Downstream Fish Migration Monitoring at Woodbridge Irrigation District Dam Lower Mokelumne River, December 2005 through July 2006

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Keywords: lower Mokelumne River, Chinook salmon, steelhead, juvenile monitoring, migration

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SUMMARY

One rotary screw trap was operated downstream of the Lower Sacramento Road Bridge crossing on the lower Mokelumne River from December 19, 2005 through July 28, 2006, and captured 26,578 naturally produced young-of-year (YOY) Chinook salmon (*Oncorhynchus tshawytscha*) and 49 YOY (FL <150 mm) steelhead (*O. mykiss*). In addition to natural production this year, one hatchery volitional release of 103,178 hatchery fingerling Chinook was made of which 244 were captured.

The first YOY Chinook salmon was captured on December 21, 2005. The estimate of abundance for naturally produced YOY Chinook salmon passing WIDD from December 21, 2005 through July 28,2006 is 1,197,778 (95% CI:883,225-2,174,338). Estimated fry and smolt passing WIDD were 1,008,289 and 179,264, respectively.

The first YOY steelhead (*O. mykiss*) was captured on May 26, 2006. Estimated abundance of YOY steelhead based on salmon trap calibrations was 9,750 (95% CI: 4,462-16,918). In addition, 8 wild, age 1+ steelhead were captured between December and March ranging in size from 109-229 mm FL ($\bar{X}$ =165 mm). A hatchery volitional release of 21,181 Mokelumne origin, adclipped, 1+ steelhead was made on February 23rd. Sixty-seven adclipped steelhead ranging in size from 173-303 mm FL ($\bar{X}$ = 232mm) were captured between February 28th and May 24th.

Twenty-five fish species were recorded in the rotary screw traps. The most common species, in order of abundance, were Chinook salmon, prickly sculpin (*Cottus asper*), common carp (*Cyprinus carpio*), and redear sunfish (*Lepomis microlophus*).

Camanche release during the monitoring period ranged from 331 cubic feet per second (cfs) (9.37 cubic meters per second (m^3/s)) to 4999 cfs (141.55 m^3/s).

INTRODUCTION

East Bay Municipal Utility District (EBMUD) has been monitoring the lower Mokelumne River (LMR) juvenile salmonid emigration since 1990 (Bianchi et al 1992, Marine 2000). Most adult salmonid spawning on the LMR occurs in the first 10 river miles (16 km) downstream of Camanche Dam. The screw traps are operated at river mile

39 (RKM 63) below Woobridge Irrigation District Dam (WIDD) to assess juvenile emigration. WIDD is approximately 15 river miles (24 km) below the lowest extent of salmonid spawning habitat. This report presents the monitoring results for rotary screw trap operations from December 2005 through July 2006.

OBJECTIVES

The objectives of this study are to:

1) Monitor the abundance and emigration patterns of naturally produced anadromous salmonids on the lower Mokelumne River past Woodbridge Irrigation District Dam;
2) Monitor the annual emigration pattern of Chinook salmon fry and smolts;
3) Monitor movement patterns and timing of all fish species utilizing the LMR from January through July; and
4) Monitor the migration patterns of a volitional release of hatchery reared Chinook salmon.

METHODS

Rotary Screw traps

One 8-foot diameter (2.4 m) rotary screw trap (EG Solutions, Inc.) was operated below the Lower Sacramento Road Bridge on the lower Mokelumne River. Due to fish ladder and dam construction at Woodbridge Irrigation District Dam (WIDD), trap placement was in the same location as 2005, approximately 1/8 mile (201 m) downstream of the location used from 1993-2004 (Figure 1). The trap was checked twice daily, 5 days per week, and not operated on the weekends. Estimates were generated for the non-trapping days (two daytime periods and three nighttime periods) by averaging the catch (and rounding to the nearest 1 fish) for three days before and after the non-trapping period. These non-trapping periods are represented by shaded areas in Appendices A and B, and are included in day and night estimate totals, but not included in day and night catch totals. Efforts were made to operate the trap to maintain a rotational speed of two rotations per minute (RPM) or greater (USFWS 1997). Rotations were measured using a stopwatch to record the time for three full rotations. RPMs were taken at each trap check. Trap cables were adjusted to optimize rotations. Morning checks were conducted within one hour of sunrise, and evening checks were conducted within one hour of sunset.

Cone rotations since the previous trap check were read off of a Remington® mechanical counter mounted on side rails near the mouth of the cone, and the counter was reset to zero. Turbidity samples were collected by submerging an inverted sample jar to a depth of 1 foot (0.3 m) and then allowing it to fill with water. Temperature, DO and turbidity samples were taken at the downstream end of the screw trap. Water samples for turbidity were read in the lab on a Hach ®P1000 turbidimeter. The trap was cleared of debris and fish were offloaded into 5 gallon (19 liter) buckets. Pontoons, cones, live boxes, and decks were scrubbed each day to reduce algal build up and maintain trap rotation. The cables, pulleys, counter, and cone were inspected daily to ensure proper function.

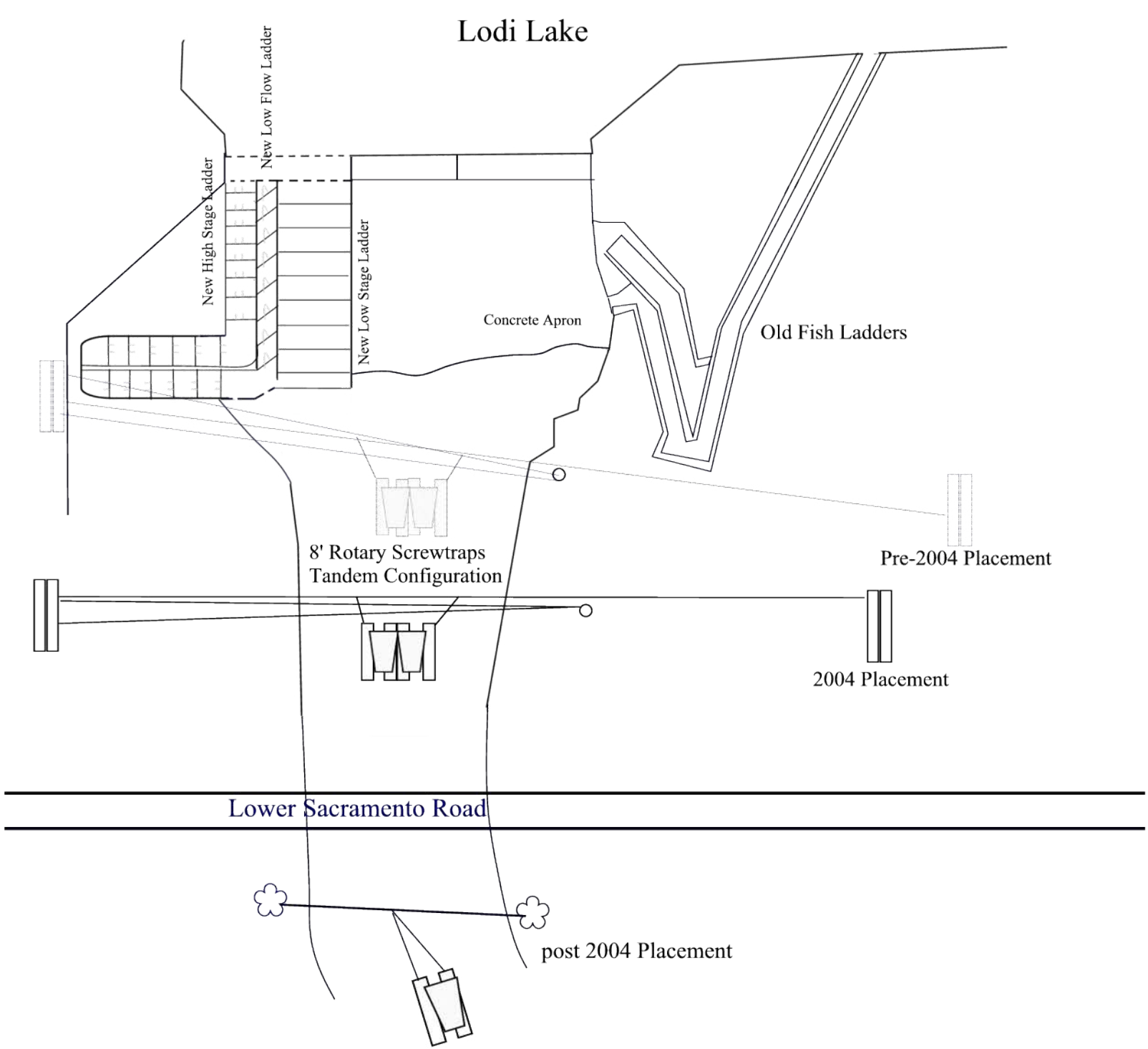

Figure 1. 2006 placement of a single eight foot diameter rotary screw trap on the lower Mokelumne River.

Fish Handling
Fish were processed on the trap. Clove oil was used to anesthetize fish. Fish were anesthetized and the first 50 Chinook salmon and the first 20 of any other species recovered from the trap were weighed to the nearest 0.1 gram with an Ohaus® Scout portable scale and measured to the nearest millimeter. Life stage of each fish and any observations of marks, injuries or anomalies were recorded. Fish were allowed to recover in oxygenated water and were then transported by boat, via 5 gallon (19 liter) buckets equipped with battery operated aerators, to the lower Mokelumne River just downstream of the Lower Sacramento Road Bridge. Release locations varied within a 250 meter (820 ft) area to reduce predation on released fish.

Calibrations
Calibration tests using hatchery produced Chinook were conducted to assess what portion of emigrating Chinook were being caught in the traps. Eighteen calibration tests for Chinook salmon captures were conducted at the WIDD spill release location, consisting of nine nighttime tests and nine daytime tests. Calibration fish were marked using caudal clips or Bismark brown® chemical stain.

Fish were held overnight in troughs at the Mokelumne River Fish Hatchery (MRFH). Mark retention and mortality rates were determined before releasing the fish. Releases were conducted after the morning trap check for the am release (between 8:00 am and 10:00 am), and at full darkness for the pm release (between 6:00 pm and 9:00 pm). Fish were released below Woodbridge Dam and distributed proportionally to the flow along the face of the dam.

RESULTS/DISCUSSION

Chinook salmon
During monitoring 26,578 naturally produced juvenile Chinook salmon were captured. Estimates for weekend catch were added to actual catch to produce a count of 50,672 to which the trap efficiencies were applied to develop the overall estimate. The estimate of abundance for naturally produced juvenile fall-run Chinook salmon passing WIDD from December 21, 2005 through July 28, 2005 is 1,197,778 (95% CI:883,225-2,174,338). This estimate consists of 1,008,289 fry and 179,264 smolts. Captures were classified as fry for all dates when average fork length did not exceed 60 mm. This was the case until April 6, 2005. Smolt numbers are based on the period of April 6th to July 28th (Figure 2).

A subsample of juvenile salmon were weighed, measured and described to lifestage as fry, parr, silvery parr, or smolt based on appearance. Average fork length (FL) for measured fry was 34.8 mm (30-40 mm, n=2,476); parr averaged 39.3 mm (34-59 mm, n=580), silvery parr averaged 59.1 mm (42-140 mm, n=62) and smolts were 100.0 mm (60-158 mm, n=758) on average. Average condition factor (weight in grams/fork length in mm^3 x 100,000) ranged from 0.55 for fry in December to 1.26 for parr in May (Figures 3 and 4).

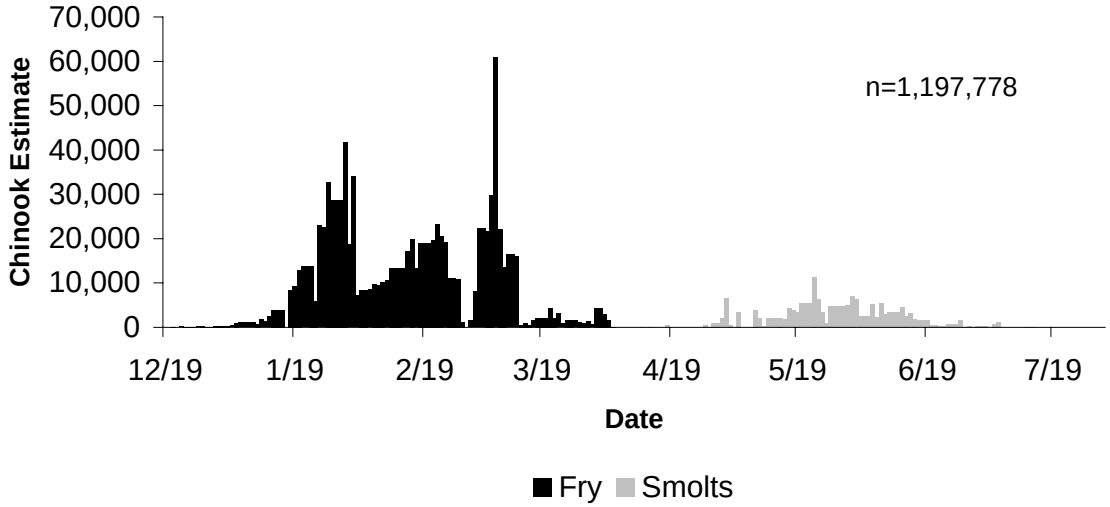

Figure 2. Estimated abundance of young-of-year Chinook salmon emigrating out of the lower Mokelumne River from December 19, 2005 through July 28, 2006.

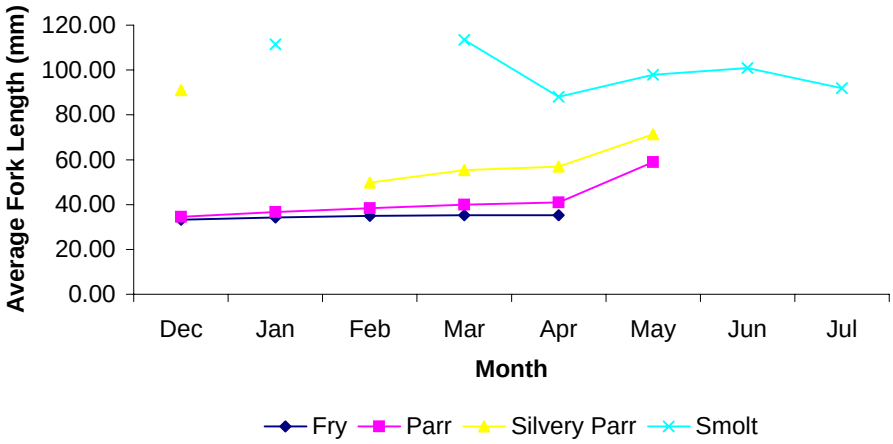

Figure 3. Average fork length (mm) of juvenile Chinook salmon lifestages by month, on the lower Mokelumne River from December 19, 2005 through July 28, 2006.

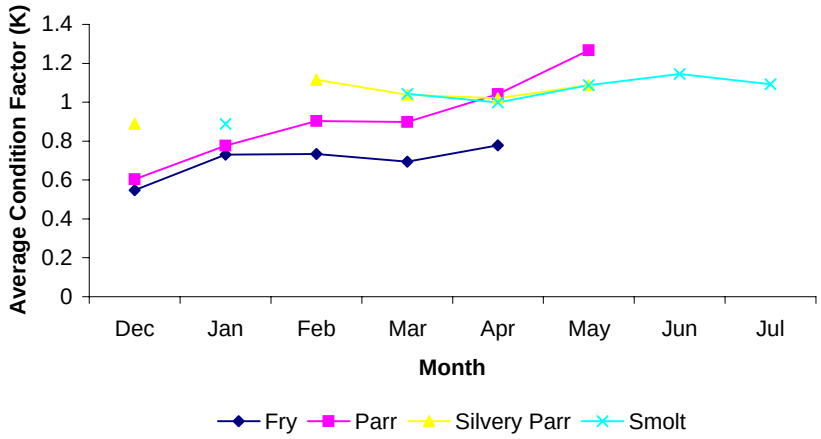

Figure 4. Average condition factor (K) of juvenile Chinook salmon lifestages by month, on the lower Mokelumne River from December 19, 2005 through July 28, 2006.

During the 147 days of trap operation the minimum recorded rotational speed was 1.4 RPM and maximum was 6.0. Average rotational speed over the course of the monitoring season was 3.86 RPM, which is above the CAMP recommended minimum rotation of 2 RPM. In only 2 days in February did an RPM < 2.0 occur this year during monitoring. The low numbers of yearling smolts could be related to the relatively high flows this spring, and having only one trap operating.

Camanche release during the monitoring period ranged from 331 cfs (9.37 m^3/s) to 4,999 cfs (141.55 m^3/s), $\bar{x}$ =2,357 cfs (66.74 m^3/s) (Figures 5 and 6).

Water temperatures recorded at Camanche Dam during the monitoring period were between 9.9 and 15.9 ^oC, with an average of 12.3 ^oC. Daily water temperature recorded at WIDD ranged from 9.7 to 17.9 ^oC with an average of 12.6 ^oC very similar to the 2005 monitoring season and around 2 ^oC cooler than 2004(Workman 2004, 2005) (Figures 7 and 8).

Young-of-year Chinook emigration numbers were compared to flow, temperature, turbidity, and precipitation both graphically and statistically (Figures 5-10). Simple linear regressions explained little of the total variation in daily abundance of fish as a function of the environmental variables examined. The R^2 values for flow below Camanche and below Woodbridge compared to fish numbers were each $R^2 < 0.02$ ($p < 0.05$). The R^2 values for temperature below Camanche and below Woodbridge compared to fish numbers were each $R^2 < 0.20$ ($p < 0.0001$) and no statistical relationship between precipitation or turbidity with fish movement was observed. Combined effect of flow below Woodbridge and temperature at Woodbridge explained 22% of the variability in daily fish numbers, $R^2 = 0.22$ ($p< 0.0001$).

Diel Abundance

Nocturnal passage accounted for 97% of estimated emigration at the screw traps, up from 92% last year (Workman 2005). This was consistent across the entire monitoring period. Very few fish were captured during the day (Figure 11).

Calibrations

Rotary screw trap efficiencies for Chinook salmon ranged from 0.001 to 0.072 (Table 1). The number of calibration fish released ranged from 878-2,062 fish per release. Efficiencies were low all trapping season, due to flood control releases throughout the spring. Daily catch numbers and associated calibration coefficients (trap efficiencies), for Chinook salmon, are presented in Appendix A.

Volitional Release of Hatchery Chinook

On May 1, 2006 a group of 103,178 coded wire tagged and adipose-fin clipped chinook fingerlings was allowed to volitionally leave the Mokelumne River Fish Hatchery just below Camanche Dam. The first of the volitional release fish was picked up in the screw traps on the morning of May 3, 2006. Over the monitoring period we captured 244 of these fish. The estimate of abundance for the volitional release was 75,835 (Figure 12). Data are in Appendix A.

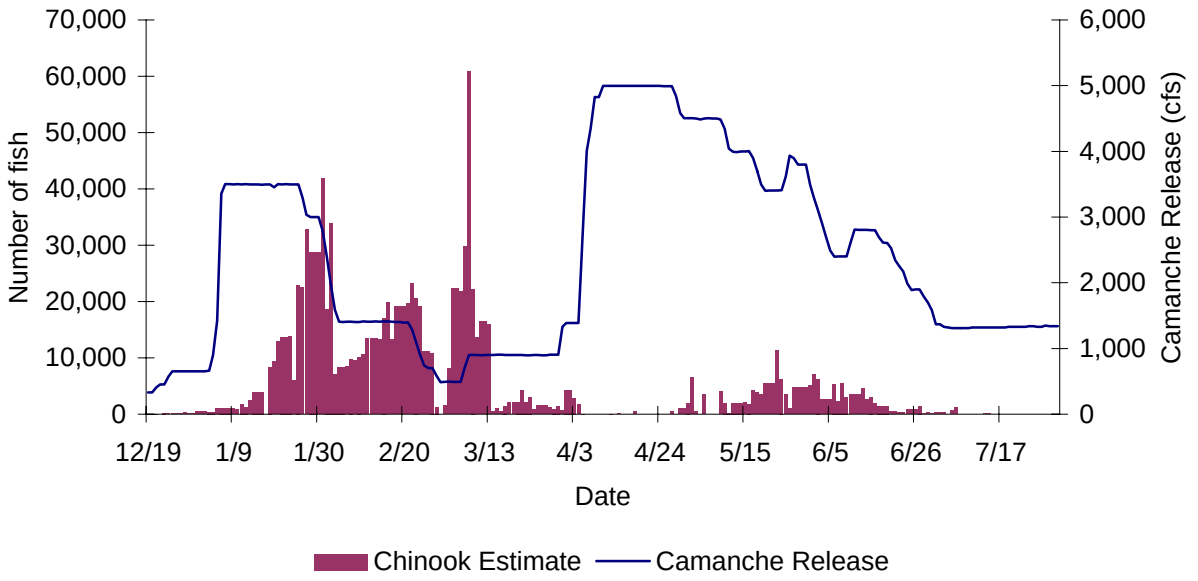

Figure 5. Juvenile Chinook salmon emigration on the lower Mokelumne River and Camanche release flows, December 19, 2005 - July 28, 2006.

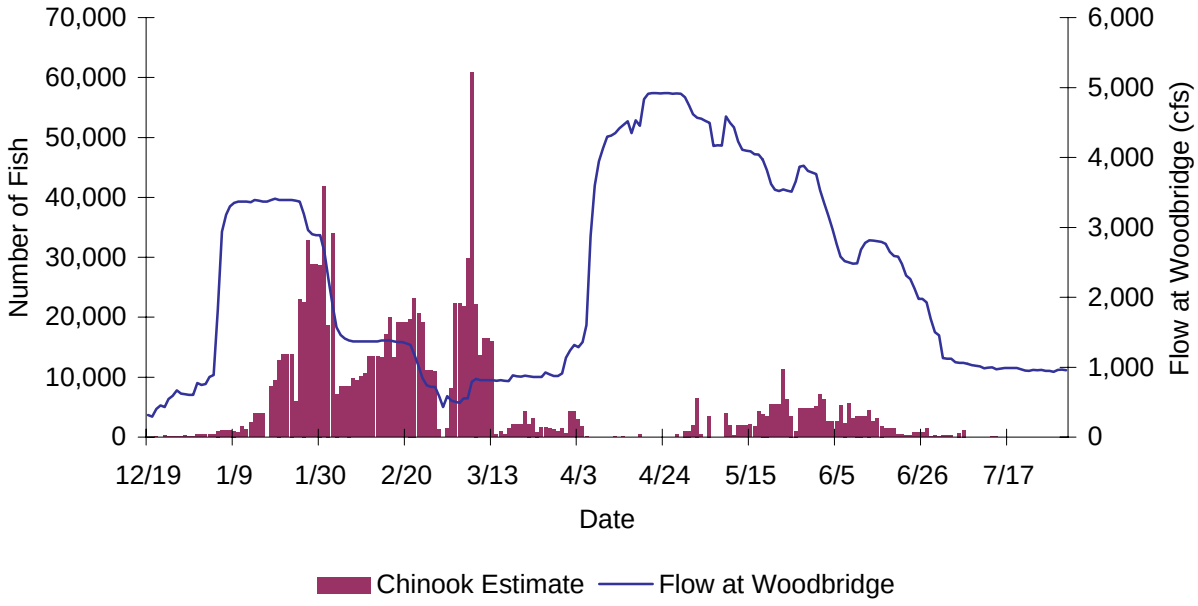

Figure 6. Juvenile Chinook salmon emigration on the lower Mokelumne River and flow at Woodbridge, December 19, 2005 - July 28, 2006.

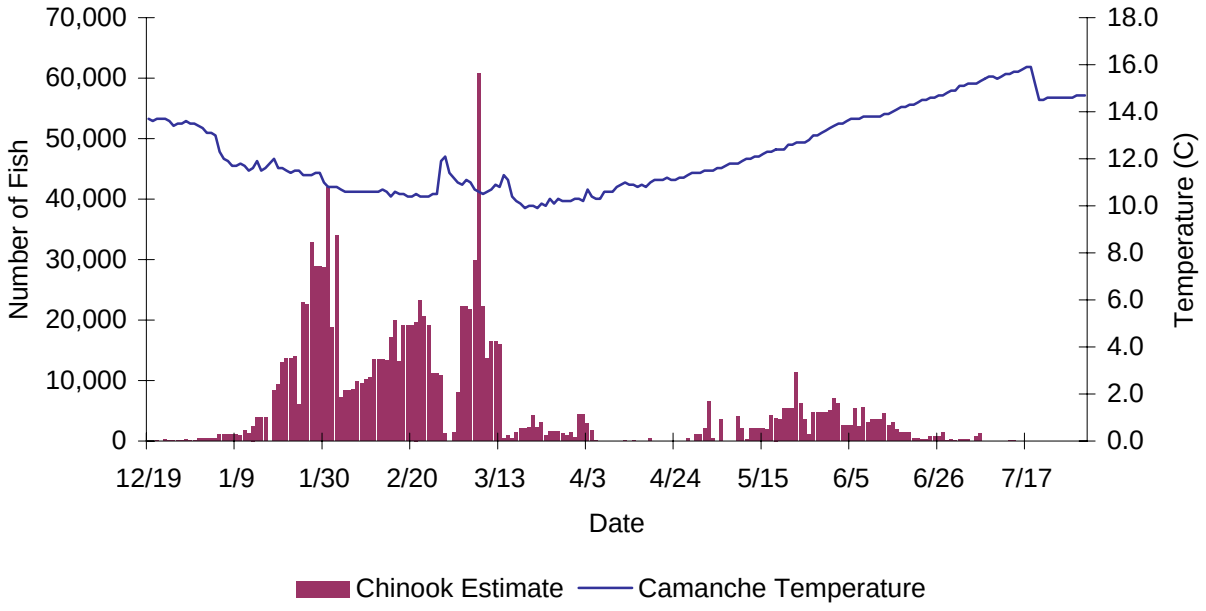

Figure 7. Juvenile Chinook salmon emigration on the lower Mokelumne River and Camanche release temperatures, December 19, 2005 - July 28, 2006.

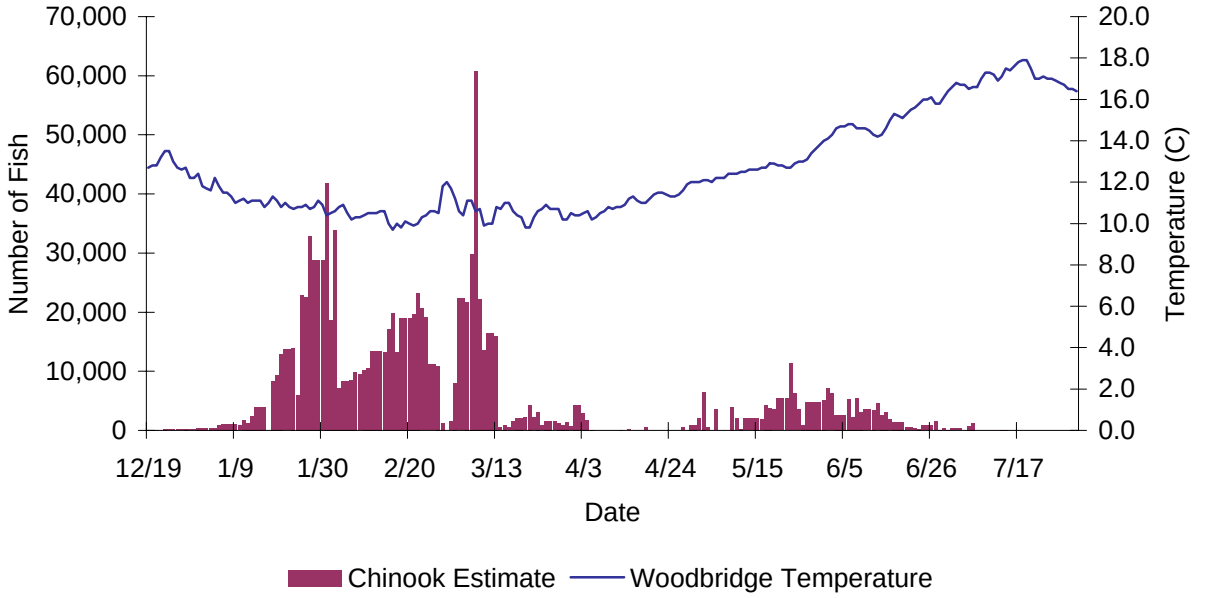

Figure 8. Juvenile Chinook salmon emigration on the lower Mokelumne River and temperature at Woodbridge, December 19, 2005 - July 28, 2006.

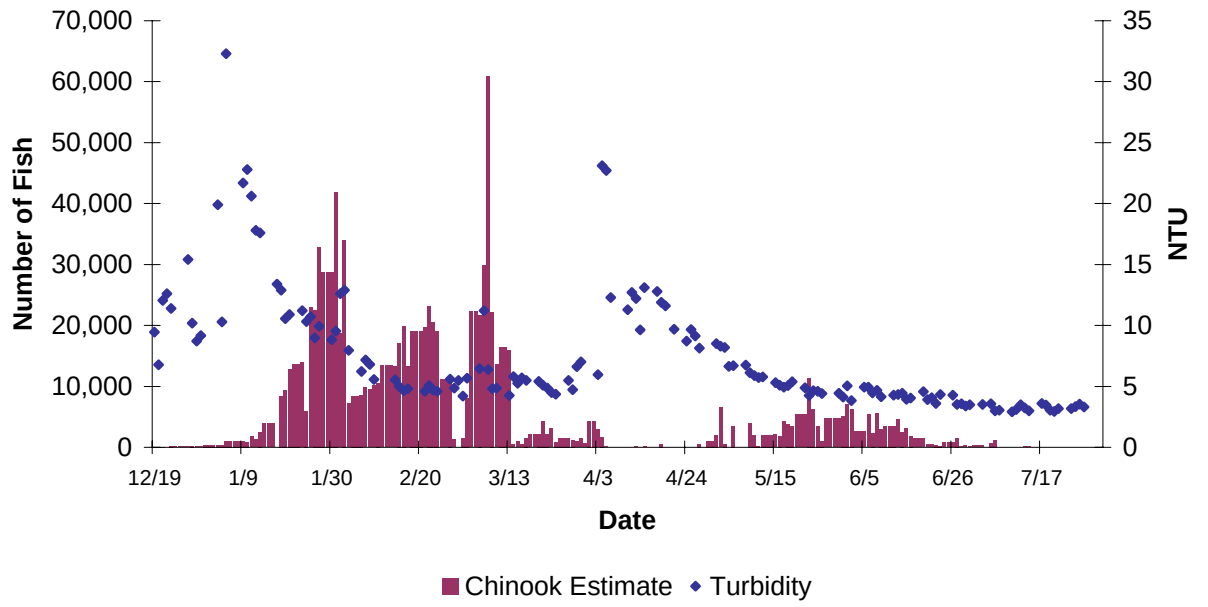

Figure 9. Juvenile Chinook salmon emigration on the lower Mokelumne River and turbidity, December 19, 2005 - July 28, 2006.

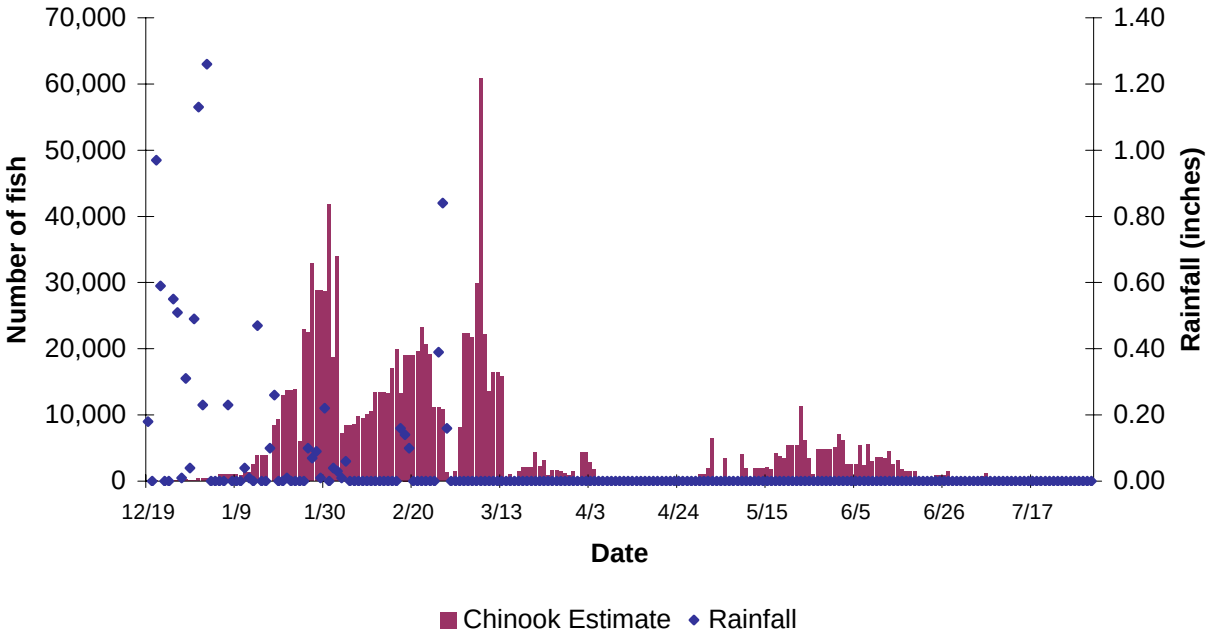

Figure 10. Juvenile Chinook salmon emigration on the lower Mokelumne River and precipitation, December 19, 2005 - July 28, 2006.

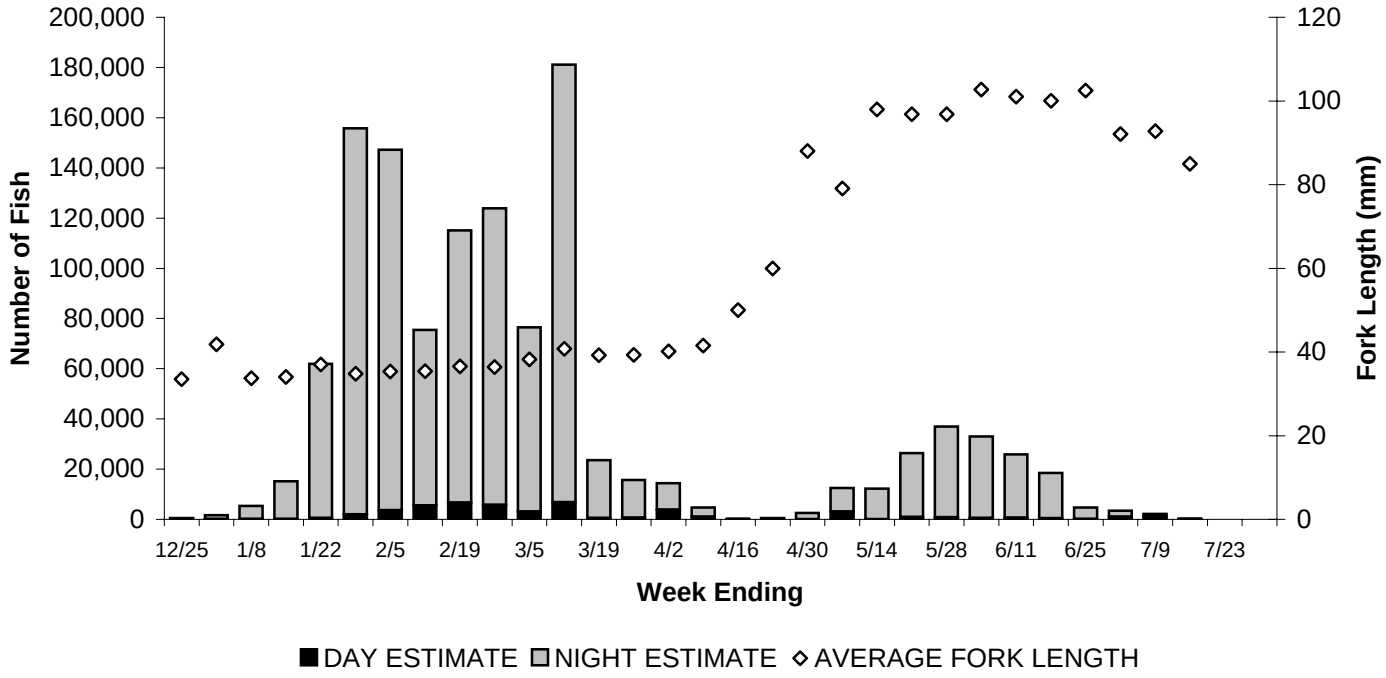

Figure 11. Weekly diel abundance of young-of-year Chinook salmon emigrating past Woodbridge Irrigation District Dam from December 19, 2005 through July 28, 2006.

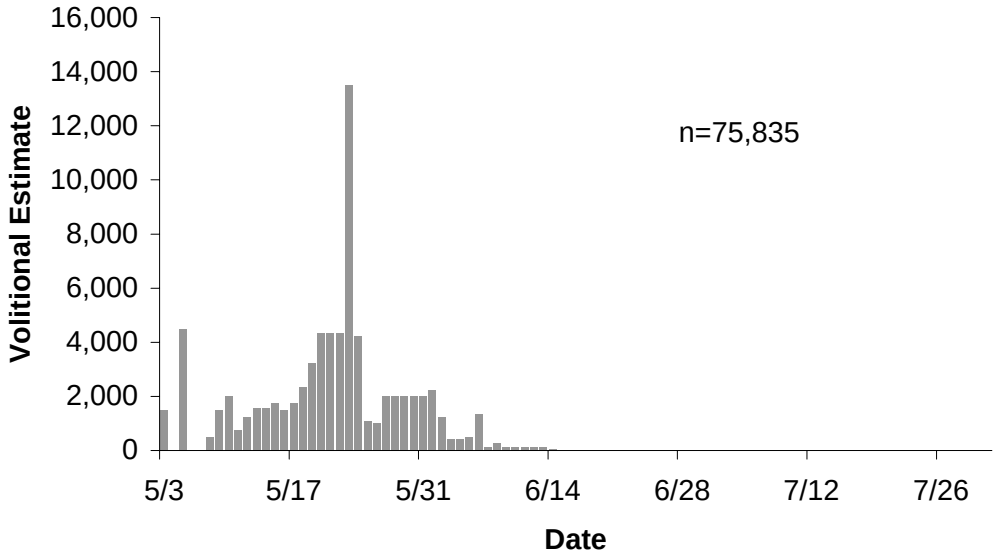

Figure 12. Pattern of emigration of juvenile Chinook salmon volitionally released from the Mokelumne River Fish Hatchery beginning on 5/1/2006.

Table 1. Trap efficiency test results for rotary screw traps fished at Woodbridge Irrigation District Dam, December 19, 2005 through July 28, 2006.

Date	Release Site	Day Release		Night Release		Trap Efficiency		Flow	Fish Size
		Marked	Recaptured	Marked	Recaptured	Day	Night	(cfs)	(mm)
1/24/06	WIDD Basin	999	55	1021	15	0.055	0.015	3498	38.5
2/14/06	WIDD Basin	1030	45	1012	63	0.044	0.062	1409	36.9
3/7/06	WIDD Basin	1008	72	989	71	0.071	0.072	714	37.4
4/3/06	WIDD Basin	1016	7	1012	12	0.007	0.012	1389	38.4
4/17/06	WIDD Basin	2062	0	2045	4	0.000	0.002	4996	62.6
5/1/06	WIDD Basin	2038	2	2015	5	0.001	0.002	4503	94.6
5/16/06	WIDD Basin	2000	23	2051	8	0.012	0.004	4003	98.7
6/6/06	WIDD Basin	1018	35	1019	36	0.034	0.035	2396	100.8
7/10/06	WIDD Basin	887	1	878	10	0.001	0.011	1256	92.6

Steelhead

Fifty-one YOY steelhead were captured in rotary screw traps from May through July. The estimate for young-of-year steelhead during this period, based on Chinook calibrations, is 9,750 (95% C.I:4,462-16,918). Data are in Appendix B.

Young-of-year steelhead were described to lifestage as parr or silvery parr. No fry were captured by rotary screw trap for 2006. Parr averaged 70.6 mm FL (37-102 mm, n=44). Silvery parr averaged 87.4 mm FL (76-100 mm, n=5). In addition, 75 age 1+ steelhead were captured between December and May. These fish averaged 224 mm FL (109-303 mm). Sixty-seven of these steelhead were adipose-fin clipped and CWT that were released volitionally from the MRFH beginning on February 23, 2006.

Incidental Species

Twenty-five fish observed in rotary screw traps were identified to species. Some juvenile black bass, and centrarchid hybrids were only identified to genus. Eight native species and 17 non native species were captured. The most abundant fish observed were Chinook salmon, followed by prickly sculpin, common carp and redear sunfish (Table 2).

Acknowledgements

I would like to thank the field staff of Charles Hunter, Ed Rible, Matthew Saldate, and Jason Shillam 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. I would also like to thank my coworkers in the EBMUD Fisheries and Wildlife Division for their assistance on the project as needed.

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Appendix A. Daily abundance of juvenile chinook salmon migrating past Woodbridge Irrigation District Dam, December 19, 2005-July28, 2006. Shaded areas represent estimates for non-trapping periods.

Date	YOY Day	YOY Night	Trap Efficiency Day	Trap Efficiency Night	Estimated YOY Day	Estimated YOY Night	Estimated YOY Total	95% Confidence Interval Low	95% Confidence Interval High	Volitional Release Catch Total	Volitional Release Estimate
12/19/2005	0	0	0.055	0.015	0	0	0	0	0		
12/20/2005	0	0	0.055	0.015	0	0	0	0	0		
12/21/2005	0	1	0.055	0.015	0	68	68	45	137		
12/22/2005	0	0	0.055	0.015	0	0	0	0	0		
12/23/2005	0	3	0.055	0.015	0	204	204	136	410		
12/24/2005	0	2	0.055	0.015	0	136	136	91	274		
12/25/2005	0	2	0.055	0.015	0	136	136	91	274		
12/26/2005	0	2	0.055	0.015	0	136	136	91	274		
12/27/2005	1	2	0.055	0.015	18	136	154	105	298		
12/28/2005	0	4	0.055	0.015	0	272	272	181	547		
12/29/2005	0	2	0.055	0.015	0	136	136	91	274		
12/30/2005	1	2	0.055	0.015	18	136	154	105	298		
12/31/2005	1	6	0.055	0.015	18	408	427	286	845		
1/1/2006	1	6	0.055	0.015	18	408	427	286	845		
1/2/2006	1	6	0.055	0.015	18	408	427	286	845		
1/3/2006	0	6	0.055	0.015	0	408	408	272	821		
1/4/2006	0	6	0.055	0.015	0	408	408	272	821		
1/5/2006	2	14	0.055	0.015	36	953	989	663	1964		
1/6/2006	2	15	0.055	0.015	36	1021	1057	709	2100		
1/7/2006	2	15	0.055	0.015	36	1021	1057	709	2100		
1/8/2006	2	15	0.055	0.015	36	1021	1057	709	2100		
1/9/2006	1	15	0.055	0.015	18	1021	1039	694	2076		
1/10/2006	4	11	0.055	0.015	73	749	821	556	1602		
1/11/2006	2	26	0.055	0.015	36	1770	1806	1207	3605		
1/12/2006	0	19	0.055	0.015	0	1293	1293	861	2599		
1/13/2006	1	36	0.055	0.015	18	2450	2469	1646	4948		
1/14/2006	1	57	0.055	0.015	18	3880	3898	2597	7821		
1/15/2006	1	57	0.055	0.015	18	3880	3898	2597	7821		
1/16/2006	1	57	0.055	0.015	18	3880	3898	2597	7821		
1/17/2006	0	0	0.055	0.015	0	0	0	0	0		
1/18/2006	1	123	0.055	0.015	18	8372	8390	5587	16848		

Appendix A. Daily abundance of juvenile chinook salmon migrating past Woodbridge Irrigation District Dam, December 19, 2005-July28, 2006. Shaded areas represent estimates for non-trapping periods.

Date	YOY Day	YOY Night	Trap Efficiency Day	Trap Efficiency Night	Estimated YOY Day	Estimated YOY Night	Estimated YOY Total	95% Confidence Interval Low	95% Confidence Interval High	Volitional Release Catch Total	Volitional Release Estimate
1/19/2006	4	137	0.055	0.015	73	9325	9398	6265	18836		
1/20/2006	5	188	0.055	0.015	91	12797	12887	8590	25836		
1/21/2006	9	199	0.055	0.015	163	13545	13709	9146	27438		
1/22/2006	9	199	0.055	0.015	163	13545	13709	9146	27438		
1/23/2006	19	199	0.055	0.015	345	13545	13890	9291	27682		
1/24/2006	14	84	0.055	0.015	254	5718	5972	4008	11831		
1/25/2006	13	334	0.055	0.015	236	22734	22970	15320	46000		
1/26/2006	11	328	0.055	0.015	200	22326	22526	15020	45130		
1/27/2006	14	479	0.055	0.015	254	32604	32858	21904	65856		
1/28/2006	18	418	0.055	0.015	327	28452	28779	19199	57611		
1/29/2006	18	418	0.055	0.015	327	28452	28779	19199	57611		
1/30/2006	15	418	0.055	0.015	272	28452	28724	19155	57538		
1/31/2006	38	605	0.055	0.015	690	41180	41871	27960	83677		
2/1/2006	18	270	0.055	0.015	327	18378	18705	12493	37369		
2/2/2006	22	493	0.055	0.015	400	33557	33956	22654	67967		
2/3/2006	24	413	0.044	0.062	549	6634	7184	5781	9488		
2/4/2006	30	479	0.044	0.062	687	7694	8381	6744	11074		
2/5/2006	30	479	0.044	0.062	687	7694	8381	6744	11074		
2/6/2006	37	479	0.044	0.062	847	7694	8541	6868	11298		
2/7/2006	43	551	0.044	0.062	984	8851	9835	7908	13011		
2/8/2006	33	544	0.044	0.062	755	8739	9494	7640	12542		
2/9/2006	20	604	0.044	0.062	458	9702	10160	8186	13393		
2/10/2006	31	613	0.044	0.062	710	9847	10556	8499	13935		
2/11/2006	37	785	0.044	0.062	847	12610	13457	10835	17759		
2/12/2006	37	785	0.044	0.062	847	12610	13457	10835	17759		
2/13/2006	37	785	0.044	0.062	847	12610	13457	10835	17759		
2/14/2006	29	785	0.044	0.062	664	12610	13274	10693	17502		
2/15/2006	52	991	0.044	0.062	1190	15919	17109	13773	22588		
2/16/2006	58	1157	0.044	0.062	1328	18585	19913	16031	26285		
2/17/2006	18	799	0.044	0.062	412	12835	13247	10678	17445		
2/18/2006	47	1120	0.044	0.062	1076	17991	19067	15356	25151		
2/19/2006	47	1120	0.044	0.062	1076	17991	19067	15356	25151		

Appendix A. Daily abundance of juvenile chinook salmon migrating past Woodbridge Irrigation District Dam, December 19, 2005-July28, 2006. Shaded areas represent estimates for non-trapping periods.

Date	YOY Day	YOY Night	Trap Efficiency Day	Trap Efficiency Night	Estimated YOY Day	Estimated YOY Night	Estimated YOY Total	95% Confidence Interval Low	95% Confidence Interval High	Volitional Release Catch Total	Volitional Release Estimate
2/20/2006	47	1120	0.044	0.062	1076	17991	19067	15356	25151		
2/21/2006	74	1120	0.044	0.062	1694	17991	19685	15837	26017		
2/22/2006	54	1369	0.044	0.062	1236	21991	23227	18708	30633		
2/23/2006	25	1247	0.044	0.062	572	20031	20603	16611	27128		
2/24/2006	23	1157	0.044	0.062	526	18585	19112	15408	25164		
2/25/2006	22	777	0.071	0.072	308	10823	11131	9094	14346		
2/26/2006	22	777	0.071	0.072	308	10823	11131	9094	14346		
2/27/2006	4	777	0.071	0.072	56	10823	10879	8888	14021		
2/28/2006	4	85	0.071	0.072	56	1184	1240	1013	1598		
3/1/2006	no check	734	0.071	0.072	n/a	10224	10224	8352	13177		
3/2/2006	39	69	0.071	0.072	546	961	1507	1232	1941		
3/3/2006	24	556	0.071	0.072	336	7745	8081	6602	10414		
3/4/2006	76	1524	0.071	0.072	1064	21229	22293	18212	28729		
3/5/2006	76	1524	0.071	0.072	1064	21229	22293	18212	28729		
3/6/2006	37	1524	0.071	0.072	518	21229	21747	17766	28027		
3/7/2006	138	2003	0.071	0.072	1932	27901	29833	24373	38445		
3/8/2006	141	4226	0.071	0.072	1974	58866	60840	49704	78408		
3/9/2006	39	1555	0.071	0.072	546	21660	22206	18142	28619		
3/10/2006	49	927	0.071	0.072	686	12913	13599	11110	17525		
3/11/2006	41	1139	0.071	0.072	574	15866	16440	13431	21187		
3/12/2006	41	1139	0.071	0.072	574	15866	16440	13431	21187		
3/13/2006	4	1139	0.071	0.072	56	15866	15922	13007	20520		
3/14/2006	6	29	0.071	0.072	84	404	488	399	629		
3/15/2006	4	65	0.071	0.072	56	905	961	785	1239		
3/16/2006	0	34	0.071	0.072	0	474	474	387	610		
3/17/2006	9	99	0.071	0.072	126	1379	1505	1230	1939		
3/18/2006	5	146	0.071	0.072	70	2034	2104	1719	2711		
3/19/2006	5	146	0.071	0.072	70	2034	2104	1719	2711		
3/20/2006	8	146	0.071	0.072	112	2034	2146	1753	2765		
3/21/2006	9	300	0.071	0.072	126	4179	4305	3517	5548		
3/22/2006	2	154	0.071	0.072	28	2145	2173	1775	2801		
3/23/2006	1	221	0.071	0.072	14	3078	3092	2526	3986		

Appendix A. Daily abundance of juvenile chinook salmon migrating past Woodbridge Irrigation District Dam, December 19, 2005-July28, 2006. Shaded areas represent estimates for non-trapping periods.

Date	YOY Day	YOY Night	Trap Efficiency Day	Trap Efficiency Night	Estimated YOY Day	Estimated YOY Night	Estimated YOY Total	95% Confidence Interval Low	95% Confidence Interval High	Volitional Release Catch Total	Volitional Release Estimate
3/24/2006	5	55	0.07	0.07179	70	766	836	683	1077		
3/25/2006	9	105	0.07	0.07179	126	1463	1589	1298	2047		
3/26/2006	9	105	0.07	0.07179	126	1463	1589	1298	2047		
3/27/2006	4	105	0.07	0.07179	56	1463	1519	1241	1957		
3/28/2006	1	86	0.07	0.07179	14	1198	1212	990	1562		
3/29/2006	41	24	0.07	0.07179	586	334	920	743	1169		
3/30/2006	12	92	0.07	0.07179	168	1282	1450	1184	1868		
3/31/2006	10	35	0.07	0.07179	140	488	628	513	808		
4/1/2006	10	35	0.01	0.012	1429	2917	4345	2724	12291		
4/2/2006	10	35	0.01	0.012	1429	2917	4345	2724	12291		
4/3/2006	0	35	0.01	0.012	0	2917	2917	1889	6746		
4/4/2006	7	9	0.01	0.012	1000	750	1750	1070	5616		
4/5/2006	0	1	0.01	0.012	0	83	83	54	193		
4/6/2006	0	0	0.01	0.012	0	0	0	0	0		
4/7/2006	0	0	0.01	0.012	0	0	0	0	0		
4/8/2006	0	0	0.01	0.012	0	0	0	0	0		
4/9/2006	0	0	0.01	0.012	0	0	0	0	0		
4/10/2006	0	0	0.01	0.012	0	0	0	0	0		
4/11/2006	0	0	0.01	0.012	0	0	0	0	0		
4/12/2006	0	1	0.01	0.012	0	83	83	54	193		
4/13/2006	0	0	0.01	0.012	0	0	0	0	0		
4/14/2006	1	0	0.01	0.012	143	0	143	83	555		
4/15/2006	0	0	0.01	0.012	0	0	0	0	0		
4/16/2006	0	0	0.01	0.012	0	0	0	0	0		
4/17/2006	0	0	0.00	0.002	0	0	0	0	0		
4/18/2006	0	1	0.00	0.002	0	500	500	258	24393		
4/19/2006	0	0	0.00	0.002	0	0	0	0	0		
4/20/2006	no check	no check	0.00	0.002	n/a	n/a	n/a	n/a	n/a		
4/21/2006	0	0	0.00	0.002	0	0	0	0	0		
4/22/2006	0	0	0.00	0.002	0	0	0	0	0		
4/23/2006	0	0	0.00	0.002	0	0	0	0	0		
4/24/2006	0	0	0.00	0.002	0	0	0	0	0		

Appendix A. Daily abundance of juvenile chinook salmon migrating past Woodbridge Irrigation District Dam, December 19, 2005-July28, 2006. Shaded areas represent estimates for non-trapping periods.

Date	YOY Day	YOY Night	Trap Efficiency Day	Trap Efficiency Night	Estimated YOY Day	Estimated YOY Night	Estimated YOY Total	95% Confidence Interval Low	95% Confidence Interval High	Volitional Release Catch Total	Volitional Release Estimate
4/25/2006	0	0	0.000	0.002	0	0	0	0	0		
4/26/2006	0	0	0.000	0.002	0	0	0	0	0		
4/27/2006	0	1	0.000	0.002	0	500	500	258	24393		
4/28/2006	0	0	0.001	0.002	0	0	0	0	0		
4/29/2006	0	2	0.001	0.002	0	1000	1000	430	6471		
4/30/2006	0	2	0.001	0.002	0	1000	1000	430	6471		
5/1/2006	1	2	0.001	0.002	1000	1000	2000	857	6471		
5/2/2006	2	9	0.001	0.002	2000	4500	6500	2788	29121		
5/3/2006	0	1	0.001	0.002	0	500	500	215	3236	3	1500
5/4/2006	0	0	0.001	0.002	0	0	0	0	0	0	0
5/5/2006	0	7	0.001	0.002	0	3500	3500	1504	22650	6	4500
5/6/2006	no check	no check	0.001	0.002	n/a	n/a	n/a	0	0	0	0
5/7/2006	no check	no check	0.001	0.002	n/a	n/a	n/a	0	0	0	0
5/8/2006	0	0	0.001	0.002	0	0	0	0	0	1	500
5/9/2006	0	8	0.001	0.002	0	4000	4000	1719	25885	3	1500
5/10/2006	0	4	0.001	0.002	0	2000	2000	860	12943	4	2000
5/11/2006	0	1	0.012	0.004	0	250	250	152	831	3	750
5/12/2006	0	8	0.012	0.004	0	2000	2000	1212	6651	5	1250
5/13/2006	0	8	0.012	0.004	0	2000	2000	1212	6651	7	1583
5/14/2006	0	8	0.012	0.004	0	2000	2000	1212	6651	7	1583
5/15/2006	1	8	0.012	0.004	83	2000	2083	1274	6797	9	1750
5/16/2006	1	7	0.012	0.004	83	1750	1833	1123	5966	6	1500
5/17/2006	3	16	0.012	0.004	250	4000	4250	2610	13741	9	1750
5/18/2006	1	15	0.012	0.004	83	3750	3833	2335	12617	10	2333
5/19/2006	0	14	0.012	0.004	0	3500	3500	2122	11639	13	3250
5/20/2006	2	21	0.012	0.004	167	5250	5417	3306	17751	18	4333
5/21/2006	2	21	0.012	0.004	167	5250	5417	3306	17751	18	4333
5/22/2006	2	21	0.012	0.004	167	5250	5417	3306	17751	18	4333
5/23/2006	7	43	0.012	0.004	583	10750	11333	6950	36773	56	13500
5/24/2006	0	25	0.012	0.004	0	6250	6250	3789	20783	17	4250

Appendix A. Daily abundance of juvenile chinook salmon migrating past Woodbridge Irrigation District Dam, December 19, 2005-July28, 2006. Shaded areas represent estimates for non-trapping periods.

Date	YOY Day	YOY Night	Trap Efficiency Day	Trap Efficiency Night	Estimated YOY Day	Estimated YOY Night	Estimated YOY Total	95% Confidence Interval Low	95% Confidence Interval High	Volitional Release Catch Total	Volitional Release Estimate
5/25/2006	0	14	0.012	0.004	0	3500	3500	2122	11639	5	1083
5/26/2006	0	4	0.012	0.004	0	1000	1000	606	3325	4	1000
5/27/2006	0	19	0.012	0.004	0	4750	4750	2880	15795	8	2000
5/28/2006	0	19	0.012	0.004	0	4750	4750	2880	15795	8	2000
5/29/2006	0	19	0.012	0.004	0	4750	4750	2880	15795	8	2000
5/30/2006	0	19	0.012	0.004	0	4750	4750	2880	15795	8	2000
5/31/2006	1	20	0.012	0.004	83	5000	5083	3093	16773	8	2000
6/1/2006	1	28	0.012	0.004	83	7000	7083	4305	23424	9	2250
6/2/2006	3	24	0.012	0.004	250	6000	6250	3823	20392	5	1250
6/3/2006	2	88	0.034	0.035	59	2514	2573	1930	3754	15	429
6/4/2006	2	88	0.034	0.035	59	2514	2573	1930	3754	15	429
6/5/2006	3	88	0.034	0.035	88	2514	2603	1952	3797	17	488
6/6/2006	2	185	0.034	0.035	59	5286	5345	4008	7797	47	1343
6/7/2006	1	81	0.034	0.035	29	2314	2344	1758	3419	4	115
6/8/2006	4	190	0.034	0.035	118	5429	5546	4159	8091	9	257
6/9/2006	7	100	0.034	0.035	206	2857	3063	2297	4470	4	114
6/10/2006	3	120	0.034	0.035	88	3429	3517	2637	5131	5	144
6/11/2006	3	120	0.034	0.035	88	3429	3517	2637	5131	5	144
6/12/2006	2	120	0.034	0.035	59	3429	3487	2615	5088	4	114
6/13/2006	2	157	0.034	0.035	59	4486	4545	3408	6630	4	116
6/14/2006	1	88	0.034	0.035	29	2514	2544	1908	3711	2	57
6/15/2006	4	104	0.034	0.035	118	2971	3089	2316	4507	0	0
6/16/2006	1	64	0.034	0.035	29	1829	1858	1393	2710	0	0
6/17/2006	2	50	0.034	0.035	59	1429	1487	1115	2170	0	0
6/18/2006	2	50	0.034	0.035	59	1429	1487	1115	2170	0	0
6/19/2006	2	50	0.034	0.035	59	1429	1487	1115	2170	0	0
6/20/2006	0	17	0.034	0.035	0	486	486	364	709	0	0
6/21/2006	1	16	0.034	0.035	29	457	487	365	710	0	0
6/22/2006	1	11	0.034	0.035	29	314	344	258	502	0	0
6/23/2006	0	9	0.03	0.04	0	257	257	193	375	0	0

Appendix A. Daily abundance of juvenile chinook salmon migrating past Woodbridge Irrigation District Dam, December 19, 2005-July28, 2006. Shaded areas represent estimates for non-trapping periods.

Date	YOY Day	YOY Night	Trap Efficiency Day	Trap Efficiency Night	Estimated YOY Day	Estimated YOY Night	Estimated YOY Total	95% Confidence Interval Low	95% Confidence Interval High	Volitional Release Catch Total	Volitional Release Estimate
6/24/2006	0	8	0.001	0.010	0	800	800	435	1830	0	0
6/25/2006	0	8	0.001	0.010	0	800	800	435	1830	0	0
6/26/2006	0	8	0.001	0.010	0	800	800	435	1830	0	0
6/27/2006	1	5	0.001	0.010	1000	500	1500	571	1144	0	0
6/28/2006	0	1	0.001	0.010	0	100	100	54	229	0	0
6/29/2006	0	3	0.001	0.010	0	300	300	163	686	0	0
6/30/2006	0	1	0.001	0.010	0	100	100	54	229	0	0
7/1/2006	0	3	0.001	0.010	0	300	300	163	686	0	0
7/2/2006	0	3	0.001	0.010	0	300	300	163	686	0	0
7/3/2006	0	3	0.001	0.010	0	300	300	163	686	0	0
7/4/2006	no check	no check	0.001	0.010	n/a	n/a	n/a	n/a	n/a	0	0
7/5/2006	0	7	0.001	0.010	0	700	700	380	1602	0	0
7/6/2006	1	2	0.001	0.010	1000	200	1200	408	458	0	0
7/7/2006	0	0	0.001	0.010	0	0	0	0	0	0	0
7/8/2006	0	0	0.001	0.010	0	0	0	0	0	0	0
7/9/2006	0	0	0.001	0.010	0	0	0	0	0	0	0
7/10/2006	0	0	0.001	0.010	0	0	0	0	0	0	0
7/11/2006	0	0	0.001	0.010	0	0	0	0	0	0	0
7/12/2006	0	0	0.001	0.010	0	0	0	0	0	0	0
7/13/2006	0	1	0.001	0.010	0	100	100	54	229	0	0
7/14/2006	0	1	0.001	0.010	0	100	100	54	229	0	0
7/15/2006	0	0	0.001	0.010	0	0	0	0	0	0	0
7/16/2006	0	0	0.001	0.010	0	0	0	0	0	0	0
7/17/2006	0	0	0.001	0.010	0	0	0	0	0	0	0
7/18/2006	0	0	0.001	0.010	0	0	0	0	0	0	0
7/19/2006	0	0	0.001	0.010	0	0	0	0	0	0	0
7/20/2006	0	0	0.001	0.010	0	0	0	0	0	0	0
7/21/2006	0	0	0.001	0.010	0	0	0	0	0	0	0
7/22/2006	0	0	0.001	0.010	0	0	0	0	0	0	0
7/23/2006	0	0	0.001	0.010	0	0	0	0	0	0	0
7/24/2006	0	0	0.001	0.010	0	0	0	0	0	0	0
7/25/2006	0	0	0.001	0.010	0	0	0	0	0	0	0

Appendix A. Daily abundance of juvenile chinook salmon migrating past Woodbridge Irrigation District Dam, December 19, 2005-July28, 2006. Shaded areas represent estimates for non-trapping periods.

Date	YOY Day	YOY Night	Trap Efficiency Day	Trap Efficiency Night	Estimated YOY Day	Estimated YOY Night	Estimated YOY Total	95% Confidence Interval Low	95% Confidence Interval High	Volitional Release Catch Total	Volitional Release Estimate
7/26/2006	0	0	0.001	0.01	0	0	0	0	0	0	0
7/27/2006	0	0	0.001	0.01	0	0	0	0	0	0	0
7/28/2006	0	0	0.001	0.01	0	0	0	0	0	0	0
Total Capture	1,362	25,263								244	
Total Estimate	2,084	48,588			48,537	1,149,241	1,197,778	883,225	2,174,338	407	75,835

Appendix B. Daily abundance of juvenile steelhead migrating past Woodbridge Irrigation District Dam, May 25, 2006-July 28, 2006. Shaded areas represent estimates for non-trapping periods.

Date	YOY Day	YOY Night	Trap Efficiency Day	Trap Efficiency Night	Estimated YOY Day	Estimated YOY Night	Estimated YOY Total	95% Confidence Interval Low	95% Confidence Interval High
5/25/2006	0	0	0.012	0.004	0	0	0	0	0
5/26/2006	0	1	0.012	0.004	0	250	250	152	831
5/27/2006	0	0	0.012	0.004	0	0	0	0	0
5/28/2006	0	0	0.012	0.004	0	0	0	0	0
5/29/2006	0	0	0.012	0.004	0	0	0	0	0
5/30/2006	0	0	0.012	0.004	0	0	0	0	0
5/31/2006	0	0	0.012	0.004	0	0	0	0	0
6/1/2006	0	0	0.012	0.004	0	0	0	0	0
6/2/2006	0	0	0.012	0.004	0	0	0	0	0
6/3/2006	0	0	0.034	0.035	0	0	0	0	0
6/4/2006	0	0	0.034	0.035	0	0	0	0	0
6/5/2006	0	0	0.034	0.035	0	0	0	0	0
6/6/2006	0	2	0.034	0.035	0	57	57	43	83
6/7/2006	0	2	0.034	0.035	0	57	57	43	83
6/8/2006	0	0	0.034	0.035	0	0	0	0	0
6/9/2006	0	3	0.034	0.035	0	86	86	64	125
6/10/2006	0	1	0.034	0.035	0	29	29	21	42
6/11/2006	0	1	0.034	0.035	0	29	29	21	42
6/12/2006	0	1	0.034	0.035	0	29	29	21	42
6/13/2006	0	0	0.034	0.035	0	0	0	0	0
6/14/2006	0	1	0.034	0.035	0	29	29	21	42
6/15/2006	0	1	0.034	0.035	0	29	29	21	42
6/16/2006	0	1	0.034	0.035	0	29	29	21	42
6/17/2006	0	1	0.034	0.035	0	29	29	21	42
6/18/2006	0	1	0.034	0.035	0	29	29	21	42
6/19/2006	0	1	0.034	0.035	0	29	29	21	42
6/20/2006	0	1	0.034	0.035	0	29	29	21	42
6/21/2006	0	2	0.034	0.035	0	57	57	43	83
6/22/2006	0	1	0.034	0.035	0	29	29	21	42
6/23/2006	0	1	0.03	0.04	0	29	29	21	42

Appendix B. Daily abundance of juvenile steelhead migrating past Woodbridge Irrigation District Dam, May 25, 2006-July 28, 2006. Shaded areas represent estimates for non-trapping periods.

Date	YOY Day	YOY Night	Trap Efficiency Day	Trap Efficiency Night	Estimated YOY Day	Estimated YOY Night	Estimated YOY Total	95% Confidence Interval Low	95% Confidence Interval High
6/24/2006	0	0	0.001	0.010	0	0	0	0	0
6/25/2006	0	0	0.001	0.010	0	0	0	0	0
6/26/2006	0	0	0.001	0.010	0	0	0	0	0
6/27/2006	0	0	0.001	0.010	0	0	0	0	0
6/28/2006	0	1	0.001	0.010	0	100	100	54	229
6/29/2006	0	0	0.001	0.010	0	0	0	0	0
6/30/2006	0	1	0.001	0.010	0	100	100	54	229
7/1/2006	0	2	0.001	0.010	0	200	200	109	458
7/2/2006	0	2	0.001	0.010	0	200	200	109	458
7/3/2006	1	2	0.001	0.010	1000	200	1200	408	1458
7/4/2006	0	0	0.001	0.010	0	0	0	0	0
7/5/2006	0	7	0.001	0.010	0	700	700	380	1602
7/6/2006	0	3	0.001	0.010	0	300	300	163	686
7/7/2006	0	6	0.001	0.010	0	600	600	326	1373
7/8/2006	0	2	0.001	0.010	0	200	200	109	458
7/9/2006	0	2	0.001	0.010	0	200	200	109	458
7/10/2006	0	2	0.001	0.010	0	200	200	109	458
7/11/2006	0	0	0.001	0.010	0	0	0	0	0
7/12/2006	0	1	0.001	0.010	0	100	100	54	229
7/13/2006	1	1	0.001	0.010	1000	100	1100	354	1229
7/14/2006	1	2	0.001	0.010	1000	200	1200	408	1458
7/15/2006	0	2	0.001	0.010	0	200	200	109	458
7/16/2006	0	2	0.001	0.010	0	200	200	109	458
7/17/2006	0	2	0.001	0.010	0	200	200	109	458
7/18/2006	0	5	0.001	0.010	0	500	500	272	1144
7/19/2006	0	2	0.001	0.010	0	200	200	109	458
7/20/2006	0	1	0.001	0.010	0	100	100	54	229
7/21/2006	0	1	0.001	0.010	0	100	100	54	229
7/22/2006	0	0	0.001	0.010	0	0	0	0	0
7/23/2006	0	0	0.001	0.010	0	0	0	0	0
7/24/2006	0	0	0.001	0.010	0	0	0	0	0
7/25/2006	0	0	0.001	0.010	0	0	0	0	0

Appendix B. Daily abundance of juvenile steelhead migrating past Woodbridge Irrigation District Dam, May 25, 2006-July 28, 2006. Shaded areas represent estimates for non-trapping periods.

Date	YOY Day	YOY Night	Trap Efficiency Day	Trap Efficiency Night	Estimated YOY Day	Estimated YOY Night	Estimated YOY Total	95% Confidence Interval Low	95% Confidence Interval High
7/26/2006	1	0	0.001	0.01	1000	0	1000	300	1000
7/27/2006	0	0	0.001	0.01	0	0	0	0	0
7/28/2006	0	0	0.001	0.01	0	0	0	0	0
Total Capture	4	47							
Total Estimate	4	71			4,000	5,750	9,750	4,463	16,918