LOWER MOKELUMNE RIVER
UPSTREAM FISH MIGRATION MONITORING
Conducted at Woodbridge Irrigation District Dam
August 2012 through March 2013

August 2013

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***Abstract*: This report summarizes data collected below Woodbridge Irrigation District Dam (WIDD) on the lower Mokelumne River (LMR) from August 1, 2012 through March 31, 2013. An estimated 12,091 fall-run Chinook salmon (*Oncorhynchus tschwaytscha*) passed the WIDD fish ladders between October 1, 2012 and January 10, 2013. Fifty percent of the run passed WIDD by November 3, 2012. Ninety percent of the run passed WIDD by November 22, 2012 which reflects a later shift in run timing similar to years prior to 2010. Highest daily passage was 861 fish on October 23, 2012. The sex and life stage was positively determined for 12,089 fish including 4,772 (39%) adult (≥70 cm FL) females, 3,478 (29%) adult males, 590 (5%) grilse (<70 cm FL) females, and 3,249 (27%) grilse males. Management actions, such as pulse flows, were followed by peaks in daily passage and contributed to high overall returns. Seventy-three adult steelhead (*O. mykiss*) passed WIDD between August 2012 and March 2013. Peak steelhead passage occurred in October (n=21). Other species using the WIDD fish ladder included: Pacific lamprey, *Lampetra tridentata*; Sacramento pikeminnow, *Ptychocheilus grandis*; Sacramento sucker, *Catostomus occidentalis;* black bass, *Micropterus sp.*; and an unidentified centrarchid.**

INTRODUCTION

East Bay Municipal Utility District (EBMUD) has been monitoring adult fall-run Chinook salmon, *Oncorhynchus tshawytscha*, escapement in the lower Mokelumne River (LMR) using video monitoring and trapping at the Woodbridge Irrigation District Dam (WIDD) at river kilometer (Rkm) 64 since fall 1990. In 1997, Woodbridge Irrigation District initiated a rebuild of the dam, fish ladders, and fish screening facilities on the LMR. Carcass surveys and video monitoring were conducted simultaneously in the fall of 2003 in order to determine the accuracy and precision of estimates generated by carcass survey versus video monitoring and trapping at WIDD (Workman 2004). During the fall of 2004, carcass surveys and video monitoring were again both completed successfully in order to estimate Chinook salmon escapement. Between 2005 and 2007, the LMR fall-run Chinook salmon escapement was estimated by conducting carcass surveys for in-river escapement and adding the salmon trapped at the Mokelumne River Fish Hatchery (MRFH) for a total Mokelumne River fall-run Chinook salmon escapement. Due to low

returns of Chinook salmon during 2008 and 2009, salmon per redd estimates were multiplied by the salmon redd counts to estimate in-river escapement. Beginning in 2010, through coordination between EBMUD and Woodbridge Irrigation District, Lodi Lake remained full of water throughout the Chinook salmon run which facilitated continuous video monitoring of Chinook salmon passage in the high stage ladder at WIDD. WIDD management remained the same during the upstream migration of fall-run Chinook salmon in 2010/2011, 2011/2012, and 2012/2013; therefore, total Mokelumne River fall-run Chinook salmon escapement during these years were based on video monitoring of fish passage at WIDD.

OBJECTIVES

The objectives of this study are to 1) develop an escapement estimate for fall-run Chinook salmon for the LMR, 2) summarize sex and age composition, run timing, and coded wire tag component of the 2012 fall-run Chinook salmon population on the LMR, 3) describe the relationship of fall-run Chinook salmon movements to environmental conditions and management actions on the LMR and in the Sacramento-San Joaquin Delta, and 4) monitor presence of native and non-native fishes in the WIDD high stage fish ladder.

METHODS

Video

EBMUD's monitoring of fall-run Chinook salmon migration began on August 1, 2012 with video monitoring in the high stage ladder at WIDD. On February 1, 2013, Woodbridge Irrigation District began lowering the dam and routing water through the low stage ladder discontinuing video monitoring operations. Monitoring in the high stage was resumed on February 24, 2013, when the bladder dams of Woodbridge Irrigation District were installed, and continued through March 31, 2013.

All other monitoring, data collection, and storage methods for video monitoring were consistent with prior year's monitoring efforts (Marine and Vogel 2000, Workman 2004).

RESULTS AND DISCUSSION

Native Anadromous Fish

Chinook Salmon (video)

The fall-run Chinook salmon escapement estimate in the LMR for 2012/2013 is 12,091 spawners entering the river between October 2012 and January 2013 (Figure 1). Fifty percent of the run passed WIDD by November 3rd (Table 1). Highest daily passage of 861 fish occurred on October 23, 2012. The sex and life stage was positively determined for 12,089 fish including 4,772 (39%) adult (≥70 cm FL) females, 3,478 (29%) adult males, 590 (5%) grilse (<70 cm FL) females, and 3,249 (27%) grilse males (Figure 2). In addition, there were 1 unknown sex grilse and 1 unknown sex adult.

Table 1. Dates when 10%, 50%, and 90% of fall-run Chinook salmon passed the Woodbridge Irrigation District Dam, 1990-2004; 2010-2012.

Year	10%	50%	90%
1990	Oct. 23	Nov. 18	Dec. 12
1991	n/a	n/a	n/a
1992	Oct. 28	Nov. 13	Dec. 2
1993	Oct. 22	Nov. 3	Nov. 21
1994	Oct. 21	Nov. 7	Dec. 2
1995	Sept. 28	Oct. 30	Nov. 23
1996	Oct. 18	Oct. 31	Nov. 20
1997	Oct. 15	Nov. 8	Nov. 22
1998	Oct. 11	Nov. 4	Nov. 24
1999	Oct. 16	Nov. 3	Nov. 20
2000	Oct. 12	Oct. 30	Nov. 16
2001	Oct. 29	Nov. 11	Nov. 25
2002	Oct. 24	Nov. 7	Nov. 24
2003	Sep. 4	Nov. 13	Dec. 4
2004	Oct. 23	Nov. 12	Nov. 29
2010	Oct. 9	Oct. 24	Nov. 24
2011	Oct. 9	Oct. 24	Nov. 13
2012	Oct. 17	Nov. 3	Nov. 22

From 1990 to 2003 and 2010, approximately a 1:3 grilse to adult ratio was observed on the LMR. In 2004, the grilse ratio was considerably higher with a ratio of closer to 1:2 grilse to adult. Conversely, the grilse to adult ratio in 2011 was reversed from previous trends with an approximate ratio of 1:3 adults to grilse. In 2012, approximately a 1:2 grilse to adult ratio was observed (32% GR; 68% AD) (Figure 3).

In the 2012/2013 monitoring season, 68% of fish passing the video monitor occurred during the day and 32% during the night. Day is defined as ½ hour before sunrise to ½ hour after sunset. Daytime passage has been consistently higher than nighttime passage (Table 2). Data show an early morning peak, between 0800hrs to 1000hrs (Figure 4).

Table 2. Percent of annual fall-run Chinook salmon passing WIDD during day and night, 1990-2004; 2010-2012.

Year	*1990*	*1991*	*1992*	*1993*	*1994*	*1995*	*1996*	*1997*	*1998*	*1999*	*2000*	*2001*	*2002*	*2003*	*2004*	*2010*	*2011*	*2012*
Day	57	64	69	59	61	68	52	56	56	62	68	58	55	73	79	87	82	68
Night	43	36	31	41	39	32	48	44	44	38	32	42	45	27	21	13	18	32

Clipped adipose fins were evident on 8,808 (73%) of the observed fall-run Chinook salmon (Table 3). The sex and life stage were positively determined for 8,807 adipose fin clipped fish including 4,487 (51%) adult (≥70 cm FL) females, 3,168 (36%) adult males, 288 (3%) grilse (<70 cm FL) females and 864 (10%) grilse males. Ninety-four percent of the returning adult females were adipose fin clipped, 91% of the adult males were adipose fin clipped, 49% of the grilse females were adipose fin clipped, and 27% of the grilse males were adipose fin clipped. The elevated percentage of adipose clipped Chinook salmon was due to increased

rates of coded wire tagging of returning broodyears. In 2008 and 2009, 100% of hatchery reared Chinook salmon at the Mokelumne River Fish Hatchery were coded wire tagged and adclipped. In 2010, approximately 25% of hatchery reared Chinook salmon at the Mokelumne River Fish Hatchery were coded wire tagged and adclipped.

Table 3. Incidence of adipose fin clips on fall-run Chinook salmon passing Woodbridge Irrigation District Dam, 1992-2004; 2010-2012.

Year	Number	Percent
Adults		
1992	10	1.4
1993	11	0.9
1994	244	10.3
1995	161	7.8
1996	169	9.2
1997/98	152	2.9
1998/99	427	7.4
1999/2000	327	10.8
2000/2001	225	4.0
2001/2002	326	8.5
2002/2003	1,228	14.4
2003/2004	996	13.4
2004/2005	614	9.7
2010/2011	1,978	38.3
2011/2012	3,508	80.1
2012/2013	7,656	92.8
Grilse		
1992	35	3.8
1993	8	1.7
1994	22	4
1995	55	15.2
1996	47	3.5
1997/98	7	1.7
1998/99	175	12
1999/2000	139	6.1
2000/2001	83	8
2001/2002	188	18.6
2002/2003	363	16.2
2003/2004	319	12.7
2004/2005	129	3.7
2010/2011	1,708	84.1
2011/2012	13,449	94.6
2012/2013	1,152	30.0

During the 2012/2013 Chinook salmon migration period, Camanche Dam releases ranged from 255 – 924 cfs (Figure 5). Average flow was 361 cfs. Flow below WIDD ranged from 32 – 757 cfs and averaged 176 cfs (Figure 6). Water temperatures from the August through January monitoring period ranged from 9.2 – 15.5 C° at below Camanche Dam (Figure 7) and 7.3 – 22.9 C° at WIDD (Figure 8). Total rainfall, collected at the California Irrigation Management Information System's Lodi West station #166, was 10.75 inches (Figure 9). Peak daily rainfall was 1.9 inches. Turbidity in the LMR increases with rainfall, but was not recorded through the migration period.

River flow, temperature, and rainfall have been investigated for their relationship to salmon returns. Regression analyses comparing these factors to the number of fish on the ascending portion of the curve were run for the 2012/2013 escapement (Table 4). Due to the variability in the response of fish passage at WIDD to management actions and environmental variability, the relationship between flow, temperature, and fish counts do not signify a strong correlation even though they are significantly correlated.

Table 4. Relationship of environmental variables measured to the number of Chinook salmon passing Woodbridge Irrigation District Dam.

	Range	R^2	*P* value
Flow below Woodbridge (cfs)	105 – 381	0.22	0.0048
Temperature below Woodbridge (C°)	14.6 – 19.2	0.59	0.0008
Precipitation (in)	0 – 0.56	0.04	0.2807

Based on the Joint Settlement Agreement Dry water year type, expected flow below WIDD through September 30, 2012 was around 35 cfs. October 1st marked the beginning of a new 6 month period with LMR flows determined by total Pardee and Camanche storage. Expected flow below WIDD was increased to a minimum of 100 cfs based on the new Below Normal Year flow schedule. Flow began to increase below WIDD on September 30th with the 1st Chinook salmon observed passing WIDD at 12:38 am on October 1st.

Similar to last year, scheduled pulse/attraction flows were conducted in October and November. Last year, daily average pulse flows ranged from 1,372 cfs to 1,594 cfs below WIDD. This year, pulse flow peaks below WIDD ranged from 235 cfs to 397 cfs. Nevertheless, peaks in passage corresponded with the 5 planned pulse flows (Figure 6). The highest daily passage was observed on the same day as the 3rd pulse flow which peaked at 322 cfs. This pulse flow event also corresponded with a three day rain event from October 21st-23rd. The rainfall total for this storm equaled 0.67 inches. The 4th pulse flow peaked on October 30th at 235 cfs with a peak in passage observed 2 days later on November 1st. This peak in passage also occurred during a three day rain event from October 31st through November 2nd. This rain event was smaller with a rainfall total 0.32 inches. The 5th pulse flow peaked on November 6th at 289 cfs with an increase in passage observed that same day. However, the associated peak in passage came on November 9th. An additional peak in passage occurred on November 18th. This spike in passage may be associated with a rain event and minor bump in flow below WIDD. The increase in flow was not associated with a planned pulse, rather could be in responses to a 3 day rain event (0.75 inches), WIDD management (although there was a small increase in flow below

CAM), and/or water pumped back into the river from drainage basins managed by the City of Lodi.

One last spike in fish passage observed at WIDD was most likely in response to management actions unrelated to fall-run Chinook salmon. The DCC was closed on November 27th as the Knights Landing Catch Index for salmon exceeded the trigger threshold for DCC closure. Between the November 28th and December 2nd, Lodi received over 4 inches of rain which culminated in a large release of water due to operational requirements. These events drew-up an additional 523 Chinook salmon into the LMR between November 29th and December 2nd.

Steelhead

Steelhead have been observed since monitoring began in 1990 (Table 5). In all years prior to 1997, adult monitoring ended in December. Spawning, however, typically occurs between January and March for winter steelhead in the Central Valley (IEP Steelhead PWT 1999).

Table 5. Steelhead observed moving upstream during video monitoring at Woodbridge Irrigation District Dam, 1990-2004; 2010-2012.

Monitoring Period	*Number*	*Monitoring Period*	*Number*
Oct. - Dec. 1990	4	Aug. 1999 – Mar. 2000	80
Oct. - Dec. 1991	n/a	Aug. 2000 – Apr. 2001	48
Oct. - Dec. 1992	7	Aug. 2001 – July 2002	91
Oct. - Dec. 1993	8	Aug. 2002 – July 2003	62
Oct. - Dec. 1994	19	Aug. 2003 – July 2004	39
Sept. - Dec. 1995	76	Aug. 2004 – Apr. 2005	44
Sept. - Dec. 1996	12	Aug. 2010 – July 2011	98
Sept. 1997 – Feb. 1998	6	Aug. 2011 – July 2012	254*
Aug. 1998 – Mar. 1999	12	Aug. 2012 – March 2013	73

* Count may include hatchery-origin steelhead released during the monitoring period at the Feist Ranch and/or New Hope.

Seventy-three adult steelhead (≥380 mm FL) were observed moving upstream through WIDD from September 26, 2012 through March 31, 2013. The highest monthly abundance of steelhead was in October (n=21). No video monitoring occurred between February 2nd and February 23rd as fish passage at WIDD was diverted to the low stage ladder. Of the 73 fish observed, 17 were males, 23 were females, and 33 were not distinguishable to sex. Ninety-six percent (n=70) were adipose fin clipped (Table 6).

Table 6. Monthly sex composition and adipose fin clip totals of steelhead passing Woodbridge Irrigation District Dam, August 1, 2012 – March 31, 2013.

Monitoring Period	*Male Count*	*Female Count*	*Unknown Sex Count*	*Total Count*	*Adclip Total*
August	-	-	-	-	-
September	-	1	-	1	1
October	1	10	10	21	18
November	3	5	5	13	13
December	6	3	11	20	20
January	5	2	5	12	12
February	-	1	-	1	1
March	2	1	2	5	5
Totals	17	23	33	73	70

Yearling steelhead (FL <200mm) and subadult steelhead (FL ≤350mm) were not counted due to their ability to pass through the bars which guide fish in front of the video monitoring vault and their tendency to hold within the high stage ladder.

Incidental Species

Prior to the fall of 1996, adult Pacific lamprey observations at WIDD were not recorded. Numbers of adult lamprey observed during video monitoring on the LMR have been sporadic since recording began in 1996, from a high of 979 in fall 1999, to one recorded passing upstream during video monitoring in 2000/2001. The years 1996 and 1999 are the only years we saw more than 100 adult lamprey ascending the ladders at Woodbridge (Table 7). Pacific lamprey are in decline in the Columbia and Snake River Basins and the same may be true in the Central Valley (Close et al 1995; Brown and Moyle 1993). This season, lamprey were not counted due to there ability to fit through the bars within the high stage ladder bypassing our video monitoring equipment, but observations were recorded (Table 8).

Table 7. Adult Pacific lamprey observed moving upstream during video monitoring at Woodbridge Irrigation District Dam, 1996-2004.

Year	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul
1996	n/a	123	13	0	0	n/a	n/a	n/a	n/a	n/a	n/a	n/a
1997	n/a	12	7	n/a	1	n/a	n/a	n/a	n/a	n/a	n/a	n/a
1998	14	0	0	0	0	0	0	0	n/a	n/a	n/a	n/a
1999	323	606	50	0	0	0	0	0	n/a	n/a	n/a	n/a
2000	1	0	0	0	0	0	0	0	-1	n/a	n/a	n/a
2001	0	0	0	0	0	0	0	0	0	0	1	2
2002	0	0	0	0	1	0	1	1	0	2	0	8
2003	16	4	0	0	1	0	0	0	0	3	11	3
2004	2	0	0	0	0	0	0	0	1	n/a	n/a	0

Presence and absence data of native and non-native species is presented in Table 8. Native resident fishes observed using the ladder include Sacramento pikeminnow and

Sacramento sucker. Non-native fish using the fish ladders at WID include black bass and an unidentified centrarchid (Table 8).

Table 8. Native and non-native fish observed in the Woodbridge Irrigation District Dam fish ladder, August 1, 2012-March 31, 2013. Species names in bold represent native species.

	Pacific Lamprey	**Sacramento Pikeminnow**	**Sacramento Sucker**	Black Bass	Unidentified Centrarchid
August		X			
September		X			X
October		X	X		
November					
December	X	X	X	X	
January					
February					
March	X	X	X		

Acknowledgements

We would like to thank the field crew of Jason Shillam, Ed Rible, and Charles Hunter for their hard work and dedication to accurate data collection, data storage, and data retrieval. Thanks to Woodbridge Irrigation District for fish ladder maintenance and access to the site. We would also like to thank EBMUD Fisheries and Wildlife Division staff for assistance on the project as needed.

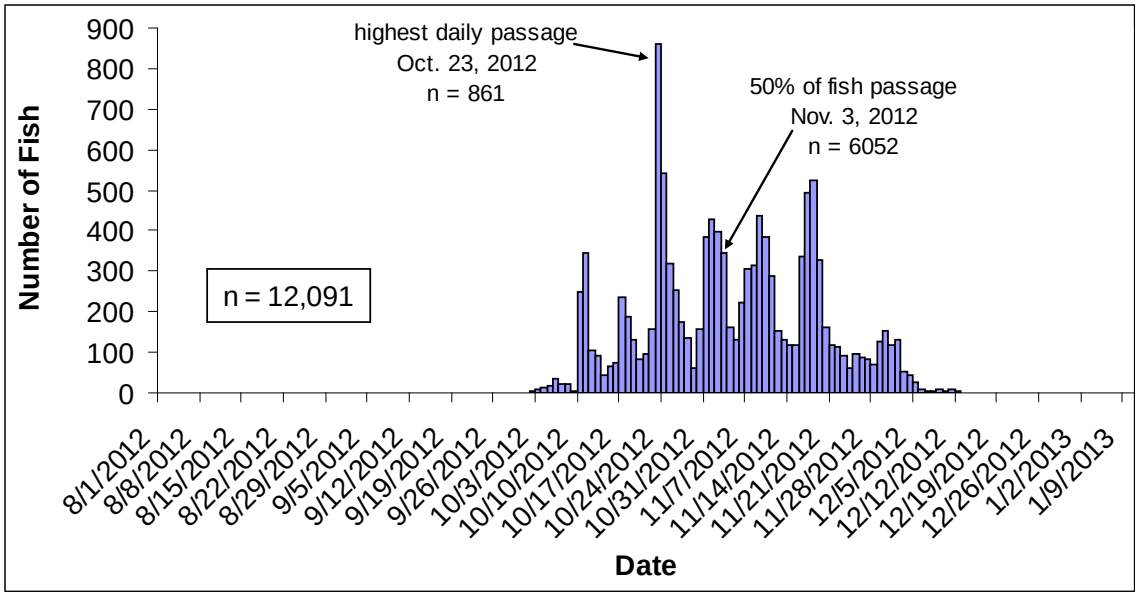

Figure 1. Daily abundance and timing of fall-run Chinook salmon migrating past WIDD, August 1, 2012 - February 1, 2013.

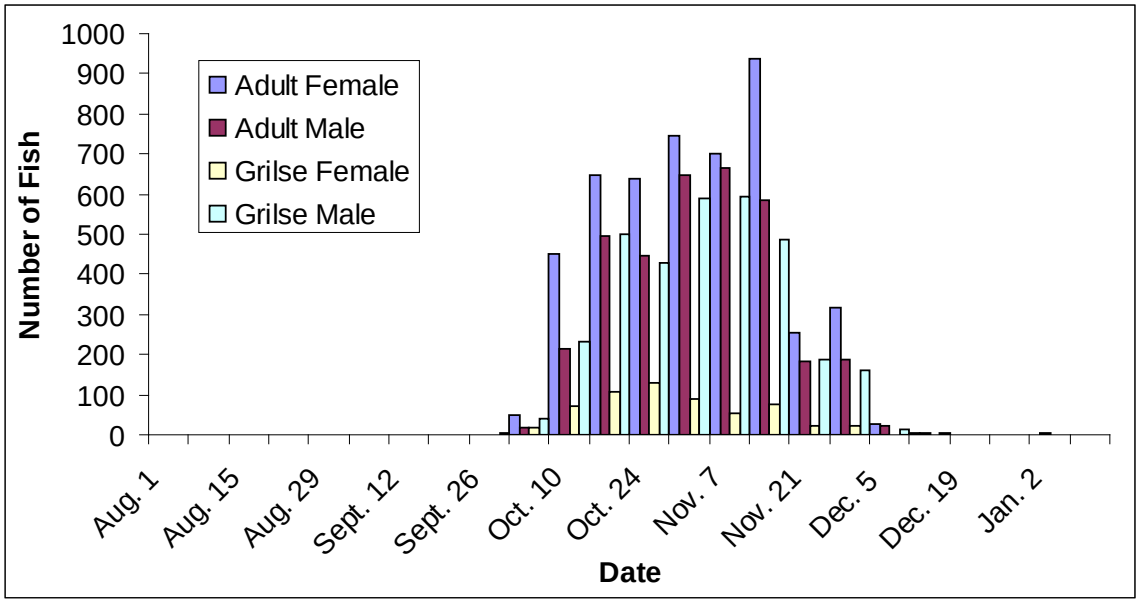

Figure 2. Weekly sex/age composition of fall-run Chinook salmon passing WIDD, August 1, 2012 – February 1, 2013.

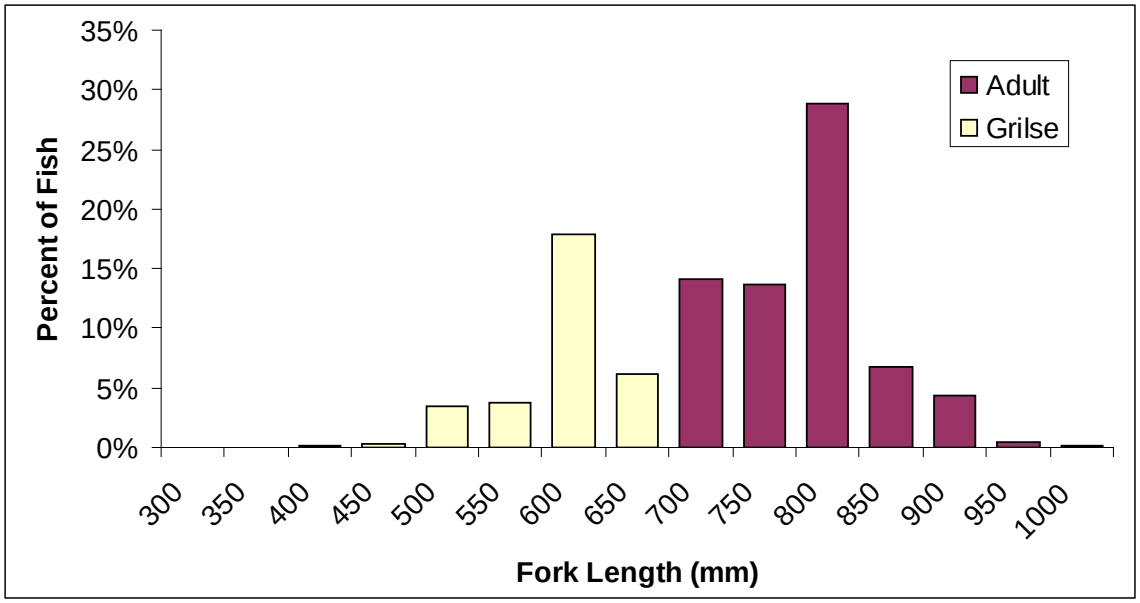

Figure 3. Length frequency of adult and grilse Chinook salmon (% by size class) passing WIDD, August 1, 2012 – February 1, 2013.

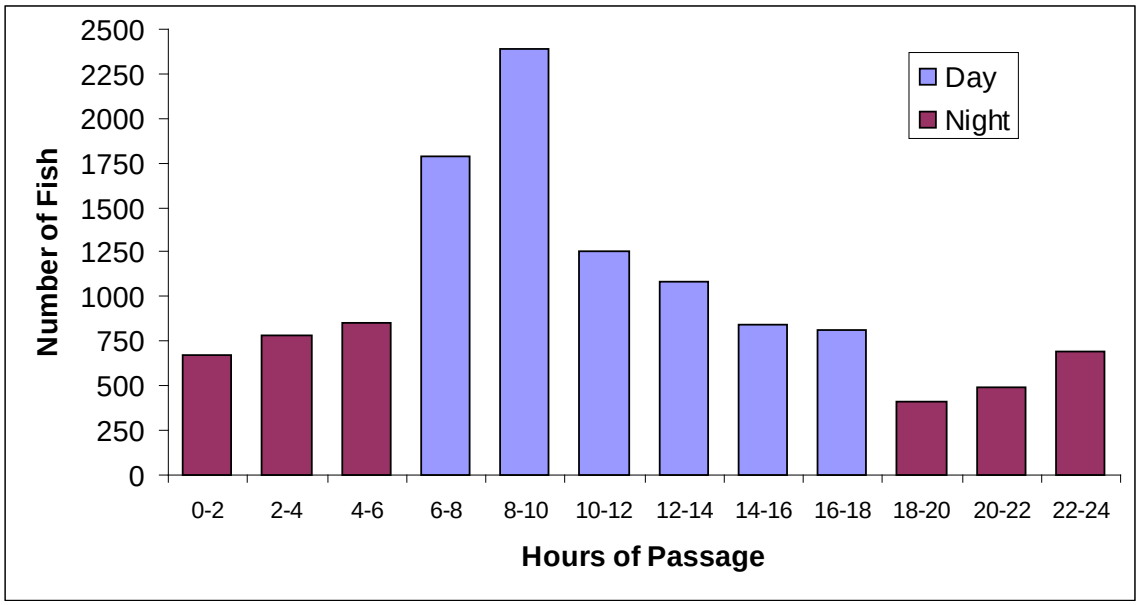

Figure 4. Chinook salmon passage (2 hour intervals) recorded from video monitoring at WIDD, August 1, 2012 - February 1, 2013.

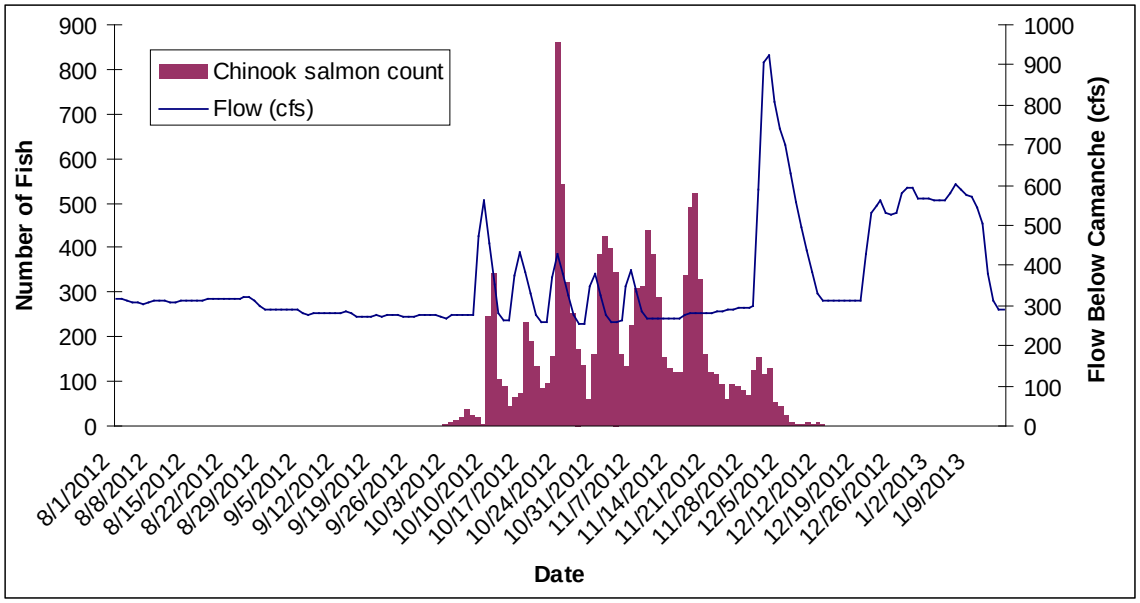

Figure 5. Daily abundance and timing of fall-run Chinook salmon migrating past WIDD compared to flow below Camanche Reservoir, August 1, 2012 - January 15, 2013.

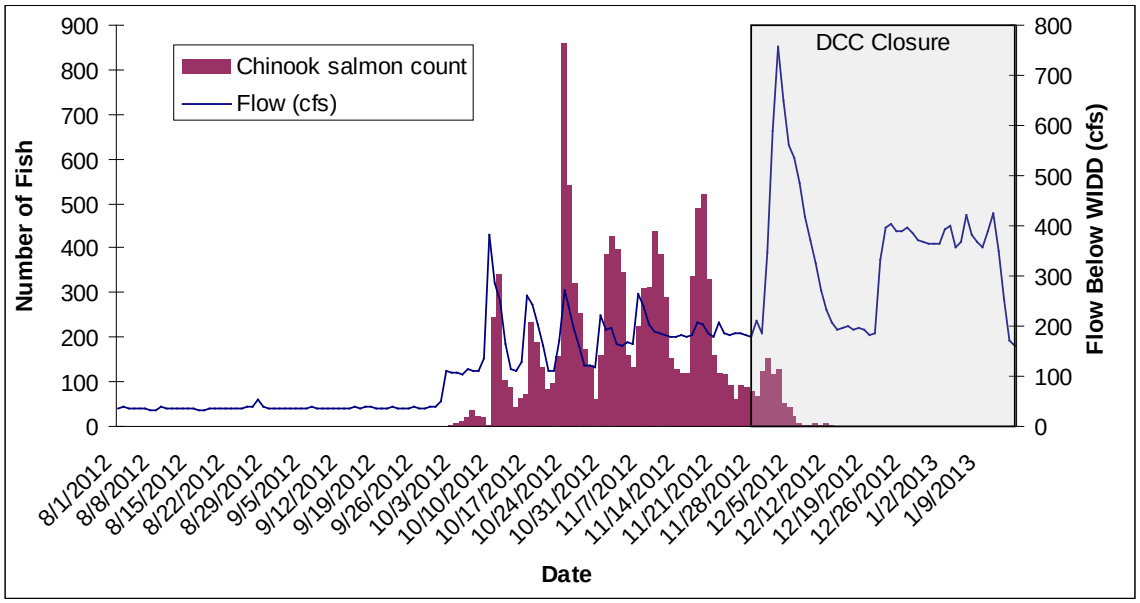

Figure 6. Daily abundance and timing of fall-run Chinook salmon migrating past WIDD compared to flow below WIDD and the DCC closure, August 1, 2012 – January 15, 2013.

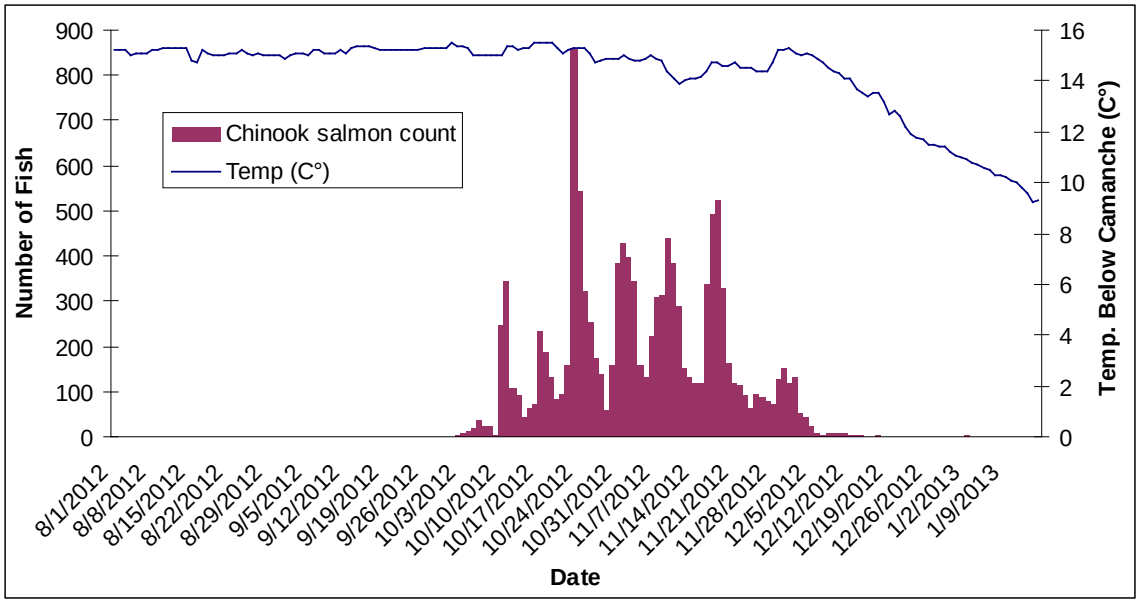

Figure 7. Daily abundance and timing of fall-run Chinook salmon migrating past WIDD compared to temperature below Camanche Reservoir, August 1, 2012 - January 15, 2013.

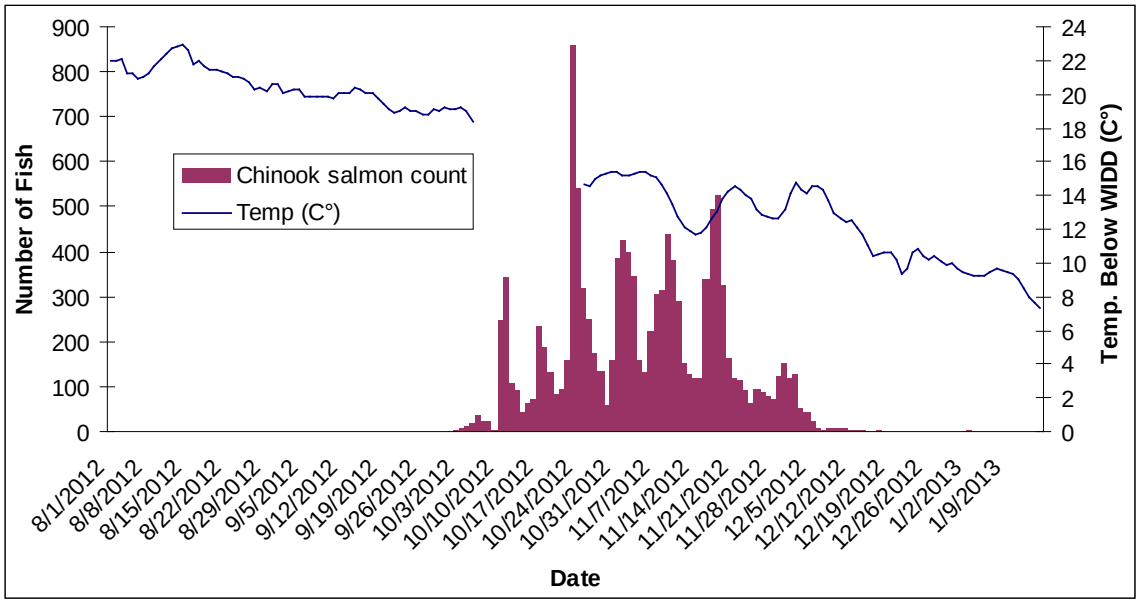

Figure 8. Daily abundance and timing of fall-run Chinook salmon migrating past WIDD compared to temperature below WIDD, August 1, 2012 - January 15, 2013.

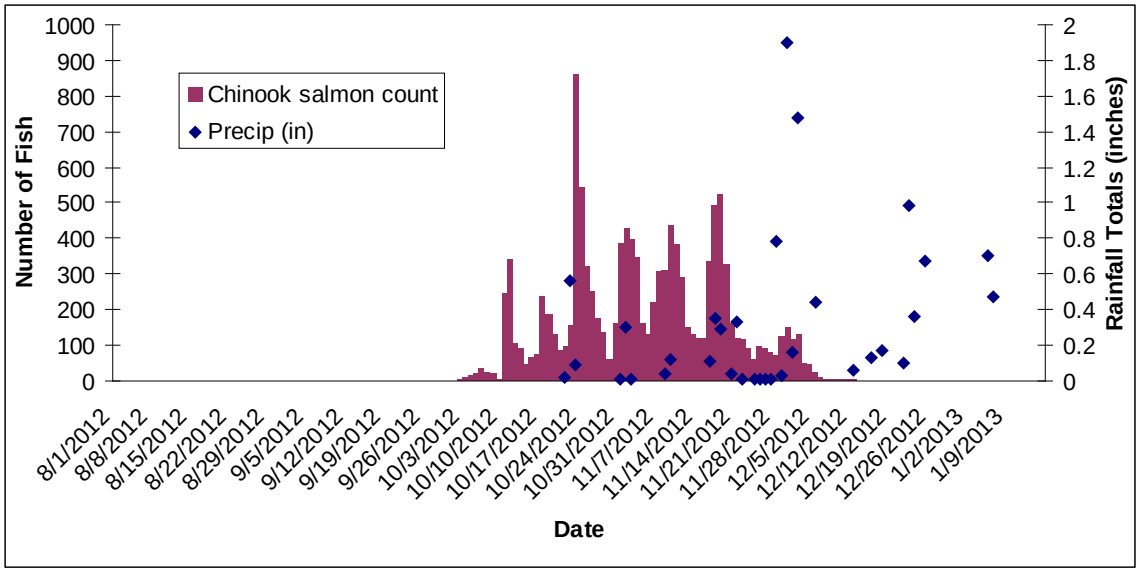

Figure 9. Daily abundance and timing of fall-run Chinook salmon migrating past WIDD compared to Lodi rainfall, August 1, 2012 - January 15, 2013.

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