Outmigrant Trapping of Juvenile Salmon in the Lower Tuolumne River, 2011

Submitted To:
Turlock Irrigation District
Modesto Irrigation District

Prepared By:
Chrissy L. Sonke
Shaara Ainsley
Andrea Fuller

FISHBIO
1617 S. Yosemite Ave.
Oakdale, CA 95361
209.847.6300
www.fishbio.com

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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 1999-2011) 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, 1995-2011.

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

[1] Passage estimate reported in the annual report cited.

<table>
<tr><th>Year</th><th>Site</th><th>Period Sampled</th><th>Proportion of Outmigration Period Sampled</th><th>Total Catch</th><th>Total Estimated Passage</th><th>Method of Passage Estimation</th><th>Results Reported In</th></tr>
<tr><td></td><td>Grayson (RM 5.2)</td><td>Jan 12-Jun 06</td><td>93%</td><td>19,327</td><td>869,636[2]</td><td>Multiple regression</td><td>Vasques and Kundargi 2001</td></tr>
<tr><td rowspan="4">2000</td><td>7/11</td><td>Jan 10-Feb 27</td><td>32%</td><td>61,196</td><td>298,755[1]</td><td>%Flow sampled</td><td>Hume and others 2001</td></tr>
<tr><td>Deardorff (RM 35.5)</td><td>Apr 09-May 25</td><td>31%</td><td>634</td><td>15,845[1]</td><td>%Flow sampled</td><td>Hume and others 2001</td></tr>
<tr><td>Hughson</td><td>Apr 09-May 25</td><td>31%</td><td>264</td><td>2,942[1]</td><td>%Flow sampled</td><td>Hume and others 2001</td></tr>
<tr><td>Grayson</td><td>Jan 09-Jun 12</td><td>95%</td><td>2,250</td><td>107,617[2]</td><td>Multiple regression</td><td>Vasques and Kundargi 2001</td></tr>
<tr><td>2001</td><td>Grayson</td><td>Jan 03-May 29</td><td>97%</td><td>6,478</td><td>106,580[2]</td><td>Multiple regression</td><td>Vasques and Kundargi 2002</td></tr>
<tr><td>2002</td><td>Grayson</td><td>Jan 15-Jun 06</td><td>91%</td><td>436</td><td>14,135[2]</td><td>Multiple regression</td><td>Blakeman 2004b</td></tr>
<tr><td>2003</td><td>Grayson</td><td>Apr 01-Jun 06</td><td>40%</td><td>359</td><td>13,928[2]</td><td>Multiple regression</td><td>Blakeman 2004c</td></tr>
<tr><td>2004</td><td>Grayson</td><td>Apr 01-Jun 09</td><td>40%</td><td>509</td><td>9,074[2]</td><td>Multiple regression</td><td>Fuller 2005</td></tr>
<tr><td>2005</td><td>Grayson</td><td>Apr 02-Jun 17</td><td>39%</td><td>1,317</td><td>17,600[2]</td><td>Multiple regression</td><td>Fuller and others 2006</td></tr>
<tr><td rowspan="3">2006</td><td>Waterford 1 (RM 29.8)</td><td>Jan 25-Apr 12</td><td rowspan="2">79%</td><td>8,648</td><td>178,034[1]</td><td rowspan="2">%Flow sampled</td><td rowspan="2">Fuller and others 2007</td></tr>
<tr><td>Waterford 2 (RM 33.5)</td><td>Apr 21-Jun 21</td><td>458</td><td>178,034[1]</td></tr>
<tr><td>Grayson</td><td>Jan 25-Jun 22</td><td>84%</td><td>1,594</td><td>181,691[2]</td><td>Multiple regression</td><td>Fuller and others 2007</td></tr>
<tr><td rowspan="2">2007</td><td>Waterford (RM 29.8)</td><td>Jan 11-Jun 05</td><td>93%</td><td>3,312</td><td>57,801[1]</td><td>Average trap efficiency</td><td>Fuller 2008</td></tr>
<tr><td>Grayson</td><td>Mar 23-May 29</td><td>45%</td><td>27</td><td>937[2]</td><td>Multiple regression</td><td>Fuller 2008</td></tr>
<tr><td>2008</td><td>Waterford</td><td>Jan 8-Jun 2</td><td>96%</td><td>3,350</td><td>24,894[1]</td><td>Average trap efficiency</td><td>Palmer and Sonke 2008</td></tr>
</table>

[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
	Grayson	Jan 29-Jun 4	82%	193	3,287[2]	Multiple regression	Palmer and Sonke 2008
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	4,598[2]	Multiple regression	Palmer and Sonke 2010
2010	Waterford	Jan 5-Jun 11	97%	2,281	29,294-55,941[3]	Average trap	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[3]	Average trap efficiency[3]	This report
	Grayson	Jan 6-Jun 30	97%	1,645	87,172[2]	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 wide funnel mouth and strikes the internal screw core, causing the funnel to rotate. As

[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 and 2011.

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 and 2011 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 and 2011 precluded the need for the "weir" structure used to increase catch efficiency during 2008 and 2009.

Trap Monitoring

Sampling at Waterford began on December 5, 2010. The trap was operated continuously (24 hours per day, 7 days per week) until June 30, 2011, when sampling was terminated due to consistently low catch.

Sampling at Grayson began on January 6, 2011. The traps were operated continuously (24 hours per day, 7 days per week) until March 21 when sampling was temporarily discontinued due to safety concerns associated with high flows. Sampling resumed on March 31 and continued until sampling was terminated on June 30, 2011, due to consistently low catch.

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 $\geq$ 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 and

Grayson traps. Juvenile salmon captured in the traps were used to conduct tests whenever catches were sufficient. Seven groups of naturally produced juvenile salmon (ranging in number from 22 to 142 fish) were marked and released at RM 30 (about 0.2 miles upstream of the Waterford trap) between January 12 and February 9 to estimate trap efficiencies at the Waterford trap. Five groups of naturally produced juvenile salmon (ranging in number from 45 to 87 fish) were marked and released at RM 6.2 between January 14 and January 26 to determine trap efficiencies at the Grayson traps. Catches of naturally produced juvenile salmon after February 8 and January 25 at Waterford and Grayson, respectively, were insufficient for trap efficiency tests. Additionally, hatchery produced fish were not available for tests during 2011. Trap efficiency calculations for both sites are discussed in further detail below.

Marking Procedure

At both trapping sites, 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 2011 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 nine 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. 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. Trap efficiency releases were only conducted for the fry lifestage in 2011 due to insufficient catch during the parr/smolt outmigration period. In some situations hatchery origin fish have also been used for trap efficiency tests, however, fish from the Merced River Hatchery were not available during 2011.

Salmon fry abundance estimates were generated based on trap efficiency tests conducted at Waterford in 2011. 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. Theresulting trap efficiency (TE) was then applied to the daily catch (DC) to estimate daily passage as follows:

Estimated Daily Passage= DC/TE

During the parr/smolt outmigration period in 2011, flows on the Tuolumne River were unusually high (averaging over 5,400 cfs). As a result of high flows, trap efficiency was severely limited, and daily catches were insufficient 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 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 2011 were based on (Table 3):

Fry:

- trap efficiency tests conducted in 2011 at Waterford = 0.98%

Parr/Smolt:

- 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 2011 RST operation were the progeny of an estimated 785 salmon (326 females) that spawned in the fall of 2010 (Becker et al. 2011). However, the total number of salmon and the number of females is most likely an underestimate since monitoring was truncated and ended on December 1 due to flood control releases from New Don Pedro Reservoir. Further, there were 142 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 2011, catches of juvenile Chinook salmon at Waterford were highest in late January to mid-March, peaking on January 22, 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 December 5 and June 30 ranged from zero to 161 fish, with a total catch of 4,394 salmon (Figure 3).

At Grayson, catches of juvenile salmon in 2011 were highest in late January and February during the fry outmigration period. Daily catches of juvenile salmon at Grayson between January 6 and June 17 ranged from zero to 132 fish (Figure 4), with a total catch of 1,645 salmon (Table 2).

Table 2. Catch by lifestage at Waterford and Grayson, 2011.

Trapping Site	*Fry (<50 mm)*	*Parr (50-69 mm)*	*Smolt (≥ 70 mm)*
Waterford	3,958	45	391
Grayson	1,434	29	182

The length of the sampling season and the trap efficiencies will affectthe 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 2011, flows were elevated during the entire outmigration season and ranged from 1,580 cfs to 8,360 cfs.

Total annual trap catch at Waterford from 2006-2011 ranged from a high of 9,106 in 2006 to a low of 2,281 in 2010, and averaged 4,337 juvenile salmon (Figure 5). In 2011, the total annual catch of juvenile salmon at Waterford was approximately doublethat of the previous year and one-quarter more than 2007-2009(Table 1; Figure 5). However, the total catch in 2011 was only half of the number of Chinook captured in 2006, 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 2008-2011, 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 3,566 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.

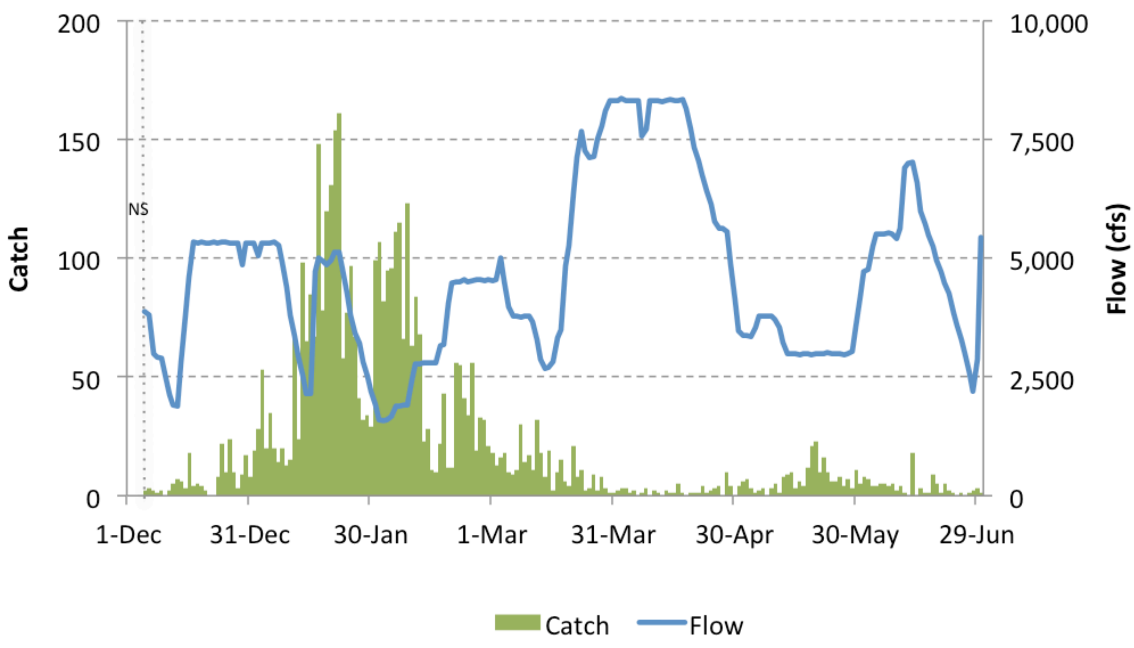

Figure 3. Daily catch of unmarked Chinook salmon at Waterford and river flow at La Grange (LGN) during 2011.

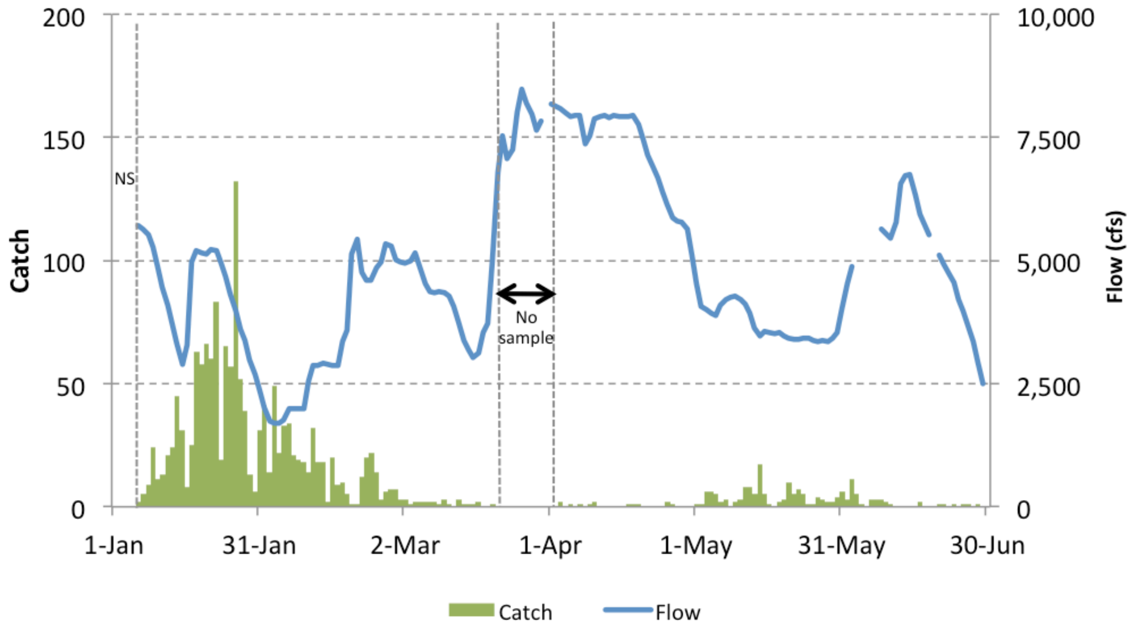

Figure 4. Daily catch of unmarked Chinook salmon at Grayson and river flow at Modesto (MOD) during 2011. Note: Flow at MOD is estimated on February 3-16 due to a malfunctioning gage.

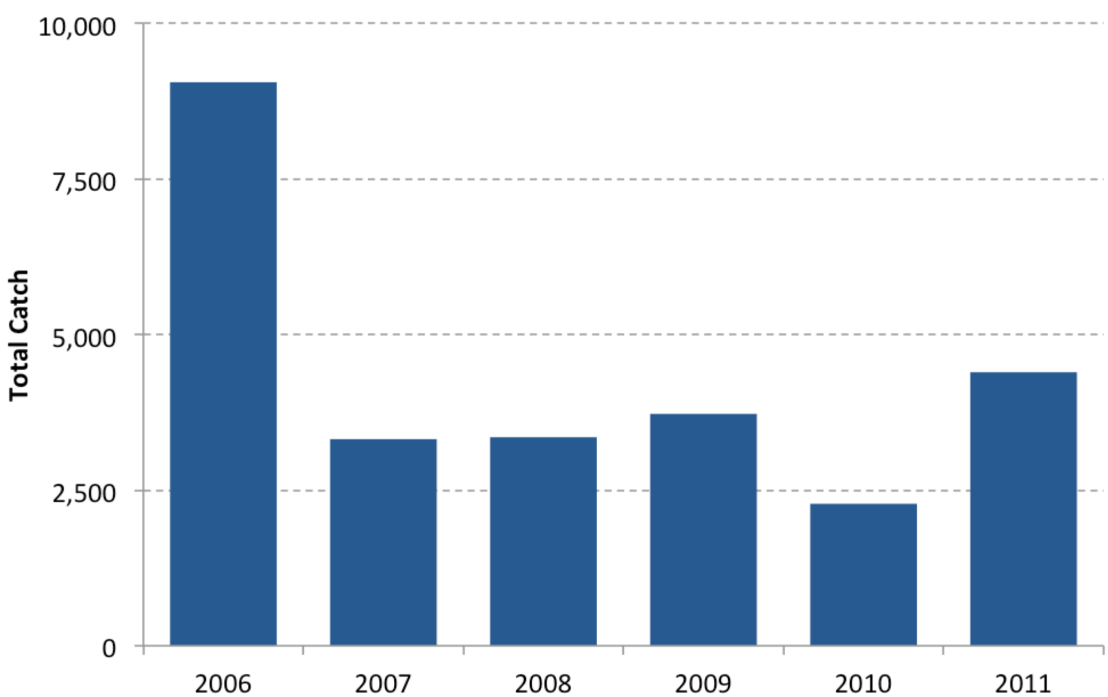

Figure 5. Total annual salmon catch at Waterford during 2006-2011.

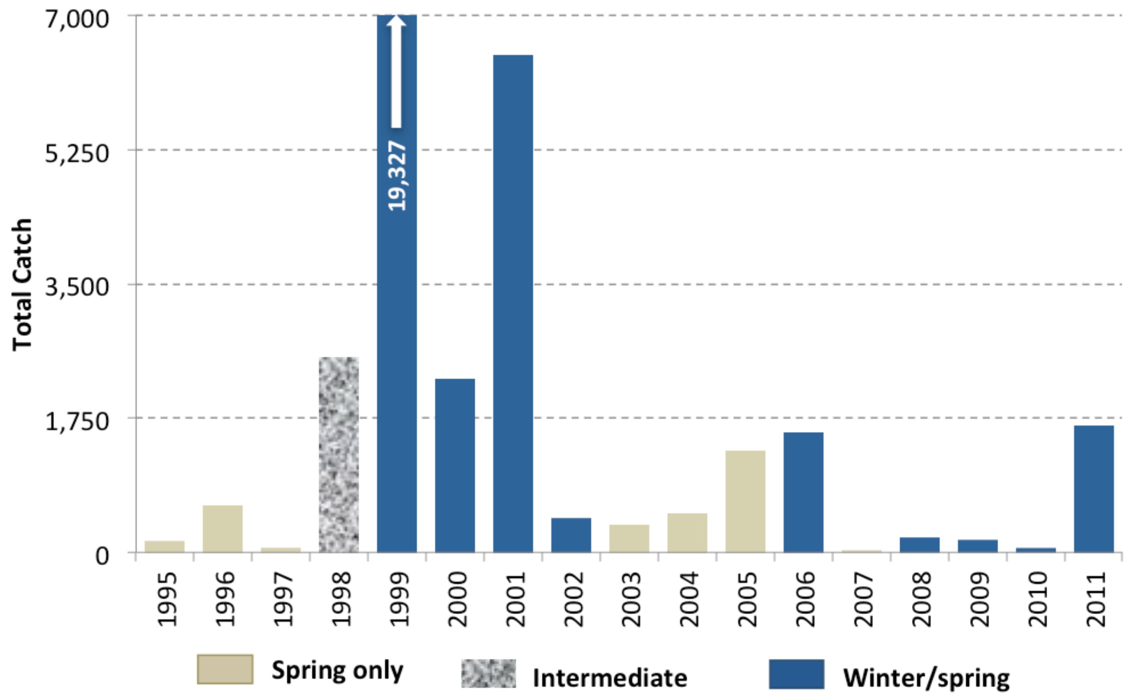

Figure 6. Total annual salmon catch at Shiloh/Grayson during 1995-2011.

Trap Efficiency

In 2011, seven trap efficiency tests were conducted at Waterford using naturally produced salmon fry. Results from these tests ranged from 0% to 3.0% at flows (La Grange) between 1,580 cfs and 5,130 cfs (Table 3).

As mentioned previously, since there were no comparable trap efficiency data available for the Waterford trap, a range of parr/smolt abundances were calculated 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 2011. 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	1/12/11	Waterford	Wild	22	0	20.0%	35	35	225	33.3
	1/15/11	Waterford	Wild	142	1	11.0%	35	35	225	21.2
	1/20/11	Waterford	Wild	116	0	2.9%	37	40	225	7.99
	1/21/11	Waterford	Wild	120	0	6.9%	37	37	225	1.16
	2/1/11	Waterford	Wild	96	1	7.1%	35	32	225	1.66
	2/2/11	Waterford	Wild	100	3	3.0%	36	35	225	1.14
	2/9/11	Waterford	Wild	116	2	6.9%	36	37	225	0.2
		TOTAL		712	7	0.98%				
Parr/smolt	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 2011 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

Release Date	Origin	Mark	Adjusted # Released	Number Recaptured	% Recaptured	Length at Release (mm)	Length at Recap. (mm)	Flow (cfs) at MOD
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
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,	2001	22	1.1%	86	np	1210

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

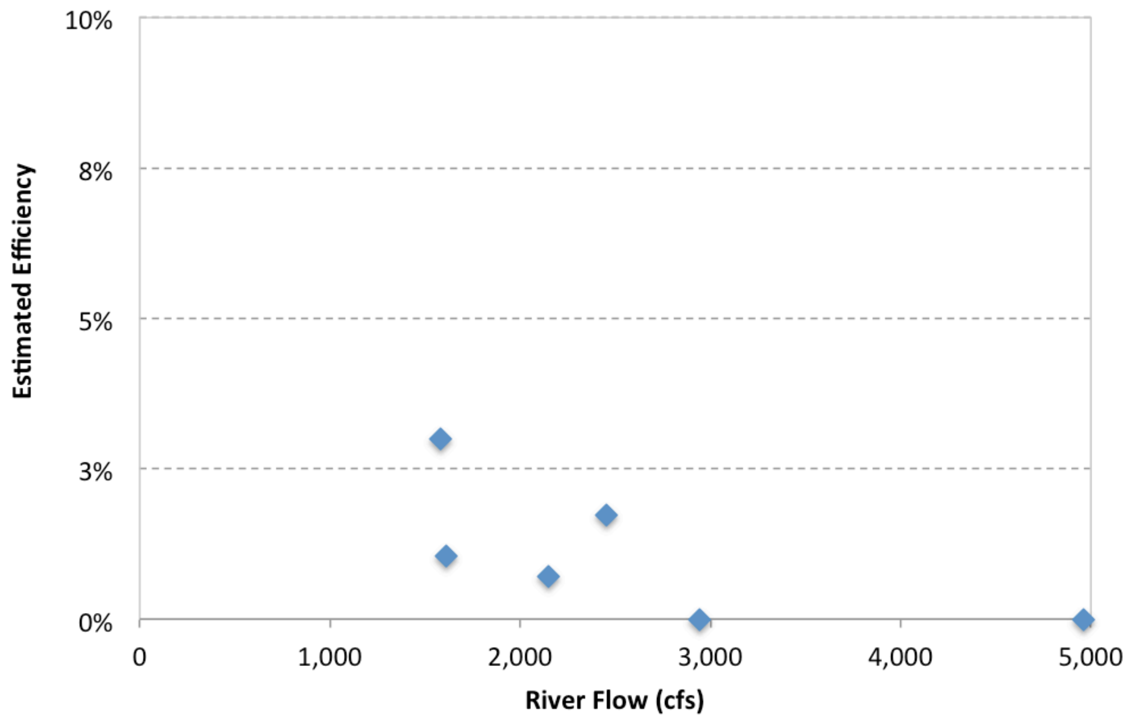

Figure 7. Trap efficiency estimates at Waterford relative to river flow at La Grange (LGN) during 2011.

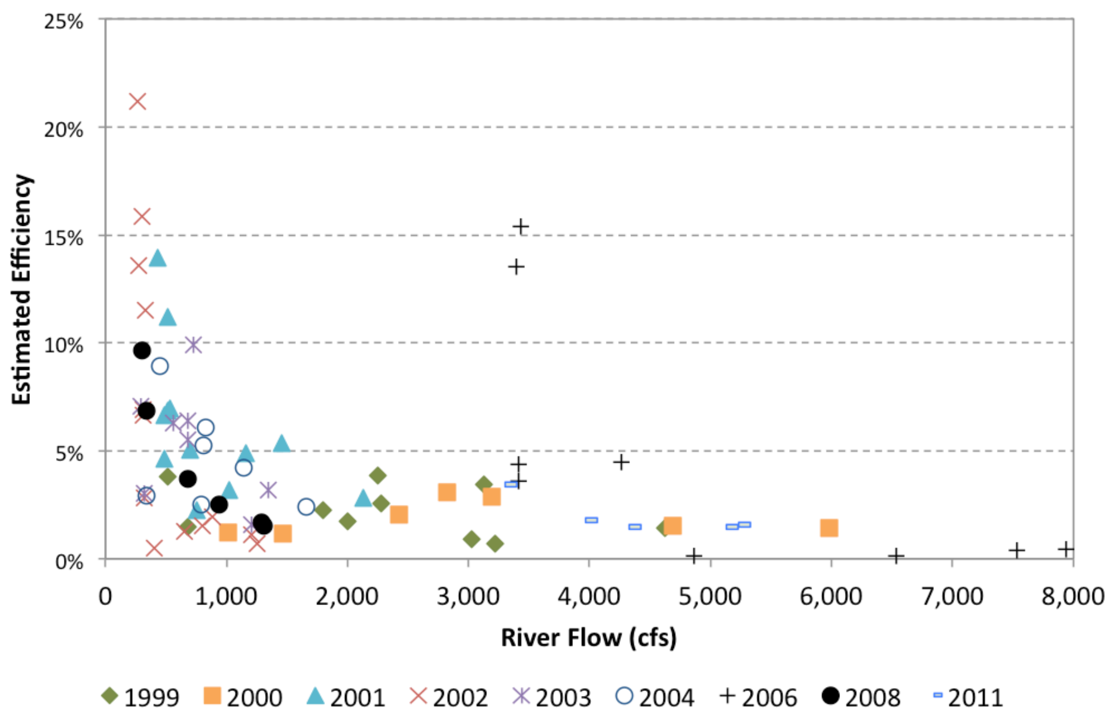

Figure 8.Trap efficiency observations at Grayson relative to river flow at Modesto (MOD), 1999-2008 and 2011.

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 (March 16-June 30), 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 420,971 (414,815-427,126) Chinook salmon passed Waterford during 2011, of which 3.7% (2.4%-5.0%) were smolts (Table 5). In comparison, the percentage of fish passing Waterford as smolts was 71.6% 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 2011, and in previous years, a majority of the salmon observedpassing 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 0to 16,376. The peak in daily passage for fry occurred on January 22 and smolt passage peaked on May 20 (Figure 11).

For comparisons, passage estimates at Waterford were also calculated based on the estimated proportion of flow sampled during 2011. This method produced an estimate of 428,317 at Waterford. This estimate is provided for the purpose of comparison only and is not reflected in the tables and figures in this report.

An estimated 87,172 unmarked Chinook salmon passed Grayson during 2011 and of these 52.5% were fry and 45.6% were smolts (Table 5). Daily estimated passage at Grayson ranged from 0 to 3,969 salmon. Peak daily passage for fry and smolts occurred on January 22 and May 14, respectively (Figure 11). During comparable seasonal sampling in previous years at Grayson (i.e., winter/spring sampling in 1999-2002, 2006, and 2008-2011), total estimated passage ranged from a high of 869,636 in 1999 to a low of 3,287 in 2008 (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 1,615,673 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 drasticoverestimation of fish passage.

During the 2010-11 spawning season, approximately 1,291 (1,272-1,310) juveniles were produced per female spawner, based on the estimated 326 female spawners[4] and the total estimated passage at the Waterford trap. This is high compared to 490 (337-643) juveniles per female in 2010, 175 in 2009, 311 in 2008, and 205 in 2007 (Table 6). However, the number of female spawners may have been underestimated due to

[4] Excludes 142 adult salmon of unknown gender and does not take into account the salmon undetected in December 2010 when sampling was terminated due to flood releases from Don Pedro Reservoir.

sampling in 2010-11 spawning season; thus, increasing the estimated juveniles per female spawner ratio. Beginning in2010 the number of female spawners was estimated based oncounts from a VakiRiverwatcher used in conjunction with a resistance board weir, rather than the traditional carcass surveys. This estimate of spawner abundance is believed to be more accurate than carcass surveys, especially during years of lower abundance (Cuthbert et al. 2010).

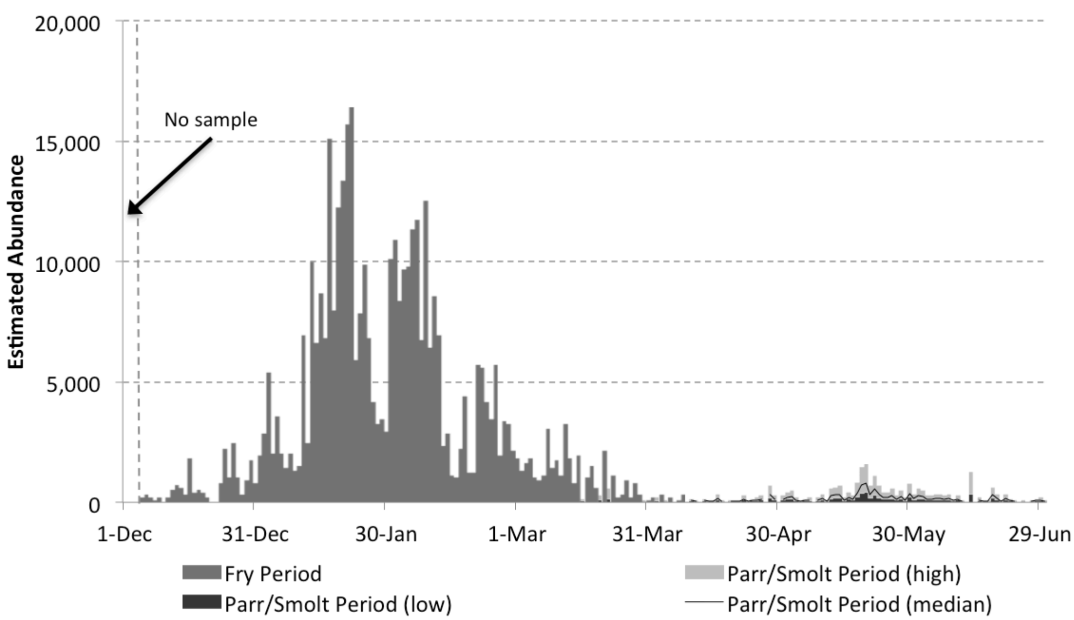

Figure 9. Daily estimated abundance of Chinook salmon at Waterford based on trap efficiencies conducted in 2011 at Waterford during the fry periodand at the 7/11 and Deardorff traps in 1998-2000 (at flows > 1,000cfs) for the parr/smolt period. A range of abundances were calculated for the parr/smolt period and the median and range are presented in this graph.

Table 5. Estimated passage by lifestage at Waterford and Grayson during 1995-2011. *For 2010-2011 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	163,805	54.0%	6,550	2.2%	133,127	43.9%	303,482
	2007	w/s	20,633	35.7%	7,614	13.2%	29,554	51.1%	57,801
	2008	w/s	15,259	61.3%	1,102	4.4%	8,534	34.3%	24,894
	2009	w/s	13,399	36.0%	4,562	12.3%	19,213	51.7%	37,174
	2010*	w/s	10,735	25.9%	1,030	2.5%	29,728	71.6%	41,493
	2011*	w/s	400,478	95.1%	4,884	1.2%	15,608	3.7%	420,971
Grayson	1995	spring	-	-	-	-	22,067	100%	22,067
	1996	spring	-	-	-	-	16,533	100%	16,533
	1997	spring	-	-	-	-	1,280	100%	1,280
	1998	intermediate	1,196,625	74.1%	327,422	20.3%	91,626	5.7%	1,615,673
	1999	w/s	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	19.4%	17,550	9.7%	128,937	71.0%	181,691
	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%	4,598
	2010	w/s	173	4.1%	0	0%	4,060	95.9%	4,060
	2011	w/s	45,781	52.5%	1,654	1.9%	39,737	45.6%	87,172

Table 6. Estimated number of juvenile salmon produced per female spawner, 2006-2011.

Year	Females	Juveniles/female spawner
2006	478	635
2007	282	205
2008	80	311
2009	212	175
2010	87	337 to 643
2011	326[5]	1,272 to 1,310

[5] Excludes 142 adult salmon of unknown gender and does not take into account the salmon undetected in December 2010 when sampling was terminated due to flood releases from Don Pedro Reservoir.

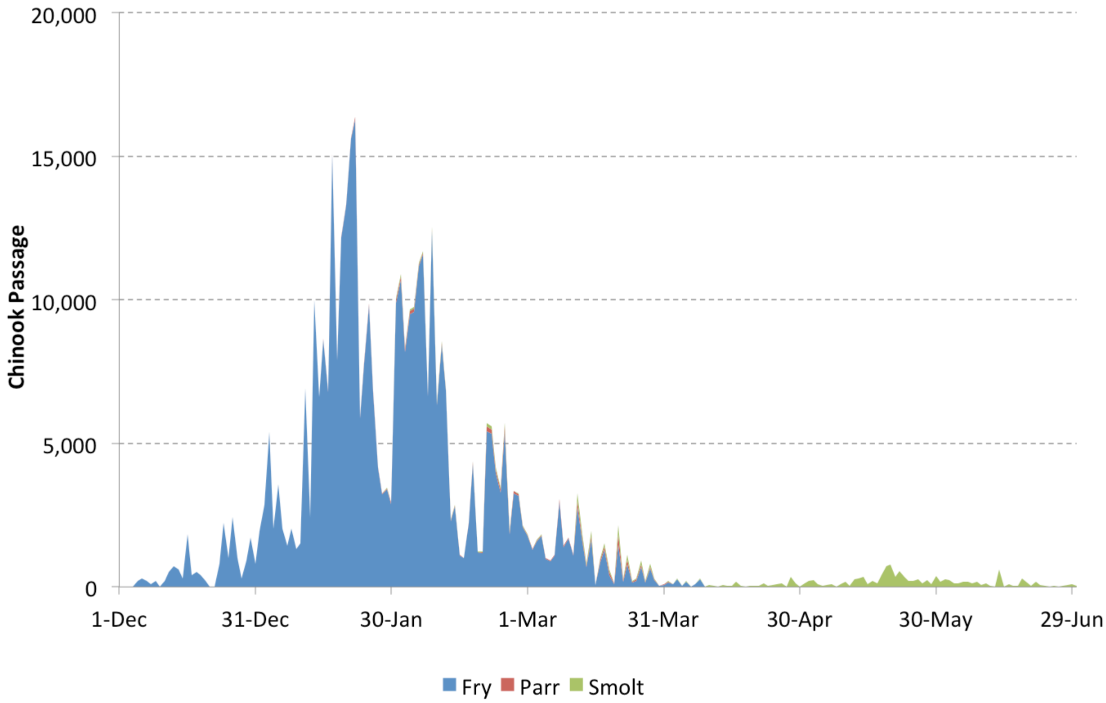

Figure 10. Juvenile salmon passage by lifestage at Waterford during 2011.

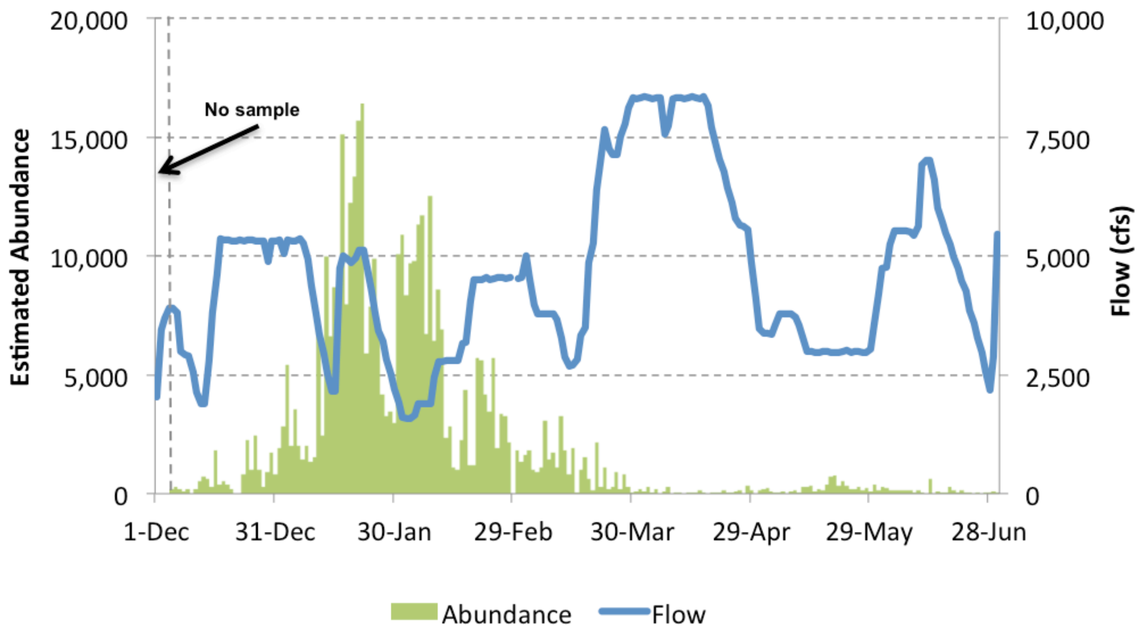

Figure 11. Daily estimated passage of unmarked Chinook salmon at Waterford and river flow at La Grange (LGN) during 2011.*NOTE: From March 16-June 30 the graph depicts median daily passage estimates - See* Figure 9*.*

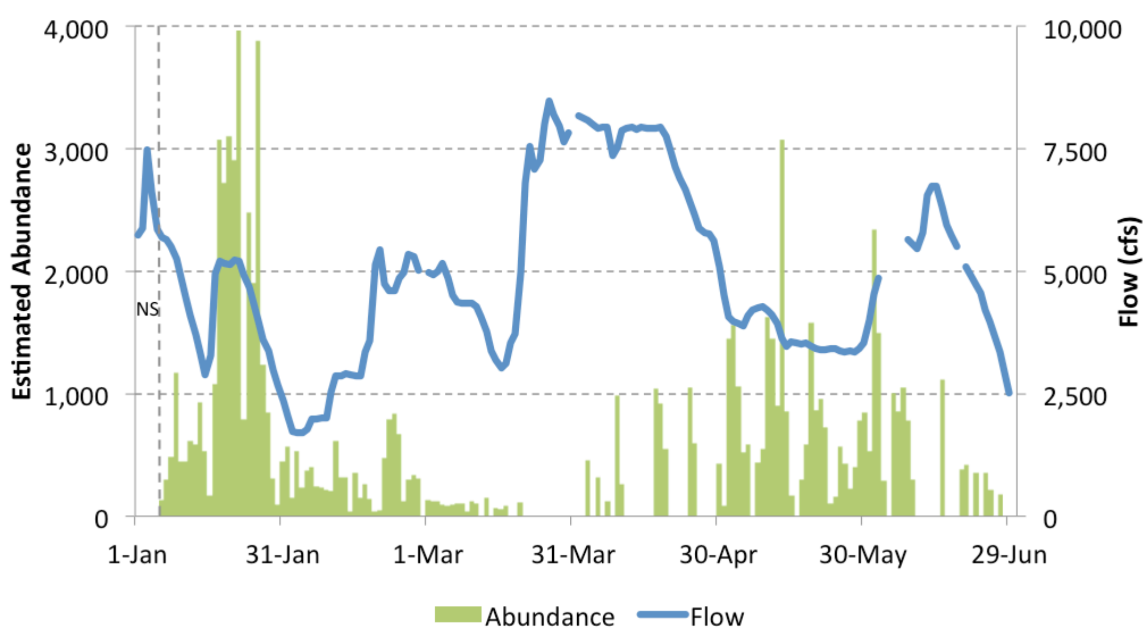

Figure 12. Daily estimated passage of unmarked Chinook salmon at Grayson and river flow at Modesto (MOD) during 2011.

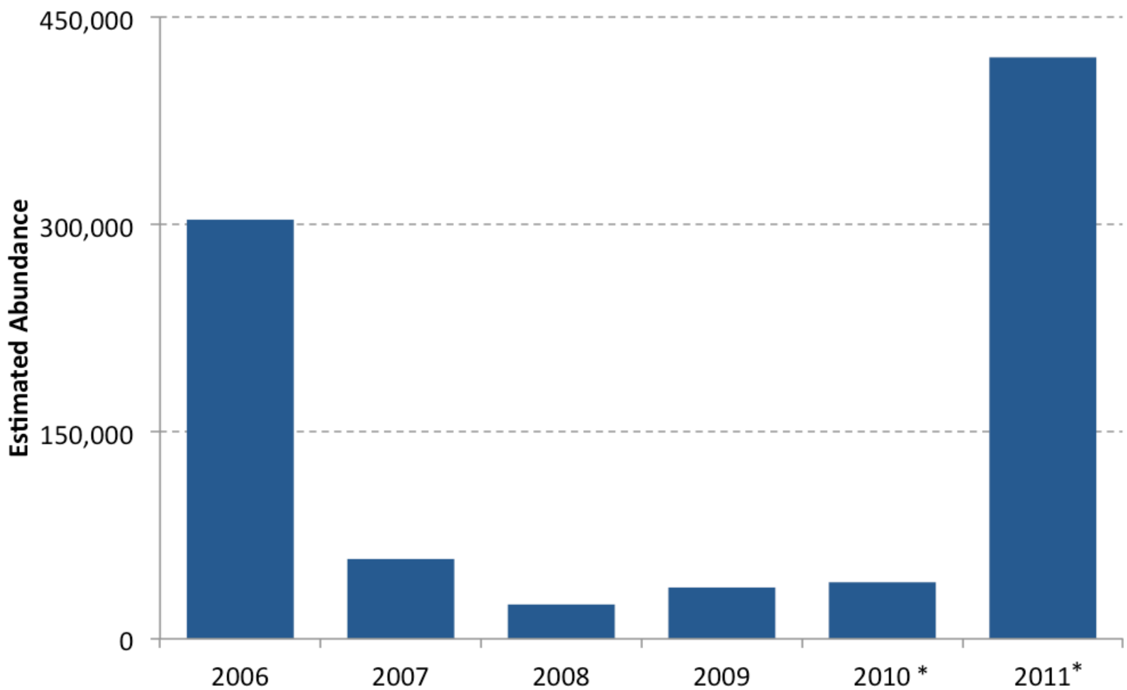

Figure 13.Total estimated Chinook passage at Waterford (2006-2011).

**Note that 2010-2011 estimates are based upon the median of historical trap efficiency.*

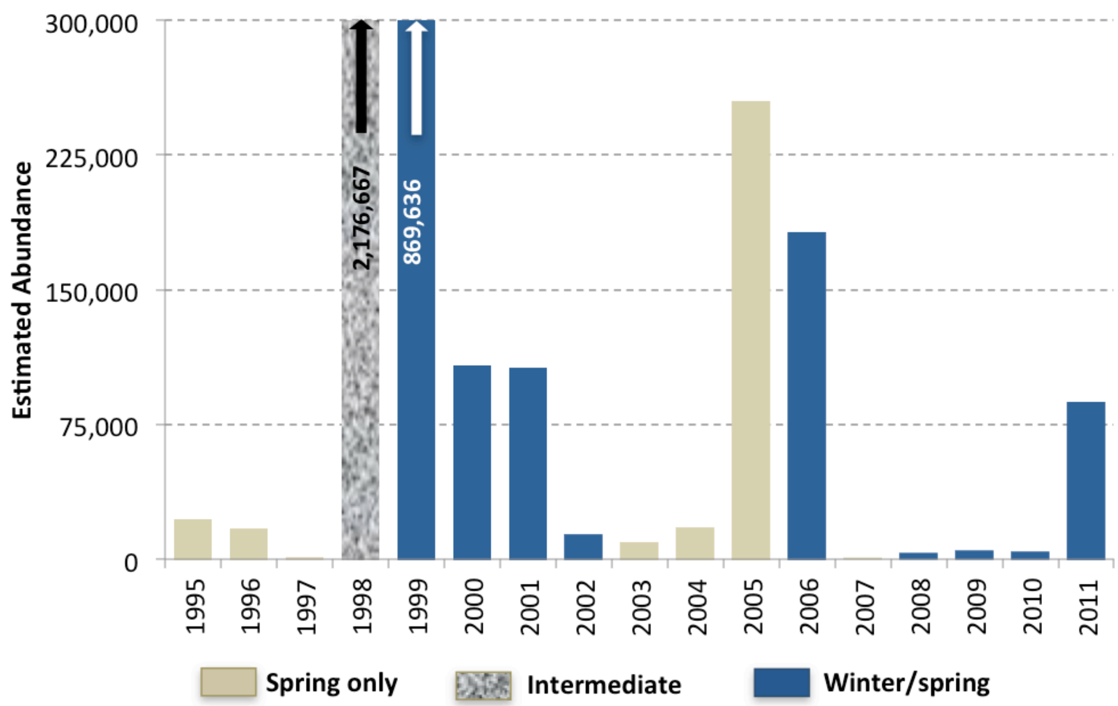

Figure 14. Total estimated Chinook passage at Shiloh and Grayson during 1995-2011. The color of the column defines the sampling period for that year.

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 high, fluctuated during this period (January to mid-March) and ranged from 1,580 cfs to 5,350 cfs. River flow near Grayson during the winter period was even more variable as a result of storm run-off, particularly from Dry Creek entering at Modesto, and ranged from 1,697 cfs to 7,490 cfs. Fewer fish moved past the Waterford trap during the spring (mid-March through June) compared to the winter period (Figure 11) even though releases were increased to over 8,000 cfs. Smolt peaks were observed at the Grayson traps, however, and were generally higher when flows were decreasing (Figure 12).

During 2011 monitoring, daily average water temperatures ranged from 49.3°F to 56.1°F at the Waterford trap (Figure 15) and from 48.3°F to 59.5°F at the Grayson traps (Figure 16). Water temperatures generally increased through the outmigration season. Fry passage at Waterford increased as temperatures decreased in January (Figure 15), and smolt passage appeared to peak with slight fluctuations in temperature at Grayson during the spring (Figure 16).

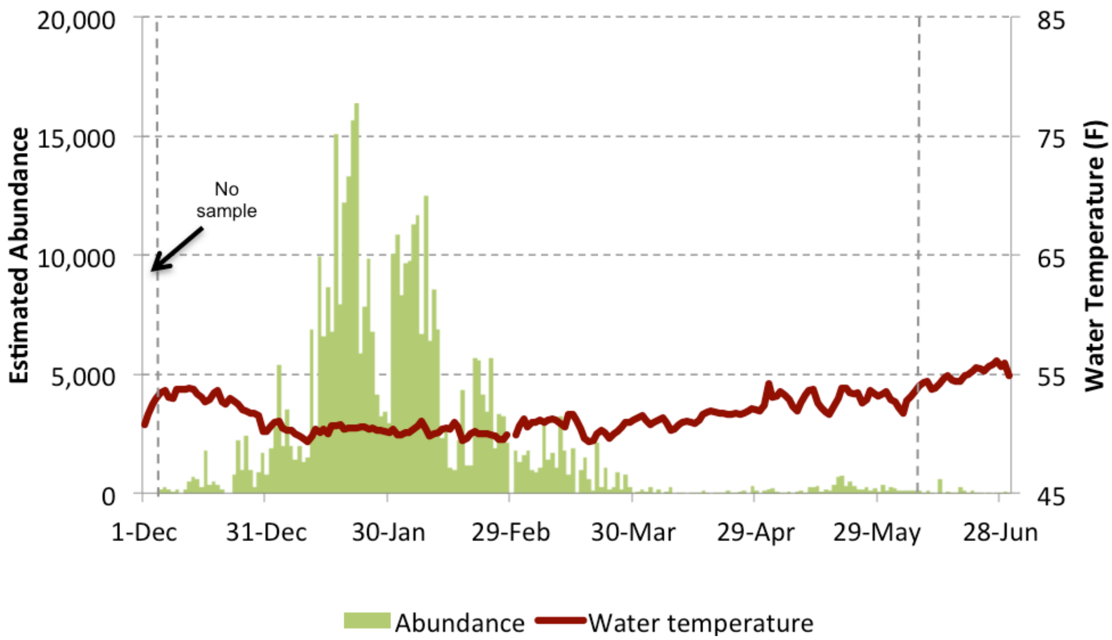

Figure 15. Daily estimated passage of unmarked Chinook salmon and daily average water temperature at the Waterford trap during 2011. NOTE: From March 16-June 30 the graph depicts median daily passage estimates - See Figure 9.

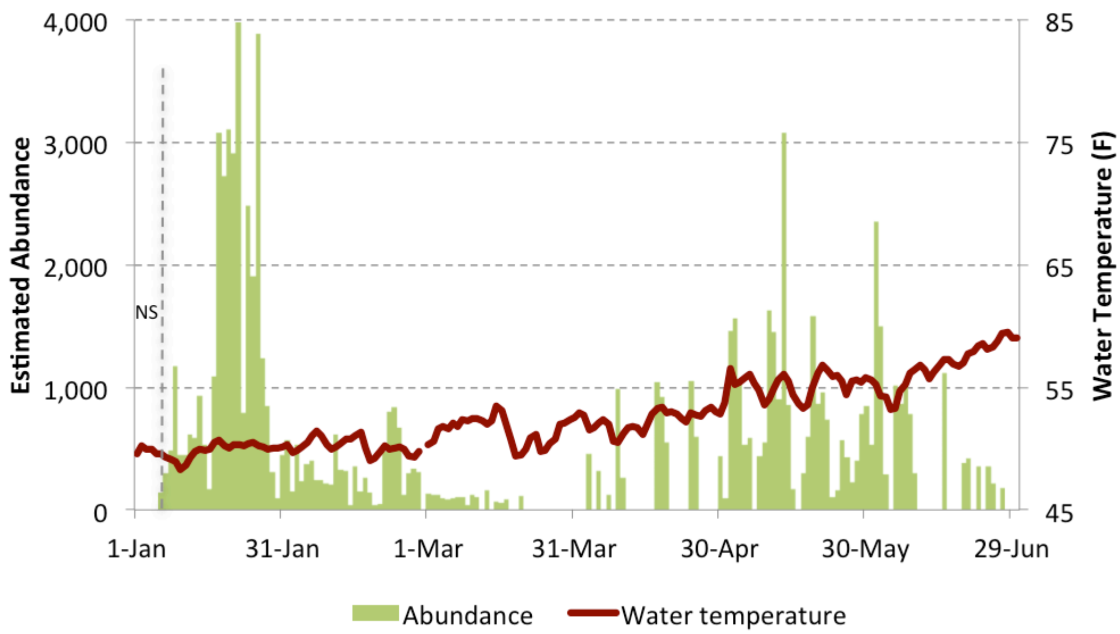

Figure 16. Daily estimated passage of unmarked Chinook salmon and daily average water temperature at the Grayson trap during 2011.

Background turbidity was generally less than 4.5 NTU at Waterford (Figure 17) and less than 7 NTU at Grayson (Figure 18) during the 2011 monitoring period. During several storm events (Figure 19), increases in turbidity were observed but only ranged as high as 8 NTU at Waterford and 13 NTU at Grayson. 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 2011, 20.7%, should be interpreted with caution, since there is some uncertainty in the total passage estimate for Waterford. This value was calculated using the median estimated total passage for Waterford, and ranges from 20.4% to 21.0% based upon the range of estimated passages. Survival indices were also calculated for 2006 and 2008-2011 (Table 7). A survival index was not calculated for 2007 because sampling did not begin until mid-March. The survival index for 2010 was calculated similar to 2011 and should also be interpreted with caution.

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

Year	Survival Index
2006	10.4
2008	23.6
2009	13.2
2010	11.9
2011	20.7

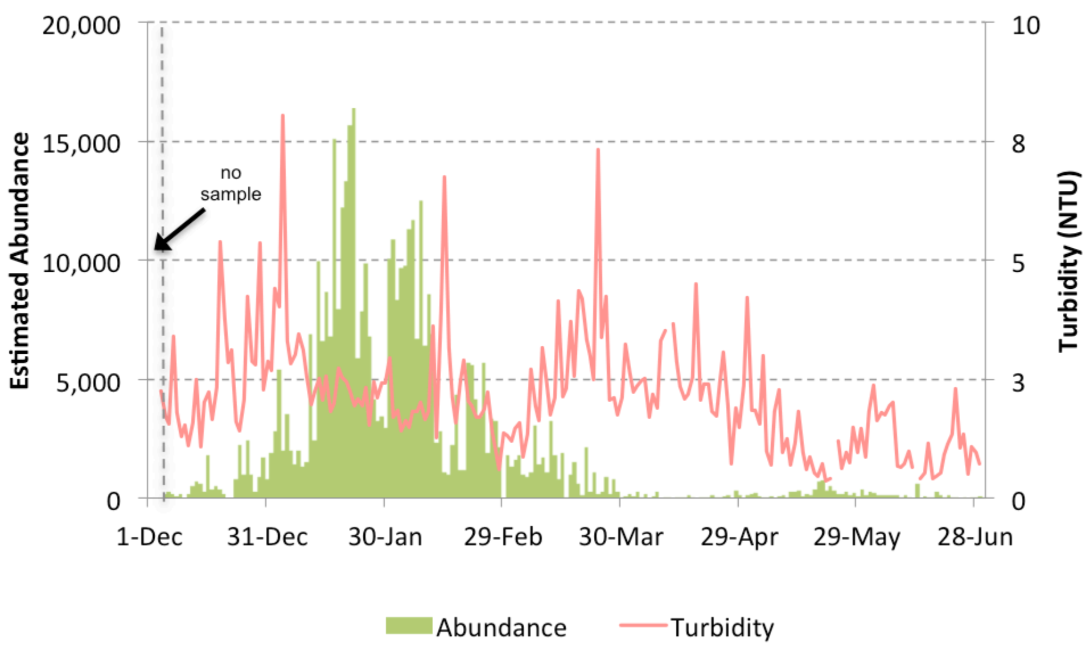

Figure 17. Daily estimated passage of unmarked Chinook salmon and instantaneous turbidity at Waterford during 2011. NOTE: From March 16-June 30 the graph depicts median daily passage estimates - See Figure 9.

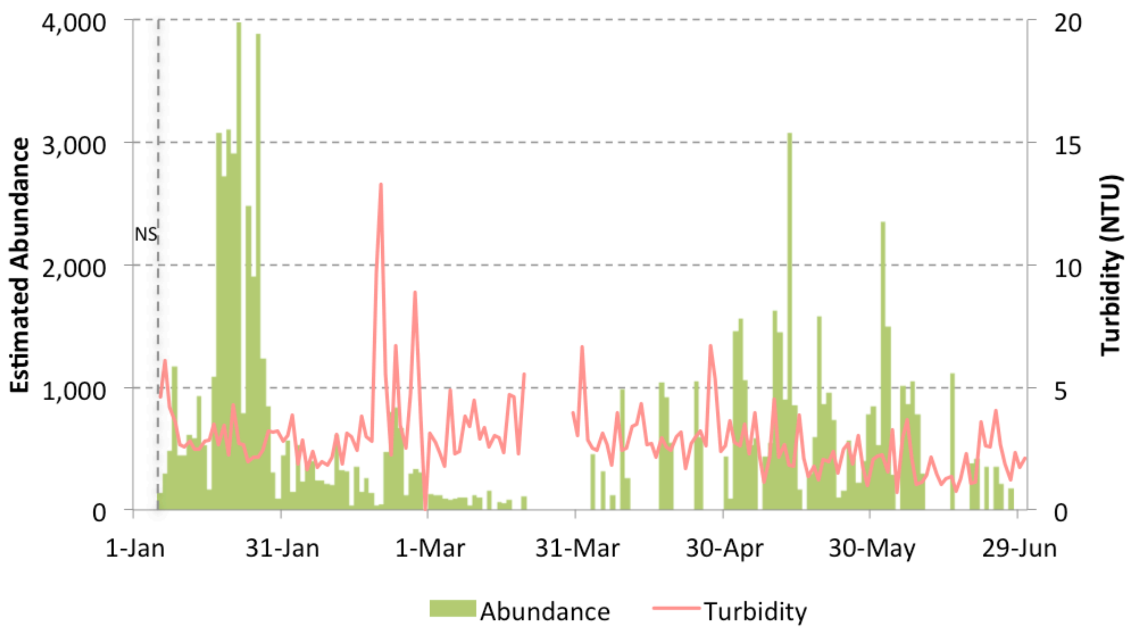

Figure 18. Daily estimated passage of unmarked Chinook salmon and instantaneous turbidity at Grayson during 2011.

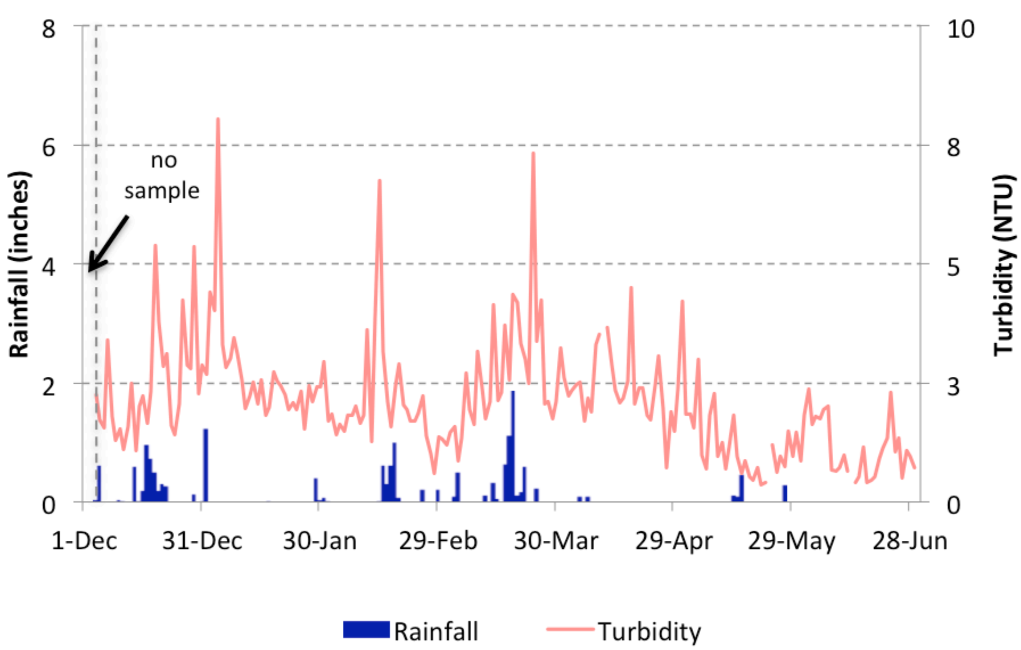

Figure 19. Daily rainfall measured at Don Pedro Reservoir and instantaneous turbidity at Waterford during 2011.

Chinook Salmon Length at Migration

Individual fork lengths of unmarked salmon captured at Waterford during 2011 ranged from 28 mm to 130 mm (Figure 20), and daily average length gradually increased from approximately 34 mm to over 90 mm during the course of the sampling period (Figure 21 and Figure 22). Most of the juvenile salmon passing Waterford during 2011 were fry measuring 30-39 mm (Figure 23). In total, it is estimated that 400,478 fry (<50 mm), 4,884 parr (50-69 mm), and 15,608 smolts (>70 mm) passed Waterford during 2011 (Table 5). Individual fork lengths of unmarked Chinook salmon captured at Grayson during 2011 ranged from 28 mm to 135 mm (Figure 24), and daily average length ranged between 32 mm and 115 mm during the sampling period (Figure 25 and Figure 26). More than 50% of the salmon estimated to have passed Grayson during 2011 were fry measuring 30-39 mm, followed by 41.5% passing as smolts measuring greater than 90 mm (Figure 26). In total, it is estimated that 45,781 fry (<50 mm), 1,654 parr (50-69 mm), and 39,737 smolts (>70 mm) passed Grayson during 2011 (Table 5).

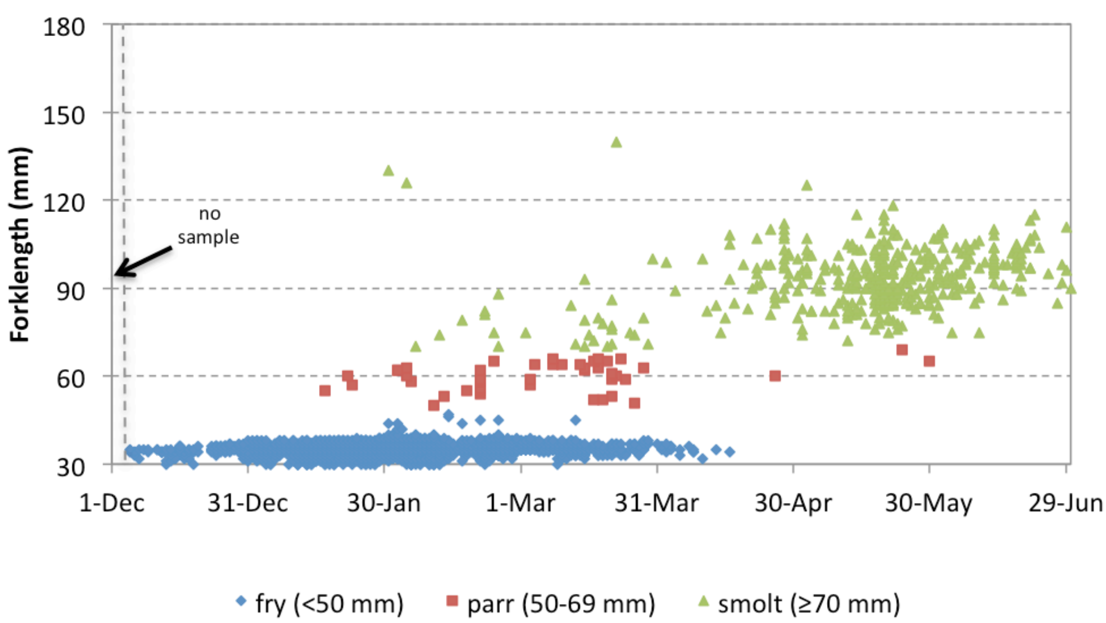

Figure 20. Individual fork lengths of juvenile salmon captured at Waterford during 2011.

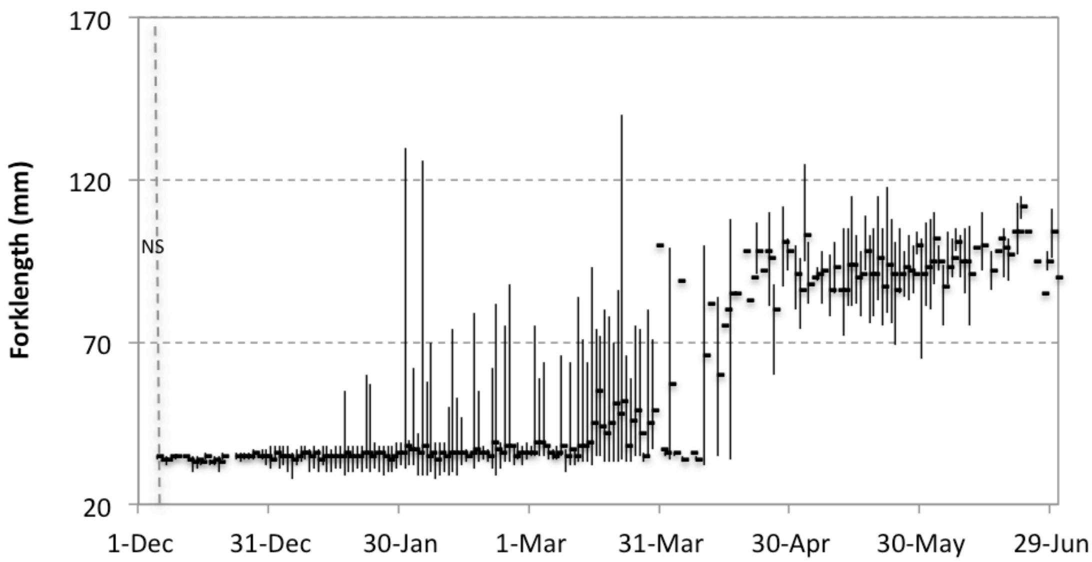

Figure 21. Daily minimum, average, and maximum fork lengths of unmarked Chinook salmon captured at Waterford during 2011.

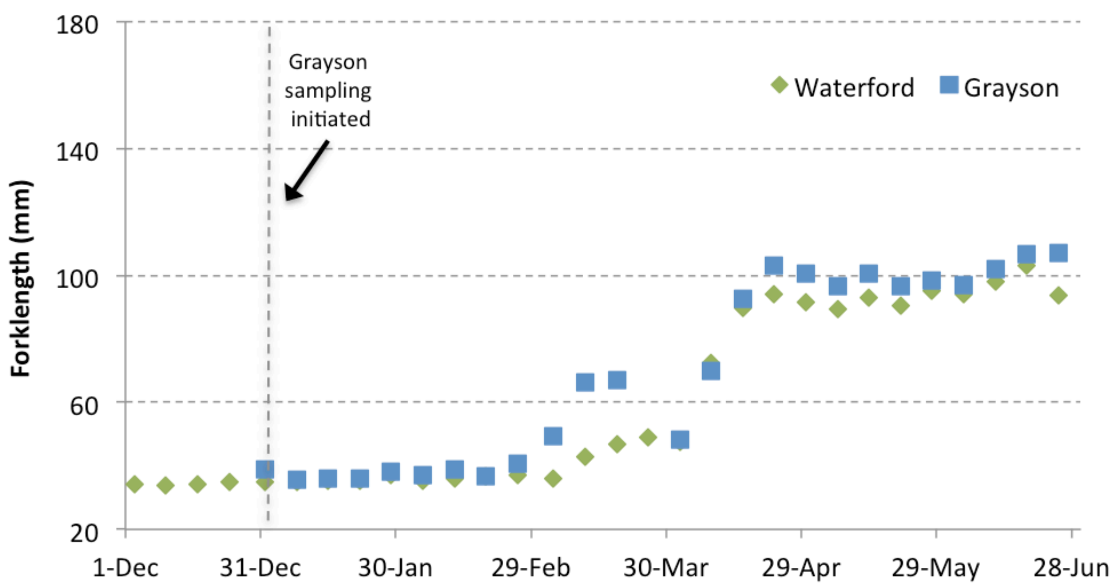

Figure 22. Average fork length of juvenile Chinook salmon captured at Waterford and Grayson by Julian week during 2011.

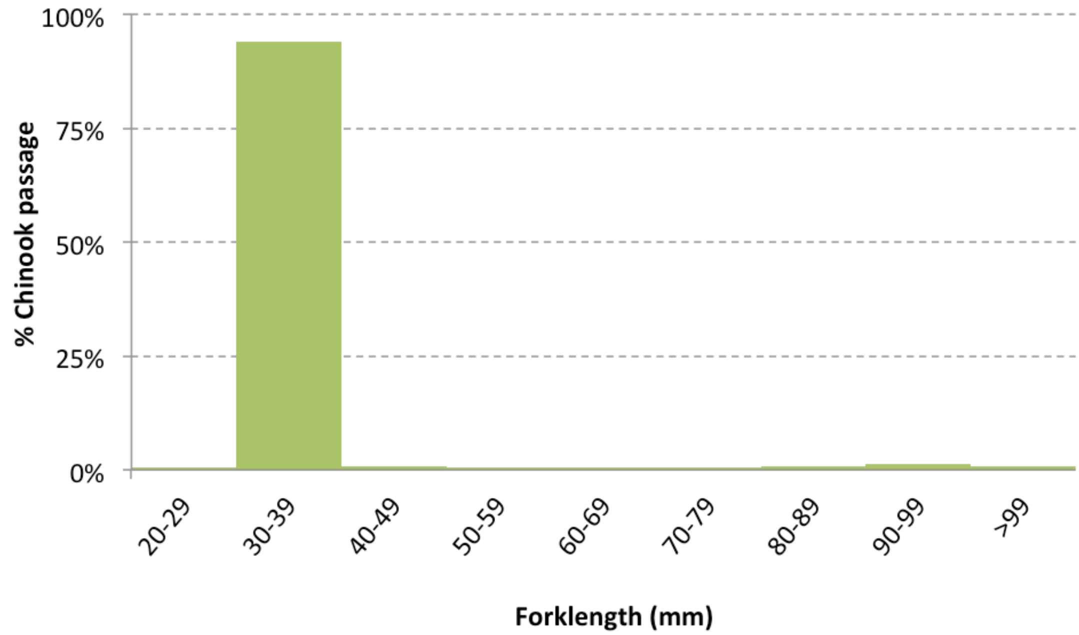

Figure 23. Length-frequency histogram of estimated Chinook passage (10 mm fork length bins) at Waterford during 2011.

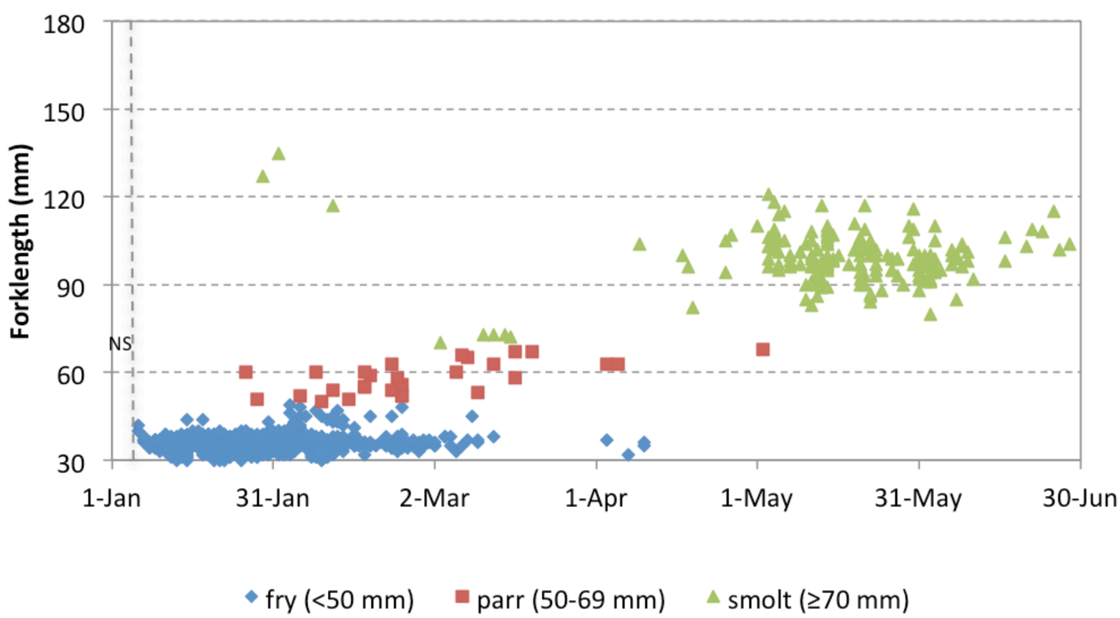

Figure 24. Individual fork lengths of juvenile salmon captured at Grayson during 2011.

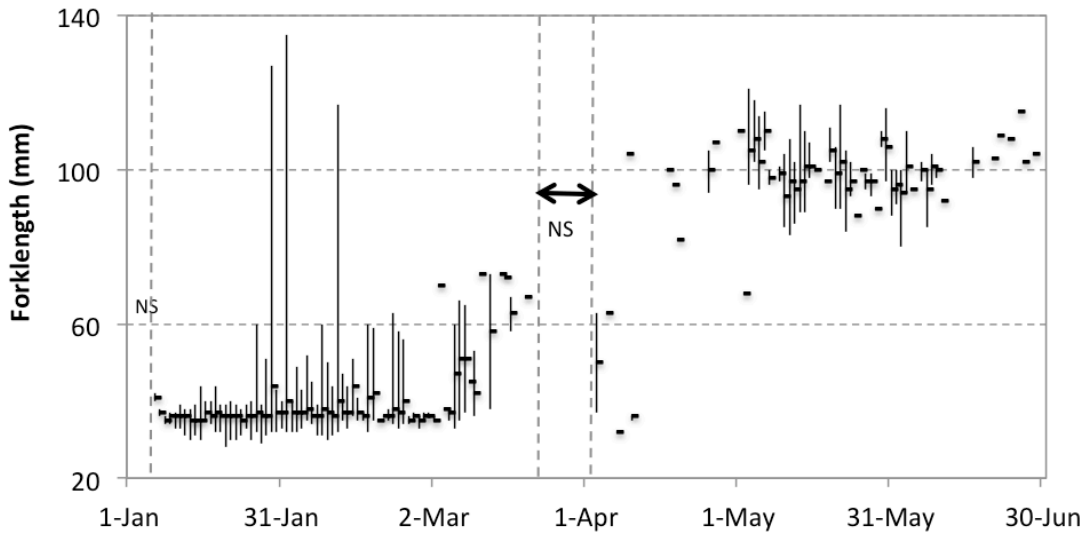

Figure 25. Daily minimum, average, and maximum fork lengths of unmarked Chinook salmon captured at Grayson during 2011.

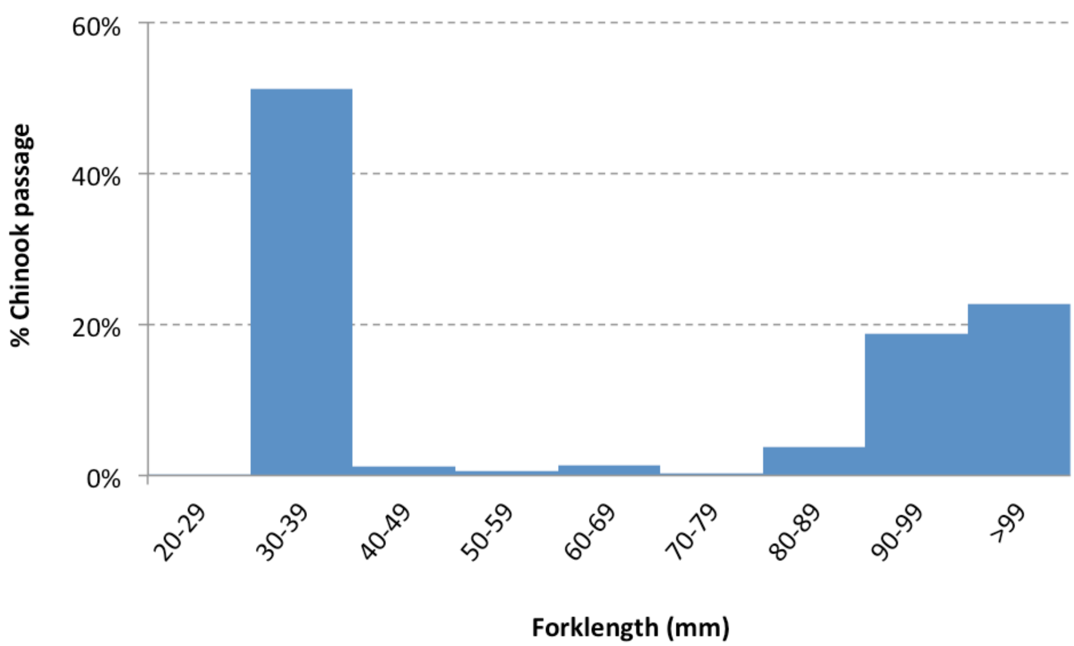

Figure 26. Length-frequency histogram of estimated Chinook passage (10 mm fork length bins) at Grayson during 2011.

Chinook Salmon Condition at Migration

Juveniles captured at both locations (Waterford and Grayson) during 2011 appeared healthy withoutvisually discernible signs of disease or stress. The length-weight relationship for individuals captured at both sites showed a very similar trend (Figure 27 and Figure 28).

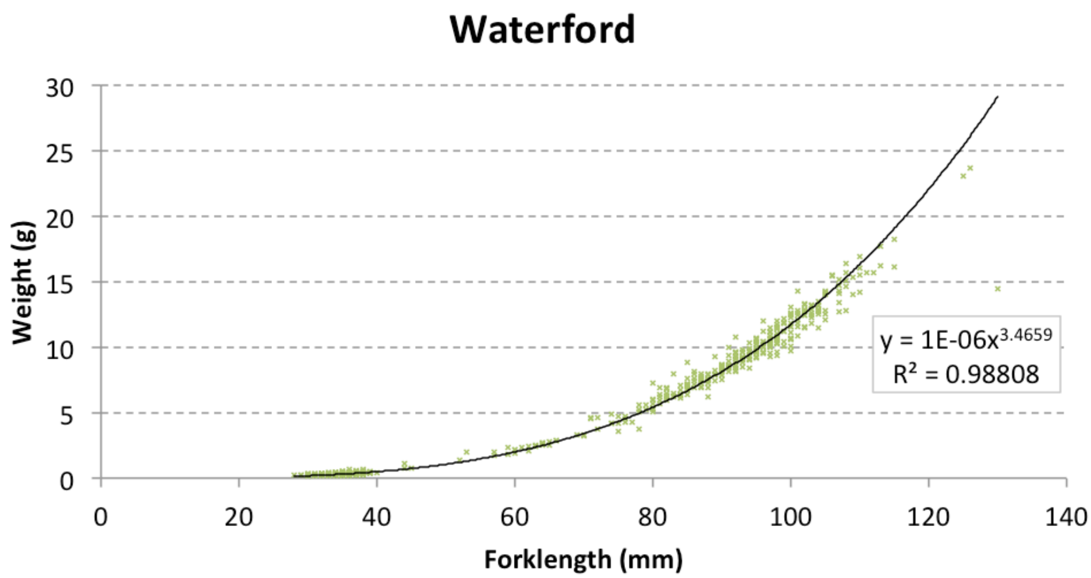

Figure 27. Length-weight relationship of fish measured at Waterford during 2011.

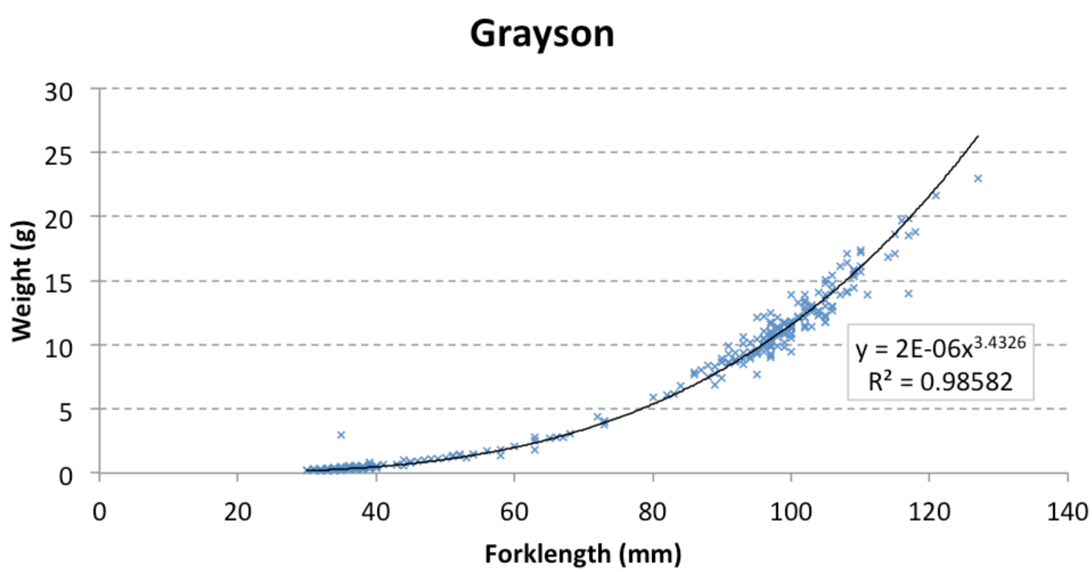

Figure 28. Length-weight relationship of fish measured at Grayson during 2011.

Oncorhynchus mykiss (Rainbow Trout/Steelhead)

No *O. mykiss* were captured at Waterford or Grayson in 2011.Total annual *O. mykiss* catch at the Grayson and Waterford traps between 2000 and 2011 ranged from 0 to 11 (Figure 29).

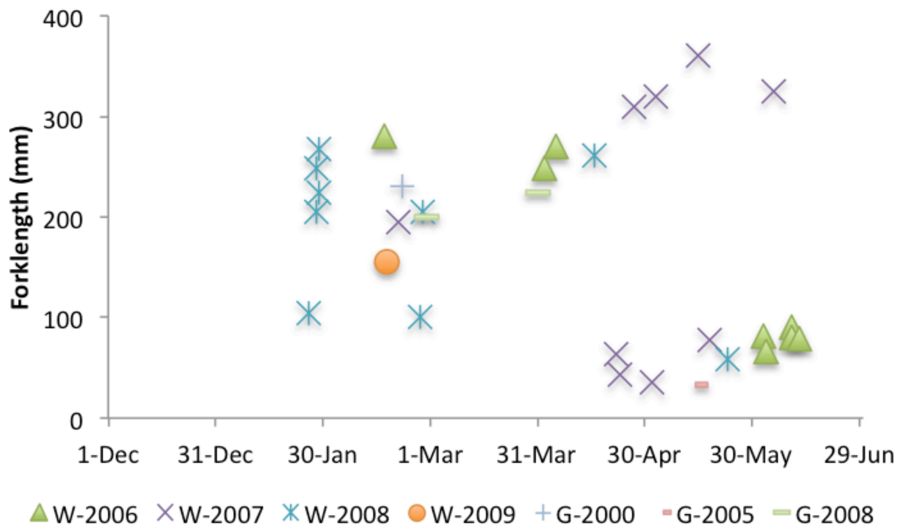

Figure 29. Date, size and location of *O. mykiss* captured at Waterford (W) and Grayson (G).

Other Fish Species Captured

A total of 49,265 non-salmonids representing at least 23 species (6 native, 17 introduced) were captured during operation of the Waterford and Grayson traps in 2011 (Table 8; Appendices C and D). Native species only comprised 1.7% of the total non-salmonid catch, consisting primarily of Sacramento pikeminnow (*n*=280). Most species captured at Waterford were also recorded at Grayson. Additional species only recorded at Waterford were green sunfish and threadfinshad. Species only recorded at Grayson were black bullhead, black crappie, carp, and inland silverside. 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.

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)
Catfish Family									
Black bullhead	*Ameiurusmelas*	0	-	-	-	2	34	40	45
Brown bullhead	*Ameiurusnebulosus*	1	-	-	-	2	-	-	-
Channel catfish	*Ictaluruspunctatus*	1	50	50	50	16	33	45	60
White catfish	*Ictaluruscatus*	2	71	85	98	183	23	44	78
Herring Family									
Threadfin shad	*Dorosomapetenense*	1	41	41	41	0	-	-	-
Lamprey Family									
Lamprey - unidentified	Not applicable	143	-	-	-	19	-	-	-
Livebearer Family									
Mosquitofish	*Gambusiaaffinis*	30	18	41	30	54	16	28	47
Minnow Family									
Carp	*Cyprinuscarpio*	0	-	-	-	47,535	9	25	47
Golden shiner	*Notemigonuscrysoleucas*	2	55	83	110	24	23	50	132
Hardhead	*Mylopharodonconocephalus*	52	22	33	48	122	24	37	55
Hitch	*Laviniaexilicauda*	1	45	45	45	1	54	54	54
Red shiner	*Cyprinellalutrennsis*	4	30	41	63	35	19	40	59
Sacramento pikeminnow	*Ptychocheliusgrandis*	109	25	38	92	171	21	43	86
Sculpin Family									
Prickly Sculpin	*Cottusasper*	4	80	103	124	1	43	43	43
Silverside Family									
Inland silverside	*Menidiaberyllina*	0	-	-	-	1	40	40	40
Sucker Family									

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)
Sacramento sucker	*Catostomusoccidentalis*	69	23	41	122	120	20	34	85
Sunfish Family									
Bluegill	*Lepomismacrochirus*	46	24	69	125	91	18	55	153
Black crappie	*Pomoxisannularis*	0	-	-	-	4	47	73	111
Green sunfish	*Lepomiscyanellus*	1	110	110	110	0	-	-	-
Largemouth bass	*Micropterussalmoides*	11	25	46	111	74	27	54	201
Redear sunfish	*Lepomismicrolophus*	15	30	79	133	20	31	76	200
Smallmouth bass	*Micropterusdolomieu*	3	28	52	82	20	21	72	227
Warmouth	*Lepomisgulosus*	4	31	84	122	14	30	55	80
Unidentified bass	Not applicable	12	25	30	46	44	12	27	130
Unidentified sunfish	Not applicable	1	-	-	-	2	22	25	27
Unidentified species	Not applicable	0	-	-	-	2	20	25	29

Total Species Captured = 23 (17 introduced, 6 native)

Total Native Individuals Captured = 812(378 at Waterford, 48,075 at Grayson)

Total Introduced Individuals Captured = 48,453 (121 at Waterford, 1,199 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 2011.

	Unmarked Chinook Salmon															*Environmental Conditions*			
		Fork Length (mm)			High Range	Estimated Passage - High				Low Range	Estimated Passage - Low				Median	Flow (cfs)		Temp	Turbidity
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	(NTU)
12/5/10	2	34	35	35	0.0098	203	0	0	203	0.0098	203	0	0	203	203	3890	2.8	53.4	1.73
12/6/10	3	33	34	34	0.0098	305	0	0	305	0.0098	305	0	0	305	305	3810	3.3	53.6	1.56
12/7/10	2	32	34	35	0.0098	203	0	0	203	0.0098	203	0	0	203	203	3000	3.4	53.0	3.41
12/8/10	1	35	35	35	0.0098	102	0	0	102	0.0098	102	0	0	102	102	2910	3.1	52.9	1.79
12/9/10	2	34	35	35	0.0098	203	0	0	203	0.0098	203	0	0	203	203	2900	2.6	53.7	1.29
12/10/10	0	-	-	-	0.0098	0	0	0	0	0.0098	0	0	0	0	0	2550	3.0	53.7	1.53
12/11/10	2	35	35	35	0.0098	203	0	0	203	0.0098	203	0	0	203	203	2130	2.5	53.7	1.11
12/12/10	5	34	34	34	0.0098	509	0	0	509	0.0098	509	0	0	509	509	1900	3.6	53.9	1.59
12/13/10	7	30	33	35	0.0098	712	0	0	712	0.0098	712	0	0	712	712	1890	3.6	53.7	2.50
12/14/10	6	31	34	35	0.0098	610	0	0	610	0.0098	610	0	0	610	610	2810	3.2	53.4	1.08
12/15/10	3	32	33	34	0.0098	305	0	0	305	0.0098	305	0	0	305	305	3810	3.4	53.1	2.01
12/16/10	18	34	35	36	0.0098	1831	0	0	1831	0.0098	1831	0	0	1831	1831	4590	4.6	52.7	2.23
12/17/10	4	32	33	34	0.0098	407	0	0	407	0.0098	407	0	0	407	407	5350	3.4	52.8	1.65
12/18/10	5	32	34	35	0.0098	509	0	0	509	0.0098	509	0	0	509	509	5330	3.0	53.5	2.33
12/19/10	4	30	33	35	0.0098	407	0	0	407	0.0098	407	0	0	407	407	5340	3.6	53.6	5.38
12/20/10	2	34	35	36	0.0098	203	0	0	203	0.0098	203	0	0	203	203	5320	1.8	52.7	3.78
12/21/10	0	-	-	-	0.0098	0	0	0	0	0.0098	0	0	0	0	0	5320	2.2	52.4	2.86
12/22/10	0	-	-	-	0.0098	0	0	0	0	0.0098	0	0	0	0	0	5340	3.9	52.9	3.10
12/23/10	8	34	35	36	0.0098	814	0	0	814	0.0098	814	0	0	814	814	5320	2.8	52.7	1.61
12/24/10	22	33	35	36	0.0098	2238	0	0	2238	0.0098	2238	0	0	2238	2238	5340	3.2	52.4	1.42
12/25/10	10	34	35	36	0.0098	1017	0	0	1017	0.0098	1017	0	0	1017	1017	5340	2.5	52.0	2.06
12/26/10	24	34	35	36	0.0098	2441	0	0	2441	0.0098	2441	0	0	2441	2441	5320	4.3	51.9	4.24
12/27/10	10	34	36	37	0.0098	1017	0	0	1017	0.0098	1017	0	0	1017	1017	5320	3.0	51.7	2.87
12/28/10	3	35	35	36	0.0098	305	0	0	305	0.0098	305	0	0	305	305	5310	3.3	51.7	2.81
12/29/10	9	34	35	37	0.0098	915	0	0	915	0.0098	915	0	0	915	915	4870	3.6	51.5	5.35
12/30/10	17	32	35	37	0.0098	1729	0	0	1729	0.0098	1729	0	0	1729	1729	5320	3.6	50.2	2.27
12/31/10	8	31	34	38	0.0098	814	0	0	814	0.0098	814	0	0	814	814	5320	3.2	50.2	2.88
1/1/11	19	33	36	38	0.0098	1933	0	0	1933	0.0098	1933	0	0	1933	1933	5330	3.1	50.7	2.68
1/2/11	28	31	35	38	0.0098	2848	0	0	2848	0.0098	2848	0	0	2848	2848	5060	2.3	51.0	4.41
1/3/11	53	32	35	38	0.0098	5391	0	0	5391	0.0098	5391	0	0	5391	5391	5330	2.6	51.1	4.01
1/4/11	20	30	35	38	0.0098	2034	0	0	2034	0.0098	2034	0	0	2034	2034	5310	2.6	50.4	8.04
1/5/11	35	28	34	36	0.0098	3560	0	0	3560	0.0098	3560	0	0	3560	3560	5320	3.5	50.2	3.31
1/6/11	20	32	35	37	0.0098	2034	0	0	2034	0.0098	2034	0	0	2034	2034	5350	3.1	50.2	2.82
1/7/11	14	33	36	38	0.0098	1424	0	0	1424	0.0098	1424	0	0	1424	1424	5260	3.7	50.0	3.01
1/8/11	20	34	36	38	0.0098	2034	0	0	2034	0.0098	2034	0	0	2034	2034	4920	3.0	49.8	3.45
1/9/11	13	30	35	37	0.0098	1322	0	0	1322	0.0098	1322	0	0	1322	1322	4390	3.6	49.6	3.12

	Unmarked Chinook Salmon															Environmental Conditions			
		Fork Length (mm)			High Range	Estimated Passage - High				Low Range	Estimated Passage - Low				Median	Flow (cfs)		Temp	Turbidity
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	(NTU)
1/10/11	15	31	36	38	0.0098	1526	0	0	1526	0.0098	1526	0	0	1526	1526	3810	2.8	49.3	2.55
1/11/11	68	30	34	37	0.0098	6917	0	0	6917	0.0098	6917	0	0	6917	6917	3340	3.1	49.8	1.96
1/12/11	24	32	35	38	0.0098	2441	0	0	2441	0.0098	2441	0	0	2441	2441	2940	2.9	50.3	2.23
1/13/11	98	30	35	38	0.0098	9968	0	0	9968	0.0098	9968	0	0	9968	9968	2530	4.0	50.0	2.52
1/14/11	65	30	35	37	0.0098	6611	0	0	6611	0.0098	6611	0	0	6611	6611	2160	3.5	50.4	2.07
1/15/11	85	31	35	38	0.0098	8623	23	0	8646	0.0098	8623	23	0	8646	8646	2150	3.6	50.0	2.57
1/16/11	67	31	35	38	0.0098	6797	18	0	6815	0.0098	6797	18	0	6815	6815	4730	3.2	50.7	1.82
1/17/11	148	29	36	55	0.0098	15014	40	0	15054	0.0098	15014	40	0	15054	15054	5000	2.7	50.7	1.99
1/18/11	78	30	35	38	0.0098	7913	21	0	7934	0.0098	7913	21	0	7934	7934	4930	3.0	50.7	2.73
1/19/11	120	30	35	38	0.0098	12174	32	0	12206	0.0098	12174	32	0	12206	12206	4860	2.7	50.4	2.53
1/20/11	131	31	35	38	0.0098	13290	35	0	13325	0.0098	13290	35	0	13325	13325	4960	3.0	50.5	2.45
1/21/11	154	30	36	38	0.0098	15623	41	0	15664	0.0098	15623	41	0	15664	15664	5130	3.3	50.4	2.24
1/22/11	161	31	36	60	0.0098	16280	96	0	16376	0.0098	16280	96	0	16376	16376	5120	4.0	50.4	1.95
1/23/11	58	30	35	57	0.0098	5865	35	0	5899	0.0098	5865	35	0	5899	5899	4770	3.8	50.5	2.08
1/24/11	77	31	36	39	0.0098	7786	46	0	7832	0.0098	7786	46	0	7832	7832	4270	3.3	50.5	1.95
1/25/11	97	30	36	38	0.0098	9808	58	0	9866	0.0098	9808	58	0	9866	9866	3810	3.5	50.3	2.33
1/26/11	67	29	35	38	0.0098	6775	40	0	6815	0.0098	6775	40	0	6815	6815	3420	2.5	50.4	1.54
1/27/11	41	30	34	38	0.0098	4146	25	0	4170	0.0098	4146	25	0	4170	4170	3200	2.9	50.2	2.45
1/28/11	32	30	35	38	0.0098	3236	19	0	3255	0.0098	3236	19	0	3255	3255	2820	3.0	50.3	2.11
1/29/11	34	31	36	39	0.0098	3397	41	21	3458	0.0098	3397	41	21	3458	3458	2520	3.6	50.1	2.43
1/30/11	29	32	36	39	0.0098	2897	35	18	2950	0.0098	2897	35	18	2950	2950	2210	2.9	50.1	2.43
1/31/11	99	31	38	130	0.0098	9890	120	60	10070	0.0098	9890	120	60	10070	10070	1910	3.8	50.4	2.94
2/1/11	107	32	37	40	0.0098	10689	130	65	10883	0.0098	10689	130	65	10883	10883	1610	3.5	49.9	1.71
2/2/11	82	32	37	62	0.0098	8192	99	50	8341	0.0098	8192	99	50	8341	8341	1580	3.7	49.9	1.84
2/3/11	95	29	36	42	0.0098	9490	115	58	9663	0.0098	9490	115	58	9663	9663	1590	3.6	50.0	1.42
2/4/11	96	29	38	126	0.0098	9590	116	58	9765	0.0098	9590	116	58	9765	9765	1660	3.5	50.1	1.62
2/5/11	111	29	35	58	0.0098	11170	60	60	11290	0.0098	11170	60	60	11290	11290	1880	3.9	50.3	1.49
2/6/11	115	30	36	70	0.0098	11572	62	62	11697	0.0098	11572	62	62	11697	11697	1880	3.6	50.7	1.83
2/7/11	66	28	34	39	0.0098	6642	36	36	6713	0.0098	6642	36	36	6713	6713	1900	3.6	51.0	1.82
2/8/11	123	29	36	39	0.0098	1237	67	67	1251	0.0098	1237	67	67	12511	12511	1900	3.6	50.4	2.00

	Unmarked Chinook Salmon															Environmental Conditions			
		Fork Length (mm)			High Range Est.	Estimated Passage - High				Low Range Est.	Estimated Passage - Low				Median	Flow (cfs)		Temp	Turbidity
Date	Catch	Min	Avg	Max	Efficiency	Fry	Parr	Smolt	Total	Efficiency	Fry	Parr	Smolt	Total	Passage	La Grange	Velocity (ft/s)	at Trap	(NTU)
						7			1		7								
2/9/11	63	30	35	39	0.0098	6340	34	34	6408	0.0098	6340	34	34	6408	6408	2450	3.6	49.8	1.66
2/10/11	84	29	36	50	0.0098	8453	46	46	8544	0.0098	8453	46	46	8544	8544	2770	4.0	50.0	1.83
2/11/11	68	30	36	74	0.0098	6843	37	37	6917	0.0098	6843	37	37	6917	6917	2780	4.0	50.1	3.61
2/12/11	23	29	36	53	0.0098	2292	31	16	2339	0.0098	2292	31	16	2339	2339	2810	4.5	50.4	1.27
2/13/11	28	32	36	47	0.0098	2791	38	19	2848	0.0098	2791	38	19	2848	2848	2800	4.5	50.5	3.87
2/14/11	11	33	35	37	0.0098	1096	15	8	1119	0.0098	1096	15	8	1119	1119	2790	4.2	50.4	6.74
2/15/11	10	35	36	36	0.0098	997	14	7	1017	0.0098	997	14	7	1017	1017	2790	3.8	50.9	3.15
2/16/11	22	31	37	79	0.0098	2193	30	15	2238	0.0098	2193	30	15	2238	2238	3170	nd	50.6	2.10
2/17/11	43	33	36	55	0.0098	4286	59	29	4374	0.0098	4286	59	29	4374	4374	3180	4.1	49.4	1.59
2/18/11	12	34	36	38	0.0098	1196	16	8	1221	0.0098	1196	16	8	1221	1221	4040	4.2	49.6	2.45
2/19/11	12	33	35	37	0.0098	1164	33	23	1221	0.0098	1164	33	23	1221	1221	4490	4.8	50.0	2.90
2/20/11	56	31	39	62	0.0098	5434	153	109	5696	0.0098	5434	153	109	5696	5696	4500	4.5	50.1	2.04
2/21/11	55	29	37	82	0.0098	5337	150	107	5594	0.0098	5337	150	107	5594	5594	4510	4.3	50.0	1.95
2/22/11	41	31	36	39	0.0098	3979	112	80	4170	0.0098	3979	112	80	4170	4170	4540	4.3	50.0	1.69
2/23/11	34	33	38	75	0.0098	3299	93	66	3458	0.0098	3299	93	66	3458	3458	4510	3.5	50.0	1.70
2/24/11	56	33	38	88	0.0098	5434	153	109	5696	0.0098	5434	153	109	5696	5696	4520	4.3	49.9	1.87
2/25/11	19	32	35	38	0.0098	1844	52	37	1933	0.0098	1844	52	37	1933	1933	4550	2.8	49.8	2.23
2/26/11	33	34	36	39	0.0098	3264	69	23	3357	0.0098	3264	69	23	3357	3357	4540	2.8	49.5	1.39
2/27/11	32	32	36	38	0.0098	3165	67	22	3255	0.0098	3165	67	22	3255	3255	4530	3.2	49.5	1.01
2/28/11	21	34	36	39	0.0098	2077	44	15	2136	0.0098	2077	44	15	2136	2136	4550	3.1	49.9	0.61
3/1/11	18	35	36	38	0.0098	1780	38	13	1831	0.0098	1780	38	13	1831	1831	4530	4.3	49.9	1.36
3/2/11	13	35	39	75	0.0098	1286	27	9	1322	0.0098	1286	27	9	1322	1322	4540	4.4	50.6	1.32
3/3/11	16	35	39	59	0.0098	1583	34	11	1627	0.0098	1583	34	11	1627	1627	5000	3.8	51.2	1.20
3/4/11	18	35	38	64	0.0098	1780	38	13	1831	0.0098	1780	38	13	1831	1831	4520	4.1	50.6	1.47
3/5/11	10	34	36	38	0.0098	987	30	0	1017	0.0098	987	30	0	1017	1017	3980	3.3	51.0	1.59
3/6/11	9	34	35	37	0.0098	889	27	0	915	0.0098	889	27	0	915	915	3780	3.4	51.0	0.9
3/7/11	11	34	36	38	0.0098	1086	33	0	1119	0.0098	1086	33	0	1119	1119	3780	3.4	51.1	1.35
3/8/11	30	35	38	66	0.0098	2962	90	0	3051	0.0098	2962	90	0	3051	3051	3770	3.8	51.0	2.71
3/9/11	14	30	35	37	0.0098	1382	42	0	1424	0.0098	1382	42	0	1424	1424	3790	3.5	51.1	1.94
3/10/11	17	32	37	64	0.0098	1678	51	0	1729	0.0098	1678	51	0	1729	1729	3780	4.2	51.3	1.63
3/11/11	11	32	35	37	0.0098	1086	33	0	1119	0.0098	1086	33	0	1119	1119	3660	3.8	51.1	3.17
3/12/11	32	33	38	84	0.0098	2785	219	250	3255	0.0098	2785	219	250	3255	3255	3280	3.4	50.9	2.39
3/13/11	18	33	38	71	0.0098	1567	123	141	1831	0.0098	1567	123	141	1831	1831	2870	3.4	50.6	1.75
3/14/11	8	33	39	64	0.0098	696	55	63	814	0.0098	696	55	63	814	814	2680	4.2	51.6	2.10
3/15/11	19	32	45	93	0.0098	1654	130	149	1933	0.0098	1654	130	149	1933	1933	2700	3.8	51.6	4.14
3/16/11	2	35	55	74	0.0560	86	7	8	100	0.0200	31	2	3	36	68	2830	4.0	51.2	2.14
3/17/11	10	35	44	72	0.0098	870	68	78	1017	0.0098	870	68	78	1017	1017	3320	4.2	50.4	2.30

	Unmarked Chinook Salmon															*Environmental Conditions*			
		Fork Length (mm)			High Range Est. Efficiency	Estimated Passage - High				Low Range Est. Efficiency	Estimated Passage - Low				Median	Flow (cfs)		Temp	Turbidity
Date	Catch	Min	Avg	Max		Fry	Parr	Smolt	Total		Fry	Parr	Smolt	Total	Passage	La Grange	Velocity (ft/s)	at Trap	(NTU)
3/18/11	15	33	42	80	0.0098	1306	103	117	1526	0.0098	1306	103	117	1526	1526	3500	4.2	49.6	3.72
3/19/11	6	33	45	78	0.0098	422	100	89	610	0.0098	422	100	89	610	610	4850	4.0	49.3	2.56
3/20/11	4	33	51	70	0.0560	138	33	29	200	0.0200	49	12	10	71	136	5260	4.2	49.4	4.4
3/21/11	21	33	48	86	0.0098	1476	350	311	2136	0.0098	1476	350	311	2136	2136	6380	4.8	50.0	4.19
3/22/11	8	34	52	140	0.0560	276	65	58	400	0.0200	99	23	21	143	271	7110	4.1	50.3	3.32
3/23/11	11	33	38	66	0.0098	773	183	163	1119	0.0098	773	183	163	1119	1119	7660	2.5	50.0	2.99
3/24/11	2	33	46	59	0.0098	141	33	30	203	0.0098	141	33	30	203	203	7260	2.7	49.6	2.49
3/25/11	3	35	49	75	0.0098	211	50	44	305	0.0098	211	50	44	305	305	7120	nd	50.0	7.33
3/26/11	9	35	42	74	0.0098	704	70	141	915	0.0098	704	70	141	915	915	7140	3.0	50.2	3.37
3/27/11	2	33	35	36	0.0098	156	16	31	203	0.0098	156	16	31	203	203	7510	3.6	50.5	4.24
3/28/11	8	35	45	80	0.0098	626	63	125	814	0.0098	626	63	125	814	814	7780	3.6	51.0	2.05
3/29/11	3	37	49	71	0.0098	235	23	47	305	0.0098	235	23	47	305	305	8110	3.9	51.0	2.10
3/30/11	1	100	100	100	0.0560	38	4	8	50	0.0200	14	1	3	18	34	8320	3.8	51.1	1.76
3/31/11	1	37	37	37	0.0098	78	8	16	102	0.0098	78	8	16	102	102	8310	3.8	51.4	2.11
4/1/11	2	35	36	36	0.0098	156	16	31	203	0.0098	156	16	31	203	203	8330	3.1	51.5	3.22
4/2/11	3	34	57	99	0.0560	127	0	23	150	0.0200	45	0	8	54	102	8360	3.6	51.2	2.62
4/3/11	3	35	36	36	0.0098	258	0	47	305	0.0098	258	0	47	305	305	8330	4.4	50.7	2.22
4/4/11	1	89	89	89	0.0560	42	0	8	50	0.0200	15	0	3	18	34	8310	4.4	50.9	2.35
4/5/11	2	33	34	35	0.0098	172	0	31	203	0.0098	172	0	31	203	203	8330	4.0	51.2	2.5
4/6/11	0	-	-	-	0.0560	0	0	0	0	0.0200	0	0	0	0	0	8330	4.0	51.3	2.51
4/7/11	1	36	36	36	0.0098	86	0	16	102	0.0098	86	0	16	102	102	7570	4.7	50.9	1.71
4/8/11	3	34	34	35	0.0098	258	0	47	305	0.0098	258	0	47	305	305	7720	4.6	50.3	2.18
4/9/11	0	-	-	-	0.0560	0	0	0	0	0.0200	0	0	0	0	0	8310	4.7	50.4	1.89
4/10/11	2	32	66	100	0.0560	29	0	71	100	0.0200	10	0	26	36	68	8320	4.2	50.8	3.30
4/11/11	1	82	82	82	0.0560	14	0	36	50	0.0200	5	0	13	18	34	8320	3.5	51.0	3.53
4/12/11	0	-	-	-	0.0560	0	0	0	0	0.0200	0	0	0	0	0	8290	nd	51.1	nd
4/13/11	2	35	60	84	0.0560	29	0	71	100	0.0200	10	0	26	36	68	8330	4.6	50.9	3.67
4/14/11	1	75	75	75	0.0560	14	0	36	50	0.0200	5	0	13	18	34	8340	4.2	50.8	2.87
4/15/11	1	80	80	80	0.0560	14	0	36	50	0.0200	5	0	13	18	34	8320	4.4	51.2	2.34
4/16/11	5	34	85	108	0.0560	21	0	229	250	0.0200	7	0	82	89	170	8310	3.8	51.6	2.08
4/17/11	1	85	85	85	0.0560	4	0	46	50	0.0200	1	0	16	18	34	8340	4.6	51.8	2.19
4/18/11	0	-	-	-	0.0560	0	0	0	0	0.0200	0	0	0	0	0	8160	3.8	51.9	2.54
4/19/11	1	98	98	98	0.0560	4	0	46	50	0.0200	1	0	16	18	34	7710	4.2	51.8	4.51
4/20/11	1	83	83	83	0.0560	4	0	46	50	0.0200	1	0	16	18	34	7330	4.7	51.7	2.06
4/21/11	1	90	90	90	0.0560	4	0	46	50	0.0200	1	0	16	18	34	7040	4.1	51.7	2.40
4/22/11	4	91	98	107	0.0560	17	0	183	200	0.0200	6	0	65	71	136	6760	4.7	51.6	2.4
4/23/11	1	92	92	92	0.0560	0	2	48	50	0.0200	0	1	17	18	34	6430	3.7	51.6	1.81
4/24/11	2	98	98	98	0.0560	0	4	96	100	0.0200	0	2	34	36	68	6130	4.2	51.7	1.73

	Unmarked Chinook Salmon																Environmental Conditions			
		Fork Length (mm)			High Range	Estimated Passage - High				Low Range	Estimated Passage - Low				Median	Flow (cfs)		Temp	Turbidity
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	(NTU)
4/25/11	3	81	96	110	0.0560	0	7	143	150	0.0200	0	2	51	54	102	5780	2.6	51.6	2.44
4/26/11	4	60	80	88	0.0560	0	9	191	200	0.0200	0	3	68	71	136	5640	2.8	51.7	3.07
4/27/11	0	-	-	-	0.0560	0	0	0	0	0.0200	0	0	0	0	0	5630	3.1	51.9	1.97
4/28/11	10	87	101	112	0.0560	0	22	478	500	0.0200	0	8	171	179	339	5550	2.4	52.1	0.72
4/29/11	4	92	98	102	0.0560	0	9	191	200	0.0200	0	3	68	71	136	4890	3.1	52.0	1.9
4/30/11	0	-	-	-	0.0560	0	0	0	0	0.0200	0	0	0	0	0	4110	3.2	51.9	1.48
5/1/11	4	80	91	100	0.0560	0	0	200	200	0.0200	0	0	71	71	136	3470	3.1	52.4	2.37
5/2/11	6	74	86	96	0.0560	0	0	300	300	0.0200	0	0	107	107	204	3380	3.1	54.2	4.20
5/3/11	7	95	103	125	0.0560	0	0	350	350	0.0200	0	0	125	125	238	3370	2.8	53.0	1.85
5/4/11	3	82	88	101	0.0560	0	0	150	150	0.0200	0	0	54	54	102	3360	3.4	53.1	1.84
5/5/11	1	90	90	90	0.0560	0	0	50	50	0.0200	0	0	18	18	34	3550	3.4	53.5	1.55
5/6/11	2	89	91	93	0.0560	0	0	100	100	0.0200	0	0	36	36	68	3780	3.1	53.3	3.00
5/7/11	3	82	92	98	0.0560	0	0	150	150	0.0200	0	0	54	54	102	3780	3.4	52.9	0.99
5/8/11	0	-	-	-	0.0560	0	0	0	0	0.0200	0	0	0	0	0	3780	3.6	52.3	0.70
5/9/11	3	78	86	97	0.0560	0	0	150	150	0.0200	0	0	54	54	102	3780	3.4	51.9	1.81
5/10/11	5	85	93	101	0.0560	0	0	250	250	0.0200	0	0	89	89	170	3720	2.9	52.5	2.28
5/11/11	1	86	86	86	0.0560	0	0	50	50	0.0200	0	0	18	18	34	3550	3.0	53.3	0.95
5/12/11	8	72	86	105	0.0560	0	0	400	400	0.0200	0	0	143	143	271	3240	2.8	53.6	1.25
5/13/11	9	81	94	105	0.0560	0	0	450	450	0.0200	0	0	161	161	305	3000	3.6	53.7	0.69
5/14/11	10	81	94	115	0.0560	0	0	500	500	0.0200	0	0	179	179	339	2990	3.3	52.6	1.15
5/15/11	3	82	90	103	0.0560	0	0	150	150	0.0200	0	0	54	54	102	2980	3.6	52.1	1.81
5/16/11	6	78	91	98	0.0560	0	0	300	300	0.0200	0	0	107	107	204	2960	3.1	51.8	0.97
5/17/11	4	92	98	109	0.0560	0	0	200	200	0.0200	0	0	71	71	136	3000	3.5	51.6	0.61
5/18/11	12	76	91	103	0.0560	0	0	600	600	0.0200	0	0	214	214	407	3000	3.0	52.3	0.87
5/19/11	21	78	91	105	0.0560	0	0	1050	1050	0.0200	0	0	375	375	713	2970	3.1	53.0	0.52
5/20/11	23	83	96	115	0.0560	0	0	1150	1150	0.0200	0	0	411	411	780	2980	3.0	53.8	0.46
5/21/11	10	75	87	105	0.0560	0	8	492	500	0.0200	0	3	176	179	339	2980	3.3	53.8	0.71
5/22/11	16	79	94	118	0.0560	0	14	786	800	0.0200	0	5	281	286	543	3000	3.3	53.4	0.35
5/23/11	10	76	91	108	0.0560	0	8	492	500	0.0200	0	3	176	179	339	3010	3.5	53.3	0.41
5/24/11	6	69	86	101	0.0560	0	5	295	300	0.0200	0	2	105	107	204	2980	3.5	53.5	nd
5/25/11	6	85	91	105	0.0560	0	5	295	300	0.0200	0	2	105	107	204	2990	3.5	52.5	1.2
5/26/11	8	84	93	98	0.0560	0	7	393	400	0.0200	0	2	140	143	271	2990	3.5	52.9	0.63
5/27/11	4	83	92	103	0.0560	0	3	197	200	0.0200	0	1	70	71	136	2970	3.0	53.6	1.0
5/28/11	7	85	91	100	0.0560	0	8	342	350	0.0200	0	3	122	125	238	2980	3.0	53.3	0.75
5/29/11	3	97	100	104	0.0560	0	3	147	150	0.0200	0	1	52	54	102	3050	2.2	53.2	1.49
5/30/11	11	65	91	102	0.0560	0	12	538	550	0.0200	0	4	192	196	373	3550	3.4	53.3	0.97
5/31/11	5	81	93	107	0.0560	0	6	244	250	0.0200	0	2	87	89	170	4180	3.0	53.5	1.45
6/1/11	8	80	95	108	0.0560	0	9	391	400	0.0200	0	3	140	143	271	4730	2.9	52.9	0.86

	Unmarked Chinook Salmon															*Environmental Conditions*			
		Fork Length (mm)			High Range	Estimated Passage - High				Low Range	Estimated Passage - Low				Median	Flow (cfs)		Temp	Turbidity
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	(NTU)
6/2/11	7	88	102	110	0.0560	0	8	342	350	0.0200	0	3	122	125	238	4770	3.5	52.7	1.82
6/3/11	4	92	95	100	0.0560	0	4	196	200	0.0200	0	2	70	71	136	5240	2.5	52.2	2.36
6/4/11	4	75	87	94	0.0560	0	0	200	200	0.0200	0	0	71	71	136	5520	2.9	51.7	1.6
6/5/11	5	88	93	104	0.0560	0	0	250	250	0.0200	0	0	89	89	170	5520	2.9	52.8	1.80
6/6/11	5	90	96	102	0.0560	0	0	250	250	0.0200	0	0	89	89	170	5520	4.0	53.1	1.75
6/7/11	4	98	101	105	0.0560	0	0	200	200	0.0200	0	0	71	71	136	5530	2.8	53.7	1.94
6/8/11	5	90	95	103	0.0560	0	0	250	250	0.0200	0	0	89	89	170	5510	2.1	54.0	2.00
6/9/11	2	85	95	105	0.0560	0	0	100	100	0.0200	0	0	36	36	68	5420	2.5	54.3	0.68
6/10/11	4	75	91	106	0.0560	0	0	200	200	0.0200	0	0	71	71	136	5620	2.9	54.4	0.65
6/11/11	1	99	99	99	0.0560	0	0	50	50	0.0200	0	0	18	18	34	6910	2.7	53.7	0.71
6/12/11	0	-	-	-	0.0560	0	0	0	0	0.0200	0	0	0	0	0	7000	3.4	53.8	1.0
6/13/11	18	92	100	110	0.0560	0	0	900	900	0.0200	0	0	321	321	611	7020	nd	54.2	0.64
6/14/11	0	-	-	-	0.0560	0	0	0	0	0.0200	0	0	0	0	0	6600	nd	54.7	nd
6/15/11	3	86	92	98	0.0560	0	0	150	150	0.0200	0	0	54	54	102	6000	nd	54.9	0.42
6/16/11	1	98	98	98	0.0560	0	0	50	50	0.0200	0	0	18	18	34	5730	3.0	54.5	0.53
6/17/11	1	102	102	102	0.0560	0	0	50	50	0.0200	0	0	18	18	34	5480	2.5	54.4	1.15
6/18/11	9	90	99	105	0.0560	0	0	450	450	0.0200	0	0	161	161	305	5240	4.2	54.4	0.42
6/19/11	5	89	97	102	0.0560	0	0	250	250	0.0200	0	0	89	89	170	4970	3.8	54.9	0.46
6/20/11	1	104	104	104	0.0560	0	0	50	50	0.0200	0	0	18	18	34	4730	3.8	54.9	0.5
6/21/11	5	97	104	113	0.0560	0	0	250	250	0.0200	0	0	89	89	170	4470	3.4	55.2	0.92
6/22/11	2	108	112	115	0.0560	0	0	100	100	0.0200	0	0	36	36	68	4270	4.0	55.5	1.12
6/23/11	1	104	104	104	0.0560	0	0	50	50	0.0200	0	0	18	18	34	3860	3.2	55.5	1.34
6/24/11	0	-	-	-	0.0560	0	0	0	0	0.0200	0	0	0	0	0	3580	4.0	55.2	2.30
6/25/11	1	95	95	95	0.0560	0	0	50	50	0.0200	0	0	18	18	34	3270	4.0	55.6	1.06
6/26/11	0	-	-	-	0.0560	0	0	0	0	0.0200	0	0	0	0	0	2980	3.8	55.8	1.34
6/27/11	1	85	85	85	0.0560	0	0	50	50	0.0200	0	0	18	18	34	2580	3.3	56.1	0.51
6/28/11	2	92	95	98	0.0560	0	0	100	100	0.0200	0	0	36	36	68	2190	3.1	55.6	1.1
6/29/11	3	96	104	111	0.0560	0	0	150	150	0.0200	0	0	54	54	102	2880	3.3	55.9	0.97
6/30/11	1	90	90	90	0.0560	0	0	50	50	0.0200	0	0	18	18	34	5450	3.5	54.9	0.73

Appendix B. Daily Chinook catch, length, predicted trap efficiency, and estimated passage at Grayson and associated environmental data from 2011.

Date	Unmarked Chinook Salmon									Environmental Conditions				
	Catch	Fork Length (mm)			Est. Efficiency	Estimated Passage				Flow (cfs) Modesto Flow	Velocity (ft/s)		Temp at the traps	Turbidity (NTU)
		Min	Avg	Max		Fry	Parr	Smolt	Total		North	South		
1/6/11	2	40	41	42	0.014	139	0	0	139	5700	2.8	2.0	49.6	4.60
1/7/11	5	36	37	38	0.017	300	0	0	300	5640	2.9	1.9	49.3	6.09
1/8/11	9	34	35	36	0.019	484	0	0	484	5520	3.2	3.4	49.1	4.21
1/9/11	24	34	36	37	0.020	1172	0	0	1172	5260	3.2	3.1	48.9	3.59
1/10/11	11	33	36	37	0.024	450	0	0	450	4870	3.2	2.6	48.3	2.65
1/11/11	13	33	36	39	0.029	453	0	0	453	4460	2.6	2.7	48.7	2.58
1/12/11	21	31	36	38	0.034	618	0	0	618	4090	2.3	2.3	49.4	2.82
1/13/11	24	30	35	38	0.041	588	0	0	588	3690	3.0	2.3	49.8	2.50
1/14/11	45	31	35	39	0.048	935	0	0	935	3300	2.8	2.4	50.0	2.50
1/15/11	31	30	35	44	0.058	534	0	0	534	2890	2.5	2.3	49.8	2.80
1/16/11	8	35	37	40	0.047	172	0	0	172	3280	2.6	2.2	50.0	2.84
1/17/11	25	34	36	40	0.023	1085	0	0	1085	4960	3.4	3.0	50.6	3.52
1/18/11	63	32	37	44	0.020	3075	0	0	3075	5200	3.6	3.3	50.7	2.68
1/19/11	58	32	36	39	0.021	2725	0	0	2725	5160	3.4	2.9	50.2	3.43
1/20/11	66	28	36	39	0.021	3103	0	0	3103	5130	2.5	2.7	50.0	2.24
1/21/11	60	30	36	40	0.021	2906	0	0	2906	5230	3.4	3.3	50.3	4.28
1/22/11	83	30	36	39	0.021	3951	19	0	3969	5210	3.8	3.4	50.3	2.70
1/23/11	19	31	35	38	0.024	789	4	0	793	4940	3.8	3.4	50.3	2.68
1/24/11	65	33	36	39	0.026	2469	12	0	2480	4670	3.5	3.0	50.4	1.98
1/25/11	57	30	36	40	0.030	1896	9	0	1905	4330	3.6	2.8	50.5	2.13
1/26/11	132	32	37	60	0.034	3863	18	0	3881	3970	3.3	3.0	50.2	2.15
1/27/11	52	29	36	39	0.042	1231	6	0	1237	3600	3.2	3.0	50.2	2.45
1/28/11	39	31	36	51	0.046	844	4	0	848	3380	3.0	2.6	49.9	3.24
1/29/11	13	32	44	127	0.042	305	0	4	308	2990	2.8	2.5	50.0	3.17
1/30/11	6	32	36.5	43	0.060	98	0	1	100	2690	2.9	2.6	50.0	3.20
1/31/11	31	33	37	40	0.069	446	0	5	452	2350	2.6	2.2	50.1	2.80
2/1/11	41	32	40	135	0.072	560	0	6	567	2020	2.7	2.8	50.3	3.04
2/2/11	14	32	37	40	0.089	155	0	2	157	1740	2.3	2.2	49.7	3.85
2/3/11	49	32	37	49	0.092	528	0	6	534	1697	2.4	2.3	49.9	1.87
2/4/11	22	33	37	43	0.093	234	0	3	237	1699	2.3	2.3	50.1	2.85
2/5/11	33	35	38	52	0.088	365	9	2	376	1767	2.5	2.3	50.5	1.62
2/6/11	34	34	36	45	0.084	394	10	2	406	1988	2.6	2.4	51.1	2.38
2/7/11	21	31	36	39	0.084	242	6	1	249	1985	2.1	2.1	51.4	1.72
2/8/11	19	31	38	60	0.079	234	6	1	241	2002	2.5	2.3	51.0	1.96
2/9/11	18	30	37	50	0.081	215	5	1	222	2000	2.3	2.1	50.3	1.82
2/10/11	14	31	36	44	0.067	202	5	1	208	2549	nd	nd	50.0	2.17
2/11/11	32	32	40	117	0.052	598	14	4	616	2863	2.8	3.0	50.1	3.08
2/12/11	18	35	37	47	0.055	304	20	0	324	2876	2.5	3.0	50.4	1.88
2/13/11	18	33	37	44	0.056	303	20	0	323	2907	2.9	3.1	50.8	3.12
2/14/11	2	36	44	51	0.045	41	3	0	44	2889	3.0	2.9	50.8	3.00
2/15/11	20	35	37	41	0.056	332	22	0	354	2871	3.4	2.9	51.1	2.44
2/16/11	9	35	36	37	0.058	145	10	0	155	2871	2.9	2.8	51.3	3.83
2/17/11	10	32	41	60	0.038	244	16	0	261	3360	2.9	2.8	50.0	2.97
2/18/11	5	35	42	59	0.034	137	9	0	146	3590	3.1	3.3	49.1	2.78

Date	Unmarked Chinook Salmon									Environmental Conditions				
	Catch	Fork Length (mm)			Est. Efficiency	Estimated Passage				Flow (cfs) Modesto Flow	Velocity (ft/s)		Temp at the traps	Turbidity (NTU)
		Min	Avg	Max		Fry	Parr	Smolt	Total		North	South		
2/19/11	1	35	35	35	0.022	42	4	0	45	5130	3.4	3.6	49.2	9.69
2/20/11	1	36	36	36	0.019	49	4	0	54	5430	3.8	3.6	49.8	13.30
2/21/11	12	35	36	38	0.025	442	40	0	481	4750	3.7	3.6	50.3	5.55
2/22/11	20	34	38	63	0.025	732	66	0	798	4610	3.4	2.9	50.0	2.25
2/23/11	22	33	37	58	0.026	772	69	0	841	4600	2.5	1.9	50.1	6.72
2/24/11	14	34	4	56	0.021	615	55	0	670	4860	3.3	2.9	50.1	3.47
2/25/11	3	34	35	36	0.024	117	10	0	127	4970	2.7	2.1	50.0	2.51
2/26/11	6	35	36	37	0.020	292	0	10	303	5340	3.4	2.5	49.4	4.73
2/27/11	7	33	35	36	0.021	329	0	12	340	5290	2.8	2.1	49.3	8.86
2/28/11	7	35	36	37	0.023	298	0	11	309	5020	3.3	2.9	49.8	3.77
3/1/11	3	36	36	37	0.023	128	0	5	133	4970	3.5	3.2	50.3	3.13
3/2/11	3	35	35	36	0.024	122	0	4	127	4940	3.5	3.4	50.6	2.74
3/3/11	1	70	70	70	0.008	124	0	4	129	4990	3.6	3.2	51.6	2.27
3/4/11	2	38	38	38	0.020	98	0	3	101	5160	3.2	2.7	51.8	1.78
3/5/11	2	35	37	38	0.024	52	26	7	85	4870	3.2	2.8	51.6	4.90
3/6/11	2	33	47	60	0.020	62	31	8	100	4520	3.3	2.6	52.1	2.29
3/7/11	2	35	51	66	0.019	66	33	8	108	4380	3.4	2.7	51.8	2.38
3/8/11	2	37	51	65	0.019	66	33	8	107	4340	3.1	2.8	52.3	3.81
3/9/11	1	45	45	45	0.022	27	14	3	45	4360	3.1	2.5	52.3	3.39
3/10/11	3	36	42	53	0.025	75	38	9	122	4350	3.1	2.5	52.5	4.46
3/11/11	1	73	73	73	0.010	64	32	8	104	4270	3.0	2.5	52.5	2.91
3/12/11	0	-	-	-	-	0	0	0	0	4080	2.8	2.5	52.2	3.38
3/13/11	3	38	58	73	0.019	23	68	68	158	3760	3.0	1.9	52.0	2.55
3/14/11	1	-	-	-	-	0	0	0	0	3380	2.8	2.3	52.3	3.04
3/15/11	1	73	73	73	0.015	9	28	28	66	3190	2.8	2.3	53.5	2.94
3/16/11	1	72	72	72	0.017	9	26	26	60	3030	3.0	2.4	53.1	2.34
3/17/11	2	58	63	67	0.022	13	39	39	92	3120	2.6	2.1	51.9	4.71
3/18/11	0	-	-	-	-	0	0	0	0	3530	3.0	2.7	50.7	4.59
3/19/11	0	-	-	-	-	0	0	0	0	3720	3.1	2.9	49.4	2.27
3/20/11	1	67	67	67	0.009	0	117	0	117	4970	3.4	2.1	49.5	5.55
3/21/11	ns	ns	ns	ns	ns	ns	ns	ns	ns	6800	ns	ns	50.0	ns
3/22/11	ns	ns	ns	ns	ns	ns	ns	ns	ns	7540	ns	ns	50.9	ns
3/23/11	ns	ns	ns	ns	ns	ns	ns	ns	ns	7080	ns	ns	51.1	ns
3/24/11	ns	ns	ns	ns	ns	ns	ns	ns	ns	7260	ns	ns	49.8	ns
3/25/11	ns	ns	ns	ns	ns	ns	ns	ns	ns	8010	ns	ns	49.9	ns
3/26/11	ns	ns	ns	ns	ns	ns	ns	ns	ns	8480	ns	ns	50.4	ns
3/27/11	ns	ns	ns	ns	ns	ns	ns	ns	ns	8200	ns	ns	50.8	ns
3/28/11	ns	ns	ns	ns	ns	ns	ns	ns	ns	7960	ns	ns	52.0	ns
3/29/11	ns	ns	ns	ns	ns	ns	ns	ns	ns	7640	ns	ns	52.1	ns
3/30/11	ns	ns	ns	ns	ns	ns	ns	ns	ns	7820	3.6	2.7	52.4	3.96
3/31/11	ns	ns	ns	ns	ns	0	0	0	ns	nd	ns	ns	52.6	3.03
4/1/11	ns	ns	ns	ns	ns	0	0	0	ns	8170	3.4	2.4	52.9	6.65
4/2/11	0	-	-	-	-	0	0	0	0	8130	3.0	2.1	52.7	2.84
4/3/11	2	37	50	63	0.004	230	230	0	459	8090	2.7	2.1	51.5	2.51
4/4/11	0	-	-	-	-	0	0	0	0	7990	2.9	2.0	51.8	2.41
4/5/11	1	63	63	63	0.003	161	161	0	323	7930	3.0	2.0	52.1	3.13
4/6/11	0	-	-	-	-	0	0	0	0	7940	2.8	2.1	52.4	2.64

Date	Unmarked Chinook Salmon									Environmental Conditions				
	Catch	Fork Length (mm)			Est. Efficiency	Estimated Passage				Flow (cfs) Modesto Flow	Velocity (ft/s)		Temp at the traps	Turbidity (NTU)
		Min	Avg	Max		Fry	Parr	Smolt	Total		North	South		
4/7/11	1	32	32	32	0.008	61	61	0	122	7940	3.1	2.0	52.0	1.85
4/8/11	0	-	-	-	-	0	0	0	0	7360	2.3	1.7	50.6	3.95
4/9/11	1	104	104	104	0.001	660	0	330	990	7530	2.7	2.3	50.5	2.43
4/10/11	2	35	35.5	36	0.008	177	0	89	266	7870	2.7	2.3	51.2	2.51
4/11/11	0	-	-	-	-	0	0	0	0	7930	2.7	2.0	51.7	3.42
4/12/11	0	-	-	-	-	0	0	0	0	7940	2.8	2.0	51.9	3.49
4/13/11	0	-	-	-	-	0	0	0	0	7900	2.8	2.0	51.7	4.34
4/14/11	0	-	-	-	-	0	0	0	0	7940	2.9	2.1	51.1	2.67
4/15/11	0	-	-	-	-	0	0	0	0	7930	2.3	2.3	51.9	2.73
4/16/11	0	-	-	-	-	0	0	0	0	7930	2.2	1.6	52.8	2.14
4/17/11	1	100	100	100	0.001	0	0	1041	1041	7930	2.8	2.8	53.3	2.92
4/18/11	1	96	96	96	0.001	0	0	922	922	7940	2.8	1.8	53.4	2.59
4/19/11	1	82	82	82	0.002	0	0	551	551	7770	2.5	1.5	52.9	2.44
4/20/11	ns	ns	ns	ns	ns	0	0	0	ns	7460	2.7	1.9	53.0	2.99
4/21/11	0	-	-	-	-	0	0	0	0	7140	2.1	1.7	52.8	3.19
4/22/11	0	-	-	-	-	0	0	0	0	6890	2.6	1.4	52.5	1.68
4/23/11	0	-	-	-	-	0	0	0	0	6680	2.7	1.7	52.2	2.69
4/24/11	0	-	-	-	-	0	0	1053	1053	6410	2.5	1.5	52.9	3.00
4/25/11	2	94	100	105	0.002	0	0	601	601	6150	2.6	1.9	52.7	3.24
4/26/11	1	107	107	107	0.002	0	0	0	0	5870	2.4	1.8	52.7	2.63
4/27/11	0	-	-	-	-	0	0	0	0	5790	2.4	1.9	53.1	6.69
4/28/11	0	-	-	-	-	0	0	0	0	5770	2.1	1.6	53.4	5.37
4/29/11	0	-	-	-	-	0	0	0	0	5630	2.3	1.5	53.0	2.38
4/30/11	0	-	-	-	-	0	21	415	436	5100	1.9	1.5	52.8	2.62
5/1/11	1	110	110	110	0.002	0	4	88	92	4520	1.8	1.0	53.8	3.64
5/2/11	1	68	68	68	0.011	0	69	1386	1456	4070	1.7	0.9	56.5	2.75
5/3/11	6	96	105	121	0.004	0	74	1488	1562	3990	2.5	1.9	55.2	2.61
5/4/11	6	102	108	118	0.004	0	51	1013	1063	3930	2.4	1.9	55.5	3.52
5/5/11	5	95	102	114	0.005	0	25	504	529	3880	2.3	2.0	55.8	2.29
5/6/11	2	105	110	115	0.004	0	0	592	592	4090	2.3	1.7	56.1	3.95
5/7/11	3	96	98	100	0.005	0	0	0	0	4210	2.7	2.0	55.3	2.25
5/8/11	0	-	-	-	-	0	0	439	439	4260	2.5	1.9	54.8	1.15
5/9/11	2	97	99	101	0.005	0	0	549	549	4280	2.6	1.9	53.6	2.16
5/10/11	3	85	93	104	0.005	0	0	1631	1631	4210	2.8	2.7	54.1	4.53
5/11/11	8	83	97	108	0.005	0	0	1450	1450	4110	2.9	2.3	54.9	2.15
5/12/11	8	86	95	102	0.006	0	0	901	901	3930	2.8	2.6	55.6	2.67
5/13/11	5	89	97	117	0.006	0	0	3073	3073	3630	2.7	2.3	56.1	1.82
5/14/11	17	89	101	110	0.006	0	0	855	855	3470	2.5	2.2	55.6	1.79
5/15/11	5	98	101	107	0.006	0	0	170	170	3570	2.9	2.2	54.4	3.89
5/16/11	1	100	100	100	0.006	0	0	0	0	3540	2.6	2.3	53.7	2.10
5/17/11	0	-	-	-	-	0	0	305	305	3520	2.7	2.0	53.3	1.37
5/18/11	2	97	97	97	0.007	0	0	593	593	3540	2.8	2.3	53.5	1.80
5/19/11	3	102	105	111	0.005	0	0	1583	1583	3470	2.5	2.2	55.0	1.21
5/20/11	10	90	99	106	0.006	0	0	863	863	3420	2.7	2.2	56.2	2.06
5/21/11	5	90	102	117	0.006	0	0	959	959	3410	2.8	2.0	56.9	1.95
5/22/11	7	84	95	105	0.007	0	0	733	733	3400	2.6	2.2	56.4	2.38
5/23/11	5	93	97	102	0.007	0	0	110	110	3420	2.7	2.0	55.8	1.51

Date	Unmarked Chinook Salmon									Environmental Conditions				
	Catch	Fork Length (mm)			Est. Efficiency	Estimated Passage				Flow (cfs) Modesto Flow	Velocity (ft/s)		Temp at the traps	Turbidity (NTU)
		Min	Avg	Max		Fry	Parr	Smolt	Total		North	South		
5/24/11	1	88	88	88	0.009	0	0	161	161	3420	2.6	2.1	56.0	2.49
5/25/11	1	100	100	100	0.006	0	0	574	574	3370	2.6	2.1	55.5	2.71
5/26/11	4	95	97	99	0.007	0	0	430	430	3360	2.7	2.2	54.4	1.86
5/27/11	3	93	97	99	0.007	0	0	231	231	3380	2.6	2.2	55.5	3.04
5/28/11	2	90	90	90	0.009	0	0	406	406	3360	2.3	2.0	55.7	1.73
5/29/11	2	106	108	110	0.005	0	0	782	782	3430	1.9	1.8	55.4	0.98
5/30/11	4	97	106	116	0.005	0	0	852	852	3530	2.7	2.4	55.8	2.07
5/31/11	6	88	95	100	0.007	0	0	536	536	4010	3.0	2.4	55.6	2.18
6/1/11	3	91	96	100	0.006	0	0	2347	2347	4530	3.0	2.5	55.2	2.24
6/2/11	11	80	94	100	0.005	0	0	1495	1495	4870	3.1	2.5	54.3	1.57
6/3/11	5	94	101	110	0.003	0	0	291	291	nd	3.2	2.9	54.2	3.25
6/4/11	1	95	95	95	0.003	0	0	0	0	nd	1.8	1.2	53.2	0.71
6/5/11	0	-	-	-	-	0	0	1011	1011	nd	3.6	3.3	53.3	2.92
6/6/11	3	97	100	102	0.003	0	0	863	863	nd	3.4	3.2	54.7	3.68
6/7/11	3	85	95	100	0.003	0	0	1054	1054	nd	3.7	3.2	55.2	2.12
6/8/11	3	96	101	104	0.003	0	0	782	782	5640	3.4	3.0	56.1	1.06
6/9/11	2	98	100	101	0.003	0	0	298	298	5550	3.4	2.7	56.5	1.11
6/10/11	1	92	92	92	0.003	0	0	0	0	5460	2.9	2.8	56.8	1.43
6/11/11	0	-	-	-	-	0	0	0	0	5780	3.7	3.2	56.4	2.13
6/12/11	0	-	-	-	-	0	0	0	0	6560	3.4	3.2	55.7	1.45
6/13/11	0	-	-	-	-	0	0	0	0	6730	4.0	3.6	56.2	1.02
6/14/11	0	-	-	-	-	0	0	0	0	6740	3.8	3.6	56.8	1.29
6/15/11	0	-	-	-	-	0	0	1115	1115	6330	3.4	3.2	57.3	1.38
6/16/11	2	98	102	106	0.002	0	0	0	0	5940	3.2	3.0	57.3	0.78
6/17/11	0	-	-	-	-	0	0	0	0	5730	3.4	3.2	56.9	1.29
6/18/11	0	-	-	-	-	0	0	0	0	5520	3.6	3.2	56.8	2.30
6/19/11	0	-	-	-	-	0	0	383	383	nd	3.2	2.8	57.0	1.09
6/20/11	1	103	103	103	0.003	0	0	426	426	5100	3.6	3.2	57.8	1.15
6/21/11	1	109	109	109	0.002	0	0	0	0	4920	3.4	3.0	57.9	3.58
6/22/11	0	-	-	-	-	0	0	355	355	4710	3.0	3.0	58.4	2.63
6/23/11	1	108	108	108	0.003	0	0	0	0	4550	3.0	2.7	58.6	2.58
6/24/11	0	-	-	-	-	0	0	358	358	4200	2.7	2.2	58.1	4.05
6/25/11	1	115	115	115	0.003	0	0	216	216	3970	2.7	2.1	58.3	2.64
6/26/11	1	102	102	102	0.005	0	0	0	0	3640	2.7	2.3	58.8	1.87
6/27/11	0	-	-	-	-	0	0	179	179	3350	2.4	2.0	59.4	1.22
6/28/11	1	104	104	104	0.006	0	0	0	0	2940	2.0	1.9	59.5	2.34
6/29/11	0	-	-	-	-	0	0	0	0	2510	1.7	1.4	59.1	1.74
6/30/11	0	-	-	-	-	0	0	0	0	nd	2.3	2.2	59.1	2.11

Appendix C. Daily counts of non-salmonids captured at Waterford during 2011. See key below for species codes.

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

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

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

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

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

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

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

Appendix D. Daily counts of non-salmonids captured at Grayson during 2011.See key in Appendix E for species codes

Date	BAS	BGS	BKB	BKS	BRB	C	CHC	GSN	HCH	HH	LAM	LMB
1/6/11		1										
1/7/11		3										
1/8/11												
1/9/11												
1/10/11		1										1
1/11/11		2										
1/12/11		2										1
1/13/11		1										
1/14/11		3										
1/15/11		1						1				2
1/16/11		3	1									4
1/17/11		4	1									4
1/18/11		1										2
1/19/11								1				
1/20/11												
1/21/11		1										
1/22/11												
1/23/11												
1/24/11												
1/25/11								1				
1/26/11		2										
1/27/11							1					1
1/28/11		2										
1/29/11		1		1								6
1/30/11		1										1
1/31/11		1										1
2/1/11		2										3
2/2/11		2										9
2/3/11		3					2					10
2/4/11		2										1
2/5/11		4		1								2
2/6/11		3									3	2
2/7/11		1		1			1					
2/8/11		2										6
2/9/11												2
2/10/11		3										
2/11/11		2										1
2/12/11	2	1		1								
2/13/11												1
2/14/11												

Date	BAS	BGS	BKB	BKS	BRB	C	CHC	GSN	HCH	HH	LAM	LMB
2/15/11		1									1	
2/16/11												
2/17/11							2					
2/18/11							1					
2/19/11											10	
2/20/11											4	
2/21/11												
2/22/11		1					1					
2/23/11		1								2		2
2/24/11												
2/25/11												
2/26/11												
2/27/11												
2/28/11		1										
3/1/11												
3/2/11		1										
3/3/11												
3/4/11							1					
3/5/11										1		1
3/6/11		1						1				
3/7/11												
3/8/11												
3/9/11												
3/10/11												
3/11/11								2				
3/12/11												
3/13/11								2				
3/14/11		1						1				
3/15/11		1						1				
3/16/11								1				
3/17/11								1				1
3/18/11		2						2				
3/19/11												
3/20/11												
4/2/11												
4/3/11										8		
4/4/11										5		
4/5/11										13		
4/6/11										5		
4/7/11								1				
4/8/11										5		
4/9/11												
4/10/11												

Date	BAS	BGS	BKB	BKS	BRB	C	CHC	GSN	HCH	HH	LAM	LMB
4/11/11										5		
4/12/11										4		
4/13/11										3		
4/14/11										2		
4/15/11												
4/16/11		1								1		
4/17/11												
4/18/11										1		
4/19/11										2		
4/21/11												
4/22/11										3		
4/23/11							1			4		
4/24/11								1		1		
4/25/11								5		1		
4/26/11						959				3		
4/27/11						832	1	1				
4/28/11						851						
4/29/11						525	1			3		
4/30/11		1				2170						
5/1/11						13544						1
5/2/11						6316				1		
5/3/11						5925				1		
5/4/11		1				4287						
5/5/11						4132						
5/6/11	2					1921						
5/7/11						976				4		
5/8/11						307		1		2		
5/9/11						690						
5/10/11	6	1				314				1		
5/11/11						275				2		1
5/12/11	1					202	1			3		
5/13/11	1					463						
5/14/11		1				422						
5/15/11	1	1				129						
5/16/11	1					88						1
5/17/11	4					110						
5/18/11	3	2				143				2	1	
5/19/11	2					163				2		
5/20/11		1			1	121				1		
5/21/11		1				137	1			1		1
5/22/11						168				4		
5/23/11						160						
5/24/11	1					205						

Date	BAS	BGS	BKB	BKS	BRB	C	CHC	GSN	HCH	HH	LAM	LMB
5/25/11	4					100						
5/26/11	3	2				113						
5/27/11						127				1		
5/28/11		1				96						
5/29/11	1					16				1		
5/30/11						52				1		
5/31/11						26						
6/1/11						15						1
6/2/11						41				1		
6/3/11						103				1		
6/4/11						82				1		
6/5/11						35						
6/6/11						11						
6/7/11						47				1		
6/8/11						25						
6/9/11					1	28						
6/10/11						27						1
6/11/11		1				8				1		
6/12/11												
6/13/11						8	2					
6/14/11						2						
6/15/11						4				6		
6/16/11						2				1		
6/17/11						4				5		
6/18/11		1				8				1		
6/19/11		1				4		1				
6/20/11	1											
6/21/11	1					2						1
6/22/11	1	1				1				2		
6/23/11	1	1				1				2		
6/24/11	2	1				1						
6/25/11	2	1				4						
6/26/11	3	1				6			1			
6/27/11	1	1										
6/28/11												3
6/29/11		1				1				1		
6/30/11		3										

Date	MQK	MSS	PRS	RES	RSN	SASQ	SASU	SMB	SNF	UNID	W	WHC
1/6/11												
1/7/11												
1/8/11												
1/9/11												

Date	MQK	MSS	PRS	RES	RSN	SASQ	SASU	SMB	SNF	UNID	W	WHC
1/10/11	1										1	
1/11/11	1					1						
1/12/11	3											
1/13/11	4			3	1	1		3				2
1/14/11	5			1	2			2				1
1/15/11	7			3	2							4
1/16/11						3	2					2
1/17/11	2											2
1/18/11					3							
1/19/11				1								1
1/20/11						1						
1/21/11												1
1/22/11						1						2
1/23/11												2
1/24/11	1			2								2
1/25/11	1											
1/26/11	1											
1/27/11	1											
1/28/11	1			1				1				3
1/29/11	3			2						1		1
1/30/11	2											1
1/31/11	2					1		1				5
2/1/11	1						1					3
2/2/11							1					2
2/3/11	1				3	1	1		2			16
2/4/11					2							4
2/5/11	1											
2/6/11	3											6
2/7/11	1											3
2/8/11				1								3
2/9/11	1					1						
2/10/11	3											1
2/11/11				1								3
2/12/11				1								1
2/13/11												1
2/14/11												2
2/15/11												2
2/16/11												
2/17/11												2
2/18/11												
2/19/11												
2/20/11												1
2/21/11											1	5

Date	MQK	MSS	PRS	RES	RSN	SASQ	SASU	SMB	SNF	UNID	W	WHC
2/22/11											1	4
2/23/11												4
2/24/11						1						7
2/25/11												1
2/26/11												
2/27/11						1	1					3
2/28/11						1						
3/1/11								1				5
3/2/11						1						3
3/3/11						2						3
3/4/11												1
3/5/11												1
3/6/11	1											1
3/7/11										1		2
3/8/11	1											3
3/9/11						2						1
3/10/11							2	1				5
3/11/11							1					1
3/12/11						1						1
3/13/11												1
3/14/11						1						
3/15/11												1
3/16/11												
3/17/11	1											
3/18/11							1					3
3/19/11					1							
3/20/11												
4/2/11						4	2					
4/3/11						16	2					1
4/4/11												
4/5/11						4	2	1			1	
4/6/11						6						1
4/7/11						4						
4/8/11						2	2					1
4/9/11						6						
4/10/11						7						
4/11/11						5	2	1				
4/12/11						7						
4/13/11						3	1					1
4/14/11						3	3					
4/15/11						4						
4/16/11						1						
4/17/11						3	1					1

Date	MQK	MSS	PRS	RES	RSN	SASQ	SASU	SMB	SNF	UNID	W	WHC
4/18/11					1							
4/19/11							1					1
4/21/11						4		1				
4/22/11							2					
4/23/11						1	1					
4/24/11						3	2					
4/25/11						3	1	1				1
4/26/11						1	3					
4/27/11						2	1					
4/28/11	1						5					
4/29/11					1	3	4					
4/30/11						1	10					
5/1/11						2						
5/2/11		1			1	4	1	1				
5/3/11					1							2
5/4/11					1							1
5/5/11				1	1							
5/6/11						1	1					1
5/7/11												1
5/8/11						3						1
5/9/11						2	1	1				
5/10/11						5	1					
5/11/11						2						1
5/12/11				1		1						
5/13/11					1	2						
5/14/11	1					2						1
5/15/11						4						
5/16/11						3	3					
5/17/11							1					
5/18/11							4					
5/19/11	1				1		5					1
5/20/11						1	5					1
5/21/11						2	4					1
5/22/11						1	1					
5/23/11						1	3	1				
5/24/11						2						2
5/25/11							1					
5/26/11												
5/27/11												1
5/28/11			1				1					1
5/29/11												
5/30/11						1	1					
5/31/11							1					1

Date	MQK	MSS	PRS	RES	RSN	SASQ	SASU	SMB	SNF	UNID	W	WHC
6/1/11												1
6/2/11						2	1					2
6/3/11							2					
6/4/11							6					
6/5/11						1	1					2
6/6/11												
6/7/11						1						4
6/8/11						2	3	1			2	2
6/9/11						2					1	2
6/10/11												1
6/11/11								1				1
6/12/11						1						1
6/13/11						2						
6/14/11						2						2
6/15/11							1					1
6/16/11												1
6/17/11						1	1					
6/18/11						1						1
6/19/11						1						
6/20/11					1			1				1
6/21/11	1					1						2
6/22/11					1						2	
6/23/11					1	1	2					
6/24/11					1		2					
6/25/11						1	3					1
6/26/11							5					
6/27/11	1				3							
6/28/11				1	2		2	1				
6/29/11				1	2						3	
6/30/11					2		2				2	

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
GSF	Green sunfish
GSN	Golden shiner
HCH	Hitch
HH	Hardhead
LAM	Lamprey, unidentified species
LMB	Largemouth bass
MQK	Mosquitofish
MSS	Inland silverside
PRS	Prickly sculpin
RES	Redear sunfish
RSN	Red shiner
SASQ	Sacramento pikeminnow
SASU	Sacramento sucker
SMB	Smallmouth bass
SNF	Unidentified sunfish
TFS	Threadfin shad
UNID	Unidentified species
W	Warmouth
WHC	White catfish