Downstream Fish Migration Monitoring at Woodbridge Irrigation District Dam Lower Mokelumne River, December 2006 through July 2007

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SUMMARY

One rotary screw trap was operated downstream of the Lower Sacramento Road Bridge on the lower Mokelumne River from December 18, 2006 through May 25, 2007. A smolt bypass trap was operated from May 22, 2007 through July 27, 2007. This trap was positioned in the smolt bypass pipe at Woodbridge Irrigation District Dam (WIDD) to capture smolts that were screened off at the diversion canal upstream of the dam. From July 6, 2007 through July 11, 2007 all Chinook salmon (*Oncorhynchus tshawytscha*) captured in the bypass trap were transported to various locations below Wimpy's Marina on the Mokelumne River to avoid elevated temperatures in the river below WIDD.

The first young-of-year (YOY) Chinook salmon was captured by rotary screw trap on December 19, 2006. The estimate of abundance for naturally produced YOY Chinook salmon passing WIDD from December 19, 2006 through May 25, 2007 based on calibrated trap captures of 1,018 naturally produced young-of-year (YOY) Chinook salmon was 19,582 (95% CI:15,039-41,761). The smolt bypass trap catch was 13,088 naturally produced YOY Chinook salmon, which was expanded for weekend estimates to 20,356. Combined total outmigration was 39,938 consisting of 10,349 fry and 29,278 smolt sized fish.

The first YOY steelhead (*O. mykiss*) was captured on March 8, 2007. Estimated abundance of YOY steelhead based on salmon trap calibrations applied to 35 YOY (FL <150 mm) steelhead was 1,111 (95% CI: 818-2,144). In addition, rotary screw trap catch included nine wild, age 1+ steelhead captured between February and March ranging in size from 134-266 mm FL ($\bar{X}$ =214 mm). Seventy-seven adipose fin-clipped steelhead ranging in size from 180-437 mm FL ($\bar{X}$ = 233 mm) were captured between February 21st and May 17th. The smolt bypass trap catch was 108 wild YOY steelhead, expanded to 157 for weekend estimates, and one adclipped 1+ steelhead. Combined total estimate of steelhead YOY was 1,268.

Twenty fish species were recorded in the rotary screw trap and bypass trap. The most common species, in order of abundance, were Chinook salmon, black bass (*Micropterus sp.*), prickly sculpin (*Cottus asper*), common carp (*Cyprinus carpio*), and steelhead.

Camanche Reservoir release during the monitoring period ranged from 288 cubic feet per second (cfs) (8.16 cubic meters per second (m^3/s)) to 403 cfs (11.41 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 trap is operated at river mile 39 (RKM 63) below Woobridge Irrigation District Dam (WIDD) to assess juvenile emigration. The objectives of this study are to monitor the abundance and emigration patterns of fish species in the lower Mokelumne River migrating past Woodbridge Irrigation District Dam. This report presents the monitoring results for rotary screw trap and bypass trap operations from December 2006 through July 2007.

METHODS

Rotary Screw trap

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. 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 Redington® 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.

Bypass trap

On May 22, 2007 an incline plane trap was installed in the bypass pipe at Woodbridge dam. This pipe conveys fish that are screened off of the Woodbridge Irrigation Canal

upstream. The trap was checked twice daily, until fish abundances were sufficiently low enough to warrant one check per day. A fish crowder and a long-handled dip net were used to capture fish and place them into buckets. Debris accumulation was cleared from the live box at each trap check. Turbidity samples were collected by submerging an inverted sample jar to a depth of 1 foot (0.3 m) in the trap and then allowing it to fill with water. Temperature, DO and turbidity samples were taken inside of the bypass trap. Water samples for turbidity were read in the lab on a Hach ®P1000 turbidimeter.

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 31, 2007 through June 15, 2007. Chinook salmon fry $\geq$40mm total length (TL) 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.

Trapping and Trucking

The Lower Mokelumne River Joint Settlement Agreement (1998) recommends outmigrating smolts be trapped and transported around the Delta in dry and critically dry years, when agreed upon by the California Department of Fish and Game (CDFG), the United States Fish and Wildlife Service (USFWS), and EBMUD. Trapping and trucking of juvenile fall-run Chinook salmon began on July 6, 2007. A transport tank with two 75-gallon compartments equipped with mechanical aerators was used to haul fish. Tanks were filled with water from the bypass trap using a submersible pump. Water was treated with Novaqua®, ice made from Mokelumne River water, pressurized O_2 and salt to minimize stress to fish. A recommended concentration of salt for fish transport of a 0.1 to 0.3% salt solution was used in transport (Piper et al 1992). Oxygen levels in transport tanks were initially set at 9.00 ppm to accommodate high oxygen consumption associated with stress. Transport levels were kept at > 7.00 ppm. Each tank was supplied with a 1-gallon container of frozen Mokelumne River water to maintain constant temperatures during transport.

Calibrations
Calibration tests using hatchery produced Chinook were conducted to assess what portion of emigrating Chinook were being caught in the traps. Twelve calibration tests for Chinook salmon captures were conducted at the WIDD spill release location, consisting of six nighttime tests and six daytime tests. Calibration fish were marked using caudal clips or NEWWEST Technologies photonic marking dye.

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 rotary screw trap monitoring, 1,018 naturally produced juvenile Chinook salmon were captured. Estimates for weekend catch were added to actual catch to produce a count of 1,700 to which the trap efficiencies were applied to develop the overall estimate. During bypass trap monitoring, 13,088 naturally produced juvenile Chinook salmon were captured. Estimates for weekend catch were added to actual catch to produce a count of 20,356. The estimate of abundance for naturally produced juvenile fall-run Chinook salmon passing the rotary screw trap from December 18, 2006 through May 25, 2007 is 19,582 (95% CI:15,039-41,761). Total emigration calculated from adding the bypass trap and rotary screw trap estimates is 39,938. This estimate consists of 10,349 fry and 29,278 smolt-sized fish. Captures were classified as fry for all dates when average fork lengths did not exceed 60 mm. This was the case until April 6, 2007. Smolt numbers are based on the period of April 6th to July 27th (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 35.9 mm (29-45 mm, n=431); parr averaged 39.6 mm (35-56 mm, n=70), silvery parr averaged 70.5 mm (43-107 mm, n=42) and smolts were 87.9 mm (67-143 mm, n=1,625) on average. Average condition factor (weight in grams/fork length in mm^3 x 100,000) ranged from 0.43 for fry in December to 1.05 for parr in June (Figures 3 and 4). Fish were not measured in July due to concerns of temperature related handling stress.

During the 109 days of trap operation the minimum recorded rotational speed was 1.1 RPM and maximum was 3.2. Average rotational speed over the course of the monitoring season was 2.05 RPM, which is above the CAMP recommended minimum rotation of 2 RPM (USFWS 1997).

Camanche release during the monitoring period ranged from 288 cfs (8.16 m^3/s) to 403 cfs (11.41 m^3/s), $\bar{X}$ = 337 cfs (9.54 m^3/s). Flow at WIDD ranged from 34 cfs (0.96 m^3/s) to 343 cfs (9.71 m^3/s), $\bar{X}$ = 194 cfs (5.49 m^3/s) (Figures 5 and 6). Linear regression

shows only 3% ($R^2 = 0.03$) and 12% ($R^2 = 0.12$) of the variability in outmigration can be explained by variability in flow for Camanche release and flow past Woodbridge, respectively. The corresponding p value ($p<0.01$) shows that there is indeed a linear relationship between flow and outmigration,

Water temperatures recorded at Camanche Dam during the monitoring period were between 9.0 and 13.6 ^{o}C, with an average of 11.5 ^{o}C. Daily water temperature recorded at WIDD ranged from 6.9 to 21.8 ^{o}C with an average of 13.9 ^{o}C (Figures 7 and 8). Again, the linear regression of outmigration showed a significant linear relationship ($p< 0.01$)with temperature, but only 9% ($R^2 = 0.09$) of the variability in outmigration is explained by temperature for both Camanche and Woodbridge temperatures.

Water turbidity in NTUs at the rotary screw trap and smolt bypass trap ranged from 1.6 to 10.5 with a mean of 2.9. The peak value of 10.5 was the only value over 5 NTU and there were only 9 days with daily values over 4 NTU (Figure 9). Overall, the water was clear throughout the monitoring period. Linear regression showed no significant linear relationship ($p= 0.37$) and only 1% of the variability in outmigration was related to turbidity. ($R^2 = 0.01$).

Overall, simple linear regressions explained little of the total variation in daily abundance of fish as a function of the environmental variables examined.

Diel Abundance

Nocturnal passage accounted for 96% of estimated emigration at the screw traps, down from 97% last year (Workman 2006). This was consistent across the entire monitoring period. Very few fish were captured during the day (Figure 10).

Calibrations

Rotary screw trap efficiencies for Chinook salmon ranged from 0.019 to 0.136 (Table 1). The number of calibration fish released ranged from 75-1,027 fish per release. Daily catch numbers and associated calibration coefficients (trap efficiencies), for Chinook salmon, are presented in Appendix A.

Trapping and Trucking

Trapping and trucking occurred from July 6, 2007 through July 11, 2007 and was initiated when daily mean water temperatures at the Frandy gauging station (approximately 8 miles downstream of WIDD) exceeded a 24 ^{o}C daily average. During this period 295 Chinook salmon were trapped and transported. The number of fish released alive was 293. The mortalities, which were less than 1 percent, can be attributed to handling and transport stress. All fish were acclimated to within 1.0^{o}C of release water in the transport tanks by introducing release water into the tanks before release. The two release locations were Lighthouse Marina and Pirate's Lair Marina on the Mokelumne River.

Coded Wire Tagging

Natural production tagging conducted at WIDD began on January 31, 2007 and ended on June 15, 2007. One tag code (06-01-13-02-10) was used to tag 10,538 YOY Chinook

salmon captured in the rotary screw trap and bypass trap. Average FL 83.3 mm (n=1,250). Fish ranged in size from 38 mm to 143 mm. Another tag code (06-48-55) was used to tag 1,173 fish captured in the bypass trap. Average FL was 90.43 mm (n=288). Fish ranged in size from 73 mm to 115 mm.

Steelhead

Thirty-five YOY steelhead were captured in the rotary screw trap and 108 in the smolt bypass trap from March through July. The estimate for young-of-year steelhead during this period, based on Chinook salmon calibrations, is 1,111 (95% C.I:818-2,144) plus smolt bypass trap count with weekend estimates (157) for an estimate of 1,268. Data are in Appendix B.

Young-of-year steelhead were described to lifestage as fry or parr. Fry averaged 25.0 mm FL (21-29 mm, n=6). Parr averaged 57.5 mm FL (26-97 mm, n=62). In addition, 85 age 1+ steelhead were captured between February and May. These fish averaged 231 mm FL (134-437 mm, n=83). Seventy-seven of these steelhead were adipose-fin clipped ranging in size from 180-437 mm FL ($\bar{X}$ = 233 mm). The nine wild fish measured 134-266 mm FL ($\bar{X}$ =214 mm).

Incidental Species

Twenty fish species were observed in rotary screw traps. Some juvenile black bass and centrarchid hybrids were only identified to genus. Eight native species and 12 non native species were captured. The most abundant fish observed were Chinook salmon, followed by black bass, prickly sculpin, common carp and steelhead trout (Table 2).

Table 1. Chinook salmon trap efficiency test results for rotary screw traps fished at Woodbridge Irrigation District Dam, December 18, 2006 through May 22, 2007.

Date of Test	Source	Release Site	Day Release		Night Release		Trap Efficiency		Flow	Fish Size	Sample
			Marked	Recaptured	Marked	Recaptured	Day	Night	cfs	mm	Size
08-Jan-07	Hatchery	WIDD Basin	1027	88	1023	93	0.086	0.091	341	35.2	n=186
29-Jan-07	Hatchery	WIDD Basin	762	68	759	96	0.089	0.126	341	39.2	n=46
27-Feb-07	Hatchery	WIDD Basin	514	50	514	70	0.097	0.136	348	37.9	n=405
26-Mar-07	Hatchery	WIDD Basin	547	15	504	14	0.027	0.028	323	59.3	n=45
23-Apr-07	Hatchery	WIDD Basin	500	14	500	40	0.028	0.080	332	82.9	n=177
22-May-07	Wild	WIDD Basin	469	9	75	5	0.019	0.067	376	85.7	n=2004

Acknowledgements

We would like to thank Ed Rible for hard work and dedication to accurate data collection, data storage, and data retrieval. Thanks to Woodbridge Irrigation District for access to the site. We would also like to thank EBMUD Fisheries and Wildlife Division staff for their assistance on the project as needed.

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Table 2 . Raw capture data of fish species trapped below Woodbridge Dam on the Lower Mokelumne River, December 18, 2006 - July 27, 2007. Numbers in parentheses represent Smolt bypass trap catch. (Native species are in bold)

Species	**Life Stage**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Total**
Black Crappie	Juvenile						1 (1)	(1)		1(2)
Pomoxis nigromaculatus	Adult									0
Bluegill	Juvenile	2	2	2	1	1			(1)	8 (1)
Lepomis macrochirus	Adult		1		1		(1)			2 (1)
Brown Bullhead	Juvenile						1			1
Ictalurus nebulosus	Adult									0
Common Carp	Juvenile	1	2		2	32	438 (24)	(40)	(45)	475 (109)
Cyprinus carpio	Adult									0
Chinook salmon	YOY	39	151	67	388	58	315 (2518)	(9874)	(696)	1018 (13088)
Oncorhynchus tschawytscha	YOY Adclipped									0
Channel Catfish	Juvenile	1					3		(2)	4 (2)
Ictalurus punctatus	Adult						2		(1)	2 (1)
Golden Shiner	Juvenile	3		1			1	(2)	(1)	5 (3)
Notemigonus crysoleucas	Adult	21	8	4	7		1			41
Goldfish	Juvenile				1					1
Carassius auratus	Adult									0
Hitch	Juvenile			1	2		1		(1)	4 (1)
Lavinia exilicauda	Adult				1					1
Inland Silverside	Juvenile					1				1
Menidia beryllina	Adult									0
Lepomis hybrid	Juvenile			1						1
Lepomis sp.	Adult									0

Table 2 . Raw capture data of fish species trapped below Woodbridge Dam on the Lower Mokelumne River, December 18, 2006 - July 27, 2007. Numbers in parentheses represent Smolt bypass trap catch(cont.). (Native species are in bold)

Species	Life Stage	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Total
Pacific Lamprey	Adult				1	1	2	(1)		4 (1)
Lampetra tridentata	Ammocoete									0
	Juvenile	1	2	17	1	8	1			30
Prickly Sculpin	Juvenile	16	34	46	98	176	535 (19)	(10)	(75)	905(104)
Cottus asper	Adult	2	12	45	78	23	8 (1)	(7)	(23)	168 (31)
Redear Sunfish	Juvenile		1	1	4		2			8
Lepomis microlophus	Adult				2	1				3
Spotted Bass	Juvenile									0
Micropterus punctulatus	Adult								(2)	(2)
Sacramento Sucker	Juvenile					1	40 (2)			41 (2)
Catostomus occidentalis	Adult				1			(1)	(1)	1 (2)
Sacramento Pikeminnow	Juvenile					1				1
Ptychocheilus grandis	Adult									0
Steelhead Trout	YOY				6	18	11 (7)	(39)	(62)	35 (108)
Oncorhynchus mykiss	1+			5	4					9
	1+ Adclipped			39	36		1		(1)	76 (1)
Tule Perch	Juvenile					1		(5)	(34)	1 (39)
Hysterocarpus traski	Adult			1	7	8	(3)		(3)	16 (6)
Unknown Black Bass	Juvenile						2470 (7457)	(967)	(2329)	2470 (10753)
Micropterus sp.	Adult									0
Warmouth	Juvenile	2		14	14	1	1			32
Lepomis gulosis	Adult									0
White Catfish	Juvenile							(1)	(1)	(2)
Ameiurus catus	Adult						5			5

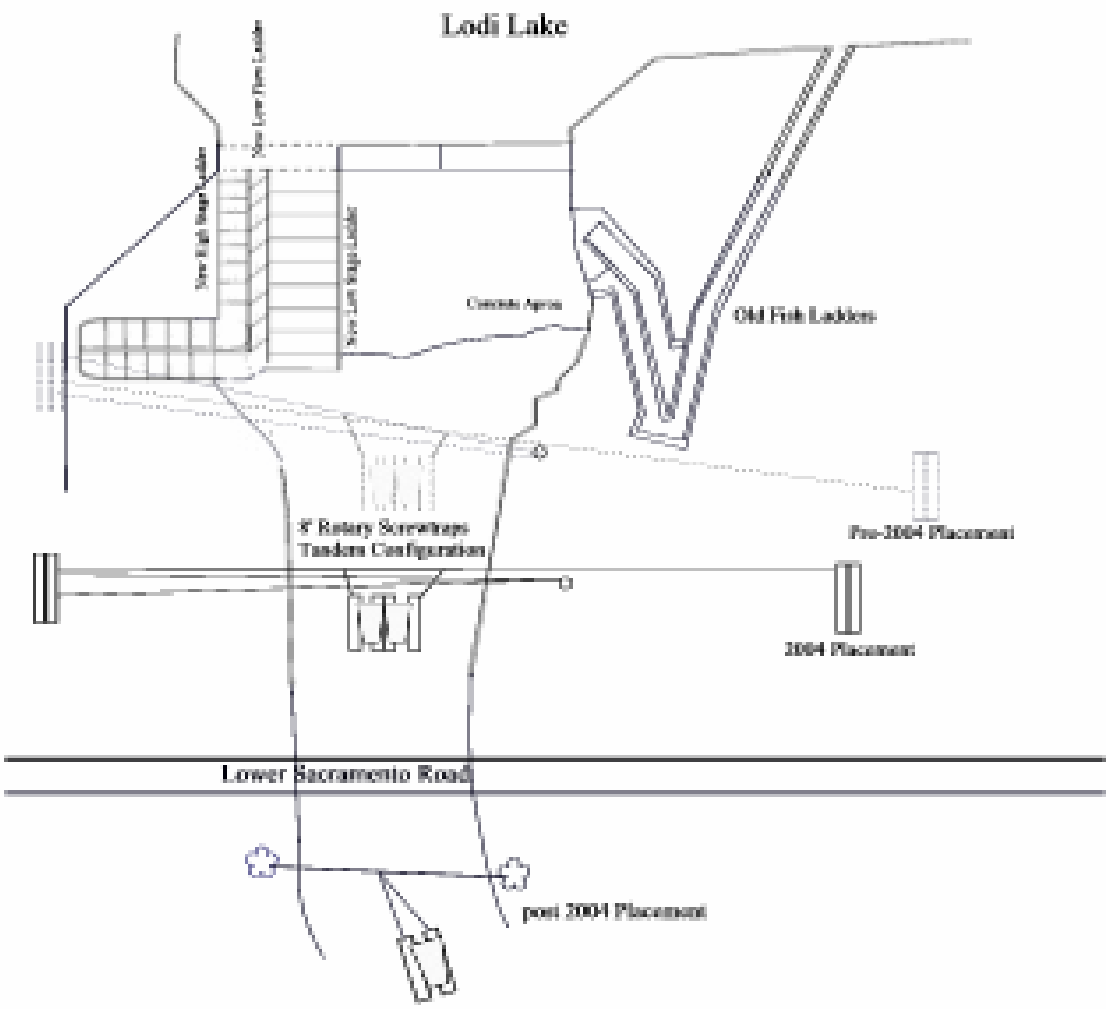

Figure 1. 2007 placement of a single eight foot diameter rotary screw trap on the lower Mokelumne River.

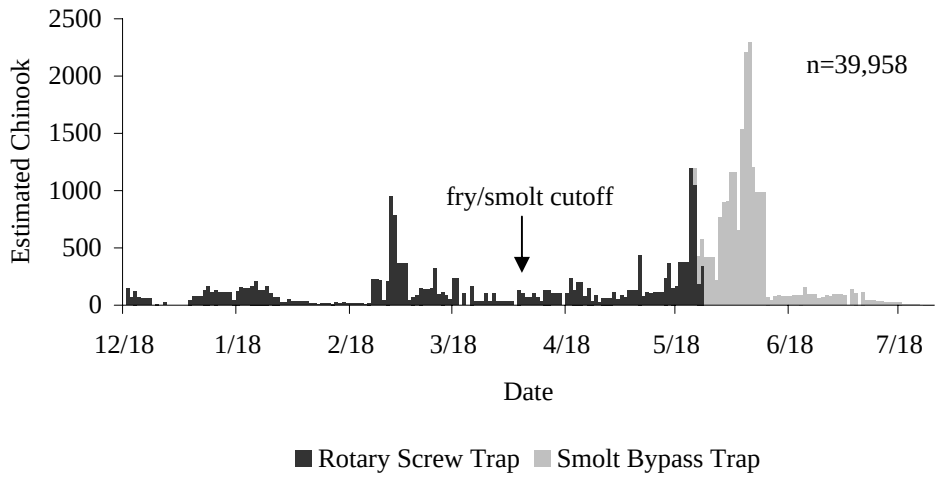

Figure 2. Estimated abundance of young-of-year chinook salmon emigrating out of the lower Mokelumne River, Ca. December 18, 2006 through July 27, 2007.

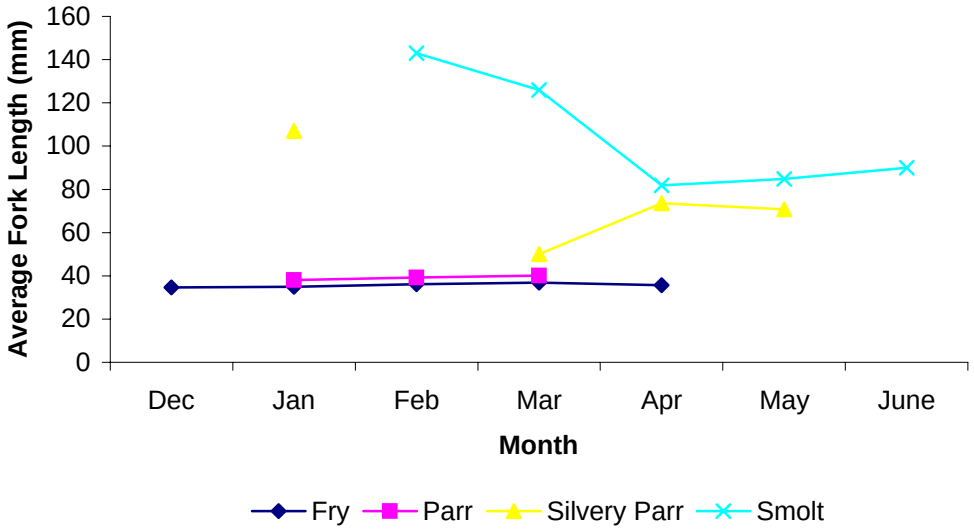

Figure 3. Average fork length (mm) of juvenile Chinook salmon lifestages by month, on the lower Mokelumne River from December 18, 2006 through June 29, 2007.

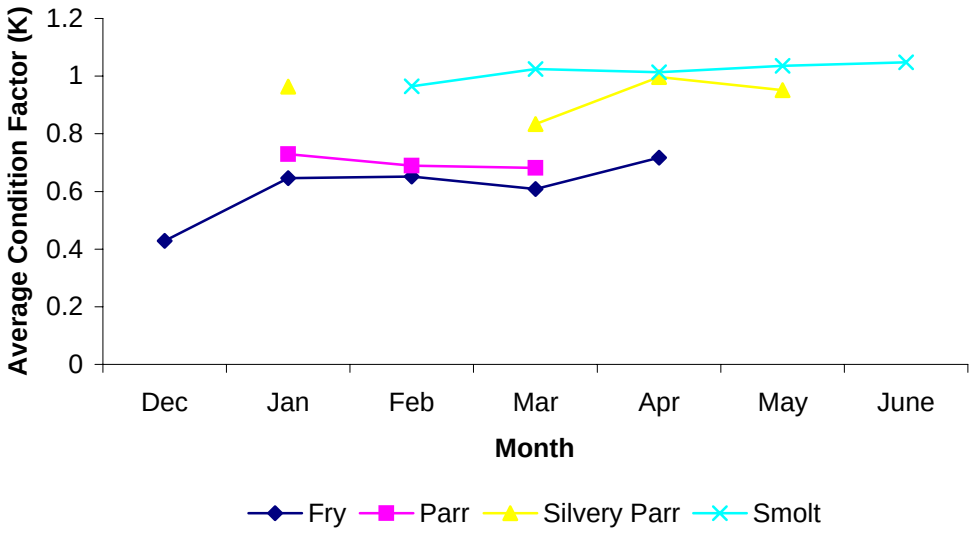

Figure 4. Average condition factor (K) of juvenile Chinook salmon lifestages by month, on the lower Mokelumne River from December 18, 2006 through June 29, 2007.

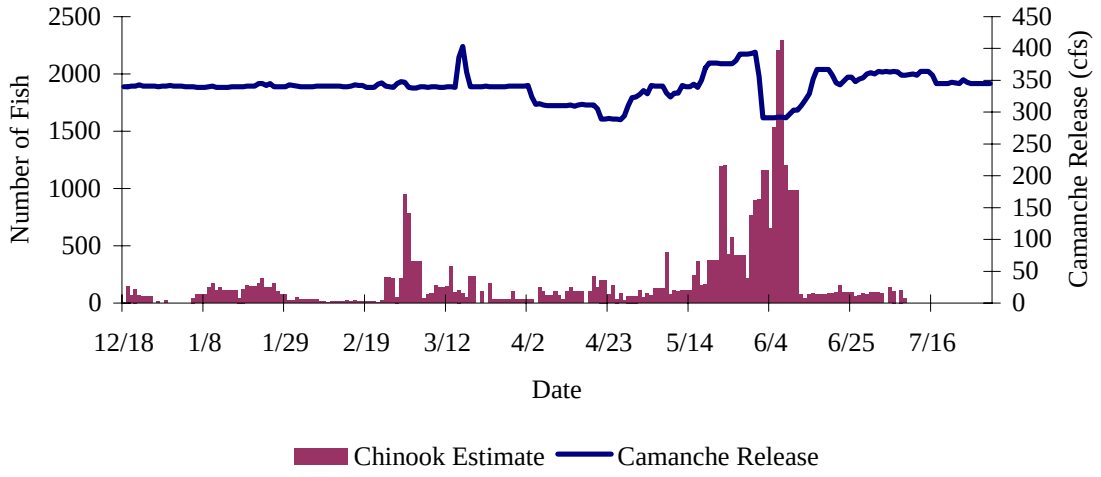

Figure 5. Juvenile Chinook salmon emigration on the lower Mokelumne River and Camanche release flows, December 18, 2006 - July 29, 2007.

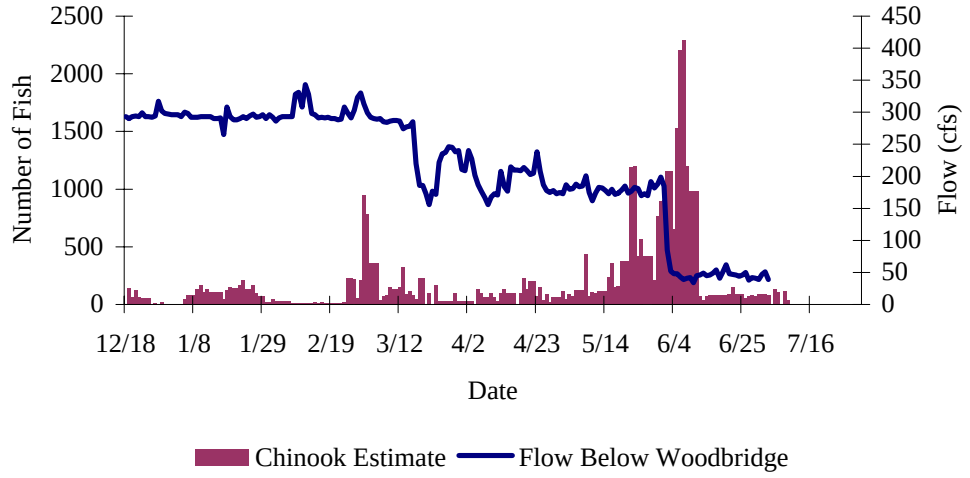

Figure 6. Juvenile Chinook salmon emigration on the lower Mokelumne River and flow below WIDD, December 18, 2006 - July 29, 2007.

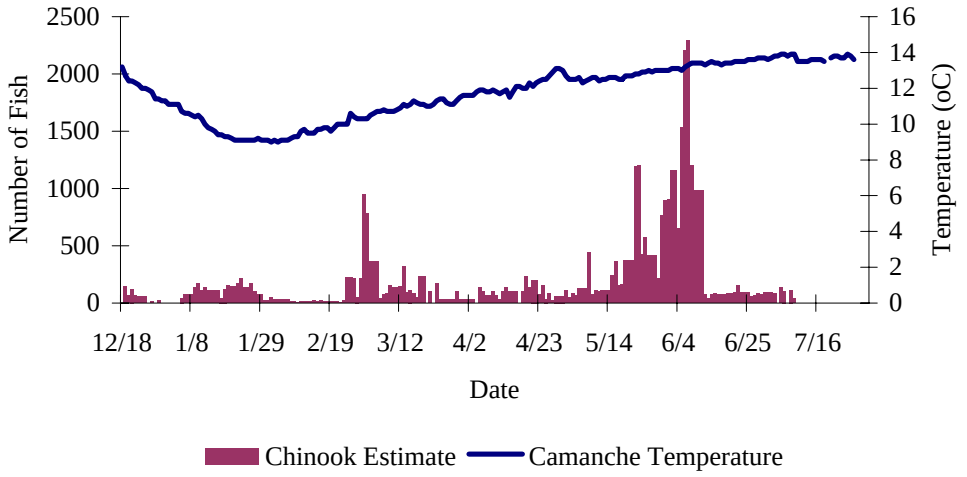

Figure 7. Juvenile Chinook salmon emigration on the lower Mokelumne River and Camanche temperature, December 18, 2006 - July 29, 2007.

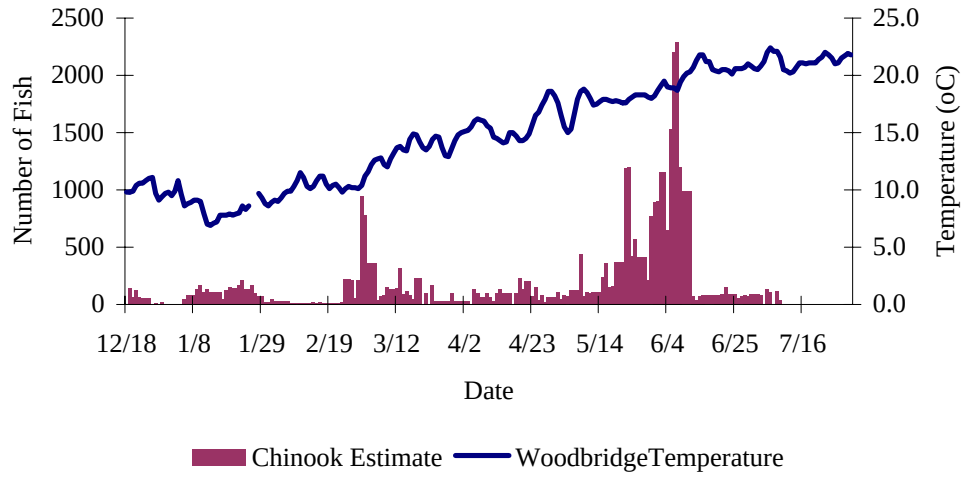

Figure 8. Juvenile Chinook salmon emigration on the lower Mokelumne River and WIDD temperature, December 18, 2006 - July 29, 2007.

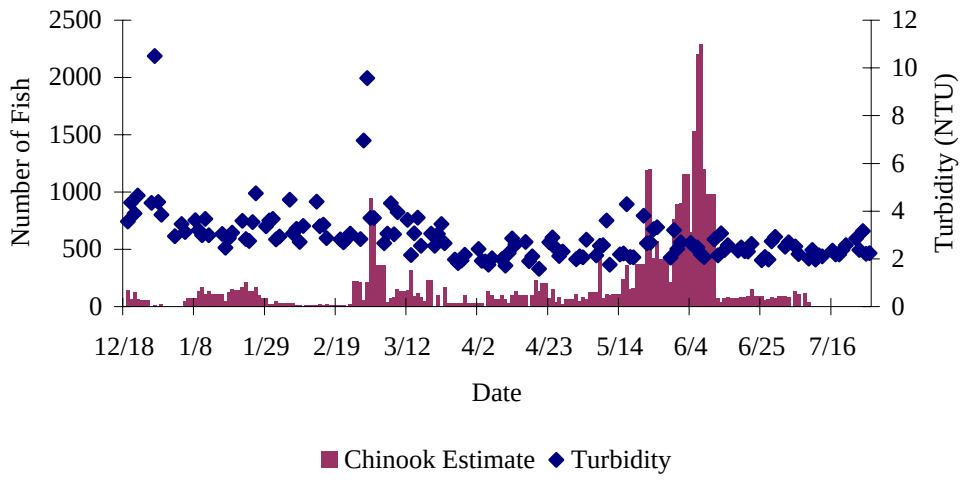

Figure 9. Juvenile Chinook salmon emigration on the lower Mokelumne River and turbidity , December 18, 2006 - July 29, 2007.

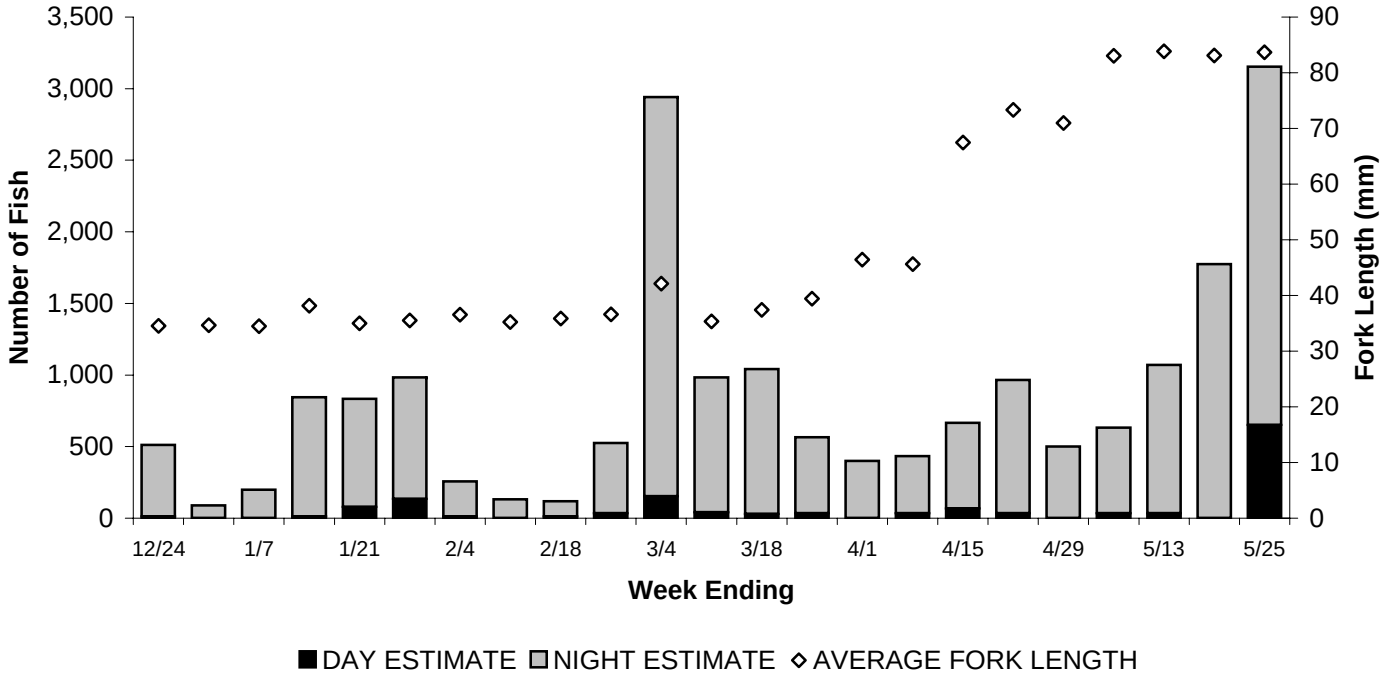

Figure 10. Weekly diel abundance of young-of-year Chinook salmon emigrating past Woodbridge Irrigation District Dam from December 18, 2006 through May 25, 2007.

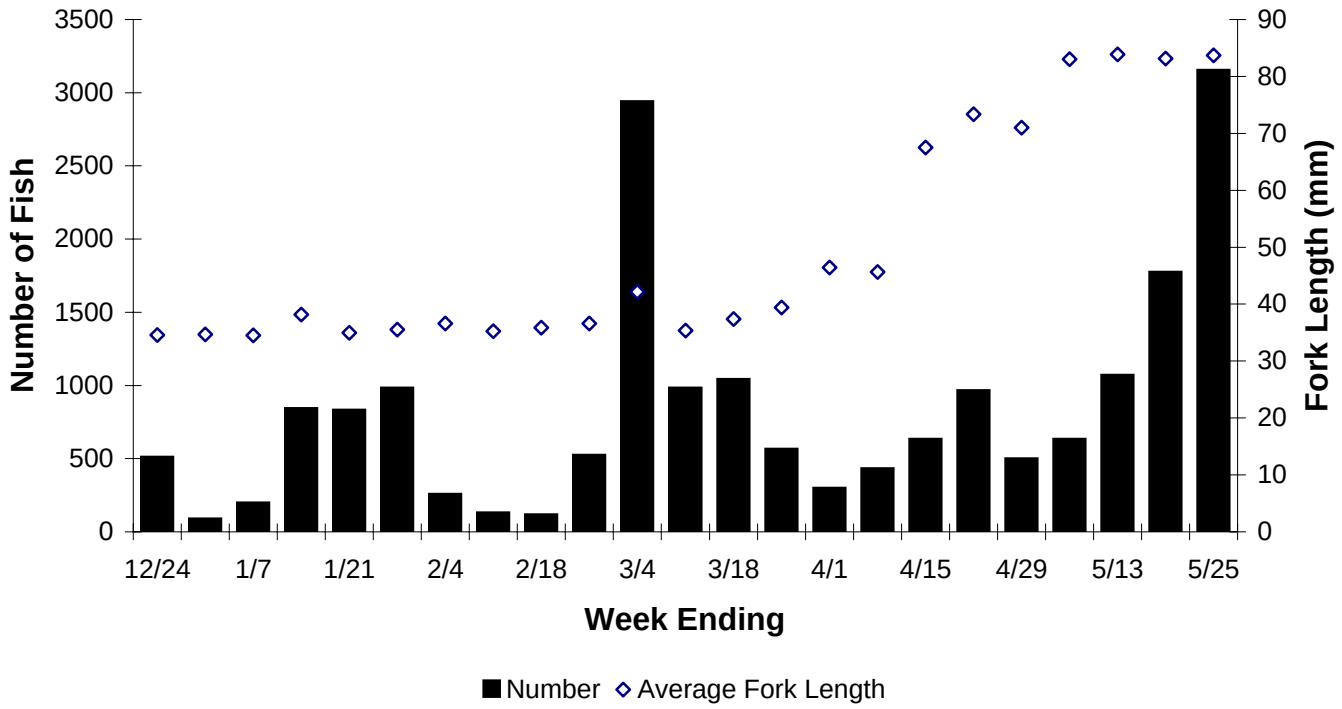

Figure 11. Weekly abundance and average fork length of young-of-year Chinook Salmon emigrating past Woodbridge Irrigation District Dam from December 18,2006 through May 25, 2007.

Appendix A. Daily abundance of juvenile fall-run Chinook migrating past Woodbridge Irrigation District Dam, December 18, 2006 through July 29, 2007. Data estimated from screw trap captures and bypass trap captures

Date	YOY Day	YOY Night	Trap Efficiency Day	Trap Efficiency Night	Estimated YOY Day	Estimated YOY Night	Estimated YOY Total	95% Confidence Interval High	95% Confidence Interval Low	Bypass Catch Total
12/18/2006	0	0	0.090	0.090	0	0	0	0	0	
12/19/2006	1	12	0.090	0.090	11	133	144	178	156	
12/20/2006	0	6	0.090	0.090	0	67	67	82	67	
12/21/2006	0	11	0.090	0.090	0	122	122	150	122	
12/22/2006	0	6	0.090	0.090	0	67	67	82	67	
12/23/2006	0	5	0.090	0.090	0	56	56	68	56	
12/24/2006	0	5	0.090	0.090	0	56	56	68	56	
12/25/2006	0	5	0.090	0.090	0	56	56	68	56	
12/26/2006	0	0	0.090	0.090	0	0	0	0	0	
12/27/2006	0	1	0.090	0.090	0	11	11	14	11	
12/28/2006	0	0	0.090	0.090	0	0	0	0	0	
12/29/2006	0	2	0.090	0.090	0	22	22	27	22	
12/30/2006	0	0	0.090	0.090	0	0	0	0	0	
12/31/2006	0	0	0.090	0.090	0	0	0	0	0	
1/1/2007	0	0	0.090	0.090	0	0	0	0	0	
1/2/2007	0	0	0.090	0.090	0	0	0	0	0	
1/3/2007	0	0	0.090	0.090	0	0	0	0	0	
1/4/2007	0	0	0.090	0.090	0	0	0	0	0	
1/5/2007	0	4	0.090	0.090	0	44	44	55	44	
1/6/2007	0	7	0.090	0.090	0	78	78	96	78	
1/7/2007	0	7	0.090	0.090	0	78	78	96	78	
1/8/2007	0	7	0.090	0.090	0	78	78	96	78	
1/9/2007	0	12	0.090	0.090	0	133	133	164	133	
1/10/2007	1	14	0.090	0.090	11	156	167	206	178	
1/11/2007	0	10	0.090	0.090	0	111	111	136	111	
1/12/2007	0	12	0.090	0.090	0	133	133	164	133	
1/13/2007	0	10	0.090	0.090	0	111	111	136	111	
1/14/2007	0	10	0.090	0.090	0	111	111	136	111	
1/15/2007	0	10	0.090	0.090	0	111	111	136	111	
1/16/2007	0	10	0.090	0.090	0	111	111	136	111	
1/17/2007	0	4	0.090	0.090	0	44	44	55	44	

Appendix A. Daily abundance of juvenile fall-run Chinook migrating past Woodbridge Irrigation District Dam, December 18, 2006 through July 29, 2007. Data estimated from screw trap captures and bypass trap captures

Date	YOY Day	YOY Night	Trap Efficiency Day	Trap Efficiency Night	Estimated YOY Day	Estimated YOY Night	Estimated YOY Total	95% Confidence Interval High	95% Confidence Interval Low	Bypass Catch Total
1/18/2007	2	9	0.090	0.090	22	100	122	152	102	
1/19/2007	1	13	0.090	0.090	11	144	156	192	130	
1/20/2007	2	11	0.090	0.090	22	122	144	179	121	
1/21/2007	2	11	0.090	0.090	22	122	144	179	121	
1/22/2007	4	11	0.090	0.090	44	122	167	208	140	
1/23/2007	2	17	0.090	0.090	22	189	211	261	176	
1/24/2007	1	11	0.090	0.090	11	122	133	165	111	
1/25/2007	1	11	0.090	0.090	11	122	133	165	111	
1/26/2007	2	13	0.090	0.090	22	144	167	207	139	
1/27/2007	1	8	0.090	0.090	11	89	100	124	83	
1/28/2007	1	8	0.090	0.130	11	62	73	92	62	
1/29/2007	1	8	0.090	0.130	11	62	73	92	62	
1/30/2007	0	3	0.090	0.130	0	23	23	29	20	
1/31/2007	0	3	0.090	0.130	0	23	23	29	20	
2/1/2007	0	6	0.090	0.130	0	46	46	58	40	
2/2/2007	0	4	0.090	0.130	0	31	31	39	27	
2/3/2007	0	4	0.090	0.130	0	31	31	39	27	
2/4/2007	0	4	0.090	0.130	0	31	31	39	27	
2/5/2007	0	4	0.090	0.130	0	31	31	39	27	
2/6/2007	0	4	0.090	0.130	0	31	31	39	27	
2/7/2007	0	2	0.090	0.130	0	15	15	19	13	
2/8/2007	0	2	0.090	0.130	0	15	15	19	13	
2/9/2007	0	1	0.090	0.130	0	8	8	10	7	
2/10/2007	0	2	0.090	0.130	0	15	15	19	13	
2/11/2007	0	2	0.090	0.130	0	15	15	19	13	
2/12/2007	0	2	0.090	0.130	0	15	15	19	13	
2/13/2007	1	0	0.090	0.130	11	0	11	14	9	
2/14/2007	0	3	0.090	0.130	0	23	23	29	20	
2/15/2007	0	2	0.090	0.130	0	15	15	19	13	
2/16/2007	0	3	0.090	0.130	0	23	23	29	20	

Appendix A. Daily abundance of juvenile fall-run Chinook migrating past Woodbridge Irrigation District Dam, December 18, 2006 through July 29, 2007. Data estimated from screw trap captures and bypass trap captures

Date	YOY Day	YOY Night	Trap Efficiency Day	Trap Efficiency Night	Estimated YOY Day	Estimated YOY Night	Estimated YOY Total	95% Confidence Interval High	95% Confidence Interval Low	Bypass Catch Total
2/17/2007	0	2	0.090	0.130	0	15	15	19	13	
2/18/2007	0	2	0.090	0.130	0	15	15	19	13	
2/19/2007	0	2	0.090	0.130	0	15	15	19	13	
2/20/2007	0	2	0.090	0.130	0	15	15	19	13	
2/21/2007	0	2	0.090	0.130	0	15	15	19	13	
2/22/2007	0	1	0.090	0.130	0	8	8	10	7	
2/23/2007	1	1	0.090	0.130	11	8	19	24	16	
2/24/2007	1	28	0.090	0.130	11	215	226	287	196	
2/25/2007	1	28	0.090	0.130	11	215	226	287	196	
2/26/2007	0	28	0.090	0.130	0	215	215	272	187	
2/27/2007	1	4	0.090	0.130	11	31	42	53	36	
2/28/2007	2	27	0.100	0.140	20	193	213	281	179	
3/1/2007	0	133	0.100	0.140	0	950	950	1248	802	
3/2/2007	7	100	0.100	0.140	70	714	784	1036	660	
3/3/2007	2	48	0.100	0.140	20	343	363	478	306	
3/4/2007	2	48	0.100	0.140	20	343	363	478	306	
3/5/2007	2	48	0.100	0.140	20	343	363	478	306	
3/6/2007	0	6	0.100	0.140	0	43	43	56	36	
3/7/2007	0	10	0.100	0.140	0	71	71	94	60	
3/8/2007	2	9	0.100	0.140	20	64	84	112	71	
3/9/2007	0	21	0.100	0.140	0	150	150	197	127	
3/10/2007	0	19	0.100	0.140	0	136	136	178	115	
3/11/2007	0	19	0.100	0.140	0	136	136	178	115	
3/12/2007	1	19	0.100	0.140	10	136	146	192	123	
3/13/2007	0	45	0.100	0.140	0	321	321	422	271	
3/14/2007	0	13	0.100	0.140	0	93	93	122	78	
3/15/2007	0	16	0.100	0.140	0	114	114	150	96	
3/16/2007	2	9	0.100	0.140	20	64	84	112	71	
3/17/2007	0	7	0.100	0.140	0	50	50	66	42	
3/18/2007	0	7	0.030	0.030	0	233	233	521	166	
3/19/2007	0	7	0.030	0.030	0	233	233	521	166	

Appendix A. Daily abundance of juvenile fall-run Chinook migrating past Woodbridge Irrigation District Dam, December 18, 2006 through July 29, 2007. Data estimated from screw trap captures and bypass trap captures

Date	YOY Day	YOY Night	Trap Efficiency Day	Trap Efficiency Night	Estimated YOY Day	Estimated YOY Night	Estimated YOY Total	95% Confidence Interval High	95% Confidence Interval Low	Bypass Catch Total
3/20/2007	0	0	0.030	0.030	0	0	0	0	0	
3/21/2007	0	3	0.030	0.030	0	100	100	223	71	
3/22/2007	0	0	0.030	0.030	0	0	0	0	0	
3/23/2007	1	4	0.030	0.030	33	133	167	371	119	
3/24/2007	0	1	0.030	0.030	0	33	33	74	24	
3/25/2007	0	1	0.030	0.030	0	33	33	74	24	
3/26/2007	0	1	0.030	0.030	0	33	33	74	24	
3/27/2007	0	3	0.030	0.030	0	100	100	223	71	
3/28/2007	0	1	0.030	0.030	0	33	33	74	24	
3/29/2007	0	3	0.030	0.030	0	100	100	223	71	
3/30/2007	0	1	0.030	0.030	0	33	33	74	24	
3/31/2007	0	1	0.030	0.030	0	33	33	74	24	
4/1/2007	0	1	0.030	0.030	0	33	33	74	24	
4/2/2007	0	1	0.030	0.030	0	33	33	74	24	
4/3/2007	0	1	0.030	0.030	0	33	33	74	24	
4/4/2007	0	0	0.030	0.030	0	0	0	0	0	
4/5/2007	0	4	0.030	0.030	0	133	133	298	95	
4/6/2007	1	2	0.030	0.030	33	67	100	222	72	
4/7/2007	0	2	0.030	0.030	0	67	67	149	47	
4/8/2007	0	2	0.030	0.030	0	67	67	149	47	
4/9/2007	1	2	0.030	0.030	33	67	100	222	72	
4/10/2007	0	2	0.030	0.030	0	67	67	149	47	
4/11/2007	0	1	0.030	0.030	0	33	33	74	24	
4/12/2007	1	3	0.030	0.030	33	100	133	296	96	
4/13/2007	0	4	0.030	0.030	0	133	133	298	95	
4/14/2007	0	3	0.030	0.030	0	100	100	223	71	
4/15/2007	0	3	0.030	0.030	0	100	100	223	71	
4/16/2007	0	3	0.030	0.030	0	100	100	223	71	
4/17/2007	0	0	0.030	0.030	0	0	0	0	0	
4/18/2007	1	2	0.030	0.030	33	67	100	222	72	

Appendix A. Daily abundance of juvenile fall-run Chinook migrating past Woodbridge Irrigation District Dam, December 18, 2006 through July 29, 2007. Data estimated from screw trap captures and bypass trap captures

Date	YOY Day	YOY Night	Trap Efficiency Day	Trap Efficiency Night	Estimated YOY Day	Estimated YOY Night	Estimated YOY Total	95% Confidence Interval High	95% Confidence Interval Low	Bypass Catch Total
4/19/2007	0	7	0.030	0.030	0	233	233	521	166	
4/20/2007	0	4	0.030	0.030	0	133	133	298	95	
4/21/2007	0	6	0.030	0.030	0	200	200	447	142	
4/22/2007	0	6	0.030	0.030	0	200	200	447	142	
4/23/2007	0	6	0.030	0.080	0	75	75	107	58	
4/24/2007	0	12	0.030	0.080	0	150	150	213	116	
4/25/2007	0	3	0.030	0.080	0	38	38	53	29	
4/26/2007	0	7	0.030	0.080	0	88	88	125	67	
4/27/2007	0	2	0.030	0.080	0	25	25	36	19	
4/28/2007	0	5	0.030	0.080	0	63	63	89	48	
4/29/2007	0	5	0.030	0.080	0	63	63	89	48	
4/30/2007	0	5	0.030	0.080	0	63	63	89	48	
5/1/2007	0	9	0.030	0.080	0	113	113	160	87	
5/2/2007	0	4	0.030	0.080	0	50	50	71	39	
5/3/2007	0	7	0.030	0.080	0	88	88	125	67	
5/4/2007	1	3	0.030	0.080	33	38	71	127	52	
5/5/2007	0	10	0.030	0.080	0	125	125	178	96	
5/6/2007	0	10	0.030	0.080	0	125	125	178	96	
5/7/2007	0	10	0.030	0.080	0	125	125	178	96	
5/8/2007	0	35	0.030	0.080	0	438	438	623	337	
5/9/2007	0	6	0.030	0.080	0	75	75	107	58	
5/10/2007	1	6	0.030	0.080	33	75	108	181	81	
5/11/2007	0	8	0.030	0.080	0	100	100	142	77	
5/12/2007	0	9	0.030	0.080	0	113	113	160	87	
5/13/2007	0	9	0.030	0.080	0	113	113	160	87	
5/14/2007	0	9	0.030	0.080	0	113	113	160	87	
5/15/2007	0	19	0.030	0.080	0	238	238	338	183	
5/16/2007	0	29	0.030	0.080	0	363	363	516	279	
5/17/2007	0	12	0.030	0.080	0	150	150	213	116	
5/18/2007	0	13	0.030	0.080	0	163	163	231	125	
5/19/2007	0	30	0.030	0.080	0	375	375	534	289	

Appendix A. Daily abundance of juvenile fall-run Chinook migrating past Woodbridge Irrigation District Dam, December 18, 2006 through July 29, 2007. Data estimated from screw trap captures and bypass trap captures

Date	YOY Day	YOY Night	Trap Efficiency Day	Trap Efficiency Night	Estimated YOY Day	Estimated YOY Night	Estimated YOY Total	95% Confidence Interval High	95% Confidence Interval Low	Bypass Catch Total
5/20/2007		30	0.030	0.080	0	375	375	534	289	
5/21/2007		30	0.030	0.080	0	375	375	534	289	
5/22/2007	13	38	0.020	0.070	650	543	1193	5640	720	
5/23/2007		74	0.020	0.070	0	1057	1057	7246	601	142
5/24/2007		13	0.020	0.070	0	186	186	1273	106	237
5/25/2007		24	0.020	0.070	0	343	343	2350	195	229
5/26/2007										415
5/27/2007										415
5/28/2007										415
5/29/2007										214
5/30/2007										769
5/31/2007										897
6/1/2007										904
6/2/2007										1160
6/3/2007										1160
6/4/2007										653
6/5/2007										1533
6/6/2007										2205
6/7/2007										2293
6/8/2007										1205
6/9/2007										986
6/10/2007										986
6/11/2007										986
6/12/2007										74
6/13/2007										40
6/14/2007										75
6/15/2007										85
6/16/2007										77
6/17/2007										77
6/18/2007										77
6/19/2007										84

Appendix A. Daily abundance of juvenile fall-run Chinook migrating past Woodbridge Irrigation District Dam, December 18, 2006 through July 29, 2007. Data estimated from screw trap captures and bypass trap captures

Date	YOY Day	YOY Night	Trap Efficiency Day	Trap Efficiency Night	Estimated YOY Day	Estimated YOY Night	Estimated YOY Total	95% Confidence Interval High	95% Confidence Interval Low	Bypass Catch Total
6/20/2007										87
6/21/2007										90
6/22/2007										155
6/23/2007										91
6/24/2007										91
6/25/2007										91
6/26/2007										58
6/27/2007										69
6/28/2007										87
6/29/2007										76
6/30/2007										91
7/1/2007										91
7/2/2007										91
7/3/2007										86
7/4/2007										
7/5/2007										136
7/6/2007										106
7/7/2007										
7/8/2007										114
7/9/2007										42
7/10/2007										39
7/11/2007										42
7/12/2007										31
7/13/2007										32
7/14/2007										26
7/15/2007										26
7/16/2007										26
7/17/2007										21
7/18/2007										27

Appendix A. Daily abundance of juvenile fall-run Chinook migrating past Woodbridge Irrigation District Dam, December 18, 2006 through July 29, 2007. Data estimated from screw trap captures and bypass trap captures

Date	YOY Day	YOY Night	Trap Efficiency Day	Trap Efficiency Night	Estimated YOY Day	Estimated YOY Night	Estimated YOY Total	95% Confidence Interval High	95% Confidence Interval Low	Bypass Catch Total
7/19/2007										6
7/20/2007										5
7/21/2007										7
7/22/2007										7
7/23/2007										7
7/24/2007										1
7/25/2007										3
7/26/2007										2
7/27/2007										3
7/28/2007										
7/29/2007										
Total	67	1633			1383	18198	19582	41761	15386	20356

Appendix B. Daily abundance of steelhead migrating past Woodbridge Irrigation District Dam, February 17, 2007 through July 29, 2007. Data estimated from screw trap captures and bypass trap captures

Date	YOY Day	YOY Night	Trap Efficiency Day	Trap Efficiency Night	Estimated YOY Day	Estimated YOY Night	Estimated YOY Total	95% Confidence Interval High	95% Confidence Interval Low	Bypass Catch Total
2/17/2007	0	0	0.090	0.130	0	0	0	0	0	
2/18/2007	0	0	0.090	0.130	0	0	0	0	0	
2/19/2007	0	0	0.090	0.130	0	0	0	0	0	
2/20/2007	0	0	0.090	0.130	0	0	0	0	0	
2/21/2007	0	0	0.090	0.130	0	0	0	0	0	
2/22/2007	0	0	0.090	0.130	0	0	0	0	0	
2/23/2007	0	0	0.090	0.130	0	0	0	0	0	
2/24/2007	0	0	0.090	0.130	0	0	0	0	0	
2/25/2007	0	0	0.090	0.130	0	0	0	0	0	
2/26/2007	0	0	0.090	0.130	0	0	0	0	0	
2/27/2007	0	0	0.090	0.130	0	0	0	0	0	
2/28/2007	0	0	0.100	0.140	0	0	0	0	0	
3/1/2007	0	0	0.100	0.140	0	0	0	0	0	
3/2/2007	0	0	0.100	0.140	0	0	0	0	0	
3/3/2007	0	0	0.100	0.140	0	0	0	0	0	
3/4/2007	0	0	0.100	0.140	0	0	0	0	0	
3/5/2007	0	0	0.100	0.140	0	0	0	0	0	
3/6/2007	0	0	0.100	0.140	0	0	0	0	0	
3/7/2007	0	0	0.100	0.140	0	0	0	0	0	
3/8/2007	0	1	0.100	0.140	0	7	7	9	6	
3/9/2007	0	1	0.100	0.140	0	7	7	9	6	
3/10/2007	0	0	0.100	0.140	0	0	0	0	0	
3/11/2007	0	0	0.100	0.140	0	0	0	0	0	
3/12/2007	0	0	0.100	0.140	0	0	0	0	0	
3/13/2007	0	0	0.100	0.140	0	0	0	0	0	
3/14/2007	0	0	0.100	0.140	0	0	0	0	0	
3/15/2007	0	1	0.100	0.140	0	7	7	9	6	
3/16/2007	0	2	0.100	0.140	0	14	14	19	12	
3/17/2007	0	0	0.100	0.140	0	0	0	0	0	
3/18/2007	0	0	0.030	0.030	0	0	0	0	0	
3/19/2007	0	0	0.030	0.030	0	0	0	0	0	

Appendix B. Daily abundance of steelhead migrating past Woodbridge Irrigation District Dam, February 17, 2007 through July 29, 2007. Data estimated from screw trap captures and bypass trap captures

Date	YOY Day	YOY Night	Trap Efficiency Day	Trap Efficiency Night	Estimated YOY Day	Estimated YOY Night	Estimated YOY Total	95% Confidence Interval High	95% Confidence Interval Low	Bypass Catch Total
3/20/2007	0	0	0.030	0.030	0	0	0	0	0	
3/21/2007	0	0	0.030	0.030	0	0	0	0	0	
3/22/2007	0	0	0.030	0.030	0	0	0	0	0	
3/23/2007	0	1	0.030	0.030	0	33	33	74	24	
3/24/2007	0	0	0.030	0.030	0	0	0	0	0	
3/25/2007	0	0	0.030	0.030	0	0	0	0	0	
3/26/2007	0	0	0.030	0.030	0	0	0	0	0	
3/27/2007	0	0	0.030	0.030	0	0	0	0	0	
3/28/2007	0	0	0.030	0.030	0	0	0	0	0	
3/29/2007	0	0	0.030	0.030	0	0	0	0	0	
3/30/2007	0	0	0.030	0.030	0	0	0	0	0	
3/31/2007	0	0	0.030	0.030	0	0	0	0	0	
4/1/2007	0	0	0.030	0.030	0	0	0	0	0	
4/2/2007	0	0	0.030	0.030	0	0	0	0	0	
4/3/2007	0	2	0.030	0.030	0	67	67	149	47	
4/4/2007	0	2	0.030	0.030	0	67	67	149	47	
4/5/2007	0	2	0.030	0.030	0	67	67	149	47	
4/6/2007	0	0	0.030	0.030	0	0	0	0	0	
4/7/2007	0	1	0.030	0.030	0	33	33	74	24	
4/8/2007	0	1	0.030	0.030	0	33	33	74	24	
4/9/2007	0	1	0.030	0.030	0	33	33	74	24	
4/10/2007	0	2	0.030	0.030	0	67	67	149	47	
4/11/2007	0	0	0.030	0.030	0	0	0	0	0	
4/12/2007	0	2	0.030	0.030	0	67	67	149	47	
4/13/2007	0	1	0.030	0.030	0	33	33	74	24	
4/14/2007	0	1	0.030	0.030	0	33	33	74	24	
4/15/2007	0	1	0.030	0.030	0	33	33	74	24	
4/16/2007	0	1	0.030	0.030	0	33	33	74	24	
4/17/2007	0	0	0.030	0.030	0	0	0	0	0	
4/18/2007	0	0	0.030	0.030	0	0	0	0	0	

Appendix B. Daily abundance of steelhead migrating past Woodbridge Irrigation District Dam, February 17, 2007 through July 29, 2007. Data estimated from screw trap captures and bypass trap captures

Date	YOY Day	YOY Night	Trap Efficiency Day	Trap Efficiency Night	Estimated YOY Day	Estimated YOY Night	Estimated YOY Total	95% Confidence Interval High	95% Confidence Interval Low	Bypass Catch Total
4/19/2007	0	1	0.030	0.030	0	33	33	74	24	
4/20/2007	0	0	0.030	0.030	0	0	0	0	0	
4/21/2007	0	1	0.030	0.030	0	33	33	74	24	
4/22/2007	0	1	0.030	0.030	0	33	33	74	24	
4/23/2007	0	1	0.030	0.080	0	13	13	18	10	
4/24/2007	0	2	0.030	0.080	0	25	25	36	19	
4/25/2007	0	1	0.030	0.080	0	13	13	18	10	
4/26/2007	0	1	0.030	0.080	0	13	13	18	10	
4/27/2007	0	2	0.030	0.080	0	25	25	36	19	
4/28/2007	0	1	0.030	0.080	0	13	13	18	10	
4/29/2007	0	1	0.030	0.080	0	13	13	18	10	
4/30/2007	0	1	0.030	0.080	0	13	13	18	10	
5/1/2007	0	0	0.030	0.080	0	0	0	0	0	
5/2/2007	0	0	0.030	0.080	0	0	0	0	0	
5/3/2007	0	1	0.030	0.080	0	13	13	18	10	
5/4/2007	0	1	0.030	0.080	0	13	13	18	10	
5/5/2007	0	1	0.030	0.080	0	13	13	18	10	
5/6/2007	0	1	0.030	0.080	0	13	13	18	10	
5/7/2007	0	1	0.030	0.080	0	13	13	18	10	
5/8/2007	0	0	0.030	0.080	0	0	0	0	0	
5/9/2007	0	2	0.030	0.080	0	25	25	36	19	
5/10/2007	0	3	0.030	0.080	0	38	38	53	29	
5/11/2007	0	0	0.030	0.080	0	0	0	0	0	
5/12/2007	0	1	0.030	0.080	0	13	13	18	10	
5/13/2007	0	1	0.030	0.080	0	13	13	18	10	
5/14/2007	0	1	0.030	0.080	0	13	13	18	10	
5/15/2007	0	1	0.030	0.080	0	13	13	18	10	
5/16/2007	0	1	0.030	0.080	0	13	13	18	10	
5/17/2007	0	1	0.030	0.080	0	13	13	18	10	
5/18/2007	0	1	0.030	0.080	0	13	13	18	10	
5/19/2007	0	1	0.030	0.080	0	13	13	18	10	

Appendix B. Daily abundance of steelhead migrating past Woodbridge Irrigation District Dam, February 17, 2007 through July 29, 2007. Data estimated from screw trap captures and bypass trap captures

Date	YOY Day	YOY Night	Trap Efficiency Day	Trap Efficiency Night	Estimated YOY Day	Estimated YOY Night	Estimated YOY Total	95% Confidence Interval High	95% Confidence Interval Low	Bypass Catch Total
5/20/2007	0	1	0.030	0.080	0	13	13	18	10	
5/21/2007	0	1	0.030	0.080	0	13	13	18	10	
5/22/2007			0.020	0.070						3
5/23/2007			0.020	0.070						
5/24/2007			0.020	0.070						2
5/25/2007			0.020	0.070						1
5/26/2007										1
5/27/2007										
5/28/2007										
5/29/2007										
5/30/2007										1
5/31/2007										
6/1/2007										1
6/2/2007										1
6/3/2007										1
6/4/2007										1
6/5/2007										3
6/6/2007										1
6/7/2007										7
6/8/2007										11
6/9/2007										5
6/10/2007										5
6/11/2007										
6/12/2007										
6/13/2007										2
6/14/2007										1
6/15/2007										2
6/16/2007										
6/17/2007										
6/18/2007										
6/19/2007										1

Appendix B. Daily abundance of steelhead migrating past Woodbridge Irrigation District Dam, February 17, 2007 through July 29, 2007. Data estimated from screw trap captures and bypass trap captures

Date	YOY Day	YOY Night	Trap Efficiency Day	Trap Efficiency Night	Estimated YOY Day	Estimated YOY Night	Estimated YOY Total	95% Confidence Interval High	95% Confidence Interval Low	Bypass Catch Total
6/20/2007										1
6/21/2007										
6/22/2007										
6/23/2007										1
6/24/2007										1
6/25/2007										
6/26/2007										1
6/27/2007										5
6/28/2007										
6/29/2007										2
6/30/2007										1
7/1/2007										1
7/2/2007										
7/3/2007										
7/4/2007										
7/5/2007										1
7/6/2007										2
7/7/2007										
7/8/2007										4
7/9/2007										3
7/10/2007										1
7/11/2007										10
7/12/2007										9
7/13/2007										11
7/14/2007										8
7/15/2007										8
7/16/2007										8
7/17/2007										6
7/18/2007										6

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Date	YOY Day	YOY Night	Trap Efficiency Day	Trap Efficiency Night	Estimated YOY Day	Estimated YOY Night	Estimated YOY Total	95% Confidence Interval High	95% Confidence Interval Low	Bypass Catch Total
7/19/2007										2
7/20/2007										4
7/21/2007										3
7/22/2007										3
7/23/2007										3
7/24/2007										1
7/25/2007										1
7/26/2007										
7/27/2007										
7/28/2007										
7/29/2007										
Total	0	56			0	1111	1111	2144	818	157