LOWER MOKELUMNE RIVER
UPSTREAM FISH MIGRATION MONITORING
Conducted at Woodbridge Irrigation District Dam
August 2010 through July 2011

August 2011

Casey Del Real
Matt Saldate
East Bay Municipal Utility District, 1 Winemasters Way, Lodi, CA 95240

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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, 2010 through July 31, 2011. An estimated 7,196 fall-run Chinook salmon (*Oncorhynchus tschwaytscha*) passed the WIDD fish ladders between August 2, 2010 and January 29, 2011. Fifty percent of the run passed WIDD by October 24, 2010. Highest daily passage was 538 fish on October 20, 2010. The sex and life stage was positively determined for 7,191 fish including 2,222 (31%) adult (≥70 cm FL) females, 2,943 (41%) adult males, 496 (7%) grilse (<70 cm FL) females and 1,530 (21%) grilse males. River flow, combined with management actions such as pulse flows and the closure of the Delta Cross Channel for 48 hours between Oct. 13th through Oct. 15th, were followed by peaks in daily passage and contributed to the high overall returns. Ninety-eight adult steelhead (*O. mykiss*) passed WIDD between August 2010 and July 2011. Peak steelhead passage occurred in January (n=30). Other species using the WIDD fish ladder included: black bass, *Micropterus sp.*; common carp, *Cyprinus carpio*; striped bass, *Morone saxatilis*; channel catfish, *Ictalurus punctatus*; Pacific lamprey, *Lampetra tridentata*; Sacramento pikeminnow, *Ptychocheilus grandis*; 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 Rkm 64 since fall 1990. In 1997, Woodbridge Irrigation District initiated a rebuild of the dam, fish ladders, and fish screening facilities on the lower Mokelumne River. 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. In 2010, through coordination between EBMUD and Woodbridge Irrigation District, Lodi Lake was left in throughout the Chinook salmon run and drained on January 31, 2011. Therefore, the 2010 total Mokelumne River fall-run Chinook salmon escapement is 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 CWT component of the 2010 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, 2010 with video monitoring in the high stage ladder at WIDD. On January 31, 2011, 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, 2011, when the bladder dams of Woodbridge Irrigation District were installed, and continued through July 31, 2011.

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 2010/2011 is 7,196 spawners entering the river between August 2010 and January 2011 (Figure 1). Fifty percent of the run passed WIDD by October 24th (Table 1). Highest daily passage of 538 fish occurred on October 20, 2010. The sex and life stage was positively determined for 7,191 fish including 2,222 (31%) adult (≥70 cm FL) females, 2,943 (41%) adult males, 496 (7%) grilse (<70 cm FL) females and 1,530 (21%) grilse males (Figure 2). In addition, there were 5 unknown sex grilse.

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

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

Between 1990 and 2003, a 1:3 grilse to adult ratio was observed on the LMR, and approximately the same ratio exists for 2010 (28% grilse; 72% adults). In 2004, the grilse ratio was significantly higher with a ratio of closer to 1:2 grilse to adult (Figure 3).

In the 2010/2011 monitoring season, 87% of fish passing the video monitor occurred during the day and 13% 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.

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

Clipped adipose fins were evident on 3,686 (51%) of the observed fall-run Chinook salmon. The sex and life stage was positively determined for 3683 adipose fin clipped fish including 771 (21%) adult (≥70 cm FL) females, 1,207 (33%) adult males, 413 (11%) grilse (<70 cm FL) females and 1,292 (35%) grilse males. Thirty-five percent of the returning adult females were adipose fin clipped, 41% of the adult males were adipose fin clipped, 83% of the grilse females were adipose fin clipped, and 84% 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 wiring tagging of returning broodyears. In 2006 and 2007, approximately 25% of hatchery reared Chinook salmon at the Mokelumne River Fish Hatchery were CWTed and adclipped. In 2008 and 2009, 100% of hatchery reared

Chinook salmon at the Mokelumne River Fish Hatchery were CWTed and adclipped (Table 3).

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

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	1978	38.3
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	1708	84.1

During the 2010/2011 Chinook salmon migration period, Camanche Dam releases ranged from 333 – 2999 cfs (Figure 5). Average flow was 1022 cfs. Flow below WIDD ranged from 53 – 2823 cfs and averaged 871 cfs (Figure 6). Water temperatures from the August through January monitoring period ranged from 8.8 – 16 C° at Camanche Dam (Figure 7) and 8.7 – 20.7 C° at WIDD (Figure 8). Total rainfall, collected at the California Irrigation Management Information System's Lodi West station, was 10.3 inches (Figure 9). Peak daily rainfall was

1.5 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 number of fish on the ascending portion of the curve were run for the 2010/2011 escapement (Table 4). Management actions, such as pulse flows and the closure of the Delta Cross Channel for 48 hours from Oct. 13th through Oct. 15th, were followed by peaks in daily passage (until Oct. 24th) and contributed to the high overall returns (Figure 6). However, due to the delayed response of fish passage at WIDD to pulse flow peaks, the relationship between flow and fish counts do not signify a strong correlation even though they are significantly positively 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)	53 – 2197	0.41	<.0001
Temperature below Woodbridge (C°)	15.6 – 20.7	0.46	<.0001
Precipitation (in)	0 – 0.7	0.15	0.0110

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.

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

Ninety-eight adult steelhead (≥380 mm FL) were observed moving upstream through WIDD from August 20, 2010 through July 17, 2011. The highest monthly abundance of steelhead was in January (n=30). No video monitoring occurred in February as fish passage at WIDD was diverted to the low stage ladder. Of the 98 fish observed, 29 were males, 16 were females, and 53 were not distinguishable to sex. Ninety-two percent (n=90) 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, 2010 – July 31, 2011.

Monitoring Period (2010-2011)	*Male Count*	*Female Count*	*Unknown Sex Count*	*Total Count*	*Adclip Total*
August	-	-	1	1	1
September	-	-	2	2	2
October	5	-	12	17	15
November	-	1	2	3	3
December	11	4	4	19	18
January	6	7	17	30	28
February	n/a	n/a	n/a	n/a	n/a
March	3	2	4	9	9
April	-	-	4	4	3
May	-	-	4	4	4
June	1	2	2	5	4
July	3	-	1	4	3
Totals	29	16	53	98	90

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. Moyle (2002) states ripe pikeminnow usually move upstream to spawn in April and May. Sacramento suckers typically congregate and begin moving toward spawning areas from February to June with peak activity in March and April (Moyle 2002). Non-native fish using the fish ladders at WIDD include common carp, black bass, striped bass, and channel catfish (Table 8).

Table 8. Native and non-native fish observed in the Woodbridge Irrigation District Dam fish ladder, Aug 01, 2010-July 31, 2011. Species names in bold represent native species.

	Pacific Lamprey	**Sacramento Pikeminnow**	**Sacramento Sucker**	Common Carp	Black Bass	Striped Bass	Channel Catfish
August		x	x				
September		x					
October	x	x	x			x	
November							
December	x						
January		x	x				
February							
March	x	x	x	x	x	x	
April		x	x	x	x	x	
May		x					
June	x	x	x				
July	x	x	x	x	x	x	x

Acknowledgements

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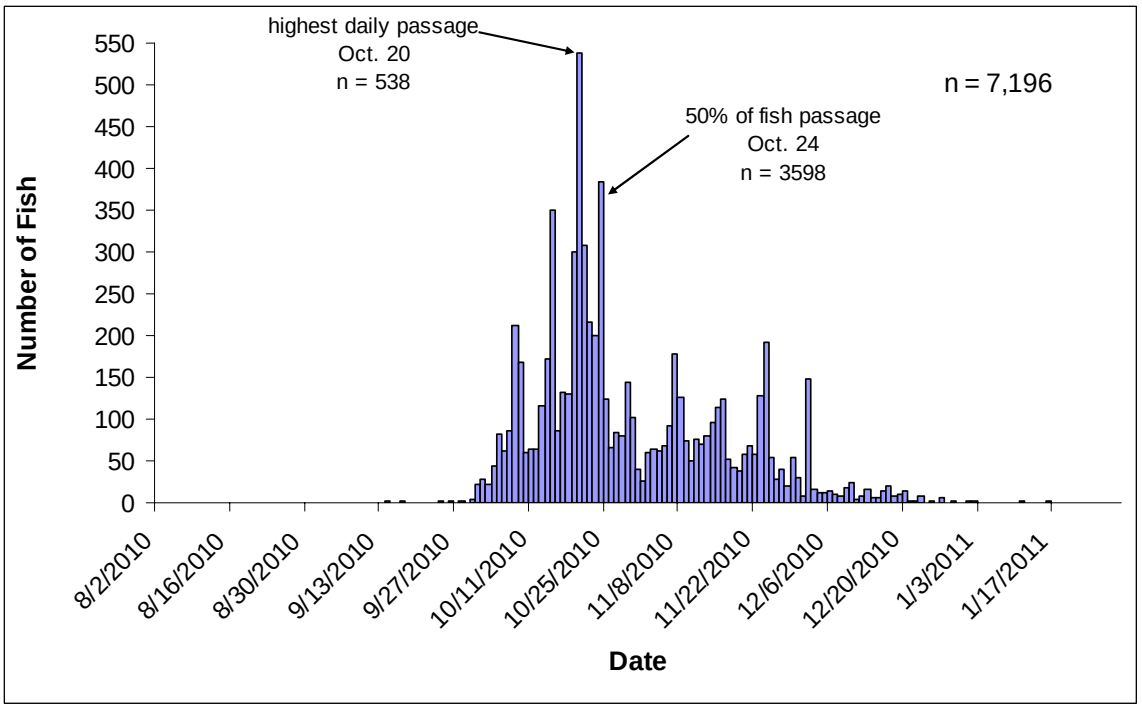

Figure 1. Daily abundance and timing of fall-run Chinook salmon migrating past WIDD, August 1, 2010 - January 31, 2011.

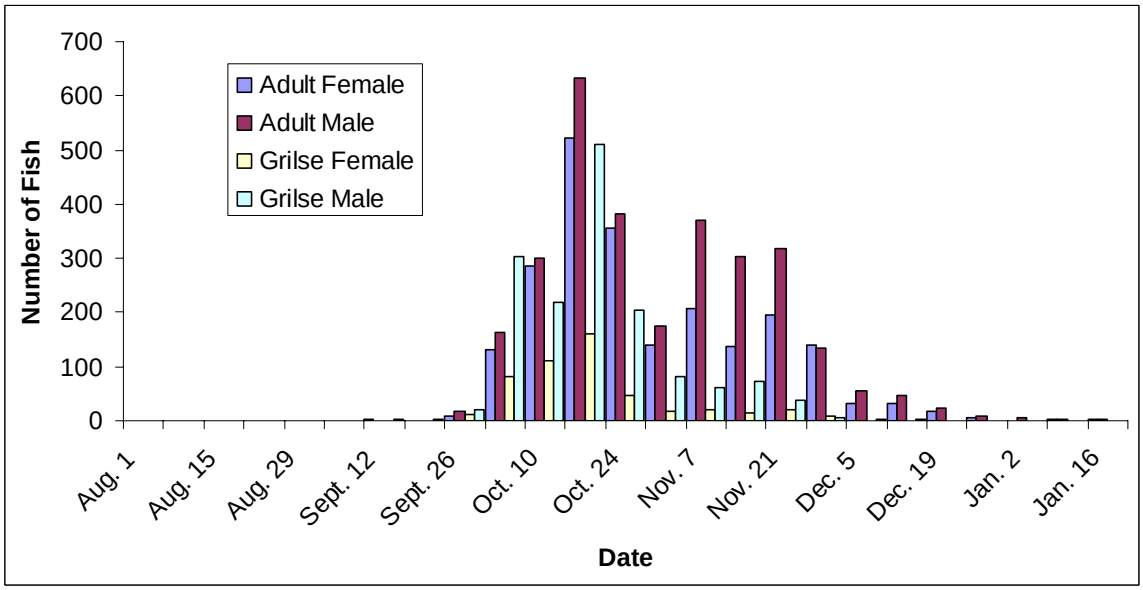

Figure 2. Weekly sex/age composition of fall-run Chinook salmon passing Woodbridge Irrigation District Dam, August 1, 2010 - January 31, 2011.

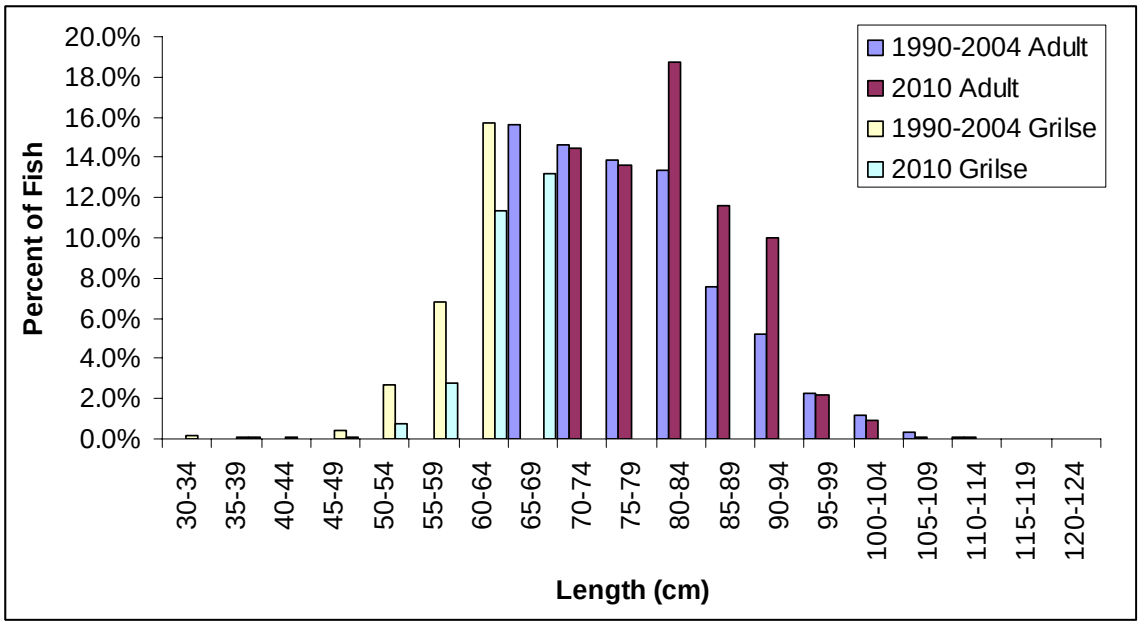

Figure 3. Length frequency of adult and grilse Chinook salmon (% by size class) passing WIDD in 2010 compared to the cumulative length frequency from 1990 – 2004.

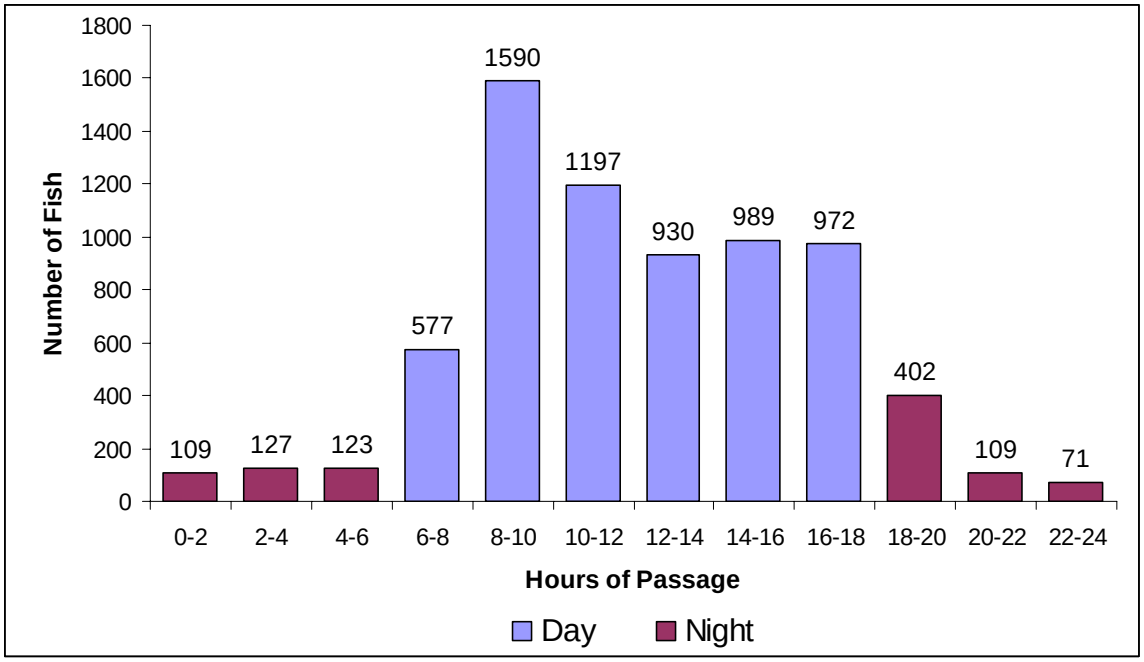

Figure 4. Chinook salmon passage (2 hour intervals) recorded from video monitoring at WIDD, August 1, 2010 - January 31, 2011.

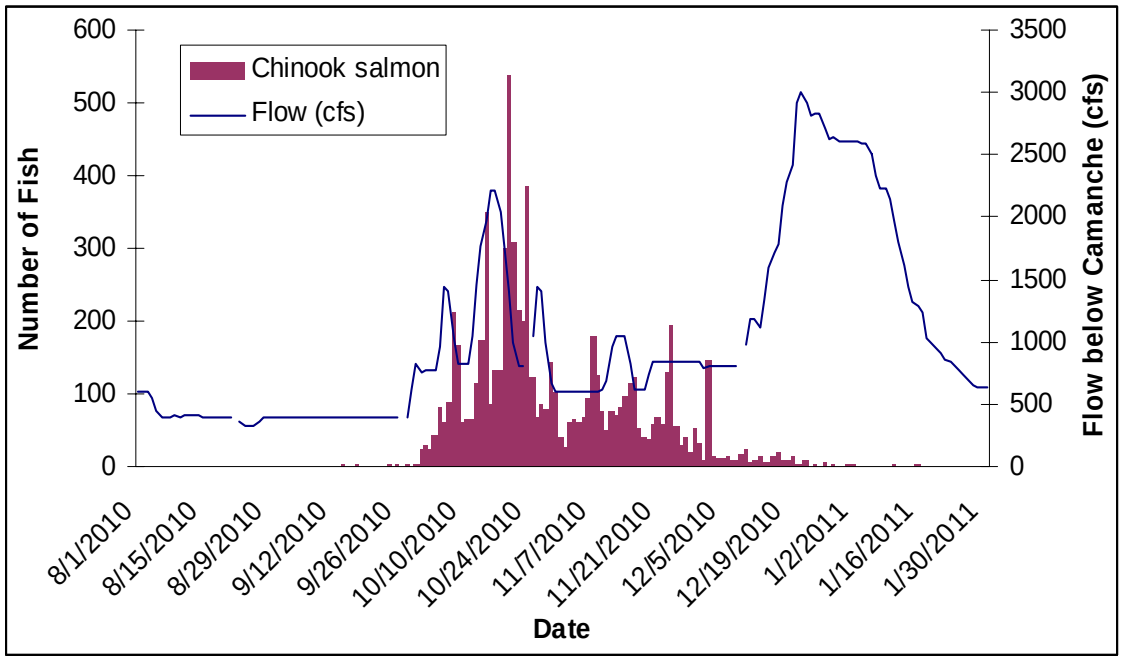

Figure 5. Daily abundance and timing of fall-run Chinook salmon migrating past WIDD compared to flow below Camanche Reservoir, August 1, 2010 - January 31, 2011.

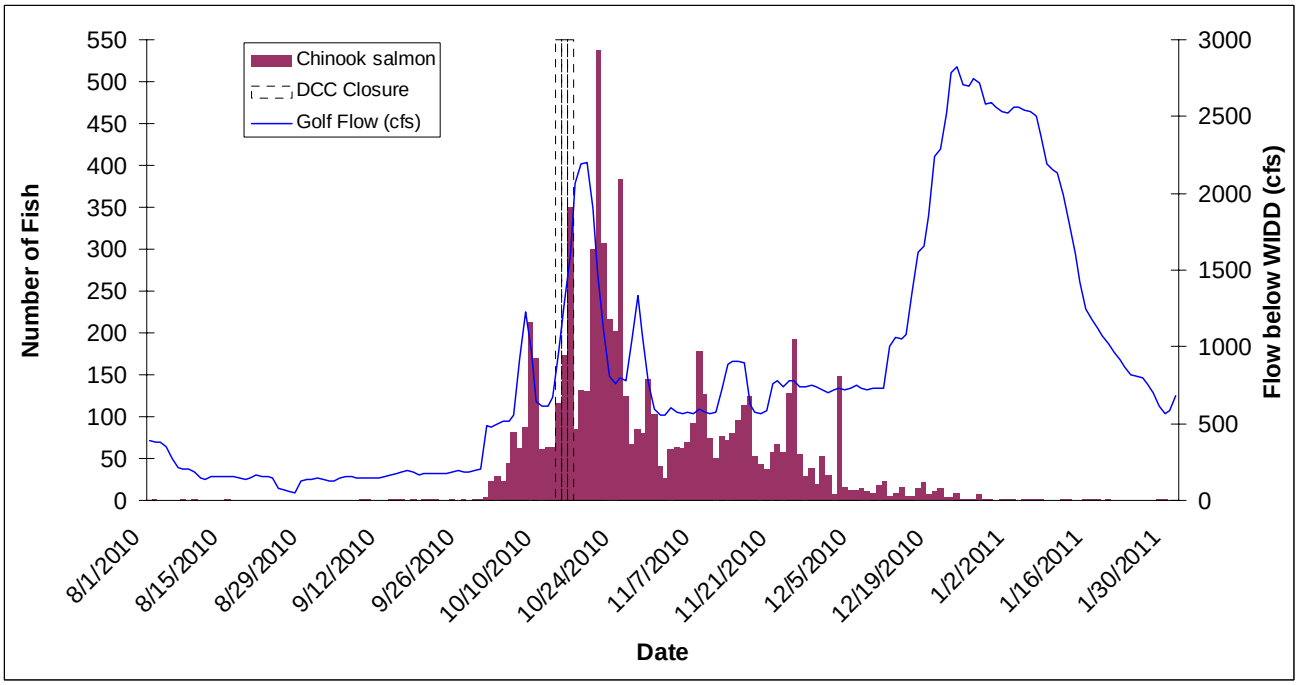

Figure 6. Daily abundance and timing of fall-run Chinook salmon migrating past WIDD compared to flow below WIDD and the DCC closure, August 1, 2010 - January 31, 2011.

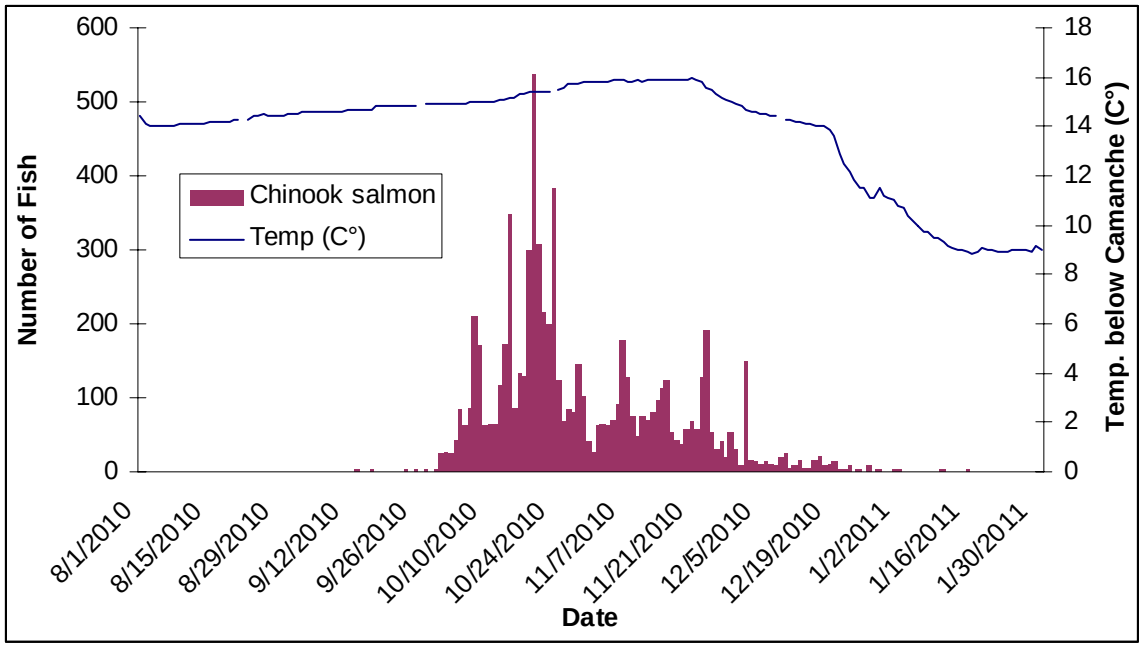

Figure 7. Daily abundance and timing of fall-run Chinook salmon migrating past WIDD compared to temperature below Camanche Reservoir, August 1, 2010 - January 31, 2011.

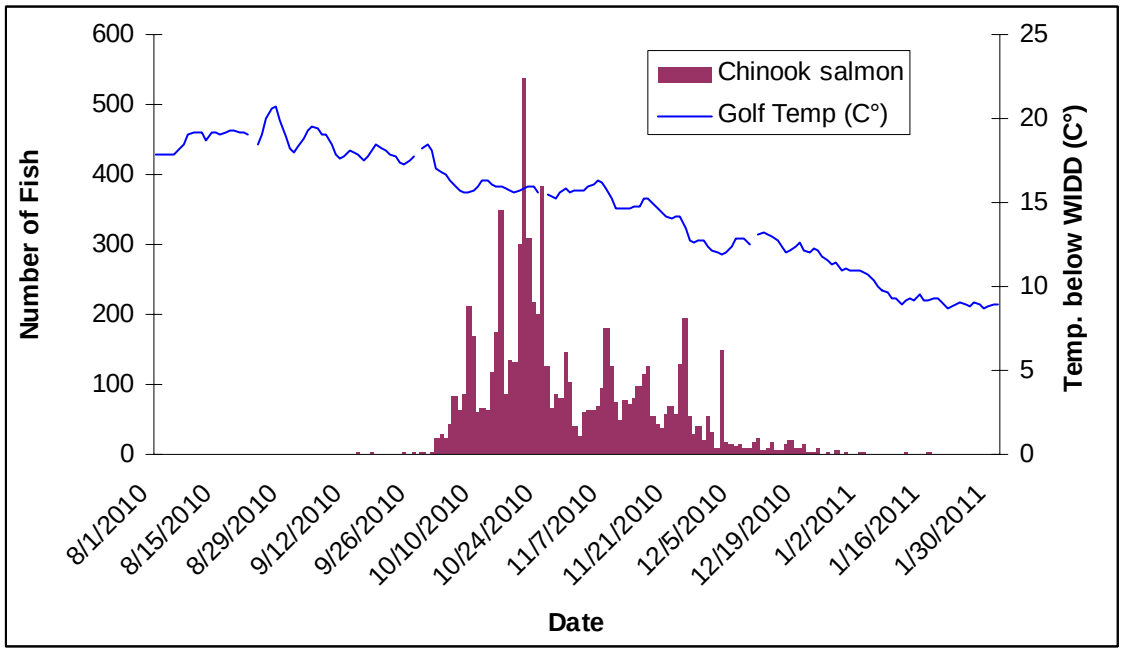

Figure 8. Daily abundance and timing of fall-run Chinook salmon migrating past WIDD compared to temperature below WIDD, August 1, 2010 - January 31, 2011.

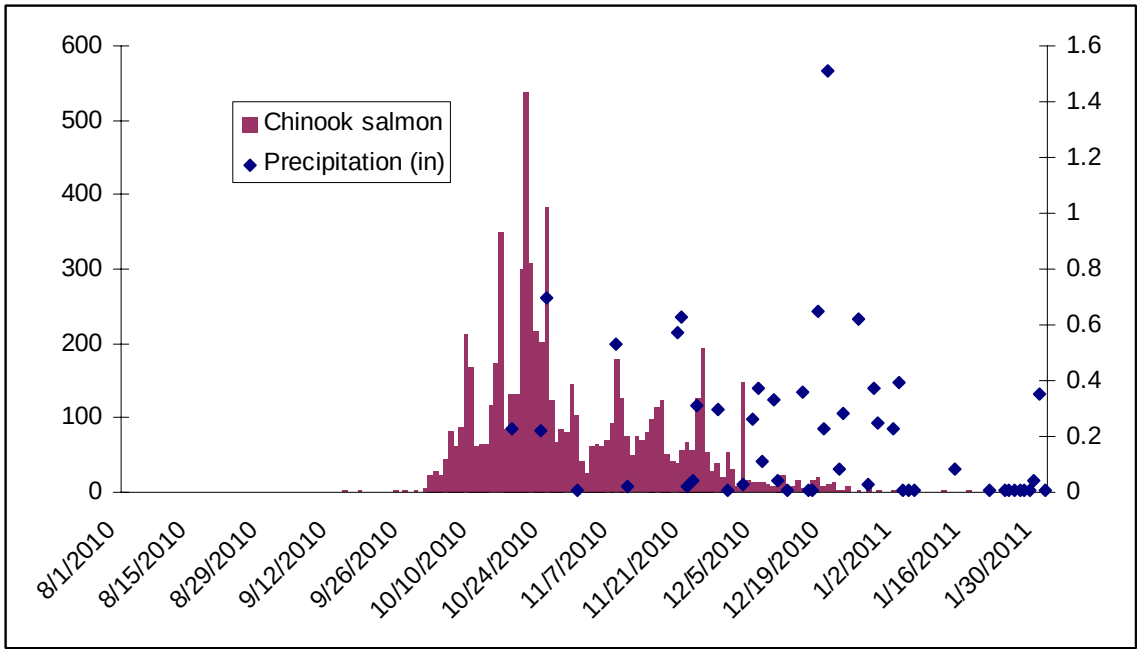

Figure 9. Daily abundance and timing of fall-run Chinook salmon migrating past WIDD compared to Lodi rainfall , August 1, 2010 - January 31, 2011.

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