Outmigrant Trapping of Juvenile Salmonids in the Lower Tuolumne River, 2008

FINAL REPORT
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Turlock Irrigation District
Modesto Irrigation District

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INTRODUCTION

Study Area Description

The Tuolumne River is the largest of the three major tributaries (Tuolumne, Merced, and Stanislaus Rivers) to the San Joaquin River, originating in the central Sierra Nevada and flowing west between the Merced River to the south and the Stanislaus River to the north (Figure 1). The San Joaquin River itself flows north and joins the Sacramento River in the Sacramento-San Joaquin Delta within California's Central Valley. The Tuolumne River is dammed at several locations for generation of power, water supply, and flood control – the largest impoundment is Don Pedro Reservoir.

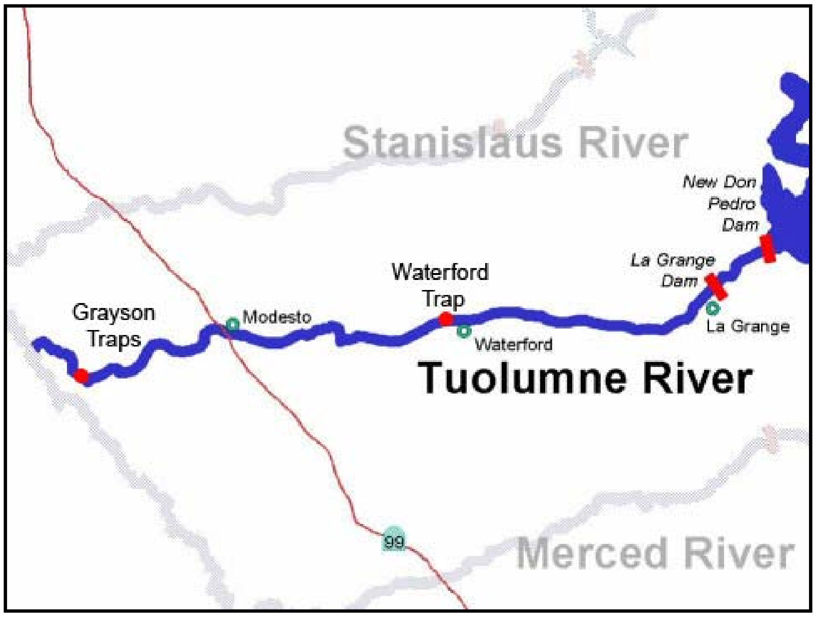

Figure 1. Location map of study area on the Tuolumne River.

The lower Tuolumne River corridor extends from its confluence with the San Joaquin River to La Grange Dam at river mile (RM) 52.2. The La Grange Dam site has been the upstream limit for anadromous migration since 1871.

Purpose and History of Study

Rotary screw traps have been operated at various locations in the Tuolumne River since 1995 within the winter/spring period to meet several objectives including monitoring the abundance and migration characteristics of juvenile salmonids and other fishes, and evaluation of reach-specific survival relative to environmental conditions (Table 1). The Turlock Irrigation District and Modesto Irrigation District (Districts) have supported all the RST program in 1995-97 and 2003-2008, and at the upstream sites in 1998-2000. Since 2006, sampling has also been conducted annually near the town of Waterford, about 25 miles upstream of the Grayson site, to provide comparative information in size, migration timing, and juvenile fall-run Chinook salmon production at a site downstream from most Chinook spawning activity, along with data on other fishes. An estimated 211 salmon (80 females) spawned in fall 2007.

Table 1. Rotary screw trap monitoring in the Lower Tuolumne River, 1995-2008.

Year	*Site*	*Period Sampled*	*Proportion of Outmigration Period Sampled*	*Total Catch*	*Total Estimated Passage*	*Method of Passage Estimation*	*Results Reported In*
1995	Shiloh (RM 3.4)	Apr 25-Jun 01	24%	141	15,667[1]		Heyne and Loudermilk 1997
1996	Shiloh	Apr 18 - May 29	27%	610	40,385[1]		Heyne and Loudermilk 1997
1997	Shiloh	Apr 18 - May 24	24%	57	2,850[1]		Heyne and Loudermilk 1998
1998	Turlock Lake State Rec. (RM 42.0)	Feb 11-Apr 13	41%	7,125	259,581[1]	Mean efficiency	Vick and others 1998
	7/11 (RM 38.5)	Apr 15-May 31	31%	2,413			Vick and others 1998
	Charles Road (RM 25.0)	Mar 27-Jun 01	43%	981	66,848[1]	Mean efficiency	Vick and others 1998
	Shiloh	Feb 15-Jul 01	70%	2,546	1,615,673[1]	Regression	Blakeman 2004a
1999	7/11	Jan 19-May 17	79%	80,792	1,737,052[1]	%Flow sampled	Vick and others 2000
	Hughson (RM 23.7)	Apr 08-May 24	31%	449	7,175[1]	%Flow sampled	Vick and others 2000
	Grayson (RM 5.2)	Jan 12-Jun 06	93%	19,327	755,604[2]	Multiple regression	Vasques and Kundargi 2001
2000	7/11	Jan 10-Feb 27	32%	61,196	298,755[1]	%Flow sampled	Hume and others 2001
	Deardorff (RM 35.5)	Apr 09-May 25	31%	634	15,845[1]	%Flow sampled	Hume and others 2001
	Hughson	Apr 09-May 25	31%	264	2,942[1]	%Flow sampled	Hume and others 2001
	Grayson	Jan 09-Jun 12	95%	2,250	99,797[2]	Multiple regression	Vasques and Kundargi 2001

[1] Passage estimate reported in the annual report cited in the last column to the right.
[2] Passage estimate derived from multiple regression equation based on data collected from 1999-2006 as described in this report.

Year	Site	Period Sampled	Proportion of Outmigration Period Sampled	Total Catch	Total Estimated Passage	Method of Passage Estimation	Results Reported In
2001	Grayson	Jan 03-May 29	97%	6,478	99,584[2]	Multiple regression	Vasques and Kundargi 2002
2002	Grayson	Jan 15-Jun 06	91%	436	14,135[2]	Multiple regression	Blakeman 2004b
2003	Grayson	Apr 01-Jun 06	40%	359	9,091[2]	Multiple regression	Blakeman 2004c
2004	Grayson	Apr 01-Jun 09	40%	509	17,771[2]	Multiple regression	Fuller 2005
2005	Grayson	Apr 02-Jun 17	39%	1,317	255,710[2]	Multiple regression	Fuller and others 2006
2006	Waterford 1 (RM	Jan 25-Apr 12	79%	8,648	178,034[1]	%Flow sampled	Fuller and others 2007
	Waterford 2 (RM	Apr 21-Jun 21		458	178,034[1]		
	Grayson	Jan 25-Jun 22	84%	1,594	71,670[2]	Multiple regression	Fuller and others 2007
2007	Waterford (RM 29.8)	Jan 11-Jun 05	93%	3,312	57,801[1]	Average trap efficiency	Fuller 2008
	Grayson	Mar 23-May 29	45%	27	923[2]	Multiple regression	Fuller 2008
2008	Waterford (RM 29.8)	Jan 8-Jun 2	95%	3,350	24,894[1]	Average trap efficiency	This report
	Grayson	Jan 29-Jun 4	82%	193	3,283[2]	Multiple regression	This report

[1] Passage estimate reported in the annual report cited in the last column to the right.
[2] Passage estimate derived from multiple regression equation based on data collected from 1999-2006 and 2008 as described in this report.

METHODS

Juvenile Outmigrant Monitoring

Sampling Gear and Trapping Site Locations

Rotary screw traps were installed and operated near Waterford and at Grayson River Ranch (Grayson). The traps, manufactured by E.G. Solutions in Eugene, Oregon, consist of a funnel-shaped core suspended between two pontoons. Traps are positioned in the current so that water enters the 8 ft wide funnel mouth and strikes the internal screw core, causing the funnel to rotate.

As the funnel rotates, fish are trapped in pockets of water and forced rearward into a livebox, where they remain until they are processed by technicians.

The single Waterford trap was located at RM 29.8 approximately two miles downstream of the Hickman Bridge. The trap was held in place by a 3/8-inch overhead cable strung between two large trees located on opposing banks. Cables fastened to the front of each pontoon were attached to the overhead cable. Warning signs, flashing safety lights, and buoys marked the location of the trap and cables for public safety. In 2008, two "wings" were attached at 45-degree angles to the outer edge of each pontoon near the upstream end of the trap (Figure 2). The "wings" consisted of 4 ft x 4 ft aluminum frames with removable plywood inserts. The "wings" were created to increase velocity at the trap, as well as improve catch efficiency.

Figure 2. Waterford rotary screw trap with "wings" attached to the upstream end of the pontoons.

At Grayson (RM 5.2), two traps were held in place by an overhead cable strung between two large trees located on opposing banks. Leader cables descended from the overhead cable and were attached to the front of each of four trap pontoons. The downstream force of the water on the traps kept the leader cables taut. In 2008, a structure similar to a weir was constructed and placed in the river approximately 50 ft upstream of the Grayson traps on the south bank in order to divert more water towards the traps and thereby increasing velocity at the traps (Figure 3).

The “weir” was constructed of three 4 ft x 8 ft sheets of plywood attached to t-posts that were set in the substrate at a slight angle to the flow.

Figure 3. Grayson rotary screw traps with “weir” structure approximately 50 feet upstream of the traps on the opposite bank.

Trap Monitoring

Sampling at Waterford began on January 8. The trap was operated continuously (24 hours per day, 7 days per week) until June 2 when sampling was terminated due to low catch and inadequate depth and water velocity for trap operation. Rotary screw traps with 8-ft. diameter cones generally require water at least 4 feet deep and velocity of at least 1.5 ft/s for the cone to rotate.

Sampling at Grayson began on January 29 - an earlier onset was delayed due to continuing wet levee conditions that hampered access for installation by boom truck. Installation of the Grayson traps occurred when it was determined feasible to assemble them further upstream with suitable access followed by transport on the river to the sampling location. The traps were operated continuously (24 hours per day, 7 days per week) until sampling was terminated on June 4 due to low catch and inadequate depth and water velocity for trap operation.

Regardless of location, each trap was checked at least every morning throughout the sampling period, with additional trap checks conducted as conditions required. During each trap check, contents of the liveboxes were removed; all fish were identified and counted; and any marked fish were noted. In addition, random samples of up to 50 salmon and 20 of each non-salmon species during each morning check and up to 20 salmon and 10 of each non-salmon species during each evening check were anesthetized, measured (forklengths in millimeters), and recorded. Salmon were assigned to lifestage category based on a forklength scale, where <50 mm= fry, 50-69 mm= parr, and $\geq$ 70 mm= smolt. In addition, the smolting appearance of all measured salmon and trout was rated based on a scale, where 1= yolk-sac fry, 2= fry, 3= parr, 4= silvery parr, 5= smolt, 6= mature adult, and IAD= immature adult (Interagency Ecological Program unpublished). Weights were taken from up to 50 salmon each week (i.e., Monday through Sunday) and from all trout. A weight boat partially filled with stream water was placed on an Ohaus digital balance and the balance was tared. One fish was placed in the weigh boat and after the weight was recorded to the nearest tenth of a gram, the balance was tared again before adding the next fish. Several fish were weighed before the weigh boat was emptied into a recovery bucket.

Salmon daily catch was equivalent to the number of salmon captured during a morning trap check plus the number of salmon captured during any trap check(s) that occurred within the period after the previous morning check. For example, the daily salmon catch for April 10 is the sum of salmon from the morning trap check on April 10 and the evening trap check conducted on April 9. Separate daily catch data was maintained for marked and unmarked salmon.

After all fish were measured and recorded, the traps were cleaned to prevent accumulation of debris that might impair trap rotation or cause fish mortality within the liveboxes. Trap cleaning included removal of debris from all trap surfaces and from within the liveboxes. The amount of debris load in the liveboxes was estimated and recorded whenever traps were checked.

Trap Efficiency Releases

Trap efficiency tests using natural or hatchery juvenile salmon were conducted to estimate the proportion of migrating juvenile salmon sampled by the Waterford and Grayson traps. Natural salmon captured in the traps were used to conduct tests whenever catches were sufficient to obtain a group of at least 30 fish over no more than two days. Due to low catches of natural salmon at the Grayson traps, only one natural release group was used and remaining tests were performed using hatchery fish. Conversely, no hatchery fish were released for Waterford trap efficiency tests.

For trap efficiency estimates at Waterford, nine groups of fish (all natural release groups ranging in number from 32 to 140 marked fish) were released at RM 30 (about 0.2 miles upstream of the trap) between January 13 and May 16. All marked fish were released after dark.

For trap efficiency estimates at Grayson, six groups of fish (one natural and five hatchery groups ranging in number from 73 to 1,131 marked fish) were released at RM 6.2 (about 1 mile upstream of the traps) between March 1 and May 21. All marked fish were released after dark.

Holding Facility and Transport Method

Natural fish were transferred from liveboxes into either 5-gallon buckets or 20-gallon insulated coolers depending on the number of fish, temperatures, and distance traveled and transported by boat upstream to the release site.

Hatchery fish for trap efficiency releases were transported from the Merced River Hatchery (MRH) to the release site on the Tuolumne River by the California Department of Fish and Game (CDFG).

At release sites, fish were held in live cars constructed of 15” diameter PVC pipe cut into 34” length (Figure 4). A rectangle approximately 6” wide by 23” long was cut longitudinally along the pipe and fitted with aluminum or stainless mesh. Live cars were tethered to vegetation or other structures and kept in areas of low water velocity to reduce fish stress.

Figure 4. Live car used for holding trap efficiency test fish.

Marking Procedure

At both trapping sites, natural fish were marked on shore immediately adjacent to the trap and were then transported to the release site where they were held until release. Hatchery fish were marked at the Merced River Hatchery and then transported to the release site approximately 8-12 hours before the release. A photonic marking system was used for marking all of the release groups because of the high quality of marks and the ability to use the marking equipment in rapid succession. All fish were anesthetized with Tricaine-S before the appropriate mark was applied. With this method, a marker tip was placed against the caudal fin and orange photonic dye was injected into the fin rays. The photonic dye was chosen because of its known ability to provide a highly visible, long-lasting mark. The photonic dyes were purchased from Day-Glo, Cleveland, OH.

Pre-release Sampling

Prior to release, marked fish were sampled for mean length and mark retention. Fifty fish (or the entire release group if fewer than 50 fish) were randomly selected from each release group, anesthetized, and examined for marks; and the remaining fish in each group were enumerated. Mark retention was rated as present or absent. A total of four fish were found to have no marks upon examination and were removed from the release groups. All fish released in 2008 had visible marks.

Release Procedure

Livecars were located several feet away from the specific release point and fish were poured from the live cars into buckets for release. Fish were released by placing a dip net into the bucket, scooping up a "net-full" of fish, and then emptying the fish into the river so they could swim away. After releasing a "net-full" of fish, about 30 seconds to 3 minutes elapsed before another group of about a "net-full" of fish was released. Amount of time between “net-full” releases varied depending on how fast fish swam away after their release. Total release time for marked groups ranged from six minutes to 70 minutes depending on the size of the group.

Monitoring Environmental Factors

Flow Measurements and Trap Speed

Provisional daily average flow for the Tuolumne River at La Grange was obtained from USGS at http://waterdata.usgs.gov/ca/nwis/dv/?site_no=11265000&agency_cd=USGS. Provisional daily average flow for the Tuolumne River at Modesto was obtained from the USGS at http://waterdata.usgs.gov/ca/nwis/dv/?site_no=11290000&agency_cd=USGS. The Modesto flow station is below Dry Creek, the largest seasonal tributary entering the river downstream of La Grange Dam. As a result, that site includes flow associated with major winter runoff events. Velocity of water entering the traps was measured using two methods. First, the water velocity entering the traps was measured daily with a Global Flow Probe, manufactured by Global Water (Fair Oaks, CA). Second, an average daily trap rotation speed was calculated for each trap by recording the time (in seconds) for three continuous revolutions of the cone both before and after the morning trap cleaning, then averaging the two times per revolution recorded.

River Temperature, Relative Turbidity and Dissolved Oxygen

Instantaneous water temperature was measured daily with a mercury thermometer at the trap site. Data was also available from hourly recording thermographs maintained by the Districts at Shiloh Road (RM 3.4) near the Grayson traps and by California Department of Fish and Game at Hickman Bridge (RM 32) near the Waterford trap. To measure daily instantaneous turbidity, a water sample was collected each morning and later tested at the field station with a LaMotte turbidity meter, model 2020e. Turbidity was recorded in nephelometric turbidity units (NTU). Instantaneous dissolved oxygen was measured during trap checks with an Exstick II D600 Dissolved Oxygen Meter at the trapping sites and recorded in mg/L.

Estimating Trap Efficiency and Chinook Abundance

The estimated daily number of fish passing each site was generated by either expanding the catch data by the average estimated trap efficiency for the lifestage captured (Waterford) or by a trap efficiency predictor equation (Grayson).

At Waterford, the trap efficiency dataset is limited because sampling has only been conducted during 2006-2008, and the dataset is not yet sufficient to develop meaningful regression relationships between trap efficiency and predictor variables such as river flow, fish size, or turbidity. In the interim, an estimate of salmon relative abundance for the sampling season was calculated by expanding the daily number of fish by the average observed trap efficiency for each lifestage during 2008, or 14.2% (97 recoveries from 685 released) for fry and 12.2% (5 recoveries from 41 released) for parr/smolts.

At Grayson, flow and trap efficiency data collected from 1999 through 2008 were used to develop a multiple regression equation to estimate daily trap efficiencies. Specifically, average daily river flow at Modesto, average fish size at release, and transformed (e.g., natural log) proportions of fish recovered from each release event were used to develop the following trap efficiency predictor equation with an adjusted R^2 of 0.64:

Daily Predicted Trap Efficiency= EXP(-0.29176+(-0.00042*Flow at MOD)+(-0.03410*Fish size))

Where Flow at MOD= daily average river flow at Modesto
Fish Size= daily average forklength of fish captured at Grayson

These daily predicted trap efficiencies (DPTE) were then applied to the daily catch (DC) to estimate daily passage as follows:

Estimated Daily Passage= DC/DPTE

Rough estimates of daily passage were also calculated using the proportion of flow sampled by the trap(s) as a surrogate for trap efficiency. The proportion of flow sampled at each site was estimated by the following equation:

$$N_t = C_d \sqrt{\frac{V_d\left(3.14 * \frac{r^2}{2}\right)}{F_d}}$$

where, N_e is the expanded daily number of fish; C_d is the daily catch; V_d is the daily velocity, r is the radius of the trap; and F_d is the daily flow measured at La Grange plus flow from the Hickman spill.

RESULTS AND DISCUSSION

Chinook Salmon

Number of Unmarked Chinook Salmon Captured

Juvenile salmon outmigration in the San Joaquin Basin typically occurs during the winter and spring, extending from January through May. The winter migration period is dominated by fry migrants that are typically less than 50 mm forklength, and the spring period is dominated by smolts which are typically greater than 70 mm forklength. During 2008, daily catches of juvenile salmon at Waterford were highest from late-January through late-February, and daily catches through mid-March primarily consisted of fry (<50 mm) (Figure 5). Daily catches of juvenile salmon at Waterford between January 8 and June 2 ranged from zero to 236 fish and totaled 3,350 fish (Figure 5).

At Grayson, catches of juvenile salmon were highest during the month of February, and daily catches through early March primarily consisted of fry (<50 mm)(Figure 6). Daily catches of juvenile salmon at Grayson between January 29 and June 4 ranged from zero to 73 fish and totaled 193 fish (Figure 6).

Total annual catch of juvenile salmon has varied substantially between years at Grayson/Shiloh (Table 1; Figure 7). This variation is likely due to differences in one or more factors including the duration and timing of the sampling periods, flow conditions, and overall fish abundance (Table 1; Figure 7). Sampling periods have varied between years with sampling initiated as early as January or as late as April and continuing through May/June.

During 1999-2002, 2006 and 2008 sampling at Grayson encompassed the majority of the expected winter/spring outmigration season (i.e., January-May/June) and can be described as comprehensive (Table 1; Figure 7). In contrast, sampling was only conducted during the spring smolt outmigration period (i.e., April-May/June) in 1995-1997 at Shiloh and 2003-2005 and 2007 at Grayson, so sampling was incomplete for those years. Sampling during 1998 began in February but was limited to a single trap (note: two traps were operated in all other years); thus, 1998 sampling covered an intermediate proportion of the entire outmigration period relative to all other years of monitoring.

Of the winter/spring sampling years, total trap catch at Grayson ranged from a high of 19,327 during 1999 to a low of 436 during 2002, and averaged 5,040 juvenile salmon (Figure 7). In all years of spring-only sampling, catches ranged from a high of 1,239 during 2001 to a low of 27 during 2007. The proportion of the typical outmigration period monitored each year ranged from 81.5% to 97% during winter/spring sampling years, from 24% to 45% during spring-only sampling years, and was 70% in the intermediate sampling year (Table 1). These proportions were calculated by taking the total number of sampling days in a given year and dividing by the total number of days for a typical complete outmigration period (i.e., January 1 through May 31). The proportion of the outmigration period sampled may not be representative of the proportion of the juvenile population migrating during the sample period because migration timing can be influenced by environmental factors such as flow.

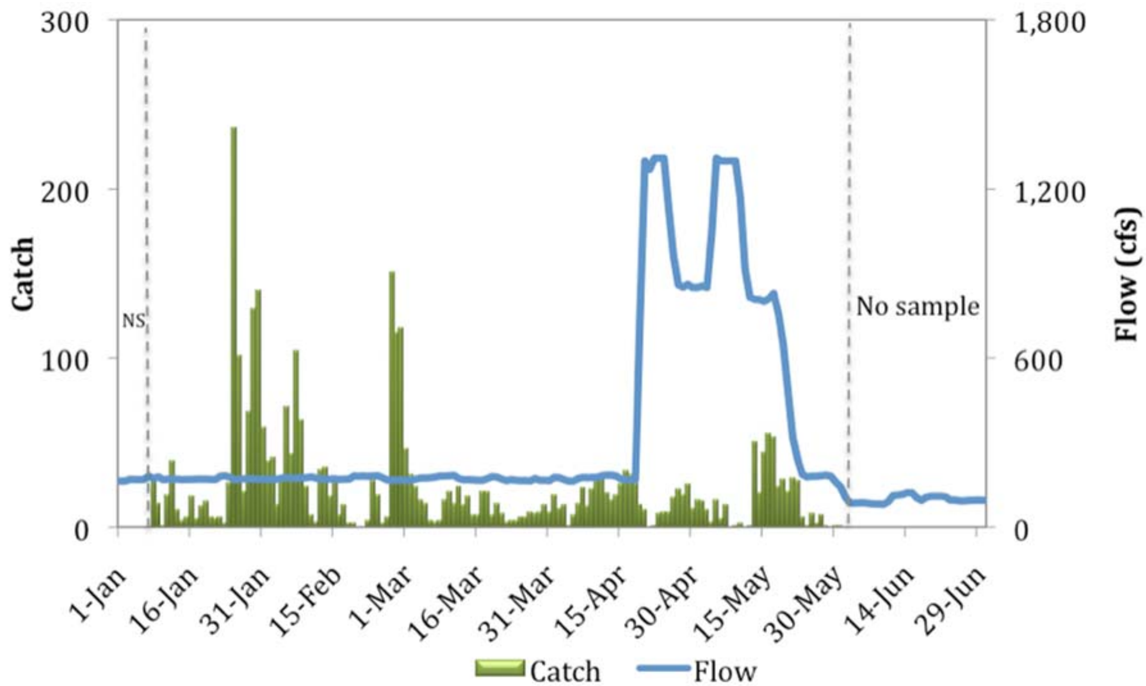

Figure 5. Daily catch of unmarked Chinook salmon at Waterford and river flow at La Grange (LGN) during 2008.

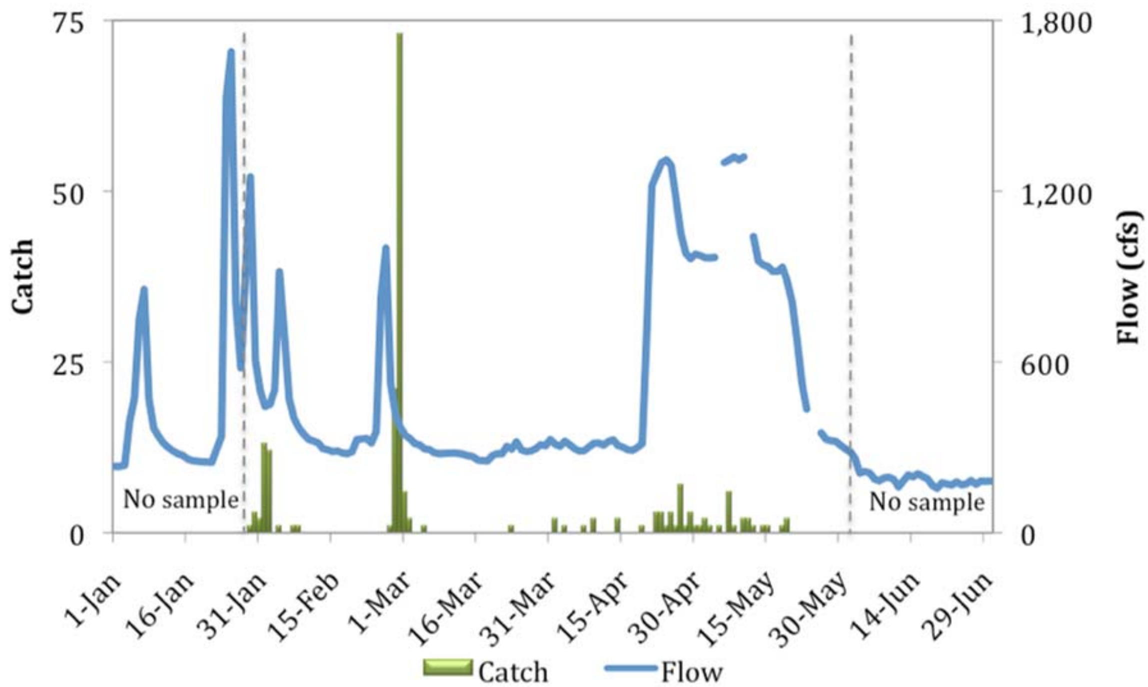

Figure 6. Daily catch of unmarked Chinook salmon at Grayson and river flow at Modesto (MOD) during 2008.

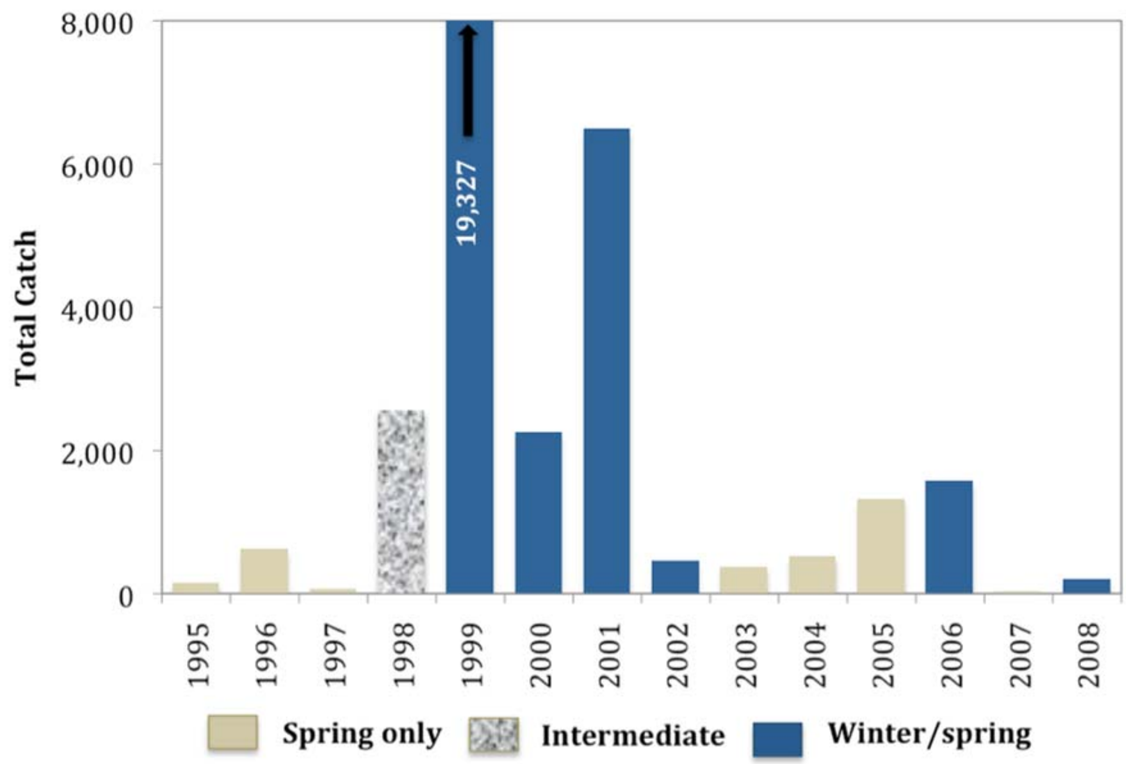

Figure 7. Total annual salmon catch at Shiloh/Grayson during 1995-2008.

Trap Efficiency and Estimated Chinook Salmon Abundance

In 2008, eight trap efficiency estimates for natural fry at Waterford ranged from 9.2% to 34.4% at flows (La Grange) ranging between 167 cfs and 173 cfs (Table 2; Figure 8). One trap efficiency estimate for natural, smolt sized fish at Waterford in 2008 was 12.2% at a flow of 811 cfs (Table 2). Average forklength at release of the nine trap efficiency test groups in 2008 ranged from 36 mm to 88 mm (Table 2).

At Grayson, observed trap efficiency estimates from 1999-2008 ranged from zero to 21.2% at flows (Modesto) ranging between 280 cfs and 7,942 cfs (Table 3; Figure 9). One trap efficiency estimate for natural fry at Grayson in 2008 was 6.9% at a flow of 342 cfs (Table 3). In 2008, five trap efficiency estimates for hatchery, smolt sized fish at Grayson ranged from 1.5% to 9.6% at flows ranging between 300 cfs and 1,310 cfs (Table 3). Average forklength at release of the six trap efficiency test groups in 2008 ranged from 38 mm to 96 mm (Table 3).

Daily predicted trap efficiency, and daily estimated passage at Waterford and Grayson in 2008 are provided in Appendices A and B, respectively.

Table 2. Trap efficiency results from Waterford during 2008.

Lifestage	Release Date	Origin	Adjusted # Released	Number Recaptured	% Recaptured	Length at Release (mm)	Length at Recap. (mm)	Flow (cfs) at LGN	Turbidity
Fry	1/13/08	Wild	32	11	34.4%	37	37	170	3.86
	1/26/08	Wild	132	15	11.4%	36	36	170	75.2
	1/27/08	Wild	98	13	13.3%	37	37	171	18.6
	1/31/08	Wild	131	12	9.2%	37	38	170	15.7
	2/1/08	Wild	55	9	16.4%	37	37	169	9.33
	2/6/08	Wild	64	6	9.4%	37	37	173	14
	2/13/08	Wild	33	11	33.3%	37	37	170	nd
	2/28/08	Wild	140	20	14.3%	38	38	167	13
		TOTAL	685	97	14.2%				
Parr/smolt	5/16/08	Wild	41	5	12.2%	88	88	811	0.67
		TOTAL	41	5	12.2%				

Table 3. Trap efficiency results from 1999- 2008 used to derive the regression equation for predicting daily trap efficiencies at Grayson.

Release Date	Origin	Mark	Adjusted # Released	Number Recaptured	% Recaptured	Length at Release (mm)	Length at Recap. (mm)	Flow (cfs) at MOD
11-Mar-99	Hatchery	Anal fin blue	1946	28	1.4%	54	53	4620
24-Mar-99	Hatchery	Bottom caudal blue, ad-clip	1938	67	3.5%	61	61	3130
31-Mar-99	Hatchery	Top caudal blue, ad-clip	1885	73	3.9%	65	64	2250
7-Apr-99	Hatchery	Bottom caudal blue, ad-clip	1949	50	2.6%	68	68	2280
14-Apr-99	Hatchery	Anal fin blue, ad-clip	1953	34	1.7%	73	72	2000

Release Date	Origin	Mark	Adjusted # Released	Number Recaptured	% Recaptured	Length at Release (mm)	Length at Recap. (mm)	Flow (cfs) at MOD
20-Apr-99	Hatchery	Top caudal blue, ad-clip	2007	45	2.2%	73	75	1800
29-Apr-99	Hatchery	Bottom caudal blue, ad-clip	1959	14	0.7%	79	80	3220
4-May-99	Hatchery	Anal fin blue, ad-clip	2008	18	0.9%	83	82	3030
18-May-99	Hatchery	Top caudal blue, ad-clip	2001	29	1.4%	86	84	677
26-May-99	Hatchery	Bottom caudal blue, ad-clip	1984	75	3.8%	96	92	518
1-Mar-00	Hatchery	Top caudal blue	1964	30	1.5%	56	53	4690
16-Mar-00	Hatchery	Bottom caudal blue	1548	22	1.4%	56	56	5980
23-Mar-00	Hatchery	Anal fin blue	1913	55	2.9%	59	60	3190
30-Mar-00	Hatchery	Top caudal blue	1942	60	3.1%	62	63	2820
29-Apr-00	Hatchery	Top caudal blue, ad-clip	1931	22	1.1%	81	82	1470
6-May-00	Hatchery	Bottom caudal blue, ad-clip	1987	41	2.1%	85	85	2430
24-May-00	Hatchery	Top caudal blue, ad-clip	2010	24	1.2%	85	85	1010
18-Jan-01	Hatchery	Top caudal blue	1810	120	6.6%	37	np	487
8-Feb-01	Hatchery	Bottom caudal blue	1980	276	13.9%	47	np	434
1-Mar-01	Hatchery	Top caudal yellow	2017	57	2.8%	41	np	2130
14-Mar-01	Hatchery	Bottom caudal yellow	1487	75	5.0%	46	np	703
21-Mar-01	Hatchery	Bottom caudal blue, Dorsal fin blue, Top caudal yellow	3025	207	6.8%	61	np	519
28-Mar-01	Hatchery	Anal fin blue	1954	219	11.2%	51	np	515
11-Apr-01	Hatchery	Bottom caudal yellow, ad-clip	2021	141	7.0%	66	np	535
18-Apr-01	Hatchery	Top caudal blue, ad-clip	2060	95	4.6%	68	np	483
25-Apr-01	Hatchery	Ad-clip dorsal fin yellow, Bottom caudal blue, Dorsal fin blue	1515	34	2.2%	71	np	753
2-May-01	Hatchery	Anal fin blue, ad-clip	3053	163	5.3%	72	np	1460
9-May-01	Hatchery	Bottom caudal yellow, ad-clip	3002	147	4.9%	75	np	1160
16-May-01	Hatchery	Top caudal blue, ad-clip	2942	93	3.2%	76	np	1020
20-Feb-02	Hatchery	Bottom caudal red	2094	444	21.2%	57	np	265
6-Mar-02	Hatchery	Anal fin red	2331	316	13.6%	68	np	278
13-Mar-02	Hatchery	Top caudal red	2042	324	15.9%	65	np	300
20-Mar-02	Hatchery	Dorsal fin red	2105	242	11.5%	68	np	328
27-Mar-02	Hatchery	Bottom caudal red	2121	147	6.9%	68	np	314
3-Apr-02	Hatchery	Anal fin red, ad-clip	1962	130	6.6%	76	np	312
9-Apr-02	Hatchery	Top caudal red, ad-clip	1995	56	2.8%	79	np	319
17-Apr-02	Hatchery	Dorsal fin red, ad-clip	2048	40	2.0%	84	np	889

Release Date	Origin	Mark	Adjusted # Released	Number Recaptured	% Recaptured	Length at Release (mm)	Length at Recap. (mm)	Flow (cfs) at MOD
25-Apr-02	Hatchery	Bottom caudal red, ad-clip	2001	22	1.1%	86	np	1210
1-May-02	Hatchery	Anal fin red, ad-clip	2033	14	0.7%	89	np	1250
8-May-02	Hatchery	Dorsal fin red, ad-clip	2021	31	1.5%	95	np	798
15-May-02	Hatchery	Top caudal red, ad-clip	2047	26	1.3%	97	np	653
22-May-02	Hatchery	Bottom caudal red, ad-clip	2043	10	0.5%	94	np	403
10-Apr-03	Hatchery	Top caudal green	1956	138	7.1%	77	np	297
17-Apr-03	Hatchery	Bottom caudal green	2047	65	3.2%	77	np	1350
24-Apr-03	Hatchery	Anal fin green	1979	31	1.6%	88	np	1210
1-May-03	Hatchery	Dorsal fin green	2044	113	5.5%	96	np	685
8-May-03	Hatchery	Top caudal green	2078	206	9.9%	83	np	726
15-May-03	Hatchery	Bottom caudal green	1996	125	6.3%	83	np	559
20-May-03	Hatchery	Anal fin green	1989	60	3.0%	89	np	317
28-May-03	Hatchery	Dorsal fin green	1950	125	6.4%	94	np	685
13-Apr-04	Hatchery	Dorsal fin green	1992	84	4.2%	79	74	1140
20-Apr-04	Hatchery	Anal fin green	1980	48	2.4%	81	79	1660
27-Apr-04	Hatchery	Top caudal green	1941	118	6.1%	86	85	826
4-May-04	Hatchery	Bottom caudal green	2008	50	2.5%	90	87	789
11-May-04	Hatchery	Anal fin green	1972	104	5.3%	86	79	815
18-May-04	Hatchery	Dorsal fin green	1996	178	8.9%	88	77	446
25-May-04	Hatchery	Top caudal green	2013	59	2.9%	92	90	337
9-Feb-06	Wild	Caudal fin pink	37	5	13.5%	34.6	35.2	3393
11-Feb-06	Wild	Caudal fin pink	26	4	15.4%	34.9	37.3	3437
12-Feb-06	Wild	Caudal fin pink	23	1	4.3%	36.1	37.0	3416
13-Feb-06	Wild	Caudal fin pink	28	1	3.6%	35.5	33.0	3418
3-Mar-06	Wild	Caudal fin green	89	4	4.5%	34.8	35.3	4261
5-May-06	Hatchery	Caudal fin yellow	949	4	0.4%	73.2	74.3	7942
12-May-06	Hatchery	Caudal fin yellow	1,286	5	0.4%	81.8	76.6	7534
25-May-06	Hatchery	Top caudal yellow	1,532	2	0.1%	83.7	69.5	6537
1-Jun-06	Hatchery	Top caudal yellow	1,694	0	0.0%	91.9	-	
14-Jun-06	Hatchery	Top caudal yellow	1,507	2	0.1%	85.4	83.0	4864
3/1/08	Wild	Caudal fin yellow	73	5	6.9%	38	38	342
4/15/08	Hatchery	Caudal fin orange	1131	109	9.6%	77	76	300
4/25/08	Hatchery	Dorsal fin orange	1005	17	1.7%	86	84	1290
5/7/08	Hatchery	Anal fin orange	526	8	1.5%	96	96	1310
5/14/08	Hatchery	Caudal fin orange	519	13	2.5%	93	91	941
5/21/08	Hatchery	Lower caudal orange, anal fin orange	515	19	3.7%	92	91	678

np= not provided

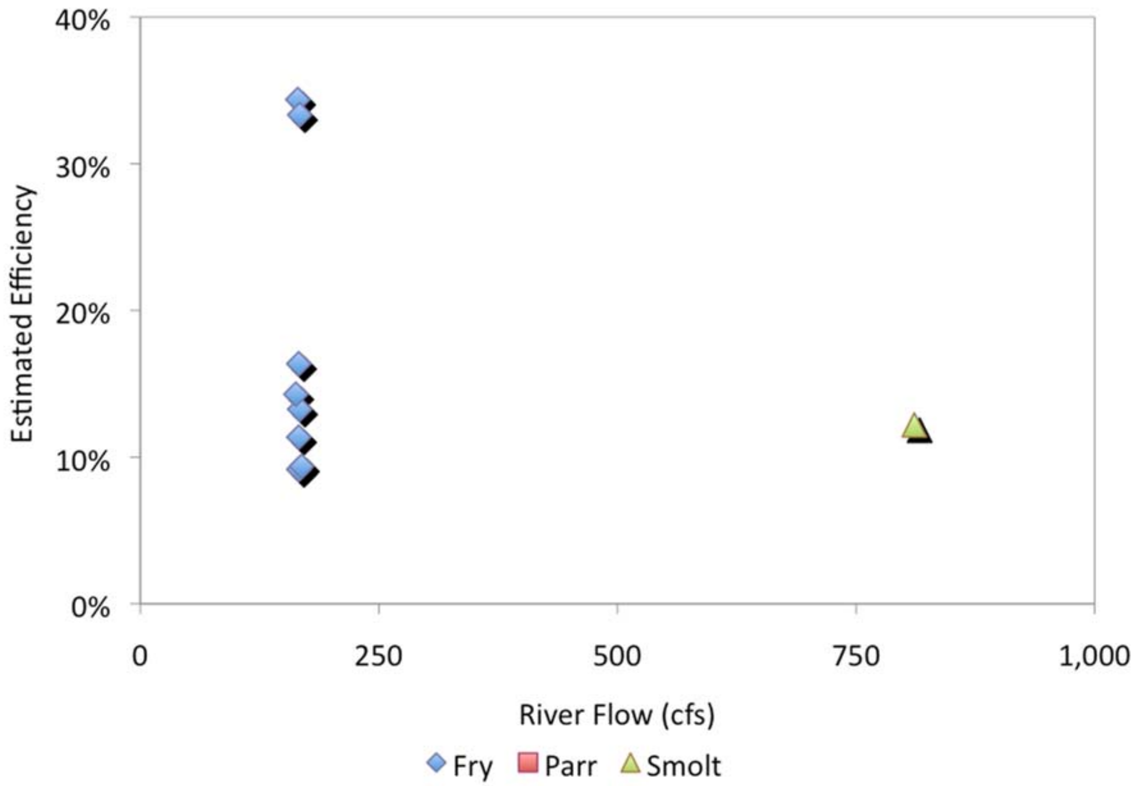

Figure 8. Trap efficiency estimates at Waterford relative to river flow at La Grange (LGN) during 2008.

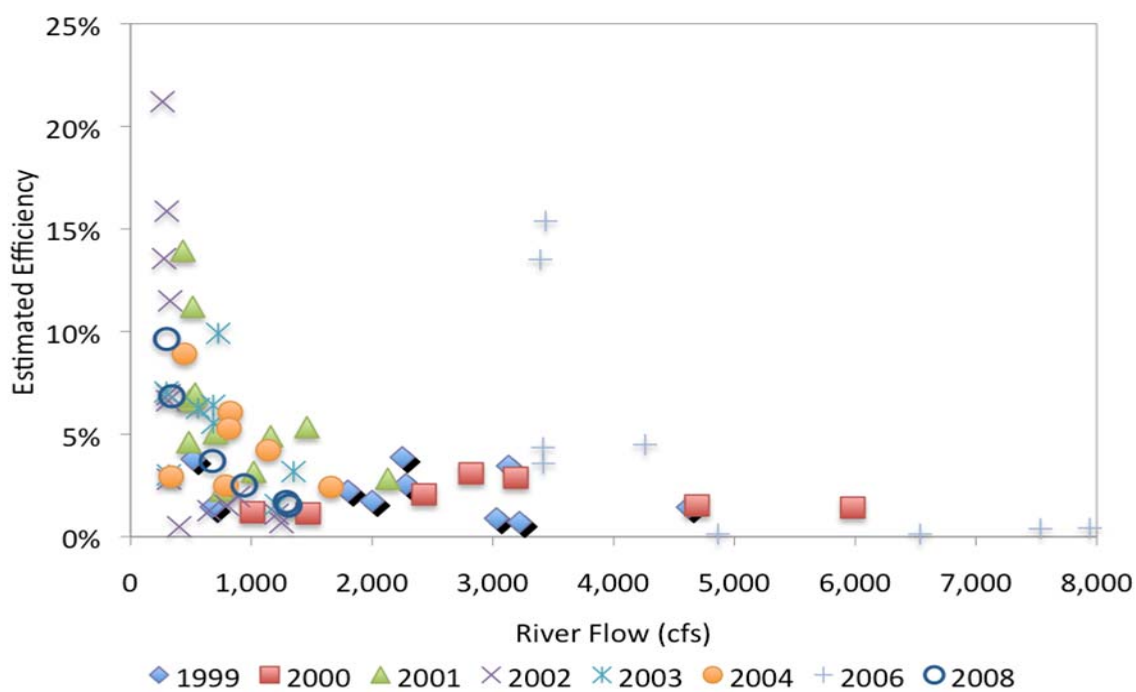

Figure 9. Trap efficiency observations at Grayson relative to river flow at Modesto (MOD), 1999-2008.

Based on calculated daily passage estimates, an estimated 24,894 unmarked Chinook salmon passed Waterford during 2008 and 34.3% of these were smolts. Relative to the estimated escapement of 211 spawners (Blakeman 2008) approximately 311 juveniles were produced per female spawner (Table 4). In comparison, 51% of the total number of unmarked fish that passed Waterford during 2007 were smolts and approximately 206 juveniles were produced per female spawner. In 2006, sampling efforts were affected by high spring flows resulting in passage estimates that were likely underestimated-particularly for smolts-so no comparisons between 2006 and other years were made. Similar to the pattern observed for catch, it is estimated that a majority of the salmon passing Waterford in 2008 prior to mid-March were fry and catch was then dominated by smolts from late-March through May (Table 4; Figure 10). Daily estimated passage at Waterford ranged from zero to 1,667 salmon. Peaks in daily passage for fry occurred on January 25 and smolt passage peaked on May 16 (Figure 10; Figure 11).

Table 4. Estimated passage by lifestage at Waterford and Grayson during 1995-2008.

		Sampling Period	Fry		Parr		Smolts		Total
			Number	%	Number	%	Number	%	
Waterford	2006	w/s	163,805	54.0%	6,550	2.2%	133,127	43.9%	303,482
	2007	w/s	20,633	35.7%	7,614	13.2%	29,554	51.1%	57,801
	2008	w/s	15,259	61.3%	1,102	4.4%	8,534	34.3%	24,894
Grayson	1995	spring	-	-	-	-	22,067	100%	22,067
	1996	spring	-	-	-	-	16,533	100%	16,533
	1997	spring	-	-	-	-	1,280	100%	1,280
	1998	intermediate	1,196,625	74.1%	327,422	20.3%	91,626	5.7%	1,615,673
	1999	w/s	716,858	94.9%	8,452	1.1%	30,293	4.0%	755,604
	2000	w/s	48,338	48.4%	8,431	8.4%	43,028	43.1%	99,797
	2001	w/s	59,153	59.4%	12,480	12.5%	27,951	28.1%	99,584
	2002	w/s	75	0.5%	696	4.9%	13,364	94.5%	14,135
	2003	spring	27	0.3%	0	0%	9,064	99.7%	9,091
	2004	spring	155	0.9%	732	4.1%	16,884	95.0%	17,771
	2005	spring	-	-	416	0.2%	255,294	99.8%	255,710
	2006	w/s	62,901	87.8%	1,536	2.1%	7,233	10.1%	71,670
	2007	spring	-	-	-	-	937	100%	937
	2008	w/s	917	27.9%	14	0.4%	2,352	71.6%	3,283

An estimated 3,283 unmarked Chinook salmon passed Grayson during 2008 and 71.6% of these were smolts (Table 4). Daily estimated passage at Grayson ranged from 0 to 445 salmon. Peak daily passage for fry occurred on February 29 and smolt passage peaked on April 27 (Figure 12). During comparable seasonal sampling in previous years at Grayson (i.e., winter/spring sampling in 1999-2002, 2006, and 2008), total estimated passage ranged from a high of 696,115 in 1999 to a low of 3,283 in 2008 (Table 1; Figure 13) and the proportion of passage as smolts was the highest in 2002 (94.5%) and the lowest in 1999 (4%). In spring-only sampling years at Grayson/Shiloh (i.e., 2003-2005 and 2007 at Grayson and 1995-1997 at Shiloh), total estimated passage ranged from a high of 255,710 in 2005 to a low of 937 in 2007 (Table 1; Figure 13) and the majority of spring migrants in all years were smolts (>95.0%; Table 4). Among all years, estimated passage was the highest during 1998 (Table 1; Figure 13) and the proportion passing as smolts was low (5.7%) when sampling effort was intermediate. However, this estimate of

1,615,673 may be inflated and the proportion passing as smolts may be underestimated because no trap efficiency tests were conducted with fry.

For comparison, passage estimates were also calculated based on the estimated proportion of flow sampled at each site during 2008. This method produced estimates of 19,980 salmon at Waterford and 733 salmon at Grayson. These estimates are provided for the purpose of comparison only and they are not reflected in the tables and figures presented in this report.

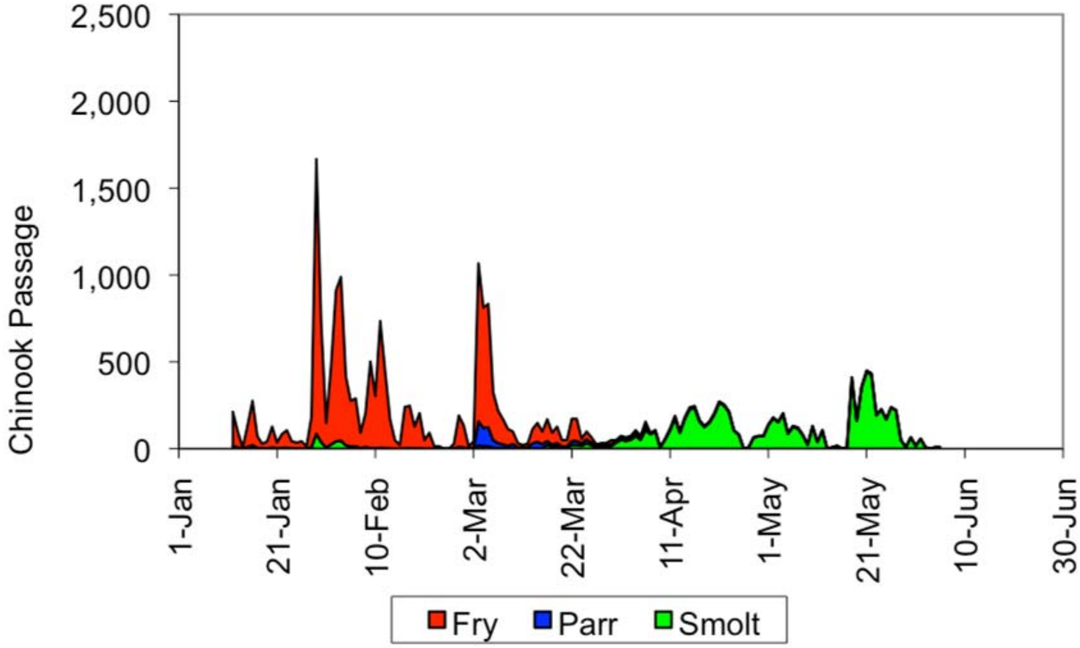

Figure 10. Juvenile salmon passage by lifestage at Waterford during 2008.

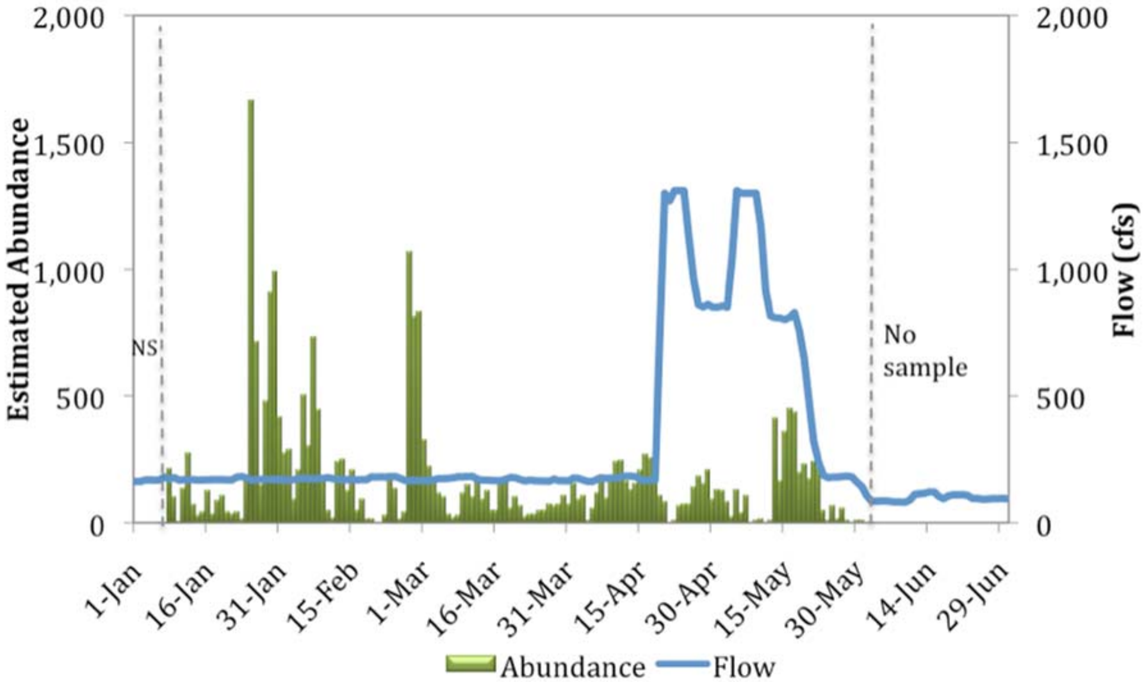

Figure 11. Daily estimated passage of unmarked Chinook salmon at Waterford and river flow at La Grange (LGN) during 2008.

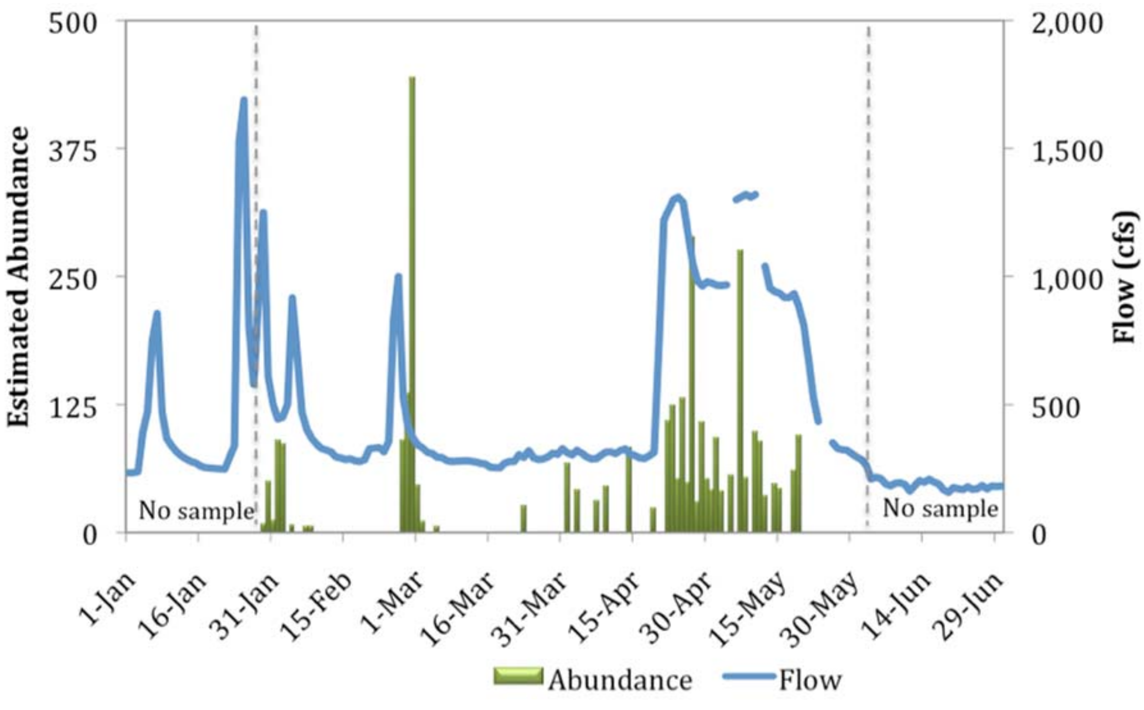

Figure 12. Daily estimated passage of unmarked Chinook salmon at Grayson and river flow at Modesto (MOD) during 2008.

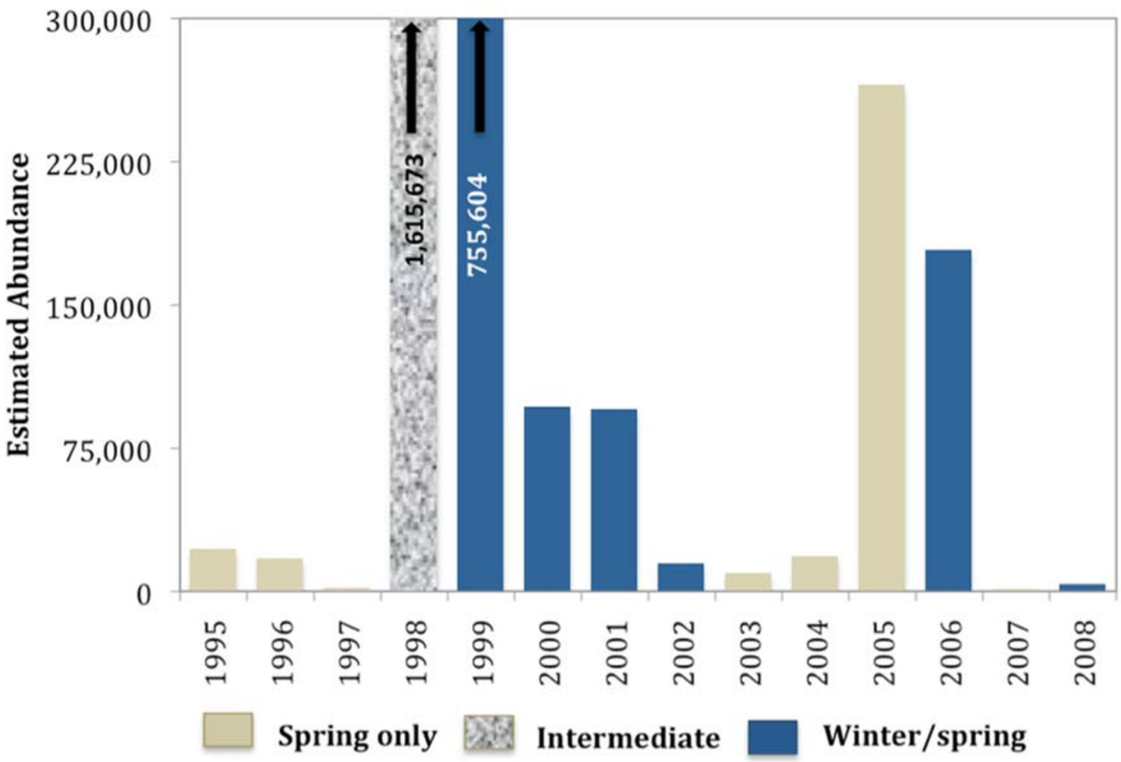

Figure 13. Total estimated Chinook passage at Shiloh and Grayson during 1995-2008.

Estimated Chinook Salmon Abundance and Environmental Factors

Trends in passage at Waterford and Grayson during 2008 were similar to the trends described for catch, and peaks in juvenile salmon passage coincided with storm events and a late April pulse flow event. River releases during January through mid-April ranged only from 163 cfs to 184 cfs which translated to relatively stable flow conditions in the river at Waterford. Higher pulse flows with two peaks occurred during the spring. River flow was more variable near Grayson as a result of storm run-off, particularly from Dry Creek entering at Modesto, and ranged from 233 cfs to 1,690 cfs.

During 2008 monitoring, daily average water temperatures ranged from 47.4°F to 70.0°F near Waterford (Figure 14) and from 49.6°F to 72.4°F near Grayson (Figure 15). Water temperatures generally increased through the outmigration season as ambient air temperatures increased. There were no obvious correlations between trends in passage and water temperature during 2008, but comparisons between years indicate that migration occurs over a more extended timeframe during years when late spring water temperatures in the lower Tuolumne River remain cooler. Relative to earlier migrants, late spring migrants may be exposed to higher water temperatures in the Delta and higher export rates.

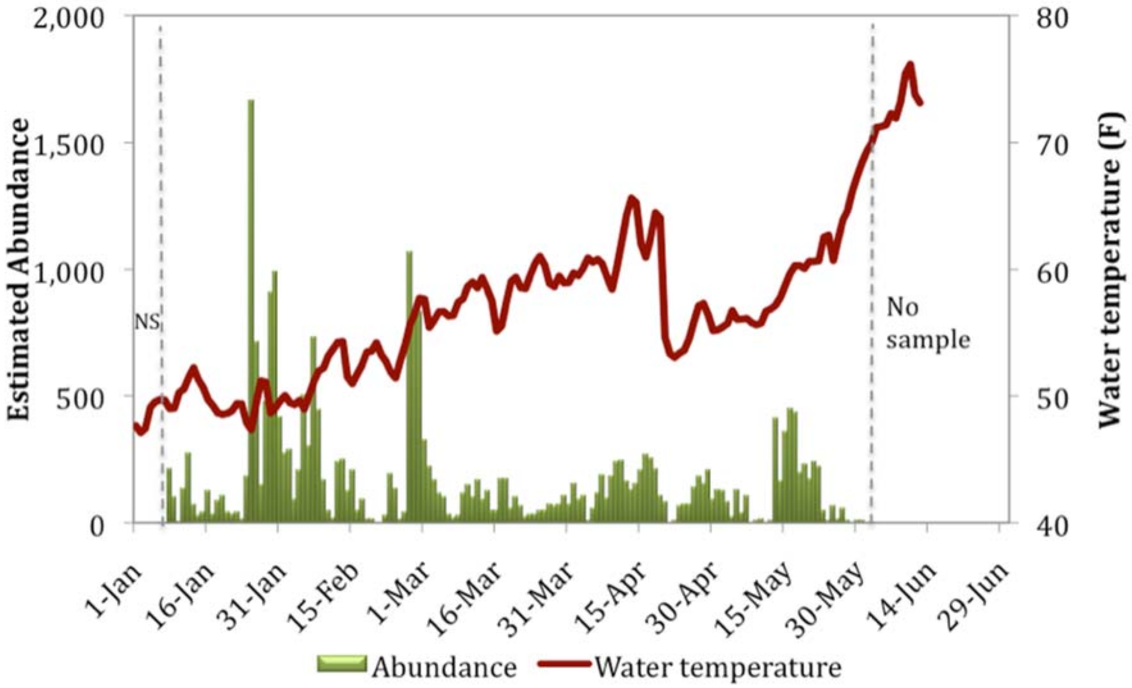

Figure 14. Daily estimated passage of unmarked Chinook salmon at Waterford and daily average water temperature at Hickman Bridge (RM 32) during 2008.

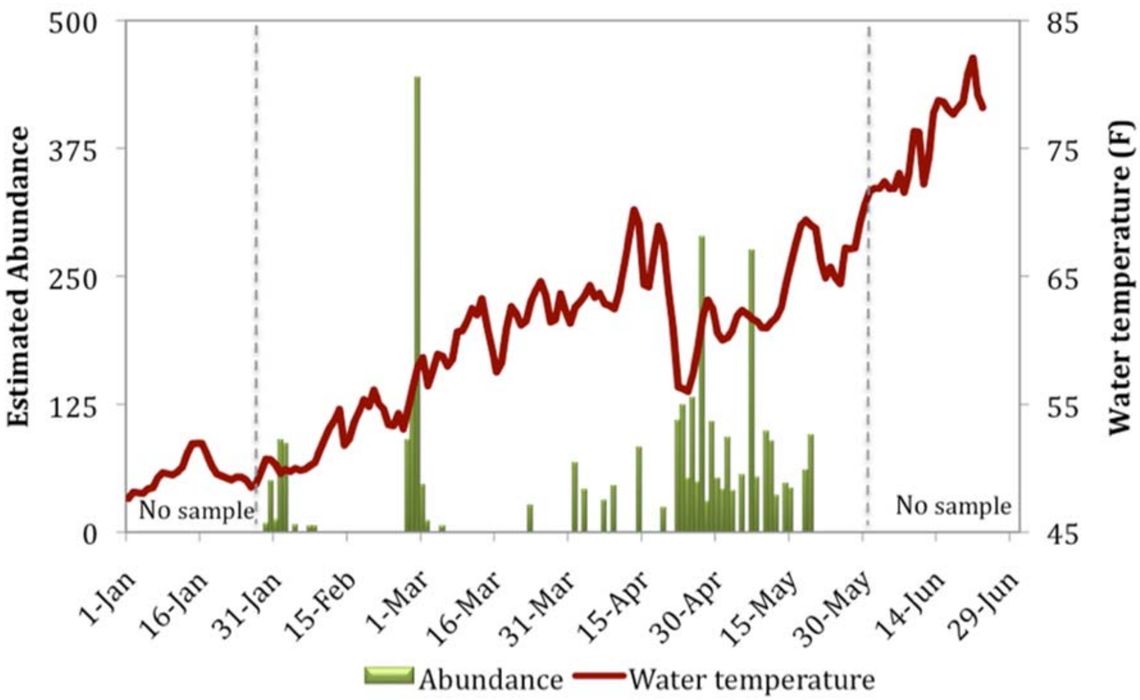

Figure 15. Daily estimated passage of unmarked Chinook salmon at Grayson and daily average water temperature at Shiloh (RM 3.4) during 2008.

Background turbidity was generally less than 2 NTU at Waterford (Figure 16) and less than 4 NTU at Grayson (Figure 17) during the 2008 monitoring periods. During several storm events from mid-January through late February, spikes in turbidity were observed at Waterford ranging as high as 411 NTU, and at Grayson ranging as high as 95.7 NTU. These values were well above the range associated with normal storm run-off and were caused by erosion from extensive grading activity in the Peaslee Creek watershed. Peaslee Creek enters the Tuolumne River at river mile 45.25.

Peaks in passage on January 8-9, January 24-26, January 28-31, February 4-8, and February 27-29 at Waterford, and February 1-2 and February 27-29 at Grayson coincided with periods of elevated turbidity. Unlike previous years, turbidity events at Waterford were not associated with flow changes so it appears that changes in turbidity alone can stimulate migration. At Grayson, changes in turbidity were generally associated with flow changes so it is unclear whether migration was stimulated by elevated turbidity or a combined influence of flow and turbidity factors.

The ratio of estimated total passage at Grayson relative to the estimated total passage at Waterford provides an index of survival through the river between the sites (24.6 miles) during years when the majority of the outmigration period is sampled. The survival index estimated for 2008 was 13.2%. A survival index was not calculated for 2007 because sampling did not begin until mid-March. However, an index of 58.7% was calculated for 2006.

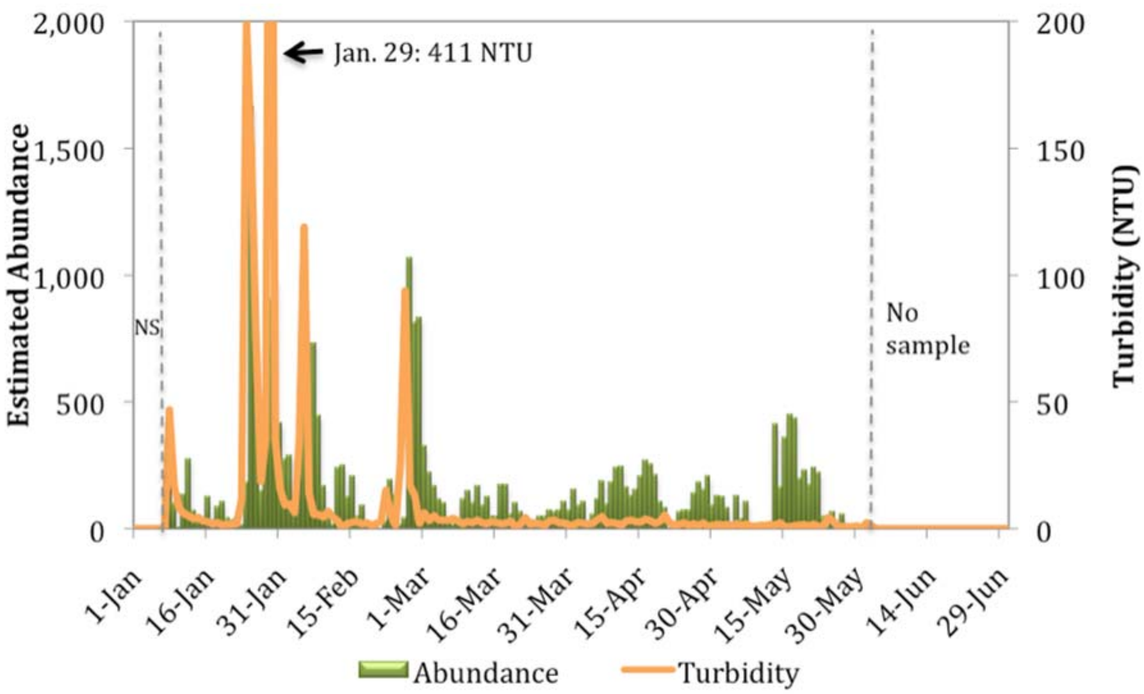

Figure 16. Daily estimated passage of unmarked Chinook salmon and instantaneous turbidity at Waterford during 2008.

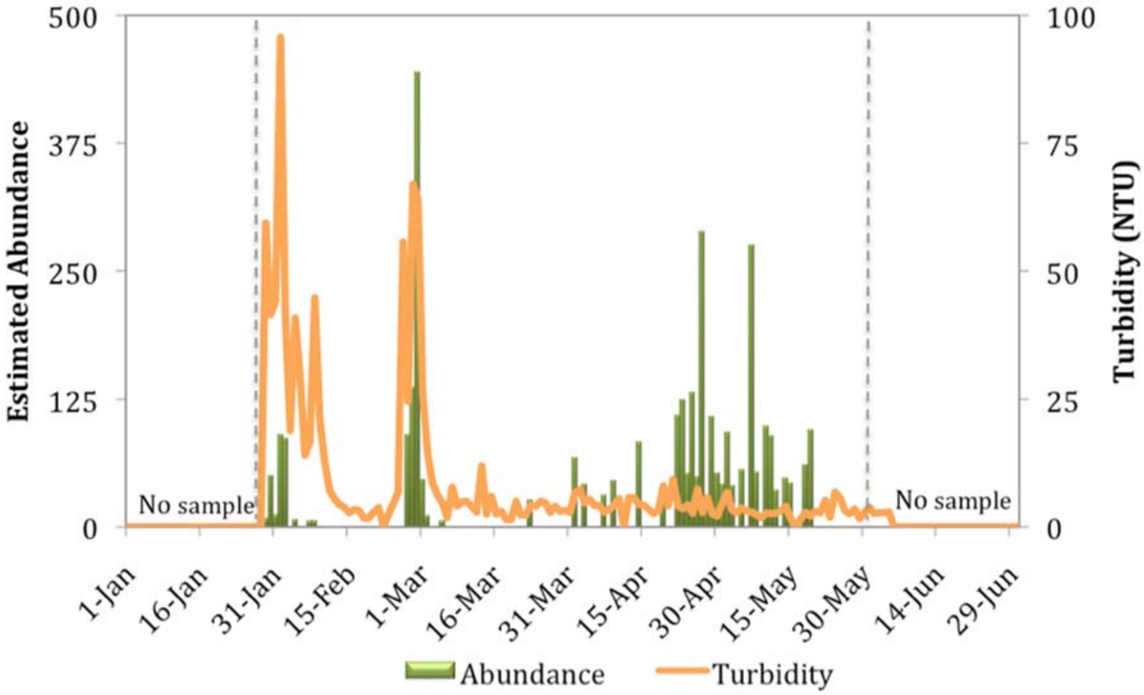

Figure 17. Daily estimated passage of unmarked Chinook salmon and instantaneous turbidity at Grayson during 2008.

Chinook Salmon Length at Migration

Individual forklengths of unmarked salmon captured at Waterford during 2008 ranged from 31 mm to 151 mm (Figure 18), and daily average length gradually increased from approximately 36 mm to 90 mm over the course of the sampling period (Figure 19 and Figure 20). Most of the juvenile salmon passing Waterford during 2008 were fry measuring 30-39 mm, followed by smolts measuring 70-99 mm (Figure 21). In total, it is estimated that 15,259 fry (<50 mm), 1,102 parr (50-69 mm), and 8,534 smolts (≥70 mm) passed Waterford during 2008. There were a number of fish captured throughout the season that were atypical sizes for fall-run Chinook salmon production. For instance, during January through mid-March there were 54 fish much larger than the majority of juvenile salmon captured during that period (average size of larger fish was almost 50 mm larger than majority of juvenile salmon) and 11 fish in the spring that were much smaller than other juvenile salmon captured during that period (34-39 mm versus 56-115 mm). Based on sizes, it is possible that these fish may have been spawned from out-of-basin strays of a different race.

Individual forklengths of unmarked Chinook salmon captured at Grayson during 2008 ranged from 35 mm to 117 mm (Figure 22), and daily average length fluctuated between 38 mm and 117 mm during the sampling period (Figure 23 and Figure 20). Nearly 70% of the salmon estimated to have passed Grayson during 2008 were smolts measuring 70-99 mm (Figure 24). In total, it is estimated that 917 fry (<50 mm), 14 parr (50-69 mm), and 2,352 smolts (≥70 mm) passed Grayson during 2008. Similar to Waterford, a few (n=6) larger sized Chinook were also captured during January through early March.

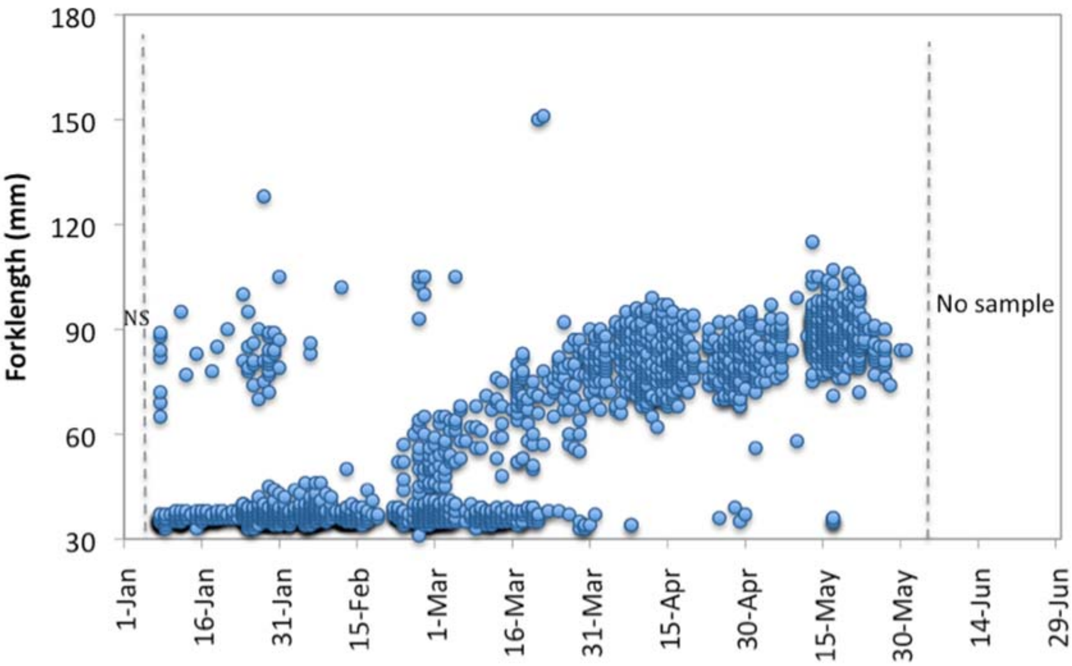

Figure 18. Individual forklengths of juvenile salmon captured at Waterford during 2008.

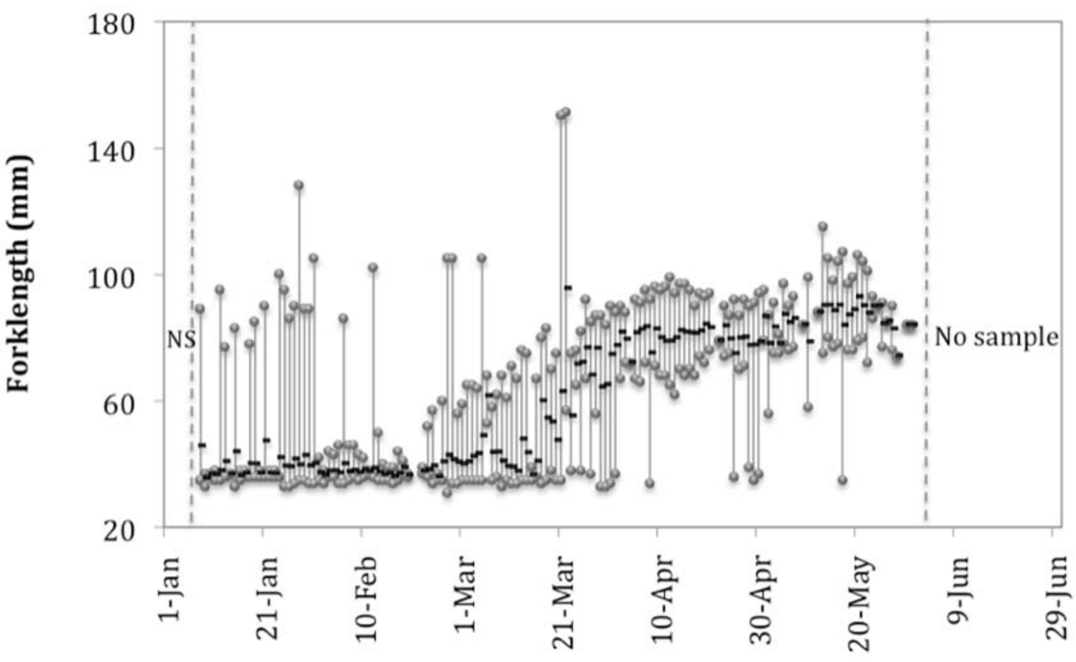

Figure 19. Daily minimum, average, and maximum fork lengths of unmarked Chinook salmon captured at Waterford during 2008.

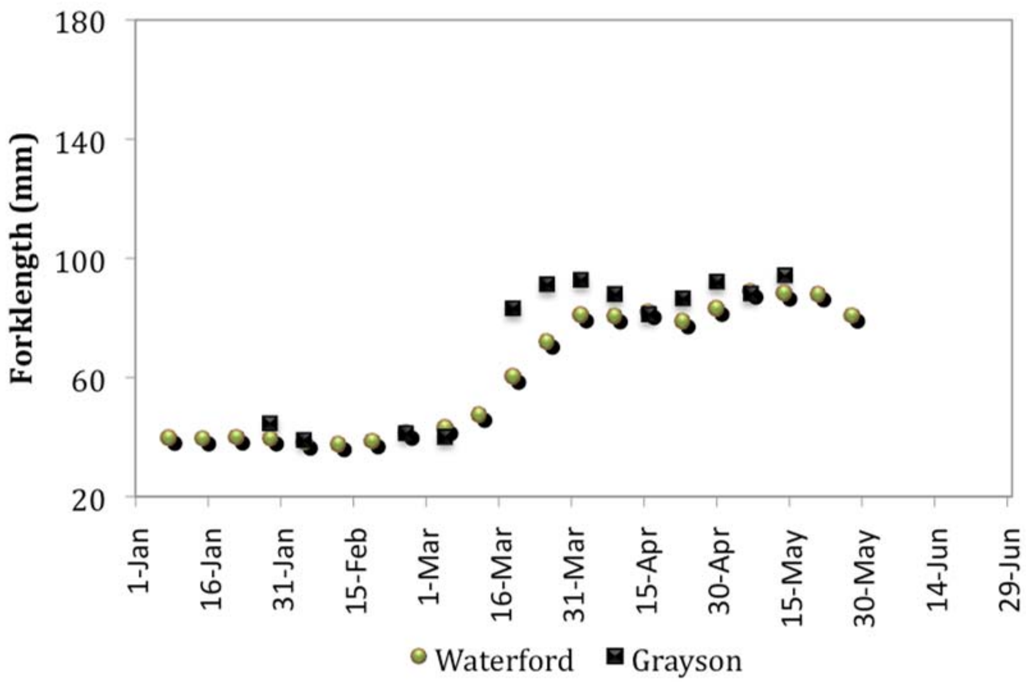

Figure 20. Average forklength of juvenile Chinook salmon captured at Waterford and Grayson by Julian week during 2008.

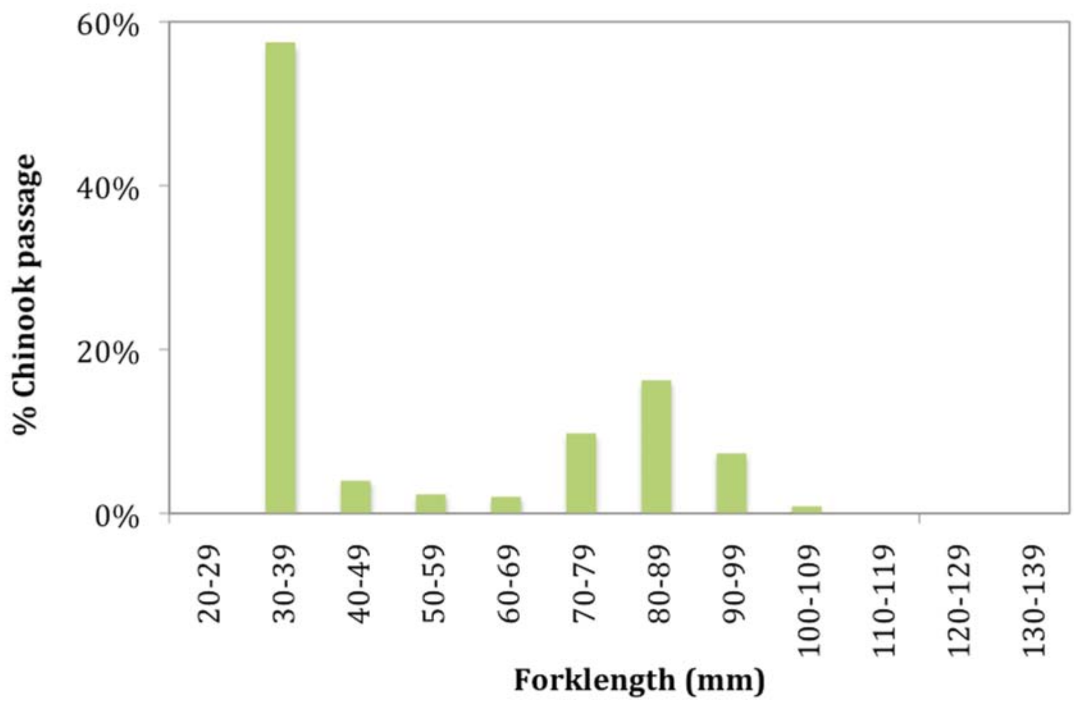

Figure 21. Estimated Chinook passage by 10 mm fork length intervals at Waterford during 2008.

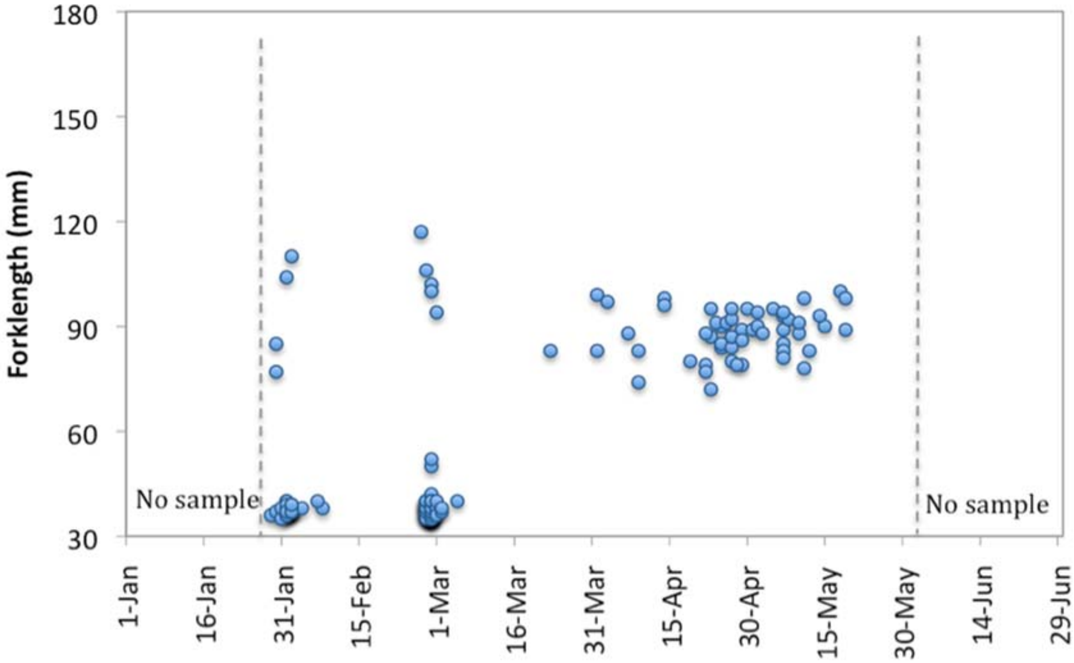

Figure 22. Individual forklengths of juvenile salmon captured at Grayson during 2008.

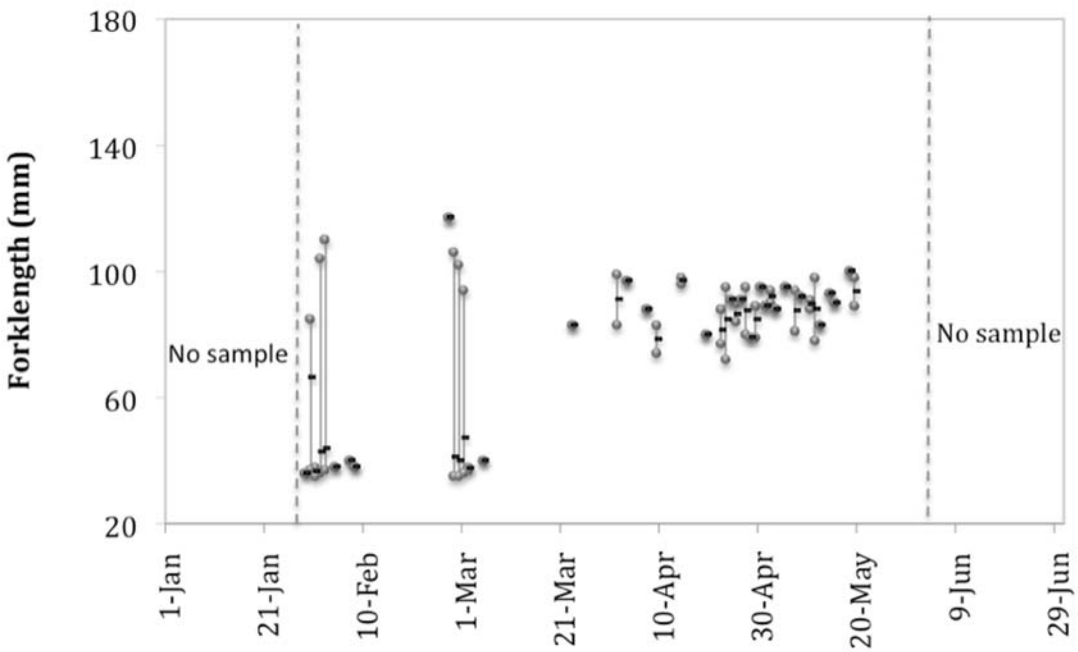

Figure 23. Daily minimum, average, and maximum fork lengths of unmarked Chinook salmon captured at Grayson during 2008.

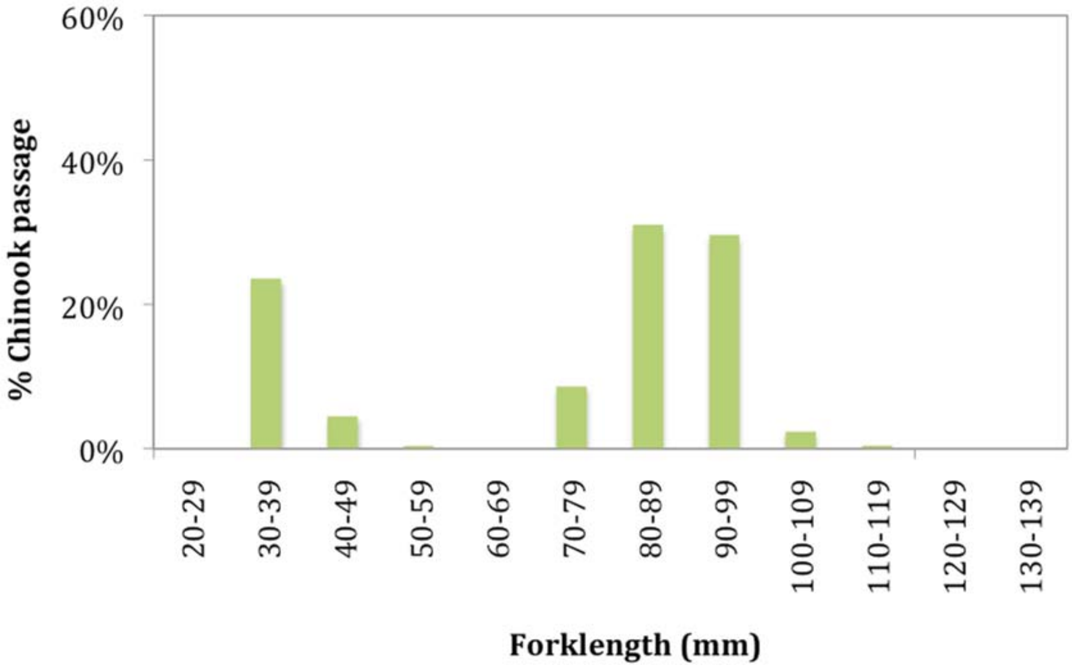

Figure 24. Estimated Chinook passage by 10 mm fork length intervals at Grayson during 2008.

Chinook Salmon Condition at Migration

Juveniles captured at both Waterford and Grayson during 2008 were generally healthy with no apparent signs of disease or stress. Trends in individual salmon forklength to weight completely overlapped between Waterford and Grayson (Figure 25).

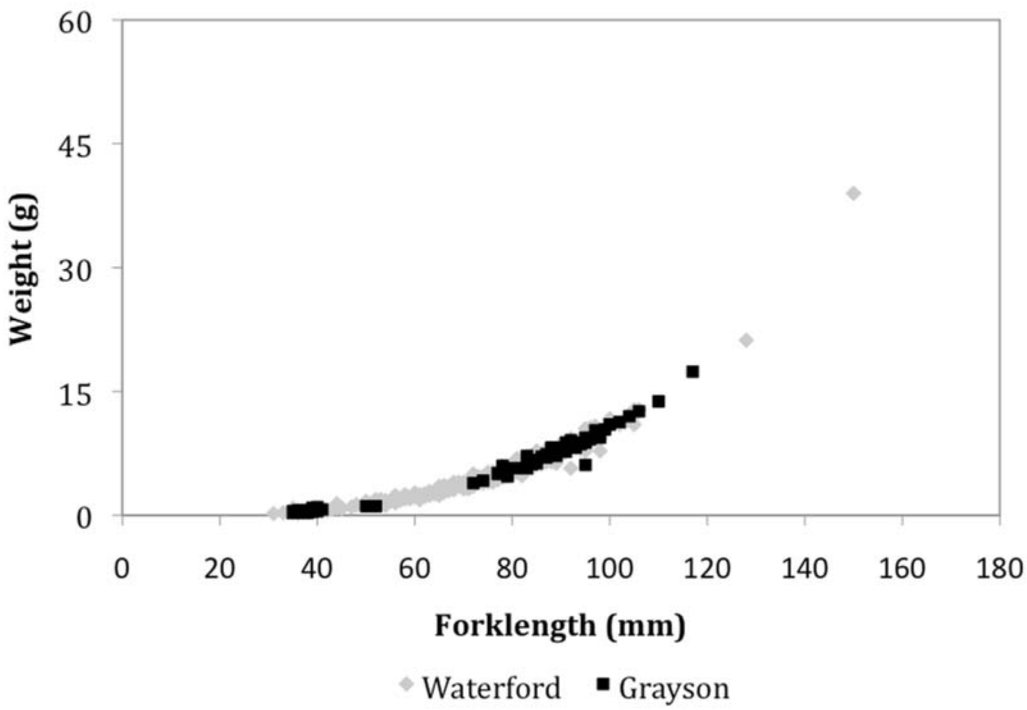

Figure 25. Individual forklength and weight of individual juvenile Chinook salmon measured at Waterford and Grayson during 2008.

Oncorhynchus mykiss (Rainbow Trout)

Nine *O. mykiss* were captured at Waterford between January 26 and May 23, 2008 (Table 5). One *O. mykiss* was classified as young-of-the-year (<100 mm; 58 mm), and eight were classified as Age 1+ (100 mm-299 mm; range: 100 mm to 268 mm).

Two *O. mykiss* were captured at Grayson between February 28 and March 31, 2008 (Table 5). Both *O. mykiss* were classified as Age 1+ (100 mm-299 mm; range: 200 mm to 224 mm).

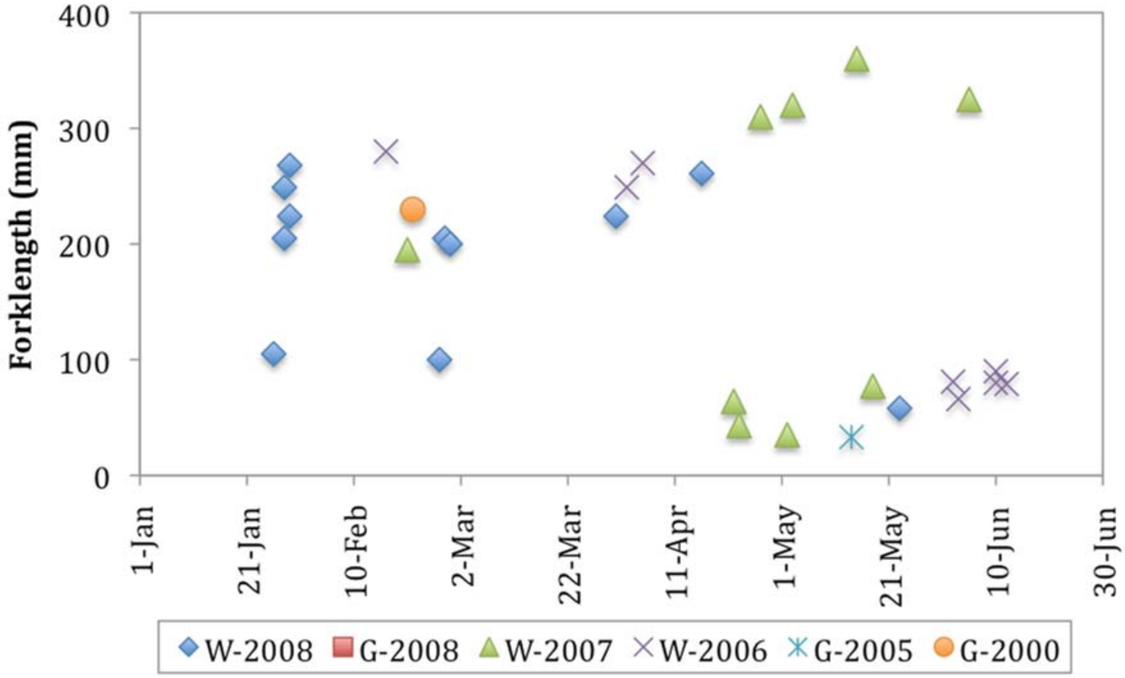

Figure 26. Date, size and location of *O. myhiss* captured at Waterford (W) and Grayson (G).

Table 5. Length, weight, and smolt index of *O. mykiss* captured at Waterford and Grayson [a] during 2008.

Date	Fork Length (mm)	Total Length (mm)	Weight (g)	Smolt Index*	Mortality
1/26/2008	105	120	89.2	5	No
1/28/2008	249	267	np	np	Yes
1/28/2008	205	221	87.4	5	No
1/29/2008	268	285	173	5	No
1/29/2008	224	240	112.3	5	No
2/26/2008	100	109	10.5	3	No
2/27/2008	205	222	91.1	5	No
2/28/2008[a]	200	217	78.3	5	No
3/31/2008[a]	224	242	102.3	5	No
4/16/2008	261	280	181.5	5	No
5/23/2008	58	61	2.5	3	No

*Smolt index 1=yolk-sac fry; 2=fry; 3=parr, 4=silvery parr;, 5=smolt, 6=mature adult; IAD= immature adult; np= not provided

Other Fish Species Captured

A total of 16,429 non-salmonids representing at least 24 species (5 native, 19 introduced) were captured during operation of the Waterford and Grayson traps in 2008 (Table 6; Appendices C and D). Native species comprised 79% of the total non-salmonid catch, consisting primarily of unidentified lampreys (n= 11,949). Species captured at Waterford were all also recorded at Grayson and additional species only recorded at Grayson were American shad, black crappie, carp, green sunfish, inland silverside, and threadfin shad. Lampreys captured in the traps were primarily ammocoetes and were not identified to species or measured.

Table 6. Non-salmonid species captured at Waterford and Grayson during 2008. Native species are indicated in bold.

		Waterford				Grayson			
Common Name	Scientific Name	Total Catch	Minimum Length (mm)	Average Length (mm)	Maximum Length (mm)	Total Catch	Minimum Length (mm)	Average Length (mm)	Maximum Length (mm)
Catfish Family									
Black bullhead	*Ameiurus melas*	25	52	99	220	7	108	192	245
Brown Bullhead	*Ictalurus nebulosus*	2	78	194	310	1	145	145	145
Channel catfish	*Ictalurus punctatus*	28	57	93	251	21	50	153	570
White catfish	*Ictalurus catus*	292	40	81	288	1704	32	67	500
Hering Family									
Threadfin shad	*Dorosoma petenense*	0	-	-	-	1	118	118	118
American shad	*Alosa sapidissima*	0	-	-	-	1	130	130	130
Lamprey Family									
Lamprey - unidentified	**Not applicable**	9858	-	-	-	2091	-	-	-
Livebearer Family									
Mosquitofish	*Gambusia affinis*	3	24	30	36	85	20	31	47
Minnow Family									
Carp	*Cyprinus carpio*	0	-	-	-	4	22	56	152
Golden shiner	*Notemigonus crysoleucas*	62	39	97	131	24	40	88	175
Goldfish	*Carassius auratus*	0	-	-	-	1	265	265	265
Hardhead	***Mylopharodon conocephalus***	121	39	96	210	2	73	112	150
Red shiner	*Cyprinella lutrennsis*	8	66	86	105	215	27	48	93
Sacramento pikeminnow	***Ptychochelius grandis***	225	36	86	196	21	45	92	160
Sculpin Family									
Prickly Sculpin	***Cottus asper***	87	59	80	122	7	71	99	194
Silverside Family									
Inland silverside	*Menidia beryllina*	0	-	-	-	42	20	75	112
Sucker Family									
Sacramento sucker	***Catostomus occidentalis***	114	20	91	620	312	14	27	41

Common Name	Scientific Name	Waterford				Grayson			
		Total Catch	Minimum Length (mm)	Average Length (mm)	Maximum Length (mm)	Total Catch	Minimum Length (mm)	Average Length (mm)	Maximum Length (mm)
Sunfish Family									
Bluegill	*Lepomis macrochirus*	153	25	60	185	55	27	79	165
Black crappie	*Pomoxis annularis*	0	-	-	-	2	66	71	75
Green sunfish	*Lepomis cyanellus*	2	67	80	92	1	42	42	42
Largemouth bass	*Micropterus salmoides*	8	56	97	260	33	31	119	385
Redear sunfish	*Lepomis microlophus*	42	48	71	122	132	35	60	180
Smallmouth bass	*Micropterus dolomieu*	38	81	131	300	303	26	115	395
Warmouth	*Lepomis gulosus*	29	44	71	98	10	52	98	175
Unidentified bass	Not applicable	0	-	-	-	255	16	22	85
Unidentified species	Not applicable	0	-	-	-	2	21	44	67

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Appendix A. Daily Chinook catch, length, and estimated passage at Waterford and environmental data from 2008.

	Unmarked Chinook Salmon									*Environmental Conditions*					
		Fork Length (mm)				Estimated Passage				Flow (cfs)					
Date	Catch	Min	Avg	Max	Est. Efficiency	Fry	Parr	Smolt	Total	La Grange	Hickman spill	Trap site	Velocity (ft/s)	Temperature at Hickman Bridge (°F)	Turbidity (NTU)
8-Jan	30	35	46	89	0.1416	196	4	13	212	172	0	172	1.3	49.0	46.8
9-Jan	14	33	36	37	0.1416	91	2	6	99	178	0	178	1.4	49.1	16.4
10-Jan	1	37	37	37	0.1416	7	0	0	7	168	0	168	1.5	50.3	8.1
11-Jan	19	35	37	38	0.1416	124	2	8	134	170	0	170	1.4	50.6	6.0
12-Jan	39	35	38	95	0.1416	254	5	16	275	170	0	170	1.3	51.5	5.0
13-Jan	10	36	41	77	0.1416	65	1	4	71	170	0	170	1.3	52.2	3.9
14-Jan	4	37	37	37	0.1416	26	0	2	28	168	0	168	1.3	51.3	4.5
15-Jan	6	33	44	83	0.1416	40	0	3	42	169	0	169	1.4	50.7	3.0
16-Jan	18	35	36	38	0.1416	120	0	8	127	169	0	169	1.4	49.7	2.8
17-Jan	5	36	37	38	0.1416	33	0	2	35	170	0	170	1.4	49.2	1.8
18-Jan	12	36	40	78	0.1416	80	0	5	85	170	0	170	1.3	48.7	2.4
19-Jan	15	36	40	85	0.1416	100	0	6	106	170	0	170	1.3	48.5	1.3
20-Jan	6	36	37	38	0.1416	40	0	3	42	169	0	169	1.4	48.6	1.8
21-Jan	5	36	47	90	0.1416	33	0	2	35	169	0	169	1.4	48.9	1.6
22-Jan	6	36	37	38	0.1416	40	0	2	42	180	0	180	1.4	49.4	2.0
23-Jan	2	36	37	38	0.1416	13	0	1	14	182	0	182	1.7	49.4	11.8
24-Jan	26	36	42	100	0.1416	174	0	10	184	177	0	177	3.1	47.9	200.0
25-Jan	236	33	39	95	0.1416	1580	0	86	1667	168	0	168	1.7	47.4	151.0
26-Jan	101	33	39	86	0.1416	676	0	37	713	170	0	170	1.5	49.4	75.2
27-Jan	21	34	42	90	0.1416	141	0	8	148	171	0	171	1.5	51.2	18.6
28-Jan	68	35	40	128	0.1416	455	0	25	480	171	0	171	1.8	51.1	35.6
29-Jan	129	35	43	89	0.1416	868	0	43	911	171	0	171	1.7	48.7	411.0
30-Jan	140	34	39	89	0.1416	942	0	46	989	170	0	170	1.6	49.1	35.1
31-Jan	59	34	40	105	0.1416	397	0	20	417	170	0	170	1.4	49.6	15.7
1-Feb	39	35	37	42	0.1416	263	0	13	275	170	0	170	1.6	50.1	9.3
2-Feb	41	34	37	38	0.1416	276	0	14	290	169	0	169	1.4	49.5	9.7
3-Feb	13	36	38	44	0.1416	88	0	4	92	170	0	170	1.3	49.3	6.4
4-Feb	29	36	38	43	0.1416	195	0	10	205	174	0	174	1.4	49.7	34.4
5-Feb	71	34	37	46	0.1416	497	0	4	501	175	0	175	1.6	49.0	119.0
6-Feb	43	34	40	86	0.1416	301	0	2	304	173	0	173	1.3	50.1	14.0

	Unmarked Chinook Salmon									*Environmental Conditions*					
		Fork Length (mm)				Estimated Passage				Flow (cfs)					
Date	Catch	Min	Avg	Max	Est. Efficiency	Fry	Parr	Smolt	Total	La Grange	Hickman spill	Trap site	Velocity (ft/s)	Temperature at Hickman Bridge (°F)	Turbidity (NTU)
7-Feb	104	35	38	46	0.1416	728	0	6	734	173	0	173	1.2	51.1	5.6
8-Feb	63	36	38	46	0.1416	441	0	4	445	175	0	175	1.3	52.0	5.6
9-Feb	24	35	37	43	0.1416	168	0	1	169	175	0	175	1.5	52.2	4.5
10-Feb	7	36	38	42	0.1416	49	0	0	49	178	0	178	1.3	53.2	6.8
11-Feb	3	37	38	38	0.1416	21	0	0	21	174	0	174	1.3	53.7	4.5
12-Feb	34	36	39	102	0.1416	237	2	2	240	171	0	171	1.2	54.3	3.1
13-Feb	35	35	37	50	0.1416	244	2	2	247	170	0	170	1.2	54.3	-
14-Feb	18	35	37	40	0.1416	125	1	1	127	170	0	170	1.0	51.5	2.0
15-Feb	29	35	37	39	0.1416	202	2	2	205	171	0	171	1.3	51.0	2.5
16-Feb	7	34	36	39	0.1416	49	0	0	49	169	0	169	1.2	51.7	2.8
17-Feb	13	35	37	44	0.1416	90	1	1	92	170	0	170	1.1	52.4	1.9
18-Feb	2	37	39	41	0.1416	14	0	0	14	170	0	170	1.1	53.5	2.4
19-Feb	2	36	37	37	0.1416	13	1	0	14	181	0	181	0.9	53.5	1.4
20-Feb	0	-	-	-	0.1416	0	0	0	0	180	0	180	1.1	54.2	1.9
21-Feb	0	-	-	-	0.1416	0	0	0	0	181	0	181	1.3	53.3	2.9
22-Feb	4	37	38	39	0.1416	27	2	0	28	180	0	180	1.1	52.7	15.1
23-Feb	27	36	38	52	0.1416	180	11	0	191	181	0	181	1.4	51.9	5.6
24-Feb	19	34	39	57	0.1416	127	7	0	134	182	0	182	1.4	51.4	1.4
25-Feb	2	35	36	37	0.1416	13	1	0	14	175	0	175	2.2	52.8	25.0
26-Feb	6	35	41	60	0.1416	36	6	1	42	167	0	167	1.0	54.1	93.8
27-Feb	151	31	43	105	0.1416	909	139	18	1066	166	0	166	1.1	55.7	17.2
28-Feb	115	34	41	105	0.1416	692	106	14	812	167	0	167	1.1	56.6	13.0
29-Feb	118	34	41	56	0.1416	710	109	14	833	167	0	167	1.2	57.7	2.2
1-Mar	46	35	40	59	0.1416	277	42	6	325	166	0	166	1.2	57.7	6.2
2-Mar	31	35	41	65	0.1416	187	29	4	219	167	0	167	1.2	55.4	3.2
3-Mar	24	35	42	65	0.1416	144	22	3	169	170	0	170	1.0	56.0	5.1
4-Mar	16	35	43	64	0.1416	96	15	2	113	174	0	174	1.1	56.7	3.4
5-Mar	14	35	49	105	0.1416	72	25	1	99	174	0	174	1.1	56.7	3.3
6-Mar	4	53	62	68	0.1220	24	8	0	33	175	0	175	1.0	56.3	3.4
7-Mar	3	35	44	58	0.1416	15	5	0	21	177	0	177	1.0	56.4	4.1
8-Mar	4	36	44	62	0.1416	21	7	0	28	181	0	181	1.3	57.4	3.1
9-Mar	16	33	41	68	0.1416	83	29	1	113	181	0	181	1.3	57.7	1.9

	Unmarked Chinook Salmon									*Environmental Conditions*					
		Fork Length (mm)				Estimated Passage				Flow (cfs)					
Date	**Catch**	**Min**	**Avg**	**Max**	**Est. Efficiency**	**Fry**	**Parr**	**Smolt**	**Total**	**La Grange**	**Hickman spill**	**Trap site**	**Velocity (ft/s)**	**Temperature at Hickman Bridge (°F)**	**Turbidity (NTU)**
10-Mar	21	35	39	61	0.1416	108	38	2	148	182	0	182	1.2	58.7	2.8
11-Mar	14	34	39	71	0.1416	72	25	1	99	183	0	183	1.2	59.0	2.4
12-Mar	24	34	38	67	0.1416	125	23	21	169	172	0	172	1.2	58.6	3.3
13-Mar	13	35	48	76	0.1416	68	12	11	92	168	0	168	1.2	59.3	2.4
14-Mar	18	35	44	75	0.1416	94	17	16	127	168	0	168	1.3	58.5	1.9
15-Mar	7	35	37	39	0.1416	37	7	6	49	167	0	167	1.2	57.5	2.8
16-Mar	7	36	41	67	0.1416	37	7	6	49	166	0	166	1.1	55.2	2.4
17-Mar	21	34	60	80	0.1220	127	23	22	172	166	0	166	1.2	55.5	1.9
18-Mar	21	35	55	83	0.1220	127	23	22	172	172	0	172	1.3	57.4	2.2
19-Mar	7	38	53	70	0.1220	26	14	18	57	179	0	179	1.1	59.0	3.0
20-Mar	14	35	48	75	0.1416	45	23	30	99	177	0	177	1.3	59.4	0.6
21-Mar	8	35	63	150	0.1220	30	16	20	66	170	0	170	1.2	58.6	1.8
22-Mar	3	57	95	151	0.1220	11	6	8	25	165	0	165	1.1	58.5	4.4
23-Mar	4	38	55	75	0.1220	15	8	10	33	168	0	168	1.1	59.5	1.8
24-Mar	4	65	72	76	0.1220	15	8	10	33	166	0	166	1.1	60.5	2.1
25-Mar	6	38	72	82	0.1220	23	12	15	49	165	0	165	-	61.0	1.9
26-Mar	6	67	77	92	0.1220	7	8	34	49	165	0	165	1.3	60.3	1.1
27-Mar	9	37	68	85	0.1220	11	12	50	74	164	0	164	1.3	58.9	3.1
28-Mar	8	56	77	87	0.1220	10	11	45	66	172	0	172	1.3	58.6	3.3
29-Mar	9	33	64	87	0.1220	11	12	50	74	166	0	166	1.4	59.5	2.4
30-Mar	13	33	65	84	0.1220	16	18	73	107	166	0	166	1.3	58.9	2.2
31-Mar	9	34	75	90	0.1220	11	12	50	74	165	0	165	1.1	59.0	1.5
1-Apr	19	37	77	88	0.1220	23	26	106	156	176	0	176	1.1	59.7	1.2
2-Apr	11	67	82	90	0.1220	1	6	83	90	175	0	175	-	59.5	2.5
3-Apr	13	72	79	88	0.1220	1	7	98	107	169	0	169	1.5	60.1	2.1
4-Apr	1	72	72	72	0.1220	0	1	8	8	163	0	163	1.4	60.9	1.9
5-Apr	7	67	81	92	0.1220	1	4	53	57	163	0	163	1.3	60.6	2.1
6-Apr	14	66	83	91	0.1220	1	8	106	115	172	0	172	1.1	60.8	3.6
7-Apr	23	72	83	95	0.1220	2	13	174	189	176	0	176	1.4	60.4	4.7
8-Apr	12	34	75	92	0.1220	1	7	91	98	175	0	175	1.3	59.3	2.2
9-Apr	22	71	83	96	0.1220	2	6	172	180	176	0	176	1.1	58.4	2.4
10-Apr	29	68	80	95	0.1220	3	8	226	238	176	0	176	1.5	60.2	2.0

	Unmarked Chinook Salmon									Environmental Conditions					
		Fork Length (mm)				Estimated Passage				Flow (cfs)					
Date	Catch	Min	Avg	Max	Est. Efficiency	Fry	Parr	Smolt	Total	La Grange	Hickman spill	Trap site	Velocity (ft/s)	Temperature at Hickman Bridge (°F)	Turbidity (NTU)
11-Apr	30	68	79	96	0.1220	3	8	234	246	182	0	182	1.7	62.2	1.3
12-Apr	20	65	79	99	0.1220	2	6	156	164	184	0	184	-	64.3	3.1
13-Apr	16	62	80	94	0.1220	2	5	125	131	184	0	184	1.6	65.6	3.4
14-Apr	19	70	82	97	0.1220	2	5	148	156	181	0	181	1.6	65.3	2.8
15-Apr	25	68	82	97	0.1220	3	7	195	205	170	0	170	1.5	62.0	2.6
16-Apr	33	70	81	95	0.1220	0	6	265	271	168	0	168	1.5	61.0	3.8
17-Apr	31	68	81	90	0.1220	0	6	249	254	168	0	168	1.5	62.5	3.1
18-Apr	26	74	82	94	0.1220	0	5	209	213	169	0	169	1.5	64.5	2.1
19-Apr	13	72	84	93	0.1220	0	2	104	107	756	0	756	1.8	64.1	2.9
20-Apr	10	76	83	94	0.1220	0	2	80	82	1300	0	1300	0.7	54.7	5.4
21-Apr	0	-	-	-	0.1220	0	0	0	0	1270	0	1270	0.9	53.3	2.4
22-Apr	1	79	79	79	0.1220	0	0	8	8	1310	0	1310	2.1	53.0	1.4
23-Apr	8	74	84	90	0.1220	2	0	64	66	1310	0	1310	3.7	53.4	1.6
24-Apr	9	75	79	87	0.1220	2	0	72	74	1310	0	1310	4.1	53.6	2.3
25-Apr	9	36	75	92	0.1220	2	0	72	74	1130	0	1130	3.8	54.5	1.3
26-Apr	17	70	80	87	0.1220	3	0	136	139	962	0	962	3.9	55.9	1.9
27-Apr	22	71	80	92	0.1220	4	0	176	180	861	0	861	3.9	57.1	1.1
28-Apr	19	39	77	90	0.1220	4	0	152	156	852	0	852	3.4	57.3	2.2
29-Apr	25	35	78	91	0.1220	5	0	200	205	862	0	862	3.7	56.4	0.9
30-Apr	11	37	79	94	0.1220	2	3	86	90	851	0	851	3.7	55.2	1.2
1-May	16	79	87	95	0.1220	3	4	124	131	851	0	851	3.5	55.2	1.7
2-May	15	56	78	87	0.1220	3	4	117	123	856	0	856	3.7	55.5	1.4
3-May	10	75	83	91	0.1220	2	3	78	82	851	0	851	3.5	55.7	1.5
4-May	3	75	78	81	0.1220	1	1	23	25	1040	0	1040	3.5	56.7	1.2
5-May	16	78	87	97	0.1220	3	4	124	131	1310	0	1310	3.1	56.1	1.9
6-May	5	76	85	90	0.1220	1	1	39	41	1300	0	1300	4.0	56.1	1.1
7-May	13	77	86	93	0.1220	0	5	102	107	1300	0	1300	1.7	56.1	1.7
8-May	0	-	-	-	0.1220	0	0	0	0	1300	0	1300	1.8	55.8	1.0
9-May	1	84	84	84	0.1220	0	0	8	8	1300	0	1300	3.0	55.6	1.0
10-May	2	58	79	99	0.1220	0	1	16	16	1170	0	1170	3.3	55.8	1.3
11-May	0	-	-	-	0.1220	0	0	0	0	915	0	915	2.7	56.7	1.2
12-May	1	88	88	88	0.1220	0	0	8	8	817	0	817	3.0	56.9	1.6

	Unmarked Chinook Salmon									Environmental Conditions					
		Fork Length (mm)				Estimated Passage				Flow (cfs)					
Date	Catch	Min	Avg	Max	Est. Efficiency	Fry	Parr	Smolt	Total	La Grange	Hickman spill	Trap site	Velocity (ft/s)	Temperature at Hickman Bridge (°F)	Turbidity (NTU)
13-May	50	75	90	115	0.1220	0	19	391	410	809	0	809	3.6	57.2	1.3
14-May	20	80	90	105	0.1220	3	0	161	164	808	0	808	3.7	57.8	2.3
15-May	44	77	88	98	0.1220	7	0	354	361	802	0	802	4.1	58.7	0.7
16-May	55	78	90	104	0.1220	9	0	442	451	811	0	811	3.8	59.7	0.7
17-May	53	35	84	107	0.1220	8	0	426	435	830	0	830	3.9	60.3	1.1
18-May	24	76	87	97	0.1220	4	0	193	197	758	0	758	3.6	60.3	1.4
19-May	28	76	89	99	0.1220	4	0	225	230	650	0	650	3.8	60.1	1.5
20-May	21	79	93	106	0.1220	3	0	169	172	482	0	482	3.5	60.6	1.0
21-May	29	80	90	104	0.1220	0	0	238	238	318	0	318	1.8	60.6	1.7
22-May	27	72	88	101	0.1220	0	0	221	221	241	0	241	2.3	60.7	0.8
23-May	6	86	90	93	0.1220	0	0	49	49	187	0	187	1.8	62.5	1.0
24-May	1	90	90	90	0.1220	0	0	8	8	178	0	178	1.4	62.7	4.4
25-May	8	77	84	91	0.1220	0	0	66	66	180	0	180	1.5	60.7	3.1
26-May	2	85	85	85	0.1220	0	0	16	16	180	0	180	1.3	62.4	0.8
27-May	7	76	83	90	0.1220	0	0	57	57	182	0	182	1.4	63.9	0.9
28-May	1	74	74	74	0.1220	0	0	8	8	184	0	184	1.3	64.7	0.7
29-May	0	-	-	-	0.1220	0	0	0	0	180	0	180	1.1	66.2	0.8
30-May	1	84	84	84	0.1220	0	0	8	8	160	0	160	1.4	67.4	1.0
31-May	1	84	84	84	0.1220	0	0	8	8	143	0	143	1.3	68.5	0.3
1-Jun	0	-	-	-	0.1220	0	0	0	0	107	0	107	1.4	69.3	2.3
2-Jun	0	-	-	-	0.1220	0	0	0	0	86	0	86	1.1	70.0	1.2

Appendix B. Daily Chinook catch, length, predicted trap efficiency, and estimated passage at Grayson and environmental data from 2008.

	Unmarked Chinook Salmon									*Environmental Conditions*				
		Fork Length (mm)				Estimated Passage				Flow (cfs)	Velocity (ft/s)			
Date	Catch	Min	Avg	Max	Est. Efficiency	Fry	Parr	Smolt	Total	Modesto Flow	North	South	Temperature at Shiloh (°F)	Turbidity (NTU)
29-Jan	1	36	36	36	0.1295	7	0	1	8	1250	2.4	3.1	50.7	59.4
30-Jan	3	37	66	85	0.0602	44	0	6	50	609	2.2	2.3	50.6	41.5
31-Jan	2	35	37	38	0.1744	10	0	1	11	500	1.9	1.8	50.3	44.1
1-Feb	13	36	43	104	0.1446	79	0	11	90	443	1.9	2.0	49.6	95.7
2-Feb	12	37	44	110	0.1391	75	0	11	86	450	1.5	1.4	49.9	41.6
3-Feb	0	-	-	-	-	0	0	0	0	501	2.0	1.9	49.7	18.8
4-Feb	1	38	38	38	0.1391	6	0	1	7	917	2.7	2.3	50.0	40.8
5-Feb	0	-	-	-	-	0	0	0	0	698	2.2	2.3	49.8	29.6
6-Feb	0	-	-	-	-	0	0	0	0	469	1.9	1.8	49.9	14.0
7-Feb	1	40	40	40	0.1613	6	0	0	6	402	1.6	1.6	50.2	16.7
8-Feb	1	38	38	38	0.1751	6	0	0	6	368	1.7	1.5	50.4	44.8
9-Feb	0	-	-	-	-	0	0	0	0	346	1.6	1.4	51.4	21.1
10-Feb	0	-	-	-	-	0	0	0	0	328	1.3	1.3	52.3	12.8
11-Feb	0	-	-	-	-	0	0	0	0	322	1.4	1.4	53.2	7.2
12-Feb	0	-	-	-	-	0	0	0	0	315	1.3	1.2	53.7	5.5
13-Feb	0	-	-	-	-	0	0	0	0	295	1.2	1.2	54.6	4.4
14-Feb	0	-	-	-	-	0	0	0	0	291	1.3	1.3	51.8	3.8
15-Feb	0	-	-	-	-	0	0	0	0	285	1.4	1.2	52.3	2.8
16-Feb	0	-	-	-	-	0	0	0	0	287	1.4	1.3	53.6	3.4
17-Feb	0	-	-	-	-	0	0	0	0	280	1.2	1.3	54.4	3.2
18-Feb	0	-	-	-	-	0	0	0	0	277	1.2	1.2	55.4	1.7
19-Feb	0	-	-	-	-	0	0	0	0	284	1.1	1.3	54.8	1.7
20-Feb	0	-	-	-	-	0	0	0	0	327	1.6	1.7	56.1	2.9
21-Feb	0	-	-	-	-	0	0	0	0	329	1.6	1.4	55.0	3.8
22-Feb	0	-	-	-	-	0	0	0	0	331	1.5	1.4	54.6	-
23-Feb	0	-	-	-	-	0	0	0	0	315	1.2	1.3	53.4	2.4
24-Feb	0	-	-	-	-	0	0	0	0	356	1.2	1.5	53.3	4.5
25-Feb	0	-	-	-	-	0	0	0	0	832	1.3	1.6	54.3	6.9
26-Feb	0	-	-	-	-	0	0	0	0	1000	2.6	2.4	53.0	55.7
27-Feb	1	117	117	117	0.0111	84	2	4	90	523	1.9	1.9	54.7	24.5
28-Feb	21	35	41	106	0.1546	127	3	7	136	414	1.4	1.7	56.4	67.0
29-Feb	73	35	40	102	0.1641	415	9	22	445	369	1.4	1.5	58.0	64.1

	Unmarked Chinook Salmon									*Environmental Conditions*				
		Fork Length (mm)				Estimated Passage				Flow (cfs)	Velocity (ft/s)			
Date	**Catch**	**Min**	**Avg**	**Max**	**Est. Efficiency**	**Fry**	**Parr**	**Smolt**	**Total**	**Modesto Flow**	**North**	**South**	**Temperature at Shiloh (°F)**	**Turbidity (NTU)**
1-Mar	6	36	47	94	0.1295	43	1	2	46	342	1.4	1.5	58.6	25.9
2-Mar	2	37	38	38	0.1810	10	0	1	11	330	1.2	1.3	56.4	14.1
3-Mar	0	-	-	-	-	0	0	0	0	313	1.2	1.1	57.6	8.5
4-Mar	0	-	-	-	-	0	0	0	0	308	1.2	1.3	58.9	6.2
5-Mar	1	40	40	40	0.1688	6	0	0	6	294	1.4	1.5	58.7	4.7
6-Mar	0	-	-	-	-	0	0	0	0	292	1.2	1.6	58.0	1.8
7-Mar	0	-	-	-	-	0	0	0	0	281	1.3	1.3	58.5	7.7
8-Mar	0	-	-	-	-	0	0	0	0	277	1.3	1.4	60.7	4.1
9-Mar	0	-	-	-	-	0	0	0	0	278	1.1	1.3	60.7	4.9
10-Mar	0	-	-	-	-	0	0	0	0	279	1.4	1.3	61.5	5.0
11-Mar	0	-	-	-	-	0	0	0	0	280	1.3	1.3	62.5	4.0
12-Mar	0	-	-	-	-	0	0	0	0	278	1.3	1.3	62.0	2.9
13-Mar	0	-	-	-	-	0	0	0	0	275	1.2	1.4	63.3	11.9
14-Mar	0	-	-	-	-	0	0	0	0	270	1.2	1.1	61.2	2.5
15-Mar	0	-	-	-	-	0	0	0	0	267	1.4	1.3	59.5	6.0
16-Mar	0	-	-	-	-	0	0	0	0	255	1.2	1.2	57.5	2.5
17-Mar	0	-	-	-	-	0	0	0	0	253	1.2	1.3	58.2	3.1
18-Mar	0	-	-	-	-	0	0	0	0	252	1.1	1.2	60.9	1.4
19-Mar	0	-	-	-	-	0	0	0	0	270	1.2	1.3	62.6	1.4
20-Mar	0	-	-	-	-	0	0	0	0	277	1.3	1.4	62.1	5.0
21-Mar	0	-	-	-	-	0	0	0	0	277	1.1	1.1	61.2	2.3
22-Mar	0	-	-	-	-	0	0	0	0	303	1.3	1.2	61.5	2.4
23-Mar	1	83	83	83	0.0390	0	0	26	26	293	1.3	1.3	63.0	4.1
24-Mar	0	-	-	-	-	0	0	0	0	319	1.3	1.4	63.9	4.0
25-Mar	0	-	-	-	-	0	0	0	0	291	1.4	1.3	64.6	5.0
26-Mar	0	-	-	-	-	0	0	0	0	285	1.4	1.3	63.5	4.7
27-Mar	0	-	-	-	-	0	0	0	0	287	1.1	1.3	61.4	2.8
28-Mar	0	-	-	-	-	0	0	0	0	295	1.2	1.4	61.6	4.0
29-Mar	0	-	-	-	-	0	0	0	0	309	1.4	1.3	63.6	3.0
30-Mar	0	-	-	-	-	0	0	0	0	305	1.3	1.5	62.3	3.2
31-Mar	0	-	-	-	-	0	0	0	0	327	1.2	1.3	61.3	2.8
1-Apr	2	83	91	99	0.0294	0	0	68	68	311	1.2	1.3	62.6	6.6
2-Apr	0	-	-	-	-	0	0	0	0	303	-	-	63.0	7.3
3-Apr	1	97	97	97	0.0239	0	0	42	42	321	1.4	1.4	63.5	4.7

	Unmarked Chinook Salmon									*Environmental Conditions*				
		Fork Length (mm)				Estimated Passage				Flow (cfs)	Velocity (ft/s)			
Date	Catch	Min	Avg	Max	Est. Efficiency	Fry	Parr	Smolt	Total	Modesto Flow	North	South	Temperature at Shiloh (°F)	Turbidity (NTU)
4-Apr	0	-	-	-	-	0	0	0	0	309	1.2	1.4	64.3	5.4
5-Apr	0	-	-	-	-	0	0	0	0	295	1.2	1.4	63.4	4.2
6-Apr	0	-	-	-	-	0	0	0	0	287	1.1	1.3	63.7	4.1
7-Apr	1	88	88	88	0.0329	0	0	30	30	288	1.3	1.3	62.9	2.9
8-Apr	0	-	-	-	-	0	0	0	0	301	1.1	1.3	62.7	3.4
9-Apr	2	74	79	83	0.0450	0	0	44	44	314	1.2	1.2	62.5	4.3
10-Apr	0	-	-	-	-	0	0	0	0	315	1.5	1.2	63.8	5.5
11-Apr	0	-	-	-	-	0	0	0	0	308	1.4	1.5	65.9	-
12-Apr	0	-	-	-	-	0	0	0	0	320	-	-	68.1	5.7
13-Apr	0	-	-	-	-	0	0	0	0	326	1.4	1.4	70.2	5.7
14-Apr	2	96	97	98	0.0240	0	0	83	83	306	1.4	1.4	69.1	4.4
15-Apr	0	-	-	-	-	0	0	0	0	300	1.5	1.4	64.3	4.2
16-Apr	0	-	-	-	-	0	0	0	0	291	1.2	1.4	64.2	3.5
17-Apr	0	-	-	-	-	0	0	0	0	289	1.3	1.4	66.7	2.6
18-Apr	0	-	-	-	-	0	0	0	0	299	1.2	1.2	68.9	3.1
19-Apr	1	80	80	80	0.0428	0	0	23	23	313	1.5	1.5	67.6	8.0
20-Apr	0	-	-	-	-	0	0	0	0	738	1.1	1.3	63.9	4.1
21-Apr	0	-	-	-	-	0	0	0	0	1220	2.7	2.7	60.8	9.3
22-Apr	3	77	81	88	0.0275	0	0	109	109	1260	2.4	2.5	56.3	4.1
23-Apr	3	72	85	95	0.0241	0	0	124	124	1300	2.8	2.8	56.2	3.6
24-Apr	1	91	91	91	0.0194	0	0	52	52	1310	2.6	2.8	56.0	4.3
25-Apr	3	84	86	90	0.0229	0	0	131	131	1290	2.9	2.9	57.4	2.7
26-Apr	1	91	91	91	0.0205	0	0	49	49	1170	2.6	2.5	59.4	7.4
27-Apr	7	80	88	95	0.0243	0	0	288	288	1050	2.5	2.6	61.8	2.8
28-Apr	1	79	79	79	0.0334	0	0	30	30	982	2.4	2.4	63.1	5.7
29-Apr	3	79	85	89	0.0278	0	0	108	108	963	2.6	2.6	62.5	2.6
30-Apr	1	95	95	95	0.0194	0	0	52	52	979	2.3	2.6	60.6	2.1
1-May	1	89	89	89	0.0239	0	0	42	42	974	2.2	2.6	60.0	4.5
2-May	2	90	92	94	0.0216	0	0	93	93	966	2.4	2.6	60.2	6.7
3-May	1	88	88	88	0.0248	0	0	40	40	965	2.5	2.5	60.8	3.3
4-May	0	-	-	-	-	0	0	0	0	967	2.4	2.6	61.9	2.7
5-May	1	95	95	95	0.0179	0	0	56	56	-	2.6	2.7	62.3	3.7
6-May	0	-	-	-	-	0	0	0	0	1300	2.8	3.1	62.1	3.1
7-May	6	81	88	94	0.0218	0	0	275	275	1310	2.8	3.0	61.7	2.9

	Unmarked Chinook Salmon									Environmental Conditions				
		Fork Length (mm)				Estimated Passage				Flow (cfs)	Velocity (ft/s)			
Date	Catch	Min	Avg	Max	Est. Efficiency	Fry	Parr	Smolt	Total	Modesto Flow	North	South	Temperature at Shiloh (°F)	Turbidity (NTU)
8-May	1	92	92	92	0.0186	0	0	54	54	1320	2.9	3.2	61.5	2.4
9-May	0	-	-	-	-	0	0	0	0	1310	2.9	3.1	61.0	1.8
10-May	2	88	90	91	0.0203	0	0	99	99	1320	2.9	2.9	61.0	2.7
11-May	2	78	88	98	0.0226	0	0	89	89	-	2.6	2.8	61.4	2.6
12-May	1	83	83	83	0.0285	0	0	35	35	1040	2.5	2.6	61.8	2.7
13-May	0	-	-	-	-	0	0	0	0	955	2.3	2.6	62.6	3.2
14-May	1	93	93	93	0.0211	0	0	47	47	941	2.1	2.2	64.5	4.0
15-May	1	90	90	90	0.0234	0	0	43	43	935	2.4	2.5	66.1	1.6
16-May	0	-	-	-	-	0	0	0	0	918	3.3	3.3	67.6	-
17-May	0	-	-	-	-	0	0	0	0	918	2.2	2.4	69.0	1.6
18-May	1	100	100	100	0.0167	0	0	60	60	933	2.3	2.4	69.4	2.8
19-May	2	89	94	98	0.0213	0	0	94	94	882	2.4	2.4	69.0	2.1
20-May	0	-	-	-	-	0	0	0	0	810	2.1	2.1	68.7	3.0
21-May	0	-	-	-	-	0	0	0	0	678	1.9	2.0	66.2	2.8
22-May	0	-	-	-	-	0	0	0	0	528	2.0	1.8	64.9	5.2
23-May	0	-	-	-	-	0	0	0	0	434	1.4	1.9	65.7	1.9
24-May	0	-	-	-	-	0	0	0	0	-	1.6	1.6	64.9	6.8
25-May	0	-	-	-	-	0	0	0	0	-	1.6	1.7	64.4	5.7
26-May	0	-	-	-	-	0	0	0	0	350	1.4	1.7	67.2	3.2
27-May	0	-	-	-	-	0	0	0	0	328	-	1.6	67.2	2.6
28-May	0	-	-	-	-	0	0	0	0	323	-	1.4	67.2	3.5
29-May	0	-	-	-	-	0	0	0	0	321	-	1.6	69.2	1.7
30-May	0	-	-	-	-	0	0	0	0	307	-	1.4	70.6	2.8
31-May	0	-	-	-	-	0	0	0	0	294	-	1.6	71.6	3.8
1-Jun	0	-	-	-	-	0	0	0	0	284	-	1.5	71.9	2.6
2-Jun	0	-	-	-	-	0	0	0	0	261	-	1.4	71.9	2.8
3-Jun	0	-	-	-	-	0	0	0	0	209	-	1.3	72.4	2.8
4-Jun	0	-	-	-	-	0	0	0	0	215	-	1.1	71.9	2.9

Appendix C. Daily counts of non-salmonids captured at Waterford during 2008.

Date	BGS	BKB	BRB	CHC	GSF	GSN	HH	LAM	LMB	MQK	PRS	RES	RSN	SASQ	SASU	SMB	W	WHC
1/8/08	3	2		2			3	1100			4			4	1			
1/9/08	11	3	1	2			4	74						3	1			3
1/10/08	10	1		2			18				2	1		3	2			1
1/11/08	10						2	10			2	3		3				2
1/12/08	3										1	1		1				
1/13/08	4					1	1					1		1				
1/14/08	13	1						5	1		1	3						1
1/15/08	4						3								1			1
1/16/08	2							2	1		1			1				
1/17/08	6						3				3							1
1/18/08	3	1							1			1			1			
1/19/08	1						2		1		1	1				1		
1/20/08															1	1		
1/21/08	1	1					1				2							1
1/22/08											1							1
1/23/08	2														1			
1/24/08	1						1		1					2				
1/25/08	1	2		1			1	4000			6	1		5	4			
1/26/08	3						3	256	1		2			11	9			
1/27/08	1	3					3	338			2				4			1
1/28/08	6	1					12	129		1	2	2		5	7			
1/29/08	1					1	3	44			2		1	8	7			
1/30/08	3					1		1100			3		3	2	6			
1/31/08						1	6	307			1			2				
2/1/08	2					2	8	455			1			5		1	1	
2/2/08	1			2		7	1	42			2		2	2	1			
2/3/08						2	1	3			1							
2/4/08							4				1			3	1			
2/5/08						6	4	15			4			8	5			
2/6/08						1	1	26			1			2	3			1
2/7/08						2	1	25	1		4			3	1			
2/8/08		1				6								1				1
2/9/08						4	1			1	3			1				1
2/10/08											3	1						2
2/11/08	1			1							1							2
2/12/08	1						1											4
2/13/08						1								1				3
2/14/08														1	1			1
2/15/08				1														
2/16/08											1							
2/17/08		1		1														1
2/18/08	2										1			1				1
2/19/08											1							2
2/20/08																		
2/21/08											1			2				
2/22/08														1				2
2/23/08		1												2				1
2/24/08											1			2				2
2/25/08							2				2			8				2
2/26/08	1					2								15				

Date	BGS	BKB	BRB	CHC	GSF	GSN	HH	LAM	LMB	MQK	PRS	RES	RSN	SASQ	SASU	SMB	W	WHC
2/27/08	1	2				2	2	210			3			17	4	1		1
2/28/08	1	4	1	1		2	1	1500			1			4	5	1	1	6
2/29/08				1		5		170					1	7	3		1	2
3/1/08		1				2								5				2
3/2/08						2	1				1			1			1	5
3/3/08	3					2	1								1			8
3/4/08	1						1				4			1				4
3/5/08											1				1			6
3/6/08															1			1
3/7/08						1								2				2
3/8/08											1							4
3/9/08	1										1			1				
3/10/08	1						1				1			1				3
3/11/08	1					1												2
3/12/08											1				1			1
3/13/08											1							1
3/14/08	1													2		1		2
3/15/08	4													1				1
3/16/08	1																	2
3/17/08														1	1			
3/18/08	1																	
3/19/08	1										2							1
3/20/08																		2
3/21/08	5																	1
3/22/08	1																1	1
3/23/08									1									
3/24/08											1					1	1	1
3/25/08	1						1									1		3
3/26/08																1		8
3/27/08	1						1				1					2		8
3/28/08								1						1				7
3/29/08	2			2				1						3		2		8
3/30/08														1	1	1		2
3/31/08								1							1	1		3
4/1/08											1					1		6
4/2/08														3				3
4/3/08							1											1
4/4/08																		1
4/5/08					1		1	2			1			2	1	2		4
4/6/08							1				1					1		2
4/7/08	1						1							1	1		1	6
4/8/08							1							1				1
4/9/08	2						1									1		6
4/10/08				1											1			2
4/11/08	1			1														
4/12/08														2	1	1	2	6
4/13/08															1	2	1	6
4/14/08	2																	12
4/15/08														1		1	3	3
4/16/08	2						1										2	
4/17/08																		
4/18/08							1											

Date	BGS	BKB	BRB	CHC	GSF	GSN	HH	LAM	LMB	MQK	PRS	RES	RSN	SASQ	SASU	SMB	W	WHC
4/19/08	1																1	5
4/20/08	2						2					1			1			1
4/21/08							1								2		1	1
4/22/08	1									1				1	4	1	1	2
4/23/08	2			3				14						1	2			9
4/24/08				2		4	2	5				3	1	5	7			3
4/25/08	1					1		6						3	5	1		3
4/26/08	1			1		1								3				3
4/27/08	1			2		1						1		4				4
4/28/08												1		2	4			12
4/29/08						1	1					3		1				4
4/30/08												2		2				1
5/1/08					1			7							1			6
5/2/08																		1
5/3/08							2							1				1
5/4/08																		1
5/5/08								2				1					1	2
5/6/08								1						9				6
5/7/08														4		1		1
5/8/08														1				
5/9/08														4				1
5/10/08				1				2				1		2			2	
5/11/08								1				1						
5/12/08														1				1
5/13/08	2													5			1	
5/14/08														1				2
5/15/08	1													1	2			2
5/16/08												4		1				
5/17/08	2			1				2				2		1	2			4
5/18/08												1		1				3
5/19/08							1					1					2	2
5/20/08															1			
5/21/08											1	5					2	
5/22/08																	1	2
5/23/08	1														1	2		1
5/24/08	2																	1
5/25/08							1								1	1		
5/26/08							1									3		
5/27/08														1			1	1
5/28/08														1				1
5/29/08	1													1				2
5/30/08	1															1	1	2
5/31/08	1							2						1		1		4
6/1/08							2									2		2
6/2/08	1						1									1		
Totals	153	25	2	28	2	62	121	9858	8	3	87	42	8	225	114	38	29	292
	BGS	**BKB**	**BRB**	**CHC**	**GSF**	**GSN**	**HH**	**LAM**	**LMB**	**MQK**	**PRS**	**RES**	**RSN**	**SASQ**	**SASU**	**SMB**	**W**	**WHC**

Appendix D. Daily counts of non-salmonids captured at Grayson during 2008.

Date	AMS	BAS	BGS	BKB	BKS	BRB	C	CHC	GF	GSF	GSN	HH	LAM	LMB	MQK	MSS	PRS	RES	RSN	SASQ	SASU	SMB	TFS	UNID	W	WHC
1/29/08			1										4													1
1/30/08	1	1	2	1									6	2	13	2		7				2				
1/31/08				1									30		4	1		4				5			2	
2/1/08			3								1		300		1	9	1	7		1		5				
2/2/08			1	1									215	1	4		1	2				4				
2/3/08			3	1									37		2			2				6			1	1
2/4/08		3	1								1		122		1	4		8	2				1			
2/5/08			2	1							2		10			2		1				1				1
2/6/08			1								2		7	1	2	4		2				4				
2/7/08			6					1			1					1		7	4	1						2
2/8/08								1					17		1			8				1				2
2/9/08			1	1									16		2			4				1				2
2/10/08								1			3		11		3	1	1	1				1				
2/11/08											2				3	1	1	6	5							2
2/12/08			1									1						1	10							7
2/13/08																1		1	15							4
2/14/08											1		2		1			1	5							9
2/15/08																		3								3
2/16/08													1						4							4
2/17/08																								1		3
2/18/08													1					1	6							5
2/19/08																			1							2
2/20/08																			2							1
2/21/08																			2			2				3
2/22/08																			1			1				6
2/23/08												1							4							11
2/24/08																			1							7
2/25/08															1				1							6
2/26/08																										4
2/27/08			8								2		9		1			2				3				2
2/28/08								4			1		50	1	1		2	5		3		14		1		6
2/29/08			1	1				2			2		1100		1	4	1	5		10		24				30
3/1/08								1					38	2				1				8				14
3/2/08			2										29		2	1		1	1			6				16
3/3/08																						3				10

Date	AMS	BAS	BGS	BKB	BKS	BRB	C	CHC	GF	GSF	GSN	HH	LAM	LMB	MQK	MSS	PRS	RES	RSN	SASQ	SASU	SMB	TFS	UNID	W	WHC
3/4/08																			2			2				17
3/5/08										1						1			2			1				5
3/6/08																		3	2			1				14
3/7/08																			2			3				7
3/8/08			1								1											1				22
3/9/08															1							2				20
3/10/08											1							2		1		3				27
3/11/08											1				1				4	1						23
3/12/08								2							1				2							31
3/13/08																						2				22
3/14/08								1											1			1				33
3/15/08			1								1								2			2				14
3/16/08								1											2			3				14
3/17/08																			1							7
3/18/08																			2							16
3/19/08								1											6							23
3/20/08								1											4							16
3/21/08			1															3				2				22
3/22/08																						1				34
3/23/08			2			1													1			3				88
3/24/08								1										1	1			1				73
3/25/08			1																			3				26
3/26/08								1						1					2							46
3/27/08																										25
3/28/08																						1				5
3/29/08																										17
3/30/08																										17
3/31/08																						1				3
4/1/08								1														1				20
4/2/08																										1
4/3/08								1														1				9
4/4/08			1																			1				42
4/5/08			1															8								24
4/6/08																			4							8
4/7/08																						2				15
4/8/08																			9			1				7
4/9/08											1				1				4							6

Date	AMS	BAS	BGS	BKB	BKS	BRB	C	CHC	GF	GSF	GSN	HH	LAM	LMB	MQK	MSS	PRS	RES	RSN	SASQ	SASU	SMB	TFS	UNID	W	WHC
4/10/08																			1							13
4/11/08																			5							6
4/12/08																			7			1				17
4/13/08																		1	6							41
4/14/08																			5			1				81
4/15/08									1										2			5				61
4/16/08			1																4			4				29
4/17/08																1			1		2					8
4/18/08															1				2		2					5
4/19/08					1														3							10
4/20/08																										1
4/21/08														1												
4/22/08													57	12	1			6		1	8	65				16
4/23/08			1										25	6	2			3	1		4	31			2	10
4/24/08													3	4	1			2	2			4			1	14
4/25/08															7	3		3	4		50	7				8
4/26/08											1					1		3	2		26	5			1	17
4/27/08			2		1										1				2		16	1				22
4/28/08			1															5	3		2	1				26
4/29/08															1			1			1	3				27
4/30/08			2												1			2	1		1	1				16
5/1/08			1															1	2		2				1	18
5/2/08														1	1						19					9
5/3/08															1				1		45					12
5/4/08																1		1			14					10
5/5/08																			2		10					5
5/6/08															1				3		5					15
5/7/08															2			1	1		23	6				15
5/8/08								1							1			1		2	4	1				12
5/9/08			1																		4					4
5/10/08														1	4						10					10
5/11/08															4				1		9					10
5/12/08		3													1					1	5	2				11
5/13/08		4																			7	4				11
5/14/08		2													2				7		15	2				14
5/15/08			1																1		1	2				21
5/16/08			2												1				1							10

Date	AMS	BAS	BGS	BKB	BKS	BRB	C	CHC	GF	GSF	GSN	HH	LAM	LMB	MQK	MSS	PRS	RES	RSN	SASQ	SASU	SMB	TFS	UNID	W	WHC
5/17/08																										12
5/18/08		3													1				1		3	1				15
5/19/08		15																				1				6
5/20/08		3																	1			2				8
5/21/08		10																	8		2	2				3
5/22/08		27	1				1						1					1	4		8	2				15
5/23/08		35																	8			1			1	8
5/24/08		6					1											3			1					9
5/25/08		35																	2			1				2
5/26/08		17	1												2	1			1			1				3
5/27/08		15					1									1		1	2			1				8
5/28/08		12																	1			3				3
5/29/08		2																				1			1	3
5/30/08		9																								7
5/31/08		7																				3				4
6/1/08		13					1									1										7
6/2/08		19																			3	2				6
6/3/08		4														1					3	4				7
6/4/08		10													2						7	2				
Totals	1	255	55	7	2	1	4	21	1	1	24	2	2091	33	85	42	7	132	215	21	312	303	1	2	10	1704
	AMS	**BAS**	**BGS**	**BKB**	**BKS**	**BRB**	**C**	**CHC**	**GF**	**GSF**	**GSN**	**HH**	**LAM**	**LMB**	**MQK**	**MSS**	**PRS**	**RES**	**RSN**	**SASQ**	**SASU**	**SMB**	**TFS**	**UNID**	**W**	**WHC**

Key to species codes

AMS	American shad
BAS	Unidentified bass
BGS	Bluegill
BKB	Black bullhead
BKS	Black crappie
BRB	Brown bullhead
C	Common carp
CHC	Channel catfish
CHN	Chinook
GF	Goldfish
GSF	Green sunfish
GSN	Golden shiner
HH	Hardhead
LAM	Lamprey, unidentified species
LMB	Largemouth bass
MQK	Mosquitofish
MSS	Inland silverside
PRS	Prickly sculpin
RBT	Rainbow trout
RES	Redear sunfish
RSN	Red shiner
SASQ	Sacramento pikeminnow
SASU	Sacramento sucker
SMB	Smallmouth bass
TFS	Threadfin shad
UNID	Unidentified species
W	Warmouth
WHC	White catfish