Outmigrant Trapping of Juvenile Salmon in the Lower Tuolumne River, 2012

Submitted To:
Turlock Irrigation District
Modesto Irrigation District

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INTRODUCTION

Study Area Description

The Tuolumne River is the largest of three major tributaries (Tuolumne, Merced, and Stanislaus Rivers) to the San Joaquin River, originating in the central Sierra Nevadas in Yosemite National Park 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.

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 fish migration since at least 1871.

Purpose and History of Study

Rotary screw traps (RST) have been operated since 1995 at various locations in the Tuolumne River during the winter/spring period to meet several objectives, including monitoring the abundance and migration characteristics of juvenile salmonids and other fishes, and evaluating reach-specific survival relative to environmental conditions (Figure 1). The Turlock Irrigation District and Modesto Irrigation District ('Districts'), and the City and County of San Francisco have funded nearly all RST monitoring efforts in the Tuolumne River.

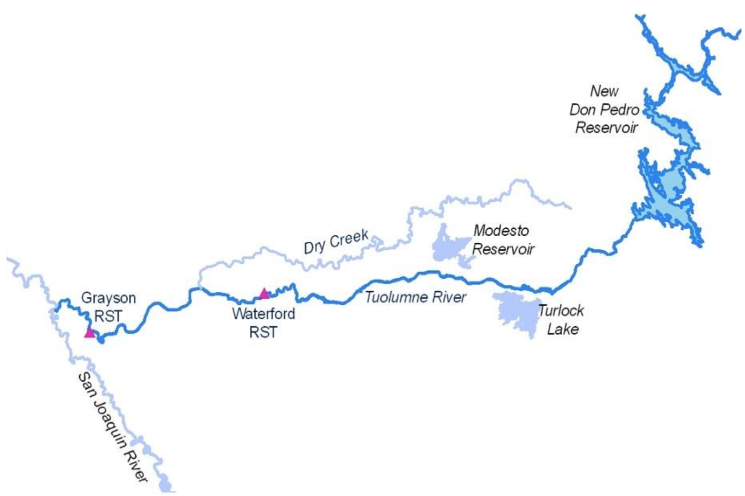

Figure 1.Location map of study area on the Tuolumne River.

Current sampling locations are Grayson River Ranch (Grayson – RM 5.2) near the mouth of the Tuolumne River and a site downstream of the city of Waterford (RM 29.8). Rotary screw trapping has been conducted annually near the mouth of the Tuolumne

River since 1995 (Shiloh in 1995-1998 and Grayson in 1999-2012) for the purpose of monitoring the abundance and migration characteristics of juvenile salmonids and other fishes. Since 2006, sampling has also been conducted annually near Waterford, about 25 miles upstream of the Grayson site, to provide comparative information on the size, migration timing, and production of juvenile fall-run Chinook salmon, as well as data on other fishes.

Table 1. Rotary screw trap monitoring in the Lower Tuolumne River, 1995-2012.

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	869,636[2]	Multiple regression	Vasques and Kundargi 2001

[1] Passage estimate reported in the annual report cited.
[2] Passage estimate derived from multiple regression equation based on data collected from 1999-2006
[2] Passage estimate derived from multiple regression equation based on data collected from 1999-2006 and 2008 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
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	107,617[2]	Multiple regression	Vasques and Kundargi 2001
2001	Grayson	Jan 03-May 29	97%	6,478	106,580[2]	Multiple regression	Vasques and Kundargi 2002
2002	Grayson	Jan 15-Jun 06	91%	436	13,928[2]	Multiple regression	Blakeman 2004b
2003	Grayson	Apr 01-Jun 06	40%	359	9074[2]	Multiple regression	Blakeman 2004c
2004	Grayson	Apr 01-Jun 09	40%	509	17,600[2]	Multiple regression	Fuller 2005
2005	Grayson	Apr 02-Jun 17	39%	1,317	254,981[2]	Multiple regression	Fuller and others 2006
2006	Waterford 1 (RM 29.8)	Jan 25-Apr 12	79%	8,648	206,983[1]	%Flow sampled	Fuller and others 2007
	Waterford 2 (RM 33.5)	Apr 21-Jun 21		458	46,674[1]		
	Grayson	Jan 25-Jun 22	84%	1,594	181,692[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	905[2]	Multiple regression	Fuller 2008
2008	Waterford	Jan 8-Jun 2	96%	3,350	24,895[1]	Average trap efficiency	Palmer and Sonke 2008
	Grayson	Jan 29-Jun 4	82%	193	3,287[2]	Multiple regression	Palmer and Sonke 2008

Year	Site	Period Sampled	Proportion of Outmigration Period Sampled	Total Catch	Total Estimated Passage	Method of Passage Estimation	Results Reported In
2009	Waterford	Jan 7-June 9	96%	3,725	37,174[1]	Average trap efficiency	Palmer and Sonke 2010
	Grayson	Jan 8-Jun 11	95%	155	4,348[2]	Multiple regression	Palmer and Sonke 2010
2010	Waterford	Jan 5-Jun 11	97%	2,281	29,294-55,941[3]	Average trap efficiency	Sonke and others 2010
	Grayson	Jan 6-Jun 17	97%	52	4,233[2]	Multiple regression	Sonke and others 2010
2011	Waterford	Dec 5-Jun 30	100%	4,394	414,815-427,126	Average trap efficiency[3]	Sonke and others 2012
	Grayson	Jan 6-Jun 30	97%	1,645	87,172[2]	Multiple regression	Sonke and others 2012
2012	Waterford	Jan 3-Jun 15	99%	3,696	68,650	Average trap efficiency[3]	This report
	Grayson	Jan 3-Jun 15	99%	85	2,969	Multiple regression	This report

METHODS

Juvenile Outmigrant Monitoring

Sampling Gear and Trapping Site Locations

Rotary screw traps (E.G. Solutions, Eugene, OR) were installed and operated at the Waterford and Grayson sites. The traps consist of a funnel-shaped core suspended between two pontoons. Traps are positioned in the current so that water enters the 8 ft

[3] Trap efficiency data not available for parr/smoltlifestage at high flows. A range of trap efficiencies from the 7/11 (RM 38) and Deardorff (RM 35.5) traps was used to obtain a range of passage estimates in 2010, 2011, and 2012.

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 moved 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 opposite 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. Sufficient velocity at the trap during 2010-2012 precluded the need for the “wings” used to increase catch efficiency during 2008 and a portion of 2009.

At Grayson two traps were fastened together in a side-by-side configuration, with ½ inch Ultra High Molecular Weight (UHMW) plastic strips that were bolted to each inner-pontoon at the cross-bars. The traps were positioned and secured in place by two 50 lb plow-style anchors (Delta Fast-Set model, Lewmar, Havant, UK). The anchors were fastened to the outer-pontoons of the traps using 3/8-inch stainless steel leader cables (each outer-pontoon was attached to a separate in-line anchor) and the length of each leader cable was adjusted using a manual winch that was bolted to the outer-pontoon. The downstream force of the water on the traps kept the leader cables taut. Sufficient velocity at the traps during 2010-2012 precluded the need for the “weir” structure used to increase catch efficiency during 2008 and 2009.

Trap Monitoring

Sampling at Waterford and Grayson began on January 3, 2012. The traps were operated continuously (24 hours per day, 7 days per week) until June 15, 2012, when sampling was terminated due to consistently low catch at both trapping locations.

Traps at both locations were checked at least every morning throughout the sampling period, with additional trap checks conducted as conditions required. During each trap check the 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 (fork length in millimeters), and recorded. Salmon were assigned to a lifestage category based on a fork length scale, where <50 mm = fry, 50-69 mm = parr, and ≥ 70 mm = smolt. In addition, the smolting appearance of all measured salmon and *O. mykiss* was rated based on a seven category 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 (to nearest tenth of a gram) were taken from up to 50 salmon each week (i.e., Monday through Sunday) and from all *O. mykiss* using a digital balance (Ohaus Corporation, Pine Brook, NJ). Fish were weighed in a small, plastic container partially filled with stream water, which was tared prior to measuring each individual fish. Fish were then placed in a bucket with freshwater and allowed to recover before release.

Daily salmon 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 were maintained for marked (i.e., dye inoculated fish used for trap efficiency tests) 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 livebox was estimated and recorded whenever a trap was checked.

Trap Efficiency Releases

Trap efficiency tests using naturally produced juvenile salmon were conducted to estimate the proportion of migrating juvenile salmon sampled by the Waterford trap. Juvenile salmon captured in the trap were used to conduct tests whenever catches were sufficient. Twently groups of naturally produced juvenile salmon (ranging in number from 30 to 96 fish) were marked and released at RM 30 (about 0.2 miles upstream of the Waterford trap) between January 7 and April 29 to estimate trap efficiencies at the Waterford trap. Catches of naturally produced juvenile salmon at Waterford after April 29th were insufficient for trap efficiency tests. Likewise, catches of natural fish throughout the study period were insufficient for trap efficiency tests to be conducted at Grayson. Additionally, hatchery produced fish were not available for tests during 2012. Trap efficiency calculations for both sites are discussed in further detail below.

Marking Procedure

At the Waterford trapping site, naturally produced juvenile salmon were marked onshore immediately adjacent to the trap and were then transported to the release site where they were held until 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. A marker tip was placed against the caudal fin and orange photonic dye was injected into the fin rays. The photonic dye (DayGlo Color Corporation, Cleveland, OH) was chosen because of its known ability to provide a highly visible, long-lasting mark.

Holding Facility and Transport Method

Juvenile salmon were transported from the marking sites to the release sites in either 5-gallon buckets or 20-gallon insulated coolers depending on the number of fish, temperature, and distance traveled.

At the release sites, fish were held in livecars constructed of 15” diameter PVC pipe cut into 34” lengths (Figure 2). A rectangle approximately 6” wide by 23” long was cut longitudinally along the pipe and fitted with aluminum or stainless steel mesh. Livecars were tethered to vegetation or other structures and kept in areas of low water velocity to reduce fish stress.

Figure 2. Livecar used for holding trap efficiency test fish.

Pre-release Sampling

Prior to release, marked fish were sampled for 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; the remaining fish in each group were enumerated. Mark retention was rated as present or absent. A total of zero fish in 2012 were found to have no marks upon examination, consequently, all fish released were presumed to have visible marks.

Release Procedure

All marked fish were released after dark. 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, and allowing them to swim away. After releasing a "net-full" of fish, about 30 seconds to 3 minutes elapsed before another group of about a "net-full" was released. The 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 eight minutes to 30 minutes depending on the group size.

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. Two methods were used to measure the velocity of water entering the traps. First, instantaneous measurements were taken daily with a Global Flow Probe (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, once before and once after the morning trap cleaning. The average of the two times was considered the average daily trap rotation speed.

River Temperature, Relative Turbidity and Dissolved Oxygen

Instantaneous water temperature was measured daily with a mercury thermometer at the trap site. Data were also available from hourly recording thermographs maintained by the Districts at both trapping sites. 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, LaMotte Company, Chestertown, MD). Turbidity was recorded in nephelometric turbidity units (NTU). Instantaneous dissolved oxygen was measured during trap checks with an ExStik® II D600 Dissolved Oxygen Meter (Extech Instruments Corporation, Waltham, MA) at the trapping sites and recorded in milligrams per liter (mg/L).

Estimating Trap Efficiency and Chinook Salmon Abundance

An estimate of the number of fish passing each site daily 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).

Waterford Trap Efficiency

There is a limited trap efficiency dataset for Waterford primarily due to the lack of fish available to conduct trap efficiency tests at a range of flows with each lifestage. The existing data are currently inadequate for developing regression relationships between trap efficiency and explanatory variables such as river flow, fish size, or turbidity. In the future, when more tests have been conducted with each lifestage over a range of flows, a multiple regression may be developed similar to the one described below for the Grayson traps. 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 using the best available data.

Salmon fry abundance estimates were generated based on trap efficiency tests conducted at Waterford in 2012. Trap efficiency was calculated by pooling data from all release events conducted under similar conditions (i.e., fish size and flow at release), then dividing the total number of fish released by the total number of fish recovered. The resulting trap efficiency (TE) was then applied to the daily catch (DC) to estimate daily passage as follows:

Estimated Daily Passage= DC/TE

During the majority of the parr/smolt outmigration period in 2012, flows on the Tuolumne River were less than 1,000 cfs. However, there was a 6-day period when flows were above 1,000 cfs, which resulted in insufficient catch to conduct trap efficiency tests at Waterford. In order to mitigate for this shortcoming, efficiency estimates obtained between 1998 and 2000 during similarly high flows at 7/11 (RM 38) and Deardorff (RM 35.5) were used to provide an approximate abundance estimate (fish size 60-95mm FL, Stillwater Sciences 2001). Since these efficiency estimates were taken from different (but comparable) locations, a range of parr/smolt abundances were calculated for this 6-day period to account for the uncertainty in trap efficiencies at Waterford during higher flows (i.e., greater than 1,000cfs). The range was determined by using the lowest and highest trap efficiencies observed at both sites.

Thus, salmon abundance estimate calculations at Waterford in 2012 were based on (Table 3):

Fry:

- trap efficiency tests conducted in 2012 at Waterford = 8.6%

Parr/Smolt:

- trap efficiency tests conducted in 2012 at Waterford when flows were less than 1,000 cfs = 3.6%
- trap efficiency tests conducted in 1998-2000 at the 7/11 trap (RM 38; 1998 and 1999) and the Deardorff trap (RM 35.5; 2000) = 2.0-5.6%

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

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

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.

Grayson Trap Efficiency

At Grayson, daily trap efficiencies were estimated based on a multiple regression equation developed using flow and trap efficiency data collected from 1999 through 2008 and 2011. Specifically, average daily river flow at Modesto, average fish size at release, and proportions of fish (natural log transformed) recovered from each release event were used to develop the following trap efficiency predictor equation (adjusted R^2 =0.62):

Daily Predicted Trap Efficiency= EXP(-0.479988+(-0.00043*flow at MOD)+(-0.03153* fish size))

whereflow at MOD= daily average river flow (cfs) at Modesto
fish size= daily average fork length (mm) 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

RESULTS AND DISCUSSION

Chinook Salmon

Number of Unmarked Chinook Salmon Captured

Juvenile salmon sampled in the 2012 RST operation were the progeny of an estimated 2,817 salmon (712 females) that spawned in the fall of 2011 (Cuthbert et al. 2012). Further, there were 213 adult Chinook that were not identified to sex.

The fall-run juvenile salmon outmigration in the San Joaquin Basin typically occurs during the winter and spring, extending mainly from January through May. The outmigration consists largely of fry in winter that are typically less than 50 mm fork length, and smolts in spring, which are typically greater than 69 mm fork length. There are also some larger fish that migrate mostly in winter and some fry observed in late spring, which may be from salmon with different spawn timing than fall-run.

During 2012, catches of juvenile Chinook salmon at Waterford were highest in mid-January to mid-March, peaking on January 11, and primarily consisted of fry (<50 mm; Figure 3). Daily salmon catch did not correlate with any significant changes in environmental variables (Figure 3). Daily catches of juvenile salmon at Waterford between January 3 and June 15 ranged from zero to 146 fish, with a total catch of 3,696 salmon (Figure 3).

At Grayson, catches of juvenile salmon in 2012 were highest in April and May during the smolt outmigration period. Daily catches of juvenile salmon at Grayson between January 3 and June 15 ranged from zero to 8 fish (Figure 4), with a total catch of 85 salmon (Table 2).

Table 2. Catch by lifestage at Waterford and Grayson, 2012.

Trapping Site	*Fry (<50 mm)*	*Parr (50-69 mm)*	*Smolt (≥ 70 mm)*
Waterford	2,390	473	833
Grayson	8	13	64

The length of the sampling season and the trap efficiencies will affect the total RST catch for any given season. Sampling at Waterford is generally considered comprehensive, covering January through May each year the trap was sampled. However, in 2006 the sampling was initiated a few weeks later than usual and there was an extended non-sampling period (April 12-21) due to high flows; therefore, outmigration was not fully sampled during the 2006 season. Trap efficiency decreases at higher flows, specifically when flows are higher than approximately 1,000 cfs. During 2012, flows were less than 1,000 cfs with the exception of a 6-day period when flows reached approximately 2,100 cfs.

Total annual trap catch at Waterford from 2006-2012 ranged from a high of 9,106 in 2006 to a low of 2,281 in 2010, and averaged 4,260 juvenile salmon (Figure 5). In 2012, the total annual catch of juvenile salmon at Waterford was approximately less than the previous year and similar to 2007-2009 (Table 1; Figure 5). The total catch in 2006 was almost 2.5 times the number of Chinook captured in 2012, despite the abbreviated sampling during that year. The variation in catch during 2006 is likely due to environmental conditions, specifically high flows that averaged approximately 5,300 cfs during the juvenile migration season (i.e., January-May/June) and the higher overall abundance. The lower catch in 2010 is likely due to environmental conditions during the smolt outmigration period when flows averaged approximately 2,400 cfs and the lower overall abundance.

Total annual catch of juvenile salmon has varied substantially between years at Grayson/Shiloh (Table 1; Figure 6). This variation is likely due to differences in one or more factors including, the duration and timing of the sampling periods, environmental conditions, and overall fish abundance and survival (Table 1). 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 2008-2012, 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 6). 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, therefore 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. The proportion of the Jan-May outmigration period monitored each year ranged from 82% to 98% during winter/spring sampling years, from 24% to 44% during spring-only sampling years, and was 70% in the intermediate sampling year (Table 1). The proportion of the outmigration period sampled may not be representative of the proportion of the juvenile population migrating during the sample period because the migration pattern is not uniform. Migration timing can be influenced by environmental factors such as flow and turbidity, which are often highly variable during the outmigration period.

Of the winter/spring sampling years, total annual trap catch at Grayson ranged from a high of 19,327 during 1999 to a low of 52 during 2010, and averaged 3,218 juvenile salmon (Figure 6). In all years of spring-only sampling, catches ranged from a high of 1,239 during 2001 to a low of 27 during 2007.

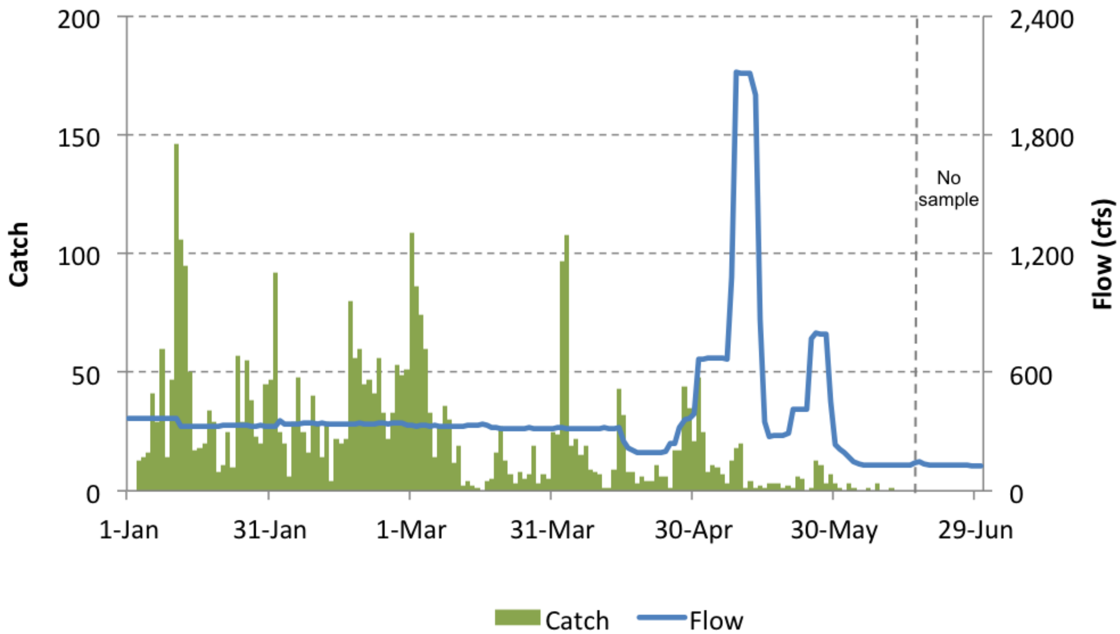

Figure 3. Daily catch of unmarked Chinook salmon at Waterford and river flow at La Grange (LGN) during 2012.

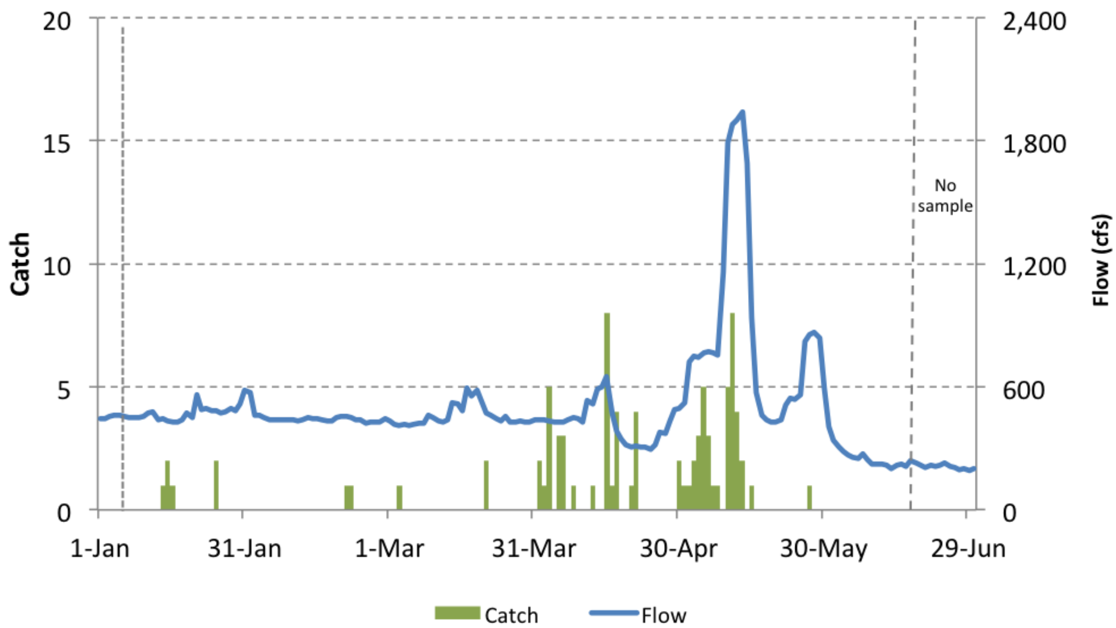

Figure 4. Daily catch of unmarked Chinook salmon at Grayson and river flow at Modesto (MOD) during 2012.

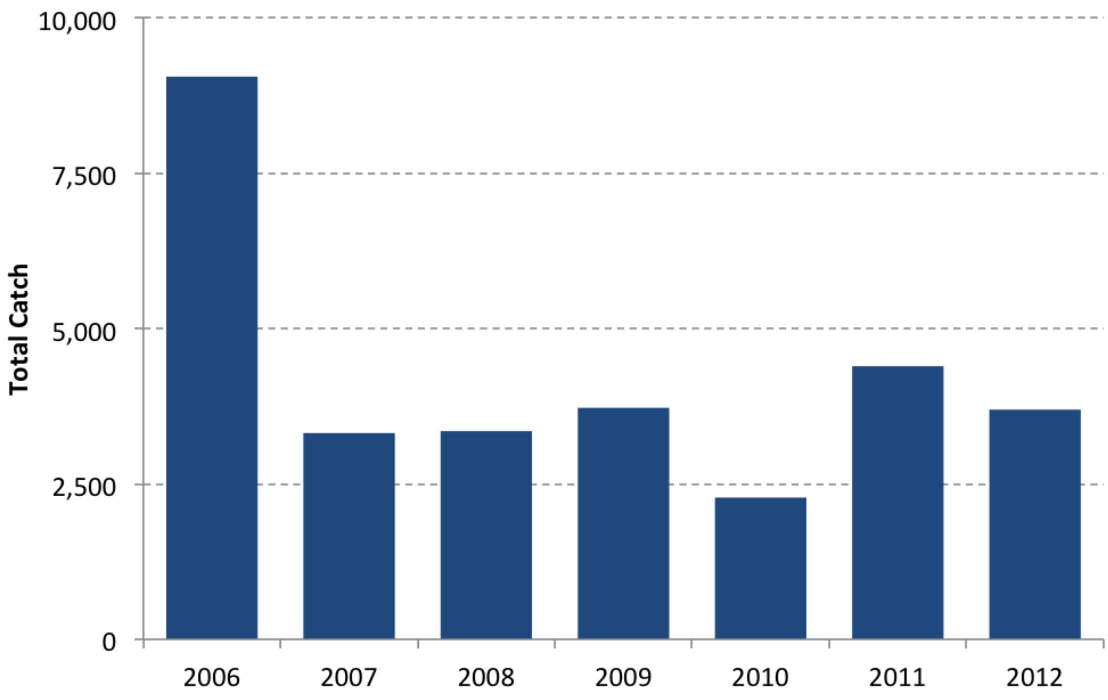

Figure 5. Total annual salmon catch at Waterford during 2006-2012.

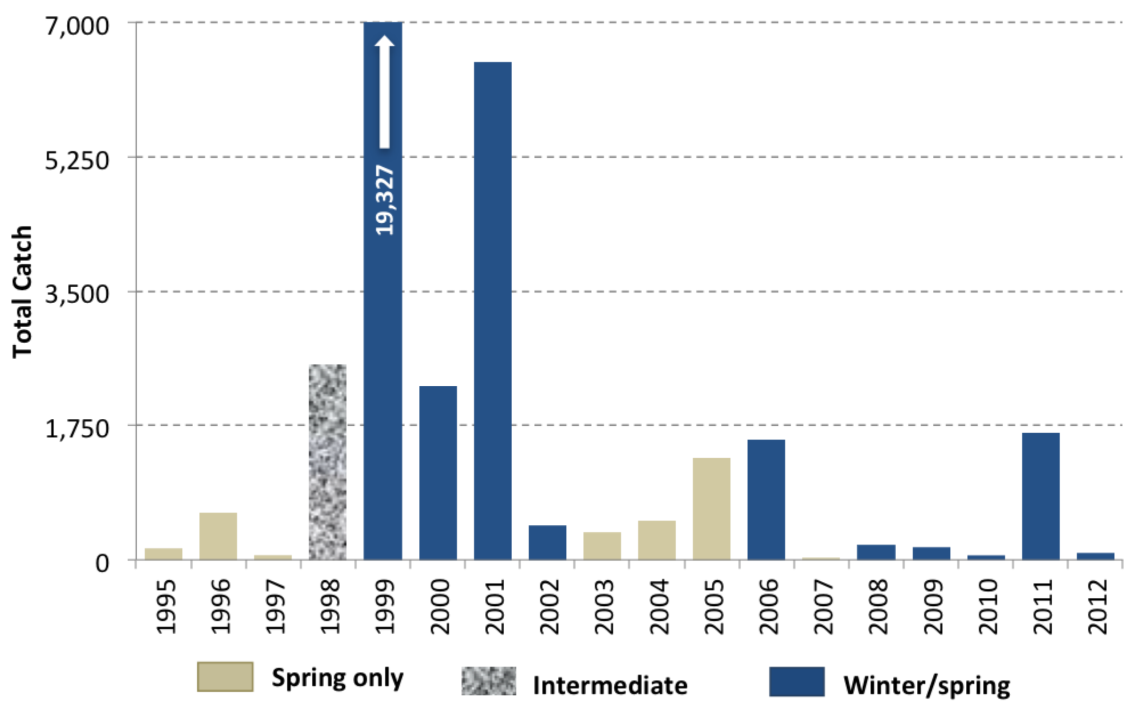

Figure 6. Total annual salmon catch at Shiloh/Grayson during 1995-2012.

Trap Efficiency

Twenty trap efficiency tests were conducted during 2012 at Waterford using naturally produced salmon fry and parr/smolt at low flows (i.e., less than 1,000 cfs). Results from these tests ranged from 0% to 26.7% at flows (La Grange) between 219 cfs and 368 cfs (Table 3).

As mentioned previously, since there were no comparable trap efficiency data available for the Waterford trap during high flows (i.e., greater than 1,000 cfs), a range of parr/smolt abundances were calculated for a 6-day period when flows exceeded 1,000 cfs that was based on data from past test results conducted under similar flow conditions at the 7/11 (RM 38) and Deardorff (RM 35.5) traps (Table 3; Stillwater Sciences 2001).

Table 3. Trap efficiency results used to estimate daily trap efficiencies at Waterford. Note: Only releases for the fry lifestage were conducted in 2012. Historical trap efficiency data from the 7/11 (RM 38) and Deardorff (RM 35.5) traps were used during the parr/smoltlifestage.

Lifestage	Release Date	Location	Origin	Adjusted # Released	Number Recaptured	% Recaptured	Length at Release (mm)	Length at Recap. (mm)	Flow (cfs) at LGN	Turbidity
Fry	1/7/12	Waterford	WILD	38	8	21.1%	34	33	367	1.32
	1/11/12	Waterford	WILD	44	6	13.6%	36	36	368	0.87
	1/14/12	Waterford	WILD	66	4	6.1%	35	35	327	1.41
	1/25/12	Waterford	WILD	55	1	1.8%	35	37	332	1.3
	1/27/12	Waterford	WILD	30	8	26.7%	35	35	328	1.9
	1/31/12	Waterford	WILD	42	3	7.1%	34	35	327	2.2
	2/2/12	Waterford	WILD	66	6	9.1%	36	35	353	1.6
	2/7/12	Waterford	WILD	46	4	8.7%	42	37	342	1.9
	2/10/12	Waterford	WILD	39	2	5.1%	42	30	339	2
	2/18/12	Waterford	WILD	80	10	12.5%	42	36	340	1.9
	2/21/12	Waterford	WILD	39	2	5.1%	35	33	340	1.6
	2/22/12	Waterford	WILD	43	1	2.3%	40	31	340	2.1
	2/28/12	Waterford	WILD	53	1	1.9%	44	35	342	1.5
	2/29/12	Waterford	WILD	47	2	4.3%	40	35	333	1.9
	3/5/12	Waterford	WILD	32	4	12.5%	34	35	328	1.9
		TOTAL		720	62	8.6%				
Parr/smolt (<1,000 cfs)	4/3/12	Waterford	WILD	96	4	4.2%	71	69	317	2.7
	4/4/12	Waterford	WILD	50	2	4.0%	67	62	316	1.9
	4/15/12	Waterford	WILD	43	1	2.3%	83	75	250	1.9
	4/16/12	Waterford	WILD	32	1	3.1%	78	71	219	1.6
	4/29/12	Waterford	WILD	43	0	0%	83	-	367	1.9
		TOTAL		264	8	3.0%				
Parr/smolt (> 1,000 cfs)	4/26/98	7-Eleven	Hatchery	1504	54	3.6%	79.9	-	4051	3.5
	5/5/98	7-Eleven	Hatchery	4408	184	4.2%	88.1	-	2300	2.45
	5/11/98	7-Eleven	Hatchery	1560	88	5.6%	88.2	-	3244	2.3

	5/20/98	7-Eleven	Hatchery	877	21	2.4%	92.6	-	4768	1.95
	4/10/99	7-Eleven	Hatchery	295	6	2.0%	61.3	-	2721	1.3
	4/18/99	7-Eleven	Hatchery	2401	113	4.7%	70.8	-	2027	1.1
	4/30/99	7-Eleven	Hatchery	912	33	3.6%	78.3	-	3018	2.3
	4/27/00	Deardorff	Hatchery	1003	41	4.1%	np	-	1275	np
	5/4/00	Deardorff	Hatchery	1000	24	2.4%	np	-	2368	np
Minimum TE						2.0%				
Maximum TE						5.6%				

np=not provided

At Grayson, observed trap efficiency estimates from 1999-2008 and 2011 were used to derive the regression equation for predicting daily trap efficiencies, and the observed efficiencies ranged from zero to 21.2% at flows (Modesto) ranging between 280 cfs and 7,942 cfs (Table 4; Figure 8).

Daily predicted trap efficiency, and daily estimated passage at Waterford and Grayson in 2012 are provided in Appendices A and B, respectively.

Table 4. Trap efficiency results from 1998-2008 and 2011 used to derive the regression equation for predicting 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
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

Release Date	Origin	Mark	Adjusted # Released	Number Recaptured	% Recaptured	Length at Release (mm)	Length at Recap. (mm)	Flow (cfs) at MOD
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
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

Release Date	Origin	Mark	Adjusted # Released	Number Recaptured	% Recaptured	Length at Release (mm)	Length at Recap. (mm)	Flow (cfs) at MOD
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/anal fin orange	515	19	3.7%	92	91	678
1/14/11	Wild	caudal fin pink	87	3	3.45%	36	35	3,300
1/20/11	Wild	caudal fin pink	51	1	1.50%	36	32	5,130
1/21/11	Wild	caudal fin pink	63	1	1.60%	36	30	5,230
1/25/11	Wild	caudal fin pink	62	1	1.50%	36	36	4,330
1/26/11	Wild	caudal fin pink	45	1	1.80%	36	29	3,970

np= not provided

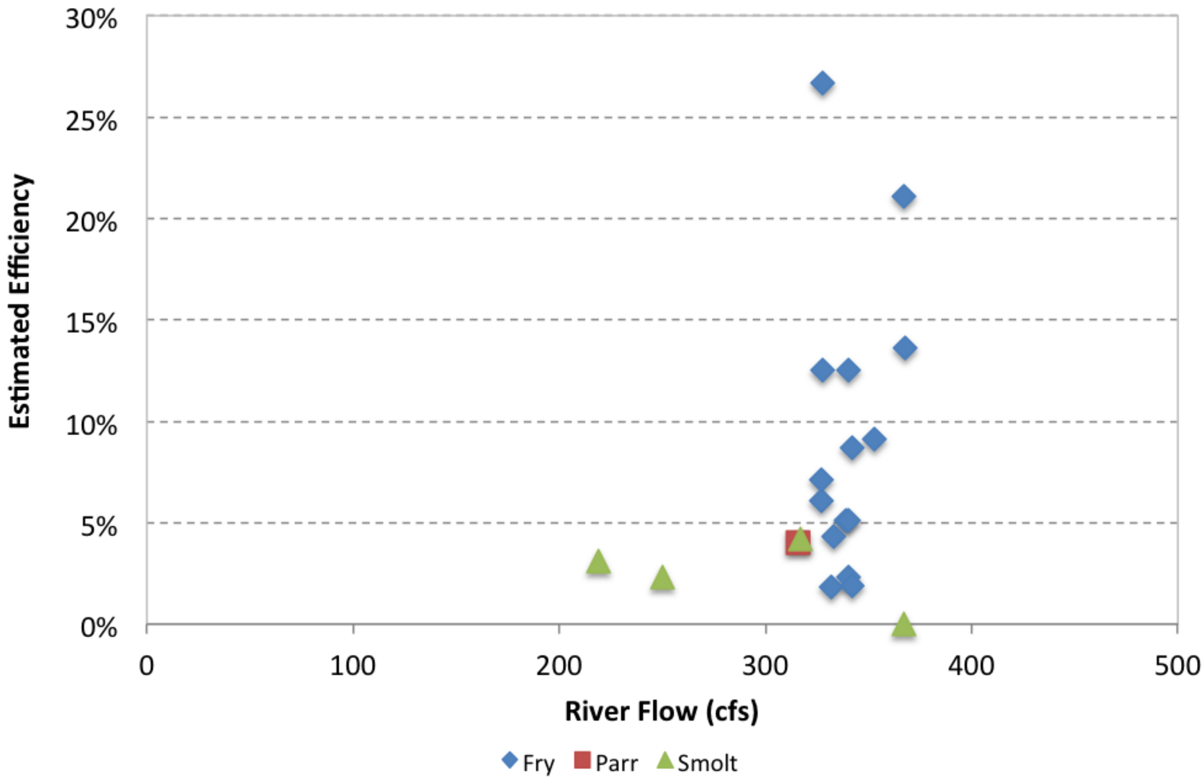

Figure 7. Trap efficiency estimates at Waterford relative to river flow at La Grange (LGN) during 2012.

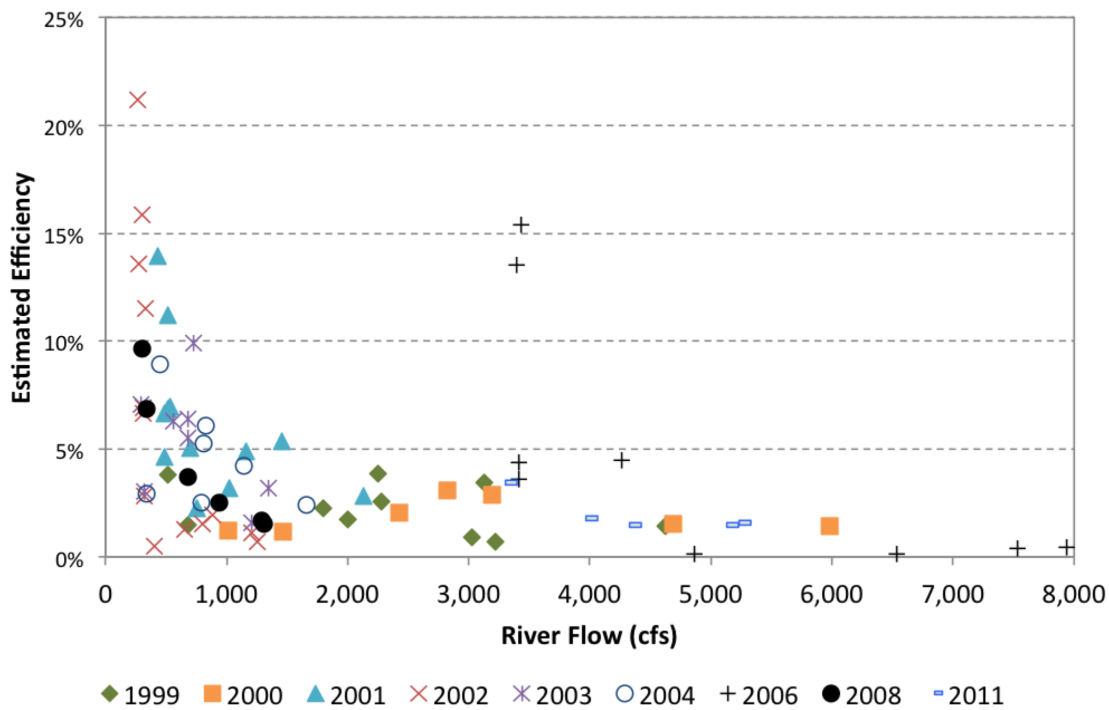

Figure 8.Trap efficiency observations at Grayson relative to river flow at Modesto (MOD), 1999-2008 and 2011.

Estimated Chinook Salmon Abundance

As mentioned previously, in order to account for the uncertainty in trap efficiencies at Waterford during periods of parr/smolt outmigration during high flow periods (i.e., May 8-May 13), a range of abundances were calculated using trap efficiency data from previous study years. In this section, for ease of explanation, the population estimate was calculated using the median historical efficiency with the range in parentheses (Figure 9). Based on calculated daily passage estimates, an estimated 68,462 (67,546-69,378) Chinook salmon passed Waterford during 2012, of which 38.9% (38.1%-39.6%) were smolts (Table 5). In comparison, the percentage of fish passing Waterford as smolts was 3.7% in 2011, 70.7% in 2010, 51.7% in 2009, 34.3% in 2008, and 51.1% in 2007. In 2006, sampling efforts were affected by high spring flows resulting in passage estimates that were likely underestimated (particularly for smolts). In 2012, and in previous years, a majority of the salmon observed passing Waterford prior to mid-March were fry and passage was then dominated by smolts from late-March through June (Table 5; Figure 10). Daily estimated salmon passage at Waterford ranged from 0 to 3,600. The peak in daily passage for fry occurred on January 11 and smolt passage peaked on April 3 (Figure 11).

An estimated 2,969 unmarked Chinook salmon passed Grayson during 2012 and of these, 1.6% were fry and 81.7% were smolts (Table 5). Daily estimated passage at Grayson ranged from 0 to 451 salmon. Peak daily passage for smolts occurred on May 11 (Figure 11). During comparable seasonal sampling in previous years at Grayson (i.e., winter/spring sampling in 1999-2002, 2006, and 2008-2012), total estimated passage ranged from a high of 869,636 in 1999 to a low of 2,969 in 2012 (Table 1; Figure 14); the proportion of passage as smolts was the highest in 2010 (95.9%) and the lowest in 1999 (2.9%). 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 254,981 in 2005 to a low of 905 in 2007 (Table 1; Figure 14); the vast majority of migrants in all spring-only years were smolts (≥95.0%; Table 5). Among all years, estimated passage was the highest during 1998 (Table 1; Figure 14), when sampling effort was intermediate and the proportion passing as smolts was low (5.7%). However, the 1998 passage estimate of 2,176,667 fish may be inflated and the proportion passing as smolts may be underestimated because no trap efficiency tests were conducted with fry. In 1998, estimates for trap efficiency only existed for smolts, which were subsequently applied to other life stages. The use of smolt-specific (low) capture probability to extrapolate on fry captures may result in drastic overestimation of fish passage.

During the 2011-12 spawning season, approximately 96 (95-97) juveniles were produced per female spawner, based on the estimated 712 female spawners[4] and the total estimated passage at the Waterford trap. This is low compared to 1,291 (1,272-1,310) in 2011, 490 (337-643) juveniles per female in 2010, 175 in 2009, 311 in 2008, and 205 in 2007 (Table 6). Approximately 78% of the female Chinook salmon observed at the Tuolumne River weir were less than 700 mm indicating they were most likely two-year old fish (Cuthbert et al 2012), which would explain the low female spawner to juvenile ratio.

[4] Excludes 213 adult salmon of unknown gender that passed upstream of the Tuolumne River weir in fall 2011.

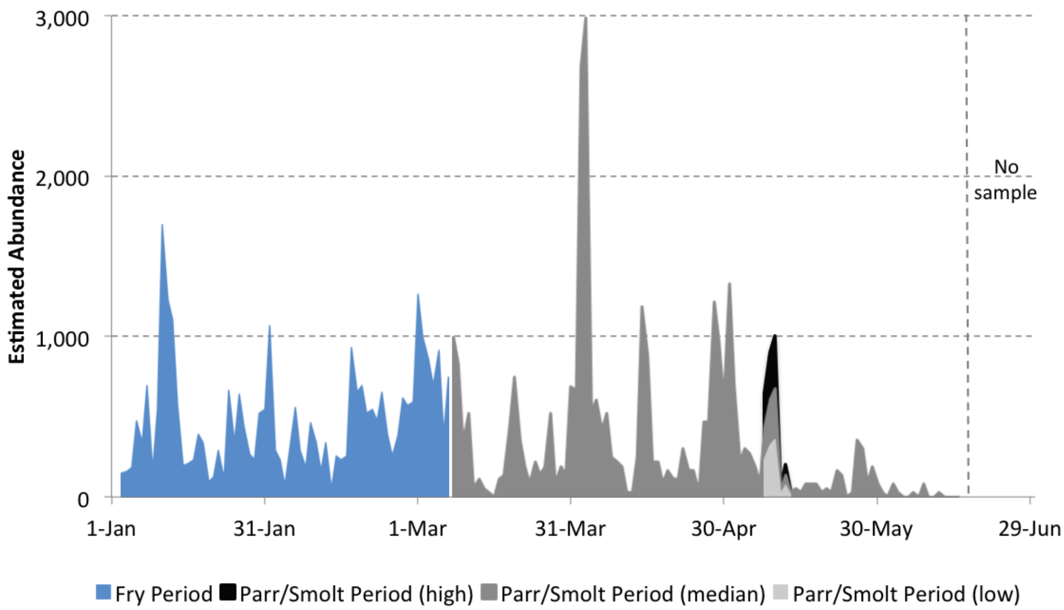

Figure 9. Daily estimated abundance of Chinook salmon at Waterford based on trap efficiencies conducted in 2012 at Waterford during the fry periodand at the 7/11 and Deardorff traps in 1998-2000 (at flows > 1,000cfs) for the parr/smolt period. A range of abundances were calculated for the parr/smolt period and the median and range are presented in this graph.

Table 5. Estimated passage by lifestage at Waterford and Grayson during 1995-2012. *For 2010-2012 the estimated passage values used in this table for Waterford are the median values of the estimated ranges.

		Sampling Period	Fry		Parr		Smolts		Total
			Number	%	Number	%	Number	%	
Waterford	**2006**	w/s	190,188	74.98%	13,979	5.51%	49,490	19.51%	253,657
	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%	24,895
	2009	w/s	13,399	36.0%	4,562	12.3%	19,213	51.7%	37,174
	2010*	w/s	11,471	26.92%	1,023	2.4%	30,124	70.68%	42,618
	2011*	w/s	400,478	95.1%	4,884	1.2%	15,608	3.7%	420,971
	2012*	w/s	29,429	42.87%	12,594	18.35%	26,627	38.79%	68,650
Grayson	**1995**	spring	-	-	-	-	22,067	100%	22,067
	1996	spring	-	-	-	-	16,533	100%	16,533
	1997	spring	-	-	-	-	1,280	100%	1,280
	1998	intermediate	1,612,117	74.06%	441,109	20.27%	123,440	5.67%	2,176,667
	1999	w/s	830,064	95.4%	14,379	1.7%	25,193	2.9%	869,636
	2000	w/s	55,309	51.4%	21,396	19.9%	30,912	28.7%	107,617
	2001	w/s	65,845	61.8%	26,620	25.0%	14,115	13.2%	106,580
	2002	w/s	75	0.5%	5,705	41.0%	8,147	58.5%	13,928
	2003	spring	26	0.3%	128	1.4%	8,920	98.3%	9,074
	2004	spring	155	0.9%	727	4.1%	16,718	95.0%	17,600
	2005	spring	-	-	442	0.2%	254,539	99.8%	254,981
	2006	w/s	35,204	19.38%	8,185	4.5%	138,303	76.12%	181,692
	2007	spring	-	-	-	-	905	100%	905
	2008	w/s	981	29.9%	15	0.5%	2,291	69.7%	3,287
	2009	w/s	139	3.0%	162	3.5%	4,047	88.0%	4,348
	2010	w/s	173	4.1%	0	0%	4,060	95.9%	4,233
	2011	w/s	45,781	52.5%	1,654	1.9%	39,737	45.6%	87,172
	2012	w/s	46	1.6%	498	16.8%	2,424	81.7%	2,969

Table 6. Estimated number of juvenile salmon produced per female spawner, 2006-2012.

Year	Females	Juveniles/female spawner
2006	478	530
2007	282	205
2008	80	311
2009	212	175
2010	87	337 to 643
2011	326[5]	1,272 to 1,310
2012	712	95 to 97

[5] Excludes 213 adult salmon of unknown gender that passed upstream of the Tuolumne River weir in fall 2011.

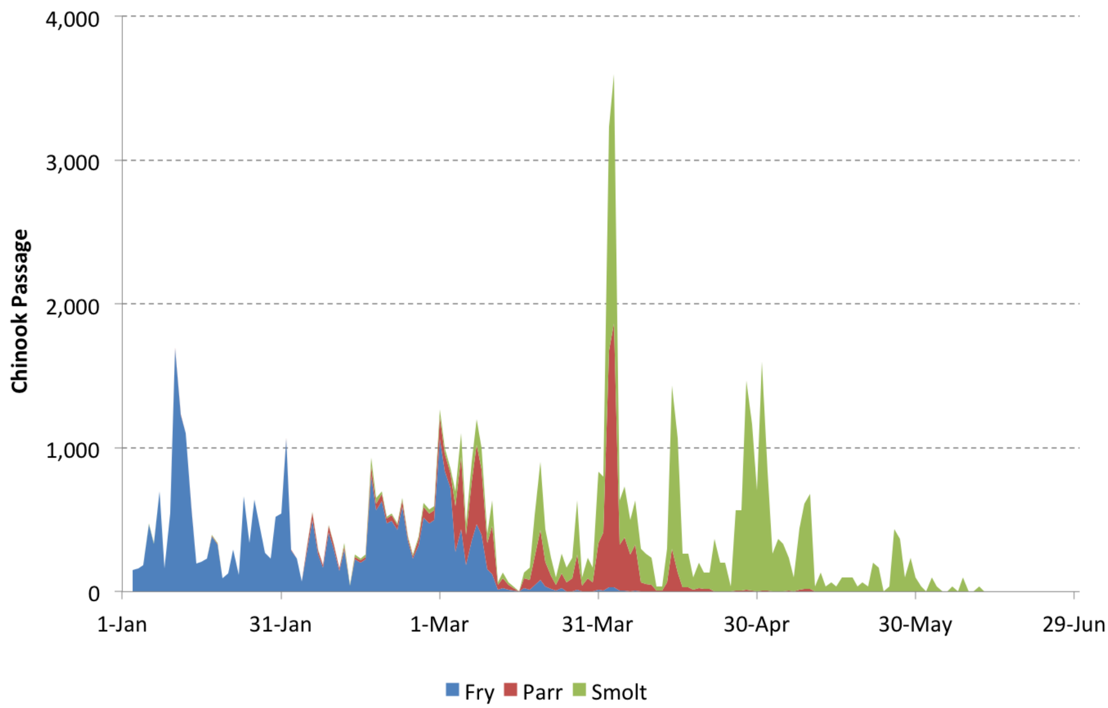

Figure 10. Juvenile salmon passage by lifestage at Waterford during 2012.

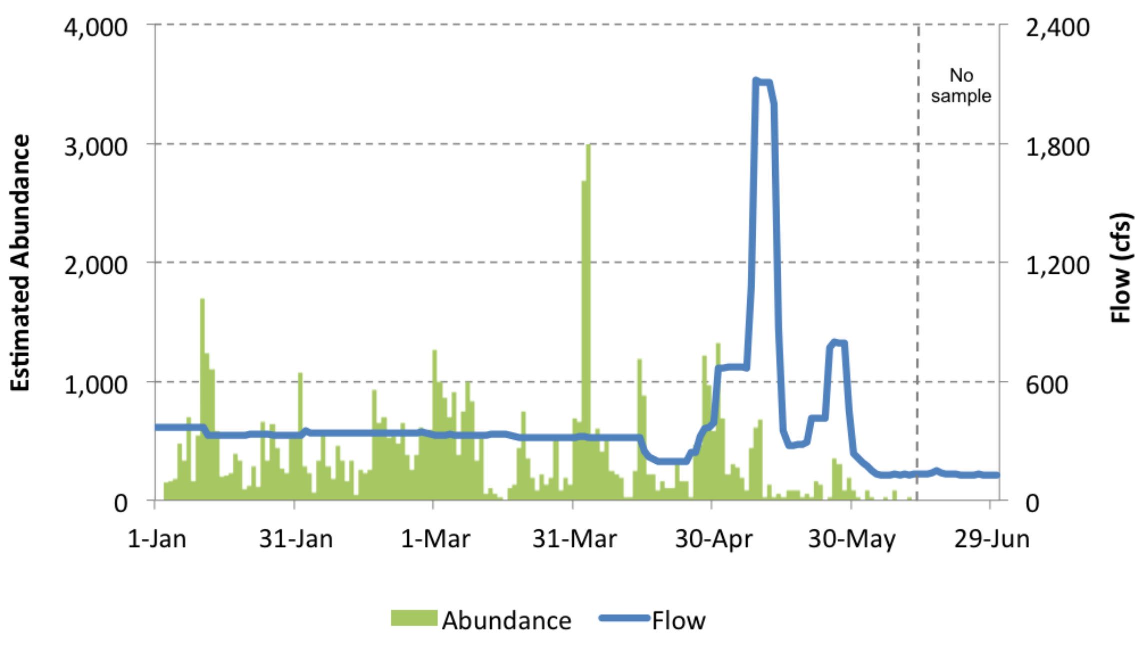

Figure 11. Daily estimated passage of unmarked Chinook salmon at Waterford and river flow at La Grange (LGN) during 2012. ***NOTE: From May 8-May 13 the graph depicts median daily passage estimates - See*** **Figure 9*.***

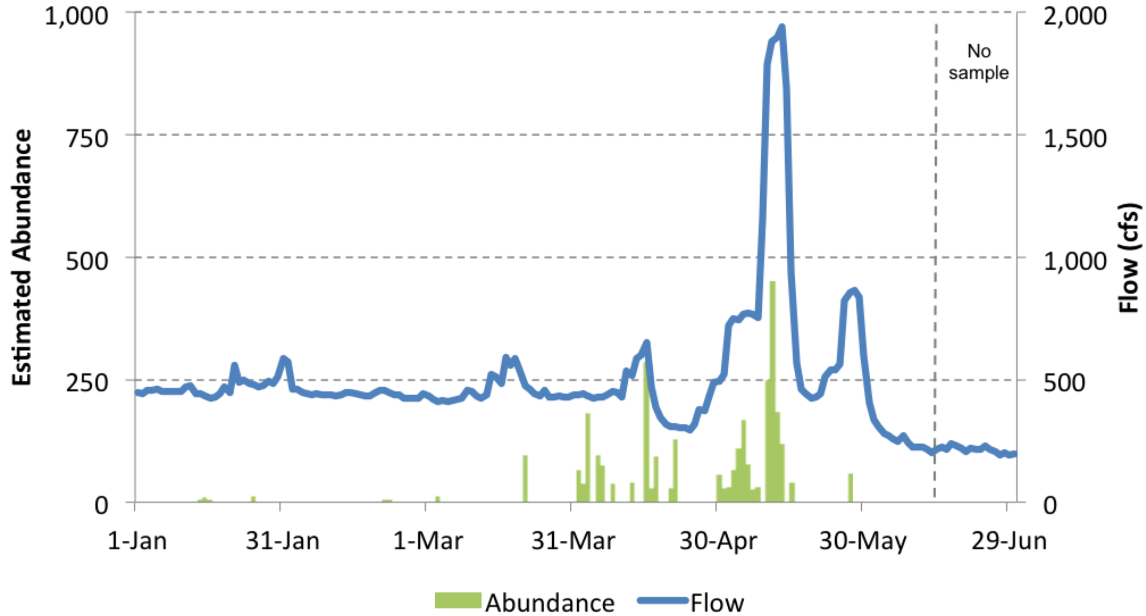

Figure 12. Daily estimated passage of unmarked Chinook salmon at Grayson and river flow at Modesto (MOD) during 2012.

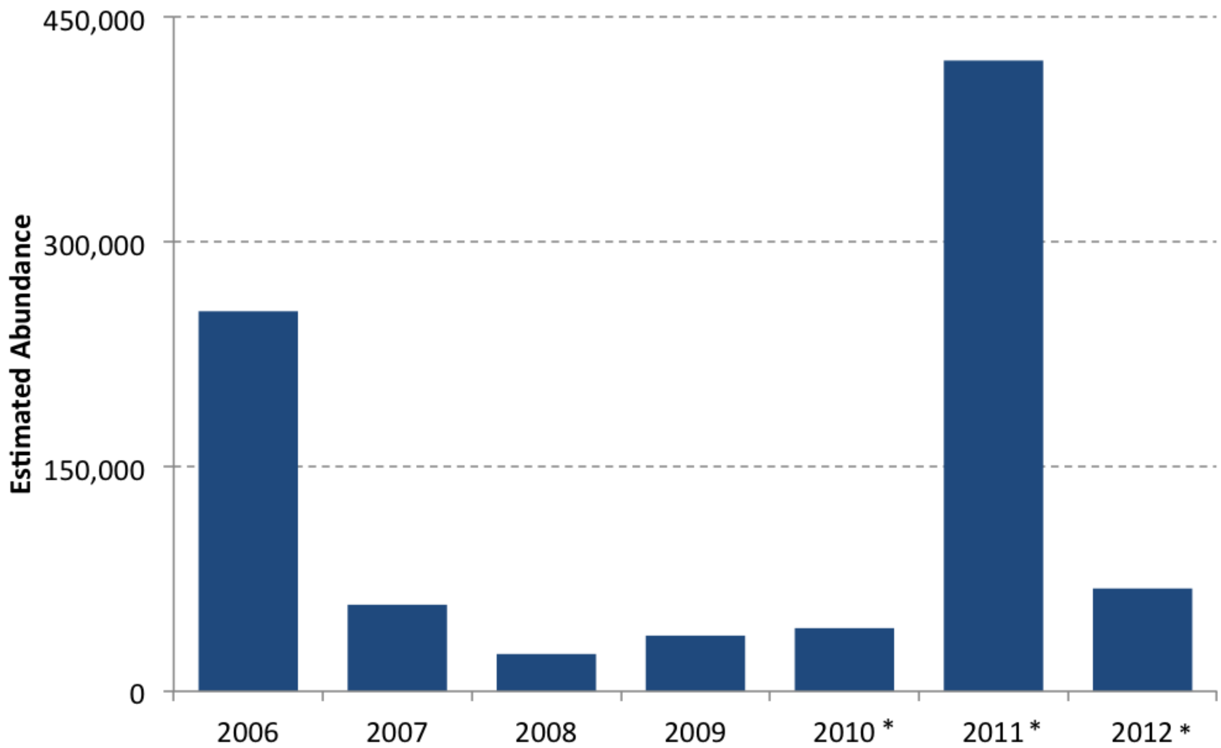

Figure 13. Total estimated Chinook passage at Waterford (2006-2012). *Note that 2010-2012 estimates are based upon the median of historical trap efficiency.

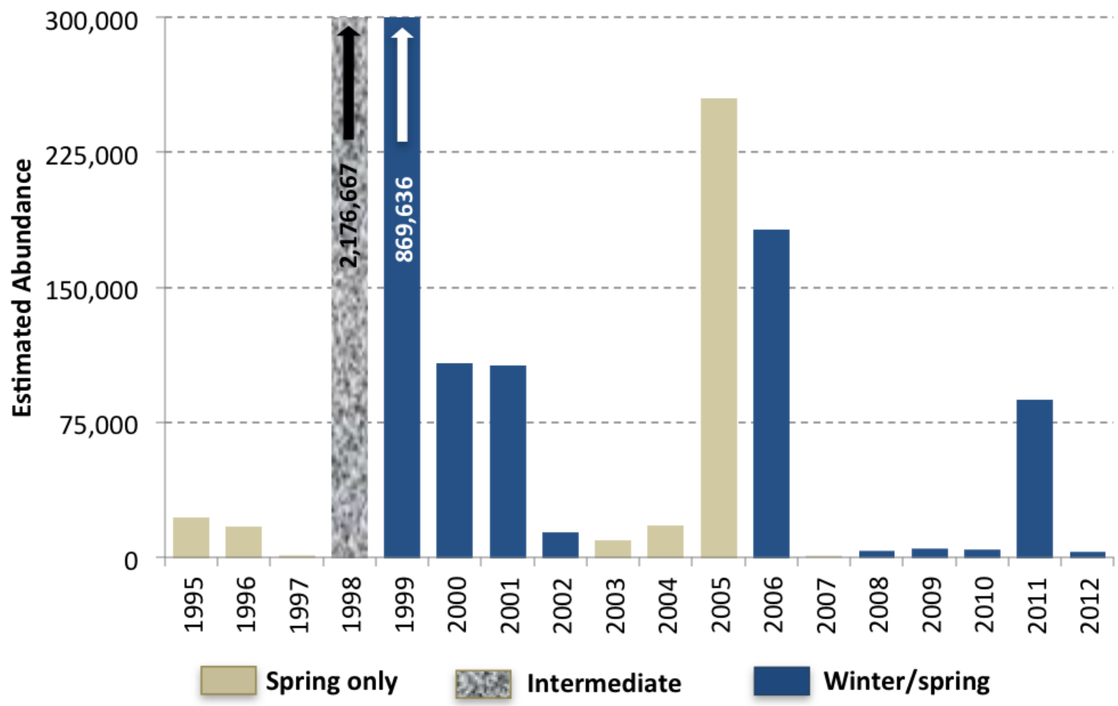

Figure 14. Total estimated Chinook passage at Shiloh and Grayson during 1995-2012. The color of the column defines the sampling period for that year.

Estimated Chinook Salmon Abundance and Environmental Factors

Peaks in salmon fry passage at Waterford in the winter were generally associated with changes in flow, rainfall and peaks in turbidity conditions. River releases were relatively stable during this period (January-mid-March) and ranged from 325 cfs to 368 cfs. River flow near Grayson during the winter period was slightly more variable as a result of storm run-off, particularly from Dry Creek entering at Modesto, and ranged from 413 cfs to 585 cfs. During the spring (mid-March through June), higher pulse flows produced a few peaks in flow at both traps (Figure 11 and Figure 12). Smolt peaks were observed at the Grayson traps that coincided with the spring pulse flows (Figure 12).

During 2012 monitoring, daily average water temperatures ranged from 47.3°F to 77.3°F at the Waterford trap (Figure 15) and from 46.3°F to 77.4°F at the Grayson traps (Figure 16). Water temperatures generally increased throughout the outmigration season. There were no obvious correlations between trends in fry passage and water temperature during 2012 (Figure 15), but smolt passage appeared to peak with slight fluctuations in temperature at both traps during the spring (Figure 16).

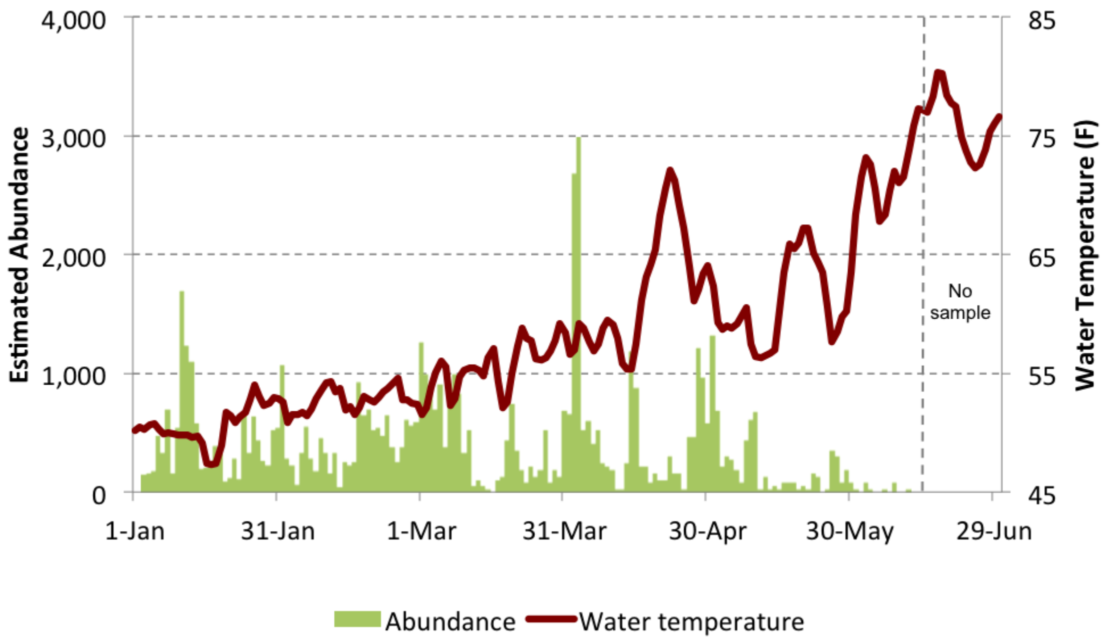

Figure 15. Daily estimated passage of unmarked Chinook salmon and daily average water temperature at the Waterford trap during 2012. NOTE: From May 8-May 13 the graph depicts median daily passage estimates - See Figure 9.

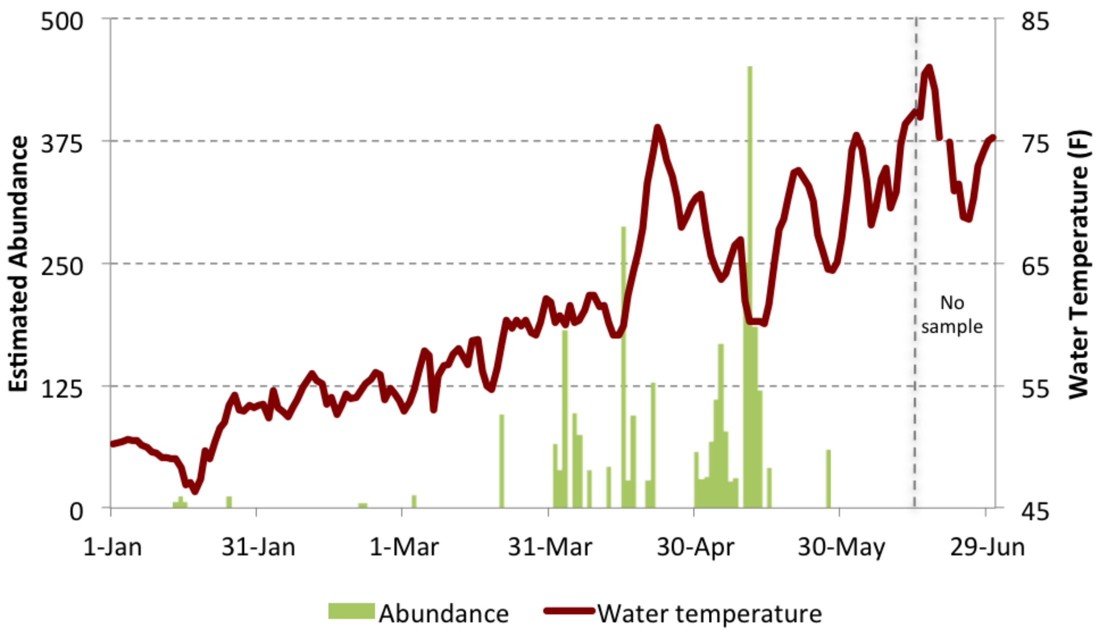

Figure 16. Daily estimated passage of unmarked Chinook salmon and daily average water temperature at the Grayson trap during 2012.

Background turbidity was generally less than 4.5 NTU at Waterford (Figure 17) and less than 10 NTU at Grayson (Figure 18) during the 2012 monitoring period. During storm events (Figure 19), increases in turbidity were observed but only ranged as high as 9.5 NTU at Waterford. Increases in turbidity at Grayson ranged as high as 38.5 NTU following a storm event (Figure 18). Peaks in passage generally occurred one to several days after periods of elevated turbidity at both trapping sites.

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 for 2012 was 4.3%, which is the lowest survival index. Survival indices for 2008-2012 are provided in Table 7. Survival indices were not calculated for 2006 and 2007 because of incomplete sampling seasons. The survival indices for 2010 and 2011 should be interpreted with caution since the entire parr/smolt outmigration was calculated based on a range of trap efficiencies at an alternate site since no trap efficiency data exists at Waterford during high flows (i.e., > 1,000 cfs).

Table 7. Survival index through the lower Tuolumne River between Waterford and Grayson.

Year	Survival Index
2008	13.2
2009	11.7
2010	9.9
2011	20.7
2012	4.3

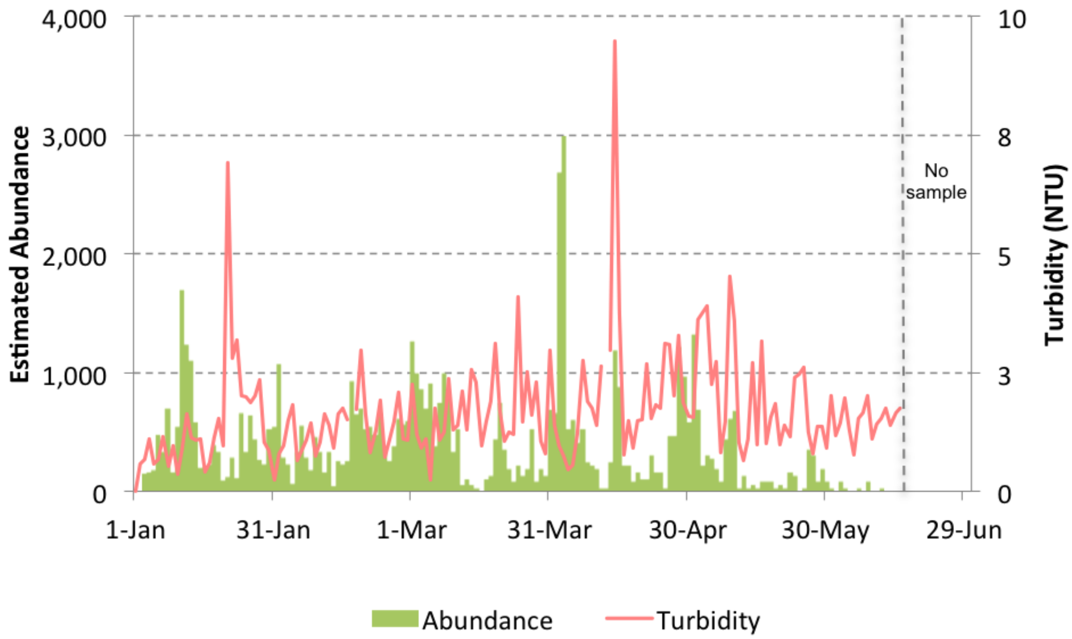

Figure 17. Daily estimated passage of unmarked Chinook salmon and instantaneous turbidity at Waterford during 2012. NOTE: From May 8-May 13 the graph depicts median daily passage estimates - See Figure 9.

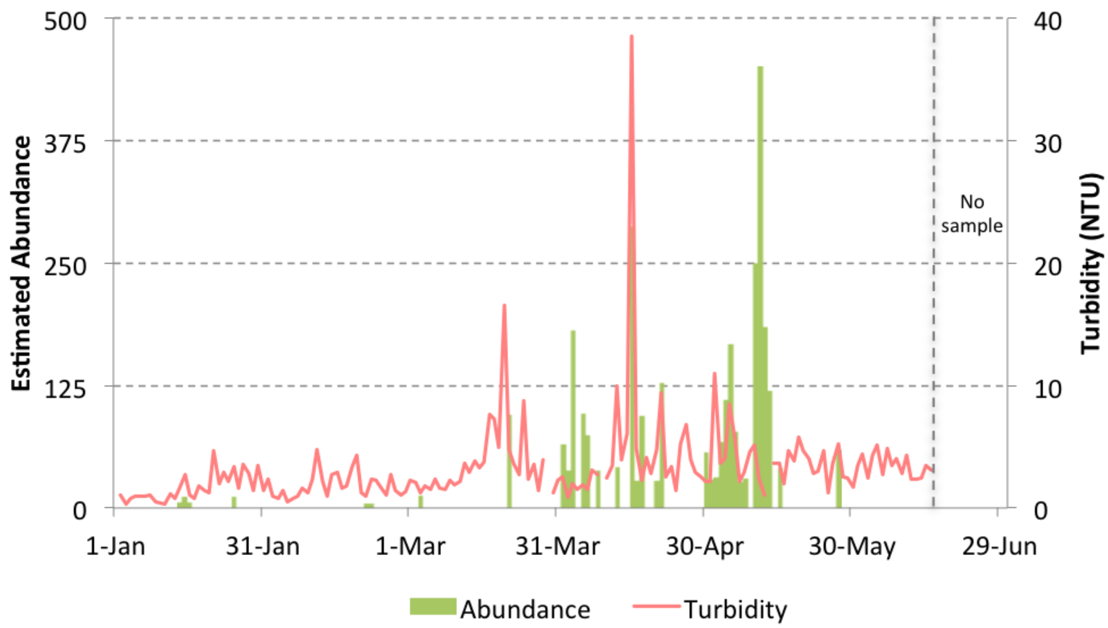

Figure 18. Daily estimated passage of unmarked Chinook salmon and instantaneous turbidity at Grayson during 2012.

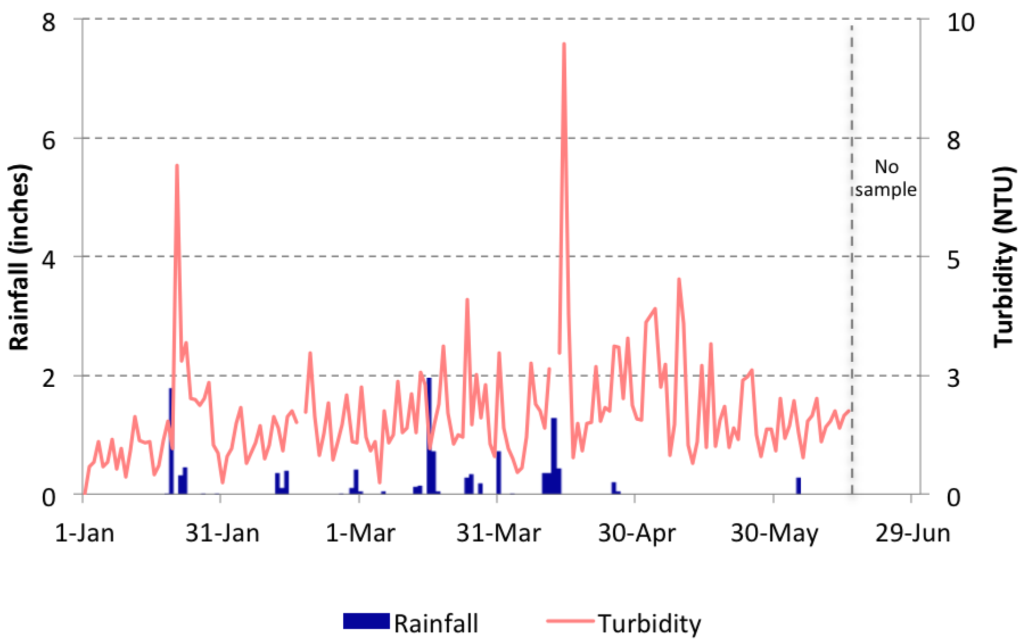

Figure 19. Daily rainfall measured at Don Pedro Reservoir and instantaneous turbidity at Waterford during 2012.

Chinook Salmon Length at Migration

Individual fork lengths of unmarked salmon captured at Waterford during 2012 ranged from 21 mm to 119 mm (Figure 20), and daily average length gradually increased from approximately 33 mm to 92 mm during the course of the sampling period (Figure 21 and Figure 22). Most of the juvenile salmon passing Waterford during 2012 were fry measuring 30-39 mm (Figure 23). In total, it is estimated that 29,429 fry (<50 mm), 12,594 parr (50-69 mm), and 26,627 smolts (>70 mm) passed Waterford during 2012 (Table 5). Individual fork lengths of unmarked Chinook salmon captured at Grayson during 2012 ranged from 30 mm to 120 mm (Figure 24), and daily average length ranged between 30 mm and 103 mm during the sampling period (Figure 25 and Figure 26). More than 80% of the salmon estimated to have passed Grayson during 2012 were smolt measuring greater than 69 mm, followed by 16.8% passing as parr measuring 50-69 mm (Figure 26). In total, it is estimated that 46 fry (<50 mm), 498 parr (50-69 mm), and 2,969 smolts (>70 mm) passed Grayson during 2012 (Table 5).

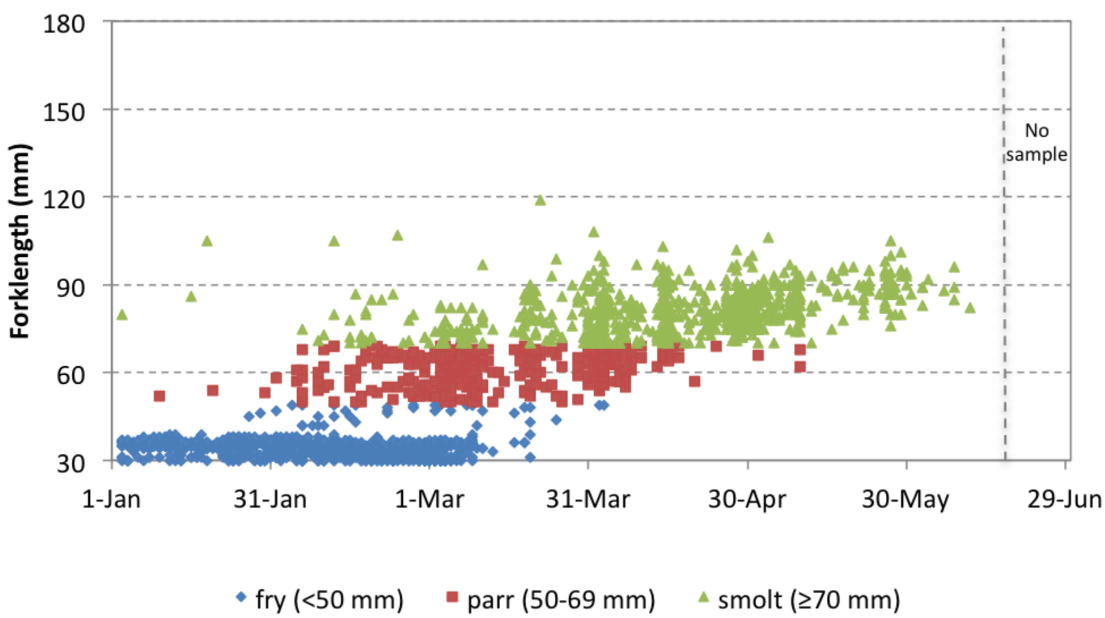

Figure 20. Individual fork lengths of juvenile salmon captured at Waterford during 2012.

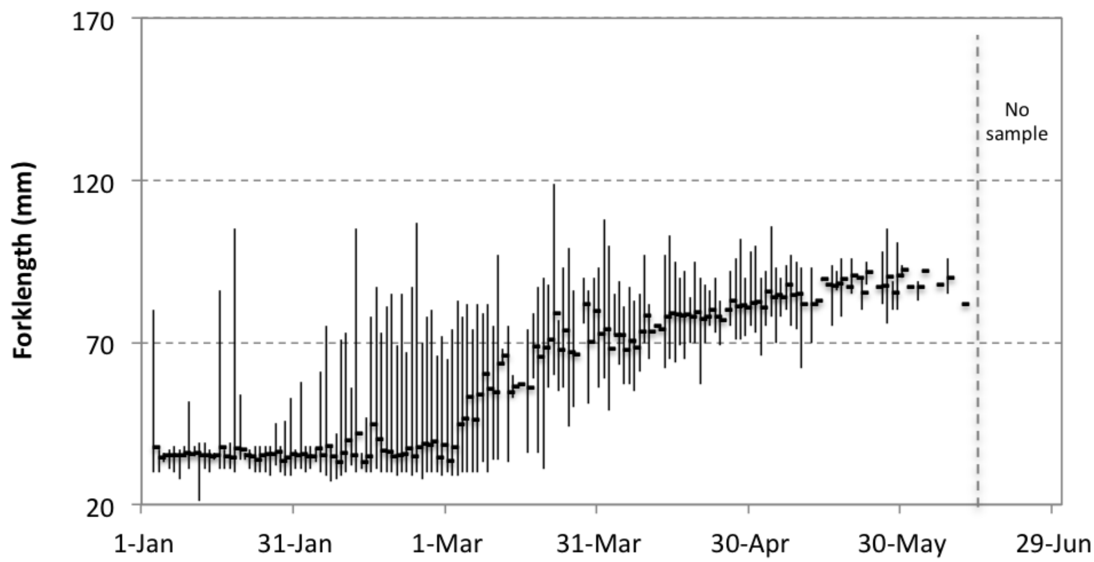

Figure 21. Daily minimum, average, and maximum fork lengths of unmarked Chinook salmon captured at Waterford during 2012.

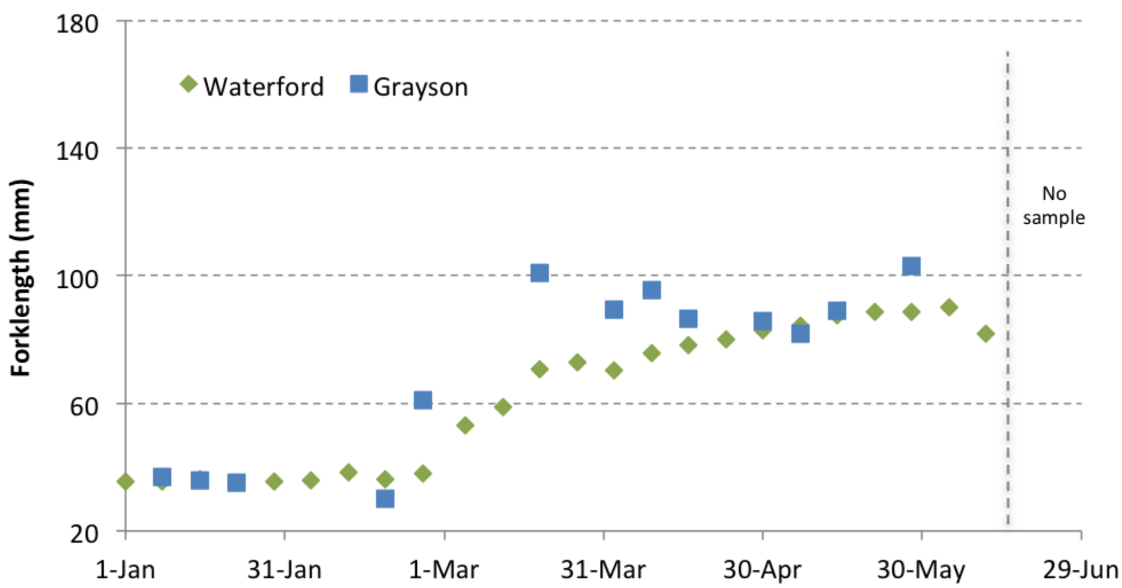

Figure 22. Average fork length of juvenile Chinook salmon captured at Waterford and Grayson by Julian week during 2012.

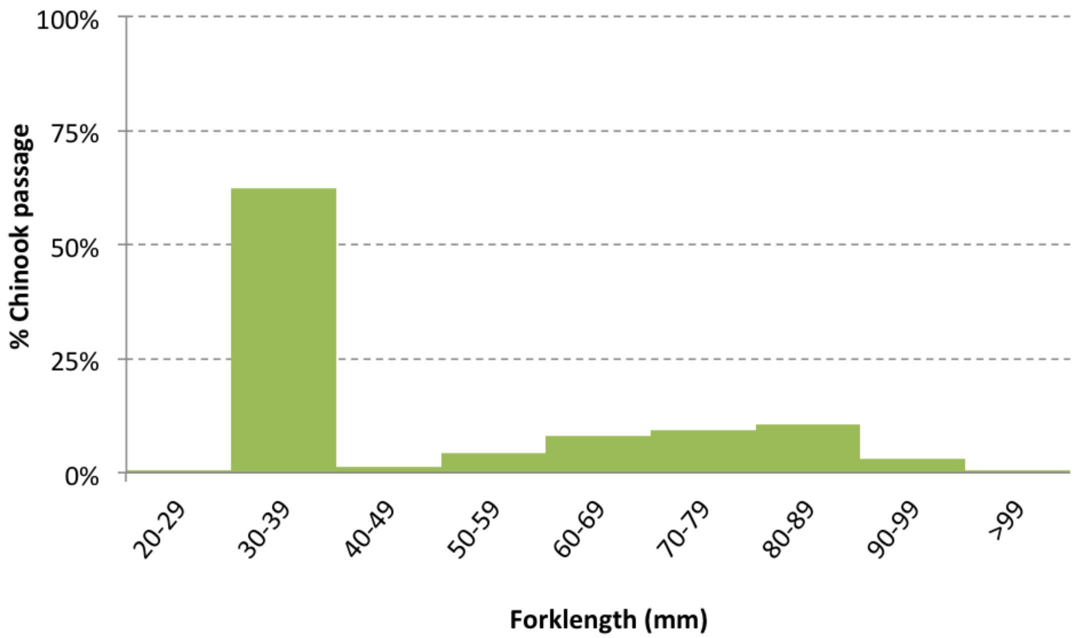

Figure 23. Length-frequency histogram of estimated Chinook passage (10 mm fork length bins) at Waterford during 2012.

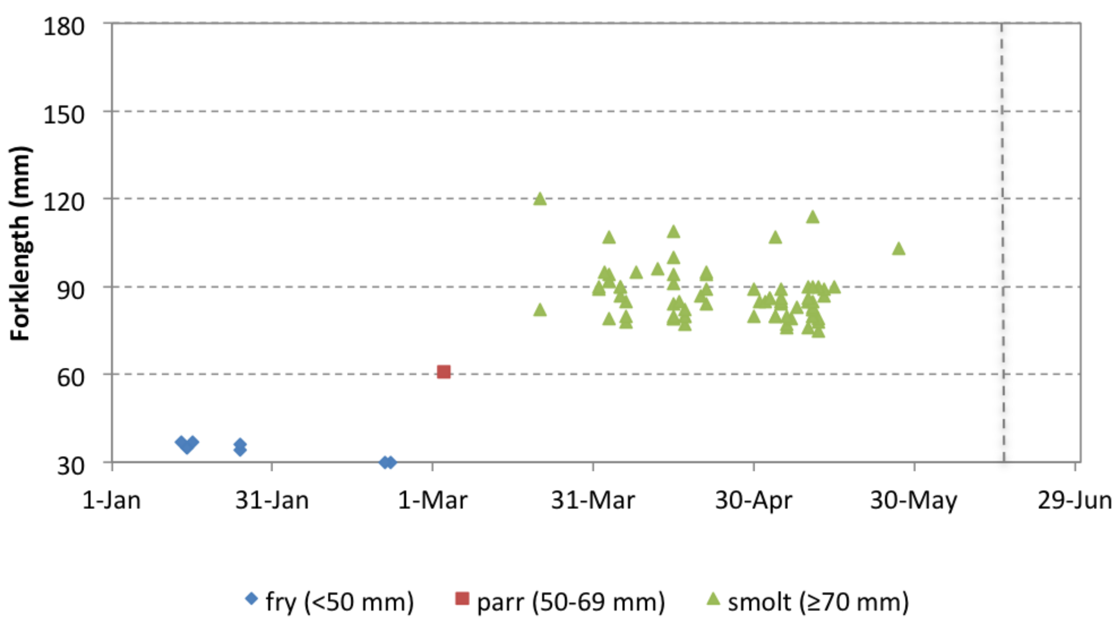

Figure 24. Individual fork lengths of juvenile salmon captured at Grayson during 2012.

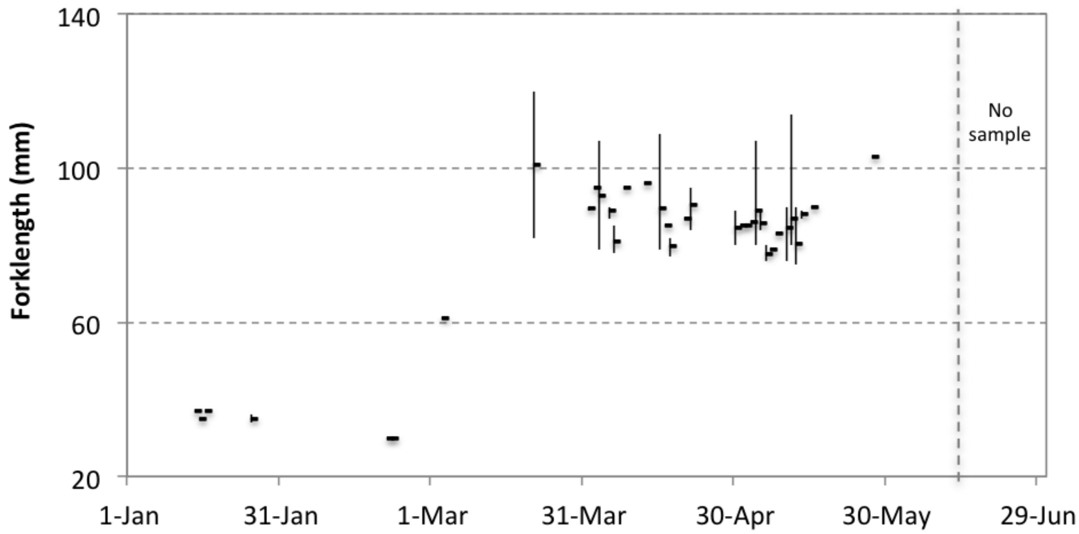

Figure 25. Daily minimum, average, and maximum fork lengths of unmarked Chinook salmon captured at Grayson during 2012.

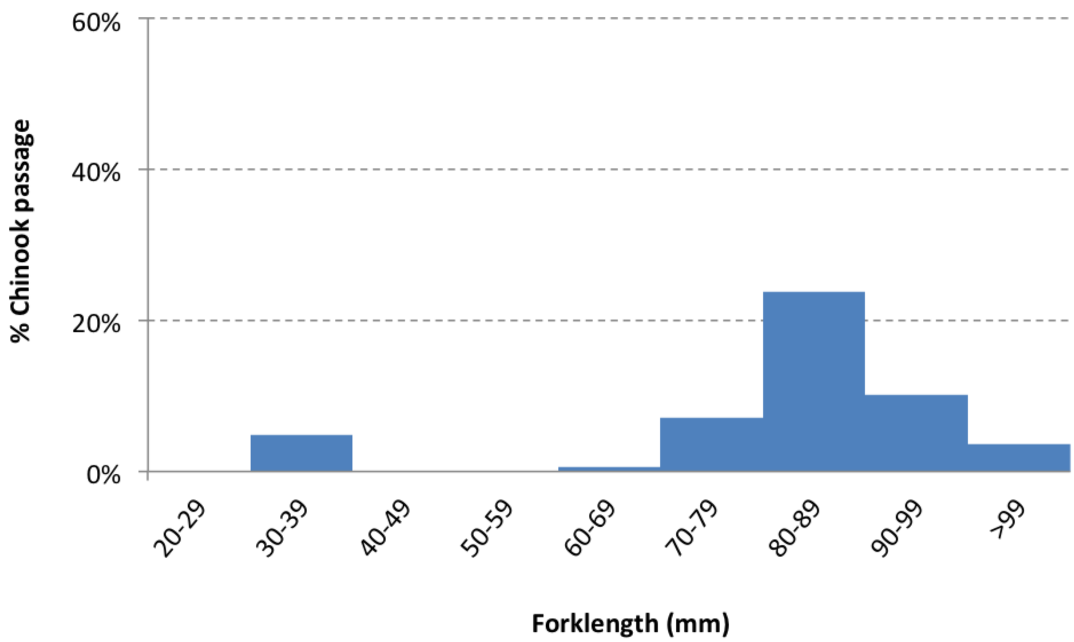

Figure 26. Length-frequency histogram of estimated Chinook passage (10 mm fork length bins) at Grayson during 2012.

Chinook Salmon Condition at Migration

Juveniles captured at both locations (Waterford and Grayson) during 2012 appeared healthy without visually discernible signs of disease or stress. The length-weight relationship for individuals captured at both sites showed a very similar trend (Figure 27 and 28).

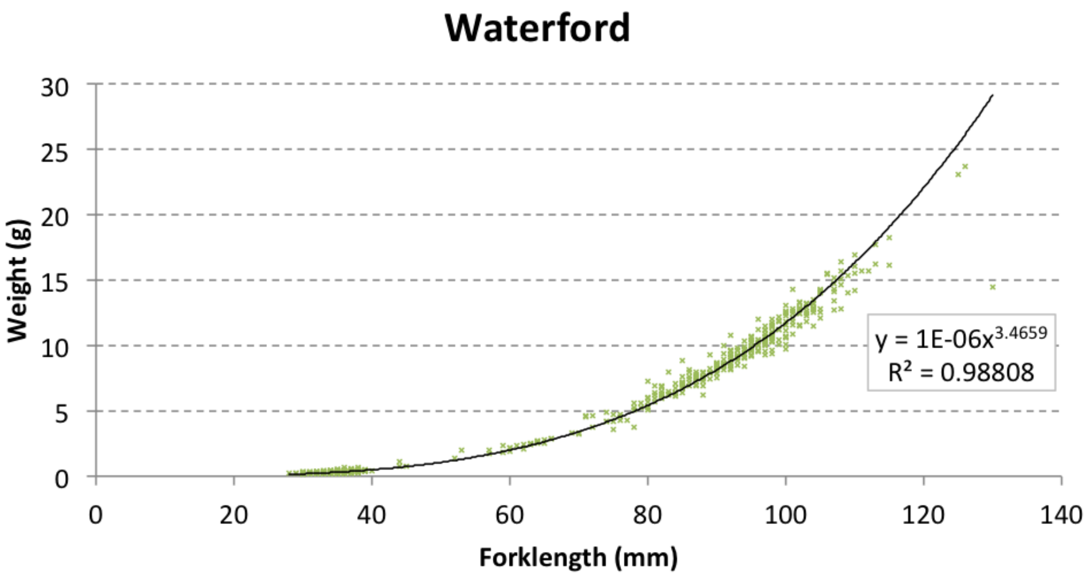

Figure 27. Length-weight relationship of fish measured at Waterford during 2012.

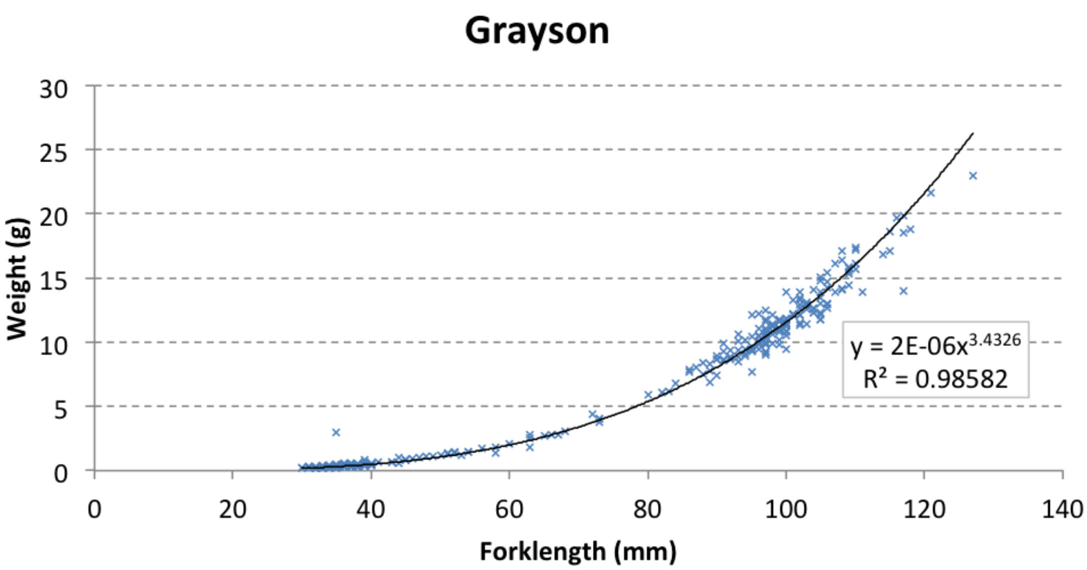

Figure 28. Length-weight relationship of fish measured at Grayson during 2012.

Oncorhynchus mykiss **(Rainbow Trout/Steelhead)**

One *O. mykiss* was captured at Waterford and zero were captured at Grayson in 2012. Total annual *O. mykiss* catch at the Grayson and Waterford traps between 2000 and 2012 ranged from 0 to 11 (Figure 29).

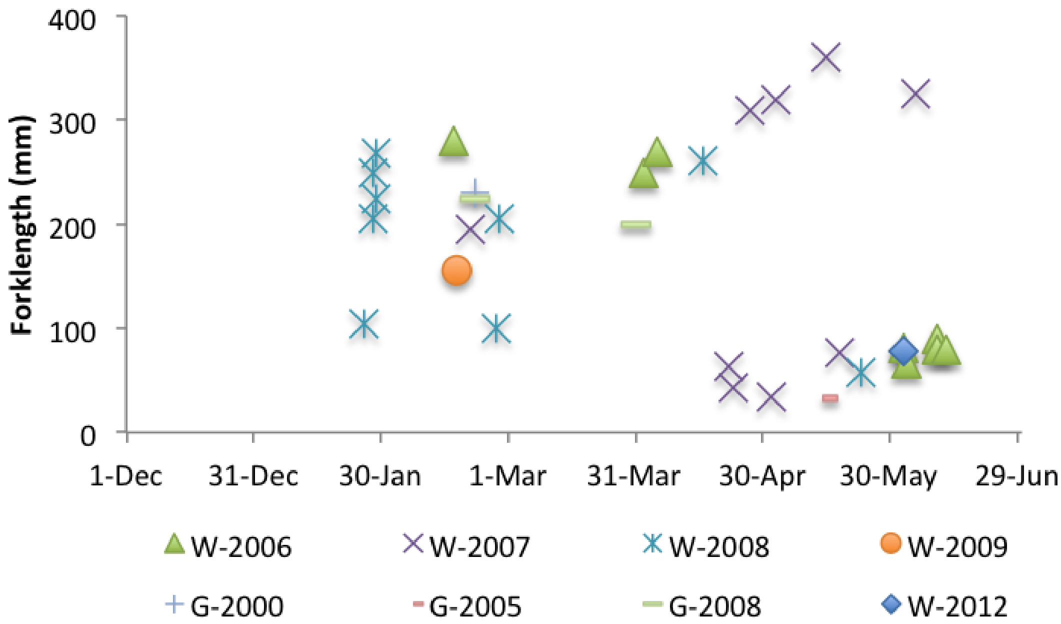

Figure 29. Date, size and location of *O. mykiss* captured at Waterford (W) and Grayson (G).

Other Fish Species Captured

A total of 4,047 non-salmonids representing at least 22 species (6 native, 16 introduced) were captured during operation of the Waterford and Grayson traps in 2012 (Table 8; Appendices C and D). Native species comprised 65% of the total non-salmonid catch, consisting primarily of Sacramento sucker (n=2,427). Most species captured at Waterford were also recorded at Grayson. Additional species only recorded at Waterford were redeye bass and striped bass. Species only recorded at Grayson were black crappie, hitch, inland silverside, largemouth bass, warmouth, and white catfish. Lampreys captured in the traps were primarily ammocoetes and were not identified to species or measured. No adult lamprey were captured at either trapping location.

Table 8. Non-salmonid species captured at Waterford and Grayson during 2012. 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	*Ameiurusmelas*	1	227	227	227	9	164	201	225
Brown bullhead	*Ameiurusnebulosus*	1	204	204	204	1	52	52	52
Channel catfish	*Ictaluruspunctatus*	2	98	102	105	6	33	114	340
White catfish	*Ictaluruscatus*	0	-	-	-	97	35	88	256
Unidentified catfish	Not applicable	0	-	-	-	1	-	-	-
Lamprey Family									
Lamprey - unidentified	Not applicable	31	-	-	-	14	-	-	-
Livebearer Family									
Mosquitofish	*Gambusiaaffinis*	2	44	45	45	7	25	33	45
Minnow Family									
Carp	*Cyprinuscarpio*	1	51	51	51	54	19	28	37
Golden shiner	*Notemigonuscrysoleucas*	3	38	46	54	127	34	62	92
Hardhead	*Mylopharodonconocephalus*	23	36	53	79	4	37	43	48
Hitch	*Laviniaexilicauda*	0	-	-	-	3	60	74	93
Red shiner	*Cyprinellalutrennsis*	7	30	46	68	19	23	55	137
Sacramento pikeminnow	*Ptychocheliusgrandis*	25	30	62	92	7	21	44	74
Sculpin Family									
Prickly Sculpin	*Cottusasper*	88	55	80	108	11	27	73	107
Silverside Family									
Inland silverside	*Menidiaberyllina*	0	-	-	-	5	31	75	90
Sucker Family									
Sacramento sucker	*Catostomusoccidentalis*	116	24	33	68	2,311	14	31	48

Common Name	Scientific Name	Waterford Total Catch	Waterford Minimum Length (mm)	Waterford Average Length (mm)	Waterford Maximum Length (mm)	Grayson Total Catch	Grayson Minimum Length (mm)	Grayson Average Length (mm)	Grayson Maximum Length (mm)
Sunfish Family									
Bluegill	*Lepomismacrochirus*	5	41	136	350	24	240	103	150
Black crappie	*Pomoxisannularis*	0	-	-	-	1	29	29	29
Largemouth bass	*Micropterus salmoides*	0	25	46	111	3	33	44	57
Redeye bass	*Micropterus coosae*	1	202	202	202	0	-	-	-
Smallmouth bass	*Micropterusdolomieu*	7	192	229	260	11	115	194	282
Striped bass	*Morone saxatilis*	1	365	365	365	0	-	-	-
Warmouth	*Lepomisgulosus*	0	-	-	-	1	117	117	117
Unidentified bass	Not applicable	3	24	74	165	999	17	27	185
Unidentified sunfish	Not applicable	1	59	59	59	0	-	-	-
Unidentified species	Not applicable	2	27	37	46	12	18	22	29

Total Species Captured = 22 (16 introduced, 6 native)

Total Native Individuals Captured = 2,633 (283 at Waterford, 2,350 at Grayson)

Total Introduced Individuals Captured = 1,414 (37 at Waterford, 1,377 at Grayson)

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Appendix A. Daily Chinook catch, length, predicted trap efficiency, and estimated passage at Waterford and associated environmental data from 2012.

	Unmarked Chinook Salmon															*Environmental Conditions*			
		Fork Length (mm)			High Range	Estimated Passage - High				Low Range	Estimated Passage - Low				Median	Flow (cfs)		Temp	
Date	Catch	Min	Avg	Max	Est. Efficiency	Fry	Parr	Smolt	Total	Est. Efficiency	Fry	Parr	Smolt	Total	Passage	La Grange	Velocity (ft/s)	at Trap	Turbidity
1/3/12	13	30	38	80	0.0861	150	0	1	151	0.0861	150	0	1	151	151	366	2.2	50.3	0.68
1/4/12	14	30	34	37	0.0861	161	0	1	163	0.0861	161	0	1	163	163	366	2.1	50.7	1.10
1/5/12	16	33	35	36	0.0861	184	0	2	186	0.0861	184	0	2	186	186	366	2.2	50.7	0.57
1/6/12	41	31	35	37	0.0861	472	0	4	476	0.0861	472	0	4	476	476	366	2.0	50.3	0.68
1/7/12	29	30	35	38	0.0861	334	0	3	337	0.0861	334	0	3	337	337	367	2.1	49.9	1.16
1/8/12	60	28	35	37	0.0861	695	2	0	697	0.0861	695	2	0	697	697	367	nd	50.0	0.53
1/9/12	14	35	36	38	0.0861	162	0	0	163	0.0861	162	0	0	163	163	366	2.2	49.9	0.97
1/10/12	47	31	36	52	0.0861	544	1	0	546	0.0861	544	1	0	546	546	368	1.9	49.8	0.37
1/11/12	146	35	36	38	0.0861	1691	5	0	1695	0.0861	1691	5	0	1695	1695	368	2.1	49.8	0.91
1/12/12	106	21	35	39	0.0861	1228	3	0	1231	0.0861	1228	3	0	1231	1231	327	1.9	49.8	1.64
1/13/12	95	31	35	39	0.0861	1100	3	0	1103	0.0861	1100	3	0	1103	1103	328	1.7	49.6	1.13
1/14/12	50	30	35	37	0.0861	579	2	0	581	0.0861	579	2	0	581	581	327	2.0	49.7	1.09
1/15/12	17	34	35	36	0.0861	193	1	3	197	0.0861	193	1	3	197	197	326	1.3	49.1	1.11
1/16/12	18	31	38	86	0.0861	204	2	3	209	0.0861	204	2	3	209	209	325	nd	47.4	0.41
1/17/12	20	31	35	37	0.0861	227	2	3	232	0.0861	227	2	3	232	232	328	nd	47.3	0.60
1/18/12	34	31	35	39	0.0861	386	3	6	395	0.0861	386	3	6	395	395	325	nd	47.4	1.13
1/19/12	29	30	37	105	0.0861	329	2	5	337	0.0861	329	2	5	337	337	326	2.0	48.9	1.53
1/20/12	8	34	37	54	0.0861	91	1	1	93	0.0861	91	1	1	93	93	325	1.7	51.7	0.96
1/21/12	11	34	35	36	0.0861	125	1	2	128	0.0861	125	1	2	128	128	331	2.5	51.4	6.92
1/22/12	25	31	35	37	0.0861	290	0	0	290	0.0861	290	0	0	290	290	333	2.1	50.9	2.80
1/23/12	10	30	34	38	0.0861	116	0	0	116	0.0861	116	0	0	116	116	332	2.0	51.3	3.18
1/24/12	57	30	35	38	0.0861	662	0	0	662	0.0861	662	0	0	662	662	331	2.0	51.7	2.01
1/25/12	29	30	35	38	0.0861	337	0	0	337	0.0861	337	0	0	337	337	332	1.7	52.7	1.99
1/26/12	55	29	36	38	0.0861	639	0	0	639	0.0861	639	0	0	639	639	330	1.9	54.0	1.87
1/27/12	38	32	36	45	0.0861	441	0	0	441	0.0861	441	0	0	441	441	328	1.7	53.1	2.00
1/28/12	23	30	33	38	0.0861	267	0	0	267	0.0861	267	0	0	267	267	327	1.6	52.3	2.34
1/29/12	20	29	35	46	0.0861	230	2	0	232	0.0861	230	2	0	232	232	329	1.9	52.5	1.02
1/30/12	45	29	36	53	0.0861	518	4	0	523	0.0861	518	4	0	523	523	325	1.8	52.9	0.86
1/31/12	47	31	35	37	0.0861	541	5	0	546	0.0861	541	5	0	546	546	327	2.1	52.8	0.25
2/1/12	92	31	36	58	0.0861	1059	9	0	1068	0.0861	1059	9	0	1068	1068	327	1.4	52.6	0.79
2/2/12	25	30	35	38	0.0861	288	2	0	290	0.0861	288	2	0	290	290	353	1.2	50.9	0.95
2/3/12	20	31	35	38	0.0861	230	2	0	232	0.0861	230	2	0	232	232	340	1.6	51.6	1.49
2/4/12	6	33	37	33	0.0861	69	1	0	70	0.0861	69	1	0	70	70	339	1.6	51.5	1.81
2/5/12	29	30	35	61	0.0861	300	32	5	337	0.0861	300	32	5	337	337	340	1.9	51.7	0.64
2/6/12	48	29	38	75	0.0861	496	53	8	557	0.0861	496	53	8	557	557	339	1.9	51.5	0.86

	Unmarked Chinook Salmon															Environmental Conditions			
		Fork Length (mm)			High Range	Estimated Passage - High				Low Range	Estimated Passage - Low				Median	Flow (cfs)			
Date	Catch	Min	Avg	Max	Est. Efficiency	Fry	Parr	Smolt	Total	Est. Efficiency	Fry	Parr	Smolt	Total	Passage	La Grange	Velocity (ft/s)	Temp at Trap	Turbidity
2/7/12	25	27	35	38	0.0861	259	27	4	290	0.0861	259	27	4	290	290	342	1.7	52.0	1.08
2/8/12	16	28	33	42	0.0861	165	18	3	186	0.0861	165	18	3	186	186	342	1.9	52.9	1.44
2/9/12	40	29	36	71	0.0861	414	44	7	465	0.0861	414	44	7	465	465	342	1.9	53.6	0.74
2/10/12	29	30	40	73	0.0861	300	32	5	337	0.0861	300	32	5	337	337	339	1.8	54.2	1.03
2/11/12	14	32	35	56	0.0861	145	15	2	163	0.0861	145	15	2	163	163	341	2.9	54.3	1.64
2/12/12	29	30	42	105	0.0861	292	25	20	337	0.0861	292	25	20	337	337	340	2.0	53.4	1.39
2/13/12	4	31	33	36	0.0861	40	3	3	46	0.0861	40	3	3	46	46	340	2.2	53.7	0.91
2/14/12	22	30	35	47	0.0861	221	19	15	255	0.0861	221	19	15	255	255	339	2.0	51.9	1.62
2/15/12	20	30	45	78	0.0861	201	17	14	232	0.0861	201	17	14	232	232	340	1.8	52.2	1.74
2/16/12	22	31	40	87	0.0861	221	19	15	255	0.0861	221	19	15	255	255	338	2.3	51.5	1.52
2/17/12	80	30	36	73	0.0861	805	69	55	929	0.0861	805	69	55	929	929	340	2.1	52.1	nd
2/18/12	56	30	36	81	0.0861	563	48	39	650	0.0861	563	48	39	650	650	340	2.1	53.0	1.72
2/19/12	60	30	35	85	0.0861	630	50	16	697	0.0861	630	50	16	697	697	341	2.1	52.8	2.97
2/20/12	45	29	35	69	0.0861	473	38	12	523	0.0861	473	38	12	523	523	338	1.9	52.6	1.62
2/21/12	47	30	36	85	0.0861	494	39	13	546	0.0861	494	39	13	546	546	340	2.1	53.0	0.82
2/22/12	41	30	37	67	0.0861	431	34	11	476	0.0861	431	34	11	476	476	340	1.7	53.5	1.28
2/23/12	56	29	35	87	0.0861	588	47	15	650	0.0861	588	47	15	650	650	341	nd	53.7	1.91
2/24/12	33	30	38	107	0.0861	347	28	9	383	0.0861	347	28	9	383	383	341	1.9	54.2	0.71
2/25/12	22	28	39	70	0.0861	231	18	6	255	0.0861	231	18	6	255	255	340	1.7	54.6	1.09
2/26/12	33	30	38	78	0.0861	321	47	16	383	0.0861	321	47	16	383	383	342	0.9	52.7	1.45
2/27/12	53	30	40	80	0.0861	516	75	25	615	0.0861	516	75	25	615	615	344	0.9	52.8	2.08
2/28/12	49	30	35	66	0.0861	477	69	23	569	0.0861	477	69	23	569	569	342	1.6	52.4	1.11
2/29/12	51	29	38	72	0.0861	496	72	24	592	0.0861	496	72	24	592	592	333	1.5	52.4	1.07
3/1/12	109	30	33	65	0.0861	1061	154	51	1266	0.0861	1061	154	51	1266	1266	329	1.5	51.5	2.25
3/2/12	86	29	38	74	0.0861	837	121	40	999	0.0861	837	121	40	999	999	328	1.6	52.1	1.19
3/3/12	74	29	45	83	0.0861	720	104	35	859	0.0861	720	104	35	859	859	329	1.5	53.8	0.90
3/4/12	60	30	46	78	0.0861	274	318	105	697	0.0861	274	318	105	697	697	331	2.2	55.1	1.10
3/5/12	33	30	53	82	0.0300	433	502	166	1100	0.0300	433	502	166	1100	1100	328	1.6	56.0	0.25
3/6/12	14	30	46	74	0.0300	183	213	70	467	0.0300	183	213	70	467	467	330	1.7	55.5	1.74
3/7/12	27	30	54	82	0.0300	354	411	135	900	0.0300	354	411	135	900	900	326	2.0	52.3	1.09
3/8/12	36	33	60	79	0.0300	472	548	181	1200	0.0300	472	548	181	1200	1200	326	1.4	52.8	1.24
3/9/12	30	30	56	82	0.0300	393	456	150	1000	0.0300	393	456	150	1000	1000	326	2.3	54.7	2.38
3/10/12	12	34	55	75	0.0300	157	183	60	400	0.0300	157	183	60	400	400	327	1.8	55.3	1.29
3/11/12	19	34	64	97	0.0300	119	336	178	633	0.0300	119	336	178	633	633	328	1.9	55.4	1.39
3/12/12	2	64	66	68	0.0300	13	35	19	67	0.0300	13	35	19	67	67	326	1.7	55.5	2.10
3/13/12	4	33	55	75	0.0300	25	71	38	133	0.0300	25	71	38	133	133	331	1.7	55.3	1.30
3/14/12	2	53	57	60	0.0300	13	35	19	67	0.0300	13	35	19	67	67	331	1.9	54.8	2.57
3/15/12	1	57	57	57	0.0300	6	18	9	33	0.0300	6	18	9	33	33	331	1.8	56.3	2.31

	Unmarked Chinook Salmon															*Environmental Conditions*			
		Fork Length (mm)			High Range	Estimated Passage - High				Low Range	Estimated Passage - Low				Median	Flow (cfs)			
Date	Catch	Min	Avg	Max	Est. Efficiency	Fry	Parr	Smolt	Total	Est. Efficiency	Fry	Parr	Smolt	Total	Passage	La Grange	Velocity (ft/s)	Temp at Trap	Turbidity
3/16/12	0	nd	nd	nd	0.0300	0	0	0	0	0.0300	0	0	0	0	0	336	1.8	57.1	0.97
3/17/12	4	36	56	74	0.0300	25	71	38	133	0.0300	25	71	38	133	133	329	2.2	54.3	1.47
3/18/12	5	59	69	79	0.0300	15	64	88	167	0.0300	15	64	88	167	167	320	1.6	52.1	1.88
3/19/12	16	36	65	87	0.0300	48	205	280	533	0.0300	48	205	280	533	533	319	2.0	52.6	3.11
3/20/12	27	31	68	90	0.0300	81	346	473	900	0.0300	81	346	473	900	900	315	2.0	55.0	1.70
3/21/12	13	56	71	88	0.0300	39	167	228	433	0.0300	39	167	228	433	433	315	1.9	57.3	1.06
3/22/12	7	60	79	119	0.0300	21	90	123	233	0.0300	21	90	123	233	233	315	1.9	58.8	1.25
3/23/12	3	55	68	77	0.0300	9	38	53	100	0.0300	9	38	53	100	100	316	2.0	58.0	1.21
3/24/12	8	56	74	93	0.0300	24	103	140	267	0.0300	24	103	140	267	267	315	1.7	57.7	4.09
3/25/12	5	44	67	99	0.0300	3	64	99	167	0.0300	3	64	99	167	167	317	1.7	56.2	1.47
3/26/12	7	50	66	86	0.0300	4	90	139	233	0.0300	4	90	139	233	233	319	1.9	56.1	2.51
3/27/12	19	nd	nd	nd	0.0300	12	244	378	633	0.0300	12	244	378	633	633	315	1.6	56.3	1.61
3/28/12	3	76	82	90	0.0300	2	38	60	100	0.0300	2	38	60	100	100	315	1.1	56.8	2.29
3/29/12	7	51	70	86	0.0300	4	90	139	233	0.0300	4	90	139	233	233	316	1.9	57.8	1.06
3/30/12	5	70	80	90	0.0300	3	64	99	167	0.0300	3	64	99	167	167	314	1.9	59.1	0.80
3/31/12	25	56	72	93	0.0300	16	321	497	833	0.0300	16	321	497	833	833	314	1.9	58.4	2.97
4/1/12	24	59	74	108	0.0300	7	407	385	800	0.0300	7	407	385	800	800	320	1.9	56.6	1.40
4/2/12	97	49	68	100	0.0300	29	1646	1558	3233	0.0300	29	1646	1558	3233	3233	320	2.4	57.0	0.96
4/3/12	108	85	72	85	0.0300	33	1833	1735	3600	0.0300	33	1833	1735	3600	3600	317	1.9	59.2	0.8
4/4/12	19	63	72	89	0.0300	6	322	305	633	0.0300	6	322	305	633	633	316	1.9	58.8	0.45
4/5/12	22	57	68	81	0.0300	7	373	353	733	0.0300	7	373	353	733	733	316	1.8	57.6	0.55
4/6/12	15	57	70	87	0.0300	5	255	241	500	0.0300	5	255	241	500	500	317	1.9	56.9	1.19
4/7/12	19	55	68	83	0.0300	6	322	305	633	0.0300	6	322	305	633	633	317	1.7	57.4	2.75
4/8/12	9	61	73	85	0.0300	0	62	238	300	0.0300	0	62	238	300	300	317	2.0	58.8	1.88
4/9/12	8	70	78	97	0.0300	0	55	211	267	0.0300	0	55	211	267	267	315	1.7	59.5	1.75
4/10/12	7	65	73	82	0.0300	0	48	185	233	0.0300	0	48	185	233	233	317	1.8	59.1	1.40
4/11/12	1	75	75	75	0.0300	0	7	26	33	0.0300	0	7	26	33	33	318	1.8	57.9	2.63
4/12/12	1	74	74	74	0.0300	0	7	26	33	0.0300	0	7	26	33	33	317	1.3	55.8	nd
4/13/12	9	62	78	97	0.0300	0	62	238	300	0.0300	0	62	238	300	300	317	1.7	55.4	2.98
4/14/12	43	65	79	103	0.0300	0	298	1135	1433	0.0300	0	298	1135	1433	1433	318	2.1	55.4	9.48
4/15/12	32	64	79	95	0.0300	0	131	935	1067	0.0300	0	131	935	1067	1067	250	1.9	57.5	3.77
4/16/12	8	69	78	90	0.0300	0	33	234	267	0.0300	0	33	234	267	267	219	1.5	61.2	0.77
4/17/12	8	65	79	92	0.0300	0	33	234	267	0.0300	0	33	234	267	267	207	1.5	63.1	1.5
4/18/12	3	70	78	84	0.0300	0	12	88	100	0.0300	0	12	88	100	100	195	1.5	64.1	0.91
4/19/12	6	70	79	95	0.0300	0	25	175	200	0.0300	0	25	175	200	200	195	1.5	65.4	1.48
4/20/12	4	57	77	90	0.0300	0	16	117	133	0.0300	0	16	117	133	133	195	1.3	68.3	1.52
4/21/12	4	70	78	88	0.0300	0	16	117	133	0.0300	0	16	117	133	133	195	1.0	70.6	2.69
4/22/12	11	75	80	86	0.0300	0	4	363	367	0.0300	0	4	363	367	367	195	1.3	72.1	1.53

	Unmarked Chinook Salmon															Environmental Conditions			
		Fork Length (mm)			High Range	Estimated Passage - High				Low Range	Estimated Passage - Low				Median	Flow (cfs)			
Date	Catch	Min	Avg	Max	Est. Efficiency	Fry	Parr	Smolt	Total	Est. Efficiency	Fry	Parr	Smolt	Total	Passage	La Grange	Velocity (ft/s)	Temp at Trap	Turbidity
4/23/12	6	73	78	90	0.0300	0	2	198	200	0.0300	0	2	198	200	200	195	1.3	71.2	1.81
4/24/12	6	69	77	83	0.0300	0	2	198	200	0.0300	0	2	198	200	200	197	1.2	69.1	1.76
4/25/12	1	80	80	80	0.0300	0	0	33	33	0.0300	0	0	33	33	33	242	1.2	67.2	3.11
4/26/12	17	75	83	92	0.0300	0	6	561	567	0.0300	0	6	561	567	567	240	1.6	63.9	3.08
4/27/12	17	71	81	96	0.0300	0	6	561	567	0.0300	0	6	561	567	567	320	1.5	61.1	2.01
4/28/12	44	71	82	102	0.0300	0	15	1452	1467	0.0300	0	15	1452	1467	1467	362	1.9	62.0	3.27
4/29/12	35	72	81	90	0.0300	0	7	1159	1167	0.0300	0	7	1159	1167	1167	367	2.1	63.4	1.86
4/30/12	21	75	82	98	0.0300	0	4	696	700	0.0300	0	4	696	700	700	389	1.9	64.0	1.59
5/1/12	48	73	82	100	0.0300	0	10	1590	1600	0.0300	0	10	1590	1600	1600	667	2.5	62.3	1.55
5/2/12	25	66	81	90	0.0300	0	5	828	833	0.0300	0	5	828	833	833	668	2.8	59.3	3.62
5/3/12	8	75	86	92	0.0300	0	2	265	267	0.0300	0	2	265	267	267	672	2.4	58.7	3.8
5/4/12	11	78	84	106	0.0300	0	2	364	367	0.0300	0	2	364	367	367	672	2.8	59.0	3.91
5/5/12	10	70	85	93	0.0300	0	2	331	333	0.0300	0	2	331	333	333	673	2.7	58.7	2.25
5/6/12	7	78	84	90	0.0300	0	7	226	233	0.0300	0	7	226	233	233	670	3.0	59.2	2.72
5/7/12	3	80	88	94	0.0300	0	3	97	100	0.0300	0	3	97	100	100	665	3.0	59.9	0.81
5/8/12	13	75	85	97	0.0560	0	20	630	650	0.0200	0	7	225	232	441	1080	3.0	60.5	1.46
5/9/12	18	74	85	95	0.0560	0	28	872	900	0.0200	0	10	311	321	611	2120	3.4	57.5	4.53
5/10/12	20	62	82	93	0.0560	0	31	969	1000	0.0200	0	11	346	357	679	2110	3.5	56.4	3.59
5/11/12	1	nd	nd	nd	0.0560	0	2	48	50	0.0200	0	1	17	18	34	2110	3.7	56.3	1.03
5/12/12	4	70	82	93	0.0560	0	6	194	200	0.0200	0	2	69	71	136	2110	3.2	56.5	0.65
5/13/12	1	83	83	83	0.0560	0	0	50	50	0.0200	0	0	18	18	34	2000	3.3	56.6	1.11
5/14/12	2	89	90	90	0.0300	0	0	67	67	0.0300	0	0	67	67	67	870	2.8	57.0	2.70
5/15/12	1	88	88	88	0.0300	0	0	33	33	0.0300	0	0	33	33	33	348	1.6	60.2	0.99
5/16/12	3	75	87	94	0.0300	0	0	100	100	0.0300	0	0	100	100	100	276	1.9	63.5	3.16
5/17/12	3	86	88	92	0.0300	0	0	100	100	0.0300	0	0	100	100	100	278	1.9	65.8	1.01
5/18/12	3	78	90	96	0.0300	0	0	100	100	0.0300	0	0	100	100	100	279	1.8	65.5	1.55
5/19/12	1	87	87	87	0.0300	0	0	33	33	0.0300	0	0	33	33	33	279	1.7	66.0	1.84
5/20/12	2	85	91	96	0.0300	0	0	67	67	0.0300	0	0	67	67	67	294	1.9	67.2	1.0
5/21/12	1	90	90	90	0.0300	0	0	33	33	0.0300	0	0	33	33	33	415	2.0	67.2	1.38
5/22/12	6	80	85	90	0.0300	0	0	200	200	0.0300	0	0	200	200	200	415	2.0	65.1	1.15
5/23/12	5	88	92	95	0.0300	0	0	167	167	0.0300	0	0	167	167	167	415	2.5	64.3	2.39
5/24/12	0	nd	nd	nd	0.0300	0	0	0	0	0.0300	0	0	0	0	0	415	1.9	63.4	2.47
5/25/12	1	87	87	87	0.0300	0	0	33	33	0.0300	0	0	33	33	33	770	2.4	60.7	2.61
5/26/12	13	82	87	98	0.0300	0	0	433	433	0.0300	0	0	433	433	433	798	3.3	57.7	1.24
5/27/12	11	76	90	105	0.0300	0	0	367	367	0.0300	0	0	367	367	367	792	3.2	58.5	0.8
5/28/12	3	80	85	89	0.0300	0	0	100	100	0.0300	0	0	100	100	100	792	3.2	59.8	1.37
5/29/12	7	80	91	101	0.0300	0	0	233	233	0.0300	0	0	233	233	233	452	3.1	60.2	1.37
5/30/12	3	90	92	94	0.0300	0	0	100	100	0.0300	0	0	100	100	100	236	1.9	63.5	0.92

	Unmarked Chinook Salmon															Environmental Conditions			
		Fork Length (mm)			High Range	Estimated Passage - High				Low Range	Estimated Passage - Low				Median	Flow (cfs)			
Date	Catch	Min	Avg	Max	Est. Efficiency	Fry	Parr	Smolt	Total	Est. Efficiency	Fry	Parr	Smolt	Total	Passage	La Grange	Velocity (ft/s)	Temp at Trap	Turbidity
5/31/12	1	87	87	87	0.0300	0	0	33	33	0.0300	0	0	33	33	33	213	1.5	68.4	2.01
6/1/12	0	nd	nd	nd	0.0300	0	0	0	0	0.0300	0	0	0	0	0	191	1.3	71.5	1.17
6/2/12	3	83	87	89	0.0300	0	0	100	100	0.0300	0	0	100	100	100	170	1.4	73.1	1.44
6/3/12	1	92	92	92	0.0300	0	0	33	33	0.0300	0	0	33	33	33	147	1.5	72.5	1.96
6/4/12	0	nd	nd	nd	0.0300	0	0	0	0	0.0300	0	0	0	0	0	133	1.1	70.6	1.29
6/5/12	0	nd	nd	nd	0.0300	0	0	0	0	0.0300	0	0	0	0	0	128	1.3	67.7	0.77
6/6/12	1	88	88	88	0.0300	0	0	33	33	0.0300	0	0	33	33	33	129	1.2	68.3	1.54
6/7/12	0	nd	nd	nd	0.0300	0	0	0	0	0.0300	0	0	0	0	0	129	1.0	70.3	1.66
6/8/12	3	85	90	96	0.0300	0	0	100	100	0.0300	0	0	100	100	100	130	1.6	72.0	2.00
6/9/12	0	nd	nd	nd	0.0300	0	0	0	0	0.0300	0	0	0	0	0	129	1.6	71.1	1.10
6/10/12	0	nd	nd	nd	0.0300	0	0	0	0	0.0300	0	0	0	0	0	130	1.7	71.5	1.41
6/11/12	1	82	82	82	0.0300	0	0	33	33	0.0300	0	0	33	33	33	129	1.5	73.8	1.53
6/12/12	0	nd	nd	nd	0.0300	0	0	0	0	0.0300	0	0	0	0	0	130	1.8	75.8	1.75
6/13/12	0	nd	nd	nd	0.0300	0	0	0	0	0.0300	0	0	0	0	0	130	1.8	77.3	1.40
6/14/12	0	nd	nd	nd	0.0300	0	0	0	0	0.0300	0	0	0	0	0	130	1.7	77.1	1.66
6/15/12	0	nd	nd	nd	0.0300	0	0	0	0	0.0300	0	0	0	0	0	130	0.8	77.0	1.75

Appendix B. Daily Chinook catch, length, predicted trap efficiency, and estimated passage at Grayson and associated environmental data from 2012.

	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	Temp at the traps	Turbidity
1/3/12	0	nd	nd	nd	0.509	0	0	0	0	456	1.7	1.8	49.8	0.30
1/4/12	0	nd	nd	nd	0.508	0	0	0	0	459	1.5	1.9	49.4	0.75
1/5/12	0	nd	nd	nd	0.507	0	0	0	0	463	1.6	1.9	48.9	0.99
1/6/12	0	nd	nd	nd	0.509	0	0	0	0	454	1.9	1.7	49.8	0.96
1/7/12	0	nd	nd	nd	0.509	0	0	0	0	453	1.6	nd	49.6	0.97
1/8/12	0	nd	nd	nd	0.509	0	0	0	0	453	1.7	1.5	50.5	1.02
1/9/12	0	nd	nd	nd	0.509	0	0	0	0	452	1.5	1.6	49.1	0.53
1/10/12	0	nd	nd	nd	0.509	0	0	0	0	454	2.2	1.9	48.3	0.42
1/11/12	0	nd	nd	nd	0.505	0	0	0	0	472	1.8	1.7	50.1	0.34
1/12/12	0	nd	nd	nd	0.504	0	0	0	0	477	1.4	1.5	51.0	1.19
1/13/12	0	nd	nd	nd	0.512	0	0	0	0	442	nd	nd	49.1	0.82
1/14/12	1	37	37	37	0.159	6	0	0	6	445	2.0	1.7	47.4	1.64
1/15/12	2	35	35	35	0.170	12	0	0	12	436	1.5	1.7	48.7	2.71
1/16/12	1	37	37	37	0.160	6	0	0	6	426	nd	nd	46.7	1.09
1/17/12	0	nd	nd	nd	0.514	0	0	0	0	431	nd	nd	45.8	0.74
1/18/12	0	nd	nd	nd	0.512	0	0	0	0	441	nd	nd	45.1	1.82
1/19/12	0	nd	nd	nd	0.505	0	0	0	0	473	2.3	1.9	nd	1.40
1/20/12	0	nd	nd	nd	0.510	0	0	0	0	449	2.2	2.1	46.9	1.29
1/21/12	0	nd	nd	nd	0.486	0	0	0	0	561	2.1	2.2	49.6	4.68
1/22/12	0	nd	nd	nd	0.501	0	0	0	0	491	0.5	2.3	48.3	2.02
1/23/12	0	nd	nd	nd	0.500	0	0	0	0	497	2.4	2.4	50.1	2.87
1/24/12	0	nd	nd	nd	0.502	0	0	0	0	486	2.1	2.0	51.1	2.18
1/25/12	2	34	35	36	0.167	12	0	0	12	481	2.2	2.2	50.9	3.40
1/26/12	0	nd	nd	nd	0.505	0	0	0	0	473	2.1	1.9	53.7	1.60
1/27/12	0	nd	nd	nd	0.504	0	0	0	0	476	2.1	1.9	53.6	3.57
1/28/12	0	nd	nd	nd	0.500	0	0	0	0	495	2.3	2.0	50.9	2.85
1/29/12	0	nd	nd	nd	0.503	0	0	0	0	484	2.4	2.0	51.4	1.46
1/30/12	0	nd	nd	nd	0.496	0	0	0	0	515	2.4	2.0	53.2	3.46
1/31/12	0	nd	nd	nd	0.481	0	0	0	0	585	2.6	2.3	52.3	1.46
2/1/12	0	nd	nd	nd	0.484	0	0	0	0	573	2.5	2.1	53.5	2.37
2/2/12	0	nd	nd	nd	0.508	0	0	0	0	460	1.9	1.8	52.6	1.01
2/3/12	0	nd	nd	nd	0.508	0	0	0	0	461	1.8	1.9	53.2	0.75
2/4/12	0	nd	nd	nd	0.510	0	0	0	0	448	2.4	2.4	51.0	1.47
2/5/12	0	nd	nd	nd	0.512	0	0	0	0	442	2.2	1.9	50.5	0.53
2/6/12	0	nd	nd	nd	0.513	0	0	0	0	438	2.1	2.0	53.4	0.74
2/7/12	0	nd	nd	nd	0.512	0	0	0	0	442	1.9	1.9	53.2	0.99
2/8/12	0	nd	nd	nd	0.512	0	0	0	0	439	2.4	2.3	54.6	1.62
2/9/12	0	nd	nd	nd	0.513	0	0	0	0	437	2.2	2.1	55.5	1.22
2/10/12	0	nd	nd	nd	0.513	0	0	0	0	437	2.1	2.1	55.7	2.37
2/11/12	0	nd	nd	nd	0.513	0	0	0	0	436	2.2	1.9	55.4	4.81
2/12/12	0	nd	nd	nd	0.513	0	0	0	0	437	1.9	1.3	53.9	2.14
2/13/12	0	nd	nd	nd	0.510	0	0	0	0	450	2.2	2.1	54.6	0.95
2/14/12	0	nd	nd	nd	0.511	0	0	0	0	447	2.0	2.1	53.6	2.77

	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	Temp at the traps	Turbidity
2/15/12	0	nd	nd	nd	0.511	0	0	0	0	443	2.1	2.0	53.0	2.89
2/16/12	0	nd	nd	nd	0.513	0	0	0	0	438	2.4	2.1	50.5	1.62
2/17/12	0	nd	nd	nd	0.513	0	0	0	0	434	2.0	1.6	53.0	1.83
2/18/12	0	nd	nd	nd	0.513	0	0	0	0	435	2.2	1.9	52.5	3.40
2/19/12	0	nd	nd	nd	0.510	0	0	0	0	450	2.2	2.0	52.7	4.34
2/20/12	0	nd	nd	nd	0.508	0	0	0	0	458	2.1	2.1	55.5	1.25
2/21/12	1	30	30	30	0.198	5	0	0	5	456	2.5	1.9	56.8	1.01
2/22/12	1	30	30	30	0.198	5	0	0	5	448	1.8	1.7	53.6	2.33
2/23/12	0	nd	nd	nd	0.513	0	0	0	0	437	2.1	1.9	55.2	2.27
2/24/12	0	nd	nd	nd	0.513	0	0	0	0	437	1.9	1.7	54.8	1.67
2/25/12	0	nd	nd	nd	0.515	0	0	0	0	425	1.9	1.7	55.5	1.03
2/26/12	0	nd	nd	nd	0.515	0	0	0	0	426	1.7	1.3	52.3	2.70
2/27/12	0	nd	nd	nd	0.515	0	0	0	0	426	1.9	1.7	55.4	1.43
2/28/12	0	nd	nd	nd	0.515	0	0	0	0	426	2.2	1.9	57.2	1.03
2/29/12	0	nd	nd	nd	0.511	0	0	0	0	443	2.1	1.9	51.2	1.30
3/1/12	0	nd	nd	nd	0.514	0	0	0	0	432	2.2	2.0	51.9	2.28
3/2/12	0	nd	nd	nd	0.517	0	0	0	0	418	1.9	1.9	51.2	2.05
3/3/12	1	61	61	61	0.076	0	13	0	13	413	1.9	1.9	57.5	1.26
3/4/12	0	nd	nd	nd	0.518	0	0	0	0	415	2.3	2.1	56.6	1.76
3/5/12	0	nd	nd	nd	0.518	0	0	0	0	413	1.9	1.9	57.3	1.56
3/6/12	0	nd	nd	nd	0.517	0	0	0	0	416	1.9	1.6	58.6	2.35
3/7/12	0	nd	nd	nd	0.516	0	0	0	0	422	2.1	1.9	54.0	1.66
3/8/12	0	nd	nd	nd	0.515	0	0	0	0	425	2.1	1.8	53.9	1.50
3/9/12	0	nd	nd	nd	0.508	0	0	0	0	459	2.3	2.1	55.5	2.31
3/10/12	0	nd	nd	nd	0.510	0	0	0	0	451	2.1	1.9	56.8	1.86
3/11/12	0	nd	nd	nd	0.513	0	0	0	0	434	2.1	1.9	56.8	2.14
3/12/12	0	nd	nd	nd	0.515	0	0	0	0	427	1.9	1.9	55.0	3.64
3/13/12	0	nd	nd	nd	0.512	0	0	0	0	440	1.7	1.9	56.3	2.93
3/14/12	0	nd	nd	nd	0.494	0	0	0	0	524	2.4	2.1	55.9	3.87
3/15/12	0	nd	nd	nd	0.496	0	0	0	0	515	2.3	2.0	57.3	3.25
3/16/12	0	nd	nd	nd	0.502	0	0	0	0	485	2.1	1.9	58.2	3.73
3/17/12	0	nd	nd	nd	0.480	0	0	0	0	593	2.5	1.9	55.0	7.66
3/18/12	0	nd	nd	nd	0.487	0	0	0	0	557	1.6	2.1	53.9	7.31
3/19/12	0	nd	nd	nd	0.481	0	0	0	0	585	2.4	2.3	53.6	4.96
3/20/12	0	nd	nd	nd	0.493	0	0	0	0	529	2.3	2.1	55.7	16.57
3/21/12	2	82	101	120	0.021	0	0	96	96	475	2.3	1.9	55.9	4.80
3/22/12	0	nd	nd	nd	0.508	0	0	0	0	460	2.1	1.9	59.5	3.62
3/23/12	0	nd	nd	nd	0.511	0	0	0	0	443	2.1	2.2	56.6	2.74
3/24/12	0	nd	nd	nd	0.513	0	0	0	0	435	1.7	1.5	57.5	8.74
3/25/12	0	nd	nd	nd	0.509	0	0	0	0	456	1.9	1.7	56.8	2.35
3/26/12	0	nd	nd	nd	0.514	0	0	0	0	431	2.0	1.9	57.9	3.54
3/27/12	0	nd	nd	nd	0.514	0	0	0	0	431	1.8	1.8	60.9	1.40
3/28/12	0	nd	nd	nd	0.513	0	0	0	0	435	1.8	1.5	57.3	3.92
3/29/12	0	nd	nd	nd	0.515	0	0	0	0	428	1.7	1.1	57.7	nd
3/30/12	0	nd	nd	nd	0.515	0	0	0	0	428	1.9	1.9	59.3	1.20
3/31/12	0	nd	nd	nd	0.513	0	0	0	0	438	2.1	1.7	63.1	2.22

	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	Temp at the traps	Turbidity
4/1/12	2	89	89.5	90	0.031	0	0	66	66	437	2.0	1.7	61.7	2.53
4/2/12	1	95	95	95	0.026	0	0	39	39	442	2.1	1.8	60.2	0.83
4/3/12	5	79	92.8	107	0.028	0	0	182	182	436	1.9	1.9	63.6	1.96
4/4/12	0	nd	nd	nd	0.515	0	0	0	0	426	1.9	1.6	58.4	1.52
4/5/12	3	87	89	90	0.031	0	0	96	96	428	1.9	1.7	57.3	1.85
4/6/12	3	78	81	85	0.040	0	0	75	75	430	1.9	1.7	57.7	1.55
4/7/12	0	nd	nd	nd	0.512	0	0	0	0	440	1.9	1.6	57.5	3.09
4/8/12	1	95	95	95	0.025	0	0	39	39	451	1.9	1.7	58.2	2.74
4/9/12	0	nd	nd	nd	0.511	0	0	0	0	446	2.0	1.8	59.5	nd
4/10/12	0	nd	nd	nd	0.515	0	0	0	0	428	2.0	1.8	59.9	2.47
4/11/12	0	nd	nd	nd	0.492	0	0	0	0	534	1.9	1.7	60.0	3.49
4/12/12	1	96	96	96	0.024	0	0	42	42	519	1.5	1.0	58.4	9.99
4/13/12	0	nd	nd	nd	0.481	0	0	0	0	587	1.9	1.0	58.4	3.94
4/14/12	0	nd	nd	nd	0.478	0	0	0	0	602	2.1	1.9	56.8	6.03
4/15/12	8	79	89.5	109	0.028	0	0	287	287	650	2.1	1.9	59.7	38.50
4/16/12	1	85	85	85	0.035	0	0	29	ns	473	2.0	1.9	59.7	4.87
4/17/12	4	77	79.75	82	0.042	0	0	94	94	386	1.9	1.5	61.8	2.24
4/18/12	0	nd	nd	nd	0.533	0	0	0	0	347	1.7	1.8	61.8	4.15
4/19/12	0	nd	nd	nd	0.540	0	0	0	0	318	1.7	1.5	64.7	2.82
4/20/12	1	87	87	87	0.035	0	0	29	29	308	1.6	1.6	67.2	4.81
4/21/12	4	84	90.5	95	0.031	0	0	128	128	311	1.4	1.7	69.9	9.43
4/22/12	0	nd	nd	nd	0.543	0	0	0	0	306	1.6	1.9	72.5	2.50
4/23/12	0	nd	nd	nd	0.543	0	0	0	0	305	1.5	1.4	72.3	3.39
4/24/12	0	nd	nd	nd	0.545	0	0	0	0	296	1.7	1.5	70.5	1.45
4/25/12	0	nd	nd	nd	0.540	0	0	0	0	316	1.7	1.1	68.5	5.19
4/26/12	0	nd	nd	nd	0.526	0	0	0	0	380	1.7	1.5	66.9	6.79
4/27/12	0	nd	nd	nd	0.527	0	0	0	0	374	1.8	1.7	64.5	3.94
4/28/12	0	nd	nd	nd	0.514	0	0	0	0	432	1.8	1.6	66.0	2.88
4/29/12	0	nd	nd	nd	0.501	0	0	0	0	490	1.8	1.9	70.5	2.52
4/30/12	2	80	84.5	89	0.035	0	0	57	57	496	2.1	1.9	70.1	2.20
5/1/12	1	85	85	85	0.034	0	0	30	30	522	1.9	1.7	68.3	2.13
5/2/12	1	85	85	85	0.031	0	0	32	32	723	1.9	1.9	65.6	10.97
5/3/12	2	86	86	86	0.030	0	0	67	67	750	2.3	2.1	65.4	3.70
5/4/12	3	80	89	107	0.027	0	0	111	111	745	2.3	1.9	63.8	4.03
5/5/12	5	84	85.8	89	0.030	0	0	168	168	766	nd	1.9	nd	8.45
5/6/12	3	76	77.6	80	0.038	0	0	78	78	772	2.3	1.9	63.3	5.63
5/7/12	1	79	79	79	0.037	0	0	27	27	767	2.3	2.1	64.2	2.19
5/8/12	1	83	83	83	0.033	0	0	31	31	753	1.9	2.2	65.1	2.87
5/9/12	0	nd	nd	nd	0.376	0	0	0	0	1160	nd	nd	65.5	4.54
5/10/12	5	76	84.4	90	0.020	0	0	250	250	1790	nd	nd	61.7	5.11
5/11/12	8	80	87	114	0.018	0	0	451	451	1880	3.0	2.4	60.0	2.34
5/12/12	4	75	80.5	90	0.022	0	0	185	185	1900	2.7	2.7	59.3	1.08
5/13/12	2	87	88	89	0.017	0	0	119	119	1940	3.1	2.0	59.7	nd
5/14/12	0	nd	nd	nd	0.299	0	0	0	0	1690	2.8	2.8	71.8	3.68
5/15/12	1	90	90	90	0.024	0	0	41	41	939	2.4	2.3	63.6	3.64
5/16/12	0	nd	nd	nd	0.484	0	0	0	0	570	2.0	1.9	63.5	1.97

	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	Temp at the traps	Turbidity
5/17/12	0	nd	nd	nd	0.508	0	0	0	0	460	1.9	1.4	64.7	4.66
5/18/12	0	nd	nd	nd	0.512	0	0	0	0	442	1.0	1.3	66.9	3.80
5/19/12	0	nd	nd	nd	0.515	0	0	0	0	427	1.2	1.4	68.3	5.80
5/20/12	0	nd	nd	nd	0.515	0	0	0	0	429	1.3	1.1	70.1	4.66
5/21/12	0	nd	nd	nd	0.512	0	0	0	0	442	1.5	1.3	72.5	4.04
5/22/12	0	nd	nd	nd	0.496	0	0	0	0	513	1.7	1.7	72.5	2.81
5/23/12	0	nd	nd	nd	0.490	0	0	0	0	542	1.6	1.6	68.9	3.04
5/24/12	0	nd	nd	nd	0.491	0	0	0	0	540	1.7	1.5	68.1	4.68
5/25/12	0	nd	nd	nd	0.486	0	0	0	0	563	1.6	1.5	67.4	1.21
5/26/12	0	nd	nd	nd	0.434	0	0	0	0	824	2.1	1.7	66.2	3.67
5/27/12	1	103	103	103	0.017	0	0	60	60	857	nd	nd	66.9	5.22
5/28/12	0	nd	nd	nd	0.427	0	0	0	0	864	2.0	2.1	66.0	2.53
5/29/12	0	nd	nd	nd	0.432	0	0	0	0	836	1.9	1.7	67.1	2.45
5/30/12	0	nd	nd	nd	0.479	0	0	0	0	597	1.9	1.5	68.1	1.72
5/31/12	0	nd	nd	nd	0.520	0	0	0	0	406	1.7	1.4	68.5	3.51
6/1/12	0	nd	nd	nd	0.535	0	0	0	0	337	1.5	2.4	71.8	4.36
6/2/12	0	nd	nd	nd	0.542	0	0	0	0	308	1.4	1.1	76.4	2.46
6/3/12	0	nd	nd	nd	0.548	0	0	0	0	283	1.2	1.1	72.8	4.29
6/4/12	0	nd	nd	nd	0.551	0	0	0	0	270	1.1	0.9	73.0	5.12
6/5/12	0	nd	nd	nd	0.554	0	0	0	0	259	1.4	1.6	69.9	2.69
6/6/12	0	nd	nd	nd	0.556	0	0	0	0	250	1.3	1.5	69.2	4.90
6/7/12	0	nd	nd	nd	0.550	0	0	0	0	274	1.3	1.3	78.2	3.45
6/8/12	0	nd	nd	nd	0.557	0	0	0	0	244	1.1	1.1	70.5	4.05
6/9/12	0	nd	nd	nd	0.562	0	0	0	0	225	1.4	1.0	75.0	2.86
6/10/12	0	nd	nd	nd	0.562	0	0	0	0	225	1.3	0.9	70.8	4.27
6/11/12	0	nd	nd	nd	0.561	0	0	0	0	226	1.3	1.0	72.3	2.38
6/12/12	0	nd	nd	nd	0.564	0	0	0	0	216	1.1	0.7	75.3	2.40
6/13/12	0	nd	nd	nd	0.567	0	0	0	0	203	1.3	1.0	74.1	2.47
6/14/12	0	nd	nd	nd	0.564	0	0	0	0	216	1.5	0.6	81.1	3.43
6/15/12	0	nd	nd	nd	0.561	0	0	0	0	226	1.2	0.9	75.2	3.09

Appendix C. Daily counts of non-salmonids captured at Waterford during 2012. See key below for species codes.

Date	BAS	BGS	BKB	BRB	C	CHC	GSN	HH	LAM	MQK	PRS	REB	RSN	SASQ	SASU	SMB	SNF	STB	UNID
1/3/12																			
1/4/12																			
1/5/12															2				
1/6/12								1											
1/7/12																			
1/8/12											1								
1/9/12																			
1/10/12																			
1/11/12		1																	
1/12/12																			
1/13/12		1									1		1						
1/14/12											1								
1/15/12																			
1/16/12															1				
1/17/12											4								
1/18/12								1			1								
1/19/12								1											
1/20/12																			
1/21/12											1								
1/22/12								1	3		2								
1/23/12															1		1		
1/24/12											3								
1/25/12								1			2								
1/26/12											4								
1/27/12																			
1/28/12								1			2								
1/29/12								1			1								

Date	BAS	BGS	BKB	BRB	C	CHC	GSN	HH	LAM	MQK	PRS	REB	RSN	SASQ	SASU	SMB	SNF	STB	UNID
1/30/12																			
1/31/12								1			2								
2/1/12		1																	
2/2/12																			
2/3/12		1									1								
2/4/12											1								
2/5/12													1						
2/6/12																			
2/7/12											3								
2/8/12											1								
2/9/12								1			1								
2/10/12																			
2/11/12								1						1					
2/12/12																			
2/13/12											1					1			
2/14/12																			
2/15/12											1								
2/16/12																			
2/17/12											2								
2/18/12								1			2								
2/19/12									1		1								
2/20/12											1								
2/21/12						1					2			1					
2/22/12											1								
2/23/12															1				
2/24/12											1								
2/25/12											1								
2/26/12											2								
2/27/12								2											

Date	BAS	BGS	BKB	BRB	C	CHC	GSN	HH	LAM	MQK	PRS	REB	RSN	SASQ	SASU	SMB	SNF	STB	UNID
2/28/12											1			1					
2/29/12								1			1								
3/1/12																			
3/2/12																			
3/3/12																			
3/4/12																			
3/5/12		1									1				1				
3/6/12											1								
3/7/12											2								
3/8/12														1					
3/9/12															1				
3/10/12							1				1			1		2			
3/11/12											1								
3/12/12									2										
3/13/12											1								
3/14/12											1								
3/15/12																			
3/16/12																			
3/17/12									2										
3/18/12																			
3/19/12																			
3/20/12									2										
3/21/12																			
3/22/12																			
3/23/12											3								
3/24/12											1				1				
3/25/12																			
3/26/12											1								
3/27/12											1	1							

Date	BAS	BGS	BKB	BRB	C	CHC	GSN	HH	LAM	MQK	PRS	REB	RSN	SASQ	SASU	SMB	SNF	STB	UNID
3/28/12											1				1				
3/29/12											1								
3/30/12													1						
3/31/12																			
4/1/12						1			1										
4/2/12											1				1				
4/3/12														1					
4/4/12																1			
4/5/12														1	1				
4/6/12																			
4/7/12																			
4/8/12																			
4/9/12																			
4/10/12																			
4/11/12								1											
4/12/12																			
4/13/12											2								
4/14/12																			
4/15/12								1	5		1			2					
4/16/12									1										
4/17/12											1		1	1					
4/18/12																			
4/19/12											1					1			
4/20/12																			
4/21/12																			
4/22/12																			
4/23/12											2								
4/24/12											5								
4/25/12																			

Date	BAS	BGS	BKB	BRB	C	CHC	GSN	HH	LAM	MQK	PRS	REB	RSN	SASQ	SASU	SMB	SNF	STB	UNID
4/26/12									1									1	
4/27/12	1																		
4/28/12																			1
4/29/12			1																
4/30/12							1				1		1						
5/1/12										1			2						
5/2/12																			
5/3/12														2					
5/4/12											1			1	2				
5/5/12														2					
5/6/12									1					1	1				
5/7/12															1				
5/8/12														1	1				
5/9/12															2				
5/10/12							1		12					2	4				
5/11/12					1						1			1	5				
5/12/12											1			1	9				
5/13/12										1					1				
5/14/12															1				1
5/15/12				1										1	21				
5/16/12								3							2				
5/17/12														1					
5/18/12											2								
5/19/12																1			
5/20/12											1								
5/21/12																			
5/22/12														1	1				
5/23/12															2				
5/24/12															1				

Date	BAS	BGS	BKB	BRB	C	CHC	GSN	HH	LAM	MQK	PRS	REB	RSN	SASQ	SASU	SMB	SNF	STB	UNID
5/25/12								1											
5/26/12								1			1				6				
5/27/12											1			1	5				
5/28/12															13				
5/29/12								1							7				
5/30/12											1				10				
5/31/12																			
6/1/12																			
6/2/12															2				
6/3/12															4				
6/4/12																			
6/5/12																			
6/6/12								1							1				
6/7/12																			
6/8/12	2														1				
6/9/12																			
6/10/12																			
6/11/12															2	1			
6/12/12																			
6/13/12																			
6/14/12																			
6/15/12																			

Appendix D. Daily counts of non-salmonids captured at Grayson during 2012. See key below for species codes.

Date	BAS	BGS	BKB	BKS	BRB	C	CAT	CHC	GSN	HCH	HH	LAM	LMB	MQK	MSS	PRS	RSN	SASQ	SASU	SMB	UNID	W	WHC
1/2/12																							
1/3/12																							
1/4/12																							
1/5/12																							
1/6/12														1									
1/7/12	1													1									
1/8/12																	1						
1/9/12	1																						
1/10/12																							
1/11/12																							
1/12/12																							
1/13/12																							
1/14/12																							
1/15/12																1							
1/16/12																							
1/17/12																							
1/18/12																							
1/19/12																							
1/20/12																							
1/21/12																							
1/22/12												7											1
1/23/12																							
1/24/12												1											
1/25/12		1																					
1/26/12																							
1/27/12																1							
1/28/12																							

Date	BAS	BGS	BKB	BKS	BRB	C	CAT	CHC	GSN	HCH	HH	LAM	LMB	MQK	MSS	PRS	RSN	SASQ	SASU	SMB	UNID	W	WHC
1/29/12																							
1/30/12																							
1/31/12																							
2/1/12																							
2/2/12																							
2/3/12																							
2/4/12																							
2/5/12																							
2/6/12		1																					1
2/7/12	1																						
2/8/12																							
2/9/12																							
2/10/12																							
2/11/12		1							1														
2/12/12	1	1																					1
2/13/12																							
2/14/12																							
2/15/12																							
2/16/12																							1
2/17/12																							
2/18/12																							1
2/19/12																1							
2/20/12														1									
2/21/12																							
2/22/12																	1						
2/23/12																							1
2/24/12																							
2/25/12																							
2/26/12																		1					

Date	BAS	BGS	BKB	BKS	BRB	C	CAT	CHC	GSN	HCH	HH	LAM	LMB	MQK	MSS	PRS	RSN	SASQ	SASU	SMB	UNID	W	WHC
2/27/12																							
2/28/12																							
2/29/12																							
3/1/12												2											
3/2/12																							
3/3/12																							
3/4/12																1							
3/5/12																							
3/6/12																1	1						
3/7/12																							
3/8/12																							
3/9/12													1				1						
3/10/12																							
3/11/12																							
3/12/12																							
3/13/12																							
3/14/12																							
3/15/12								1															
3/16/12														1									
3/17/12												3											1
3/18/12			2					1															2
3/19/12								2								1							
3/20/12			4						2														2
3/21/12			1						8								4						1
3/22/12					1				14														
3/23/12									25					1									2
3/24/12	1	1							9														
3/25/12									6														1
3/26/12									2														

Date	BAS	BGS	BKB	BKS	BRB	C	CAT	CHC	GSN	HCH	HH	LAM	LMB	MQK	MSS	PRS	RSN	SASQ	SASU	SMB	UNID	W	WHC
3/27/12									1														
3/28/12															1				1		1		
3/29/12									1									1					1
3/30/12																							
3/31/12																			2				1
4/1/12																1							
4/2/12									1												10		1
4/3/12																	1	1	3				
4/4/12																							
4/5/12																			6				
4/6/12																	2		6				
4/7/12																							1
4/8/12																			7				
4/9/12									1							1			7				
4/10/12																		1	3		1		
4/11/12										1													
4/12/12										2									40				
4/13/12			1																1				
4/14/12																			1				4
4/15/12									1										6				2
4/16/12									14		1								47				3
4/17/12									21										17				5
4/18/12									4				1						2	1			2
4/19/12									6														3
4/20/12																1				1			2
4/21/12																	1						1
4/22/12		2																	2				2
4/23/12		2																	1	1			5
4/24/12																1			2				6

Date	BAS	BGS	BKB	BKS	BRB	C	CAT	CHC	GSN	HCH	HH	LAM	LMB	MQK	MSS	PRS	RSN	SASQ	SASU	SMB	UNID	W	WHC
4/25/12		1																					1
4/26/12		2																		1			2
4/27/12		1	1																				1
4/28/12																							
4/29/12	1	1																	8				
4/30/12		1														1			5				6
5/1/12									1						1				1				4
5/2/12																							
5/3/12																	1		16				
5/4/12															1				495				1
5/5/12	2	1							1						1				349				1
5/6/12																			160				
5/7/12	14								1										116				1
5/8/12	2																		192			1	
5/9/12	8																		147				1
5/10/12	11												1						35	1			
5/11/12	1																		187				1
5/12/12	14					7			3			1		1					230				
5/13/12	2					2			1									1	39				
5/14/12						4													37				
5/15/12	7					15					1								35				1
5/16/12	4					7					1						1		7				2
5/17/12	55					6			1										10				2
5/18/12	97					9													12	1			1
5/19/12	3																						
5/20/12	3																		1				1
5/21/12	38																	1	1				1
5/22/12	34							1	1		1			1					1				1
5/23/12	3																						

Date	BAS	BGS	BKB	BKS	BRB	C	CAT	CHC	GSN	HCH	HH	LAM	LMB	MQK	MSS	PRS	RSN	SASQ	SASU	SMB	UNID	W	WHC
5/24/12	1	1																					1
5/25/12																			46				
5/26/12	78	1							1										1				
5/27/12	1																						1
5/28/12	47							1											7				
5/29/12	15					1													7				
5/30/12	72						1										1		10				
5/31/12	5																		2				
6/1/12	8	3				1																	
6/2/12	50																						
6/3/12	87					2																	
6/4/12	11																						
6/5/12	66																						1
6/6/12	88																						
6/7/12	21														1		1						1
6/8/12	22																	1					
6/9/12	25																			2			
6/10/12	17			1																			
6/11/12	54	1															3			1			
6/12/12	13																			1			
6/13/12	6	1																					
6/14/12																							
6/15/12	8	1																		1			11

Appendix E. Key to species codes.

BAS	Unidentified bass
BGS	Bluegill
BKB	Black bullhead
BKS	Black crappie
BRB	Brown bullhead
C	Carp
CHC	Channel catfish
CHN	Chinook
GSN	Golden shiner
HCH	Hitch
HH	Hardhead
LAM	Lamprey, unidentified species
LMB	Largemouth bass
MQK	Mosquitofish
MSS	Inland silverside
PRS	Prickly sculpin
REB	Redeye bass
RSN	Red shiner
SASQ	Sacramento pikeminnow
SASU	Sacramento sucker
SMB	Smallmouth bass
SNF	Unidentified sunfish
STB	Striped bass
UNID	Unidentified species
W	Warmouth
WHC	White catfish