Downstream Fish Migration Monitoring at Woodbridge Irrigation District Dam Lower Mokelumne River, January 2004 through June 2004

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SUMMARY

Two rotary screw traps, fished in tandem below Woodbridge Irrigation District Dam (WIDD) from January 27, 2004 through June 30, 2004, captured 6,420 naturally produced young-of-year (YOY) Chinook salmon (*Oncorhynchus tshawytscha*) and 35 YOY steelhead (*O. mykiss*). In addition to natural production this year, one hatchery volitional release of fingerling Chinook was made of which 7,551 were captured.

The first YOY Chinook salmon was captured on January 27, 2004. The estimate of abundance for naturally produced YOY Chinook salmon passing WIDD from January 27, 2004 through June 30, 2004 is 87,654 (95% CI:67,068-134,898). Estimated fry and smolt passing were 45,467 and 42,187, respectively.

The first YOY steelhead (*O. mykiss*) were captured in mid-March. Estimated abundance from screw trap captures based on trap calibrations was 736 steelhead. In addition, 93 age 1+ steelhead were captured between February and May ranging in size from 185 mm to 283 mm ($\bar{X}$ =208 mm).

Twenty-four fish species were recorded in the rotary screw traps. The most common species, in order of abundance, were Chinook salmon, black bass (*Micropterus sp*.), Pacific lamprey (*Lampetra tridentata*), and prickly sculpin (*Cottus asper*).

Camanche release during the monitoring period ranged from 341 cubic feet per second (cfs) (9.6 cubic meters per second (m^3/s)) to 1,350 cfs (38.2 m^3/s) ($\bar{X}$ =483 cfs (13.6 m^3/s)). A flood flow release was conducted in early May.

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). 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 January 2004 through July 2004.

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 movement patterns and timing of all fish species utilizing the LMR from January through July;
3) Coded-wire tag a portion of naturally produced YOY Chinook salmon; and,
4) Monitor the migration patterns of a volitional release of hatchery reared Chinook salmon.

METHODS

Rotary Screw traps

Two 8-foot diameter (2.4 m) rotary screw traps (EG Solutions, Inc.) were fished in tandem below WIDD. Due to fish ladder and dam construction at WIDD, trap placement was approximately 100 yards (91.4 m) downstream of the typical location (Figure 1). Traps were 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. Efforts were made to operate the traps 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.

During each trap check, weather was assessed using the Beaufort scale for wind conditions, and percent cloud cover was estimated. Cone rotations since the previous trap check were read off of a Remington® mechanical counter mounted on side rails near the mouth of each cone, and then counters were reset to zero. Water velocity into the cone was measured using a Flo-Probe® digital readout propeller driven flow meter placed at approximately one-foot water depth on the upstream side of the catwalks in front of the center of each cone. Water temperature and dissolved oxygen (DO), in percent and parts per million (ppm), were taken with a YSI® 55 DO meter, and water samples for turbidity 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 traps. Water samples for turbidity were read in the lab on a Hach ®P1000 turbidimeter. Debris load in the trap was given a rating of light, medium, or heavy. Traps were 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. All cables, pulleys, counters, and cones were inspected daily to ensure proper function.

Fish Handling

Fish were processed in a Wells Cargo™ trailer equipped with a flow-through water supply, and a recirculating anesthetic bath. Clove oil was used to anesthetize fish. Concentration varied with temperature based on minimum required concentrations for Chinook salmon Electric aerators (air stones) were used to maintain oxygen concentrations. 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.

Coded Wire Tagging

Coded wire tagging (CWT) was conducted from January 27, 2004 through June 30, 2004. Chinook salmon fry $\geq$37mm fork length (FL) and completely buttoned-up were tagged on site at WIDD. Two Northwest Marine Technologies, Inc. Mark IV tagging machines with QC devices were used to implant CWT in juvenile Chinook salmon. Standard coded-wire tagging methods for juvenile salmon, as described in Vogel and Marine (1999a), were followed.

Calibrations

Calibration tests using hatchery Chinook were conducted to assess what portion of the naturally produced emigrating Chinook were being caught in the traps. Ten calibration tests for Chinook salmon captures were conducted at the WIDD spill release location, consisting of five nighttime tests and five daytime tests. Calibration fish (juvenile Chinook salmon produced at the Mokelumne River Fish Hatchery) were marked using caudal clips or a NewWest® photonic tagging gun. Calibration fish were marked and held overnight to assess mark retention and mortality.

Fish were held in pool 8a of the low stage fish ladder. 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 at the crest of the spill of Woodbridge Dam.

RESULTS/DISCUSSION

Chinook salmon

During monitoring 6,420 naturally produced juvenile Chinook salmon were captured. Estimates for weekend catch were added to actual catch to produce a count of 8,500 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 January 27, 2004 through June 30, 2004 is 87,654 (95% CI:67,068-134,898). This estimate consists of 45,467 fry and 42,187 smolts. Captures were classified fry if they were captured from January through March, and smolts if they were captured from April through June (Figure 2).

Juvenile salmon were described to lifestage as fry, parr, silvery parr, or smolt based on appearance. Average fork length (FL) for fry was 35.9 mm (30-41 mm, n=1,145); parr averaged 39.5 mm (33-65 mm, n=330), silvery parr averaged 72.9 mm (33-95 mm, n=312) and smolts were 88 mm (46-122 mm, n=3,965) on average. Average condition factor (weight in grams/fork length in mm^3 x 100,000) ranged from 0.59 for fry in April to 1.06 for smolts in June (Figures 3 and 4).

A small number of yearling smolts are observed in most years migrating out of the Mokelumne River (Marine 2000; Workman 2003). This year, however, no fish in this size and development range were observed. Due to the change in trap placement, low stream gradient and velocity at the new placement site, the traps rarely operated at the optimum rotational speed. During the 107 days of trap operation, 7 days of 0 rotations occurred. Minimum recorded rotational speed was 0.4 RPM and maximum was 5.35. Average rotational speed over the course of the monitoring season was 1.46 RPM, which is below the CAMP recommended minimum rotation of 2 RPM. The absence of any yearling smolts during monitoring may be due to the lower rotational speed of the traps and the ability of larger fish to avoid the traps.

Camanche release during the monitoring period ranged from 341 cfs (9.6 m^3/s) to 1,350 cfs (38.2 m^3/s) ($\bar{x}$ =483 cfs (13.6 m^3/s)). Camanche release was stable at approximately 350 cfs (9.9 m^3/s) from January to mid-April. Flood control releases were initiated in early May. From May 1st to May 5th flows were raised to a maximum of 1,350 cfs (38.2 m^3/s), and ramped down to approximately 500 cfs (14.1 m^3/s) by June 2nd and were held at that level until the end of June (Figures 5 and 6).

Water temperatures recorded at Camanche Dam during the monitoring period were between 10.0 and 13.6 ^oC, with an average of 11.6 ^oC. Daily water temperature recorded at WIDD ranged from 9.4 to 18.6 ^oC with an average of 14.4 ^oC during the monitoring period (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 square of the correlation coefficient (R^2) values ranged from 0.004 for the relationship between fish numbers and Camanche temperatures, to 0.39 for the relationship between fish number and flows

below WIDD. Combined effect of flow below Woodbridge and turbidity showed an R^2 value of 0.60 when compared to fish numbers.

Diel Abundance
Nocturnal passage accounted for 79% of fish passage monitored at the screw traps. 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 0.004 to 0.19 (Table 1). Calibrations at WIDD spill usually use 200 to 300 fish to get adequate recaptures (20 fish) to calculate trap efficiencies. The number of calibration fish released was increased to approximately 500 fish per release in anticipation of lower catch rates due to reduced cone rotational speed. Higher efficiencies were observed earlier in the season, with smaller fish, than later in the season with larger fish. Results for the last night calibration could not be used, due to a lack of recaptures, even though over 500 fish were released. Larger fish may be better able to avoid the traps. Efficiencies were also lower during higher flows. During lower flows most of the WIDD spill and ladder flow is directed at the screw traps. During higher flows, more of the flow is directed away from the traps and therefore a greater chance for migrating fish, including calibration fish, to avoid the traps. Daily catch numbers and associated calibration coefficients (trap efficiencies), for Chinook salmon, are presented in Appendix A.

Coded Wire Tagging
Natural production tagging conducted at WIDD began on February 25, 2004 and ended on June 30, 2003. One tag code (06-01-05-02-00) was used to tag 4,230 YOY Chinook salmon. Fish tagged ranged in size from 37 mm to 122 mm, averaging 84mm FL, and all were released less than 250 m (820 ft) below WIDD.

Volitional Release of Hatchery Chinook
On May 3, 2004 a group of 98,980 coded wire tagged and adipose-fin clipped chinook fingerlings was allowed to volitionally leave the Mokelumne River Fish Hatchery just below Camanche Dam. This release coincided with a controlled increase in release from Camanche Dam. A control release (98,674) was also made at Thornton. The first of the volitional release fish was picked up in the screw traps on the morning of May 4, 2004. Over the monitoring period we captured 7,551 of these fish. The relationship of migration of this release group and Camanche release flow was examined and simple linear regression determined that a significant relationship between outmigration numbers and flow for the volitional release fish (R^2=0.73). The estimate of abundance for the volitional release was 72,025 (Figure 12). Data are in Appendix A

Steelhead
Thirty-five YOY steelhead were captured in rotary screw traps from March through June. The estimate for young-of-year steelhead during this period, based on Chinook calibrations, is 736 (C.I:621-3,559). Data are in Appendix B.

Young-of-year steelhead were described to lifestage as fry or parr. Fry averaged 25 mm (24-26 mm, n=3). Parr averaged 56.6 mm (28-91 mm, n=32). The diel pattern of

movement for YOY steelhead is shown in Figure 13. In addition, 93 age 1+ steelhead were captured between February and May. These fish were categorized as silvery parr or smolt. Silvery parr averaged 187 mm (139-268 mm, n=59) and smolts were 200 mm (159-283 mm, n=31) on average. Seventy of these steelhead were adipose-fin clipped. One adult adipose-fin clipped steelhead was also caught in rotary screw traps.

Incidental Species

Twenty-four fish observed in rotary screw traps were identified to species. Some juvenile black bass, and juvenile cyprinids were only identified to genus due to their small size at capture. The most common black bass species observed in the LMR are spotted bass (*Micropterus punctulatus*) and largemouth bass (*M. salmoides*) and these two species most likely composed the unknown black bass component. The unknown cyprinids were a composite of juvenile carp (*Cyprinus carpio*) and goldfish (*Carassius auratus*) based on samples brought back to the lab. Eight native species and 16 non natives were captured. The most abundant fish observed were Chinook salmon, followed by juvenile black bass, Pacific lamprey and prickly sculpin, in order of abundance (Table 2). Last year 33 species were observed composed of 22 non-natives and 11 natives. The native fish we saw last year, but not this year, are relatively uncommon in the LMR based on past years of data. These species are, Sacramento blackfish (*Orthodon microlepidotus*), Sacramento splittail (*Pogonichthys macrolepidotus*), and white sturgeon (*Acipenser transmontanus*).

A sturgeon captured during the 2003 monitoring season was initially identified to genus only, and a tissue sample was sent to University of California Davis. This specimen has since been identified as a white sturgeon (J. Isreal pers. comm.). Typically, white sturgeon use the Sacramento and Feather Rivers for spawning, but can use the San Joaquin system when conditions of flow and water quality are suitable. Spawning occurs from February through June and growth of juveniles is rapid, with juveniles reaching 18-30 cm by the end of the first year (Moyle 2002). The juvenile sturgeon captured was 160 mm in January of 2003, and most likely a brood year 2002 fish.

Acknowledgements

I would like to thank the field staff of Dillon Collins, Charles Hunter, 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.

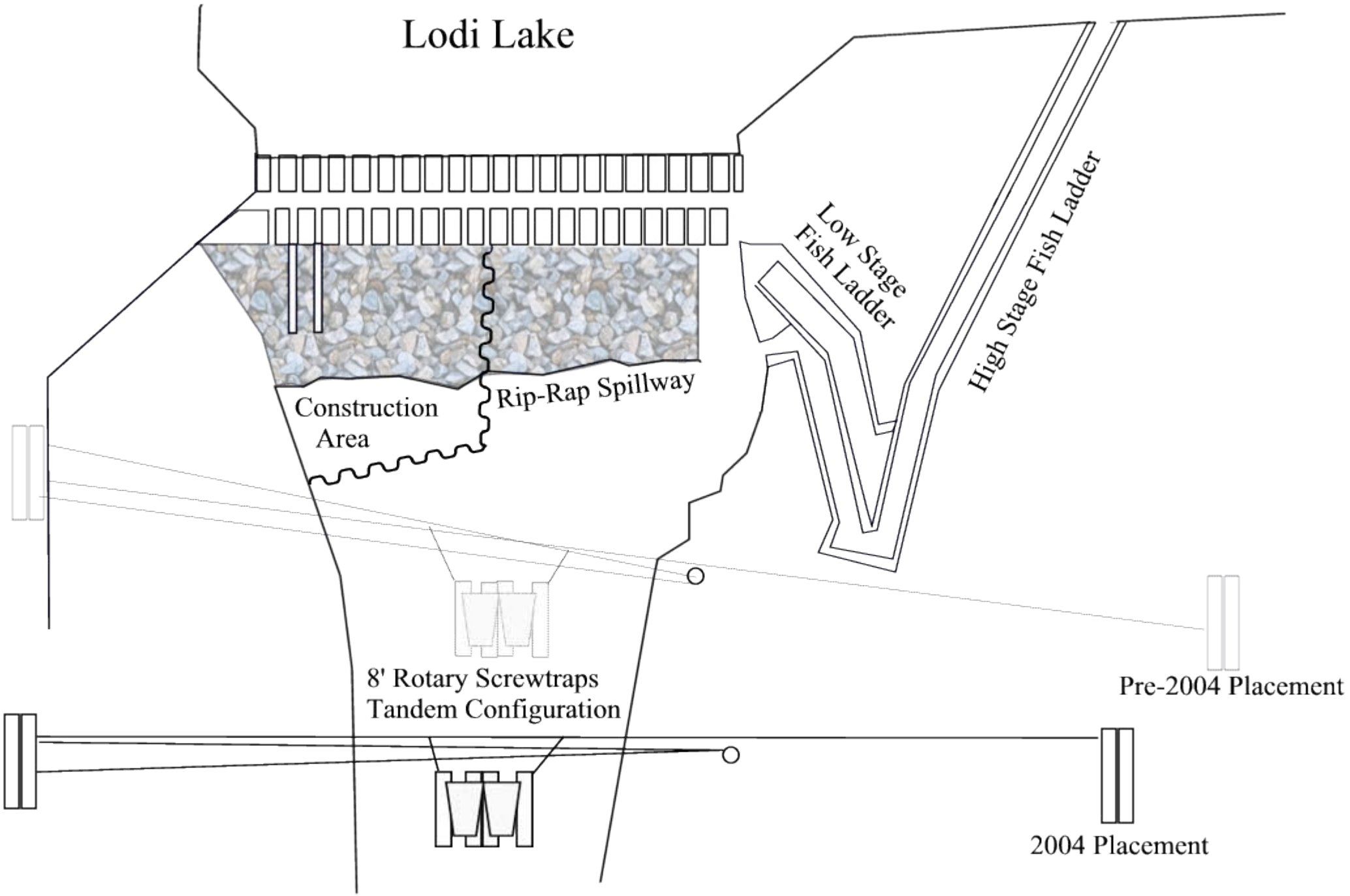

Figure 1. Placement of 2 eight-foot diameter rotary screwtraps below Woodbridge Irrigation District Dam on the lower Mokelumne River, California.

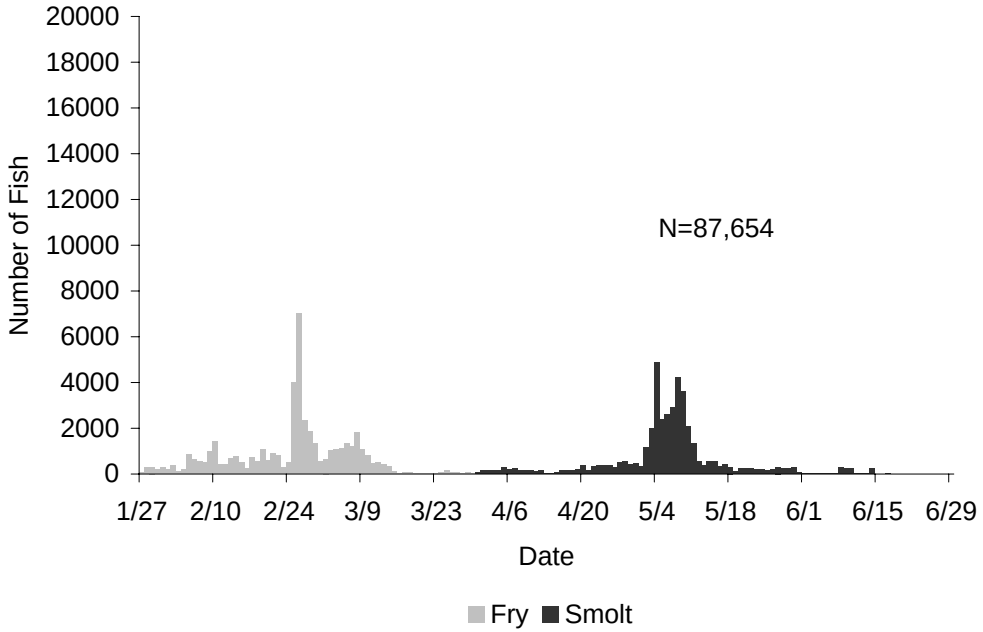

Figure 2. Estimate abundance of young-of-year chinook salmon passing Woodbridge Irrigation District Dam on the lower Mokelumne River from January 27 through June 30, 2004.

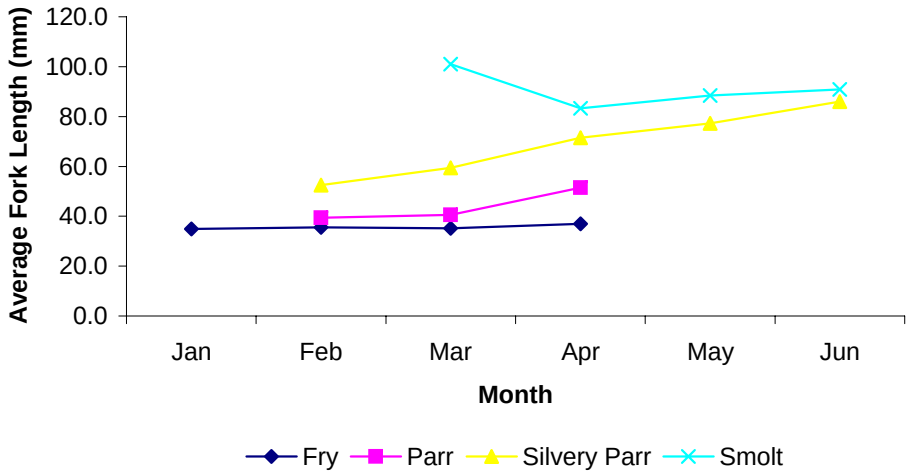

Figure 3. Average fork length (mm) of juvenile chinook salmon lifestages by date, on the lower Mokelumne River from January 27 through June 30, 2004.

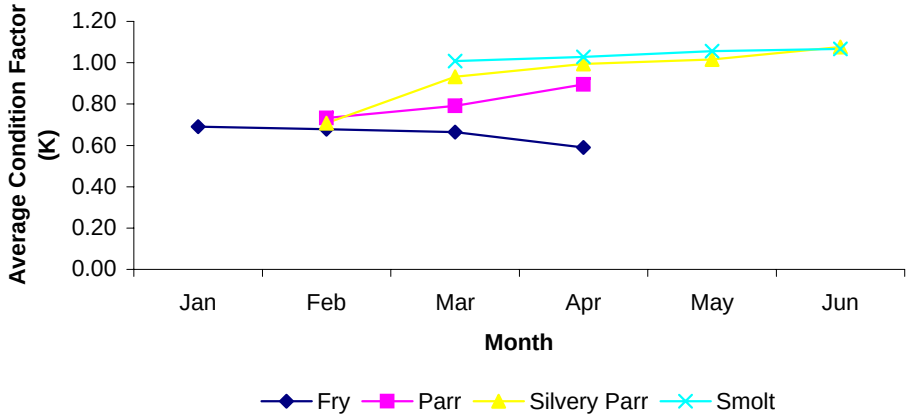

Figure 4. Average condition factor (K) of juvenile chinook salmon lifestages by date, on the lower Mokelumne River from January 27 through June 30, 2004.

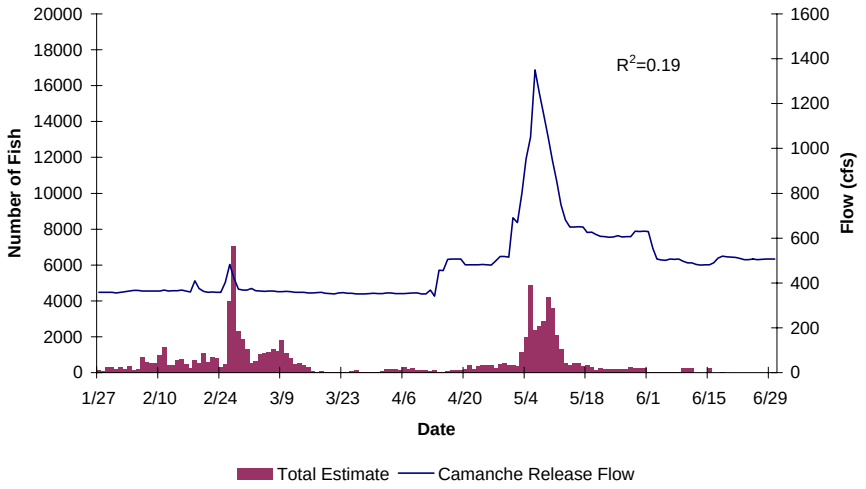

Figure 5 . Juvenile chinook salmon emigration below Woodbridge Irrigation District Dam and Camanche release flows, January 27 through June 30, 2004.

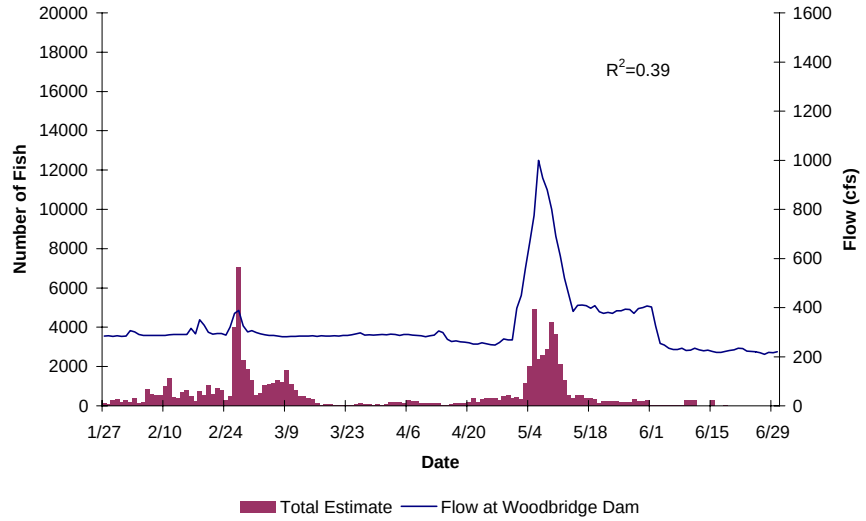

Figure 6 . Juvenile chinook salmon emigration below Woodbridge Irrigation District Dam and flow below Woodbridge Dam, January 27 through June 30, 2004.

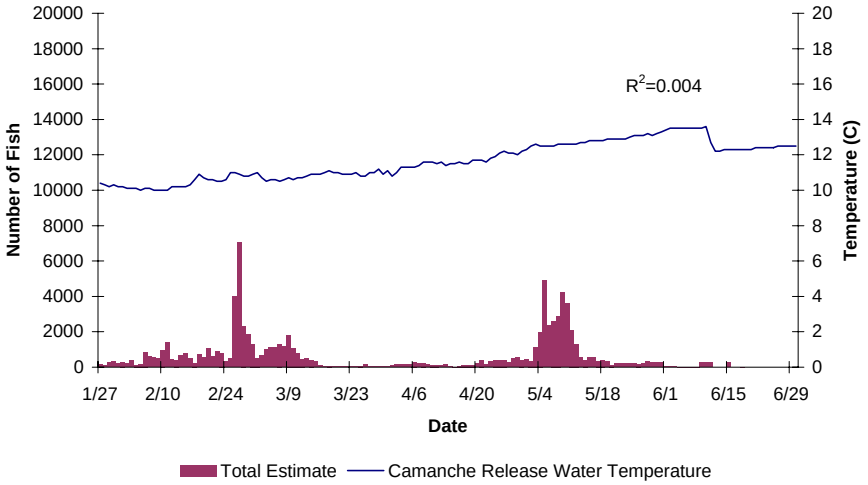

Figure 7. Juvenile chinook salmon emigration below Woodbridge Irrigation District Dam and Camanche release water temperature, January 27 through June 30, 2004.

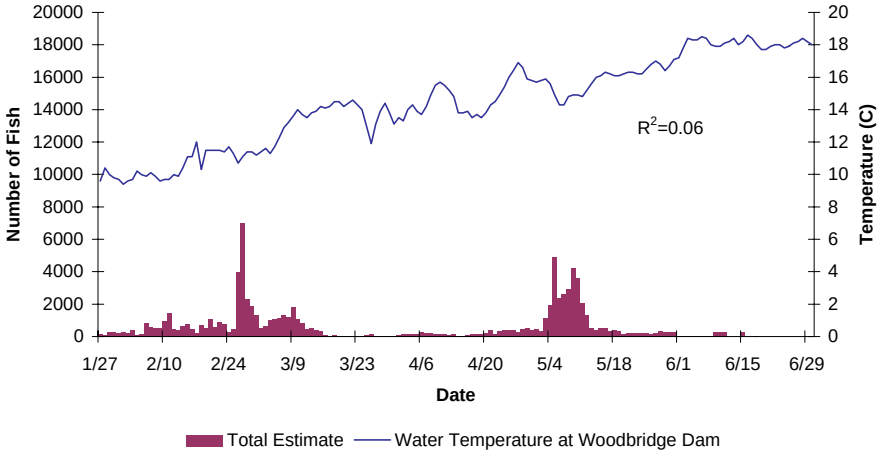

Figure 8 . Juvenile chinook salmon emigration below Woodbridge Irrigation District Dam and water temperature at Woodbridge Dam, January 27 through June 30, 2004.

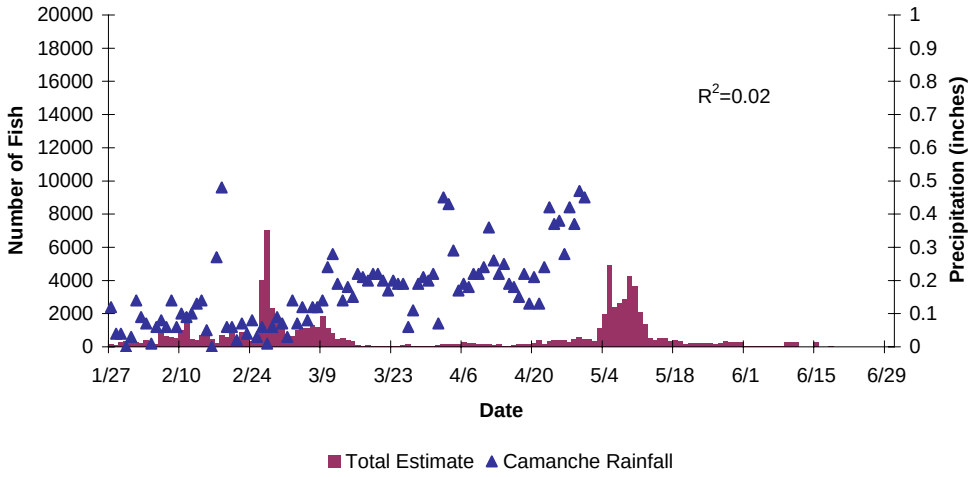

Figure 9 . Juvenile chinook salmon emigration below Woodbridge Irrigation District Dam and precipitation at Camanche Dam, January 27 through June 30, 2004.

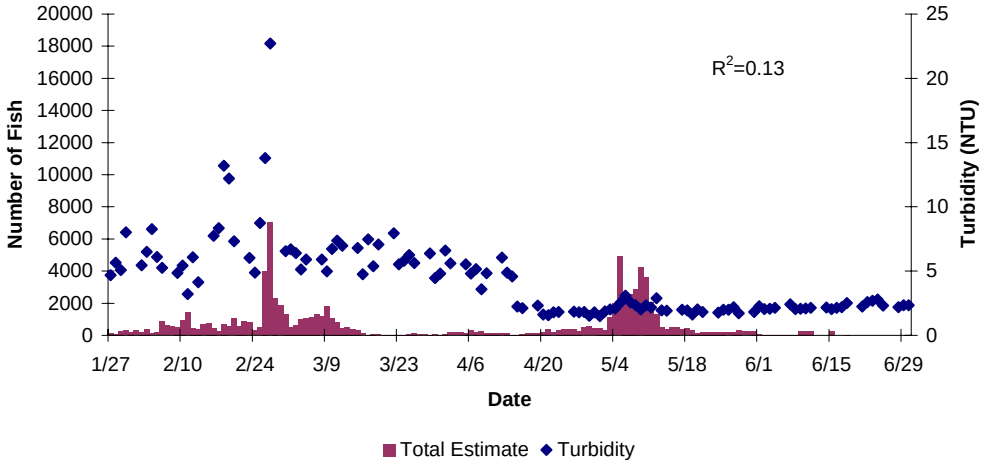

Figure 10 . Juvenile chinook salmon emigration below Woodbridge Irrigation District Dam turbidity, January 27 through June 30, 2004.

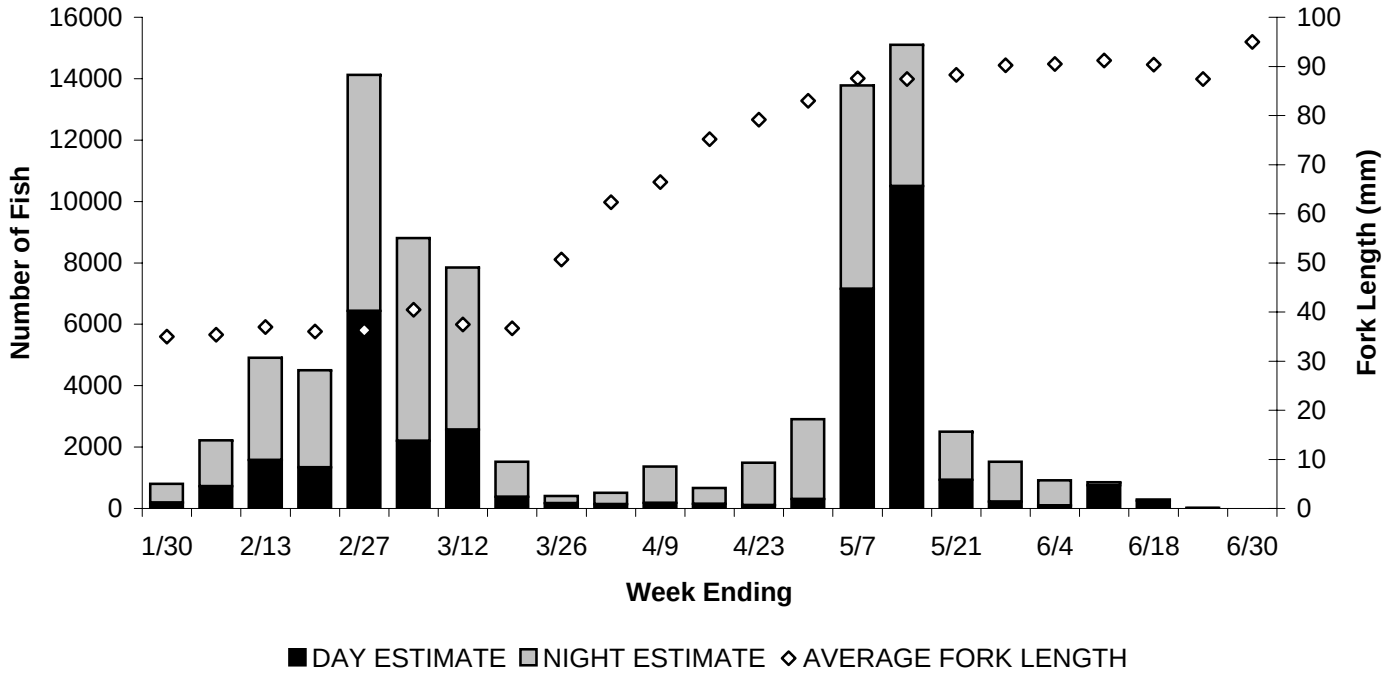

Figure 11. Weekly diel abundance of young-of-year Chinook Salmon emigrating past Woodbridge Irrigation District Dam from January 27, 2004 through June 30, 2004.

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Appendix A. Daily abundance of juvenile chinook salmon migrating past Woodbridge Irrigation District Dam, January 27-June 30, 2004. 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
1/27/2004		9	0.021	0.10	0	92	92	73	124		
1/28/2004	1	8	0.021	0.10	48	82	129	95	225		
1/29/2004	0	18	0.021	0.10	0	184	184	146	248		
1/30/2004	2	25	0.021	0.10	95	255	350	263	574		
1/31/2004	2	15	0.021	0.10	95	153	248	182	437		
2/1/2004	2	15	0.021	0.10	95	153	248	182	437		
2/2/2004	3	15	0.021	0.10	143	153	296	212	552		
2/3/2004	1	13	0.021	0.10	48	133	180	135	294		
2/4/2004	0	12	0.021	0.10	238	122	361	247	741		
2/5/2004	5	13	0.021	0.10	0	133	133	105	179		
2/6/2004	1	65	0.021	0.10	48	663	711	557	1009		
2/7/2004	4	46	0.021	0.10	190	469	660	493	1094		
2/8/2004	4	46	0.021	0.10	190	469	660	493	1094		
2/9/2004	3	46	0.021	0.10	143	469	612	463	978		
2/10/2004	2	49	0.021	0.10	95	500	595	457	904		
2/11/2004	10	111	0.021	0.10	476	1133	1609	1200	2679		
2/12/2004	6	28	0.021	0.10	286	286	571	407	1077		
2/13/2004	3	16	0.021	0.10	143	163	306	220	566		
2/14/2004	5	43	0.021	0.10	238	439	677	499	1168		
2/15/2004	5	43	0.021	0.10	238	439	677	499	1168		
2/16/2004	7	43	0.021	0.10	333	439	772	559	1398		
2/17/2004	1	14	0.021	0.10	48	143	190	144	308		
2/18/2004	2	42	0.021	0.10	95	429	524	401	808		
2/19/2004	6	45	0.021	0.10	286	459	745	545	1310		
2/20/2004	2	81	0.021	0.10	95	827	922	717	1345		
2/21/2004	5	36	0.021	0.10	238	367	605	442	1071		
2/22/2004	5	36	0.021	0.10	238	367	605	442	1071		
2/23/2004	11	36	0.021	0.10	524	367	891	622	1763		
2/24/2004	9	20	0.021	0.10	429	204	633	432	1312		
2/25/2004	2	11	0.021	0.10	95	112	207	149	382		
2/26/2004	8	14	0.021	0.10	381	143	524	354	1115		

Appendix A. Daily abundance of juvenile chinook salmon migrating past Woodbridge Irrigation District Dam, January 27-June 30, 2004. 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
2/27/2004	81	601	0.021	0.10	3857	6133	9990	7305	17602		
2/28/2004	19	140	0.021	0.10	905	1429	2333	1706	4115		
2/29/2004	19	140	0.021	0.10	905	1429	2333	1706	4115		
3/1/2004	9	140	0.037	0.118	243	1186	1430	1138	1955		
3/2/2004	5	40	0.037	0.118	135	339	474	371	671		
3/3/2004	7	58	0.037	0.118	189	492	681	534	962		
3/4/2004	6	114	0.037	0.118	162	966	1128	901	1530		
3/5/2004	2	91	0.037	0.118	54	771	825	666	1092		
3/6/2004	12	95	0.037	0.118	324	805	1129	884	1600		
3/7/2004	12	95	0.037	0.118	324	805	1129	884	1600		
3/8/2004	19	95	0.037	0.118	514	805	1319	1018	1926		
3/9/2004	14	149	0.037	0.118	378	1263	1641	1295	2286		
3/10/2004	21	100	0.037	0.118	568	847	1415	1090	2074		
3/11/2004	9	58	0.037	0.118	243	492	735	572	1055		
3/12/2004	12	31	0.037	0.118	324	263	587	443	898		
3/13/2004	8	35	0.037	0.118	216	297	513	394	756		
3/14/2004	8	35	0.037	0.118	216	297	513	394	756		
3/15/2004	4	35	0.037	0.118	108	297	405	318	570		
3/16/2004	1	10	0.037	0.118	27	85	112	88	156		
3/17/2004	1	4	0.037	0.118	27	34	61	47	90		
3/18/2004	0	9	0.037	0.118	0	76	76	62	99		
3/19/2004	0	7	0.037	0.118	0	59	59	48	77		
3/20/2004	0	5	0.037	0.118	0	42	42	35	55		
3/21/2004	0	5	0.037	0.118	0	42	42	35	55		
3/22/2004	0	5	0.037	0.118	0	42	42	35	55		
3/23/2004	0	4	0.037	0.118	0	34	34	28	44		
3/24/2004	0	4	0.037	0.118	0	34	34	28	44		
3/25/2004	2	2	0.037	0.118	54	17	71	52	115		
3/26/2004	4	4	0.037	0.118	108	34	142	104	230		
3/27/2004	1	4	0.037	0.118	27	34	61	47	90		
3/28/2004	1	4	0.037	0.118	27	34	61	47	90		
3/29/2004	0	4	0.037	0.118	0	34	34	28	44		

Appendix A. Daily abundance of juvenile chinook salmon migrating past Woodbridge Irrigation District Dam, January 27-June 30, 2004. 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
3/30/2004	1	4	0.037	0.118	27	34	61	47	90		
3/31/2004	1	1	0.037	0.118	27	8	36	26	57		
4/1/2004	0	7	0.04	0.082	0	85	85	66	121		
4/2/2004	1	12	0.04	0.082	25	146	171	131	251		
4/3/2004	1	12	0.04	0.082	25	146	171	131	251		
4/4/2004	1	12	0.04	0.082	25	146	171	131	251		
4/5/2004	0	12	0.04	0.082	0	146	146	113	207		
4/6/2004	2	20	0.04	0.082	50	244	294	224	432		
4/7/2004	1	15	0.04	0.082	25	183	208	159	302		
4/8/2004	2	15	0.04	0.082	50	183	233	176	346		
4/9/2004	0	12	0.04	0.082	0	146	146	113	207		
4/10/2004	1	9	0.04	0.082	25	110	135	102	199		
4/11/2004	1	9	0.04	0.082	25	110	135	102	199		
4/12/2004	0	9	0.04	0.082	0	110	110	85	155		
4/13/2004	3	6	0.04	0.082	75	73	148	109	235		
4/14/2004	0	3	0.04	0.082	0	37	37	28	52		
4/15/2004	0	2	0.04	0.082	0	24	24	19	34		
4/16/2004	1	4	0.04	0.082	25	49	74	55	113		
4/17/2004	0	11	0.04	0.082	0	134	134	104	190		
4/18/2004	0	11	0.04	0.082	0	134	134	104	190		
4/19/2004	0	11	0.04	0.082	0	134	134	104	190		
4/20/2004	1	14	0.04	0.082	25	171	196	150	285		
4/21/2004	0	32	0.04	0.082	0	390	390	302	552		
4/22/2004	1	12	0.04	0.082	25	146	171	131	251		
4/23/2004	2	23	0.04	0.082	50	280	330	252	484		
4/24/2004	2	28	0.04	0.082	50	341	391	299	570		
4/25/2004	2	28	0.04	0.082	50	341	391	299	570		
4/26/2004	2	28	0.04	0.082	50	341	391	299	570		
4/27/2004	1	20	0.04	0.082	25	244	269	206	389		
4/28/2004	3	34	0.04	0.082	75	415	490	373	718		
4/29/2004	1	44	0.04	0.082	25	537	562	432	803		
4/30/2004	1	32	0.04	0.082	25	390	415	319	596		

Appendix A. Daily abundance of juvenile chinook salmon migrating past Woodbridge Irrigation District Dam, January 27-June 30, 2004. 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
5/1/2004	2	78	0.072	0.186	28	419	447	376	554		
5/2/2004	4	52	0.072	0.186	56	280	335	279	423		
5/3/2004	62	53	0.072	0.186	861	285	1146	896	1604		
5/4/2004	68	193	0.072	0.186	944	1038	1982	1596	2647	146	2025
5/5/2004	151	521	0.072	0.186	2097	2801	4898	3963	6487	2019	18672
5/6/2004	84	224	0.072	0.186	1167	1204	2371	1906	3176	1213	10013
5/7/2004	144	111	0.072	0.186	2000	597	2597	2026	3646	1268	14456
5/8/2004	156	135	0.072	0.186	2167	726	2892	2262	4047	986	9005
5/9/2004	229	195	0.072	0.186	3181	1048	4229	3306	5921	870	7706
5/10/2004	171	232	0.072	0.186	2375	1247	3622	2861	4990	530	4664
5/11/2004	105	119	0.072	0.186	1458	640	2098	1650	2909	229	2040
5/12/2004	61	89	0.072	0.186	847	478	1326	1049	1821	95	886
5/13/2004	16	60	0.072	0.186	222	323	545	442	719	102	785
5/14/2004	18	27	0.072	0.186	250	145	395	313	542	43	344
5/15/2004	20	48	0.072	0.186	278	258	536	429	721	42	364
5/16/2004	20	48	0.072	0.186	278	258	536	429	721	42	364
5/17/2004	7	48	0.072	0.186	97	258	355	292	458	15	214
5/18/2004	9	53	0.072	0.186	125	285	410	336	531	13	186
5/19/2004	9	35	0.072	0.186	125	188	313	254	413	4	22
5/20/2004	1	22	0.072	0.186	14	118	132	111	165	4	22
5/21/2004	1	39	0.072	0.186	14	210	224	188	277	9	59
5/22/2004	3	33	0.072	0.186	42	177	219	182	278	3	17
5/23/2004	3	33	0.072	0.186	42	177	219	182	278	3	17
5/24/2004	2	33	0.072	0.186	28	177	205	171	258	0	0
5/25/2004	2	31	0.072	0.186	28	167	194	162	245	1	6
5/26/2004	0	32	0.072	0.186	0	172	172	145	211	3	17
5/27/2004	0	36	0.072	0.186	0	194	194	164	237	3	25
5/28/2004	6	43	0.072	0.186	83	231	315	259	405	4	22
5/29/2004	2	41	0.072	0.186	28	220	248	207	310	4	22
5/30/2004	2	41	0.072	0.186	28	220	248	207	310	4	22
5/31/2004	3	41	0.072	0.186	42	220	262	218	331	0	0
6/1/2004	0	55	0.004		0	55	55	55	55	2	11

Appendix A. Daily abundance of juvenile chinook salmon migrating past Woodbridge Irrigation District Dam, January 27-June 30, 2004. 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
6/2/2004	0	42	0.004		0	42	42	42	42	2	11
6/3/2004	0	36	0.004		0	36	36	36	36	2	11
6/4/2004	0	23	0.004		0	23	23	23	23	2	11
6/5/2004	0	23	0.004		0	23	23	23	23	0	0
6/6/2004	0	23	0.004		0	23	23	23	23	0	0
6/7/2004	0	23	0.004		0	23	23	23	23	0	0
6/8/2004	0	15	0.004		0	15	15	15	15	0	0
6/9/2004	1	16	0.004		250	16	266	124	821	1	6
6/10/2004	1	5	0.004		250	5	255	113	810	0	0
6/11/2004	1	3	0.004		250	3	253	111	808	0	0
6/12/2004	1	6	0.004		250	6	256	114	811	0	0
6/13/2004	1	6	0.004		250	6	256	114	811	0	0
6/14/2004	0	6	0.004		0	6	6	6	6	0	0
6/15/2004	1	5	0.004		250	5	255	113	810	0	0
6/16/2004	0	1	0.004		0	1	1	1	1	0	0
6/17/2004	0	3	0.004		0	3	3	3	3	0	0
6/18/2004	0	14	0.004		0	14	14	14	14	0	0
6/19/2004	0	5	0.004		0	5	5	5	5	0	0
6/20/2004	0	5	0.004		0	5	5	5	5	0	0
6/21/2004	0	5	0.004		0	5	5	5	5	0	0
6/22/2004	0	2	0.004		0	2	2	2	2	0	0
6/23/2004	0	1	0.004		0	1	1	1	1	0	0
6/24/2004	0	2	0.004		0	2	2	2	2	0	0
6/25/2004	0	2	0.004		0	2	2	2	2	0	0
6/26/2004	0	1	0.004		0	1	1	1	1	0	0
6/27/2004	0	1	0.004		0	1	1	1	1	0	0
6/28/2004	0	1	0.004		0	1	1	1	1	0	0
6/29/2004	0	1	0.004		0	1	1	1	1	0	0
6/30/2004	0	1	0.004		0	1	1	1	1	0	0
Total Capture	1,621	4,799								7,551	
Total Estimate	1,793	6,707			36,715	50,939	87,654	67,068	134,898	7,664	72,025

* no night trap efficiency was calculated for 6/1-6/30 due to no recaptures

Appendix B. Daily abundance of juvenile steelhead migrating past Woodbridge Irrigation District Dam, March 1-June 30, 2004.

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
3/1/2004	0	0	0.037	0.118	0	0	0	0	0
3/2/2004	0	0	0.037	0.118	0	0	0	0	0
3/3/2004	0	0	0.037	0.118	0	0	0	0	0
3/4/2004	0	0	0.037	0.118	0	0	0	0	0
3/5/2004	0	0	0.037	0.118	0	0	0	0	0
3/6/2004	0	0	0.037	0.118	0	0	0	0	0
3/7/2004	0	0	0.037	0.118	0	0	0	0	0
3/8/2004	0	0	0.037	0.118	0	0	0	0	0
3/9/2004	0	0	0.037	0.118	0	0	0	0	0
3/10/2004	0	0	0.037	0.118	0	0	0	0	0
3/11/2004	0	0	0.037	0.118	0	0	0	0	0
3/12/2004	0	0	0.037	0.118	0	0	0	0	0
3/13/2004	0	0	0.037	0.118	0	0	0	0	0
3/14/2004	0	0	0.037	0.118	0	0	0	0	0
3/15/2004	1	0	0.037	0.118	27	0	27	19	46
3/16/2004	0	0	0.037	0.118	0	0	0	0	0
3/17/2004	1	0	0.037	0.118	27	0	27	19	46
3/18/2004	0	0	0.037	0.118	0	0	0	0	0
3/19/2004	0	0	0.037	0.118	0	0	0	0	0
3/20/2004	0	0	0.037	0.118	0	0	0	0	0
3/21/2004	0	0	0.037	0.118	0	0	0	0	0
3/22/2004	0	0	0.037	0.118	0	0	0	0	0
3/23/2004	0	2	0.037	0.118	0	17	17	14	22
3/24/2004	0	0	0.037	0.118	0	0	0	0	0
3/25/2004	0	0	0.037	0.118	0	0	0	0	0
3/26/2004	0	0	0.037	0.118	0	0	0	0	0
3/27/2004	0	0	0.037	0.118	0	0	0	0	0
3/28/2004	0	0	0.037	0.118	0	0	0	0	0
3/29/2004	0	0	0.037	0.118	0	0	0	0	0

Appendix B. Daily abundance of juvenile steelhead migrating past Woodbridge Irrigation District Dam, March 1-June 30, 2004.

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
3/30/2004	1	0	0.037	0.118	27	0	27	19	46
3/31/2004	0	0	0.037	0.118	0	0	0	0	0
4/1/2004	0	0	0.04	0.082	0	0	0	0	0
4/2/2004	0	0	0.04	0.082	0	0	0	0	0
4/3/2004	0	0	0.04	0.082	0	0	0	0	0
4/4/2004	0	0	0.04	0.082	0	0	0	0	0
4/5/2004	0	0	0.04	0.082	0	0	0	0	0
4/6/2004	0	0	0.04	0.082	0	0	0	0	0
4/7/2004	0	0	0.04	0.082	0	0	0	0	0
4/8/2004	0	0	0.04	0.082	0	0	0	0	0
4/9/2004	0	0	0.04	0.082	0	0	0	0	0
4/10/2004	0	0	0.04	0.082	0	0	0	0	0
4/11/2004	0	0	0.04	0.082	0	0	0	0	0
4/12/2004	0	0	0.04	0.082	0	0	0	0	0
4/13/2004	0	1	0.04	0.082	0	12	12	9	17
4/14/2004	0	0	0.04	0.082	0	0	0	0	0
4/15/2004	0	1	0.04	0.082	0	12	12	9	17
4/16/2004	0	0	0.04	0.082	0	0	0	0	0
4/17/2004	0	0	0.04	0.082	0	0	0	0	0
4/18/2004	0	0	0.04	0.082	0	0	0	0	0
4/19/2004	0	0	0.04	0.082	0	0	0	0	0
4/20/2004	0	0	0.04	0.082	0	0	0	0	0
4/21/2004	0	0	0.04	0.082	0	0	0	0	0
4/22/2004	0	1	0.04	0.082	0	12	12	9	17
4/23/2004	0	0	0.04	0.082	0	0	0	0	0
4/24/2004	0	0	0.04	0.082	0	0	0	0	0
4/25/2004	0	0	0.04	0.082	0	0	0	0	0
4/26/2004	0	0	0.04	0.082	0	0	0	0	0
4/27/2004	0	2	0.04	0.082	0	24	24	19	34
4/28/2004	0	0	0.04	0.082	0	0	0	0	0

Appendix B. Daily abundance of juvenile steelhead migrating past Woodbridge Irrigation District Dam, March 1-June 30, 2004.

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
4/29/2004	0	0	0.04	0.082	0	0	0	0	0
4/30/2004	0	0	0.04	0.082	0	0	0	0	0
5/1/2004	0	0	0.072	0.186	0	0	0	0	0
5/2/2004	0	0	0.072	0.186	0	0	0	0	0
5/3/2004	0	0	0.072	0.186	0	0	0	0	0
5/4/2004	0	0	0.072	0.186	0	0	0	0	0
5/5/2004	0	0	0.072	0.186	0	0	0	0	0
5/6/2004	0	1	0.072	0.186	0	5	5	5	7
5/7/2004	0	1	0.072	0.186	0	5	5	5	7
5/8/2004	0	0	0.072	0.186	0	0	0	0	0
5/9/2004	0	0	0.072	0.186	0	0	0	0	0
5/10/2004	0	0	0.072	0.186	0	0	0	0	0
5/11/2004	0	0	0.072	0.186	0	0	0	0	0
5/12/2004	0	0	0.072	0.186	0	0	0	0	0
5/13/2004	0	0	0.072	0.186	0	0	0	0	0
5/14/2004	0	0	0.072	0.186	0	0	0	0	0
5/15/2004	0	0	0.072	0.186	0	0	0	0	0
5/16/2004	0	0	0.072	0.186	0	0	0	0	0
5/17/2004	0	0	0.072	0.186	0	0	0	0	0
5/18/2004	0	1	0.072	0.186	0	5	5	5	7
5/19/2004	0	0	0.072	0.186	0	0	0	0	0
5/20/2004	0	1	0.072	0.186	0	5	5	5	7
5/21/2004	0	0	0.072	0.186	0	0	0	0	0
5/22/2004	0	1	0.072	0.186	0	5	5	5	7
5/23/2004	0	1	0.072	0.186	0	5	5	5	7
5/24/2004	0	1	0.072	0.186	0	5	5	5	7
5/25/2004	0	1	0.072	0.186	0	5	5	5	7
5/26/2004	0	0	0.072	0.186	0	0	0	0	0
5/27/2004	0	1	0.072	0.186	0	5	5	5	7

Appendix B. Daily abundance of juvenile steelhead migrating past Woodbridge Irrigation District Dam, March 1-June 30, 2004.

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
5/28/2004	0	0	0.072	0.186	0	0	0	0	0
5/29/2004	0	0	0.072	0.186	0	0	0	0	0
5/30/2004	0	0	0.072	0.186	0	0	0	0	0
5/31/2004	0	0	0.072	0.186	0	0	0	0	0
6/1/2004	0	0	0.004		0	0	0	0	0
6/2/2004	1	0	0.004		250	0	250	216	1611
6/3/2004	1	0	0.004		250	0	250	216	1611
6/4/2004	0	1	0.004		0	1	1	1	1
6/5/2004	0	2	0.004		0	2	2	2	2
6/6/2004	0	2	0.004		0	2	2	2	2
6/7/2004	0	2	0.004		0	2	2	2	2
6/8/2004	0	2	0.004		0	2	2	2	2
6/9/2004	0	2	0.004		0	2	2	2	2
6/10/2004	0	3	0.004		0	3	3	3	3
6/11/2004	0	2	0.004		0	2	2	2	2
6/12/2004	0	0	0.004		0	0	0	0	0
6/13/2004	0	0	0.004		0	0	0	0	0
6/14/2004	0	0	0.004		0	0	0	0	0
6/15/2004	0	0	0.004		0	0	0	0	0
6/16/2004	0	2	0.004		0	2	2	2	2
6/17/2004	0	0	0.004		0	0	0	0	0
6/18/2004	0	2	0.004		0	2	2	2	2
6/19/2004	0	1	0.004		0	1	1	1	1
6/20/2004	0	1	0.004		0	1	1	1	1
6/21/2004	0	1	0.004		0	1	1	1	1
6/22/2004	0	0	0.004		0	0	0	0	0
6/23/2004	0	0	0.004		0	0	0	0	0
6/24/2004	0	2	0.004		0	2	2	2	2
6/25/2004	0	0	0.004		0	0	0	0	0
6/26/2004	0	1	0.004		0	1	1	1	1

Appendix B. Daily abundance of juvenile steelhead migrating past Woodbridge Irrigation District Dam, March 1-June 30, 2004.

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
6/27/2004	0	1	0.004		0	1	1	1	1
6/28/2004	0	1	0.004		0	1	1	1	1
6/29/2004	0	0	0.004		0	0	0	0	0
6/30/2004	0	1	0.004		0	1	1	1	1
Total Capture	5	30							
Total Estimate		45			581	155	736	621	3559

* no night trap efficiency was calculated for 6/1-6/30 due to no recaptures