LOWER MOKELUMNE RIVER
UPSTREAM FISH MIGRATION MONITORING
Conducted at Woodbridge Irrigation District Dam
August 2011 through July 2012

August 2012

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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, 2011 through July 31, 2012. An estimated 18,596 fall-run Chinook salmon (*Oncorhynchus tschwaytscha*) passed the WIDD fish ladders between August 1, 2011 and January 21, 2012. Fifty percent of the run passed WIDD by October 24, 2011, the same day as the previous year. Ninety percent of the run passed WIDD by November 13, 2011 which marks an earlier shift in run timing most likely in response to management actions. Highest daily passage was 955 fish on October 17, 2011. The sex and life stage was positively determined for 18,567 fish including 2,251 (12%) adult (≥70 cm FL) females, 2,127 (12%) adult males, 3,365 (18%) grilse (<70 cm FL) females and 10,824 (58%) grilse males. River flow, combined with management actions such as pulse flows and the closure of the Delta Cross Channel for 10 days between Oct. 4th and Oct. 14th, were followed by peaks in daily passage and contributed to high overall returns. Two-hundred and fifty four adult steelhead (*O. mykiss*) passed WIDD between August 2011 and July 2012. However, this high number may be inflated by the inclusion of Age 1+ hatchery-origin steelhead released at the Feist Ranch and New Hope Landing that moved upstream following release. Peak steelhead passage occurred in October (n=138). Other species using the WIDD fish ladder included: black bass, *Micropterus sp.*; largemouth bass, *Micropterus salmoides*; common carp, *Cyprinus carpio*; striped bass, *Morone saxatilis*; Pacific lamprey, *Lampetra tridentata*; Sacramento pikeminnow, *Ptychocheilus grandis*; Sacramento Blackfish, *Orthodon microlepidotus*; and Sacramento sucker, *Catostomus occidentalis*.**

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 and 2011/2012; 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 2011 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 fish ladders.

METHODS

Video

EBMUD's monitoring of fall-run Chinook salmon migration began on August 1, 2011 with video monitoring in the high stage ladder at WIDD. On February 1, 2012, 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 March 1, 2012, when the bladder dams of Woodbridge Irrigation District were installed, and continued through July 31, 2012.

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 2011/2012 is 18,596 spawners entering the river between August 2011 and January 2012 (Figure 1). Fifty percent of the run passed WIDD by October 24th (Table 1). Highest daily passage of 955 fish

occurred on October 17, 2011. The sex and life stage was positively determined for 18,567 fish including 2,251 (12%) adult (≥70 cm FL) females, 2,127 (12%) adult males, 3,365 (18%) grilse (<70 cm FL) females and 10,824 (58%) grilse males (Figure 2). In addition, there were 28 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; 2010-2011.

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

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 significantly higher with a ratio of closer to 1:2 grilse to adult (Figure 3). Conversely, the grilse to adult ratio in 2011 was reversed from previous trends with an approximate ration of 1:3 adults to grilse (24% adults; 76% grilse).

In the 2011/2012 monitoring season, 82% of fish passing the video monitor occurred during the day and 18% 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; 2010-2011.

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

Clipped adipose fins were evident on 16,957 (91%) of the observed fall-run Chinook salmon (Table 3). The sex and life stage were positively determined for 16,931 adipose fin clipped fish including 1,776 (11%) adult (≥70 cm FL) females, 1,731 (10%) adult males, 3,201 (19%) grilse (<70 cm FL) females and 10,223 (60%) grilse males. Seventy-nine percent of

the returning adult females were adipose fin clipped, 81% of the adult males were adipose fin clipped, 95% of the grilse females were adipose fin clipped, and 94% of the grilse males were adipose fin clipped. The percentage of adipose clipped Chinook salmon was the highest recorded during video monitoring due to increased rates of coded wire tagging of returning broodyears. In 2006 and 2007, approximately 25% of hatchery reared Chinook salmon at the Mokelumne River Fish Hatchery were coded wire tagged and adclipped. In 2008 and 2009, 100% 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; 2010-2011.

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
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

During the 2011/2012 Chinook salmon migration period, Camanche Dam releases ranged from 326 – 1808 cfs (Figure 5). Average flow was 715 cfs. Flow below WIDD ranged from 173 – 1594 cfs and averaged 579 cfs (Figure 6). Water temperatures from the August through February monitoring period ranged from 9.4 – 16.8 C° at Camanche Dam (Figure 7) and 7.8 – 19.4 C° at WIDD (Figure 8). Total rainfall, collected at the California Irrigation Management Information System's Lodi West station #166, was 2.87 inches (Figure 9). Peak daily rainfall was 0.81 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 2011/2012 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)	173 – 1594	0.28	<.0001
Temperature below Woodbridge (C°)	15.6 – 19.4	0.37	<.0001
Precipitation (in)	0 – 0.17	0.002	0.6982

Management actions, including pulse flows and the closure of the Delta Cross Channel (DCC) for 10 days from Oct. 4th through Oct. 14th, were associated with peaks in daily passage (thru Nov. 2nd) and contributed to high overall returns (Figure 6). Peaks in passage were associated with 4 pulse flows and the closure of the DCC. The first pulse flow peaked at 1594 cfs below WIDD between Oct. 8th and Oct. 10th and occurred during the DCC closure. A spike in passage (681 salmon) was observed during the pulse peak on Oct. 10th. The second pulse flow peaked at 1388 cfs below WIDD on Oct. 17th. A spike in passage (955 salmon) was observed on the same day as the pulse peak on Oct. 17th. The third pulse flow of 1372 cfs below WIDD peaked on Oct. 24th. A spike in passage (939 salmon) was observed the day after the pulse peak on Oct. 25th. The forth pulse flow of 1430 cfs below WIDD occurred on Nov. 1st. A spike in passage (913 salmon) was observed the day after the pulse peak on Nov. 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; 2010-2011.

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		

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

Two hundred and fifty four adult steelhead (≥380 mm FL) were observed moving upstream through WIDD from August 6, 2011 through March 21, 2012. However, this high number may be inflated by the inclusion of Age 1+ hatchery-origin steelhead released at the Feist Ranch and New Hope Land that moved upstream following release. On September 28, 2011, 83,619 Age 1+ steelhead were release at the Feist Ranch, downstream of WIDD. Between January 19 – 25, 2012, 211,497 yearlings were released at New Hope Landing. Spikes in passage were observed following these releases. Subsequently, the highest monthly abundance of steelhead was in October (n=138) and ninety-six percent (n=245) of all steelhead observed passing WIDD were adipose fin clipped. Of the Age 1+ steelhead released at Feist, 485 were marked with a Visible Implant Alpha (VIA) tag. Seven percent of the VIA tagged fish were trapped at the MRFH between October 4, 2011 and January 23, 2012, confirming upstream movement of some released steelhead. No video monitoring occurred in February as fish passage at WIDD was diverted to the low stage ladder. Of the 254 fish observed, 43 were males, 32 were females, and 179 were not distinguishable to sex (Table 6).

Table 6. Monthly sex composition and adipose fin clip totals of steelhead passing Woodbridge Irrigation District Dam, August 1, 2011 – July 31, 2012.

Monitoring Period (2011-2012)	*Male Count*	*Female Count*	*Unknown Sex Count*	*Total Count*	*Adclip Total*
August	1	2	3	6	5
September	7	2	27	36	35
October	18	13	107	138	135
November	2	5	21	28	28
December	3	5	5	13	12
January	7	4	13	24	24
February	n/a	n/a	n/a	n/a	n/a
March	5	1	3	9	6
April	-	-	-	-	-
May	-	-	-	-	-
June	-	-	-	-	-
July	-	-		-	-
Totals	43	32	179	254	245

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 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 fishes observed using the ladder include Pacific lamprey, Sacramento pikeminnow, Sacramento sucker, and Sacramento blackfish. Non-native fish using the fish ladders at WIDD include common carp, black bass, striped bass, and largemouth bass (Table 8).

Table 8. Native and non-native fish observed in the Woodbridge Irrigation District Dam fish ladder, August 01, 2011-July 31, 2012. Species names in bold represent native species.

	Pacific Lamprey	**Sacramento Pikeminnow**	**Sacramento Sucker**	**Sacramento Blackfish**	Common Carp	Black Bass	Striped Bass	Largemouth Bass
August	X	X	X		X	X	X	
September		X	X				X	
October		X	X	X				
November	X		X					
December								
January								
February								
March	X	X	X					
April	X	X	X					
May	X	X	X					X
June		X	X					
July		X	X					

Acknowledgements

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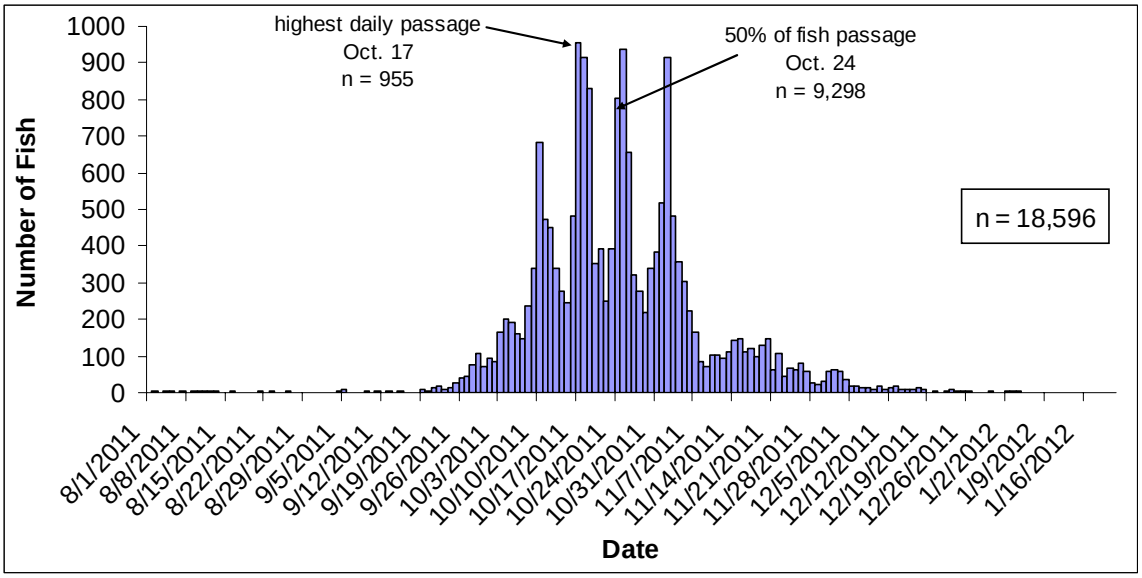

Figure 1. Daily abundance and timing of fall-run Chinook salmon migrating past WIDD, August 1, 2011 - February 1, 2012.

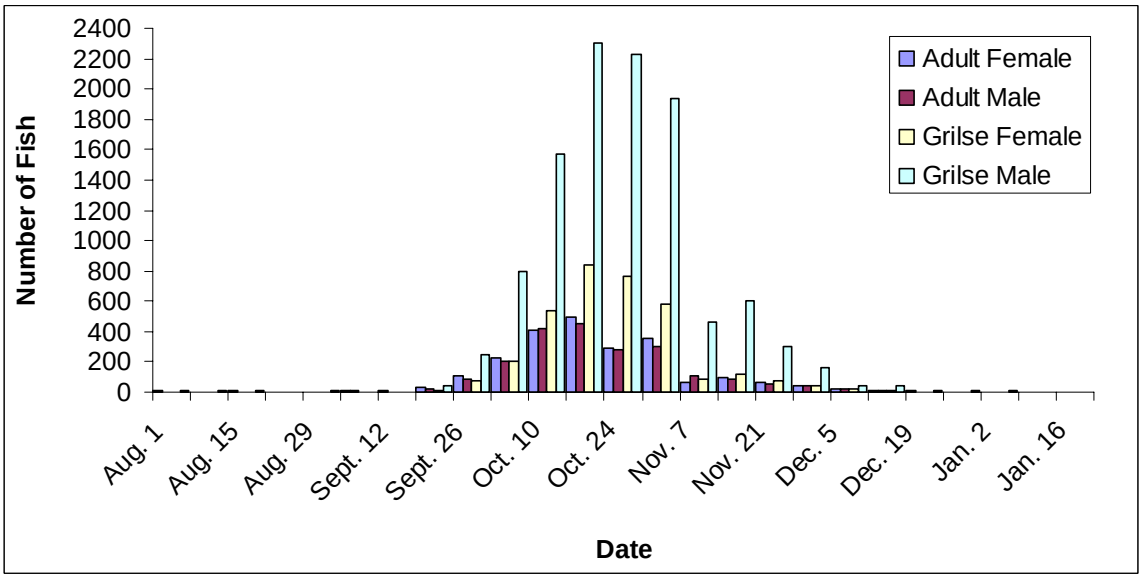

Figure 2. Weekly sex/age composition of fall-run Chinook salmon passing WIDD, August 1, 2011 – February 1, 2012.

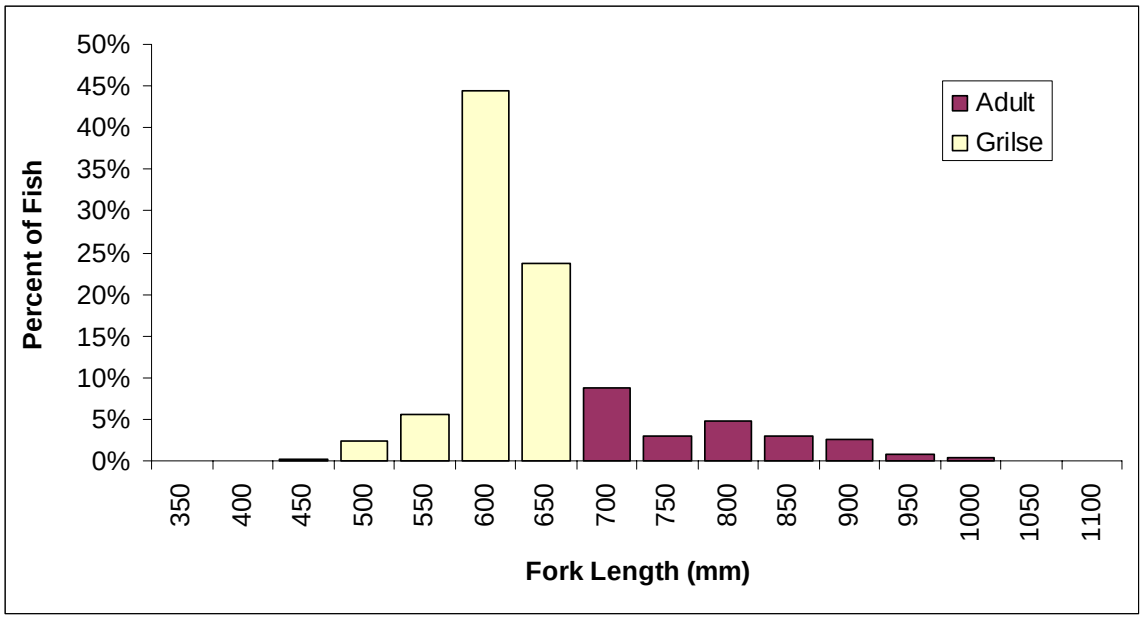

Figure 3. Length frequency of adult and grilse Chinook salmon (% by size class) passing WIDD, August 1, 2011 – February 1, 2012.

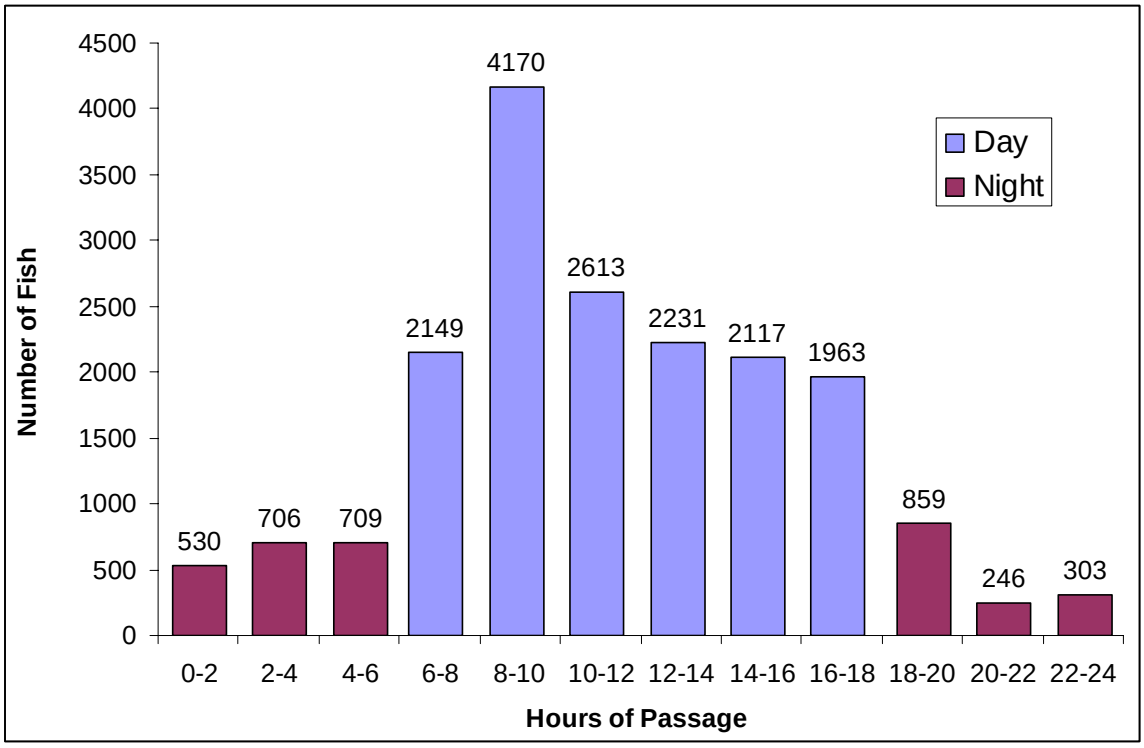

Figure 4. Chinook salmon passage (2 hour intervals) recorded from video monitoring at WIDD, August 1, 2011 - February 1, 2012.

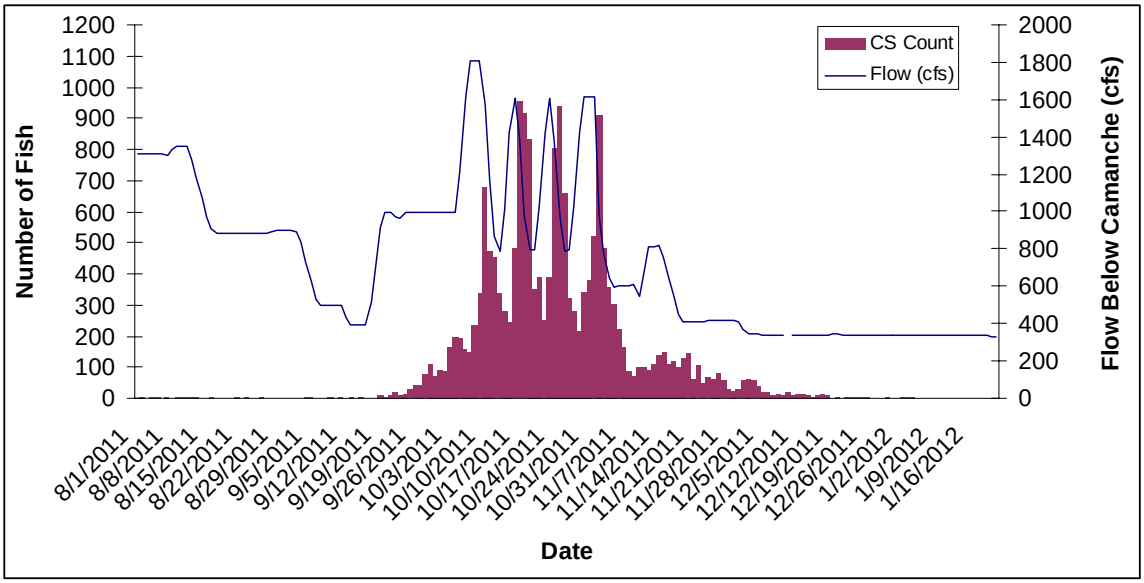

Figure 5. Daily abundance and timing of fall-run Chinook salmon migrating past WIDD compared to flow below Camanche Reservoir, August 1, 2011 - January 21, 2012.

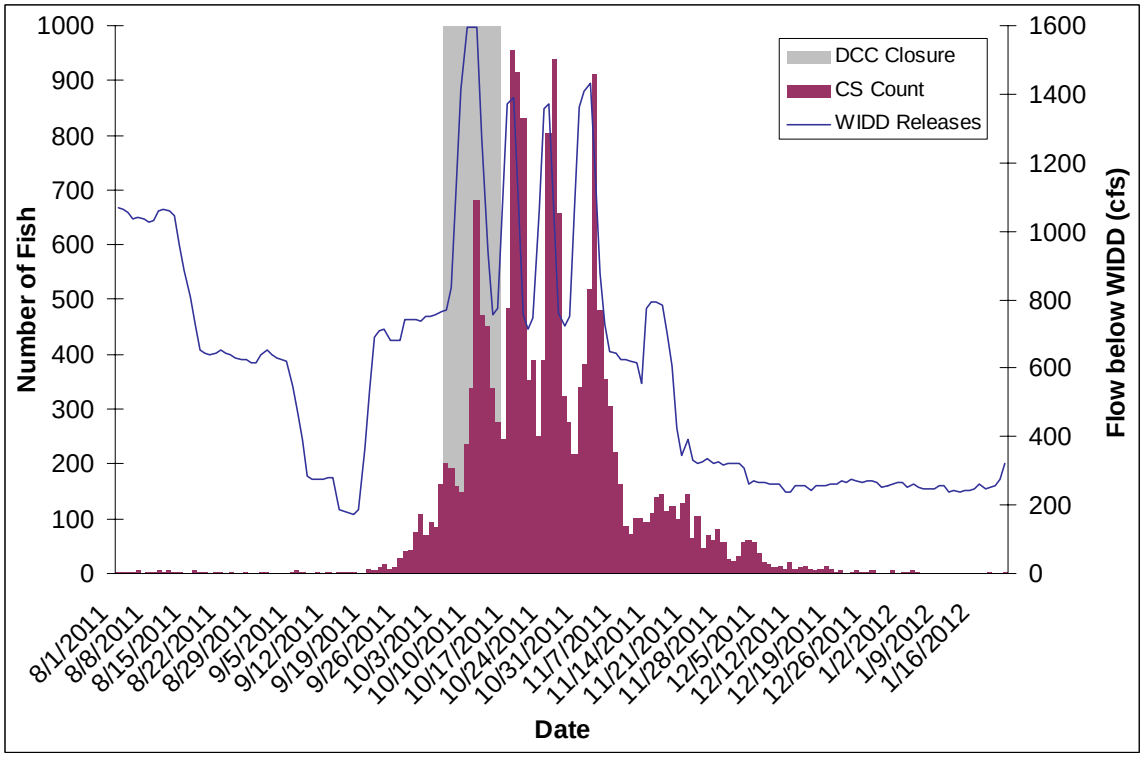

Figure 6. Daily abundance and timing of fall-run Chinook salmon migrating past WIDD compared to flow below WIDD and the DCC closure, August 1, 2011 – January 21, 2012.

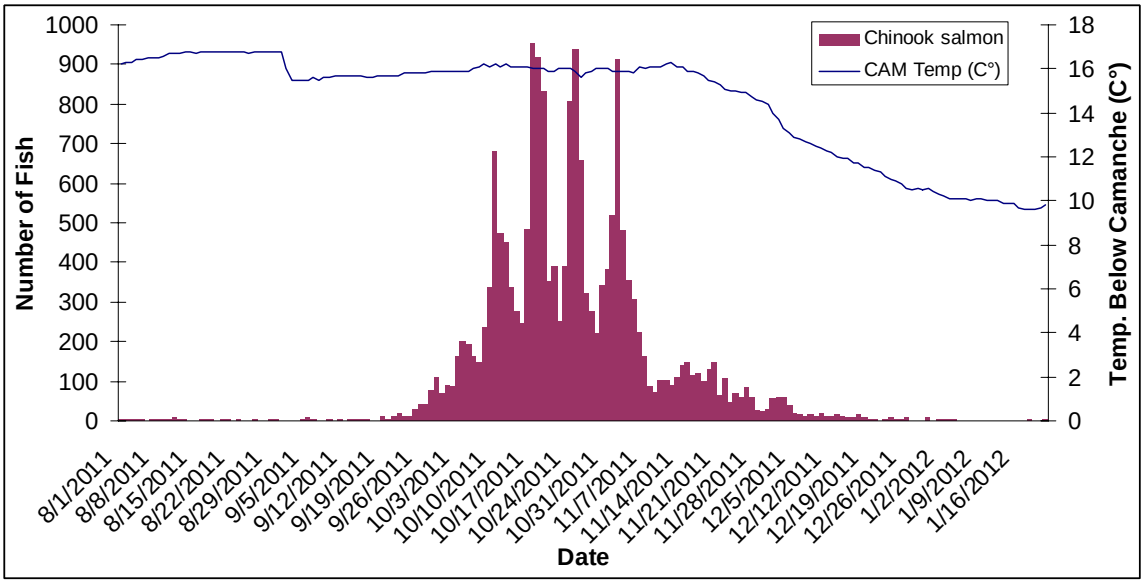

Figure 7. Daily abundance and timing of fall-run Chinook salmon migrating past WIDD compared to temperature below Camanche Reservoir, August 1, 2011 - January 21, 2012.

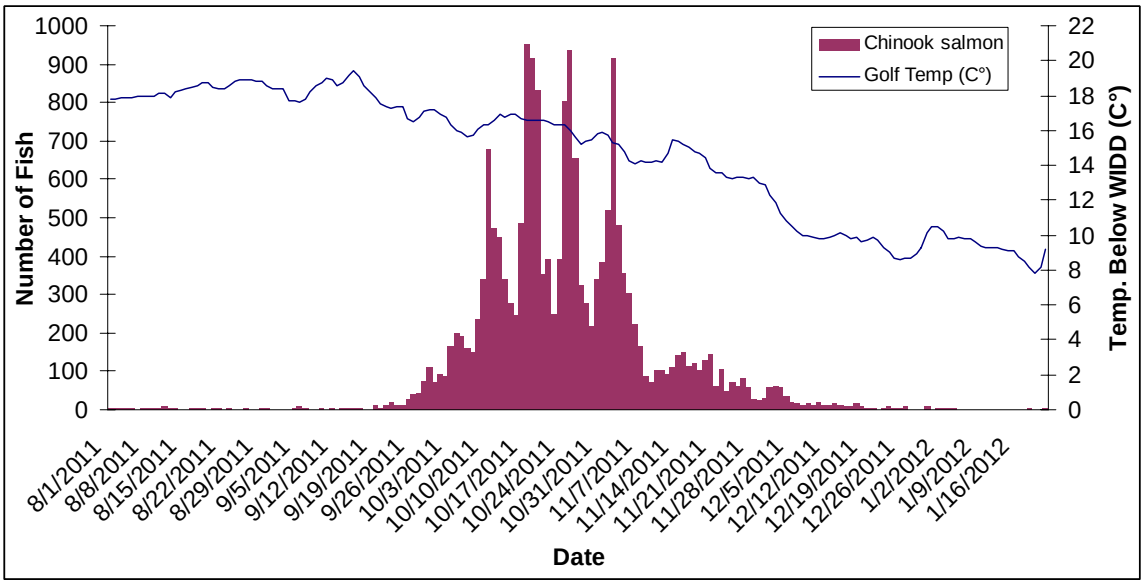

Figure 8. Daily abundance and timing of fall-run Chinook salmon migrating past WIDD compared to temperature below WIDD, August 1, 2011 - January 21, 2012.

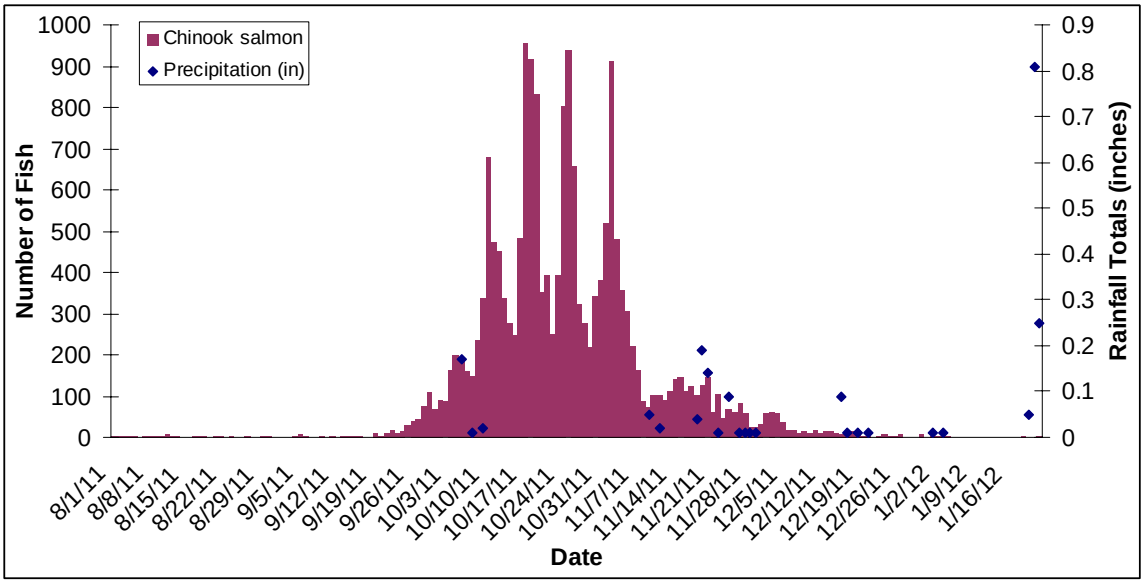

Figure 9. Daily abundance and timing of fall-run Chinook salmon migrating past WIDD compared to Lodi rainfall, August 1, 2011 - January 21, 2012.

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