5	49	6.0	2.4	1	37	37	1	0	0	0	0	0	0	0.036	0.000	0
KL	2 x 8' Cone	1/16/2014	1/17/2014	14.25	3520	1.2	1.0	1013	894	29.0	49	5.5	3.0	2	37	40	2	0	0	0	0	0	0	0.069	0.000	0
KL	2 x 8' Cone	1/24/2014	1/25/2014	14.00	3440	1.1	1.1	967	838	28.0	50	5.7	3.8	1	100	100	0	0	1	0	0	0	0	0.000	0.036	0
TIS	2 x 8' Cone	1/13/2014	1/14/2014	14.75	3880	0.8	1.5	497	1,288	24.86	49	NA	10.9	1	38	38	1	0	0	0	0	0	0	0.040	0.000	0
TIS	2 x 8' Cone	1/14/2014	1/15/2014	15.00	3873	0.6	1.5	432	1,218	25.53	48	NA	7.4	2	38	39	2	0	0	0	0	0	0	0.078	0.000	0
TIS	2 x 8' Cone	1/20/2014	1/21/2014	20.00	3476	2.8	2.2	2,728	2,823	37.63	48	NA	6.98	2	38	39	2	0	0	0	0	0	0	0.053	0.000	0
TIS	2 x 8' Cone	1/21/2014	1/22/2014	14.75	3492	2.5	2.4	2,230	1,953	28.78	47	NA	6.4	1	40	40	1	0	0	0	0	1	0	0.035	0.000	0
TIS	2 x 8' Cone	1/23/2014	1/24/2014	15.25	3483	2.6	2.1	2,348	2,002	30.86	48	NA	6.65	1	40	40	1	0	0	0	0	0	0	0.032	0.000	0
TIS	2 x 8' Cone	1/24/2014	1/25/2014	14.75	3450	2.5	2.0	2,167	1,818	29.58	48	NA	8.23	1	35	35	1	0	0	0	0	1		0.034	0.000	0
TIS	2 x 8' Cone	1/26/2014	1/27/2014	14.50	3395	2.2	1.8	1,935	1,786	31.20	48	NA	6.27	1	142	142	0	0	0	1	0	0	0	0.000	0.032	0

[5] Data updated through January 27, 2014.

Spring-run Chinook salmon

A small, but greater than average spawning run of spring-run Chinook returned to the upper Sacramento River. In 2013, this greater-than-average return of spawners was observed across many tributaries supporting spring-run Chinook salmon. The adult escapement estimate for Central Valley spring-run in 2013 is 20,057 fish returning to the Feather River Hatchery and 18,499 fish returning to the tributaries. This is the largest return in the past 25 years. Rain events during mid-November increased daily average flows in upper Sacramento River tributaries conducive to triggering outmigration of yearling spring-run Chinook into the mainstem, although the rapid return to stable tributary flows and low temperature suggest these fish may have limited the extent to which larger numbers of yearling spring-run Chinook exited these watersheds. Hundreds of smaller-sized spring-run Chinook salmon juveniles continue to be observed weekly in fish monitoring at Red Bluff Diversion Dam in larger numbers than in previous years (Figure 5), which may be expected from a larger than average adult escapement this year. These smaller sized spring-run Chinook may have been subjected to greater stranding risks during reservoir release reductions earlier this winter. Since October 2013, 90 juvenile, but no smolting, spring-run Chinook salmon were observed in middle [Glenn Colusa Irrigation District (GCID)]. Sacramento River fish monitoring stations (Figure 4, these are included in the “older juvenile” data presented) through January 27 2014. Only three juvenile spring-run Chinook salmon have been observed during late October and early November 2013, at the Tisdale Weir and Knights Landing fish monitoring stations in WY 2014 (Table 2). Spring-run Chinook salmon have been observed outmigrating past rotary screw traps on Butte Creek (~42,000 fry) and the Feather River. These spring-run Chinook salmon will not be observed emigrating through the Lower Sacramento River, since the confluences of these watersheds are downstream of mainstem rotary screw traps, and thus these fish could move undetected into the Delta. Thus, there is additional uncertainty in being able to quickly observe pulses of these spring-run Chinook entering the Delta. Since late fall, no spring-run Chinook have been observed in lower Sacramento and Delta beach seine and trawl fish monitoring surveys or at the state and federal fish collection facilities at the South Delta CVP/SWP export pumps.

Adult spring-run Chinook will migrate into the upper Sacramento between May and July 2014. These adults oversummer in the upper Sacramento River before spawning and require coldwater holding habitat for the maturation of their gonads before spawning in September and October. Lack of cold water habitat will decrease the viability of their gametes as the mature and exposes adult fish to increased mortality through other avenues, such as disease and thermal stress. Additionally, the brood year 2014 eggs will require continued cold water thermal conditions as they develop in the gravel during the September through November 2014 incubation period.

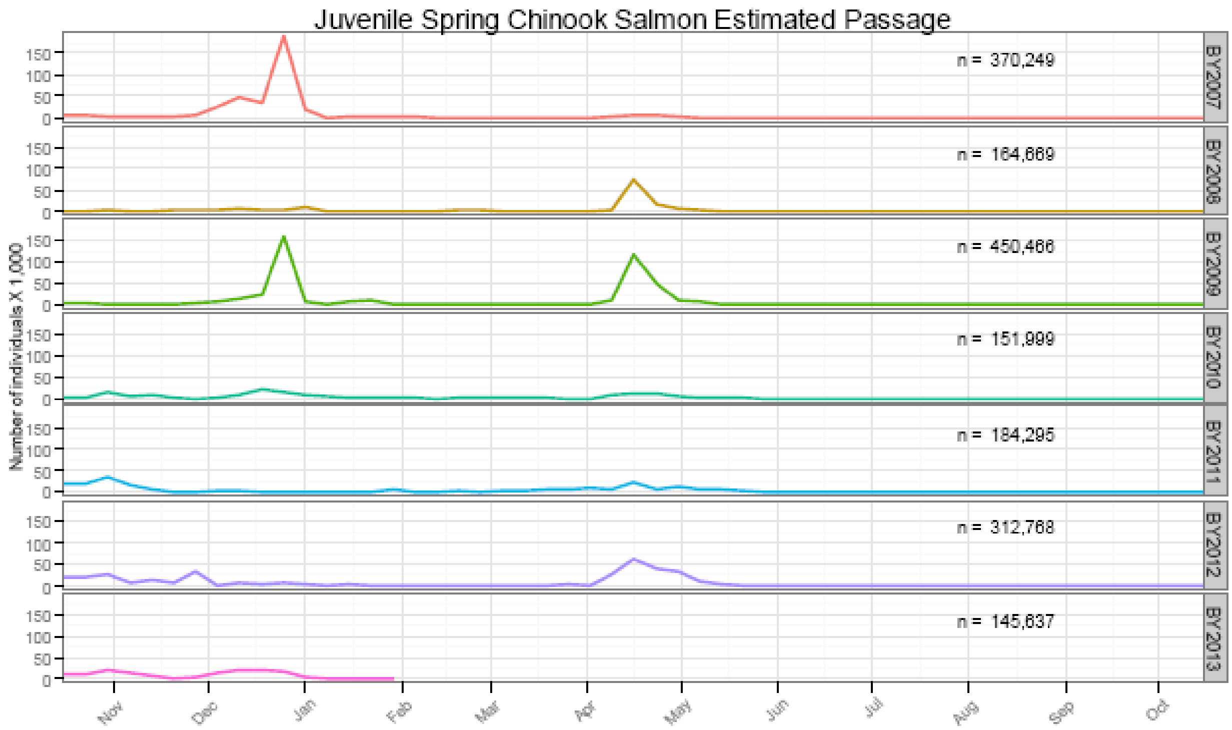

Figure 5. Weekly Estimated Passage of Juvenile Spring-Run Chinook Salmon at Red Bluff Diversion Dam (RK 391) by Brood-Year (BY).[6]

[6] Fish were sampled using rotary-screw traps for the period July 1, 2007 to present. Figure supplied by USFWS (January 29, 2014).

Table 2. Environmental Data from Tisdale and Knights Landing Rotary Screw Trap for WY 2014 When Winter-run and Spring-run Chinook Salmon were Enumerated Between October 1 and January 27, But Only Through January 14 During Other Observational Periods.
NA = Not accessed or available.

Location and number of fish recovered	Number of fish observed	Turbidity			Daily flows at Wilkins slough		
		Average	Min	Max	Average	Min	Max
Combined Tisdale and Knights Landing WY 2014							
1 fish	13	6.1	1.1	11.4	4465	3395	6405
2 fish	4	4.7	1.5	7.7	4431	3476	5902
Tisdale 2011-2012							
1 fish	7	8.41	5.8	12.4	7069	4870	11900
2 fish	6	9.27	8	10.6	6040	5050	7690
Knights Landing 2011-2012							
1 fish	4	9.39	7.8	10.6	6967	8440	5893
2 fish	6	6.73	6.1	7.3	9299	9454	9144
Knights Landing 2000-2001							
1 fish	8	NA	NA	NA	NA	NA	NA
2 fish	2	NA	NA	NA	NA	NA	NA
>3 fish	27	NA	NA	NA	NA	NA	NA
Beach Seine 2001-2001							
1 fish	6	NA	NA	NA	NA	NA	NA
> 4 fish	42	NA	NA	NA	NA	NA	NA
Sacramento Trawl 2000-2001							
1 fish	2	NA	NA	NA	NA	NA	NA
2 fish	2	NA	NA	NA	NA	NA	NA
3 fish	3	NA	NA	NA	NA	NA	NA

Steelhead

Information on steelhead is extremely limited. Observed 2013 patterns of outmigrating *O. mykiss* parr (young of year) during the summer at RBDD were similar to previously observed patterns, although a greater abundance appears to have passed than in the past previous five years (Figure 6). Steelhead smolts are seldom observed in Sacramento River and Delta fish monitoring due to sampling biases related to their larger fish size and their enhanced swimming ability. False negatives 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. Since October 2013, GCID fish monitoring has detected 10 wild steelhead, eight of which were in October. Between 1998 and 2011, temporal observations of natural steelhead juveniles (n=2137) collected in these monitoring efforts in the Delta occurs less than 10% of the time in January, >30% of the time during February, >30% of the time during February, and >20% of the time during March. So far in WY2014, A single steelhead was observed in lower Sacramento and Delta seine and trawl surveys (one 300mm steelhead observed 12/11/13 in the Chipps Island Trawl). Multiple steelhead smolts were observed in American River fish monitoring and will not be observed anywhere before entering the Delta due to the American River confluence being downstream of the mainstem rotary screw traps. Thus, there is additional uncertainty in being able to quickly observe pulses of American River steelhead entering the Delta. One steelhead was counted at the state and federal fish collection facilities at the South Delta CVP/SWP export pumps on January 1/23/14. No outmigrating steelhead have been observed in the Mossdale trawl this winter.

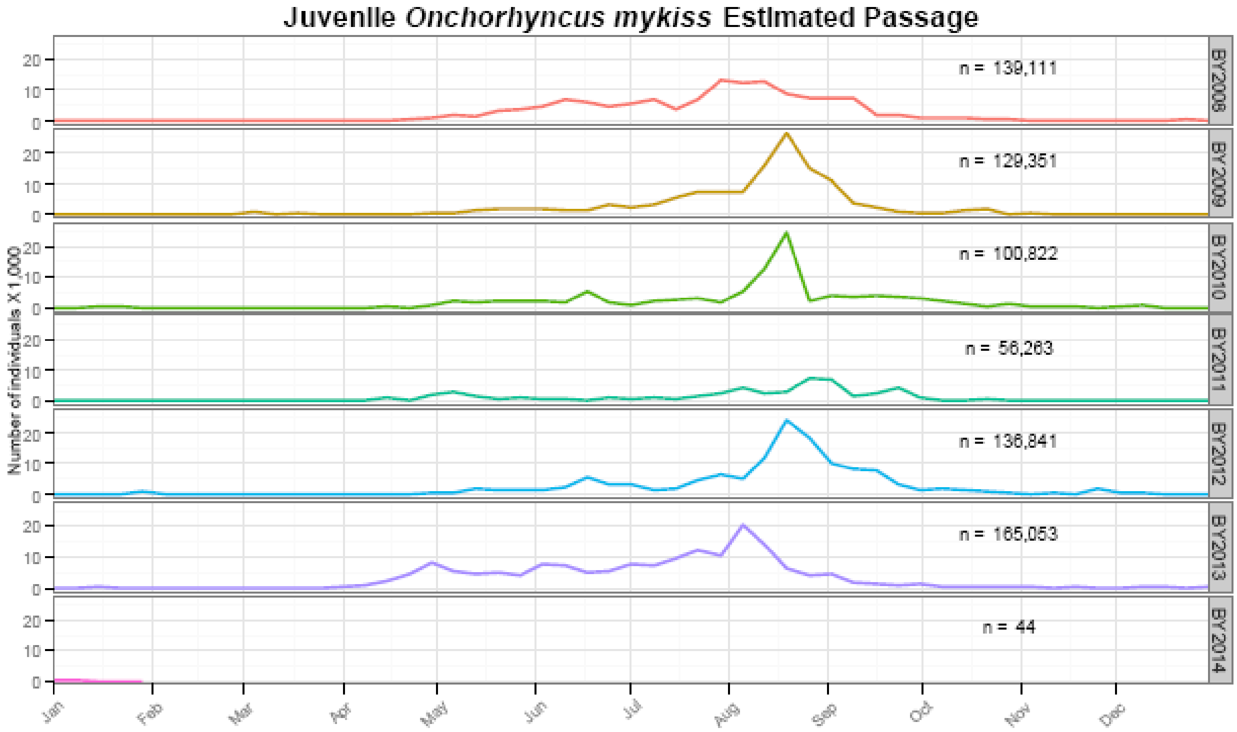

Figure 6. Weekly Estimated Passage of *O. mykiss* at Red Bluff Diversion Dam (RK 391) by Brood-Year (BY).[7]

Green sturgeon

Information on green sturgeon is extremely limited and the recovery is limited due to their low vulnerability to monitoring techniques. Adult green sturgeon will immigrate into the upper Sacramento River through the Delta between March and June. Spawning in the upper Sacramento River was documented during 2013. Juveniles were observed at RBDD and more juveniles (n=443) were enumerated than the long-term average of 426 fishes (Figure 7). At GCID, 2 green sturgeon were observed during June 2013. Green sturgeon observations are extremely rare in the Delta and none have been observed in lower Sacramento and Delta fish monitoring surveys or at the state and federal fish collection facilities at the South Delta CVP/SWP export pumps in recent years. In 2011, over a thousand juvenile green sturgeons were enumerated at RBDD and none were observed in river, Delta, or Bay fish monitoring. While this absence in the monitoring may suggest no impact due to Delta Cross Channel operations or outflow operations, it may also suggest the recruitment of juveniles may be limited before the species reaches one year old due to habitat, predation, or multiple stressors;

[7] Fish were sampled using rotary-screw traps for the period July 1, 2007 to present. Figure supplied by USFWS (January 29, 2014).

which is a phenomenon that has been observed in other North American sturgeon species. Greater monitoring needs to be conducted in order to reduce this uncertainty.

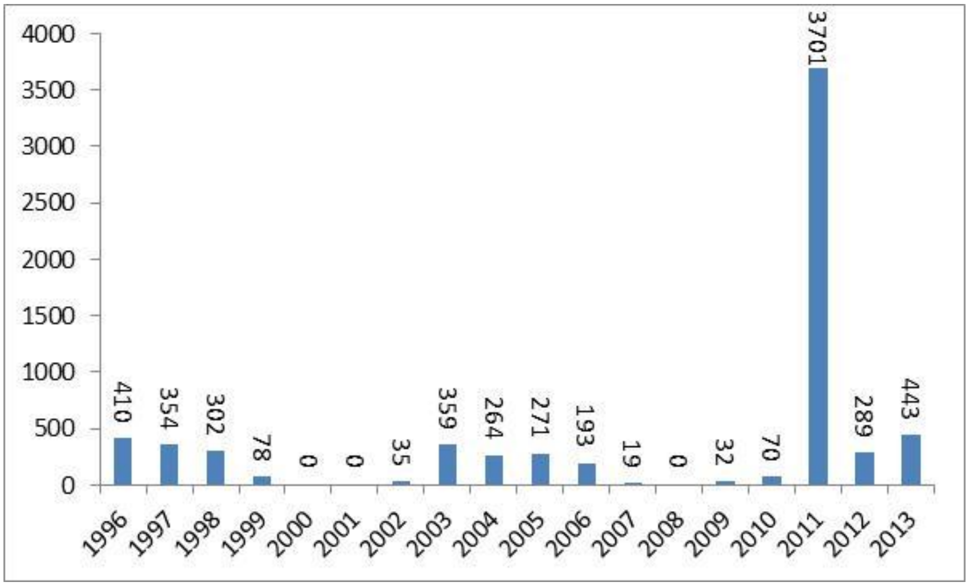

Figure 7. Juvenile Green sturgeon counted at Red Bluff Diversion Dam rotary screw traps.[8]

Analytical Framework

Methods and Metrics

To evaluate impacts to listed species due to Delta hydrodynamics caused by the petition's reduced outflow range, DSM2 output from between 1991 and 2011 for Freeport flows were examined for those that fell into relevant ranges (Figure 8) i.e. 4,000-5,000cfs and 7,000-8,000cfs). There were no Freeport flows for less than 4,000cfs, restricting our analysis from this portion of the petition's range. It is likely the patterns observed in the results are further amplified upstream as outflow is reduced. Hydrodynamics metrics such as daily proportion positive velocity and daily mean velocity were used to assess changes in the Delta caused by outflow reduction.

To evaluate impacts to listed species dues to tributary outflow changes, DCC gate opening, and Delta hydrodynamics caused by the petition's reduced outflow range, relevant peer-reviewed literature on these topics impact to fish biology, behavior, and survival were

[8] The dataset annual average is 426 fish. In 2011, an egg was observed directly above the rotary traps, thus the large number of fish in 2011 is a unique annual sampling of a spawning event (Josh Gruber, USFWS, pers comm.) If this data is removed the annual average of fish counted in 183 fishes.

reported. Results from these sources were used to evaluate modified operation of the DCC gates on reach-specific and through Delta survival. The NMFS BiOp (2009) was reviewed regarding biological rationale for outflow reduction under exceedance forecasts and DCC gate operations. Review of the development of relevant biological and physical triggers regarding historic DCC gate operations was compared to the current status of the species.

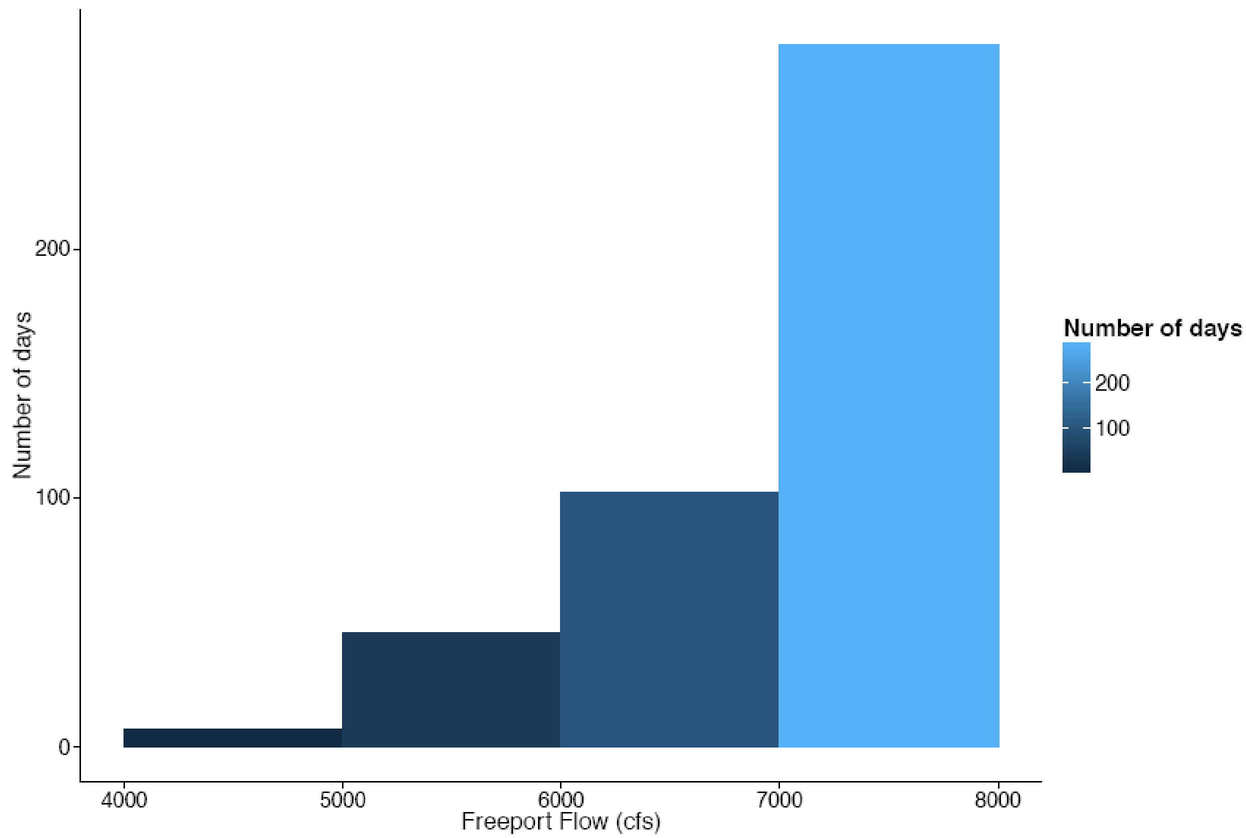

Figure 8. Histogram of the Number of Days When Freeport Flow Falls Into the Ranges Used in the Maps (for Water Years 1991-2011).[9]

[9] Figure provided by CFS, January 30, 2014.

Effects Analysis

Tributary Effects

Current storage conditions in CVP/SWP reservoirs are extremely low. CVP/SWP operators and fishery agencies are attempting to conserve cold water in these reservoirs for listed species' summertime temperature and habitat requirements. The 50% exceedance forecast issued in January 2014 (Table 3) demonstrates End-of-September (EOS) storage at all of the CVP/SWP reservoirs are projected to be at very low volumes throughout spring and summer operations for WY 2014. The 90% exceedance forecast issued for January 2014 projects EOS storage in Shasta Reservoir to be below 500TAF, which indicates a significant likelihood that reservoir releases will be unable to control water temperature downstream of Keswick Reservoir. This could lead to extremely high egg mortality or even complete brood year 2014 failure for Winter-run and spring-run Chinook (Table 4). While February exceedance forecasts are not yet available, they are predicted to be worse than the January forecasts described above due to January's continued dry metrological and hydrological conditions. Starting in February, D-1641 outflow standards require a minimum 3-day running average of daily Delta outflow of 7,100 cfs, which will require additional releases from CVP/SWP reservoirs that are inconsistent with the current implementation of NMFS BiOp Action 1.2.2.C and jeopardize implementation of NMFS BiOp Action 1.2.3.C beyond February. During the last week of January 2014, CVP operators have increased releases from Keswick Dam from the minimum 3,250 cfs to 3,750 cfs to reduced further degradation of D-1641 agricultural and municipal Delta water quality standards. These releases are not compliant with the precautionary management of the cold water pool identified in BiOp RPA 1.2.2.C, which require maintaining a release of 3,250 cfs from Shasta Reservoir to conserve storage. Thus, without a modification to the D-1641 Habitat Protection outflow standard of 7,100 cfs, Reclamation and DWR would be forced to increase releases from upstream reservoirs in February to meet Delta outflow and reduce precautionary reservoir storage conservation management necessary for minimizing extended drought impacts on brood year 2014 Winter-run Chinook salmon and spring-run Chinook salmon. The additional storage conservation measures taken during February by the petition's requested outflow range would likely preserve additional cold water pool for brood year 2014 Winter-run and spring-run Chinook salmon needs later in the year and improve the CVP storage system's ability to recover during the remainder of the winter and spring of WY2014.

Table 3. 50% Exceedance Forecast

50% Forecast

Storages

Federal End of the Month Storage/Elevation (TAF/Feet)

			Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Trinity		1187	1177	1177	1208	1221	1156	1079	975	865	752	728	725	757
	Elev.		2274	2274	2277	2278	2272	2264	2252	2239	2224	2221	2221	2225
Whiskeytown		205	206	206	206	238	238	238	238	238	238	206	206	206
	Elev.		1199	1199	1199	1209	1209	1209	1209	1209	1209	1199	1199	1199
Shasta		1673	1868	2153	2509	2602	2515	2239	1862	1576	1476	1464	1552	1741
	Elev.		949	966	985	989	985	971	949	931	924	923	929	942
Folsom		187	279	400	569	575	555	386	355	329	295	294	310	345
	Elev.		383	403	425	426	423	401	396	392	386	386	389	395
New Melones		1049	1057	1061	1061	1009	927	814	701	587	506	488	505	529
	Elev.		950	951	951	944	932	915	896	875	859	855	859	864
San Luis		329	332	382	385	372	326	245	160	224	422	633	876	1140
	Elev.		418	444	455	448	435	413	385	380	400	414	449	476
Total			4918	5379	5937	6017	5717	5001	4291	3820	3689	3814	4173	4717

State End of the Month Reservoir Storage (TAF)

			Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Oroville		1286	1432	1659	1895	2004	1918	1726	1534	1438	1404	1322	1282	1354
	Elev.		722	748	773	783	775	755	734	723	719	709	704	713
San Luis		274	338	530	640	585	503	386	250	147	98	6	88	105
Total San Luis (TAF)		603	670	911	1024	956	829	632	409	371	520	640	964	1244

Monthly River Releases (TAF/cfs)

		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Trinity	TAF	18	17	18	36	180	47	28	28	27	28	18	18
	cfs	300	300	300	600	2,924	783	450	450	450	450	300	300
Clear Creek	TAF	12	11	12	12	12	12	5	5	9	12	13	12
	cfs	200	200	200	200	200	200	85	85	150	200	225	200
Sacramento	TAF	200	180	200	327	400	535	629	532	357	277	220	200
	cfs	3250	3250	3250	5500	6500	9000	10231	8649	6000	4513	3700	3250
American	TAF	41	47	53	177	177	249	91	92	90	77	74	77
	cfs	660	852	865	2980	2887	4182	1478	1500	1504	1250	1250	1250
Stanislaus	TAF	14	28	32	46	38	37	22	23	14	39	13	12
	cfs	223	497	523	767	616	630	364	368	240	635	212	200
Feather	TAF	58	53	77	74	77	134	132	77	74	105	104	77
	cfs	950	950	1250	1250	1250	2250	2150	1250	1250	1700	1750	1250

Trinity Diversions (TAF)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Carr PP	3	27	65	110	28	56	85	86	89	8	17	7
Spring Crk. PP	25	60	90	90	30	50	80	80	80	30	10	10

Delta Summary (TAF)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Tracy	45	125	45	45	46	45	45	179	282	282	272	282
USBR Banks	0	0	0	0	0	0	11	11	11	0	0	0
Contra Costa	14	14	12.7	12.7	12.7	9.8	11.1	12.7	14	16.8	18.4	18.3
Total USBR	59	139	58	57	59	55	67	203	307	299	290	300
State Export	65	199	155	21	37	45	45	46	56	210	220	300
Total Export	124	338	213	78	96	100	112	249	363	509	510	600
COA Balance	0	1	-18	16	1	6	7	23	-3	-3	-3	-3
Old/Middle R. std.												
Old/Middle R. calc.	-1,465	-4,251	-2,228	-583	-794	-1,243	-1,545	-3,269	-4,855	-6,106	-6,443	-7,375
Computed DOI	14153	11400	11403	10405	7109	7094	4002	2993	3009	3628	4370	6735
Excess Outflow	9647	0	0	0	0	0	0	0	0	130	874	3237
% Export/Inflow	12%	34%	21%	8%	12%	12%	18%	41%	55%	65%	65%	62%
% Export/Inflow std.	65%	35%	35%	35%	35%	35%	65%	65%	65%	65%	65%	65%

Hydrology

	Clair Engle	Shasta	Folsom	New Melones
Water Year Inflow (TAF)	571	3,180	1,372	495
Year to Date + Forecasted — % of mean	47%	57%	50%	47%

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Table 4. 90% Exceedance Forecast.

Storages

Federal End of the Month Storage/Elevation (TAF/Feet)

			Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Trinity		1187	1165	1151	1150	1136	1008	842	687	532	408	355	343	354
	Elev.		2273	2271	2271	2270	2256	2236	2215	2190	2167	2155	2152	2155
Whiskeytown		205	206	206	206	238	238	238	238	238	206	206	205	206
	Elev.		1199	1199	1199	1209	1209	1209	1209	1209	1199	1199	1198	1199
Shasta		1673	1706	1782	1821	1639	1464	1099	698	473	453	#N/A	#N/A	#N/A
	Elev.		939	944	947	935	923	894	854	824	#N/A	#N/A	#N/A	#N/A
Folsom		187	176	182	244	262	272	242	198	198	190	196	206	237
	Elev.		361	362	377	380	382	376	366	366	365	366	368	375
New Melones		1049	1036	1025	1000	937	851	758	651	544	466	453	465	480
	Elev.		947	946	942	934	921	906	887	867	850	847	850	853
San Luis		329	357	384	388	375	331	251	155	94	152	243	371	415
	Elev.		422	432	434	426	410	393	373	354	361	383	420	428
Total			4645	4730	4808	4587	4163	3430	2626	2079	1875	#N/A	#N/A	#N/A

State End of the Month Reservoir Storage (TAF)

Oroville		1286	1294	1353	1413	1365	1247	1065	845	725	692	704	645	656
	Elev.		705	713	720	714	699	674	639	617	611	613	601	604
San Luis		274	347	415	431	368	273	219	171	113	98	149	316	346
Total San Luis (TAF)		603	704	799	819	743	603	469	326	207	250	391	687	761

Monthly River Releases (TAF/cfs)

Trinity	TAF	18	17	18	36	92	47	28	28	27	23	18	18
	cfs	300	300	300	600	1,498	783	450	450	450	373	300	300
Clear Creek	TAF	12	11	12	12	12	9	7	5	9	12	12	12
	cfs	200	200	200	200	200	150	120	85	150	200	200	200
Sacramento	TAF	200	180	267	405	436	631	645	467	268	295	230	231
	cfs	3250	3250	4350	6800	7100	10600	10500	7595	4501	4800	3873	3750
American	TAF	41	28	33	48	49	51	73	31	30	31	30	31
	cfs	660	500	534	801	800	860	1185	500	500	500	500	500
Stanislaus	TAF	13	12	16	29	25	33	24	22	14	36	12	12
	cfs	210	215	268	480	410	561	396	352	240	580	200	200
Feather	TAF	61	53	58	119	55	86	144	77	74	77	74	77
	cfs	1000	950	950	2000	900	1450	2350	1250	1250	1250	1250	1250

Trinity Diversions (TAF)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Carr PP	9	5	1	39	76	127	128	127	98	40	15	11
Spring Crk. PP	4	5	8	10	70	120	120	120	120	30	10	11

Delta Summary (TAF)

		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Tracy		50	75	45	45	46	45	45	63	153	161	157	62
USBR Banks		0	0	0	0	0	0	0	0	0	0	0	0
Contra Costa		9.2	7	7	6.4	6.4	6.4	4.9	5.6	6.4	7	8.4	9.2
Total USBR		59	82	52	51	53	51	50	69	159	168	165	71
State Export		75	72	67	21	22	45	45	26	39	125	203	90
Total Export		134	154	119	72	74	96	95	95	198	293	368	161
COA Balance		0	0	0	9	-16	-1	-2	-2	-2	-2	-2	-2
Old/Middle River Std.													
Old/Middle R. calc.		-1,715	-2,062	-1,330	-873	-894	-1,351	-1,359	-1,412	-2,793	-3,479	-4,799	-2,058
Computed DOI		8589	7096	7109	7245	4002	4001	4002	3026	3043	3872	3933	7483
Excess Outflow		4083	0	0	0	0	0	0	33	34	374	437	3985
% Export/Inflow		20%	27%	18%	11%	14%	15%	16%	21%	41%	54%	61%	27%
% Export/Inflow std.		65%	45%	35%	35%	35%	35%	65%	65%	65%	65%	65%	65%

Hydrology

		Clair Engle	Shasta	Folsom	New Melones
Water Year Inflow (TAF)		195	2,281	623	184
Year to Date + Forecasted	% of mean	16%	41%	23%	17%

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While Keswick releases have increased in the past week to minimize further risks to exceeding D-1641 Delta water quality standards, these increases are not at the magnitude necessary to meet the February 7,100 cfs habitat protection outflow standard. Additional increases in reservoir releases will be necessary in February to meet the D-1641 outflow and water quality standards. Any fluctuations in releases from reservoirs to meet the D-1641 unmodified outflow standard may cause reservoir release operations that may increase stranding risk to brood year 2013 juvenile Winter-run and spring-run Chinook salmon and steelhead due to unstable in-river water levels below the reservoirs. However, by increasing the stability in releases from Keswick reservoir at the lower levels, it is hypothesized that Chinook and steelhead smolt downstream emigration time will increase, resulting in reduced outmigration survival (Singer et al 2013) and reduced smoltification window (McCormick et al 1998). The quantity of storage that can be gained by operating to the petition's outflow range may be at least 144 TAF in February, which will be critical to Keswick and Nimbus operations necessary for the biological needs of winter-run Chinook, spring-run Chinook, steelhead, and green sturgeon downstream of these reservoirs during summer and fall of WY 2014.

Additionally, the reduction in reservoir storage without the petition's action will decrease the volume of water available for brood year 2014 Winter-run and spring-run Chinook later on in the year and has the potential to affect critical habitat for these species by diminishing spawning habitat area in the rivers below the reservoirs, negatively impacting food resources, and altering other principal constituent elements defined in the critical habitat designations for these species. Reductions in flow are anticipated to reduce the wetted area of the river channel below the reservoirs, which reduces the areas within the channel that can provide suitable areas for spawning, increasing the likelihood of redd superimposition, reduces habitat for the production of the invertebrate forage base needed for rearing juveniles, and altering physical and chemical attributes in the river such as dissolved oxygen and increased thermal loading due to lower flows and shallower water depth that can heat up more quickly due to ambient air temperature and solar irradiation. Thus, the petition's action regarding a reduced outflow range in February is a proactive approach by Reclamation and DWR to immediately implement appropriate contingency measures that may benefit brood year 2014 cold water listed species, as required in NMFS BiOp RPA I.2.3.C.

Storage at Folsom reservoirs are currently so low that Reclamation and DWR cannot call on them for releases to comply with the current D-1641 water quality standards and in-basin water user's needs. Reclamation is required to meet temperature criteria suitable for oversummer rearing of juvenile steelhead in the lower American River through NMFS BiOp RPA II.2. While the modeling required for this work is typically based initially on April's CVP/SWP forecast, current modeling suggests conditions to meet temperature criteria throughout the spring and summer are not achievable. Folsom reservoir storage is not an option for greater releases to meet D-1641's unmodified February outflow requirements, and thus the petition's reduction in outflow provides the only opportunities to benefit WY2014 storage in both Folsom and Shasta reservoirs.

Adult Green sturgeon are absent from the Sacramento and Feather rivers in February during the petition's action. Adult spawners are expected to start migrating upriver in March prior to spawning in the upper river. Impacts to juvenile and subadult life stages of green sturgeon are anticipated to minimal. It is expected that brood year 2013 juvenile green sturgeon are still upstream of the Delta, overwintering prior to entering the Delta. 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 rearing phase and freely move throughout the Delta to find suitable conditions for their needs.

Delta Habitat Effects Regarding Salmonids and Green Sturgeon

Outflow Action

Although the NMFS BiOp (2009) does not contain outflow standards, the reduction in outflow as identified in the petition may impact juvenile salmonids migrating through the North Delta between Sacramento and Rio Vista, where Sacramento River flows meet the tidally dominated western Delta. The outflow range described in this petition, necessary to maintain currently degraded water quality conditions, are lower than those afforded under minimum standards to meet the D-1641 X2 standard in February. This reduction in Delta inflow from 7100 cfs to a range of between 3000and 4500 cfs may reduce survival of juvenile salmonids migrating through the North Delta through increased predation mediated by hydrodynamic mechanisms. Once immigrating fish reach the tidally dominated western Delta (i.e. Rio Vista towards Chipps Island) or San Joaquin River under the petition's outflow range (3000 to 4500 cfs), they are likely to encounter daily proportion of positive velocities and mean velocity that are similar to outflow conditions observed when the 7100 cfs standard is being achieved (Figure 9- 10).

In the North Delta, a decrease in outflow will impact the Delta hydrodynamics in two ways, which influence salmonid migration speed and patterns. These hydrodynamic processes influence survival due to changing juvenile salmonids exposure to predators through the North Delta and other relevant reaches (i.e. Georgiana Slough, Delta Cross Channel). First, reduced outflow may increase tidal excursion (reduced daily proportion of positive velocities) into the North Delta region, which may increase the duration of reverse flows into Georgiana Slough and/or an open Delta Cross Channel. These increased tidal excursions are likely to increase entrainment into Georgiana Slough and, if open, the Delta Cross Channel. Survival in the mainstem or one of the multiple distributary channels is lower due to the longer duration of the downstream emigration phase resulting from reduced flows as compared to periods of greater. 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.

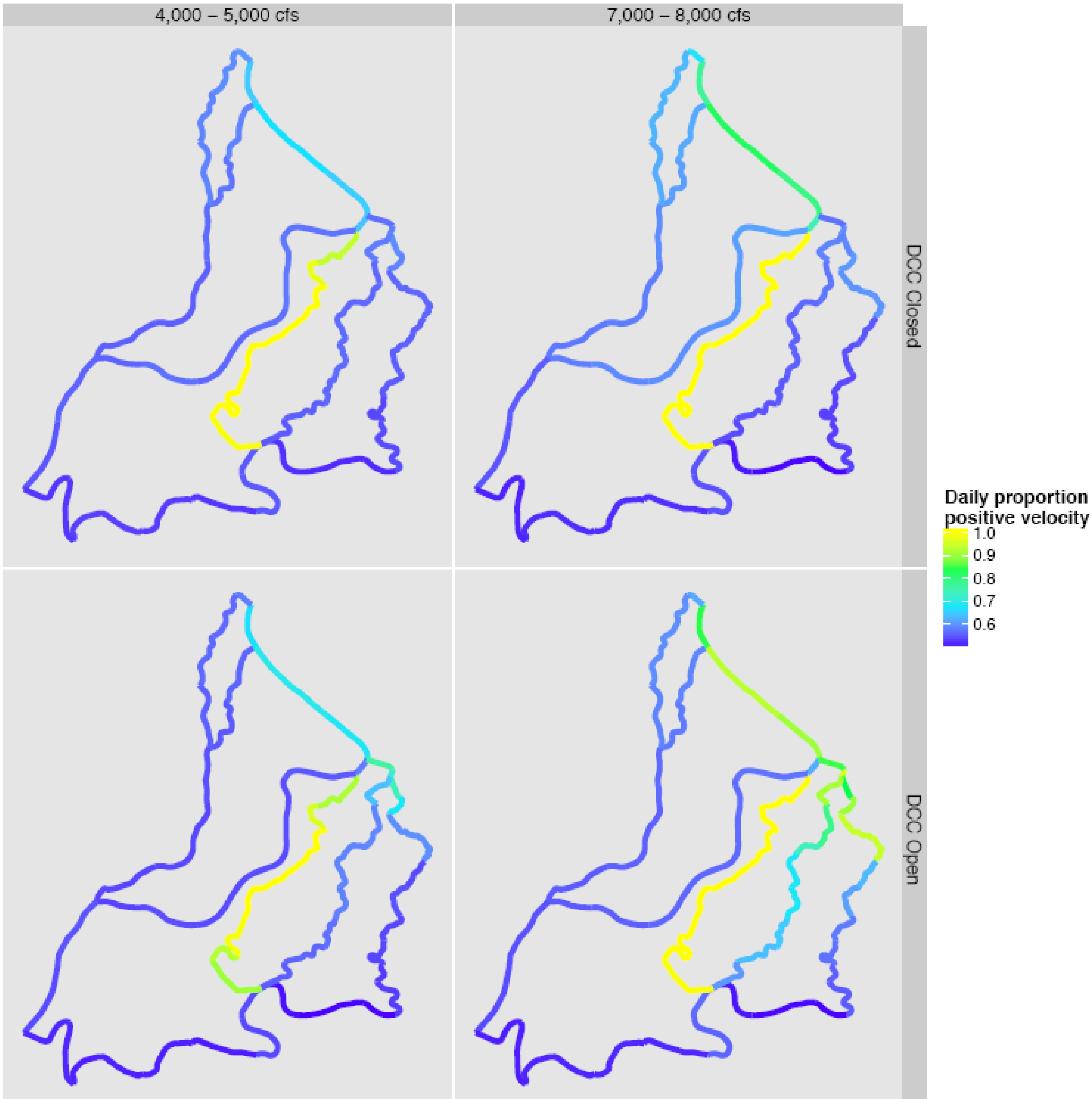

Figure 9. Maps of the Delta Region Near the DCC with the Channels Color-Coded for Daily Proportion Positive Velocity.[10]

[10] Figure provided by CFS, January 30, 2014.

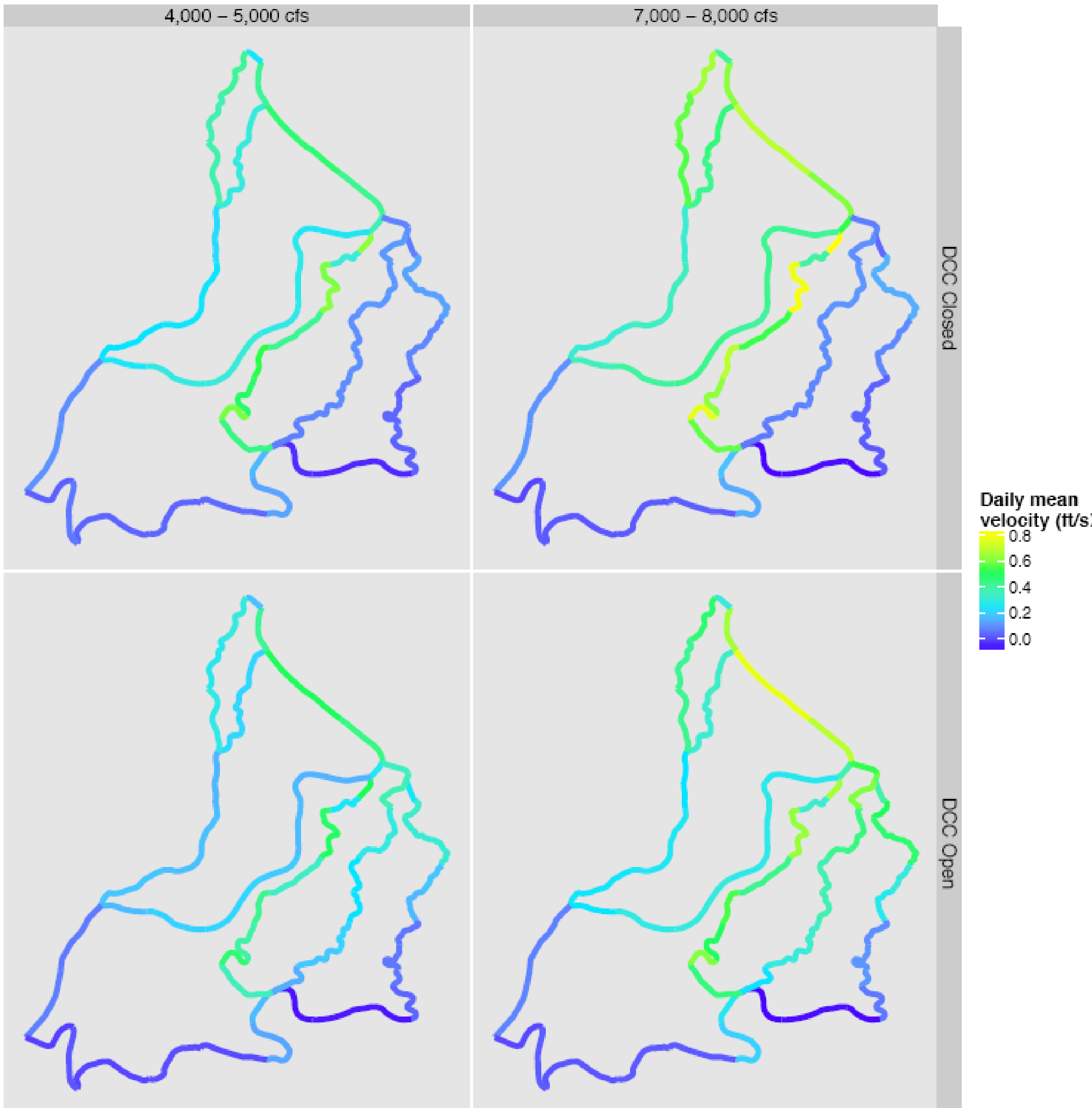

Figure 10. Maps of the Delta Region Near the DCC with the Channels Color-Coded for Daily Mean Velocity.[11]

[11] Figure provided by CFS, January 30, 2014.

Second, reduced outflow causes the daily mean channel velocity along the Sacramento River, and Sutter and Steamboat sloughs be less positive (Figure 10). When the DCC gates are open, the daily mean channel velocity becomes even less positive in these reaches (Figure 10) . Reducing outflow also causes a decrease in the daily proportion of positive velocities through the Sacramento River downstream of Sutter and Steamboat sloughs confluence with the Sacramento River (Figure 9). Also, Georgiana Slough flows become less positive as tidal excursion causes reversal 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.

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 greater predation and increases mortality. There are no models to quantify the increase in mortality due to reduced flows in this reach, however comparisons may be made. The Delta Cross Channel'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 values for salmonid through the North Delta from Sutter and Steamboat Slough 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 3, 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 variation within and between studies, and factors other than travel time and flow are suggested to have contributed to variation in survival estimates including environmental conditions and temporal shifts in predators (Perry et al 2010) and tag failure (Romine et al. 2013). Regarding steelhead, a previous study (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, Mokelumne, 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 mainstem route in both years.

BY14 adult Winter-run Chinook salmon may be affected by the petition's reduction in outflow, due to a reduction in a detectable flow signal for upriver migration. While green sturgeon may be present in February in the Delta, they do not migrate though the North Delta until March. Juveniles and sub-adults rearing and utilizing the Delta are not expected to be affected by the change in inflows to the Delta. Over the course of their rearing in the Delta (1 to 3 years for juveniles), 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.

Minimum Pumping Level Action

Action IV.2.3 in the 2009 NMFS BiOp uses fish loss density, daily loss, and surrogate Coleman National Fish Hatchery (CNFH) releases of Winter-run and late fall 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 January 1 and June 15. A calendar-based requirement for the 14-day OMR average flow to be no more negative than -5,000cfs started January 1, although it has not yet controlled export operations. Depending on what level of fish trigger is exceeded, combined exports are managed to a level so that the 5-day net average OMR flow in not more negative than -3,500 or -2,500cfs OMR until fish densities return below levels of concern.

Earlier in January 2014, operational considerations for D-1641 outflow standards controlled exports to 1,500 cfs combined exports at the state and federal export facilities, and in the past weeks operational consideration for D-1641 Municipal and Industrial water quality standards in the South Delta surpassed outflow considerations, and these considerations have controlled exports to combined exports of 1500cfs pumping. . Although some flow gauges remain inoperable along Old and Middle River, average daily flows in Old and Middle River have averaged approximately -1800cfs in December 2013, and are averaging approximately -1400 in January 2014 (Figure 11). Currently, combined export levels are less than 1,500 cfs, and are required due to the lack of Delta inflow and consideration for South Delta water quality. Current export levels, and those described in the petition for February, maintain Old and Middle River conditions less negative than the most protective Action Response in NMFS BiOp Action IV.2.3 and provide south Delta hydrodynamic conditions more conducive to salmonids successfully exiting the Delta at Chipps Island (relative to a condition with more negative OMR conditions).

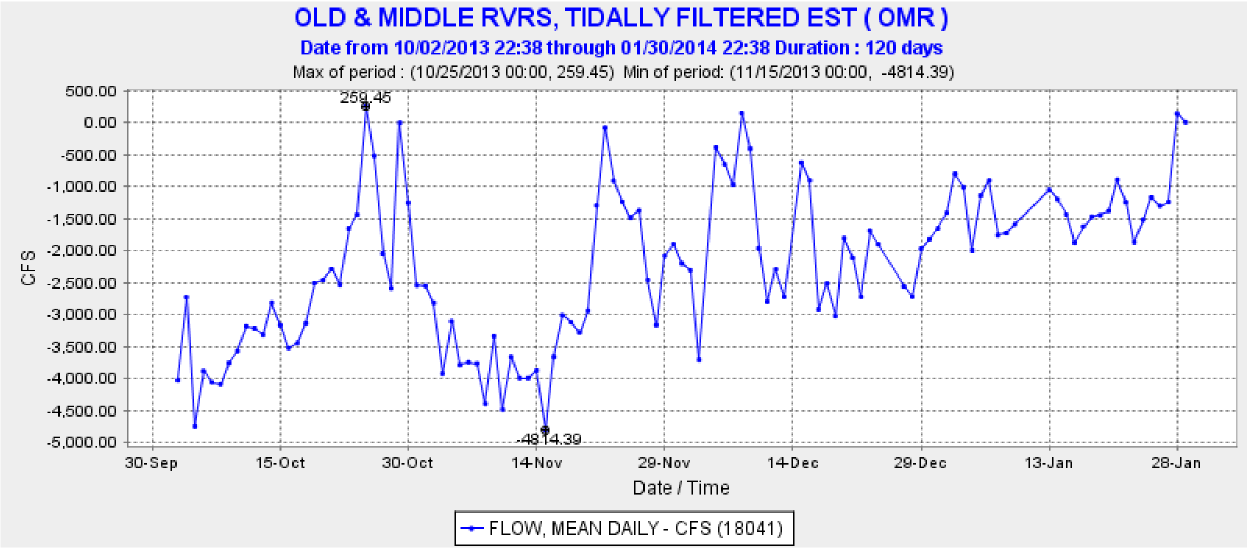

Figure 11. Old and Middle River tidally-filtered daily flows for WY 2014.[12]

DCC Gate Open Action

The NMFS BiOp (2009) and D-1641include 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. Analysis of historic recovery data from Knights Landing show in Critical and Dry years, on average 72% and 92% of Winter-run Chinook salmon enter the Lower Sacramento River by the end of January or February, respectively. Analysis of historic recovery data from Knights Landing show in Critical and Dry years, on average 14% and 29% of spring-run Chinook salmon enter the Lower Sacramento River by the end of January or February, respectively. Calendar-based closures of the DCC are based on historical patterns of outmigrating fish; with some exceptions allowed prior to January 31. 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.

[12] Downloaded from CDEC on January 30, 2014.

As described in the petition's Attachment B, fish monitoring observations made through January 27, 2014 suggest that pulses of listed salmonids have passed middle Sacramento River monitoring sites at Glen-Colusa Irrigation District, and continue to rear and slowly migrate downstream, but these pulses have not passed Knights Landing into the Lower Sacramento River. The second component of the second alert of NMFS BiOp RPA IV.1.1 and the Chinook Salmon Decision Tree exceeding 7,500 cfs at Wilkins Slough (adjacent to Knights Landing) has not been exceeded. While the absence of detecting fish in the Knights Landing and Tisdale rotary screw traps should not lead to the assumption that listed fish have not passed this location, recent synthesis of these data suggest that catch spikes of as little as 5% cumulative catch are observable and are nearly coincident with rapid increases in flow greater than 14,125 cfs (Rosario et al. 2013). Substantial catches of larger-size juvenile Winter-run Chinook continue daily at RBDD rotary screw traps, the majority of an estimated JPE has not been observed to have not past RBDD rotary screw trap, and the catch index at Knights Landing has not exceeded 1 fish/day. These lines of evidence support the Winter-run Chinook population remaining above the lower Sacramento River, which keeps risks from opening the DCC under current fish distribution conditions very low.

When emigrating salmonids are in proximity of the DCC gates they are vulnerable to entrainment through the DCC when the gates are open. A series of studies conducted by Reclamation and 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 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.).

The petition's action to open the DCC gates will increase mortality through the North Delta and Interior Delta. Perry et al (2010) includes two releases of acoustically tagged late fall 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 5) 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. The petition's opening of the DCC may increase straying of returning Winter-run Chinook adult salmon on the mainstem by diverting Sacramento River flows through the forks of the Mokelumne River and Central Delta.

Table 5. Average Values for Releases Described in Romine et al (2013).
Seven releases occurred with DCC open and three releases occurred with it closed.

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

The petitions' action to open the DCC gates without physical or biological triggers will increase mortality of juvenile outmigrating and rearing winter run and spring run Chinook salmon. Juvenile steelhead smolts through Delta survival is likely to be modified due to reduced survival through the interior Delta when the DCC gates are open. Juvenile green sturgeon through Delta survival is likely to be modified due to the DCC gates being opened, but to a lesser extent. Due to the petition's change in DCC gate operation, green sturgeon are not affected. While green sturgeon may be present, they do not migrate through the North Delta until March. No studies have been conducted with acoustically tagged green sturgeon to examine survival effect on green sturgeon, but it is hypothesized that green sturgeon survival may be impacted to a lesser extent than salmonids.

DCC Gate Modified Operation Action

During the fall and early winter when listed salmonids are typically not 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 Delta Cross Channel (DCC) 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. Neither the Knights Landing Catch Index not Sacramento River Catch Index have exceeded any action trigger threshold in WY 2014, so no DCC gate closure were required by the NMFS BiOp until December 1, the first calendar based date for DCC closure. The DCC gates were occasionally closed in October and November 2013 to assist in meeting the Rio Vista flow criterion in D-1641.

Analysis, based on Romine et al (2013), suggest a decrease in survival from operating the DCC gates with different rates of exposure to entrainment into the DCC and Georgiana Slough, due to reductions in reach-specific and total Delta survival (Table 6). Analysis, based on Perry (2010), suggests a relative decrease in survival of 10-16% assuming a 20-40%

exposure to an open DCC in the reach downstream of the DCC gates. Using the average daily Sacramento flow as measured at Freeport for the period of January 11 to January 27 of 2014 (which is the approximate period of time that Sacramento River has been at base flows to date), the estimated percent diversions (or entrainment risk) through the DCC gates, and Perry's flow-survival equation, the estimated relative reduction in the probability of survival in the mainstem Sacramento River downstream of an open DCC would be approximately 10-16% for a 25-40% flow diversion, respectively. This decrease in survival is cumulative in effect to existing exposure to Georgiana Slough and also does not account for additional impacts that are expected to occur from reductions in flow through Steamboat and Sutter sloughs.

Table 6. Reach-Specific and Total Delta Survival Estimates for Different Exposure Rates of Fish to Entrainment Into the DCC. Values Placed on Average Estimates in Table 1.

	Proportion of fish exposed through entrainment to DCC/GS					
	Closed	0.1	0.25	0.5	0.75	Open
S_A	0.177	0.1736	0.1685	0.16	0.1515	0.143
S_B	0.205	0.1945	0.1788	0.1525	0.1263	0.1
S_C	NA	0.0098	0.0245	0.0475	0.0735	0.098
S_D	0.102	0.1077	0.1163	0.1305	0.148	0.159
S_{TOTAL}	0.17	0.1712	0.1598	0.1504	0.1409	0.123

Cumulative Effects of Action

The Petition's action to: 1) Reduce the Delta outflow standard for February from 7100 to a lower outflow range and operate in a combined export rate of 1,500cfs , and 2) Modify operations of the DCC gates as water quality and fisheries conditions warrant, affect juvenile and adult life stages of Winter-run and spring-run Chinook, juvenile steelhead, and juvenile green sturgeon.

The petition's outflow action 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 through migratory corridors in the North Delta. 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 avoids reservoir release operations which increase endangerment to brood year 2014 Winter-run and spring-run Chinook salmon due to potential loss of manager's ability to control temperature that could cause catastrophic mortality to incubating eggs and holding adults during summer 2014. The petition's combined export rate of 1,500 cfs may reduce 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 may increase mortality of juvenile outmigrating and rearing Winter-run and spring-run Chinook and juvenile steelhead dependent on implementation of closure requirements warranted by water quality and fisheries conditions. The petition's DCC gate operations may also cause straying of adult listed salmonids. While specific prescriptions have yet to be developed to achieve each of the classes of listed salmonids, behavioral, operational, and hydrodynamic information is available to identify balanced actions to protect listed species and water quality.

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