RE-ANALYSIS OF TUOLUMNE RIVER ROTARY SCREW TRAP DATA TO EXAMINE THE RELATIONSHIP BETWEEN RIVER FLOW AND SURVIVAL RATES FOR CHINOOK SMOLTS MIGRATING BETWEEN WATERFORD AND GRAYSON (2006-14)

STUDY REPORT

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Prepared for:
Turlock Irrigation District – Turlock, California
Modesto Irrigation District – Modesto, California

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Re-analysis of Tuolumne River Rotary Screw Trap Data to examine the relationship between river flow and survival rates for Chinook smolts migrating between Waterford and Grayson (2006-14)

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Introduction

Following a report based on 2006-2012 data, we were asked to update our analyses given new data collected in 2013 and 2014. The same methods were used. Refer to Robichaud and English (2013) for details of the original analysis.

Methods

Catchability vs. Flow Relationships

From 1999 to 2014, 210 separate mark-and-recapture trials were conducted, including 113 at Waterford and 97 at Grayson (Appendix Tables 1 and 2). Since 2012, 32 and 10 new trials were conducted at Waterford and Grayson, respectively.

In each trial, Chinook salmon fry, parr, and smolts were collected from the RSTs or obtained from Merced River Hatchery, and were marked and released upstream of the rotary screw trap. The total numbers of marked fish released were adjusted for dye retention rates to produce an estimate of the effective number of marks released that would be available for recapture in the RSTs. The catch in the trap was examined for several subsequent days, and all marked individuals were counted and at least a sub-sample were measured.

Daily average flow values for the Tuolumne River at La Grange were obtained from a USGS website[1], and were used to represent river flow at the Waterford RST. Daily average flow data for the Tuolumne River at Modesto were obtained from another USGS website[2], and were used to represent river flow at the Grayson RSTs. The Modesto flow station was below Dry Creek, the largest seasonal tributary entering the river downstream of La Grange Diversion Dam. As a result, that site includes flow associated with major winter runoff events.

[1] http://waterdata.usgs.gov/ca/nwis/dv/?site_no=11265000&agency_cd=USGS
[2] http://waterdata.usgs.gov/ca/nwis/dv/?site_no=11290000&agency_cd=USGS

For each experimental trial, the mean fish length at release and recapture were calculated. For each trial (i) at each trap (t), the percent of flow sampled (Φ_{ti}) was calculated as the ratio of flow through the RST ($F_{RST_{ti}}$) to that of whole-river flow ($F_{RIVER_{ti}}$):

$$(\Phi_{ti}) = F_{RST_{ti}} / F_{RIVER_{ti}} \quad \text{(Eq. 1)}$$

Flow through each RST was calculated by multiplying the water velocity at the RST by the surface area of the trap. Catchability was calculated as the proportion of the total adjusted number of individuals released that were recaptured. The mean length at release was used to separate the trials into those that indicated catchability of fry (mean length at release < 50 mm), parr (50 ≥ length < 65 mm) or smolts (≥ 65 mm). Length thresholds were determined in Robichaud and English (2013).

For each life stage (s) at each trap (t), if sample-size sufficed, catchability (C_{tsi}) was regressed against percent of flow sampled (Φ_{ti}) during trial i. Both linear and non-linear curve-fitting procedures were used. Linear regression was used to estimate the slope of the line (m_{ts}), with the intercept forced through 0, as

$$C_{tsi} = (m_{ts} \cdot \Phi_{ti}) \ . \quad \text{(Eq. 2)}$$

For non-linear fitting procedures, cumulative Weibull curves,

$$C_{tsi} = 1 - e^{-(\frac{\Phi_{ti}}{\lambda_{ts}})^{k_{ts}}} \ , \quad \text{(Eq. 3)}$$

were fit to the data by estimating the parameters λ_{ts} (scale) and k_{ts} (shape) using an iterative least squares algorithm. For each life stage at each trap, ANOVA was used to compare the residual sum of squares between linear and non-linear model fits.

Passage Estimation

During 2006 and from 2008 to 2013, RSTs were operated at Waterford and Grayson from at least January 29 through May 29, and in many years sampling extended earlier or later. During 2007, sampling at Waterford began in January, but was not initiated at Grayson until March. During 2014, invasive plants blocked trap operations, and these data have been disregarded.

Daily counts of fry, parr, and smolts were tallied at each trap for all days sampled in each year. The percent of the flow sampled was estimated for each day at each trap as described above. Missing velocity observations were interpolated from adjacent values (except during two long data gaps in 2010: linear regressions were performed on the available 2010 data to estimate missing velocity values from flow). Instantaneous measurements of turbidity were also recorded daily at the traps, and daily average water temperatures were obtained from hourly recording thermographs deployed at or near each trap site.

On any given day, catchability was not expected to be 100%, and fish certainly passed the traps without being counted. Life-stage-specific catchability was to be used to calculate total passage from the numbers counted, but scaling was not possible when zero catches were recorded on a particular day. Since catchability was relatively low throughout the study, zero catches of certain life stages were not uncommon. Moreover, total catch could not be taken at face value, as each life stage was expected to have differing catchability.

To account for varying catchability, a four-stage process was used to estimate total fish passage (N) from catch numbers, as follows. First, proportional catch contributions (ρ_{jw}) were calculated for the three life stages for each week (w) as:

$$\rho_{tsw} = \frac{A_{tsw}}{\sum_s^3 A_{tsw}} \qquad \text{(Eq. 4)}$$

where

$$A_{tsw} = \frac{\sum_d^7 O_{tswd}}{\left(m_{ts} \cdot \frac{\sum_d^7 \Phi_{twd}}{7}\right)} \qquad \text{(Eq. 5)}$$

and where O_{tswd} was the observed catch of life stage s at trap t on day d in week w, and Φ_{twd} was the percent flow sampled by trap t on day d in week w. Then, average catchability was calculated for each day at each trap, weighted by the proportional life-stage-specific catch contributions, as:

$$\overline{C_{twd}} = \sum_s^3 \left[\rho_{tsw} \cdot (m_{ts} \cdot \Phi_{td}) \right] . \qquad \text{(Eq. 6)}$$

Third, daily total Chinook passage was calculated by dividing total observed catch (of all life stages combined) by the weighted average catchability:

$$N_{twd} = \frac{\sum_s^3 O_{tswd}}{\overline{C_{twd}}} . \qquad \text{(Eq. 7)}$$

Lastly, the daily total Chinook passage was partitioned into the three life stages, based on the proportional catch rates from Equation 4:

$$N_{tswd} = N_{twd} \cdot \rho_{tsw} . \qquad \text{(Eq. 8)}$$

If total fish passage on a given day was below the level of measurement error (i.e., the inverse of catchability for that day), this method produced passage estimates of zero fish.

In our previous report (Robichaud and English 2013), we allowed data gaps (e.g., days in which the traps were not operational) to persist in the dataset. However, to avoid the potential misinterpretation that these gaps represented days of zero catch, we decided to interpolate missing abundance (*Ni*, number of fish on day *i*) using the following formula:

$$N_i = e^{\frac{\sum_{j=1}^5 [6-j]\left[\ln\left(N_{i-j}+1\right)+\ln\left(N_{i+j}+1\right)\right]}{\sum_{j=1}^5 2(6-j)}} - 1 . \qquad \text{(Eq. 9)}$$

The interpolation is essentially an average of the previous and subsequent 5 observations, weighted strongly toward the adjacent days, and more weakly as the number of days increases away from the missing value. If any of the 5 previous or 5 subsequent days also had missing values, they were excluded from the calculation (i.e., the interpolation was based on fewer observations). The interpolation formula was used to separately calculate the fry, parr and smolts from adjacent life-stage-specific values; and the interpolated values for the three life stages were summed to calculate total catch for the missed day. In all, Waterford catch was interpolated for 18 days in 2006, 18 days in 2007, 4 days in 2008, and 3 days in 2011. Grayson catch was interpolated for 14 days in 2006.

Smolt Survival Estimation

Using daily smolt passage estimates, as calculated above, the proportion of smolts that passed Waterford and subsequently survived to pass Grayson were used to provide RST-based smolt survival estimates. The 2006 data were excluded because of a substantial gap in sampling at Waterford near the peak of the smolt migration period (12-21 April). During 2014, invasive plants blocked the operation of the traps for most of the season, and the data were thus disregarded. The 2010 and 2011 data were included to allow construction of survival estimates across a broader flow range. However, since substantial numbers of fry appeared to rear at locations downstream of Waterford, the resulting survival estimates may be biased high by smolts originating in the Waterford to Grayson reach. Based upon the relative timing of apparent peaks in daily smolt counts at the two traps, the Grayson data were lagged by two days to account for the timing of fish passing Waterford that are expected at Grayson. Total smolts at Grayson were then divided by the number that passed Waterford to calculate survival in that stretch of river.

To analyze the apparent smolt survival as a function of flow, daily average flow data from each year were plotted, and changes in flow rate were used to divide each year into periods of relatively uniform flow (Figure 1). During each flow period, the total number of smolts passing each trap site was calculated. Flow periods prior to March were excluded because the sample sizes for these periods were very small and the smolts migrating downstream during these periods were often much larger than those migrating during the primary migration period of April- May. During each flow period, the average turbidity, and average flow at LaGrange were calculated.

Survival was modeled as a function of average flow using several different methods. Linear regressions were performed on the untransformed and on arcsine transformed survival data. The data were also fitted with general linear models (GLMs) that assume a binomial error structure and that use a logit link function (Crawley 2007). The S-shaped curves that are fit by GLM and the arcsine transformed linear model are desirable since survival values are bounded by 0 and 1. Also, since each fish could either survive or not survive, the binomial error structure was the most appropriate for the GLM.

Multivariate general linear models with binomial error structure and logit link function were used to fit survival as a function of flow (from LaGrange), temperature and turbidity (both from Waterford), and abundance (numbers of smolts estimated past Waterford).

Statistical Methods

For GLMs, data were considered overdispersed when the residual deviance was much greater than the degrees of freedom. In such cases, GLMs were recalculated, using the 'quasibinomial' error distribution, which fits an additional 'dispersion' parameter, allowing for more accurate model output. R^2 approximations were calculated for GLMs as the squared correlation between the predicted and observed values. All statistical analyses were carried out using R (R Core Team 2013).

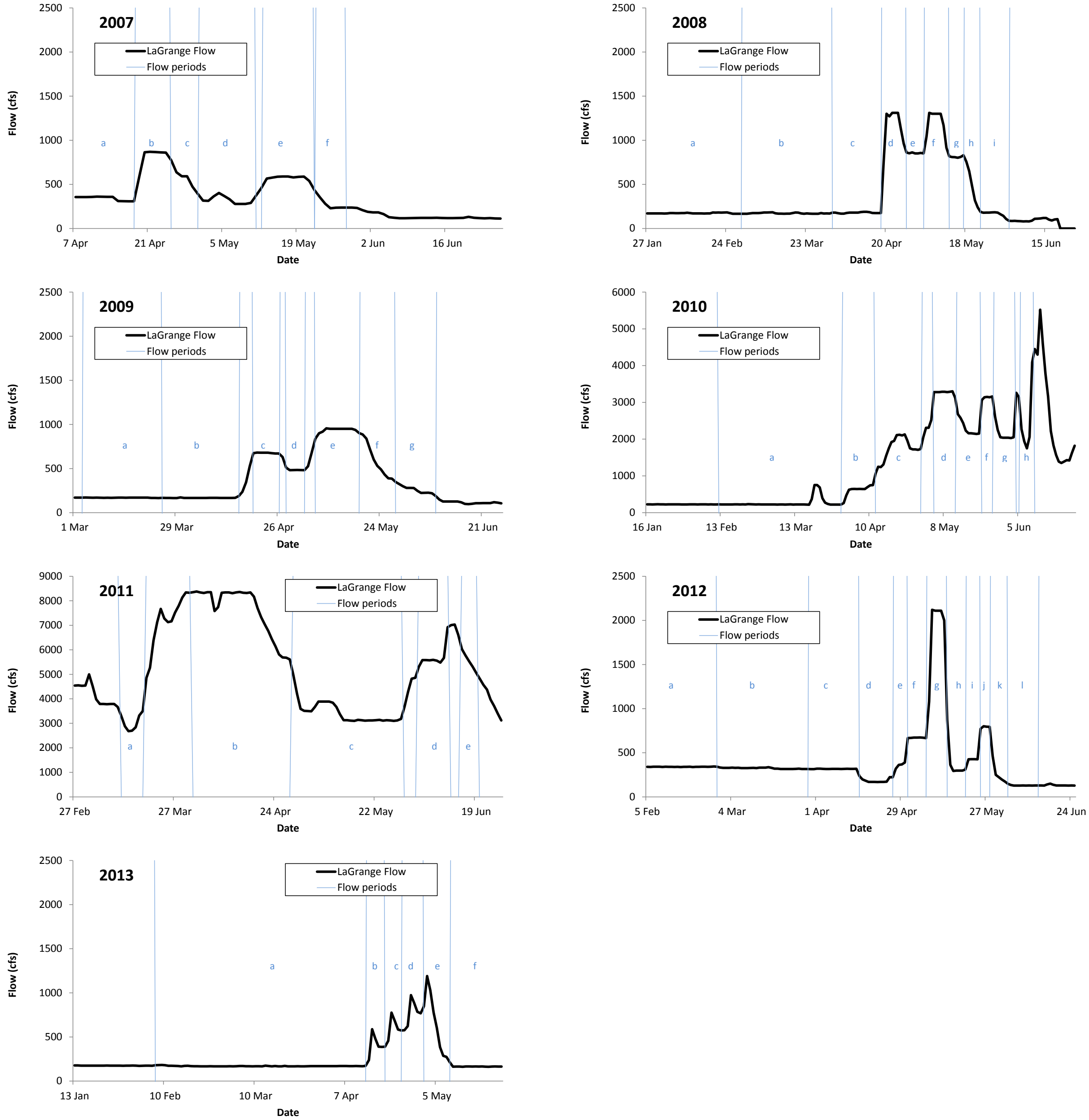


Figure 1. **Daily Flow (cfs) measured at LaGrange during the smolting periods in 2007-2013. Each study year has been divided into periods (labelled with letters) based on flow characteristics. Data periods without labels were not included in the analyses. The X and Y axis scales vary among figure panels.**

Results

Catchability vs. Percent Flow Relationships

The total number of experimental trials for which percent flow and catchability could be calculated was 161 (Appendix Tables 1 and 2). This included 89 fry (29 new since 2012), and 17 smolt (no new ones since 2012) trials at Waterford, and 15 fry (all 2014 trials were excluded), and 40 smolt (no new ones since 2012) trials at Grayson. All trials at Grayson in 2014 were excluded due to problems with trap operations associated with invasive plants. Sample sizes for parr were considered inadequate for robust curve fitting.

Curve fits and parameter estimates for each trap, life stage and model are shown in Figure 2 and Table 1, respectively. For fry at Waterford, the non-linear model had a significantly better fit than the linear model. For the other three tests, there were no significant differences between linear and non-linear model fits. Since the linear models were preferred last time (Robichaud and English 2013), and for simplicity of further analysis, the simpler (linear) models were used henceforth. Slopes for parr were set as the mean of those of fry and smolts.

Despite the two curves being very similar within the observed range data (Figure 2), the predicted values differed more widely at higher percent flows. Thus, blind extrapolation of these curves beyond the range of the currently available percent flow data is not advisable; and more work will be needed to determine the shape of the curves in high percent flow conditions.

Table 1. **Parameter estimates from linear and non-linear models fitting fry and smolt catchability to percent flow at two RST sites (Waterford and Grayson). For each site and life stage, ANOVA (df = 1) was used to compare residual sum of squares between the two model fits. See text for parameter definitions.**

Rotary Screw Trap, t	Chinook Life Stage, s	Non-linear Model Parameters		Linear Model Parameter	ANOVA (Non-linear vs. Linear)	
		k_{ts}	λ_{ts}	m_{ts}	F	P
Waterford	Fry	0.58	7.53	0.58	4.10	0.046
	Smolt	0.75	9.65	0.28	0.32	0.580
Grayson	Fry	0.39	99.20	0.53	4.51	0.053
	Smolt	1.31	1.77	0.28	1.26	0.270

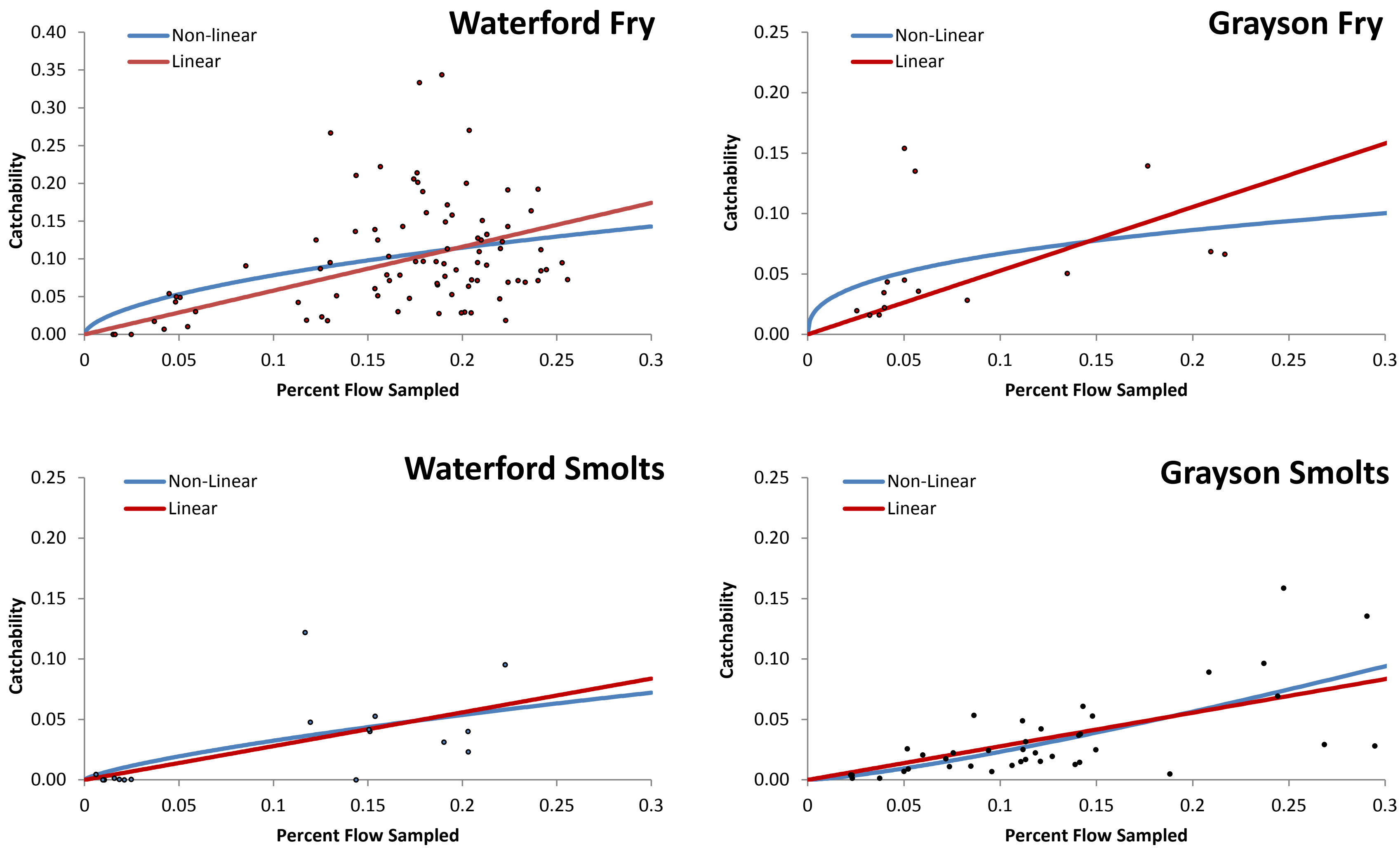


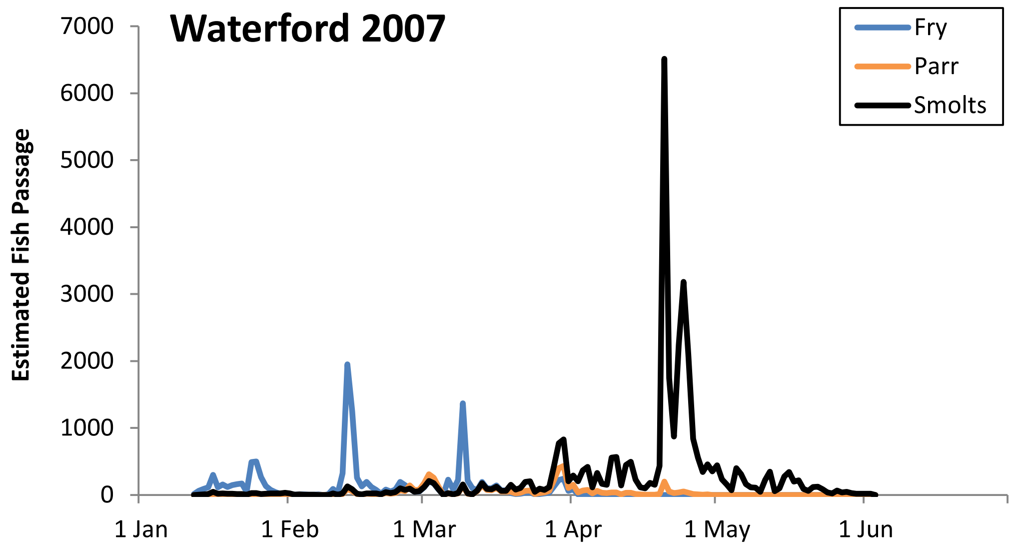
Figure 2. **Fry and smolt catchability as a function of the percent flow sampled at two RST sites (Waterford and Grayson). Linear (no intercept) and non-linear (cumulative Weibull) models were fit to each of the datasets. The Y axis scale varies among the figure panels.**

Estimated Passage

Daily total numbers of fry, parr and smolts that were estimated to have passed Waterford and Grayson from 2007 to 2013 are shown in Figure 3 to Figure 9. Total annual passage tallies are shown in Table 2. Daily and annual tallies differ from those presented previously. They differ from those presented in Sonke and Fuller (2013) primarily due to differences in the methods used to estimate catchability from the available data. They differ from those presented in Robichaud and English (2013) because catch for missing trapping days were interpolated, and to a lesser extent because different fry catchability slopes were used at Waterford.

Table 2. **Annual passage estimates for fry, parr and smolts at Waterford and Grayson (survey periods varied among traps years and between traps). 2006 estimates are underestimates, as they exclude a period of missing Waterford data from near the peak of the smolt migration period (12-21 April, 2006).**

	Waterford				Grayson			
Year	Survey Period	Fry	Parr	Smolts	Survey Period	Fry	Parr	Smolts
2006	1/26 - 6/21	332,870 *	16,592 *	169,238 *	1/26 - 6/22	47,516	2,415	34,872
2007	1/12 - 6/5	12,921	5,094	35,473	3/24 - 5/29	0	0	952
2008	1/8 - 6/2	18,347	1,967	28,364	1/29 - 6/4	1,246	25	1,744
2009	1/7 - 6/9	18,016	7,453	29,708	1/8 - 6/11	57	138	3,877
2010	1/5 - 6/10	10,913	1,070	62,854	1/6 - 6/17	92	0	1,964
2011	12/4/'10 - 6/30	292,973	5,804	76,688	1/6 - 6/30	70,815	2,125	21,955
2012	1/3 - 6/15	30,804	7,720	24,592	1/3 - 6/15	72	10	2,186
2013	1/2 - 5/31	21,951	2,011	17,098	1/3 - 5/23	6	7	629



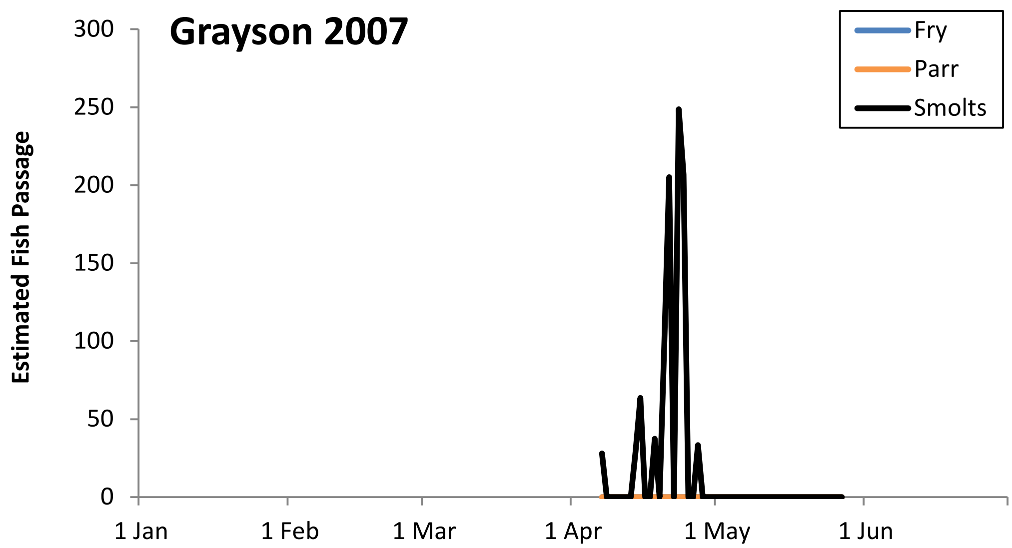
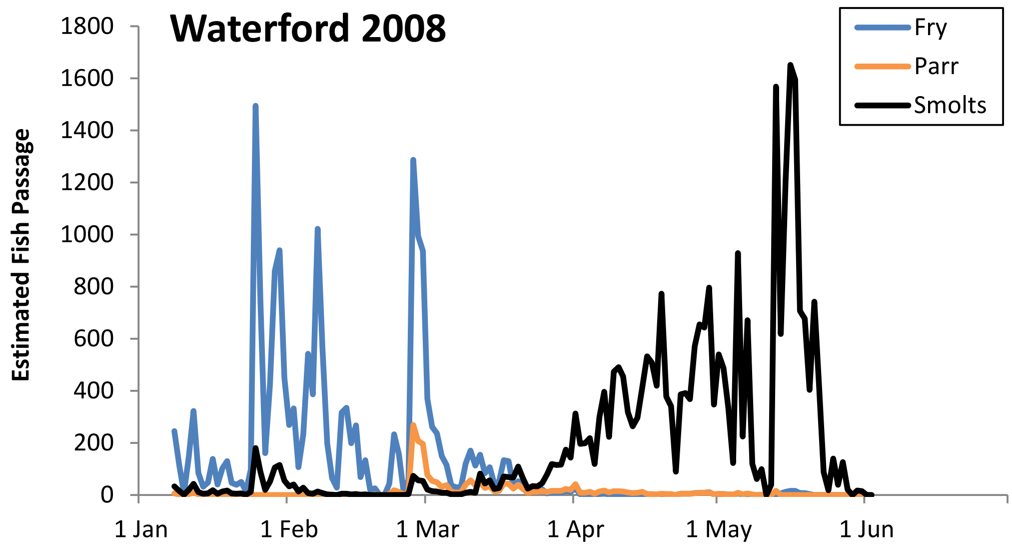


Figure 3. **Estimates of daily passage numbers for fry, parr and smolts at Waterford and Grayson in 2007. Grayson data are lagged by two days.**



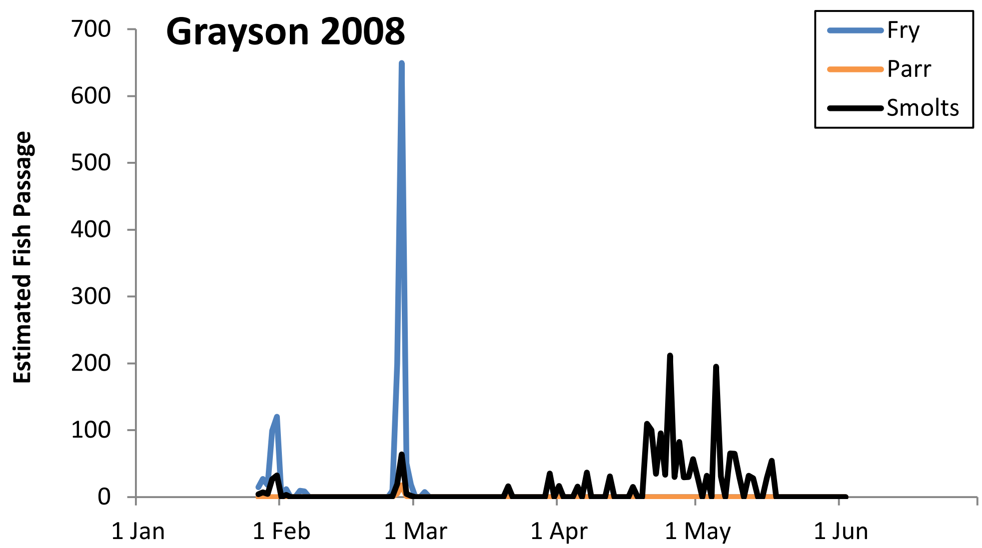
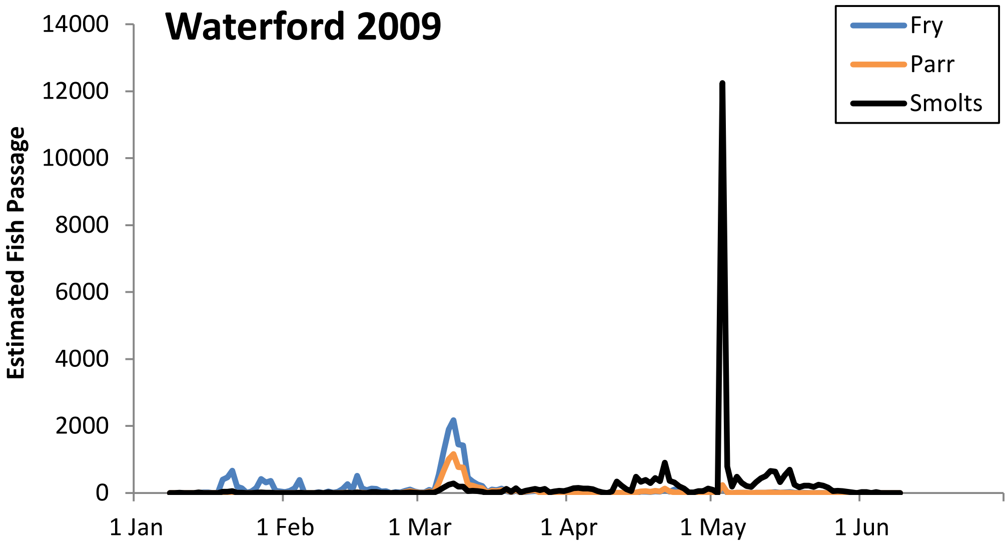


Figure 4. **Estimates of daily passage numbers for fry, parr and smolts at Waterford and Grayson in 2008. Grayson data are lagged by two days.**



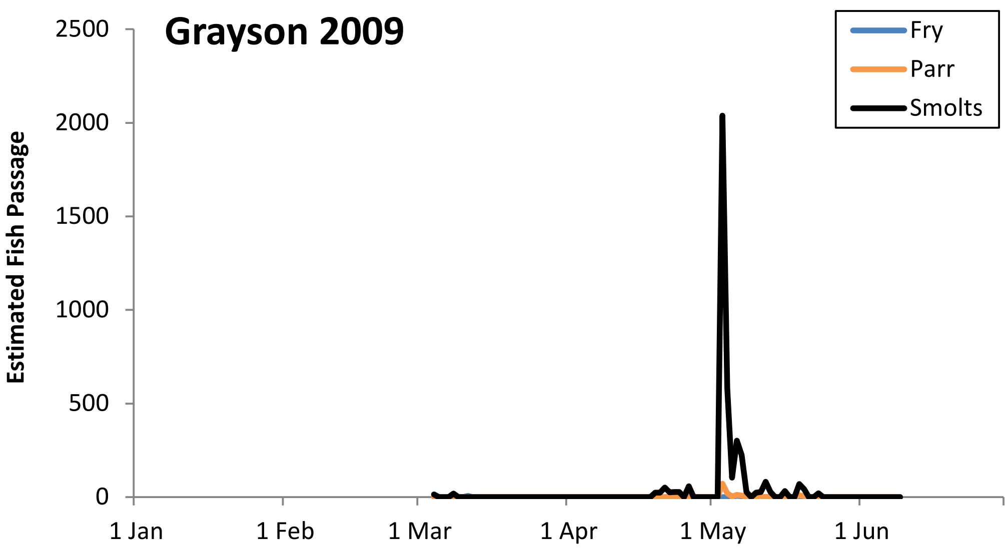
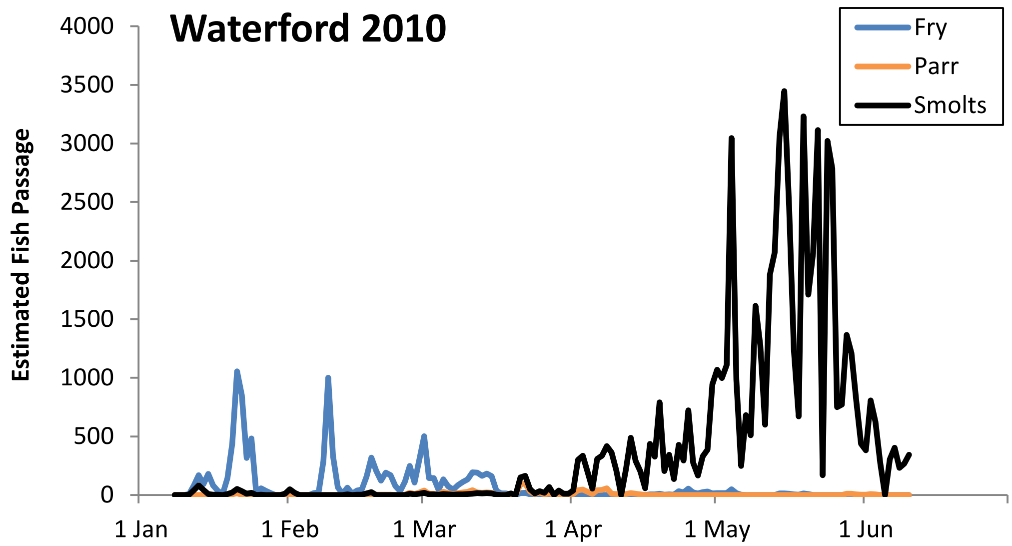


Figure 5. **Estimates of daily passage numbers for fry, parr and smolts at Waterford and Grayson in 2009. Grayson data are lagged by two days.**



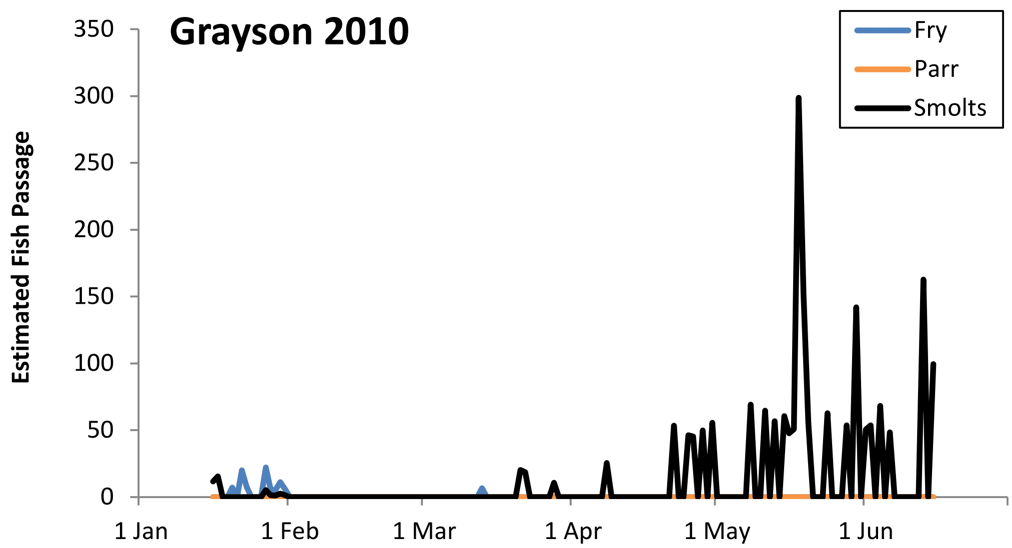
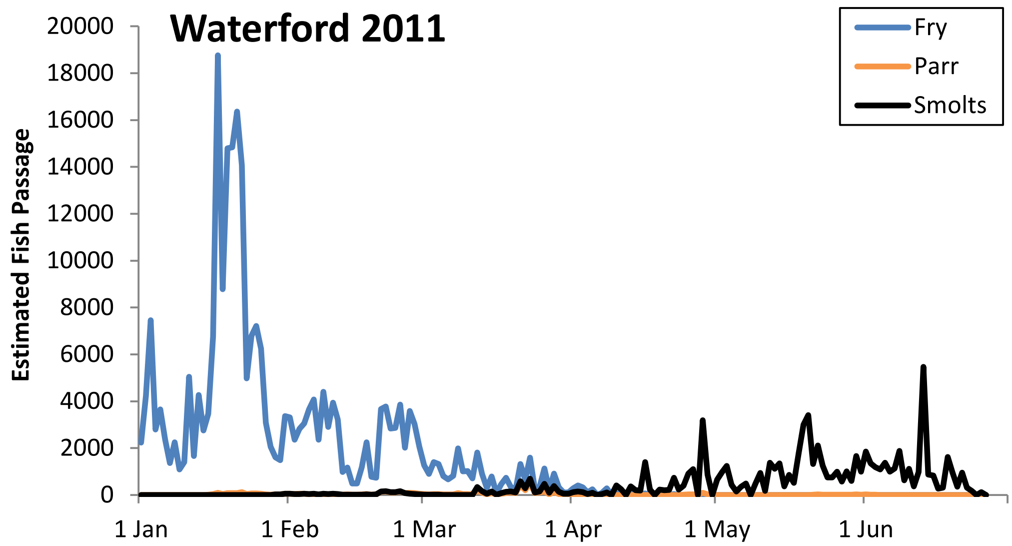


Figure 6. **Estimates of daily passage numbers for fry, parr and smolts at Waterford and Grayson in 2010. Grayson data are lagged by two days.**



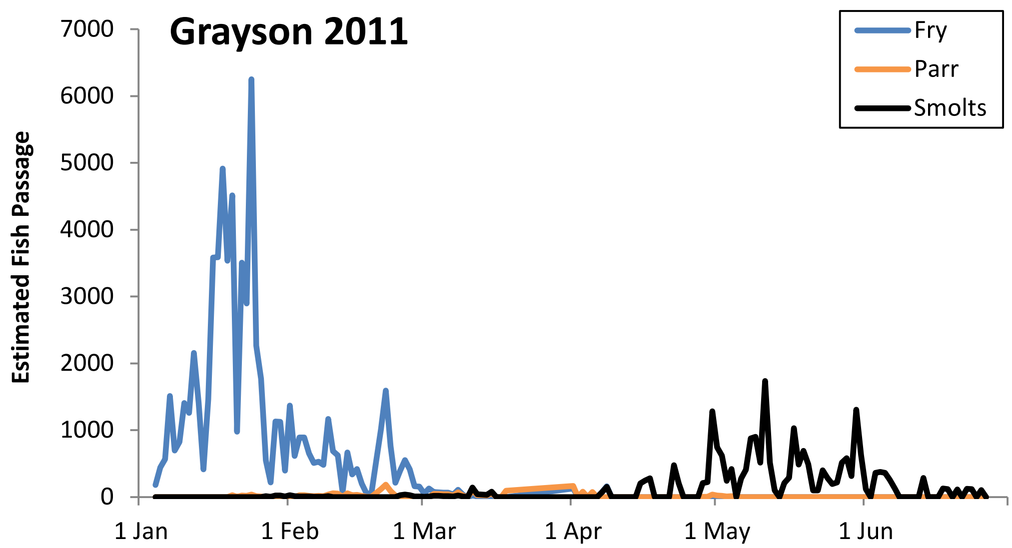
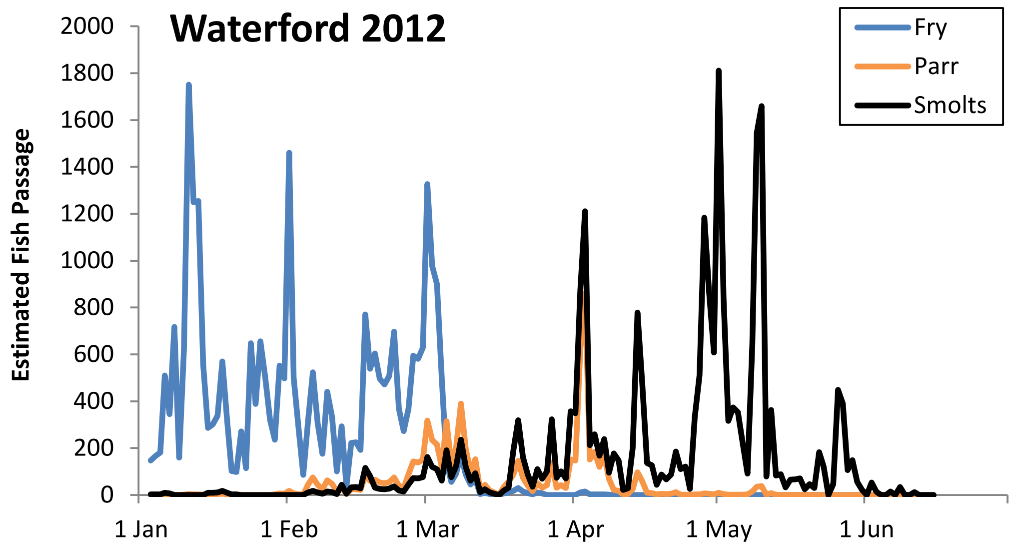


Figure 7. **Estimates of daily passage numbers for fry, parr and smolts at Waterford and Grayson in 2011. Grayson data are lagged by two days.**



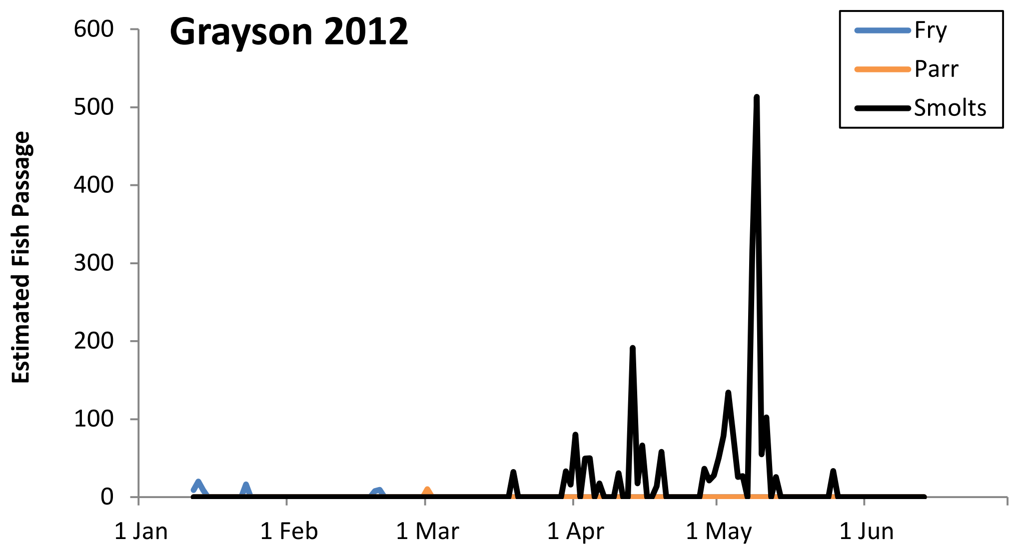
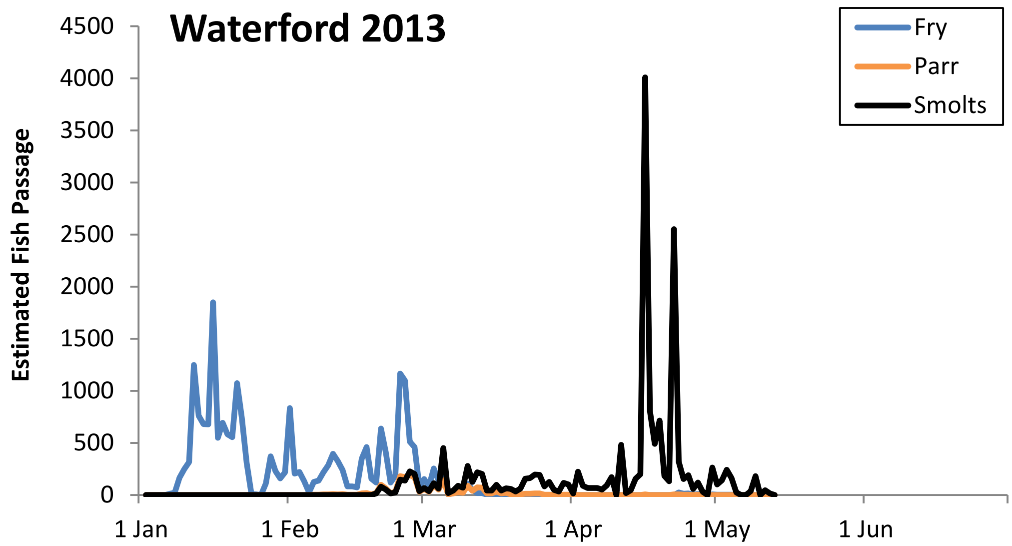


Figure 8. **Estimates of daily passage numbers for fry, parr and smolts at Waterford and Grayson in 2012. Grayson data are lagged by two days.**



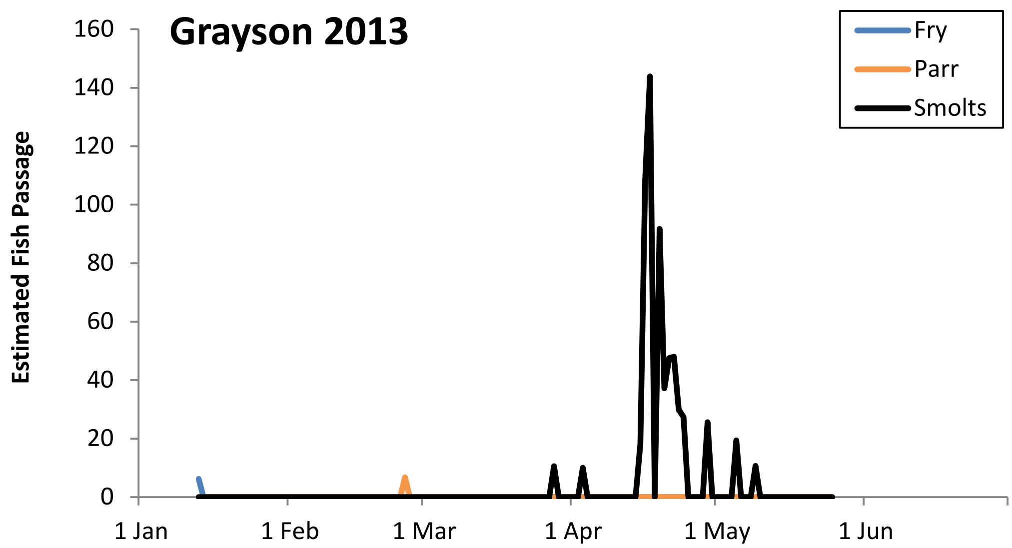


Figure 9. **Estimates of daily passage numbers for fry, parr and smolts at Waterford and Grayson in 2013. Grayson data are lagged by two days.**

Smolt Survival Estimation

Table 3 shows the total number of smolts that passed each trap, along with estimated survival from Waterford to Grayson, and mean flow, water temperature, and turbidity during each of the flow periods in 2007 to 2013. Survival ranged from 0% during many of the flow periods, to a high of 49.4% at a flow of 3,435 cfs during 29 April to 29 May 2011 (Table 3).

The linear relationship between survival and mean flow had a slope of 2.44 x10^{-5} (P = 0.002; R^2 = 0.18). The slope of the arcsine-transformed model was (in transformed units) 4.99 x10^{-5} (P < 0.001; approximate R^2 = 0.15). For the univariate GLM, the survival data were originally fitted to the mean flow data using a binomial error structure. However, the data were overdispersed, so the GLMs were recalculated using a 'quasibinomial' fit. The univariate GLM showed that flow was a statistically significant factor predicting survival (P = 0.006; Figure 10). The predictive equation for the univariate GLM was

$$Survival = \frac{1}{1+ e^{-(-2.570+(0.000242 \cdot Mean\ Flow))}} \ . \qquad \text{(Eq. 10)}$$

The approximate R^2 of the univariate model was 0.14. The effect of the exclusion of the single highest survival point (49.4% in 2011) produced shallower slopes (i.e., lower predicted survival values; linear slope = 1.72 x10^{-5}; arcsine slope = 4.10 x10^{-5}; GLM coefficients: -2.99 and 0.000155) with minor effects on fitting success (linear R^2 = 0.16; arcsine approximate R^2 = 0.15; GLM approximate R^2 = 0.15).

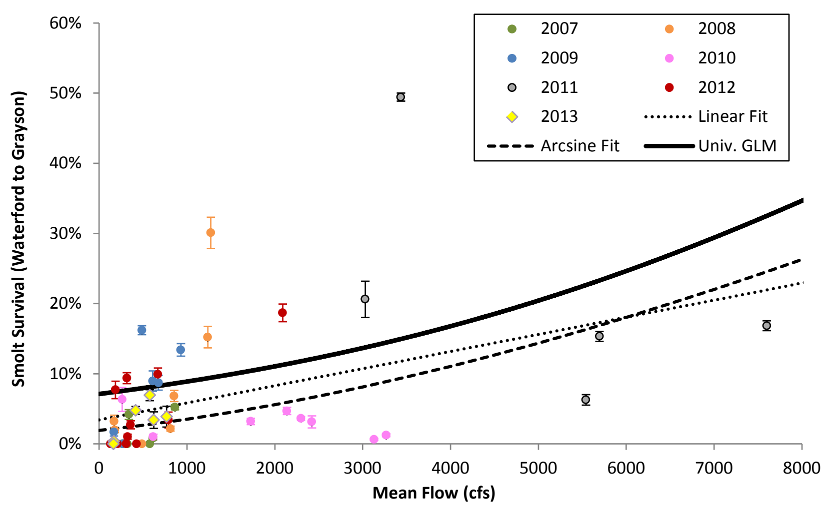


Figure 10. **Survival from Waterford to Grayson, as a function of mean flow (discharge measured at LaGrange). Linear regressions on the raw (R^2 = 0.18) and arcsine transformed (approximate R^2 = 0.15) survival data are shown, along with the results of the univariate quasibinomial general linear model, with approximate R^2 = 0.14.**

The multivariate quasibinomial GLM showed that abundance was the most important factor (P < 0.0001) predicting survival. No other predictors improved the model (turbidity: P = 0.08; flow: P = 0.07; temperature: P = 0.35). The predictive equation for the final GLM was

$$Survival = \frac{1}{1+ e^{-(-3.51+(0.000107 \cdot Smolt\ Adundance))}} \quad . \qquad \text{(Eq. 11)}$$

The approximate R^2 of the multivariate model was 0.41. However, this model fit was highly sensitive to one data-point with very high abundance and very high survival (Figure 11). With that point removed, abundance was no longer a significant factor ($P = 0.07$), discharge ($P < 0.001$) and turbidity ($P < 0.001$) were statistically significant, and temperature was not ($P = 0.55$). Figure 12 shows the 3-D plane of the fitted relationship between flow, turbidity and survival (with the high abundance data-point removed). The approximate R^2 of the fitted plane was 0.22.

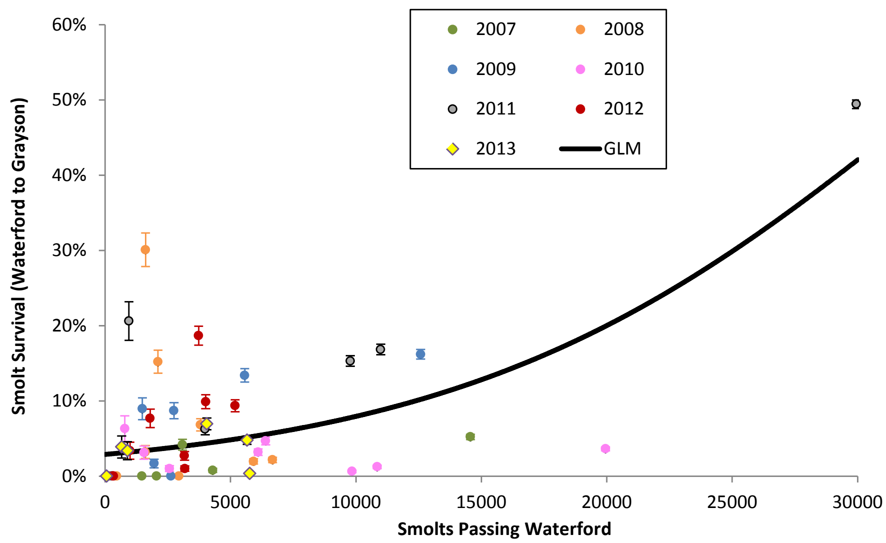


Figure 11. **Survival from Waterford to Grayson, as a function of abundance (number of smolts passing Waterford). Line is the fit from a quasibinomial general linear model, with approximate R^2 = 0.41.**

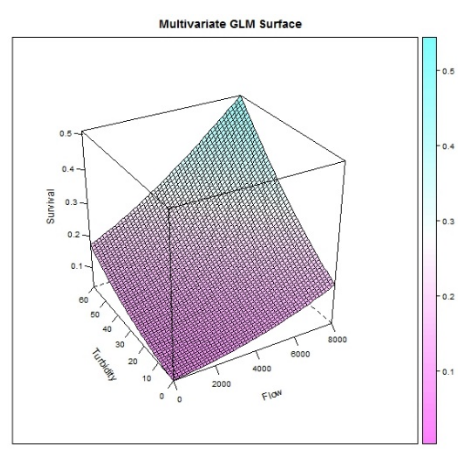


Figure 12. **Survival from Waterford to Grayson, as a function of mean flow (discharge measured in cfs at LaGrange) and turbidity (NTU), as fitted by a multivariate quasibinomial general linear model. One data point with high leverage was removed before fitting this model.**

Table 3. **Total number of smolts estimated to have passed each RST (Waterford and Grayson), survival between the RSTs (with 95% Confidence Intervals), and mean flow, temperature and turbidity during each of the flow periods from 2007 to 2013.**

	Interval Dates (at Waterford)		Estimated Smolt Passage		Survival	Survival (95 % Confedence Interval)		Mean discharge at La Grange	St Dev	Mean Temperature		Mean Turbidity	
Interval	Start	End	Waterford	Grayson	(estimate)	Lower	Upper	(cfs)	(discharge)	Waterford (°F)	Grayson (°F)	Waterford (NTU)	Grayson (NTU)
2007a	7 Apr	18 Apr	3084	129	4.2%	3.5%	4.9%	339.8	24.7	58.7	59.3	0.8	2.8
2007b	20 Apr	24 Apr	14565	760	5.2%	4.9%	5.6%	864.0	3.5	54.8	57.0	1.6	3.1
2007c	25 Apr	29 Apr	4293	33	0.8%	0.5%	1.0%	613.4	108.4	58.4	63.4	1.0	1.9
2007d	1 May	10 May	2048	0	0.0%	0.0%	0.0%	321.7	43.8	60.9	64.2	0.7	2.0
2007e	13 May	21 May	1468	0	0.0%	0.0%	0.0%	577.2	16.7	60.0	64.4	1.0	2.2
2007f	23 May	27 May	252	0	0.0%	0.0%	0.0%	266.8	52.5	64.8	69.6	0.7	1.3
2008b	1 Mar	31 Mar	1605	52	3.2%	2.3%	4.1%	172.0	5.4	58.1	61.2	2.7	4.4
2008c	1 Apr	18 Apr	5920	116	2.0%	1.6%	2.3%	178.8	5.5	61.5	65.4	2.6	4.5
2008d	20 Apr	25 Apr	1614	486	30.1%	27.9%	32.3%	1272.0	79.5	53.8	58.2	2.4	4.2
2008e	27 Apr	3 May	3804	260	6.8%	6.0%	7.6%	854.9	4.9	56.1	61.2	1.4	3.7
2008f	4 May	10 May	2109	321	15.2%	13.7%	16.7%	1236.7	110.0	56.1	61.6	1.4	2.6
2008g	12 May	17 May	6678	144	2.2%	1.8%	2.5%	812.8	9.7	58.4	67.6	1.3	2.4
2008h	18 May	22 May	2944	0	0.0%	0.0%	0.0%	489.8	217.4	60.5	66.1	1.3	3.9
2008i	23 May	2 Jun	464	0	0.0%	0.0%	0.0%	160.6	34.5	65.3	69.6	1.5	3.1
2009a	4 Mar	24 Mar	1952	33	1.7%	1.1%	2.3%	169.1	1.5	57.9	60.5	9.9	16.4
2009b	25 Mar	15 Apr	2626	0	0.0%	0.0%	0.0%	168.2	4.7	60.9	63.9	2.6	5.4
2009c	19 Apr	26 Apr	2745	239	8.7%	7.6%	9.8%	676.3	4.3	57.5	63.5	2.4	7.1
2009d	28 Apr	3 May	12579	2038	16.2%	15.6%	16.8%	487.3	11.1	56.6	62.4	55.4	39.0
2009e	6 May	18 May	5567	746	13.4%	12.5%	14.3%	931.2	34.1	58.1	64.8	3.9	6.7
2009f	19 May	26 May	1485	133	8.9%	7.5%	10.4%	610.9	185.3	60.7	67.9	1.9	4.3
2009g	27 May	8 Jun	266	0	0.0%	0.0%	0.0%	271.5	57.2	66.0	71.8	2.7	6.6
2012b	28 Feb	29 Mar	3179	32	1.0%	0.7%	1.4%	324.6	7.4	55.1	57.6	1.6	3.6
2012c	30 Mar	14 Apr	5185	486	9.4%	8.6%	10.2%	316.8	1.6	57.7	60.8	2.1	5.7
2012d	15 Apr	26 Apr	1797	138	7.7%	6.5%	8.9%	187.2	25.5	66.1	70.6	2.0	4.1
2012e	27 Apr	30 Apr	3167	86	2.7%	2.1%	3.3%	359.5	28.8	62.6	69.6	2.2	4.5
2012f	1 May	7 May	4010	397	9.9%	9.0%	10.8%	669.6	3.0	59.6	65.2	2.7	4.5
2012g	9 May	13 May	3729	696	18.7%	17.4%	19.9%	2090.0	50.5	56.7	60.5	2.2	2.7
2012h	15 May	20 May	307	0	0.0%	0.0%	0.0%	309.8	27.3	64.7	70.6	1.6	4.3
2012i	21 May	24 May	335	0	0.0%	0.0%	0.0%	426.5	0.6	65.0	68.7	1.8	3.2
2012j	25 May	28 May	991	34	3.4%	2.3%	4.5%	790.3	12.4	59.2	65.3	1.5	3.0
2012k	30 May	2 Jun	130	0	0.0%	0.0%	0.0%	210.8	32.4	69.1	74.0	1.4	4.1
2012l	3 Jun	13 Jun	76	0	0.0%	0.0%	0.0%	130.8	6.3	71.9	73.2	1.5	3.3
2011a	12 Mar	18 Mar	950	196	20.6%	18.0%	23.2%	3030.0	332.3	50.8	51.5	2.6	3.6
2011b	1 Apr	28 Apr	10987	1850	16.8%	16.1%	17.5%	7600.4	1011.5	51.3	52.3	2.5	3.0
2011c	29 Apr	29 May	29951	14807	49.4%	48.9%	50.0%	3435.5	437.5	52.9	55.2	1.3	2.3
2011d	3 Jun	11 Jun	9775	1497	15.3%	14.6%	16.0%	5695.6	470.0	53.3	55.7	1.5	1.9
2011e	15 Jun	19 Jun	3989	250	6.3%	5.5%	7.0%	5542.0	379.6	54.6	57.2	0.6	2.1
2010a	12 Feb	30 Mar	784	50	6.3%	4.6%	8.0%	263.4	127.6	55.5	57.8	3.0	8.5
2010b	31 Mar	11 Apr	2566	26	1.0%	0.6%	1.4%	616.8	132.0	54.5	56.5	1.1	3.7
2010c	12 Apr	29 Apr	6102	195	3.2%	2.8%	3.6%	1726.7	330.8	53.5	56.3	2.0	3.6
2010d	4 May	12 May	10846	134	1.2%	1.0%	1.4%	3267.8	55.9	53.2	55.4	1.2	1.9
2010e	13 May	21 May	19953	723	3.6%	3.37%	3.89%	2298.9	211.3	54.3	56.5	0.6	1.9
2010f	22 May	26 May	9843	63	0.6%	0.48%	0.80%	3130.0	40.0	53.4	55.7	1.2	2.4
2010g	27 May	3 Jun	6403	300	4.7%	4.17%	5.20%	2138.8	204.0	55.3	60.0	0.5	1.4
2010h	6 Jun	10 Jun	1550	49	3.1%	2.27%	4.00%	2422.0	951.4	56.7	58.9	0.6	3.0
2013a	7 Feb	13 Apr	5767	21	0.4%	0.20%	0.51%	169.5	3.4	58.3	61.3	1.5	3.9
2013b	14 Apr	18 Apr	5661	271	4.8%	4.23%	5.34%	416.4	129.4	60.1	63.8	1.9	4.7
2013c	19 Apr	24 Apr	4056	282	6.9%	6.16%	7.73%	576.8	141.6	59.7	66.0	1.6	4.3
2013d	25 Apr	30 Apr	661	26	3.9%	2.41%	5.35%	768.3	151.5	59.2	65.6	1.0	2.6
2013e	1 May	9 May	889	30	3.4%	2.20%	4.57%	622.6	357.4	59.6	66.3	1.2	3.0
2013f	10 May	31 May	63	0	0.0%	0.00%	0.00%	163.9	0.9	70.2	73.5	1.2	3.7

Conclusions

A. At Waterford, the added 2013 and 2014 mark-recapture trials had little impact on the fry slope (was 0.60, now 0.58) compared to Robichaud and English (2013). None of the new fry mark-recapture trials at Grayson were included in these analyses due to impacts of an invasive plant that affected trapping. No new smolt mark-recapture trails were added since 2012 (slope remained 0.28 for both sites).
B. Annual Chinook passage estimates were modestly impacted by the data-gap interpolation and by the new slopes. Waterford estimates reported here for the 2007-2012 period are 1% (smolts), 2% (parr) and 3% (fry) higher than those reported in Robichaud and English (2013). Differences at Grayson were negligible (not surprising since the slopes did not change, and very little interpolation was done).
C. There continued to be a positive and significant relationship between survival from Waterford to Grayson and river flow, although the exact relationships were sensitive to outlier values. Abundance of smolts and turbidity may also impact survival.

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Appendix Table 1. Release and recapture data recorded for each of the 113 catch efficiency experiments conducted at Waterford between 2006 and 2014, along with flow and turbidity data. Experiments with missing %flow data were excluded from analyses.

Release Date	Origin	Size Class	Adjusted Number Released	Number Recaptured	% Recaptured	Length at Release (mm)	Length at Recapture (mm)	Flow (cfs)	% Flow Sampled	Turbidity (NTU)
31 Jan 2006	Wild	Fry	240	13	0.054	35	35	3171	0.045	3.38
8 Feb 2006	Wild	Fry	225	11	0.049	35	35	2940	0.051	2.56
10 Feb 2006	Wild	Fry	120	6	0.050	35	35	3027	0.049	2.29
17 Feb 2006	Wild	Fry	163	7	0.043	34	34	2892	0.048	2.18
6 May 2006	Hatchery	Smolts	778	0	0.000	73	.	8870	0.011	1.35
13 May 2006	Hatchery	Smolts	1581	0	0.000	78	.	8480	0.010	1.31
17 May 2006	Hatchery	Smolts	2442	11	0.005	83	83	8360	0.006	1.67
26 May 2006	Hatchery	Smolts	2326	3	0.001	86	74	6780	0.016	1.41
3 Jun 2006	Hatchery	Smolts	2948	1	0.000	79	80	3243	0.025	1.30
9 Jun 2006	Hatchery	Smolts	2731	0	0.000	85	.	4623	0.021	1.34
15 Jun 2006	Hatchery	Smolts	2163	1	0.000	98	75	4793	0.018	0.59
13 Feb 2007	Wild	Fry	35	1	0.029	35	37	356	0.205	5.13
14 Feb 2007	Wild	Fry	238	23	0.097	35	33	356	0.179	1.48
3 Mar 2007	Wild	Fry	98	7	0.071	46	49	358	0.229	1.41
5 Mar 2007	Wild	Parr	75	3	0.040	56	60	359	0.231	0.62
10 Mar 2007	Wild	Fry	180	13	0.072	38	37	358	0.205	0.35
15 Mar 2007	Wild	Fry	61	4	0.066	36	36	367	0.187	0.75
29 Mar 2007	Wild	Parr	48	3	0.063	57	60	355	0.181	2.88
31 Mar 2007	Wild	Parr	75	3	0.040	58	47	356	0.203	0.52
5 Apr 2007	Wild	Smolts	50	2	0.040	76	75	354	0.203	1.48
11 Apr 2007	Wild	Smolts	63	6	0.095	81	80	361	0.223	0.70
24 Apr 2007	Wild	Smolts	63	3	0.048	82	80	860	0.119	1.42
26 Apr 2007	Wild	Smolts	171	9	0.053	80	79	637	0.154	2.26
13 Jan 2008	Wild	Fry	32	11	0.344	37	37	170	0.189	3.86
26 Jan 2008	Wild	Fry	132	15	0.114	36	36	170	0.220	75.20
27 Jan 2008	Wild	Fry	98	13	0.133	37	37	171	0.213	18.60
31 Jan 2008	Wild	Fry	131	12	0.092	37	38	170	0.213	15.70
1 Feb 2008	Wild	Fry	55	9	0.164	37	37	170	0.236	9.33
6 Feb 2008	Wild	Fry	64	6	0.094	37	37	173	0.190	14.00
13 Feb 2008	Wild	Fry	33	11	0.333	37	37	170	0.177	.
28 Feb 2008	Wild	Fry	140	20	0.143	38	38	167	0.168	13.00
16 May 2008	Wild	Smolts	41	5	0.122	88	88	811	0.117	0.67
20 Jan 2009	Wild	Fry	42	2	0.048	43	35	168	0.172	0.69
22 Jan 2009	Wild	Fry	70	5	0.071	36	36	168	0.208	1.28
28 Jan 2009	Wild	Fry	47	7	0.149	35	35	167	0.191	1.89
30 Jan 2009	Wild	Fry	37	7	0.189	37	36	167	0.179	1.18
6 Feb 2009	Wild	Fry	47	6	0.128	37	37	169	0.208	1.08
16 Feb 2009	Wild	Fry	36	1	0.028	36	36	170	0.188	7.67
21 Feb 2009	Wild	Fry	31	5	0.161	37	37	168	0.181	2.05
6 Mar 2009	Wild	Fry	74	20	0.270	44	44	169	0.204	48.70
9 Mar 2009	Wild	Fry	263	53	0.202	40	45	168	0.176	6.07
13 Mar 2009	Wild	Fry	51	4	0.078	49	49	170	0.167	2.47
20 Mar 2009	Wild	Fry	35	1	0.029	50	34	170	0.199	2.82

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Appendix Table 1 continued.

Release Date	Origin	Size Class	Adjusted Number Released	Number Recaptured	% Recaptured	Length at Release (mm)	Length at Recapture (mm)	Flow (cfs)	% Flow Sampled	Turbidity (NTU)
21 Jan 2010	Wild	Fry	110	22	0.200	35	35	225	0.202	33.30
22 Jan 2010	Wild	Fry	82	9	0.110	35	35	226	0.209	21.20
9 Feb 2010	Wild	Fry	34	1	0.029	37	40	226	0.201	7.99
10 Feb 2010	Wild	Fry	116	8	0.069	37	37	224	0.233	1.16
19 Feb 2010	Wild	Fry	42	3	0.071	35	32	225	0.240	1.66
20 Feb 2010	Wild	Fry	33	1	0.030	36	35	224	0.166	1.14
23 Feb 2010	Wild	Fry	29	2	0.069	36	37	232	0.224	0.20
1 Mar 2010	Wild	Fry	36	5	0.139	35	36	224	0.154	15.50
2 Mar 2010	Wild	Fry	44	8	0.182	36	36	223		5.50
11 Mar 2010	Wild	Fry	32	4	0.125	36	35	225	0.210	1.68
14 Mar 2010	Wild	Fry	35	3	0.086	36	36	222	0.244	1.99
12 Jan 2011	Wild	Fry	22	0	0.000	35	.	2940	0.025	2.23
15 Jan 2011	Wild	Fry	142	1	0.007	35	35	2150	0.042	2.57
20 Jan 2011	Wild	Fry	116	0	0.000	35	.	4970	0.015	2.45
21 Jan 2011	Wild	Fry	120	0	0.000	35	.	5130	0.016	2.24
1 Feb 2011	Wild	Fry	96	1	0.010	35	35	1610	0.055	1.71
2 Feb 2011	Wild	Fry	100	3	0.030	38	38	1580	0.059	1.84
9 Feb 2011	Wild	Fry	116	2	0.017	36	36	2450	0.037	1.66
7 Jan 2012	Wild	Fry	38	8	0.211	34	33	367	0.144	1.16
11 Jan 2012	Wild	Fry	44	6	0.136	36	36	368	0.143	0.91
14 Jan 2012	Wild	Fry	66	4	0.061	35	35	327	0.154	1.09
25 Jan 2012	Wild	Fry	55	1	0.018	35	37	332	0.129	1.99
27 Jan 2012	Wild	Fry	30	8	0.267	35	35	328	0.130	2.00
31 Jan 2012	Wild	Fry	42	3	0.071	34	35	327	0.161	0.25
2 Feb 2012	Wild	Fry	66	6	0.091	36	35	353	0.085	0.95
7 Feb 2012	Wild	Fry	46	4	0.087	42	37	342	0.125	1.08
10 Feb 2012	Wild	Fry	39	2	0.051	42	30	339	0.133	1.03
18 Feb 2012	Wild	Fry	80	10	0.125	42	36	340	0.155	1.72
21 Feb 2012	Wild	Fry	39	2	0.051	35	33	340	0.155	0.82
22 Feb 2012	Wild	Fry	43	1	0.023	40	31	340	0.126	1.28
28 Feb 2012	Wild	Fry	53	1	0.019	44	35	342	0.118	1.11
29 Feb 2012	Wild	Fry	47	2	0.043	40	35	333	0.113	1.07
5 Mar 2012	Wild	Fry	32	4	0.125	34	35	328	0.123	0.25
3 Apr 2012	Wild	Smolts	96	4	0.042	71	69	317	0.151	0.75
4 Apr 2012	Wild	Smolts	50	2	0.040	67	62	316	0.151	0.45
15 Apr 2012	Wild	Smolts	43	1	0.023	83	75	235	0.203	3.77
16 Apr 2012	Wild	Smolts	32	1	0.031	78	71	198	0.190	0.77
29 Apr 2012	Wild	Smolts	43	0	0.000	83	.	367	0.144	1.86

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Appendix Table 1 continued.

Release Date	Origin	Size Class	Adjusted Number Released	Number Recaptured	% Recaptured	Length at Release (mm)	Length at Recapture (mm)	Flow (cfs)	% Flow Sampled	Turbidity (NTU)
13 Jan 2013	Wild	Fry	144	32	0.222	35	35	176	0.157	1.94
14 Jan 2013	Wild	Fry	68	9	0.132	35	36	176	0.213	1.45
21 Jan 2013	Wild	Fry	63	6	0.095	36	35	174	0.130	1.28
22 Jan 2013	Wild	Fry	74	5	0.068	36	36	175	0.187	1.86
2 Feb 2013	Wild	Fry	83	8	0.096	36	38	172	0.175	1.20
11 Feb 2013	Wild	Fry	47	3	0.064	38	37	173	0.203	0.54
12 Feb 2013	Wild	Fry	34	7	0.206	37	37	173	0.174	0.40
18 Feb 2013	Wild	Fry	54	1	0.019	38	37	169	0.223	0.48
21 Feb 2013	Wild	Fry	69	5	0.072	37	37	167	0.256	0.70
25 Feb 2013	Wild	Fry	126	19	0.151	45	46	167	0.211	0.44
26 Feb 2013	Wild	Fry	117	10	0.085	37	37	166	0.197	1.06
4 Mar 2013	Wild	Fry	38	2	0.053	41	48	168	0.194	0.39
28 Jan 2014	Wild	Fry	116	12	0.103	37	37	156	0.161	1.07
29 Jan 2014	Wild	Fry	38	3	0.079	37	37	157	0.160	0.58
3 Feb 2014	Wild	Fry	38	6	0.158	37	36	155	0.194	0.56
6 Feb 2014	Wild	Fry	52	10	0.192	37	37	157	0.240	2.79
11 Feb 2014	Wild	Fry	35	6	0.171	37	36	157	0.192	1.22
12 Feb 2014	Wild	Fry	189	18	0.095	37	38	157	0.208	1.16
17 Feb 2014	Wild	Fry	57	7	0.123	37	34	159	0.221	1.81
18 Feb 2014	Wild	Fry	295	28	0.095	37	37	159	0.253	2.17
22 Feb 2014	Wild	Fry	300	34	0.113	36	38	157	0.192	1.42
24 Feb 2014	Wild	Fry	290	62	0.214	38	37	157	0.176	1.46
25 Feb 2014	Wild	Fry	298	57	0.191	37	37	157	0.224	0.63
3 Mar 2014	Wild	Fry	297	14	0.047	37	37	160	0.220	1.19
7 Mar 2014	Wild	Fry	114	11	0.096	38	40	162	0.186	2.99
10 Mar 2014	Wild	Fry	116	13	0.112	42	38	156	0.242	1.79
11 Mar 2014	Wild	Fry	95	8	0.084	38	36	156	0.242	0.98
19 Mar 2014	Wild	Fry	56	8	0.143	44	43	157	0.224	2.06
25 Mar 2014	Wild	Fry	26	2	0.077	46	40	158	0.191	2.40
3 Apr 2014	Hatchery	Parr	201	9	0.045	52	49	159	0.221	0.63
3 Apr 2014	Wild	Parr	31	1	0.032	64	56	159	0.221	0.63
10 Apr 2014	Wild	Parr	199	8	0.040	54	53	160	0.267	2.19

Appendix Table 2. Release and recapture data recorded for each of the 97 catch efficiency experiments conducted at Grayson between 1999 and 2014, along with flow and turbidity data. Experiments with missing %flow data were excluded from analyses, as were several trial in 2014 (records are stricken-out, below) because an invasive plant impacted trap operations.

Release Date	Origin	Size Class	Adjusted Number Released	Number Recaptured	% Recaptured	Length at Release (mm)	Length at Recapture (mm)	Flow (cfs)	% Flow Sampled	Turbidity (NTU)
11 Mar 1999	Hatchery	Parr	1946.4652	28	0.014	54	53	4620	0.040	9.10
24 Mar 1999	Hatchery	Parr	1938.48	67	0.035	61	61	3130	0.051	5.20
31 Mar 1999	Hatchery	Parr	1884.6232	73	0.039	65	64	2250	0.059	5.90
7 Apr 1999	Hatchery	Smolts	1948.8492	50	0.026	68	68	2280	0.052	5.00
14 Apr 1999	Hatchery	Smolts	1953.066	34	0.017	73	72	2000	0.072	3.90
20 Apr 1999	Hatchery	Smolts	2007	45	0.022	73	75	1800	0.076	4.40
29 Apr 1999	Hatchery	Smolts	1959.3346	14	0.007	79	80	3220	0.050	8.80
4 May 1999	Hatchery	Smolts	2007.5201	18	0.009	83	82	3030	0.052	6.50
18 May 1999	Hatchery	Smolts	2001	29	0.014	86	84	677	0.141	6.70
26 May 1999	Hatchery	Smolts	1984	75	0.038	96	92	518	0.142	9.60
1 Mar 2000	Hatchery	Parr	1964	30	0.015	56	53	4690	0.032	16.11
16 Mar 2000	Hatchery	Parr	1548	22	0.014	56	56	5980	0.027	7.48
23 Mar 2000	Hatchery	Parr	1913	55	0.029	59	60	3190	.	7.13
30 Mar 2000	Hatchery	Parr	1942	60	0.031	62	63	2820	0.051	6.30
29 Apr 2000	Hatchery	Smolts	1931	22	0.011	81	82	1470	0.085	9.16
6 May 2000	Hatchery	Smolts	1987	41	0.021	85	85	2430	0.060	14.23
24 May 2000	Hatchery	Smolts	2010	24	0.012	85	85	1010	0.106	9.09
18 Jan 2001	Hatchery	Fry	1810	120	0.066	37	.	487	0.217	4.30
8 Feb 2001	Hatchery	Fry	1980	276	0.139	47	.	434	0.177	3.20
1 Mar 2001	Hatchery	Fry	2017	57	0.028	41	.	2130	0.083	4.20
14 Mar 2001	Hatchery	Fry	1487	75	0.050	46	.	703	0.135	7.90
21 Mar 2001	Hatchery	Parr	3025	207	0.068	61	.	519	0.162	7.50
28 Mar 2001	Hatchery	Parr	1954	219	0.112	51	.	515	0.182	6.80
11 Apr 2001	Hatchery	Smolts	2021	141	0.070	66	.	535	.	5.20
18 Apr 2001	Hatchery	Smolts	2060	95	0.046	68	.	483	.	7.90
25 Apr 2001	Hatchery	Smolts	1515	34	0.022	71	.	753	0.118	7.20
2 May 2001	Hatchery	Smolts	3053	163	0.053	72	.	1460	0.086	7.00
9 May 2001	Hatchery	Smolts	3002	147	0.049	75	.	1160	0.112	6.20
16 May 2001	Hatchery	Smolts	2942	93	0.032	76	.	1020	0.113	9.20
20 Feb 2002	Hatchery	Parr	2094	444	0.212	57	.	265	.	5.90
6 Mar 2002	Hatchery	Smolts	2331	316	0.136	68	.	278	0.291	5.30
13 Mar 2002	Hatchery	Smolts	2042	324	0.159	65	.	300	0.247	10.10
20 Mar 2002	Hatchery	Smolts	2105	242	0.115	68	.	328	.	8.40
27 Mar 2002	Hatchery	Smolts	2121	147	0.069	68	.	314	0.244	10.00
3 Apr 2002	Hatchery	Smolts	1962	130	0.066	76	.	312	.	8.90
9 Apr 2002	Hatchery	Smolts	1995	56	0.028	79	.	319	0.295	13.30
17 Apr 2002	Hatchery	Smolts	2048	40	0.020	84	.	889	0.127	12.90
25 Apr 2002	Hatchery	Smolts	2001	22	0.011	86	.	1210	0.074	12.60
1 May 2002	Hatchery	Smolts	2033	14	0.007	89	.	1250	0.096	9.20
8 May 2002	Hatchery	Smolts	2021	31	0.015	95	.	798	0.121	9.80
15 May 2002	Hatchery	Smolts	2047	26	0.013	97	.	653	0.139	8.00
22 May 2002	Hatchery	Smolts	2043	10	0.005	94	.	403	0.188	11.30

…continued

Appendix Table 2 continued.

Release Date	Origin	Size Class	Adjusted Number Released	Number Recaptured	% Recaptured	Length at Release (mm)	Length at Recapture (mm)	Flow (cfs)	% Flow Sampled	Turbidity (NTU)
10 Apr 2003	Hatchery	Smolts	1956	138	0.071	77	.	297	.	.
17 Apr 2003	Hatchery	Smolts	2047	65	0.032	77	.	1350	.	.
24 Apr 2003	Hatchery	Smolts	1979	31	0.016	88	.	1210	.	.
1 May 2003	Hatchery	Smolts	2044	113	0.055	96	.	685	.	.
8 May 2003	Hatchery	Smolts	2078	206	0.099	83	.	726	.	.
15 May 2003	Hatchery	Smolts	1996	125	0.063	83	.	559	.	.
20 May 2003	Hatchery	Smolts	1989	60	0.030	89	.	317	.	.
28 May 2003	Hatchery	Smolts	1950	125	0.064	94	.	685	.	.
13 Apr 2004	Hatchery	Smolts	1991.88	84	0.042	79	74	1140	0.121	4.80
20 Apr 2004	Hatchery	Smolts	1979.802	48	0.024	81	79	1660	0.094	2.97
27 Apr 2004	Hatchery	Smolts	1941.0056	118	0.061	86	85	826	0.143	4.67
4 May 2004	Hatchery	Smolts	2007.91	50	0.025	90	87	789	0.150	4.75
11 May 2004	Hatchery	Smolts	1971.52	104	0.053	86	79	815	0.148	4.05
18 May 2004	Hatchery	Smolts	1996	178	0.089	88	77	446	0.208	4.29
25 May 2004	Hatchery	Smolts	2013	59	0.029	92	90	337	0.268	3.94
9 Feb 2006	Wild	Fry	37	5	0.135	35	35	3290	0.056	4.30
11 Feb 2006	Wild	Fry	26	4	0.154	35	37	3340	0.050	3.15
12 Feb 2006	Wild	Fry	23	1	0.043	36	37.0	3310	0.041	2.65
13 Feb 2006	Wild	Fry	28	1	0.036	36	33.0	3310	0.058	3.37
3 Mar 2006	Wild	Fry	89	4	0.045	35	35.3	4300	0.050	4.97
5 May 2006	Hatchery	Smolts	949	4	0.004	73	74.3	8770	0.022	3.05
12 May 2006	Hatchery	Smolts	1286	5	0.004	82	76.6	8280	0.023	2.07
25 May 2006	Hatchery	Smolts	1532	2	0.001	84	69.5	7070	0.023	1.82
1 Jun 2006	Hatchery	Smolts	1694	0	0.000	92	.	4960	.	2.79
14 Jun 2006	Hatchery	Smolts	1507	2	0.001	85	83.0	5050	0.037	1.78
1 Mar 2008	Wild	Fry	73	5	0.068	38	37.6	342	0.209	25.90
15 Apr 2008	Hatchery	Smolts	1131	109	0.096	77	75.7	300	0.237	4.24
25 Apr 2008	Hatchery	Smolts	1005	17	0.017	86	84.5	1290	0.113	2.66
7 May 2008	Hatchery	Smolts	526	8	0.015	96	95.5	1310	0.111	2.85
14 May 2008	Hatchery	Smolts	519	13	0.025	93	90.8	973	0.112	3.98
21 May 2008	Hatchery	Smolts	515	19	0.037	92	90.9	703	0.141	2.75
14 Jan 2011	Wild	Fry	87	3	0.034	36	35.0	3300	0.040	2.50
20 Jan 2011	Wild	Fry	51	1	0.020	36	32.0	5130	0.025	2.24
21 Jan 2011	Wild	Fry	63	1	0.016	36	30.0	5230	0.032	4.28
25 Jan 2011	Wild	Fry	62	1	0.016	36	36.0	4330	0.037	2.13
26 Jan 2011	Wild	Fry	45	1	0.022	36	29.0	3970	0.040	2.15
~~13 Mar 2014~~	~~Hatchery~~	~~Parr~~	~~500~~	~~1~~	~~0.002~~	~~53~~	~~49.0~~	~~195~~	~~0.335~~	~~2.43~~
~~14 Mar 2014~~	~~Hatchery~~	~~Parr~~	~~594~~	~~1~~	~~0.002~~	~~53~~	~~55.0~~	~~193~~	~~0.351~~	~~10.33~~
~~20 Mar 2014~~	~~Hatchery~~	~~Fry~~	~~579~~	~~7~~	~~0.012~~	~~48~~	~~50.1~~	~~192~~	~~0.314~~	~~9.41~~
~~21 Mar 2014~~	~~Hatchery~~	~~Fry~~	~~385~~	~~1~~	~~0.003~~	~~47~~	~~53.0~~	~~190~~	~~0.313~~	~~9.11~~
~~27 Mar 2014~~	~~Hatchery~~	~~Fry~~	~~498~~	~~59~~	~~0.118~~	~~50~~	~~50.4~~	~~202~~	~~0.460~~	~~4.88~~
28 Mar 2014	Hatchery	Parr	470	9	0.019	51	47.4	197	0.395	2.34
3 Apr 2014	Hatchery	Parr	626	30	0.048	52	53.3	209	0.469	9.63
4 Apr 2014	Hatchery	Parr	396	28	0.071	54	52.5	200	0.465	6.86
10 Apr 2014	Hatchery	Parr	422	16	0.038	55	51.8	195	0.399	4.70
10 Apr 2014	Hatchery	Parr	398	21	0.053	55	53.5	195	0.399	4.70