

**LOWER MOKELUMNE RIVER  
UPSTREAM FISH MIGRATION MONITORING  
Conducted at Woodbridge Irrigation District Dam  
August 2004 through July 2005**

**August 2005**

Michelle L. Workman  
East Bay Municipal Utility District, 1 Winemasters Way, Lodi, CA 95240

Key words: lower Mokelumne River, fall-run Chinook salmon, steelhead, escapement

---

***Abstract:*** Upstream fish migration monitoring was conducted at Woodbridge Irrigation District Dam (WIDD) and the lower Mokelumne River (LMR) from August 01, 2004 through April 5, 2005, and from July 19 through July 31, 2005. An estimated escapement of 11,944 fall-run Chinook salmon (*Oncorhynchus tshawytscha*) was calculated for the LMR based on a carcass survey estimate of in river spawners (1,588) and hatchery escapement (10,356). Video monitoring and ladder trap operations produced an estimate of 11,416 Chinook. Fifty percent of the fish observed in video monitoring passed Woodbridge Irrigation District Dam by November 12, 2004. Highest daily video passage was 615 on November 12, 2004. The sex and life stage was positively determined for 9,586 salmon and included 2,091 (22%) adult females, 4,163 (43%) adult males, 979 (10%) grilse females and 2,353 (25%) grilse males. Forty-four adult steelhead (*O. mykiss*) passed upstream of WIDD between October 2004 and February 2005. Thirteen steelhead passed downstream of WIDD between December 2004 and March 2005. Peak upstream steelhead passage occurred in November (13). Of upstream passing steelhead, 33 were adipose clipped and 11 were unclipped. Other species using the WIDD fishways included: black bass, *Micropterus sp.*; chum salmon, *O. keta*; common carp, *Cyprinus carpio*; Pacific lamprey, *Lampetra tridentata*; Sacramento pikeminnow, *Ptychocheilus grandis*; Sacramento sucker, *Catostomus occidentalis*; and tule perch, *Hysterocarpus traski*.

## **INTRODUCTION**

East Bay Municipal Utility District (EBMUD) has been monitoring adult fall-run Chinook salmon escapement in the lower Mokelumne River (LMR) using video surveillance and trapping at Woodbridge Irrigation District Dam (WIDD) since the fall of 1990. Initially, monitoring documented the timing and magnitude of the adult salmon escapement to the LMR with a secondary focus on steelhead. Monitoring from 1990 through 2000 has started between August and mid-October, and ended between December and April. Since 2001, 12 months of continuous video/trap monitoring has been conducted. Carcass surveys were initiated in 2003 to provide a secondary count

method. Due to reconstruction of WIDD it was deemed appropriate to investigate this as a secondary count method in case conditions at WIDD precluded video monitoring and trapping during the construction phase of the rebuild project.

## **OBJECTIVES**

The objectives of this study are to 1) monitor fish passage of native and non-native fishes through the WIDD fish ladders, 2) describe the relationship of fall-run Chinook salmon movements to environmental conditions on the LMR and 3) calculate an escapement estimate of adult fall-run Chinook salmon for the LMR for the 2004 season.

## **METHODS**

### *Video/live trap*

Monitoring of fall-run Chinook salmon migration began on August 01, 2004 with video monitoring in the high stage ladder at the WIDD. On November 1, Woodbridge Irrigation District (WID) began removing the boards in the dam, which necessitated operation of the low stage ladder. EBMUD began trapping in the low-stage ladder on November 2, 2004. Continuous trapping ended on November 21. Video monitoring resumed on November 21 and the trap was operated occasionally due to rain related turbidity. The last day the trap was operated was December 9, 2004. Video monitoring in the low stage ladder continued to April 5, 2004, due to construction activity at the WIDD.

All other monitoring, and data collection and storage methods for video/live trap monitoring were consistent with prior year's monitoring efforts (Marine and Vogel 2000, Workman 2001).

### *Carcass surveys*

Carcass surveys were conducted on a weekly basis from the first week in October to the second week in January from the base of Camanche Dam to Elliott Road (Figure 1). Survey methods are described in Workman (2004).

Tissue samples were collected from 39 fresh carcasses for deposit in the "Central Valley Salmonid Tissue Archive". Tissue samples were collected according to the "DNA Fin Clip Collection Protocol – Dry Method" (Navicky 2003). Otolith samples were collected from 351 fish in the river surveys, 12 fish from the ladder trapping at WIDD, and 946 fish from the Mokelumne River Fish Hatchery (MRFH).

For the first five weeks of the carcass survey, 20 fresh hatchery carcasses marked with carcass tags were distributed throughout the reach above HWY 88 and 20 were distributed below HWY 88. These hatchery carcasses were used to increase sample size for statistical analysis. A Jolly-Dickson open population mark recapture model, was used to develop an in river spawner estimate using the POPAN 5 statistical package (Arnason et al. 1998).

## RESULTS AND DISCUSSION

### Chinook Salmon (video/trapping)

The fall-run Chinook salmon escapement estimate in the LMR for 2004/2005 based on carcass surveys is 11,944 adults entering the river between August 2004 and January 2005. Video monitoring recorded 11,416 of these passages (Figure 2). Fifty percent of the run captured by video monitoring passed WIDD by November 12, 2004 as compared to November 13th of last year (Table 1). Highest daily video passage of 615 fish occurred on November 12, 2004. The sex and life stage was positively determined for 9,586 fish including 2,091 (22%) adult (>60 cm FL) females, 4,163 (43%) adult males, 979(10%) grilse ( $\leq$ 60 cm FL) females and 2,353 (25%) grilse males (Figure 3). In addition there were 100 unknown sex adults, 188 unknown sex grilse, and 1,529 unknown sex and size fish. Data are in Appendix A.

Over the past twelve years we have observed a 1:3 grilse to adult ratio. In 2004 the grilse ratio was significantly higher with a ratio of closer to 1:2 grilse to adult (Figure 4).

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

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

Since 1990 more fish have passed upstream during daylight hours than nighttime hours (Table 2). Day is defined as ½ hour before sunrise to ½ hour after sunset.

In the 2004/2005 monitoring season 79% of fish passing the video monitor occurred during the day, and 21% during the night. Daytime passage has been consistently higher than nighttime passage (Table 2, Figure 5).

**Table 2. Percent of annual fall-run Chinook salmon passing Woodbridge Irrigation District Dam during day and night, 1990-2004.**

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

Clipped adipose fins were evident on 743 (7.5%) of the known age and sex fall-run Chinook salmon. Of the identifiable grilse and adults 3.7% (129), and 9.6% (614), respectively, had adipose fin clips. The percentage of adipose clipped adults has ranged from 0.9% in 1993 to a high of 14.4% in 2002 (Table 3). The range for grilse has been from 1.7% in 1993 and 1997 to a high of 18.6% in 2001.

In addition to adipose-fin clips, observations of hook scars, fungal infections, abrasions, predator wounds and lacerations were recorded. Observations of hook scars this year rose significantly from previous years. Hook scars in grilse were recorded for 3.5% of observable grilse, compared to only 0.8% last year. Hook scars in adults were recorded for 3.4% of observable adults as compared to 1.6% last year. Other injuries and anomalies were categorized as abrasions, fungal infections, lacerations, and predator wounds. The most frequent injury for both age classes was abrasions. All injuries combined occurred in 6.2 % of adults and 3.9 % of grilse (Table 3).

River flow, rainfall, temperature, turbidity, and barometric pressure have been investigated for their relationship to salmon returns over the past 13 years. Regression analyses comparing these factors to number of fish on the ascending portion of the curve were run for the 2004/2005 escapement (Table 4). The combined effects of temperature, flow and turbidity at WIDD, and precipitation explains 72% of the variability in the number of salmon migrating upstream past WIDD ( $p < 0.0001$ ).

**Table 3. Incidence of adipose fin clips, hook-scars and injuries on fall-run Chinook salmon passing Woodbridge Irrigation District Dam, 1992-2004.**

<u>Year</u>	<u>Adipose Fin Clips</u>		<u>Hook Scars</u>		<u>Other Injuries</u>	
	<u>Number</u>	<u>Percent</u>	<u>Number</u>	<u>Percent</u>	<u>Number</u>	<u>Percent</u>
<b>Adult</b>						
1992	10	1.4	24	3.4	20	2.8
1993	11	0.9	56	4.5	83	6.7
1994	244	10.3	151	6.3	218	9.2
1995	161	7.8	74	3.6	289	14.1
1996	169	9.2	97	5.3	258	14.1
1997/98	152	2.9	105	2	785	14.7
1998/99	427	7.4	38	1.2	615	10.7
1999/2000	327	10.8	46	1.5	392	13
2000/2001	225	4.0	87	1.2	855	11.7
2001/2002	326	8.5	36	0.9	594	15.6
2002/2003	1,228	14.4	68	.08	222	2.6
2003/2004	996	13.4	122	1.6	337	4.5
2004/2005	614	9.7	214	3.4	396	6.2
<b>Grilse</b>						
1992	35	3.8	41	4.4	21	2.3
1993	8	1.7	33	6.8	15	3.1
1994	22	4	59	10.6	27	4.9
1995	55	15.2	27	7.4	25	6.9
1996	47	3.5	68	5.0	44	3.2
1997/98	7	1.7	3	0.7	18	4.5
1998/99	175	12	9	1.1	55	3.8
1999/2000	139	6.1	46	2.0	160	7.0
2000/2001	83	8	7	0.5	71	5.5
2001/2002	188	18.6	3	0.3	58	5.8
2002/2003	363	16.2	11	0.4	25	1.1
2003/2004	319	12.7	24	0.8	52	1.8
2004/2005	129	3.7	126	3.5	137	3.9

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

	<u>Range</u>	<u>R<sup>2</sup></u>	<u>P value</u>
Flow Below Woodbridge (m <sup>3</sup> /sec) (cfs)	2.8-10.7 101-378	0.64	<.0001
Woodbridge Temperature (C <sup>o</sup> ) (F <sup>o</sup> )	8.5-12.2 47.3-54.0	0.39	<.0001
Precipitation (cm) (in)	0-2.94 0-1.16	0.29	<.0001
Turbidity (NTU)	2.08-10.95	0.58	<.0001

#### Chinook Salmon (carcass surveys)

The 2004/2005 carcass survey encountered 942 carcasses. Of these, 624 (200 of these were hatchery carcasses tagged and placed in the river for subsequent recapture) were tagged producing 172 recaptures, 146 were rated as skeletons on first capture, and 30 were adipose fin clipped (Table 5). Calculation of the Popan 5 Jolly-Dickson Full Model resulted in an estimate of 1,588 river spawners (Appendix B).

Female fish were checked for spawning condition. Eighty-six percent were completely spawned out, 5% were partially spawned out, and 6% were unspawned.

Video and trap monitoring resulted in a count of 11,416 fall-run Chinook escaping to the Mokelumne River. The Mokelumne River Fish Hatchery (MRFH) counted 10,356 into the hatchery. This leaves an effective spawning population in the river of 1,050 salmon in the river based on video counts. The carcass survey estimate for in river spawners was 1,588 (+/- 713). Redd surveys counted over 900 redds in the river (Jose Setka, pers. comm.). Based on all available data the total escapement for the lower Mokelumne River was derived by adding the hatchery escapement and the carcass survey estimate, coming up with an estimate of 11,944.

**Table 5. Carcass survey data collected between Camanche Dam and Elliott Rd. on the lower Mokelumne River from October 18, 2004 through 1/10/2005.**

	<u>Week</u>	<u>Skeleton</u>	<u>Tagged</u>	<u>Recoveries</u>	<u>Total Counted</u>	<u>Adclipped</u>
A	10/18/04	1	40		41	
	10/25/04		43	5	48	
	11/01/04		40	13	53	
	11/8/04	3	44	12	59	3
	11/15/04	7	71	6	84	5
	11/22/04	14	130	24	168	8
	11/29/04	42	127	32	201	9
	12/09/04	38	80	47	165	3
	12/13/04	12	28	27	67	2
	12/20/04	18	19	3	40	
	12/27/04	6	0	3	9	
	01/03/05	4	2	0	6	
	01/10/05	1	0	0	1	
	<b>Totals</b>		<b>146</b>	<b>624</b>	<b>172</b>	<b>942</b>

Length frequency distribution for the carcass data was compared to the video/trap data. This comparison, similar to last year's data, shows a clear size bias in the carcass surveys, with smaller fish being underrepresented in the carcass surveys. (Figure 7).

Comparisons of age and sex composition (adult male:adult female; grilse male:grilse female; and adult:grilse ratios) between video/trap data, carcass data, and hatchery count were performed using Chi-square analysis (Table 6). In the 2003/2004 season, the only tests that showed a significant difference were the adult to grilse ratios between carcass surveys and hatchery counts, and carcass surveys and video counts. This season, all tests showed a significant difference except for the adult male to female ratios between the video and ladder counts, suggesting that the carcass count was selective for both size and sex of fish, and that the proportion of adult and grilse entering the hatchery may be significantly different from the total population observed in the river. A higher proportion of grilse entered the hatchery than was observed in the river.

**Table 6. Results of Chi-square analysis of age and sex ratio for chinook salmon data collected from video/trap, hatchery counts, and carcass surveys on the lower Mokelumne River, Ca. 2004/2005.**

	<u>Carcass</u> v. <u>Hatchery</u>	<u>Carcass</u> v. <u>Video</u>	<u>Video</u> v. <u>Hatchery</u>
<b>Adult</b>			
<b>Male:Female</b>	<b>7.09</b>	<b>6.74</b>	0.038
<b>Grilse</b>			
<b>Male:Female</b>	N/A	<b>28.0</b>	N/A
<b>Adult:Grilse</b>	<b>92.1</b>	<b>12.8</b>	<b>307.0</b>

\* bold indicates statistically significant results

$X^2$  0.05, 1 = 3.841

Steelhead (video/trapping)

Steelhead have been observed since monitoring began in 1990 (Table 7). 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 7. Steelhead observed moving upstream during video monitoring at Woodbridge Irrigation District Dam, 1990-2004.**

<u>Monitoring Period</u>	<u>Number</u>	<u>Monitoring Period</u>	<u>Number</u>
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 – April 2005	44
Sept. 1997 – Feb. 1998	6		

Forty-four adult steelhead ( $\geq 380$  mm FL) were observed moving upstream through WIDD from October 05, 2004 through February 21, 2005. Of the 44 observed, 8 were males, 11 were females, 25 were not distinguishable to sex, and 32 were adipose fin clipped. Highest monthly abundance of steelhead was in November (13) (Figure 8).

Yearling steelhead (FL <200mm) and subadult steelhead (FL  $\leq 350$ mm) were observed in video monitoring from August 2004 through April 2005. Accurate counts of these fish are unattainable due to their ability to pass behind and underneath the camera.

Pacific Lamprey (video/trapping)

Prior to fall 1996, adult Pacific lamprey observations at WIDD were not recorded. Numbers of adult lamprey observed during video monitoring on the LMR have varied 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 where more than 100 adult lamprey were observed ascending the ladders at Woodbridge (Table 8). Pacific lamprey are in decline in the Columbia and Snake River Basins and may also be in decline in the Central Valley (Close et al 1995; Brown and Moyle 1993). This season only three Pacific lamprey were observed in the fish ladder throughout the monitoring season.



**Table 8. Adult Pacific lamprey observed moving upstream during video monitoring at Woodbridge Irrigation District Dam, 1996-2004.**

Year	<u>Aug</u>	<u>Sep</u>	<u>Oct</u>	<u>Nov</u>	<u>Dec</u>	<u>Jan</u>	<u>Feb</u>	<u>Mar</u>	<u>Apr</u>	<u>May</u>	<u>Jun</u>	<u>Jul</u>
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

Native resident fishes observed using the ladder include Sacramento pikeminnow, Sacramento sucker, and tule perch (Table 9). This year, video monitoring was discontinued on April 5, 2005 due to construction at WIDD. In most years we see the highest numbers of pikeminnow and suckers during April, May, and June.

**Table 9. Native and non-native fish observed in the Woodbridge Irrigation District Dam fish ladders, Aug 01, 2004-July 31, 2005.**

<i>Species</i>	<u>Aug.</u>	<u>Sept.</u>	<u>Oct.</u>	<u>Nov.</u>	<u>Dec.</u>	<u>Jan.</u>	<u>Feb.</u>	<u>Mar.</u>	<u>April**</u>	<u>May</u>	<u>June</u>	<u>July</u>
Black bass	-3*	-1	1	0	0	0	0	7	3	N/A	N/A	0
Common carp	-3	-2	-1	0	0	0	0	1	0	N/A	N/A	0
<b>Sacramento pikeminnow</b>	42	15	24	3	0	0	3	3	1	N/A	N/A	6
<b>Sacramento sucker</b>	0	0	1	0	0	-1	2	151	50	N/A	N/A	4
<b>Tule perch</b>	-3	0	0	0	-1	0	-1	0	0	N/A	N/A	0
<b>Chum salmon</b>	0	0	0	1	0	0	0	0	0	N/A	N/A	0

native species appear in bold print.

\* negative numbers indicate net downstream movement

\*\* no video monitoring from 4/5/05-07/19/05

Tule perch were observed sporadically, mainly as downstream movements through the ladder. Tule perch have been observed both above and below WID fish ladders during fish community surveys (EBMUD unpublished data). Tule perch are small enough to navigate the ladders through the drain holes at the base of each weir, and may use these to pass upstream unobserved.

Last year a school of around 60 adult American shad, *Alosa sapidissima*, was observed in the high stage fish ladder for 11 weeks, from May 13<sup>th</sup> through July 31<sup>st</sup> of 2004 (Workman 2004). American shad are typically seen in the fish ladder during the summer months, but video monitoring was discontinued in April of 2005 due to construction at WIDD. Adult shad were observed during summer 2005 fish community surveys in the

basin below WIDD, as in previous years. No American shad have been observed above WIDD during fish community surveys (EBMUD unpub. data). Non-native resident fish using the fish ladders at WIDD include black bass and common carp.

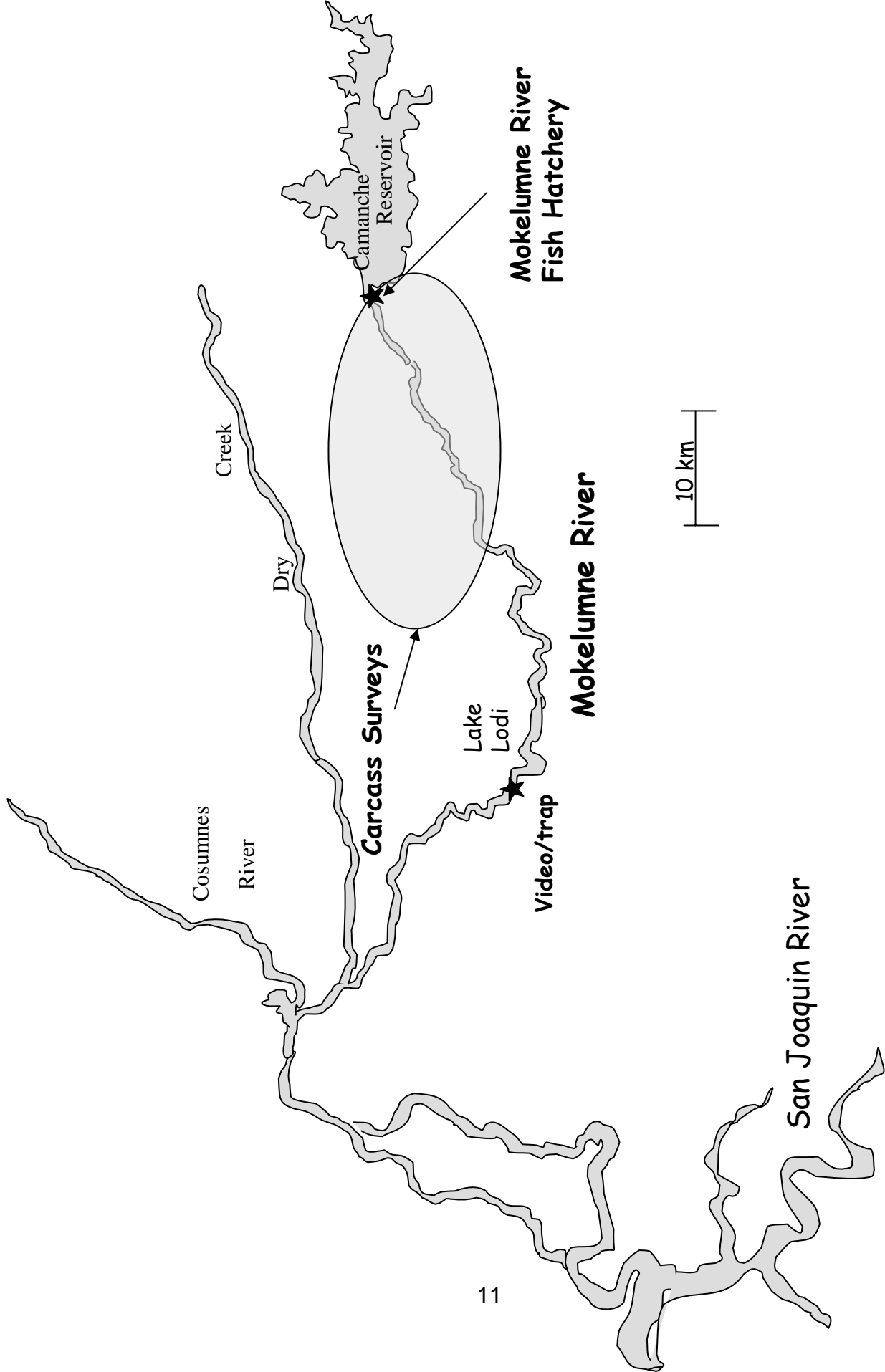


Figure 1. Location of carcass surveys and video/trap monitoring on the lower Mokelumne River, Ca.

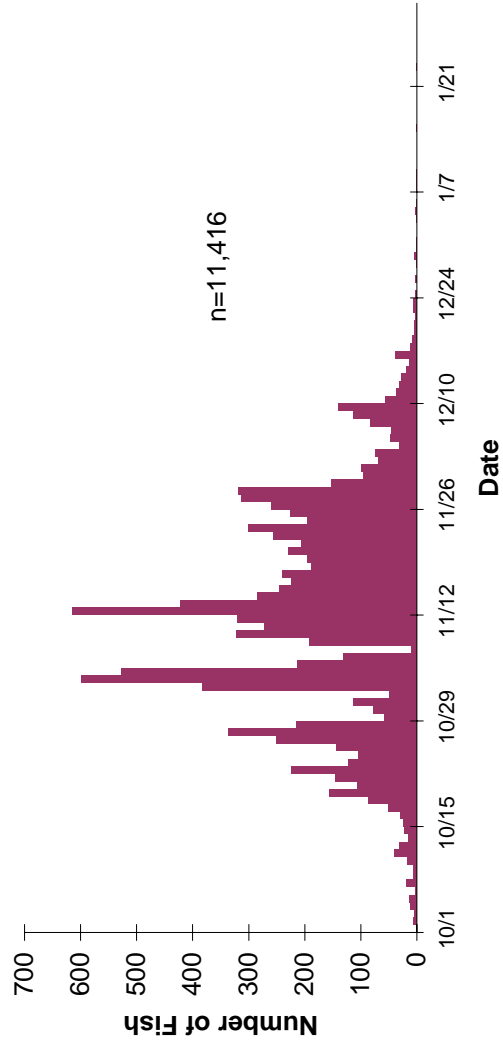


Figure 2. Daily abundance and timing of fall-run chinook salmon migrating past Woodbridge Irrigation District Dam, August 1, 2004-January 21, 2005 (Data in Appendix A).

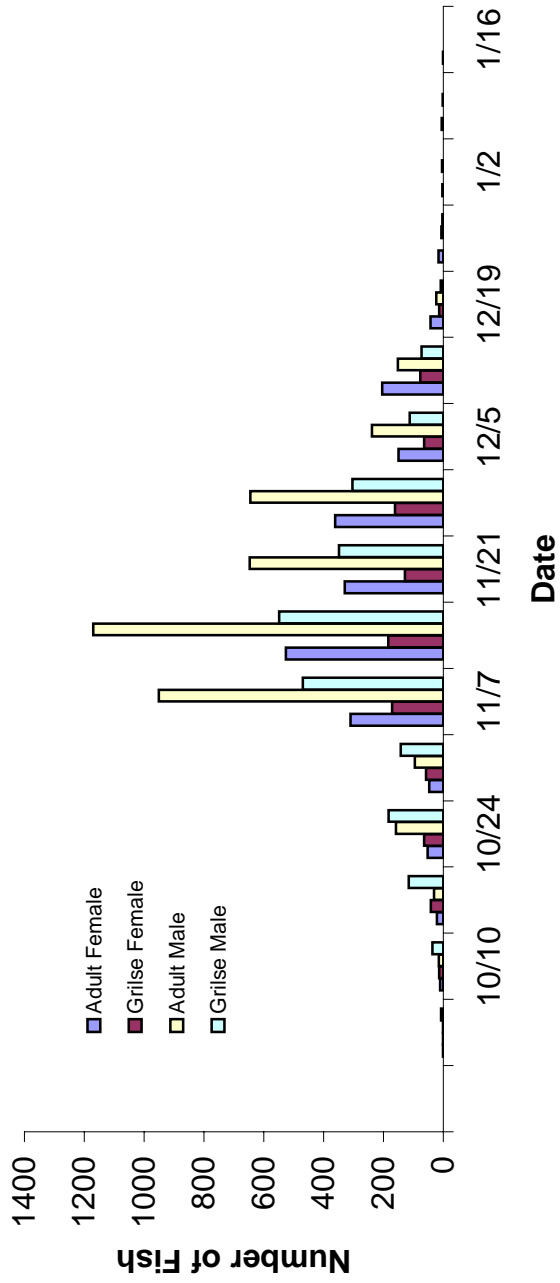


Figure 3. Weekly sex/age composition of fall-run Chinook salmon passing Woodbridge Irrigation District Dam, October 1, 2004 - January 16, 2005. (Data in Appendix A)

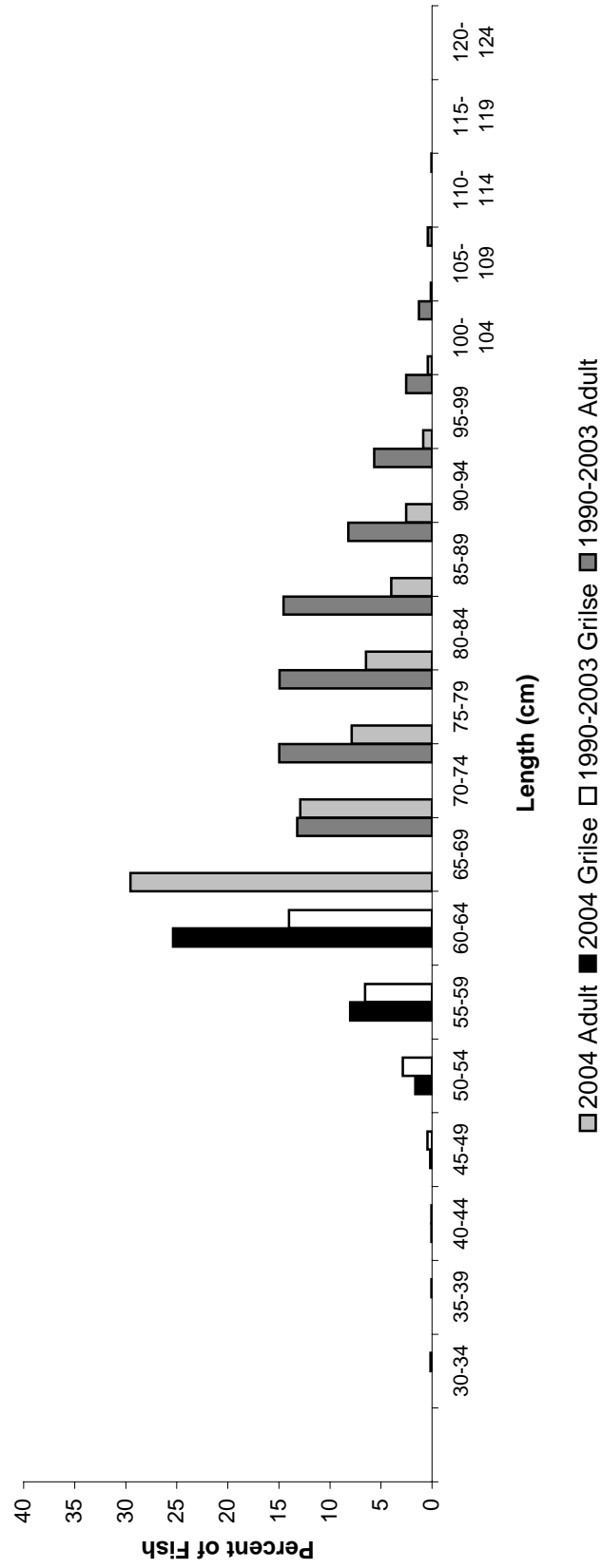


Figure 4. Length frequency of adult and grilse chinook salmon (% by size class) passing Woodbridge Irrigation District Dam in 2004 compared to the cumulative length frequency from 1990-2004.

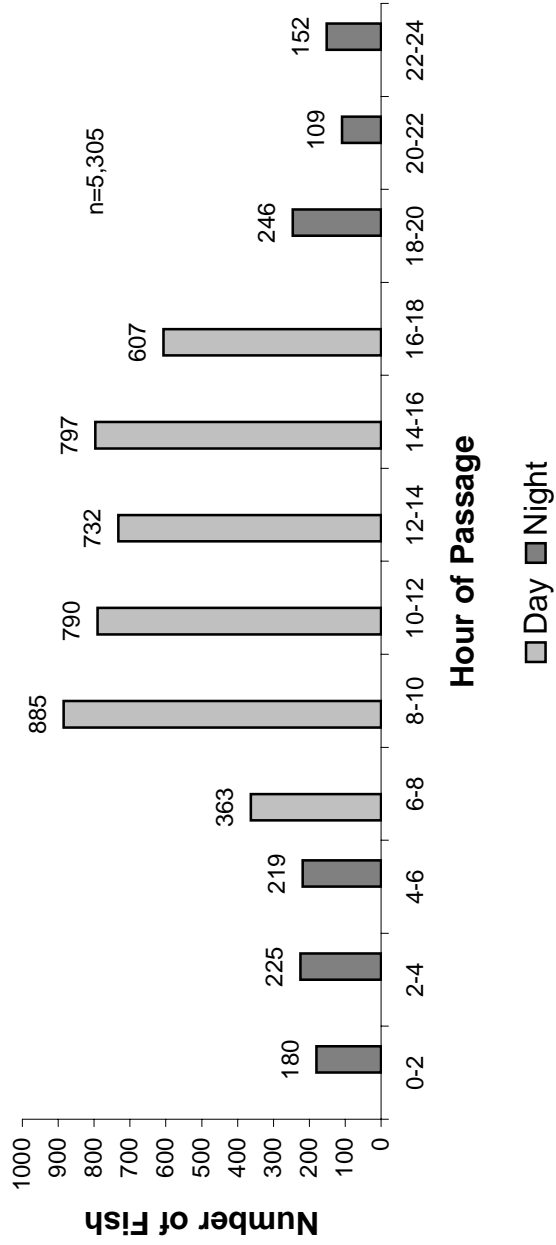


Figure 5. Chinook salmon passage (2 hour intervals) recorded from video monitoring at the Woodbridge Irrigation District am, August 1, 2004-January 21, 2005.

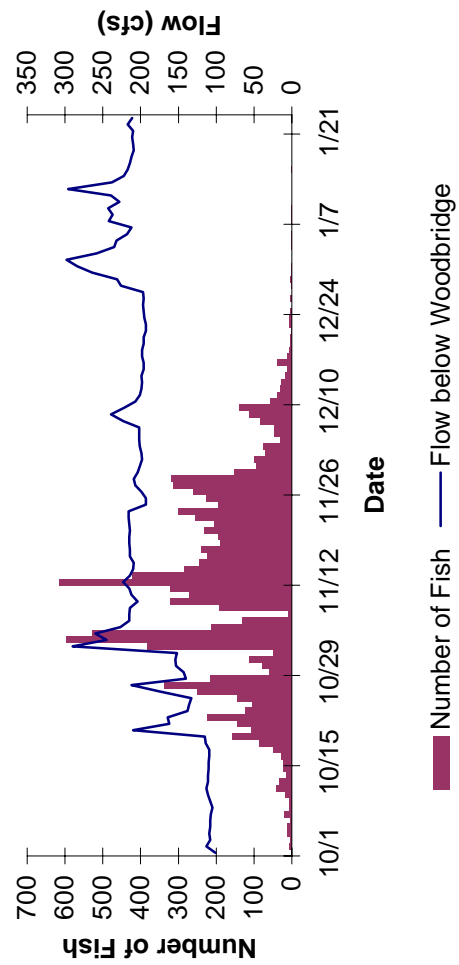
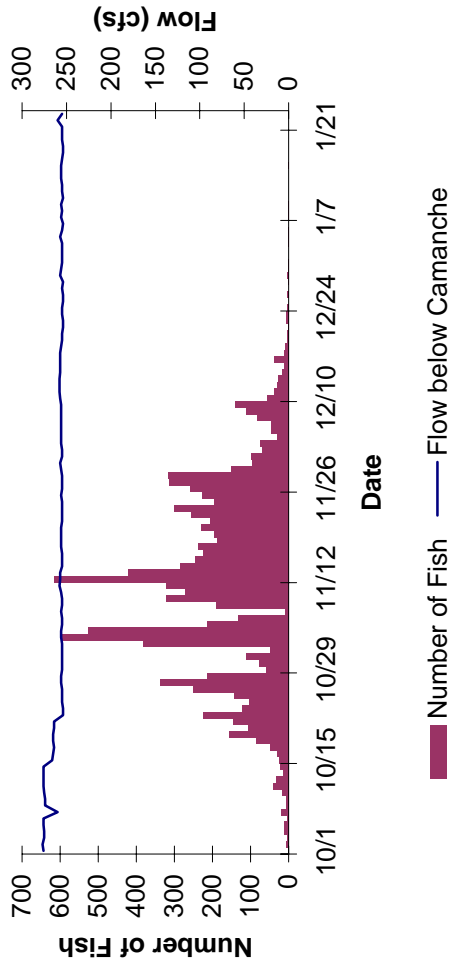


Figure 6a. Daily abundance of chinook salmon passing Woodbridge Irrigation District Dam and flow, October 1, 2004-January 21, 2005.



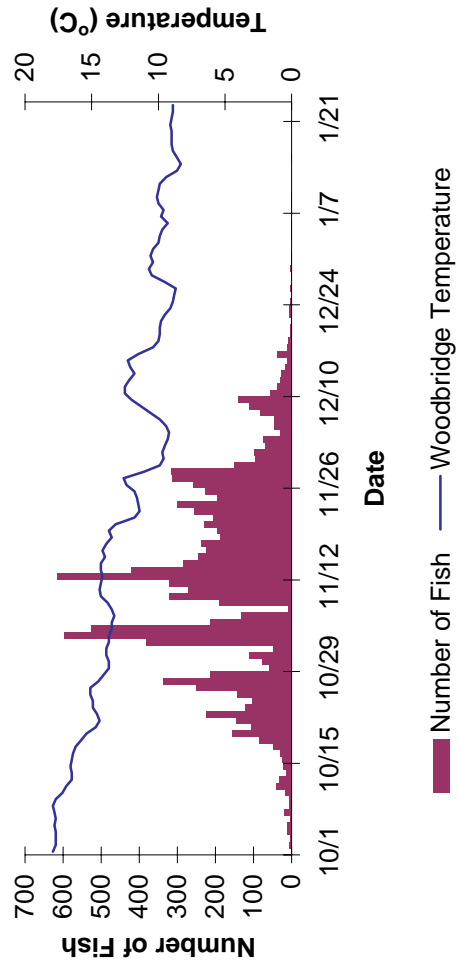
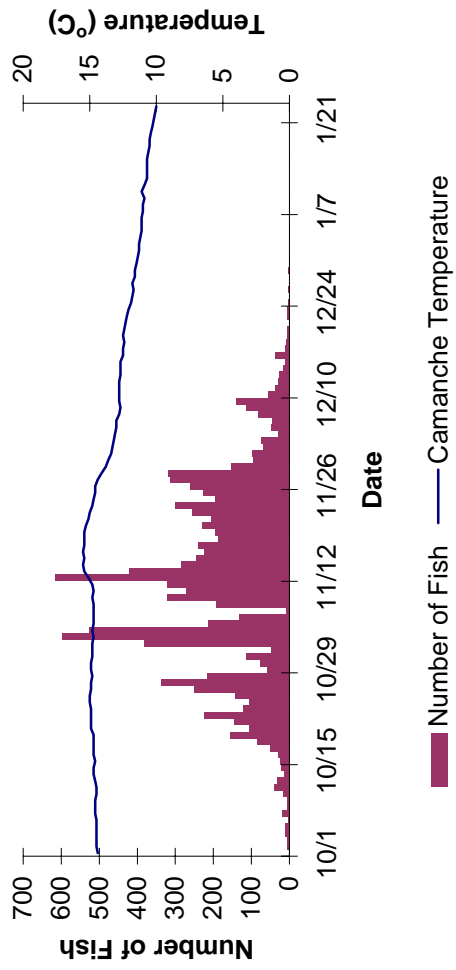


Figure 6b. Daily abundance of chinook salmon passing Woodbridge Irrigation District Dam and temperature, October 1, 2004-January 21, 2005.

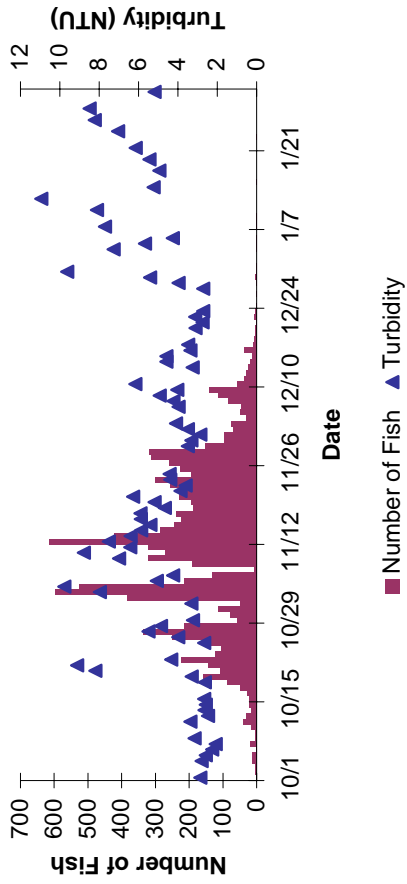


Figure 6c. Daily abundance of chinook salmon passing Woodbridge Irrigation District Dam and turbidity, October 1, 2004-January 21, 2005.

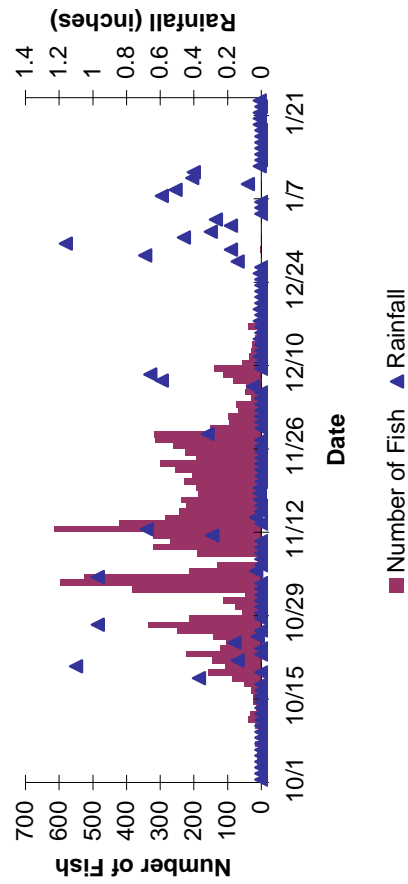


Figure 6d. Daily abundance of chinook salmon passing Woodbridge Irrigation District Dam and rainfall, October 1, 2004-January 21, 2005.

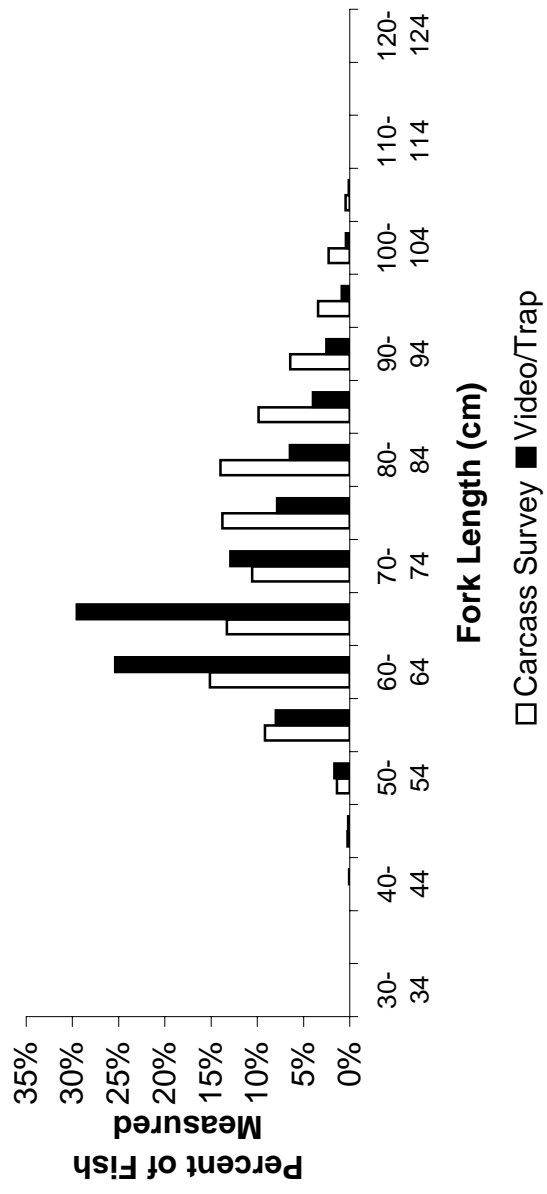


Figure 7. Comparison of length frequency data for chinook salmon from video/trap monitoring and carcass surveys on the lower Mokolumne River, Ca. 2004.

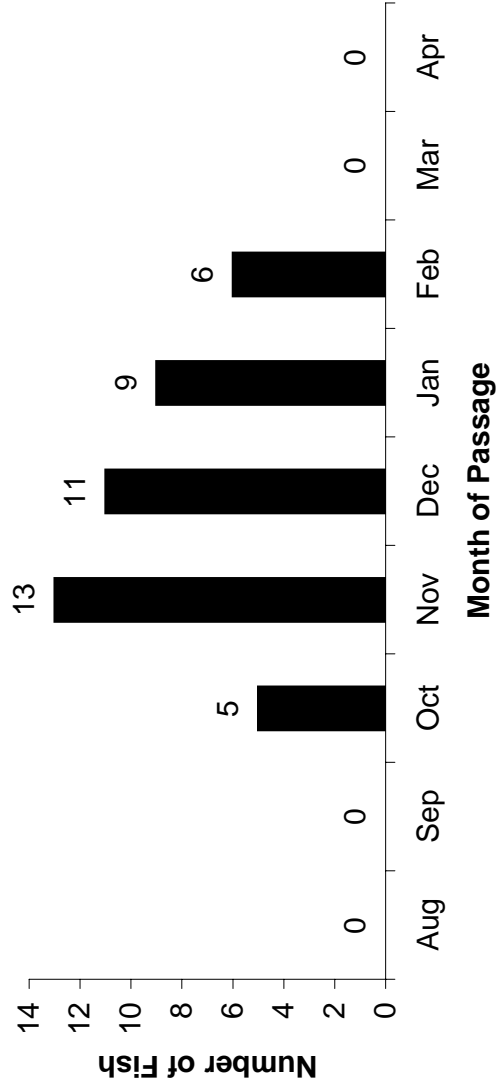


Figure 8. Monthly upstream passage of adult steelhead observed in the fish ladders at Woodbridge Irrigation District Dam on the lower Mokelumne River, Ca. 2004/2005.

## **Acknowledgements**

I would like to thank the field crew of Robyn Bilski, Charles Hunter, Matthew Saldate, Jason Shillam, and Ed Rible for their hard work and dedication to accurate data collection, data storage, and data retrieval. Thanks to Woodbridge Irrigation District for access to the site. Thanks to California Department of Fish and Game, Elk Grove Screen Shop, for their quick response and assistance with maintenance issues in the fish ladders. I would also like to thank EBMUD Fisheries and Wildlife Division staff for assistance on the project as needed.

## Literature Cited

- Arnason, A.N., C.J. Schwarz, and G. Boyer. 1998. POPAN-5: A data maintenance and analysis system for mark-recapture data. Scientific Report, Department of Computer Science, University of Manitoba, Winnipeg.
- Bayer, J.M., T.C. Robinson, and J.G. Seelye. 2001. Upstream migration of Pacific lampreys in the John Day River: behavior, timing, and habitat use. Annual Report. USGS Biological Resources Division. For: US Dept. of Energy Bonneville Power Administration. 45pp.
- Bell, M.C. 1991. Fisheries handbook of engineering requirements and biological criteria. Army Corps of Engineers. Portland, Oregon.
- Brown, L. R. and P.B. Moyle. 1993. Distribution, ecology, and status of the fishes of the San Joaquin River drainage, California. California Fish and Game. 79 (3): 96-114.
- Caywood, M.L. 1974. Contributions to the life history of the splittail (*Pogonichthys macrolepidotus*) (Ayres). Master's Thesis. California State University, Sacramento.
- Close, D.A., M. Fitzpatrick, H. Li, B. Parker, D. Hatch, G. James. 1995. Status Report of the Pacific Lamprey (*Lampetra tridentata*) in the Columbia River Basin. US Dept. of Energy. BPA Project Number 94-026. 35pp.
- East Bay Municipal Utility District. Unpublished Data. Fish community database. Lodi Fisheries and Wildlife Office. Lodi, Ca.
- Hallock, R.J. and D.H. Fry Jr. 1967. Five species of salmon, *Oncorhynchus*, on the Sacramento River, California. Calif. Fish and Game. 53:5-22.
- Hallock, R.J. 1989. Upper Sacramento River steelhead, *Oncorhynchus mykiss*, 1952-1988. Report to the US Fish and Wildlife Service. 85pp.
- Healey, M.C. 1991. Life History of Chinook Salmon (*Oncorhynchus tshawytscha*) pp313-393. IN: C. Groot and Margolis, L. eds. Pacific Salmon Life Histories. UC Press. Vancouver. 564pp.
- Interagency Ecological Program. Steelhead Project WorkTeam. 1999. Monitoring, Assessment, and research on Central Valley Steelhead: Status of Knowledge, Review of Existing Programs, and Assessment of Needs. Technical Appendix VII-A-11. CMARP Recommendations for the Implementation and Continued Refinement of a Comprehensive Monitoring, Assessment, and Research Program, March 10, 1999. 37pp
- Kelso, J.R.M. and W.M. Gardner. 2000. Emigration, upstream migration, and habitat use by sterile and fertile sea lampreys in three Lake Superior tributaries. N.Amer. J. Fish. Manage. 20:144-153.

- Marine, K.R. and D.A. Vogel. 2000. Monitoring of the upstream spawning migration of Chinook salmon and steelhead during August 1999 through March 2000. The Mokelumne River Chinook Salmon and Steelhead Monitoring Program 1998-1999. Natural Resource Scientists, Inc. Red Bluff, California. 48pp. (plus appendices)
- Moyle, P.B. 2002. Inland Fishes of California Revised and Expanded. University of California Press. Berkeley. Ca. 502pp.
- Moyle, P.B., J.E. Williams, and E.D. Wikramanayake. 1989. Fish Species of Special Concern of California. California Dept. of Fish and Game. Inland Fisheries Division. Contract report No. 7337. 222pp.
- Salo, E.O. 1991. Life History of Chum Salmon (*Oncorhynchus keta*). Pp. 231-309. IN: Groot, C. and L. Margolis, *eds.* Pacific Salmon Life Histories. UC Press. Vancouver. 564pp.
- Szerlong, Glenn. NOAA Fisheries Research Associate. Personal Communication.
- Workman, M.L. 2002. Lower Mokelumne River Upstream Fish Migration Monitoring conducted at Woodbridge Irrigation District Dam August 2001 through July 2002. Unpublished EBMUD report. Lodi, CA 20pp + Appendix.
- Workman, M.L. 2003. Lower Mokelumne River Upstream Fish Migration Monitoring conducted at Woodbridge Irrigation District Dam August 2002 through July 2003. Unpublished EBMUD report. Lodi, CA 18pp + Appendix.
- Workman, M.L. 2004. Lower Mokelumne River Upstream Fish Migration Monitoring conducted at Woodbridge Irrigation District Dam August 2003 through July 2004. Unpublished EBMUD report. Lodi, CA 23pp + Appendix.

Date	Chinook Salmon										Steelhead											
	Adult		Unknown adult		Grilse		Grilse		Unknown grilse		Unknown sex and size		Total		Male		Female		Unknown		Total	
	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female
10/1/2004	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10/2/2004	1	1	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10/3/2004	1	0	0	0	3	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10/4/2004	1	1	0	0	9	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10/5/2004	2	2	0	0	5	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
10/6/2004	0	3	0	0	1	-1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10/7/2004	3	1	0	0	9	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10/8/2004	1	1	0	0	2	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
10/9/2004	1	3	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10/10/2004	7	0	0	0	8	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10/11/2004	6	3	0	0	26	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10/12/2004	3	3	0	0	16	9	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10/13/2004	5	1	0	0	4	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10/14/2004	3	2	0	0	12	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10/15/2004	3	0	0	0	17	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10/16/2004	3	5	0	0	15	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10/17/2004	8	7	0	0	25	7	0	0	-1	0	0	0	0	0	0	0	0	0	0	0	0	0
10/18/2004	10	8	0	0	38	22	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10/19/2004	13	5	0	0	27	11	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10/20/2004	22	6	8	8	11	4	52	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10/21/2004	36	9	38	38	20	4	31	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10/22/2004	24	12	-1	-1	46	12	46	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10/23/2004	19	6	3	3	20	7	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10/24/2004	34	6	2	2	21	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10/25/2004	11	9	1	1	36	13	0	0	-1	0	0	0	0	0	0	0	0	0	0	0	0	0
10/26/2004	0	1	23	23	9	8	15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10/27/2004	6	4	9	9	4	6	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10/28/2004	0	1	1	1	6	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10/29/2004	14	8	1	1	6	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10/30/2004	36	9	0	0	23	11	-1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10/31/2004	28	15	0	0	58	11	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11/1/2004	18	7	3	3	20	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0



Appendix A. Daily passage of Chinook salmon and steelhead at Woodbridge Dam (cont.). October 1, 2004 -July 31, 2005.

Date	Chinook Salmon						Steelhead								
	Adult Male	Adult Female	Unknown adult	Grilse Male	Grilse Female	Total	Unknown grilse	Unknown Male	Unknown Female	Unknown sex and size	Total	Male	Female	Unknown	Total
11/2/2004	193	75	0	92	23	0	0	0	0	0	383	0	0	0	0
11/3/2004	312	85	0	149	52	0	0	0	0	0	598	0	0	0	0
11/4/2004	265	92	0	109	61	0	0	0	0	0	527	0	0	0	0
11/5/2004	91	38	0	64	21	0	0	0	0	0	214	0	0	2	2
11/6/2004	72	13	0	35	12	0	0	0	0	0	132	0	0	0	0
11/7/2004	0	0	0	0	0	0	0	0	9	0	9	0	0	0	0
11/8/2004	81	49	0	47	15	0	0	0	0	0	192	0	0	0	0
11/9/2004	145	61	0	87	29	0	0	0	0	0	322	0	0	0	0
11/10/2004	142	62	0	53	15	0	0	0	0	0	272	0	0	0	0
11/11/2004	148	62	0	87	24	0	0	0	0	0	321	0	0	0	0
11/12/2004	306	156	0	118	35	0	0	0	0	0	615	0	0	0	0
11/13/2004	202	90	0	89	41	0	0	0	0	0	422	0	0	0	0
11/14/2004	146	46	0	68	25	0	0	0	0	0	285	0	1	0	1
11/15/2004	115	53	0	60	17	0	0	0	0	0	245	0	1	0	1
11/16/2004	90	55	2	46	30	1	0	0	0	0	224	0	0	0	0
11/17/2004	100	55	0	64	20	0	0	0	0	0	239	0	0	0	0
11/18/2004	99	48	0	26	15	0	0	0	0	0	188	0	0	0	0
11/19/2004	89	48	0	42	16	0	0	0	0	0	195	0	0	0	0
11/20/2004	68	36	0	36	18	0	0	0	72	0	230	0	0	0	0
11/21/2004	86	34	-1	75	12	0	0	0	0	0	206	1	0	0	1
11/22/2004	118	50	0	64	21	2	0	0	1	0	256	1	0	1	2
11/23/2004	105	57	0	92	47	0	0	0	0	0	301	0	0	0	0
11/24/2004	91	55	0	26	20	3	0	0	0	0	195	0	2	1	3
11/25/2004	84	64	0	55	22	0	0	0	1	0	226	0	0	1	1
11/26/2004	110	77	4	31	30	8	0	0	0	0	260	0	0	0	0
11/27/2004	17	5	3	0	4	6	10	5	264	0	314	0	0	0	0
11/28/2004	122	54	1	37	17	1	0	0	86	0	318	0	0	0	0
11/29/2004	65	39	0	29	19	0	0	0	0	0	152	0	0	0	0
11/30/2004	51	29	0	12	3	0	0	0	0	0	95	0	0	1	1
12/1/2004	36	22	0	20	19	0	0	0	1	0	98	0	0	0	0
12/2/2004	31	18	0	15	5	0	0	0	0	0	69	0	0	0	0
12/3/2004	18	19	0	22	16	0	0	0	0	0	75	0	0	0	0

Appendix A. Daily passage of Chinook salmon and steelhead at Woodbridge Dam (cont.). October 1, 2004 -July 31, 2005.

Date	Chinook Salmon				Steelhead				
	Adult Male	Adult Female	Unknown adult	Unknown sex and size	Total	Male	Female	Unknown	Total
12/4/2004	13	6	1	0	31	0	2	1	3
12/5/2004	24	17	0	0	47	0	0	2	2
12/6/2004	14	11	0	0	46	0	0	0	0
12/7/2004	25	39	0	0	83	0	0	0	0
12/8/2004	31	49	0	0	113	0	0	0	0
12/9/2004	42	54	0	0	140	0	0	1	1
12/10/2004	22	23	0	0	57	0	0	0	0
12/11/2004	12	18	1	0	37	0	0	0	0
12/12/2004	6	10	0	0	31	0	0	1	1
12/13/2004	5	15	0	0	27	0	0	0	0
12/14/2004	5	9	0	0	18	0	0	0	0
12/15/2004	5	5	0	0	13	0	0	0	0
12/16/2004	21	12	0	0	38	0	0	0	0
12/17/2004	5	6	0	0	11	0	0	0	0
12/18/2004	1	5	0	0	8	0	0	0	0
12/19/2004	2	1	0	0	5	0	0	0	0
12/20/2004	2	3	0	0	5	0	0	0	0
12/21/2004	0	2	0	0	2	0	0	0	0
12/22/2004	3	4	0	0	7	0	0	0	0
12/23/2004	2	3	0	0	6	0	0	0	0
12/24/2004	0	2	0	0	3	1	0	0	1
12/25/2004	0	0	0	0	0	0	1	0	1
12/26/2004	0	2	0	0	3	0	0	0	0
12/27/2004	0	0	0	0	0	0	0	0	0
12/28/2004	0	1	1	-1	1	0	0	0	0
12/29/2004	4	0	0	0	4	0	0	2	2
12/30/2004	0	1	0	0	1	0	0	0	0
12/31/2004	0	1	0	0	1	0	0	0	0
1/1/2005	0	0	0	0	0	0	0	0	0
1/2/2005	0	0	0	0	0	0	0	0	0
1/3/2005	1	0	0	0	1	1	0	0	3
1/4/2005	0	2	0	0	2	0	0	0	0

Appendix A. Daily passage of Chinook salmon and steelhead at Woodbridge Dam (cont.). October 1, 2004 -July 31, 2005.

Date	Chinook Salmon				Steelhead				
	Adult Male	Adult Female	Unknown adult	Unknown sex and size	Total	Male	Female	Unknown	Total
1/5/2005	0	1	0	0	1	0	1	0	1
1/6/2005	0	0	0	0	0	0	0	0	0
1/7/2005	0	1	0	0	1	0	0	0	0
1/8/2005	0	1	0	0	1	0	0	0	0
1/9/2005	1	0	0	0	1	0	0	0	0
1/10/2005	0	0	0	0	0	0	0	0	0
1/11/2005	0	0	0	0	0	0	0	0	0
1/12/2005	0	0	0	0	0	0	0	0	0
1/13/2005	0	0	0	0	0	0	0	0	0
1/14/2005	0	0	0	0	0	0	0	0	0
1/15/2005	0	1	0	0	1	0	0	0	0
1/16/2005	0	0	0	0	0	1	0	1	2
1/17/2005	0	0	0	0	0	0	0	1	1
1/18/2005	0	0	0	0	0	0	0	0	0
1/19/2005	0	0	0	0	0	0	0	0	0
1/20/2005	0	0	0	0	0	0	1	0	1
1/21/2005	0	0	0	0	0	0	0	0	0
1/22/2005	0	0	0	0	0	0	0	0	0
1/23/2005	0	0	0	1	1	0	0	0	0
1/24/2005	0	0	0	0	0	0	0	0	0
1/25/2005	0	0	0	0	0	0	0	0	0
1/26/2005	0	0	0	0	0	0	0	0	0
1/27/2005	0	0	0	0	0	1	0	0	1
1/28/2005	0	0	0	0	0	0	0	0	0
1/29/2005	0	0	0	0	0	0	0	0	0
1/30/2005	0	0	0	0	0	0	0	0	0
1/31/2005	0	0	0	0	0	0	0	0	0
2/1/2005	0	0	0	0	0	0	0	1	1
2/2/2005	0	0	0	0	0	1	0	0	1
2/3/2005	0	0	0	0	0	0	0	0	0
2/4/2005	0	0	0	0	0	0	0	0	0
2/5/2005	0	0	0	0	0	0	0	0	0

Appendix A. Daily passage of Chinook salmon and steelhead at Woodbridge Dam (cont.). October 1, 2004 -July 31, 2005.

Date	Chinook Salmon				Steelhead			
	Adult Male	Adult Female	Unknown adult	Total	Male	Female	Unknown	Total
2/6/2005	0	0	0	0	0	0	0	0
2/7/2005	0	0	0	0	0	0	2	2
2/8/2005	0	0	0	0	0	0	0	0
2/9/2005	0	0	0	0	0	0	0	0
2/10/2005	0	0	0	0	0	0	1	1
2/11/2005	0	0	0	0	0	0	0	0
2/12/2005	0	0	0	0	0	0	0	0
2/13/2005	0	0	0	0	0	0	0	0
2/14/2005	0	0	0	0	0	0	0	0
2/15/2005	0	0	0	0	0	0	0	0
2/16/2005	0	0	0	0	0	0	0	0
2/17/2005	0	0	0	0	0	0	0	0
2/18/2005	0	0	0	0	0	0	0	0
2/19/2005	0	0	0	0	0	0	0	0
2/20/2005	0	0	0	0	0	0	0	0
2/21/2005	0	0	0	0	0	0	1	1
2/22/2005	0	0	0	0	0	0	0	0
2/23/2005	0	0	0	0	0	0	0	0
2/24/2005	0	0	0	0	0	0	0	0
2/25/2005	0	0	0	0	0	0	0	0
2/26/2005	0	0	0	0	0	0	0	0
2/27/2005	0	0	0	0	0	0	0	0
2/28/2005	0	0	0	0	0	0	0	0
3/1/2005	0	0	0	0	0	0	0	0
3/2/2005	0	0	0	0	0	0	0	0
3/3/2005	0	0	0	0	0	0	0	0
3/4/2005	0	0	0	0	0	0	0	0
3/5/2005	0	0	0	0	0	0	0	0
3/6/2005	0	0	0	0	0	0	0	0
3/7/2005	0	0	0	0	0	0	0	0
3/8/2005	0	0	0	0	0	0	0	0
3/9/2005	0	0	0	0	0	0	0	0

Appendix A. Daily passage of Chinook salmon and steelhead at Woodbridge Dam (cont.). October 1, 2004 -July 31, 2005.

Date	Chinook Salmon										Steelhead			
	Adult		Unknown adult	Grilse		Unknown grilse	Unknown		Unknown sex and size	Total	Male	Female	Unknown	Total
	Male	Female		Male	Female		Male	Female						
3/10/2005	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3/11/2005	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3/12/2005	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3/13/2005	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3/14/2005	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3/15/2005	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3/16/2005	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3/17/2005	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3/18/2005	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3/19/2005	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3/20/2005	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3/21/2005	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3/22/2005	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3/23/2005	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3/24/2005	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3/25/2005	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3/26/2005	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3/27/2005	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3/28/2005	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3/29/2005	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3/30/2005	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3/31/2005	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4/1/2005	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4/2/2005	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4/3/2005	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4/4/2005	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4/5/2005	0	0	0	0	0	0	0	0	0	0	0	0	0	0

\*\*\*\* No monitoring due to construction

Appendix A. Daily passage of Chinook salmon and steelhead at Woodbridge Dam (cont.). October 1, 2004 - July 31, 2005.

Date	Chinook Salmon			Steelhead			Total	Unknown sex and size	Total	Male	Female	Unknown	Total	
	Adult Male	Adult Female	Unknown adult	Grilse Male	Grilse Female	Unknown grilse								Unknown Male
7/19/2005	0	0	0	0	0	0	0	0	0	0	0	0	0	
7/20/2005	0	0	0	0	0	0	0	0	0	0	0	0	0	
7/21/2005	0	0	0	0	0	0	0	0	0	0	0	0	0	
7/22/2005	0	2	0	0	1	0	3	0	0	0	0	0	0	
7/23/2005	0	0	0	0	0	0	0	0	0	0	0	0	0	
7/24/2005	0	0	0	0	0	0	0	0	0	0	0	0	0	
7/25/2005	0	0	0	0	1	0	1	0	0	0	0	0	0	
7/26/2005	0	2	0	0	0	0	2	0	0	0	0	0	0	
7/27/2005	0	0	0	0	0	0	0	0	0	0	0	0	0	
7/28/2005	0	0	0	0	0	0	0	0	0	0	0	0	0	
7/29/2005	0	1	0	0	0	0	1	0	0	0	0	0	0	
7/30/2005	0	1	0	0	1	0	2	0	0	0	0	0	0	
7/31/2005	0	1	0	0	0	0	1	0	0	0	0	0	0	
Totals 10/1-4/5	4,163	2,091	100	2,353	979	188	8	5	1,529	11,416	8	11	25	44
(*) =total 7/19-7/31		(7)			(3)									