Emigration of Juvenile Chinook Salmon (*Oncorhynchus tschawytscha*) and Steelhead (*Oncorhynchus mykiss*) in the Lower Mokelumne River, December 2012 - July 2013

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SUMMARY

The emigration of juvenile Chinook salmon (*Oncorhynchus tschawytscha*) and steelhead (*Oncorhynchus mykiss*) on the lower Mokelumne River was monitored using two rotary screw traps (RST) and a bypass trap during the 2012/2013 season. The upstream rotary screw trap (VINO) was positioned just upstream of the Elliot Road bridge at river kilometer (rkm) 87.4 and was operated from 17 December 2012 to 20 June 2013. The downstream rotary screw trap (GOLF) was located just below the Lower Sacramento Road Bridge at rkm 61.8 and was operated from 7 January to 24 May 2013. The smolt bypass trap (BYPASS), located at Woodbridge Irrigation District Dam (rkm 62.2), was operated from 2 April to 2 July 2013.

The first juvenile Chinook salmon was captured at the VINO RST on 18 December 2012. Eight trap efficiency tests were conducted at VINO during the monitoring period, five using naturally produced salmon and three using hatchery produced salmon. The total estimated abundance of naturally produced young-of-the-year (YOY) Chinook salmon passing the VINO site during the monitoring period was 1,203,754 (95% CI: 958,664-1,724,580). A total of 225 wild YOY steelhead was caught at the VINO RST during the 2012/2013 season. The estimated passage of wild YOY steelhead (based on trap calibrations using Chinook salmon) was 19,098 (95% CI: 11,803-61,624).

At the downstream RST (GOLF), the first juvenile Chinook salmon was captured on 8 January 2013. Eight trap efficiency tests were conducted at GOLF using hatchery produced salmon as test fish. The total estimated abundance of naturally produced YOY Chinook salmon passing the GOLF site during the monitoring period was 69,116 (95% CI: 54,891-94,109). Zero wild YOY steelhead were captured at the GOLF RST during the 2012/2013 season.

A total of 35,674 naturally produced YOY Chinook salmon was caught at the smolt bypass trap (BYPASS) during the monitoring period. After the GOLF RST was pulled for the season, four trap efficiency tests were conducted at the BYPASS, all using hatchery produced salmon. The total estimated abundance of naturally produced YOY Chinook salmon at the BYPASS was 78,474 (95% CI: 75,450-82,471). The total

downstream salmon emigration estimate, calculated from adding the BYPASS trap estimate to the GOLF RST estimate, was 147,590 (95% CI: 130,342-176,579). A total of 123 wild YOY steelhead was caught at the BYPASS between 6 April and 12 July 2012. The total downstream passage estimate of wild YOY steelhead (based on trap calibrations using salmon) was 462 (95% CI: 411-532).

Seventeen fish species were caught at the VINO RST during the survey period, 8 native and 9 non-native species. Native fish species were more frequently caught than non-native species and Chinook salmon was the most abundant species caught. At the downstream traps (GOLF and BYPASS) 25 fish species were caught, 8 native and 17 non-native species. Native fish species were more frequently caught than non-native species and Chinook salmon was the most abundant species caught.

Average daily water releases from Camanche Reservoir ranged from 236 cfs (6.7 m^3/s) to 503 cfs (14.2 m^3/s) during the monitoring period. From 1 October 2012 through 31 March 2013 EBMUD operated under a "Below Normal" JSA water year type. From 1 April through 30 September 2013 EBMUD operated under a "Dry" JSA water year type.

INTRODUCTION

East Bay Municipal Utility District (EBMUD) has been monitoring juvenile salmonid emigration on the lower Mokelumne River (LMR) since 1990 (Bianchi et al. 1992, Marine 2000, Workman et al. 2007). Nearly all salmonid spawning occurs in a 16-rkm reach of the LMR below Camanche Dam (Setka 2004). Fish traps are operated with the objectives of estimating abundance and monitoring the emigration patterns of anadromous fish species in the LMR. This report presents the monitoring results for rotary screw trap and bypass trap operations from December 2012 through early July 2013.

METHODS

Environmental Data

All water quality measurements were collected daily at each location when trap checks took place. Turbidity samples were collected by submerging a sample jar to a depth of 0.3 m (1 ft) and allowing it to fill with water. Turbidity samples were processed in the lab using a Hach ®P1000 turbidimeter. Water temperature and dissolved oxygen data were collected using a YSI 550A handheld dissolved oxygen meter. Flow and additional water temperature measurements were provided by EBMUD's Camanche Dam (rkm 103), Elliot Road (rkm 86.1), Victor (rkm 80.7), Golf (rkm 61.3), and Frandy (rkm 46.4) gauging stations (Figure 1).

Rotary screw traps

Two eight-foot diameter rotary screw traps (E.G. Solutions, Inc.) were operated at upstream and downstream locations on the lower Mokelumne River (Figure 1). The upstream rotary screw trap (RST) was located near the Elliott Road Bridge, adjacent to property owned by Vino Farms, at rkm 87.4. The downstream RST was located adjacent to the Lodi Golf and Country Club at rkm 61.8, just downstream of Woodbridge Irrigation District Dam (WIDD). In this report, the upstream and downstream RST sites are referred to as VINO and GOLF, respectively.

During the 2012/13 monitoring season, RSTs were generally operated Monday through Friday, between December and July. However, the GOLF trap was removed from the river on 24 May 2013 because of a dry water year for the April through October period. During dry water years, the minimum flow below Woodbridge Dam during the months of June and July is 20 cfs, which is insufficient flow to operate the GOLF RST. During Monday through Friday operations, traps were taken out of service after each check on Friday afternoon. Traps were reset each Monday morning.

Efforts were made to maintain a rotational speed of two rotations per minute (RPM) or greater at both RSTs (USFWS 2008). Rotations were measured using a stopwatch to record the time for three full rotations. RPMs were taken at each trap check. Trap cables were adjusted to optimize rotations. Cone rotations since the previous trap check were read off of a Redington® mechanical counter mounted on side rails near the mouth of the cone. Water velocity was measured at the center of the trap cone, just below the water surface, at the beginning of each trap check. Pontoons, cones, live boxes and decks were cleaned daily to maintain traps in good working order. Cables, pulleys, counters and cones were inspected daily to ensure proper function.

Bypass Trap

A smolt bypass trap was operated in the bypass pipe at WIDD (rkm 62.2) during the 2012/13 trapping season (Figure 1). The bypass trap (referred to as BYPASS) conveys fish that are screened off of the Woodbridge Irrigation Canal when Woodbridge Irrigation District is diverting water from the LMR. A fish crowder and a long-handled dip net were used to capture fish. Debris was cleared from the trap during each check.

Calibrations

Multiple trap efficiency tests were conducted at each RST throughout the outmigration period to provide an estimate of the proportion of juvenile Chinook salmon each RST was capturing. Standard mark-recapture ratios were used as measurements of trap efficiency and calculated as follows:

$$TE = \frac{m}{M}, \text{ where}$$

TE = trap efficiency,
m = number of marked fish recaptured,
M = number of marked fish released.

Naturally produced Chinook salmon were used for the trap efficiency trials when catch was high enough to produce a group of test fish. Additional test fish were provided by California Department of Fish and Wildlife at the Mokelumne River Fish Installation (MRFI). Bismark® brown dye and/or upper caudal fin clips were used to mark groups of test fish for the VINO trap. A lower caudal fin clip, Bismark® brown dye, and Visible Implant Elastomer (Northwest Marine Technology ™) were used in different combinations to mark groups of test fish for the GOLF trap. The use of different marks provided the means to distinguish test fish between the two traps. The Bismark® brown dye was applied by holding test fish in an aerated tank of dye solution for approximately 60 minutes.

Mark retention and mortality rates were determined before releasing test fish. Calibration fish for GOLF were released below the face of Woodbridge Dam, approximately 0.1 rkm upstream of the trap location. Test fish for VINO were released approximately 0.25 rkm upstream of the trap location. The test fish were distributed proportionally to the flow across the river at each location.

Rotary Screw Trap Abundance Estimates

RST abundance estimates were generated for juvenile Chinook salmon and steelhead using the Petersen equation (Volkhardt et al. 2007). Daily catch estimates were generated for non-trapping days by averaging daily catch for three days preceding and following these periods (Appendix A). Trap efficiencies were applied to daily catch estimates and daily catch numbers to produce daily abundance estimates:

$$DA = \frac{C}{TE}\text{, where}$$

DA = daily abundance estimate,
C = daily catch or daily catch estimate,
TE = trap efficiency.

Annual abundance estimates were calculated by summing the daily abundance estimates. Ninety-five percent confidence intervals were calculated for each trap efficiency test using:

$$LCL = TE - 1.96\sqrt{TE\frac{(1-TE)}{M}}\text{, and}$$

$$UCL = TE + 1.96\sqrt{TE\frac{(1-TE)}{M}}\text{, where}$$

LCL = trap efficiency lower 95% confidence limit,
*UC*L = trap efficiency upper 95% confidence limit,
TE = trap efficiency,
M = number of marked fish released,
$TE\frac{(1-TE)}{M}$ = estimated variance of *TE*.

Daily confidence intervals for daily abundance estimates were calculated as follows:

$$DCI_{low} = \frac{C}{UCL}, \text{ and}$$

$$DCI_{high} = \frac{C}{LCL}, \text{ where}$$

DCI_{low} = daily abundance lower 95% confidence limit,
DCI_{high} = daily abundance upper 95% confidence limit,
C = daily catch or daily catch estimate,
UCL = trap efficiency upper 95% confidence limit,
LCL = trap efficiency lower 95% confidence limit.

Confidence intervals for annual abundance estimates were calculated by summing the daily abundance confidence intervals.

BYPASS Trap Abundance Estimates

When the BYPASS trap was in operation from 2 April to 28 May 2013, daily catch was added to the daily estimate at the GOLF trap to produce a daily downstream abundance estimate.

However, from 29 May to 2 July 2012, when the GOLF trap was removed for the season, abundance estimates were generated at the BYPASS trap using the same trap calibration methods described previously for the RSTs. Test fish used to calibrate the BYPASS trap were released in the lower Mokelumne River channel at rkm 63.3, within the Lodi Lake area. This release site was located approximately 0.5 rkm upstream of the WID canal/bypass pipe intake and approximately 0.9 rkm upstream of the WID dam and the end of the bypass pipe (where the BYPASS trap is located). Visible Implant Elastomer was used to mark the test salmon. The test salmon were distributed proportionally to the flow across the river at the release location.

Fish Handling and Condition Factors

Captured fish were processed in the field, just adjacent to the trapping site, or in a tagging trailer near the trap. The trailer was equipped with a flow-through water supply and re-circulating anesthetic bath to allow for safe processing of larger numbers of fish. The trailer was used at VINO during the early season and later transferred to Woodbridge Dam when a large number of smolt-sized salmon were caught at the GOLF and BYPASS traps. A 70 to 100 mg/L solution of tricaine methanesulfonate (MS-222) was used to anesthetize fish. Pumps and mechanical aerators were used to maintain suitable dissolved oxygen concentrations in all fish holding receptacles during processing.

During each trap check, up to 50 Chinook salmon and up to 20 fish of other species from each trap were weighed and measured. Fish were weighed to the nearest 0.1 gram using an Ohaus® Scout portable scale. Fork lengths (FL) and total lengths (TL) of each fish were measured to the nearest millimeter (mm). Life stage and any observations of marks, injuries or anomalies were also recorded. Processed fish were allowed to recover before being transported to the release site by truck or boat. The fish were transported in 19 liter (5 gallon) buckets equipped with battery operated aerators and released approximately

0.4 rkm (0.25 miles) downstream of the capture sites. When the GOLF and BYPASS traps were both in service, all fish caught at the BYPASS trap were transported and released approximately 0.4 rkm downstream of the GOLF trap to avoid counting them twice.

Fulton's Condition Factor (Bagenal and Tesh 1978) was calculated for up to 50 Chinook salmon caught each trapping day:

$$K = \left(\frac{W}{FL^3}\right) * 100{,}000, \text{ where}$$

K = Fulton's Condition Factor,
W = weight in grams,
FL = fork length in mm.

Trapping and Trucking

The Lower Mokelumne River Joint Settlement Agreement (1998) recommends that outmigrating Chinook salmon smolts be trapped at Woodbridge Dam and transported to the Delta during dry and critically dry water years, when agreed upon by the California Department of Fish and Wildlife (CDFW), the United States Fish and Wildlife Service (USFWS), and EBMUD. The purpose of the trapping and trucking operation is to reduce mortalities of emigrating juvenile salmon due to elevated water temperatures in the lower Mokelumne River downstream of Woodbridge Dam. The CDFW, USFWS, and EBMUD agreed to the criteria listed below to initiate trapping and trucking this season. Water temperature at the Frandy gage (rkm 46) must exceed 24°C or a 7-day moving average of 20°C in April, May, June or July. Trapping and trucking activities would be suspended if the 5-day average Chinook salmon count falls below 50 per day. The juvenile salmon would be trapped at Woodbridge Dam and transported to a release site with similar water temperatures.

A transport tank with two 284-liter compartments equipped with mechanical aerators was used to haul the salmon. Compartments were filled with water from the bypass trap using a submersible pump. Water was treated with Novaqua®, ice made from Mokelumne River water, and salt to minimize stress to fish. A recommended concentration of salt (0.1 to 0.3% salt solution) was used for fish transport (Piper et al 1992). Water temperatures and dissolved oxygen levels were recorded before transport, immediately after arrival at the release site, and just before the salmon were released. Mechanical aerators were used to maintain dissolved oxygen levels greater than 7.00 mg/L during transport. All fish were acclimated to within 1°C of the release water in the transport tanks before their release.

Juvenile Chinook Salmon Survival

<u>Egg to young-of-the-year survival indices</u>

Egg to young-of-the-year survival indices were calculated at the upstream and downstream trapping locations based on the brood year (BY) 2012 redd count and BY 2012 average fecundity per female at the MRFI. The annual redd count was multiplied by the average fecundity per female to estimate the total production of young-of-the-year (YOY) salmon at 100% survival. Chinook salmon passage estimates at each trapping location were divided by the total production estimate (at 100% survival) to calculate the survival index. Survival indices for BY 2012 were compared with previous years. The minimum and maximum survival indices were expected to range between 0.0 and 1.0, respectively.

In-river survival

A mark-recapture study was conducted between upstream and downstream trapping locations (25-rkm reach) on the LMR during the 2012/2013 outmigration season.

Naturally produced juvenile Chinook salmon were captured and marked with Visible Implant Elastomer (VIE) at the VINO RST over a span of 20 trapping days (between 16 January to 8 March 2013). A 70 to 100 mg/L solution of MS-222 was used to anesthetize the fish prior to tagging. Red, green, and yellow VIE was used to tag three groups of salmon. VIE marks were implanted in the snout of the salmon and approximately 2-3mm in length. All VIE-tagged salmon were held in 19 liter (5 gallon) buckets equipped with battery operated aerators for 30 minutes prior to their release roughly 0.15 rkm downstream of the VINO RST. Tag retention rates were estimated based on an independent mark retention study conducted over a 104-day study period during the 2010/2011 monitoring season (Bilski et al. 2011)

The minimum and maximum migration times (*Tmn* and *Tmx*), to the nearest day, were calculated for each recaptured salmon by subtracting the number of days between the recapture date (*Rc*) and the minimum and maximum release dates ($Rlmn_n$ and $Rlmx_n$) from the *nth* release group:

$$Tmn_n = Rc - Rlmn_n \,,\ \ Tmx_n = Rc - Rlmx_n$$

The Peterson equation was used to estimate the abundance of VIE-tagged salmon at the GOLF RST, where $\hat{N}g_i$ equals the estimated number of VIE-tagged salmon passing the GOLF RST during period *i*, M_i equals the number of salmon marked and released for a trap efficiency test during period *i*, ng_i equals the number of VIE-tagged salmon captured at GOLF during period *i*, and m_i equals the number of marked salmon recaptured during a trap efficiency test for period *i*:

$$\hat{N}g_i = \frac{ng_i M_i}{m_i}$$

The Peterson equation was also used to estimate the abundance of VIE-tagged salmon at the BYPASS when the GOLF RST was not in service: where $\hat{N}b_i$ equals the estimated number of VIE-tagged salmon passing the GOLF RST during period *i*, M_i equals the number of salmon marked and released for a trap efficiency test during period *i*, nb_i equals the number of VIE-tagged salmon captured at BYPASS during period *i*, and m_i equals the number of marked salmon recaptured during a trap efficiency test for period *i*:

$$\hat{N}b_i = \frac{nb_i M_i}{m_i}$$

The in-river survival index (*SI*) was calculated by dividing the sum of the total estimated number of VIE recaptures at the downstream traps ($\hat{N}g$ and $\hat{N}b$) by the estimated number of VIE-tagged salmon released at the upstream trap ($\hat{N}v$), where *Nv* equals the number of VIE-tagged salmon released at the upstream trap and *Re* is the mark retention of VIE-tagged salmon fry over a 104-day study period, as determined by the study previously mentioned.

$$SI = \frac{\hat{N}g + +\hat{N}b}{\hat{N}v}, \text{ where } \hat{N}g = \sum_{i=1}^{ng} \hat{N}g_i, \ \hat{N}b = \sum_{i=1}^{nb} \hat{N}b_i \text{ and } \hat{N}v = Nv \times Re$$

Data Analysis

Generalized linear models were constructed to examine the relationship between weekly salmon abundance (expressed as percent of annual abundance) and average weekly flow, water temperature, turbidity, and redd emergence timing (expressed as percent of annual redds) at the upstream and downstream trapping locations during the 2010 (2009/10) – 2013 (2012/13) juvenile monitoring seasons. A correlation matrix was built to determine if variables had a high level of collinearity with each other. Independent variables that correlated with one another at 0.70 or greater were not used together in the same models. The Minimum AICc (corrected Akaike Information Criterion) was used to select the best models. The top models at each trapping location were reported.

A redd emergence timeline based on an egg model developed by Vogel (1993) from Piper et al. (1992) was used to offset Chinook salmon spawn timing by the appropriate length of time until fry emergence. Seven extra days were added to the date of predicted emergence at the downstream traps to account for travel time from the spawning grounds to the downstream traps. No timing offset was used at the upstream trap because it is located just downstream of the majority of Chinook salmon spawning habitat (Setka 2004).

Graphics were created and data were analyzed using ArcMAP™ 10.0 (ESRI Inc.), JMP® 9.0.0 (SAS Institute Inc.), Microsoft® Office Access 2003 and Excel 2003. Statistical tests were considered significant if the *P*-value was ≤ 0.05. Mean fork lengths were reported with ±1 standard deviation (SD) for n > 3. Trap abundance estimates were reported with 95% confidence intervals (CI).

RESULTS

Mokelumne River Flow, Water Temperature, and Turbidity

Average daily flow at the Elliot Road gauging station (just downstream of the VINO trapping site) ranged from 194 cfs (5.5 m^3/s) to 508 cfs (14.4 m^3/s) during the time when the VINO trap was operated (17 December 2012 through 20 June 2013). The mean flow during that time was 284 cfs (8.0 m^3/s). Water temperatures recorded at the VINO trapping site fell between 8.2 and 16.9°C, with a mean of 11.9°C. Water turbidity at the

VINO RST ranged from 1.1 to 6.7 Nephelometric Turbidity Units (NTU), with a mean of 1.9 NTU.

Average daily flow at the GOLF gauging station ranged from 114 cfs (3.3 m^3/s) to 396 cfs (11.2 m^3/s) during the time when the GOLF RST was operated (7 January through 26 May 2013). The mean flow during that time was 165 cfs (4.7 m^3/s). Water temperatures recorded at the GOLF trapping site ranged between 7.1 and 18.9°C, with a mean of 13.2°C. Water turbidity at GOLF ranged from 1.5 to 14.4 NTU, with a mean of 2.6 NTU.

During the time that the BYPASS trap was operated (2 April through 2 July 2013) average daily flow at the Victor gauging station ranged from 171 cfs (4.8 m^3/s) to 356 cfs (10.1 m^3/s), with a mean of 274 cfs (7.8 m^3/s). Flow at the Woodbridge Irrigation District Canal ranged from 0 cfs to 160 cfs (4.5 m^3/s) and averaged 101 cfs (2.9 m^3/s) when the BYPASS was in service. Water temperatures recorded at the BYPASS trap ranged from 14.5 to 23.2°C, with a mean of 18.2°C. Water turbidity at the BYPASS ranged from 1.6 to 3.3 NTU, with a mean of 2.3 NTU.

Average daily flow, water temperature and turbidity in the lower Mokelumne River are presented at locations between Camanche Dam and the GOLF gauging station in Figure 2.

Trap Operations

The VINO RST was operated between 17 December 2012 and 20 June 2013. The cone was stopped by debris on 2 of 97 days when the trap was checked. Excluding days with trap stoppages, the minimum recorded cone rotation rate was 1.9 RPM and the maximum was 3.9 RPM. The mean rotation rate during the monitoring season was 2.6 RPM. The VINO trap met or exceeded the CAMP recommended minimum rotation speed of 2.0 RPMs (USFWS 2008) on 98% of all operating days (excluding stoppage days). Water velocity entering the center of the trap cone ranged between 0.3 and 1.2 m/s, with a mean of 0.8 m/s.

The GOLF RST was operated from 7 January to 26 May 2013. Debris stopped the cone from rotating on 8 of 75 days when the trap was checked. Excluding trap stoppages, the minimum recorded cone rotation rate was 1.2 RPM and the maximum was 4.2 RPM. Average rotational speed over the course of the monitoring period was 2.5 RPM. The GOLF trap met or exceeded the CAMP recommended minimum rotation speed of 2.0 RPMs (USFWS 2008) on 76% of all operating days (excluding stoppage days). Water velocities entering the center of the trap cone ranged between 0.3 and 1.1 m/s, with a mean of 0.6 m/s.

The BYPASS trap at WIDD was operated between 2 April and 2 July 2013. During this time frame the trap was checked on 51 days. Water velocities at the top of the trap ranged between 0.2 and 0.9 m/s and averaged 0.6 m/s.

RST Calibrations

Eight calibration tests were conducted for the VINO RST during the 2012/13 juvenile monitoring season (Table 1). Naturally produced Chinook salmon were used as test fish for five tests and Chinook salmon from the MRFI were used for three tests. Trap efficiency tests 7 and 8 were pooled because there was an insufficient number of fish recaptured to generate 95% CIs for each individual test. Smolt-sized salmon were released under similar flow conditions during tests 7 and 8 (Table 1). Trap efficiencies ranged from 0.3% to 13.7% and averaged 7.1% (n = 8).

Eight calibration tests were conducted for the GOLF RST during the 2012/13 juvenile monitoring season (Table 1). Chinook salmon produced at the hatchery (MRFI) were used as test fish for all of the tests. GOLF trap efficiencies ranged from 2.6% to 28.6%, with a mean of 9.1% (n = 8).

Four calibration tests were conducted for the BYPASS during the 2012/13 juvenile monitoring season (Table 1). Chinook salmon from the MRFI were used as test fish for all four tests. Trap efficiencies for the BYPASS ranged from 27.0% to 62.0%, with a mean of 38.8% (n = 4).

Chinook Salmon

<u>Catch and Abundance Estimates</u>

During the monitoring season, 51,669 naturally produced young-of-the-year (YOY) Chinook salmon were captured at the VINO RST. Estimates for weekend catch were added to actual catch to produce an estimated count of 113,995 YOY Chinook salmon. Using trap efficiency data, the total estimated abundance of YOY salmon passing the upstream RST (VINO) was 1,203,754 (95% CI: 958,664-1,724,580). The first and last salmon were caught on 18 December 2012 and 20 June 2013, respectively. The highest monthly abundance estimate was recorded at the VINO trap during the month of February (Table 2).

At the GOLF RST, 2,516 naturally produced YOY Chinook salmon were captured between 7 January and 24 May 2013. Estimates for weekend catch were added to the actual catch to produce an estimated count of 5,305 YOY Chinook salmon. Using trap efficiency data, the estimated abundance of YOY Chinook salmon at the downstream RST (GOLF) was 69,116 (95% CI: 54,891-94,109).

A total of 35,674 naturally produced juvenile Chinook salmon were captured at the BYPASS trap between 2 April and 2 July 2013. Estimates for weekend catch were added to the actual catch to produce an estimated count of 63,894 YOY Chinook salmon. Using trap efficiency data, the estimated abundance of YOY Chinook salmon at the BYPASS trap was 78,474 (95% CI: 75,450-82,471).

The total downstream emigration estimate of 147,590 YOY Chinook salmon (95% CI: 130,342-176,579) was calculated by adding the BYPASS trap estimate to the GOLF RST estimate. At the downstream traps, the highest monthly abundance estimate was recorded during the month of May (Table 2).

Life stage, size and condition

At the VINO RST, 99.2% (n=51,241) of the Chinook salmon catch (natural production) was classified as fry. The remaining naturally produced Chinook salmon catch was classified as parr (0.1%, n=74), silvery parr (0.3%, n=139), and smolts (0.4%, n=215). In addition, two hatchery-origin (adipose fin-clipped) Chinook salmon yearlings, seven hatchery-origin smolts, and nine hatchery-origin silvery parr were caught at the VINO trap. The size distribution by life stage of naturally produced Chinook salmon caught and measured at the VINO trap during the 2012/13 season is provided by Figure 3.

Chinook salmon catch (natural production) at the downstream traps (GOLF and BYPASS) was primarily composed of smolts (94.8%, n=36,224). The remaining naturally produced Chinook salmon catch was classified as fry (4.9%, n=1,872), parr (0.04%, n=14), silvery parr (0.2%, n=80), and yearlings (0.04%, n=15). In addition, 220 hatchery-origin (adipose fin-clipped) Chinook salmon yearlings, 93 hatchery-origin smolts, and two hatchery-origin silvery parr were caught at the downstream traps. The size distribution by life stage of naturally produced Chinook salmon caught and measured at the downstream traps during the 2012/13 season is provided by Figure 3.

The monthly average condition factors by life stage for Chinook salmon caught and measured at the upstream and downstream traps are presented in Figure 4.

Migration Response

The relationships between three environmental variables (average daily flow, water temperature and turbidity) and estimated daily salmon passage at the upstream and downstream traps during the 2012/2013 monitoring season are presented graphically in Figures 5 and 6.

At the upstream trap, trapping year, water temperature (rkm 87), redd emergence, and the interaction between trapping year and water temperature were the variables included in the generalized linear model with the lowest AICc (Table 3). Redd emergence had a significant positive relationship with weekly salmon abundance, while water temperature had a significant negative relationship with weekly salmon abundance. However, the interaction between water temperature and trapping year was also significant, demonstrating that the relationship between salmon abundance and water temperature varied on an annual basis. Average weekly flow (rkm 86), average weekly turbidity (rkm 87), and the interactions between those variables and trapping year were also examined, but not included in the model.

At the downstream traps, trapping year, flow (rkm 80), and the interaction between trapping year and flow (rkm 80) were the variables included in the generalized linear model with the lowest AICc (Table 3). The significant interaction between trapping year and flow (rkm 80) demonstrated that the relationship between salmon abundance and flow (rkm 80) varied on an annual basis. Average weekly flow (rkm 61), average weekly water diversion at the WID canal (rkm 62), average weekly turbidity (rkm 61), and predicted Chinook salmon redd emergence were other variables examined, but not included in the model.

Trapping and Trucking

Trapping and trucking was initiated on 5 June 2013, the first trapping day after the daily mean water temperature at the Frandy gauging station (rkm 46) exceeded a 7-day moving average of 20°C. Juvenile Chinook salmon were transported for a total of 13 trapping days, until 26 June 2013, when the 5-day Chinook salmon count average fell below 50 per day at the BYPASS trap. During this time 3,204 smolt-sized Chinook salmon were trapped at Woodbridge Dam (BYPASS, rkm 62) and transported to the South Fork of the lower Mokelumne River at Wimpy's Marina (rkm 30). The number of fish released alive was 3,202. Two salmon died during transport, resulting in a 0.1% mortality rate. The mortalities were attributed to handling and/or transport stress. All fish were acclimated in the transport tanks to within 1.0ºC of the release water temperature by introducing water into the tanks before release.

Egg-to-young-of-the-year survival indices

During the BY 2012 spawning season, 1,287 Chinook salmon redds were identified in the LMR. The average fecundity per female salmon spawned at the MRFI was 4,965 and the resulting estimated salmon production at 100% survival was 6,389,955 juveniles. The BY 2012 survival index for naturally produced YOY Chinook salmon passing the upstream trap (VINO) was 0.19 (95% CI: 0.15-0.27). At the downstream trapping locations (BYPASS and GOLF), the BY 2012 survival index was 0.02 (95% CI: 0.02-0.03). The BY 2012 downstream survival index was relatively low, similar to BY 2009 and BY 2011 (Table 4).

In-River Survival

A total of 4,713 naturally produced juvenile Chinook salmon were captured and marked with VIE at the Vino Farms RST over the course of 20 trapping days, which fell between 16 January and 8 March 2013. Subsampled VIE-tagged Chinook salmon had a mean FL of 35.6 mm (SD = 1.8, n=1,000). A total of 4,708 (99.9%) VIE-tagged salmon were classified as fry, while 5 (0.1%) were classified as parr.

The release timing of VIE-tagged salmon was similar to the outmigration pattern of juvenile Chinook salmon at the upstream trap (Figure 7A). At the downstream traps, the outmigration timing of VIE-tagged salmon appeared to be similar to the outmigration timing of all naturally produced juvenile Chinook salmon (Figure 7B).

A total of 44 VIE-tagged Chinook salmon was recaptured at the downstream traps (GOLF and BYPASS) between 5 February and 6 June 2013. Recaptured VIE-tagged salmon consisted of 4 seamed fry having a mean FL of 36 mm (SD = 0) and 40 smolts with a mean FL of 89.5 mm (SD = 6.9). A total of 40 recaptured VIE-tagged salmon remained in the 25-rkm reach for more than 56 days, while 4 recaptured VIE-tagged salmon spent 30 days or less in the reach.

Estimates for weekend catch were added to the actual catch to produce an estimated count of 80 recaptured VIE-tagged Chinook salmon. Using trap efficiency data, the estimated abundance of VIE-tagged Chinook salmon at the downstream traps was 242 (95% CI: 205-304). The in-river survival index of VIE-tagged salmon was 0.05 (95% CI: 0.05-0.07), while the in-river survival index of all naturally produced salmon was 0.12 (Table 5).

Steelhead

<u>Catch and Abundance Estimates</u>

The first wild (natural production) YOY steelhead was captured at the VINO RST on 5 February 2013. A total of 225 wild YOY steelhead was caught between 17 December 2012 and 20 June 2013. Estimates for weekend catch were added to actual catch to produce an estimated count of 435 naturally produced steelhead. Estimated passage of wild YOY steelhead (based on trap calibrations using Chinook salmon) was 19,098 (95% CI: 11,803-61,624). The largest monthly catch of wild steelhead (89) occurred at VINO in April.

Zero wild YOY steelhead was captured at the GOLF RST during the 2012/2013 season. Steelhead catch at GOLF also consisted of two wild age 1+ smolts.

At the BYPASS trap, 123 wild YOY steelhead were captured between 9 May and 2 July 2013. Estimates for weekend catch were added to actual catch to produce an estimated count of 219 naturally produced YOY steelhead. The estimated passage of wild YOY steelhead (based on BYPASS trap calibrations using Chinook salmon) was 462 (95% CI: 411-532). Steelhead catch at the BYPASS also consisted of 5 wild age 1+ individuals and eight hatchery origin (adipose fin-clipped) yearlings. The largest monthly catch of wild steelhead (99) occurred at the downstream traps in June.

<u>Life stage and size</u>

At the VINO RST, 88% of the naturally produced steelhead catch was classified as fry. The remaining wild steelhead catch was composed of parr (12%). Steelhead parr were also frequently caught at the downstream traps (GOLF and BYPASS), comprising 95% of the wild steelhead catch. Other wild steelhead catch at the downstream traps included fry (1%) and age 1+ silvery parr and smolts (4%). The size distribution by life stage of all wild steelhead measured at the upstream and downstream traps is presented in Figure 8.

Species Composition

Seventeen fish species were caught at the VINO RST during the survey period, 8 native and 9 non-native species. Native fish species were more frequently caught than non-native species, comprising 99.9% of the total catch. Chinook salmon (no adipose fin-clip) was the most abundant species caught (97.5%), followed by Pacific lamprey (*Lampetra tridentata)* (1.4%).

At the downstream traps (GOLF and BYPASS) 25 fish species were caught, 8 native and 17 non-native species. Native fish species were more frequently caught than non-native species, comprising 64% of the total catch. Chinook salmon (no adipose fin-clip) was the most abundant species caught (56.1%) at the downstream traps, followed by unidentified black bass (*Micropterus* spp.) (34.3%), and prickly sculpin (*Cottus asper*) (6.3%).

DISCUSSION

During the 2012/2013 juvenile outmigration monitoring season, the VINO RST experienced only two stoppages. The first stoppage in early March took place after 2,535 trap revolutions and the stoppage in April took place when small numbers of salmon were being caught at the trap. Consequently, salmon catch was not estimated at VINO on the two trapping days with stoppages. At the GOLF RST, eight trap stoppages took place throughout the 2012/2013 monitoring season. Salmon catch was not estimated at GOLF on days with trap stoppages, which may have led to a small underestimate of salmon catch and abundance at the GOLF trap.

At the VINO RST, naturally produced salmon fry were used as test fish for trap efficiency trials that took place during the beginning of the monitoring season. Conversely, near the middle and the end of the season, trap efficiency trials were conducted using parr and smolt-sized salmon from the MRFI. Initially, recapture rates of the MRFI salmon were sufficient to generate reliable abundance estimates and 95% CIs. However, tests 7 and 8, which used larger smolt-sized salmon from the MRFI, yielded just a few recaptures and were pooled to improve the abundance estimates and the 95% confidence intervals. These tests were performed within two weeks of each other using smolt-sized salmon that were released under similar flow conditions.

At the GOLF RST, eight trap efficiency trials were run using groups of test salmon from the MRFI. All of the tests were successful this season. Of these tests, two paired tests were run in May in an attempt to examine the impacts of striped bass (*Morone saxatilis*) predation on juvenile Chinook salmon survival just below WIDD. The first paired test (tests 5 and 6) occurred in early May. Efficiency test 5 was conducted just prior to the relocation of eleven striped bass ranging between 400-700 mm FL. Efficiency test 6 took place two days after the first relocation effort. The second paired test (tests 7 and 8) occurred in late May. Efficiency test 7 was conducted just prior to the relocation of one striped bass (560 mm). Efficiency test 8 took place two days after the second relocation effort. The size of the test salmon and the flow below WIDD were nearly identical for the paired tests.

The recapture rate of juvenile Chinook salmon at the GOLF RST increased from 2.6% to 6.7% after the first striped bass relocation effort. However, the recapture rate dropped from 4.9% to 2.9% after the second relocation effort. The results of the first paired test indicated that efforts to relocate striped bass may improve Chinook salmon survival just below WIDD when large numbers of striped bass are present. However, more data will be needed to support this idea, as the recapture rate of juvenile Chinook salmon dropped during the second paired trial, demonstrating that there may be some variability in recapture rates at the GOLF trap that is not related to flow, origin of test salmon, the size of test salmon, or the presence of striped bass.

The 2012/2013 monitoring season was the second season that calibration tests for the BYPASS trap took place. Recapture rates of test salmon from releases 1, 3, and 4 were similar to the recapture rates during the previous monitoring season, ranging between 27 - 37%. However, the recapture rate for efficiency test 2 was much higher, as 62% of the test salmon were recaptured. Interestingly, the proportion of water diverted into the WID canal during test 2 was not vastly different than the proportion diverted during tests 3 and 4. Unlike the previous season, a unique mark was used for each efficiency release group used to calibrate the BYPASS during the 2012/2013 monitoring season. These data provided information on how quickly the test salmon moved from their release location to the BYPASS trap. Over 94% (439) of all test salmon were recaptured at the BYPASS within 4 days or less of their release at Lodi Lake. Roughly 6% (27) of all test salmon were recaptured at the BYPASS after 5 days or more of their release at Lodi Lake. These data indicated that most of the test salmon are moving through Lodi Lake within a short window of time, allowing for reasonable efficiency assessments of the BYPASS trap.

The upstream passage estimate of 1,203,754 YOY Chinook salmon was the highest on record at the VINO FARMS trap location. The BY 2012 egg-to-YOY survival index of 0.19 was a large improvement over the previous season. Careful management of the Camanche Reservoir hypolimnion allowed for cold water releases from the low level outlet into the LMR during the 2012/2013 Chinook salmon embryo incubation period. Consequently average daily surface water temperatures at rkm 101 were maintained below 15.1°C from 1 November 2012 to 1 February 2013, the critical time period for Chinook salmon embryo incubation. The downstream Chinook salmon passage estimate of 147,590 ranked the 11th highest (of 21) on record since the 1992/93 juvenile outmigration season. The downstream egg-to-YOY survival index of 0.02 was low relative to previous seasons. Dry conditions may have contributed to the low survival index, as Calendar Year (CY) 2013 was the driest CY on record in the Mokelumne River watershed. Other factors that may contribute to the survival rate of juvenile Chinook salmon in the upstream reaches of the LMR include predation by native and non-native fish species, pre-spawn mortality, egg loses that take place during egg deposition (Schroder et al. 2008), mortality associated with the physical and chemical habitat parameters associated at the spawning site (Merz et al. 2004), and small unscreened surface water diversions in the LMR. Moyle and Israel (2005) indicated that small diversions may have a cumulative impact on fish populations, but the impacts of individual diversions may be highly variable depending on their size and location.

The 2012/2013 in-river survival indices were also somewhat low, most likely due to many of the reasons formerly mentioned. This season there was a noticeable difference between the in-river survival index calculated by using VIE- tagged salmon and the survival index calculated by using the upstream and downstream abundance estimates. The in-river survival index generated by using VIE-tagged salmon was 0.05. In contrast, the in-river survival index calculated by using the upstream and downstream abundance estimates was 0.12. During the 2011/2012 juvenile monitoring season the in-river survival index for VIE-tagged salmon was 0.08, while the in-river survival index for all naturally produced salmon was 0.26. There may be several reasons the in-river survival index for VIE-tagged salmon is consistently lower than the index calculated by using the upstream and downstream abundance estimates. This season 4,713 VIE-tagged salmon were released at the upstream trapping location. This may be an insufficient release number due to the low probability of recapture at the GOLF RST, which had trap efficiencies that averaged 9.1% over the monitoring period. It is also possible that VIE-tagged salmon had a higher mortality rate due to increased stress associated with handling and/or reduced fitness associated with possessing a mark. Additional mortality studies may be warranted in the future. Also, a larger number of VIE-tagged salmon may be needed for release at the upstream trapping location to help increase the number of recaptures at the downstream trapping locations.

Water temperature, adult spawn timing, and the interaction between water temperature and trapping year were significant factors in influencing the number of Chinook salmon passing the upstream trapping location during the 2010-2013 outmigration seasons. The relationship between adult spawn timing and Chinook salmon abundance was positive, indicating that the majority of juvenile salmon pass the upstream trapping location as fry and only a small proportion of juvenile salmon rear in the uppermost reaches of the LMR. This result also reinforces the idea that the upstream RST provides a good measurement of salmon fry production and egg-to-fry survival rates during the first three to four months of the monitoring season. A similar relationship was found between Chinook salmon spawn timing and weekly Chinook salmon catch at the upstream RST in the lower Feather River, which was also positioned just below the majority of Chinook salmon spawning habitat (Seesholtz et al. 2004). Trapping year and the interaction between flow (rkm 80) and trapping year were significant factors in influencing the number of Chinook salmon passing the downstream trapping locations during the 2010-2013 outmigration seasons.

While these analyses provide some insight about the factors that influence juvenile Chinook salmon passage over four trapping years at the upstream and downstream trapping locations, a larger set of data may help reveal how environmental cues influence Chinook salmon outmigration during specific water year types. Additionally, environmental variables such as accumulated thermal units, lunar cycle, and change in discharge should also be examined and may improve the strength of the models (Roper and Scarnecchia 1999; Sykes et al. 2009).

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Table 1. Summary of trap efficiency tests conducted at trapping locations on the lower Mokelumne River during the 2012/2013 juvenile monitoring season. Abbreviations are as follows: MRFI = Mokelumne River Fish Installation, LMR = lower Mokelumne River.

VINO FARMS (UPSTREAM RST)

Test #	Release date	Flow at release (cfs) - Elliot Rd.	Origin of test salmon	Ave. FL of test salmon (mm)	# Released	# Recaptured	% Recaptured	Used for abundance estimate?
1	08-Jan-13	439	LMR	34	236	27	**11.4%**	Yes
2	15-Jan-13	201	LMR	34	468	64	**13.7%**	Yes
3	05-Feb-13	197	LMR	35	750	69	**9.2%**	Yes
4	26-Feb-13	241	LMR	36	321	34	**10.6%**	Yes
5	12-Mar-13	231	LMR	35	271	19	**7.0%**	Yes
6	08-Apr-13	261	MRFI	59	1,020	45	**4.4%**	Yes
7	13-May-13	343	MRFI	75	998	4	**0.4%**	Yes
8	28-May-13	317	MRFI	82	1,008	3	**0.3%**	Yes

GOLF (DOWNSTREAM RST)

Test #	Release date	Flow at release (cfs) - Golf	Origin of test salmon	Ave. FL of test salmon (mm)	# Released	# Recaptured	% Recaptured	Used for abundance estimate?
1	28-Jan-13	189	MRFI	34	748	50	**6.7%**	Yes
2	26-Feb-13	114	MRFI	36	797	228	**28.6%**	Yes
3	02-Apr-13	175	MRFI	56	999	104	**10.4%**	Yes
4	24-Apr-13	163	MRFI	72	1,004	98	**9.8%**	Yes
5	06-May-13	164	MRFI	79	1,000	26	**2.6%**	Yes
6	08-May-13	163	MRFI	79	1,005	67	**6.7%**	Yes
7	20-May-13	161	MRFI	83	1,000	49	**4.9%**	Yes
8	22-May-13	161	MRFI	82	1,000	29	**2.9%**	Yes

BYPASS (DOWNSTREAM)

Test #	Release date	Flow at release (cfs) - Victor (WID canal)	Origin of test salmon	Ave. FL of test salmon (mm)	# Released	# Recaptured	% Recaptured	Used for abundance estimate?
1	28-May-13	328 (104)	MRFI	92	300	111	**37.0%**	Yes
2	03-Jun-13	204 (116)	MRFI	91	300	186	**62.0%**	Yes
3	17-Jun-13	207 (110)	MRFI	93	300	81	**27.0%**	Yes
4	24-Jun-13	225 (120)	MRFI	86	300	88	**29.3%**	Yes

Table 2. Expanded monthly catch, juvenile passage estimates with 95% confidence intervals (LCI and UCI), and percent passage of Chinook salmon captured at the upstream and downstream trapping locations on the lower Mokelumne River during the 2012/2013 juvenile monitoring season.

Upstream (VINO FARMS)

Month	Catch	Estimate	95% LCI	95% UCI	Percent passage (%)
December	648	5,662	4,179	8,778	0.5%
January	14,896	118,797	92,145	169,248	9.9%
February	90,211	942,227	768,264	1,218,503	78.3%
March	7,562	73,157	55,193	108,804	6.1%
April	218	4,567	3,502	6,626	0.4%
May	432	51,177	30,685	181,267	4.3%
June	29	8,167	4,695	31,354	0.7%
Total	**113,995**	**1,203,754**	**958,664**	**1,724,580**	**100%**

Downstream (GOLF and BYPASS)

Month	Catch	Estimate	95% LCI	95% UCI	Percent passage (%)
January	34	504	397	688	0.3%
February	3,320	45,706	36,188	62,127	31.0%
March	826	2,886	2,600	3,241	2.0%
April	849	3,630	3,268	4,156	2.5%
May	33,635	76,297	71,354	85,137	51.7%
June	4,277	18,360	16,358	20,979	12.4%
July	31	208	177	252	0.1%
Total	**42,970**	**147,590**	**130,342**	**176,579**	**100%**

Table 3. Generalized linear models for juvenile Chinook salmon abundance at the upstream and downstream trapping locations based on environmental variables and redd emergence timing on the lower Mokelumne River during the 2010-2013 juvenile outmigration monitoring seasons.

Model						
Upstream (VINO FARMS)						
AICc	df	*P*	Independent Variable	df	X^2	*P*
175.621	8, 105	**<0.0001**				
			Year	3	4.837	0.1841
			Water temperature	1	38.022	**<0.0001**
			Year x Water temperature	3	7.950	**0.0471**
			Redd emergence	1	17.832	**<0.0001**
Downstream (GOLF and BYPASS)						
Model						
AICc	df	*P*	Independent Variable	df	X^2	*P*
154.418	7, 102	**<0.0001**				
			Year	3	12.702	**0.0053**
			Flow (rkm 80)	1	3.058	0.0803
			Year x Flow (rkm 80)	3	30.051	**<0.0001**

Table 4. A summary of annual upstream and downstream juvenile Chinook salmon survival indices (egg to young-of-the-year) on the lower Mokelumne River. Indices were calculated by dividing the annual upstream and downstream juvenile passage estimates by the estimated number of naturally produced Chinook salmon on the LMR for a given brood year (BY). The total estimated natural production for each BY was calculated by multiplying the annual Chinook salmon redd count by the average annual fecundity estimate for a female Chinook salmon spawned at the Mokelumne River Fish Installation (MRFI). Ave. flow = Average of daily flow (cfs) at Camanche Dam (upstream) and Golf (downstream) from January-July following each BY.

BY	Trap(s) used	Chinook salmon redd count	Estimated production (at 100% survival)	Abundance estimate	95% LCI	95% UCI	Survival index (LCI - UCI)	Ave. flow (min-max)
Upstream (rkm 87.4)								
2007	Vino Farms	306	1,615,887	1,117,451	798,895	7,184,950	0.69 (0.49-4.45)	264 (208-517)
2008	Vino Farms	63	377,044	175,612	131,191	280,979	0.47 (0.35-0.75)	293 (205-425)
2009	Vino Farms	248	1,329,217	124,279	93,555	199,950	0.09 (0.07-0.15)	647 (298-1,464)
2010	Vino Farms	314	1,574,651	842,570	631,115	2,039,099	0.54 (0.40-1.29)	1,903 (550-4,702)
2011	Vino Farms	564	3,083,952	202,772	152,937	312,856	0.07 (0.05-0.10)	293 (202-370)
2012	Vino Farms	1,287	6,389,955	1,203,754	958,664	1,724,580	0.19 (0.15-0.27)	311 (236-503)
Downstream (rkm 62)								
2007	Golf	306	1,615,887	18,347	14,513	25,152	0.01 (0.01-0.02)	138 (23-283)
2008	Golf & Bypass	63	377,044	30,614	29,171	32,802	0.08 (0.08-0.09)	150 (26-256)
2009	Golf & Bypass	248	1,329,217	67,349	39,512	283,914	0.05 (0.03-0.21)	512 (120-1,248)
2010	Golf & Bypass	314	1,574,651	281,500	186,249	606,084	0.18 (0.12-0.38)	1,822 (380-4,106)
2011	Golf & Bypass	564	3,083,952	51,799	42,063	70,631	0.02 (0.01-0.02)	162 (32-506)
2012	Golf & Bypass	1,287	6,389,955	147,590	130,342	176,579	0.02 (0.02-0.03)	141 (22-426)

Table 5. A comparison of the in-river survival indices (SI) between VIE-tagged Chinook salmon and all naturally produced Chinook salmon within a 25-rkm reach of the lower Mokelumne River during the 2012/2013 juvenile monitoring season.

	Upstream release estimate (Nv)	Downstream abundance estimate (Ng+Nb)	95% LCI (downstream abundance)	95% UCI (downstream abundance)	SI ((Ng+Nb)/Nv)
VIE-tagged salmon	4,442	242	205	304	0.05
	Upstream abundance estimate (UAb)	Downstream abundance estimate (DAb)	95% LCI (downstream abundance)	95% UCI (downstream abundance)	SI (DAb/UAb)
All naturally produced salmon	1,203,754	147,590	130,342	176,579	0.12

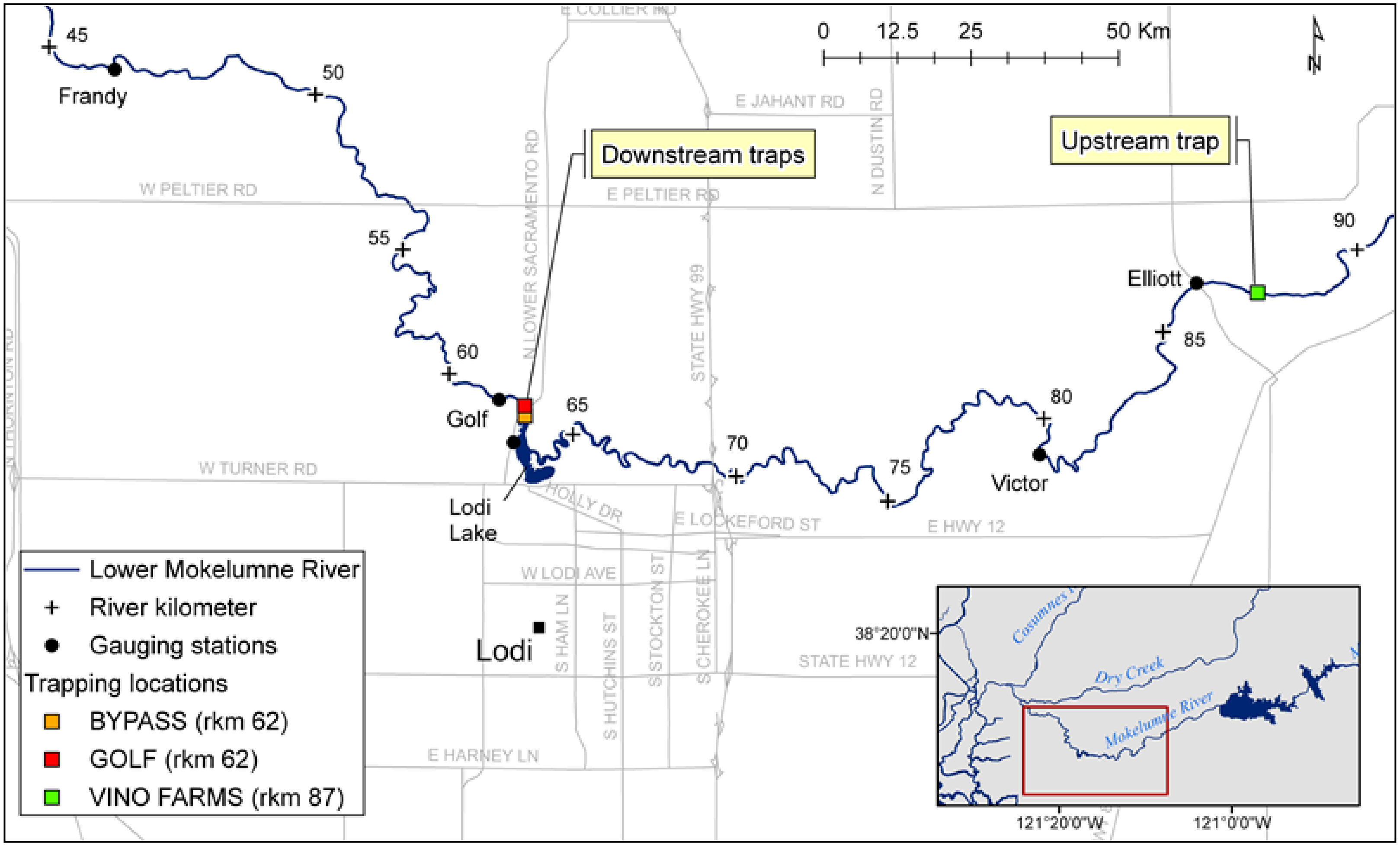


Figure 1. Trapping sites used for juvenile outmigration monitoring on the lower Mokelumne River during the 2012/13 season.

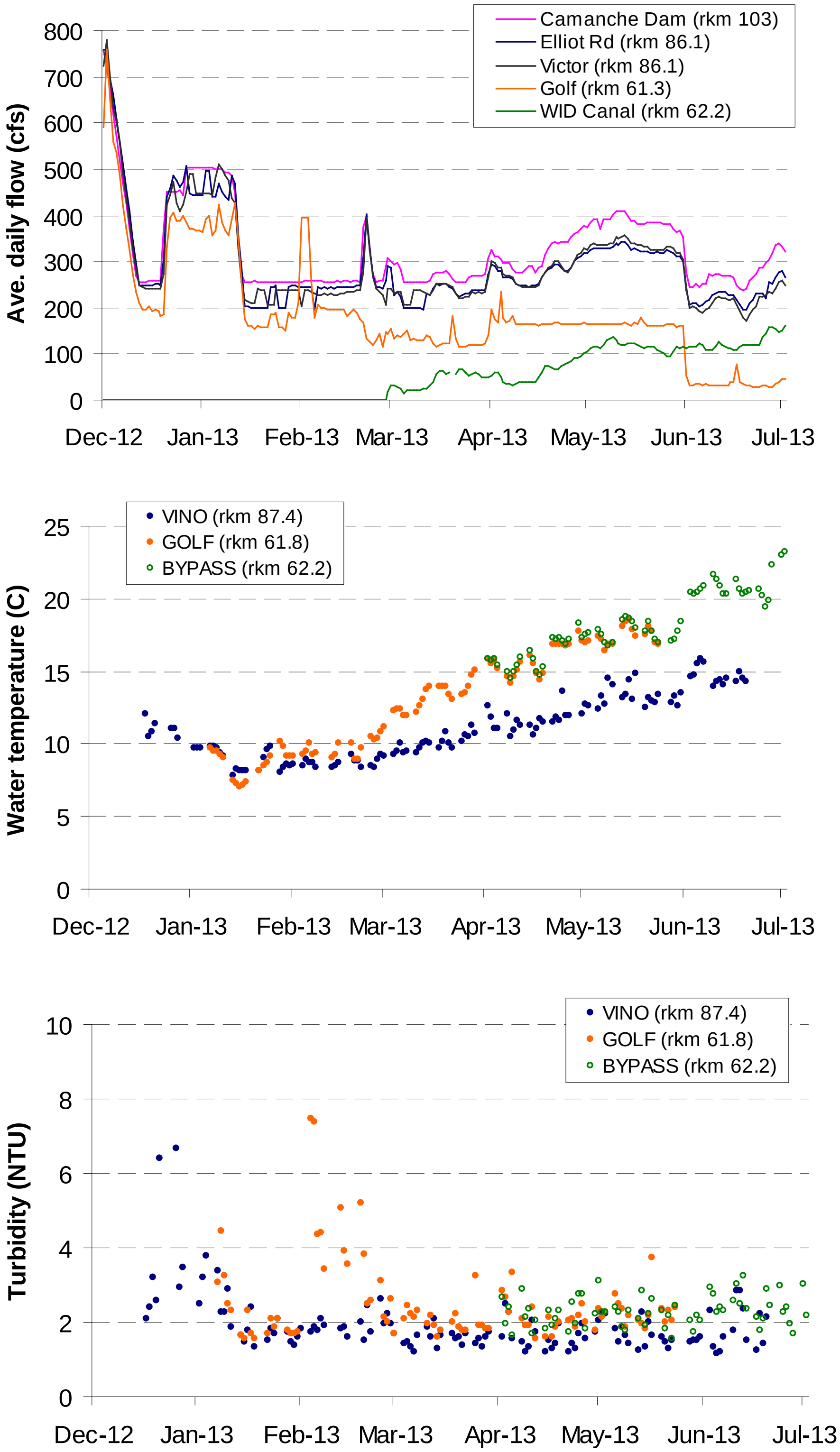


Figure 2. Average daily flow, turbidity and water temperature in the lower Mokelumne River between Camanche Dam (rkm 103) and Golf (rkm 61.3) during the 2012/13 juvenile outmigration monitoring season.

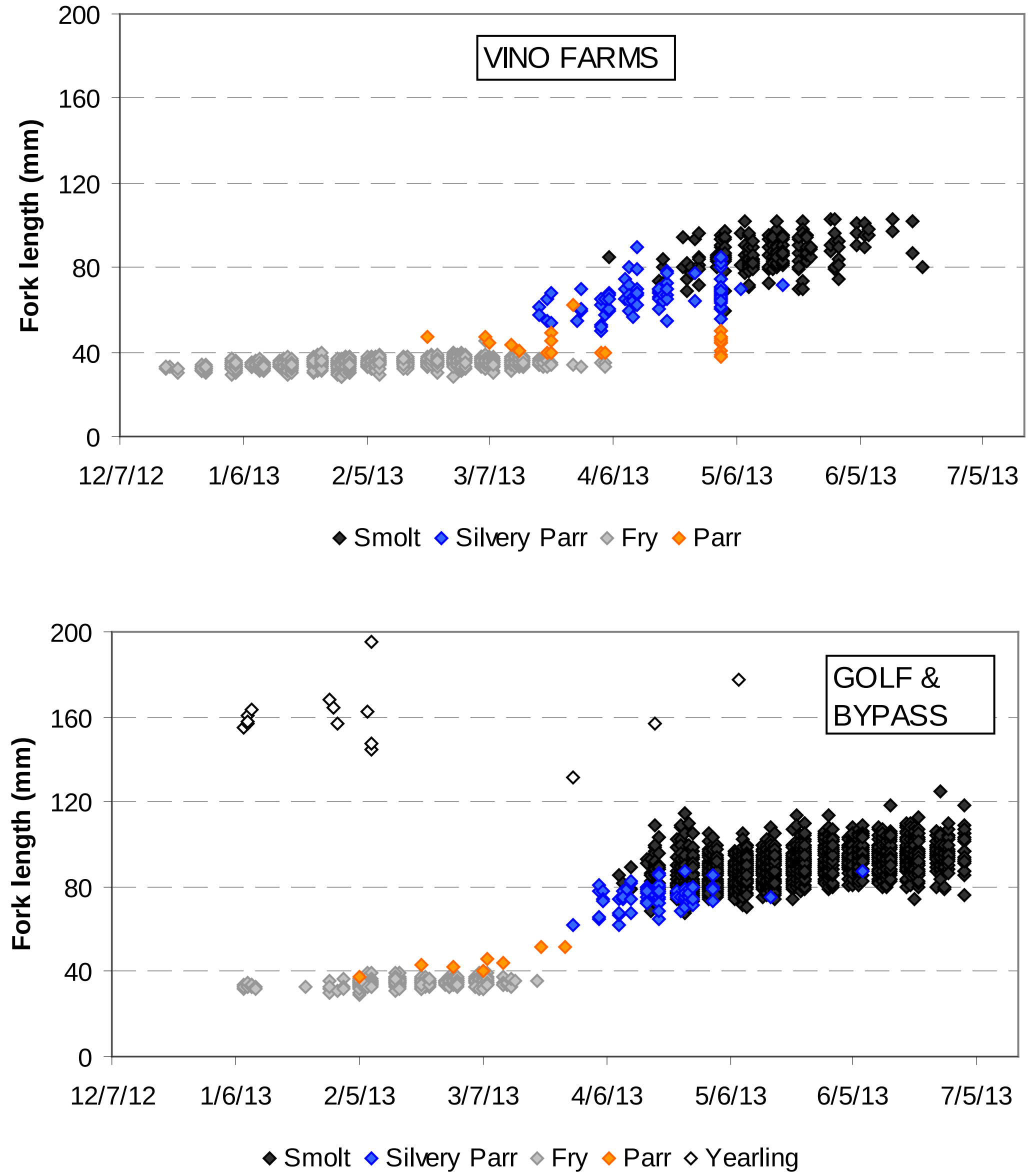


Figure 3. Size distribution by life stage of wild juvenile Chinook salmon caught and measured at the upstream (VINO FARMS) and downstream (GOLF and BYPASS) trapping locations during the 2012/13 juvenile outmigration season on the lower Mokelumne River.

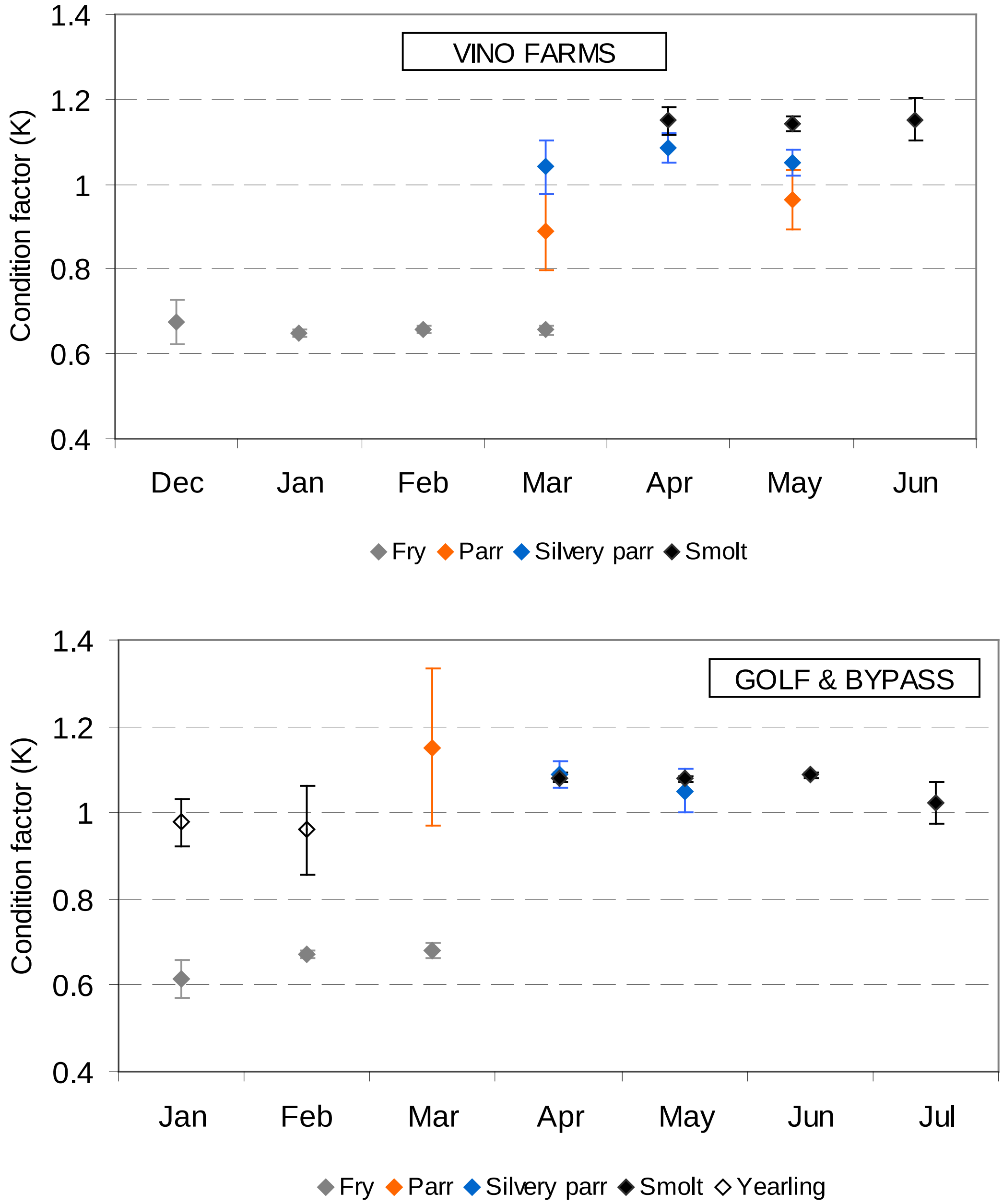


Figure 4. Monthly average condition factor (diamonds) ± 2 SE (vertical lines) of wild juvenile Chinook salmon caught and measured at the upstream (VINO FARMS) and downstream (GOLF & BYPASS) trapping locations during the 2012/13 juvenile outmigration monitoring season on the lower Mokelumne River.

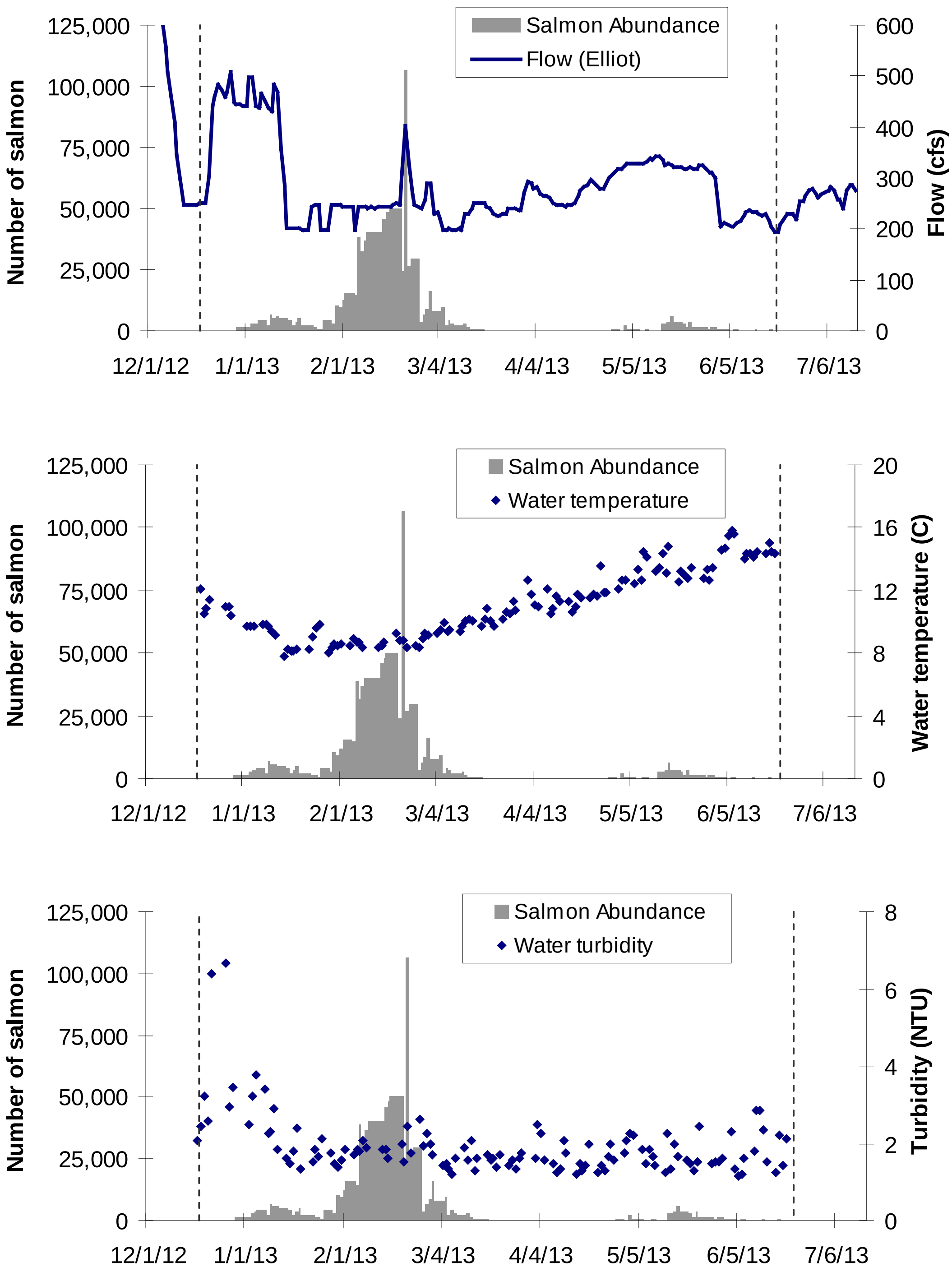


Figure 5. The relationship between estimated daily Chinook salmon passage and flow (top), water temperature (middle), and turbidity (bottom) at the VINO RST (upstream trapping location) during the 2012/13 juvenile outmigration monitoring season. The dashed vertical lines indicate the beginning and the end of the monitoring period.

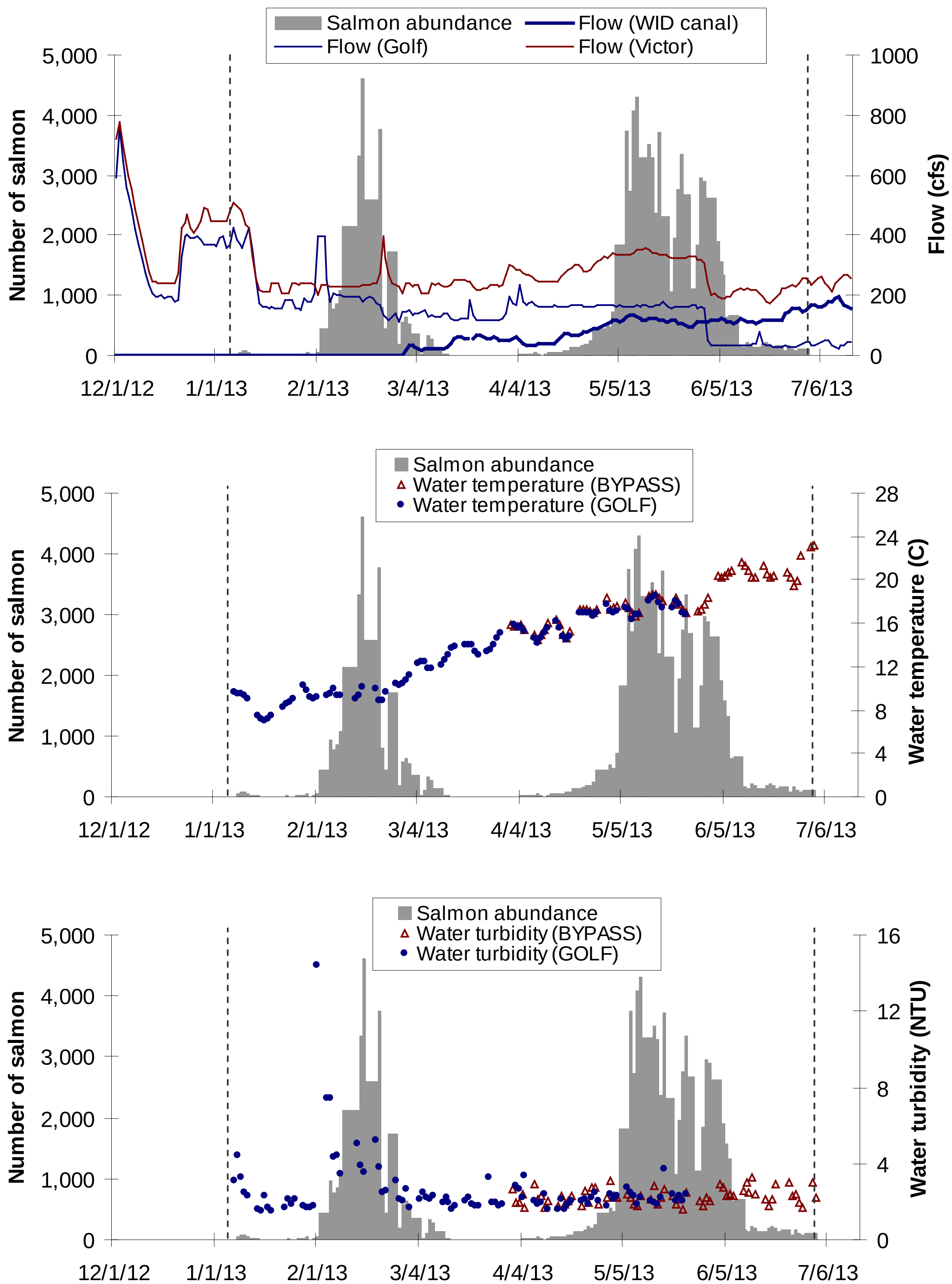


Figure 6. The relationship between estimated daily Chinook salmon passage and flow (top), water temperature (middle), and turbidity (bottom) at the downstream trapping locations (GOLF & BYPASS) during the 2012/13 juvenile outmigration monitoring season. The dashed vertical lines indicate the beginning and the end of the monitoring period.

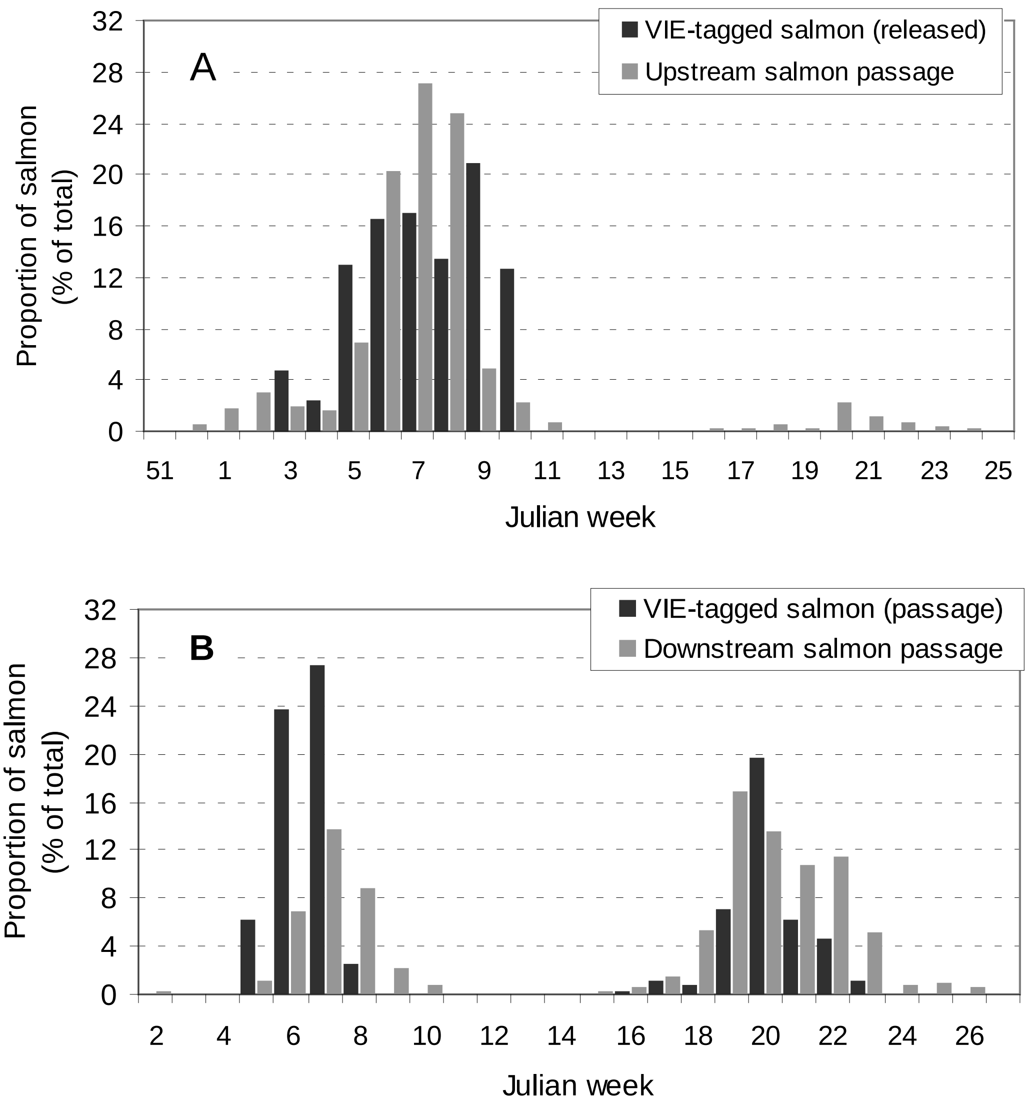
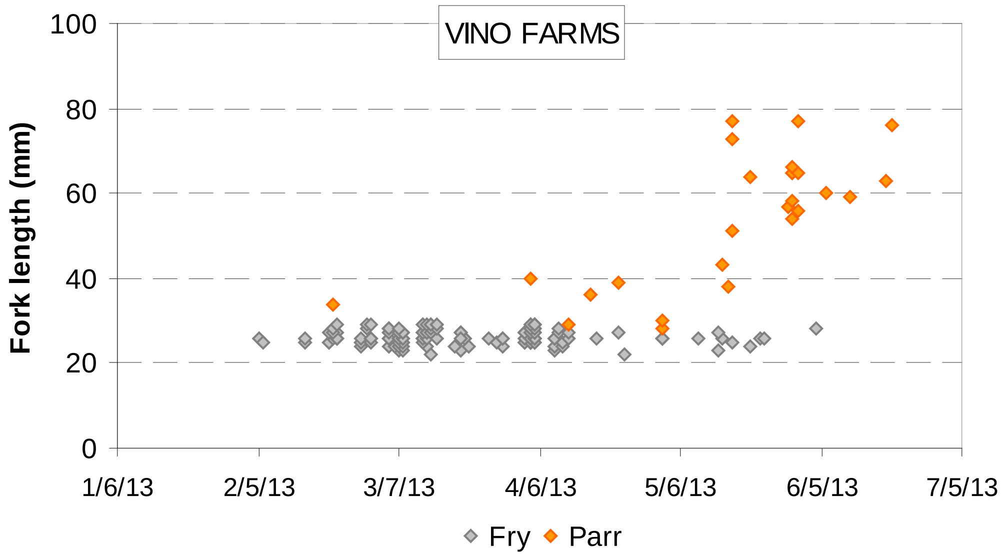


Figure 7. A comparison between the release timing of VIE-tagged Chinook salmon and the passage of all juvenile Chinook salmon at the upstream trapping location (**A**). A comparison between the passage of recaptured VIE-tagged Chinook salmon and the passage of all juvenile Chinook salmon at the downstream trapping locations (**B**).



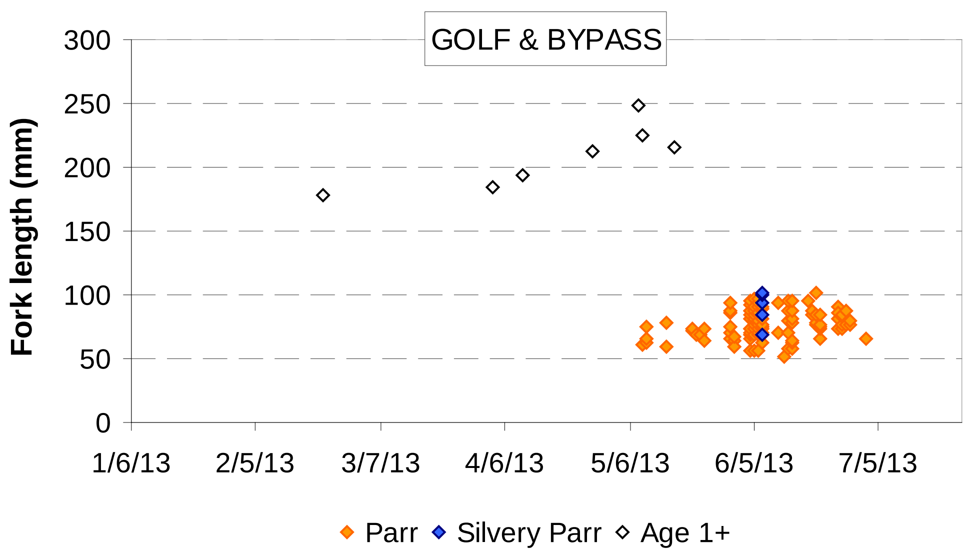


Figure 8. Size and life stage distribution of wild steelhead caught and measured at the upstream (VINO FARMS) and downstream (GOLF & BYPASS) trapping locations during the 2012/13 juvenile outmigration monitoring season on the lower Mokelumne River.

Appendix A. Daily trap catch, trap efficiency, abundance estimates, and 95% confidence intervals (CI) of emigrating juvenile Chinook salmon at the upstream rotary screw trap (VINO) on the lower Mokelumne River during the 2012/13 monitoring period. Shaded areas represent non-trapping periods.

Date	Catch	Efficiency	Abundance estimate	95% Lower CI	95% Upper CI
12/18/2012	3	0.1144	**26**	19	41
12/19/2012	1	0.1144	**9**	6	14
12/20/2012	0	0.1144	**0**	0	0
12/21/2012	3	0.1144	**26**	19	41
12/22/2012	10	0.1144	**86**	63	133
12/23/2012	10	0.1144	**86**	63	133
12/24/2012	10	0.1144	**86**	63	133
12/25/2012	10	0.1144	**86**	63	133
12/26/2012	10	0.1144	**86**	63	133
12/27/2012	30	0.1144	**262**	194	407
12/28/2012	15	0.1144	**131**	97	203
12/29/2012	182	0.1144	**1,593**	1,176	2,470
12/30/2012	182	0.1144	**1,593**	1,176	2,470
12/31/2012	182	0.1144	**1,593**	1,176	2,470
1/1/2013	182	0.1144	**1,593**	1,176	2,470
1/2/2013	182	0.1144	**1,593**	1,176	2,470
1/3/2013	310	0.1144	**2,710**	2,000	4,201
1/4/2013	374	0.1144	**3,269**	2,413	5,068
1/5/2013	465	0.1144	**4,068**	3,002	6,307
1/6/2013	465	0.1144	**4,068**	3,002	6,307
1/7/2013	465	0.1144	**4,068**	3,002	6,307
1/8/2013	239	0.1144	**2,089**	1,542	3,239
1/9/2013	776	0.1144	**6,783**	5,006	10,515
1/10/2013	628	0.1144	**5,489**	4,051	8,510
1/11/2013	677	0.1144	**5,917**	4,367	9,174
1/12/2013	558	0.1144	**4,880**	3,602	7,566
1/13/2013	558	0.1144	**4,880**	3,602	7,566
1/14/2013	558	0.1144	**4,880**	3,602	7,566
1/15/2013	471	0.1144	**4,117**	3,038	6,382
1/16/2013	300	0.1368	**2,194**	1,787	2,840
1/17/2013	498	0.1368	**3,642**	2,966	4,715
1/18/2013	682	0.1368	**4,987**	4,062	6,457
1/19/2013	317	0.1368	**2,317**	1,887	3,000
1/20/2013	317	0.1368	**2,317**	1,887	3,000
1/21/2013	317	0.1368	**2,317**	1,887	3,000
1/22/2013	317	0.1368	**2,317**	1,887	3,000
1/23/2013	191	0.1368	**1,397**	1,138	1,808
1/24/2013	148	0.1368	**1,082**	882	1,401
1/25/2013	82	0.1368	**600**	488	776
1/26/2013	582	0.1368	**4,256**	3,467	5,510
1/27/2013	582	0.1368	**4,256**	3,467	5,510
1/28/2013	582	0.1368	**4,256**	3,467	5,510

Appendix A continued

Date	Catch	Efficiency	Abundance estimate	95% Lower CI	95% Upper CI
1/29/2013	375	0.1368	**2,742**	2,234	3,550
1/30/2013	1,401	0.1368	**10,245**	8,345	13,264
1/31/2013	1,295	0.1368	**9,470**	7,714	12,261
2/1/2013	1,687	0.1368	**12,336**	10,049	15,972
2/2/2013	2,148	0.1368	**15,704**	12,792	20,332
2/3/2013	2,148	0.1368	**15,704**	12,792	20,332
2/4/2013	2,148	0.1368	**15,704**	12,792	20,332
2/5/2013	2,009	0.1368	**14,691**	11,967	19,020
2/6/2013	3,544	0.0920	**38,522**	31,450	49,695
2/7/2013	2,949	0.0920	**32,054**	26,170	41,352
2/8/2013	3,372	0.0920	**36,652**	29,924	47,283
2/9/2013	3,701	0.0920	**40,230**	32,845	51,900
2/10/2013	3,701	0.0920	**40,230**	32,845	51,900
2/11/2013	3,701	0.0920	**40,230**	32,845	51,900
2/12/2013	3,701	0.0920	**40,230**	32,845	51,900
2/13/2013	3,701	0.0920	**40,230**	32,845	51,900
2/14/2013	4,206	0.0920	**45,717**	37,325	58,978
2/15/2013	4,435	0.0920	**48,207**	39,357	62,189
2/16/2013	4,623	0.0920	**50,246**	41,022	64,820
2/17/2013	4,623	0.0920	**50,246**	41,022	64,820
2/18/2013	4,623	0.0920	**50,246**	41,022	64,820
2/19/2013	4,623	0.0920	**50,246**	41,022	64,820
2/20/2013	2,202	0.0920	**23,935**	19,541	30,877
2/21/2013	9,813	0.0920	**106,663**	87,083	137,601
2/22/2013	2,457	0.0920	**26,707**	21,804	34,453
2/23/2013	2,730	0.0920	**29,674**	24,227	38,281
2/24/2013	2,730	0.0920	**29,674**	24,227	38,281
2/25/2013	2,730	0.0920	**29,674**	24,227	38,281
2/26/2013	323	0.0920	**3,511**	2,866	4,529
2/27/2013	667	0.1059	**6,297**	4,778	9,231
2/28/2013	918	0.1059	**8,667**	6,577	12,705
3/1/2013	1,705	0.1059	**16,097**	12,215	23,597
3/2/2013	827	0.1059	**7,809**	5,926	11,448
3/3/2013	827	0.1059	**7,809**	5,926	11,448
3/4/2013	827	0.1059	**7,809**	5,926	11,448
3/5/2013	989	0.1059	**9,337**	7,085	13,688
3/6/2013	220	0.1059	**2,077**	1,576	3,045
3/7/2013	464	0.1059	**4,381**	3,324	6,422
3/8/2013	339	0.1059	**3,201**	2,429	4,692
3/9/2013	241	0.1059	**2,278**	1,729	3,340
3/10/2013	241	0.1059	**2,278**	1,729	3,340
3/11/2013	241	0.1059	**2,278**	1,729	3,340
3/12/2013	274	0.1059	**2,587**	1,963	3,792
3/13/2013	95	0.0701	**1,355**	945	2,392
3/14/2013	56	0.0701	**799**	557	1,410
3/15/2013	40	0.0701	**571**	398	1,007

Appendix A continued

Date	Catch	Efficiency	Abundance estimate	95% Lower CI	95% Upper CI
3/16/2013	36	0.0701	**518**	361	915
3/17/2013	36	0.0701	**518**	361	915
3/18/2013	36	0.0701	**518**	361	915
3/19/2013	12	0.0701	**171**	119	302
3/20/2013	6	0.0701	**86**	60	151
3/21/2013	9	0.0701	**128**	90	227
3/22/2013	8	0.0701	**114**	80	201
3/23/2013	5	0.0701	**64**	45	113
3/24/2013	5	0.0701	**64**	45	113
3/25/2013	5	0.0701	**64**	45	113
3/26/2013	0	0.0701	**0**	0	0
3/27/2013	2	0.0701	**29**	20	50
3/28/2013	2	0.0701	**29**	20	50
3/29/2013	4	0.0701	**57**	40	101
3/30/2013	5	0.0701	**64**	45	113
3/31/2013	5	0.0701	**64**	45	113
4/1/2013	5	0.0701	**64**	45	113
4/2/2013	5	0.0701	**64**	45	113
4/3/2013	7	0.0701	**100**	70	176
4/4/2013	6	0.0701	**86**	60	151
4/5/2013	6	0.0701	**86**	60	151
4/6/2013	6	0.0701	**78**	55	139
4/7/2013	6	0.0701	**78**	55	139
4/8/2013	6	0.0701	**78**	55	139
4/9/2013	4	0.0441	**91**	71	127
4/10/2013	7	0.0441	**159**	123	222
4/11/2013	3	0.0441	**68**	53	95
4/12/2013	8	0.0441	**181**	141	254
4/13/2013	6	0.0441	**144**	112	201
4/14/2013	6	0.0441	**144**	112	201
4/15/2013	6	0.0441	**144**	112	201
4/16/2013	0	0.0441	**0**	0	0
4/17/2013	12	0.0441	**272**	212	381
4/18/2013	8	0.0441	**181**	141	254
4/19/2013	8	0.0441	**181**	141	254
4/20/2013	6	0.0441	**136**	106	190
4/21/2013	6	0.0441	**136**	106	190
4/22/2013	6	0.0441	**136**	106	190
4/23/2013	2	0.0441	**45**	35	63
4/24/2013	3	0.0441	**68**	53	95
4/25/2013	3	0.0441	**68**	53	95
4/26/2013	4	0.0441	**91**	71	127
4/27/2013	6	0.0441	**136**	106	190
4/28/2013	23	0.0441	**518**	403	725
4/29/2013	23	0.0441	**518**	403	725

Appendix A continued

Date	Catch	Efficiency	Abundance estimate	95% Lower CI	95% Upper CI
4/30/2013	23	0.0441	**518**	403	725
5/1/2013	9	0.0441	**204**	159	286
5/2/2013	98	0.0441	**2,221**	1,728	3,110
5/3/2013	17	0.0441	**385**	300	539
5/4/2013	25	0.0441	**563**	438	788
5/5/2013	25	0.0441	**563**	438	788
5/6/2013	25	0.0441	**563**	438	788
5/7/2013	3	0.0441	**68**	53	95
5/8/2013	4	0.0441	**91**	71	127
5/9/2013	18	0.0441	**408**	317	571
5/10/2013	16	0.0441	**363**	282	508
5/11/2013	12	0.0441	**268**	209	375
5/12/2013	12	0.0441	**268**	209	375
5/13/2013	12	0.0441	**268**	209	375
5/14/2013	10	0.0035	**2,866**	1,647	11,002
5/15/2013	10	0.0035	**2,866**	1,647	11,002
5/16/2013	13	0.0035	**3,725**	2,142	14,302
5/17/2013	21	0.0035	**6,018**	3,460	23,103
5/18/2013	12	0.0035	**3,391**	1,949	13,018
5/19/2013	12	0.0035	**3,391**	1,949	13,018
5/20/2013	12	0.0035	**3,391**	1,949	13,018
5/21/2013	9	0.0035	**2,579**	1,483	9,901
5/22/2013	5	0.0035	**1,433**	824	5,501
5/23/2013	13	0.0035	**3,725**	2,142	14,302
5/24/2013	4	0.0035	**1,146**	659	4,401
5/25/2013	6	0.0035	**1,672**	961	6,418
5/26/2013	6	0.0035	**1,672**	961	6,418
5/27/2013	6	0.0035	**1,672**	961	6,418
5/28/2013	6	0.0035	**1,672**	961	6,418
5/29/2013	3	0.0035	**860**	494	3,300
5/30/2013	5	0.0035	**1,433**	824	5,501
5/31/2013	5	0.0035	**1,433**	824	5,501
6/1/2013	3	0.0035	**907**	522	3,484
6/2/2013	3	0.0035	**907**	522	3,484
6/3/2013	3	0.0035	**907**	522	3,484
6/4/2013	3	0.0035	**860**	494	3,300
6/5/2013	0	0.0035	**0**	0	0
6/6/2013	3	0.0035	**860**	494	3,300
6/7/2013	2	0.0035	**573**	329	2,200
6/8/2013	1	0.0035	**334**	192	1,284
6/9/2013	1	0.0035	**334**	192	1,284
6/10/2013	1	0.0035	**334**	192	1,284
6/11/2013	0	0.0035	**0**	0	0
6/12/2013	0	0.0035	**0**	0	0
6/13/2013	2	0.0035	**573**	329	2,200

Appendix A continued

Date	Catch	Efficiency	Abundance estimate	95% Lower CI	95% Upper CI
6/14/2013	0	0.0035	**0**	0	0
6/15/2013	1	0.0035	**239**	137	917
6/16/2013	1	0.0035	**239**	137	917
6/17/2013	1	0.0035	**239**	137	917
6/18/2013	2	0.0035	**573**	329	2,200
6/19/2013	0	0.0035	**0**	0	0
6/20/2013	1	0.0035	**287**	165	1,100

Appendix B. Daily trap catch, trap efficiency, abundance estimates, and 95% confidence intervals (CI) of emigrating juvenile Chinook salmon at the downstream traps (GOLF and BYPASS) on the lower Mokelumne River during the 2012/13 monitoring period. Shaded areas represent non-trapping periods.

Date	GOLF catch	Bypass catch	GOLF efficiency	BYPASS efficiency	Downstream abundance estimate	95% Lower CI	95% Upper CI
1/8/2013	3	–	0.0668	–	**45**	35	61
1/9/2013	5	–	0.0668	–	**75**	59	102
1/10/2013	5	–	0.0668	–	**75**	59	102
1/11/2013	3	–	0.0668	–	**45**	35	61
1/12/2013	2	–	0.0668	–	**32**	26	44
1/13/2013	2	–	0.0668	–	**32**	26	44
1/14/2013	2	–	0.0668	–	**32**	26	44
1/15/2013	0	–	0.0668	–	**0**	0	0
1/16/2013	0	–	0.0668	–	**0**	0	0
1/17/2013	0	–	0.0668	–	**0**	0	0
1/18/2013	0	–	0.0668	–	**0**	0	0
1/19/2013	0	–	0.0668	–	**2**	2	3
1/20/2013	0	–	0.0668	–	**2**	2	3
1/21/2013	0	–	0.0668	–	**2**	2	3
1/22/2013	0	–	0.0668	–	**2**	2	3
1/23/2013	1	–	0.0668	–	**15**	12	20
1/24/2013	0	–	0.0668	–	**0**	0	0
1/25/2013	0	–	0.0668	–	**0**	0	0
1/26/2013	1	–	0.0668	–	**17**	14	24
1/27/2013	1	–	0.0668	–	**17**	14	24
1/28/2013	1	–	0.0668	–	**17**	14	24
1/29/2013	4	–	0.0668	–	**60**	47	82
1/30/2013	0	–	0.0668	–	**0**	0	0
1/31/2013	2	–	0.0668	–	**30**	24	41
2/1/2013	3	–	0.0668	–	**45**	35	61
2/2/2013	30	–	0.0668	–	**446**	352	610
2/3/2013	30	–	0.0668	–	**446**	352	610
2/4/2013	30	–	0.0668	–	**446**	352	610
2/5/2013	64	–	0.0668	–	**957**	755	1,308
2/6/2013	52	–	0.0668	–	**778**	614	1,062
2/7/2013	58	–	0.0668	–	**868**	684	1,185
2/8/2013	73	–	0.0668	–	**1,092**	861	1,491
2/9/2013	143	–	0.0668	–	**2,139**	1,687	2,922
2/10/2013	143	–	0.0668	–	**2,139**	1,687	2,922
2/11/2013	143	–	0.0668	–	**2,139**	1,687	2,922
2/12/2013	143	–	0.0668	–	**2,139**	1,687	2,922
2/13/2013	143	–	0.0668	–	**2,139**	1,687	2,922
2/14/2013	223	–	0.0668	–	**3,336**	2,631	4,556
2/15/2013	309	–	0.0668	–	**4,623**	3,646	6,313
2/16/2013	173	–	0.0668	–	**2,594**	2,046	3,543
2/17/2013	173	–	0.0668	–	**2,594**	2,046	3,543
2/18/2013	173	–	0.0668	–	**2,594**	2,046	3,543
2/19/2013	173	–	0.0668	–	**2,594**	2,046	3,543

Appendix B continued

Date	GOLF catch	Bypass catch	GOLF efficiency	BYPASS efficiency	Downstream abundance estimate	95% Lower CI	95% Upper CI
2/20/2013	252	–	0.0668	–	**3,770**	2,974	5,148
2/21/2013	54	–	0.0668	–	**808**	637	1,103
2/22/2013	29	–	0.0668	–	**434**	342	592
2/23/2013	116	–	0.0668	–	**1,728**	1,363	2,360
2/24/2013	116	–	0.0668	–	**1,728**	1,363	2,360
2/25/2013	116	–	0.0668	–	**1,728**	1,363	2,360
2/26/2013	13	–	0.0668	–	**194**	153	266
2/27/2013	163	–	0.2861	–	**570**	513	640
2/28/2013	182	–	0.2861	–	**636**	573	715
3/1/2013	155	–	0.2861	–	**542**	488	609
3/2/2013	106	–	0.2861	–	**372**	335	417
3/3/2013	106	–	0.2861	–	**372**	335	417
3/4/2013	106	–	0.2861	–	**372**	335	417
3/5/2013	11	–	0.2861	–	**38**	35	43
3/6/2013	35	–	0.2861	–	**122**	110	137
3/7/2013	92	–	0.2861	–	**322**	290	361
3/8/2013	77	–	0.2861	–	**269**	243	302
3/9/2013	36	–	0.2861	–	**127**	114	143
3/10/2013	36	–	0.2861	–	**127**	114	143
3/11/2013	36	–	0.2861	–	**127**	114	143
3/12/2013	7	–	0.2861	–	**24**	22	27
3/13/2013	4	–	0.2861	–	**14**	13	16
3/14/2013	3	–	0.2861	–	**10**	9	12
3/15/2013	1	–	0.2861	–	**3**	3	4
3/16/2013	2	–	0.2861	–	**6**	5	7
3/17/2013	2	–	0.2861	–	**6**	5	7
3/18/2013	2	–	0.2861	–	**6**	5	7
3/19/2013	0	–	0.2861	–	**0**	0	0
3/20/2013	1	–	0.2861	–	**3**	3	4
3/21/2013	1	–	0.2861	–	**3**	3	4
3/22/2013	0	–	0.2861	–	**0**	0	0
3/23/2013	1	–	0.2861	–	**2**	2	2
3/24/2013	1	–	0.2861	–	**2**	2	2
3/25/2013	1	–	0.2861	–	**2**	2	2
3/26/2013	0	–	0.2861	–	**0**	0	0
3/27/2013	1	–	0.2861	–	**3**	3	4
3/28/2013	0	–	0.2861	–	**0**	0	0
3/29/2013	1	–	0.2861	–	**3**	3	4
3/30/2013	1	–	0.2861	–	**3**	3	4
3/31/2013	1	–	0.2861	–	**3**	3	4
4/1/2013	1	–	0.2861	–	**3**	3	4
4/2/2013	1	–	0.2861	–	**3**	3	4
4/3/2013	0	0	0.1041	–	**0**	0	0
4/4/2013	2	2	0.1041	–	**21**	18	25
4/5/2013	2	1	0.1041	–	**20**	17	24
4/6/2013	2	1	0.1041	–	**20**	17	24

Appendix B continued

Date	GOLF catch	Bypass catch	GOLF efficiency	BYPASS efficiency	Downstream abundance estimate	95% Lower CI	95% Upper CI
4/7/2013	2	1	0.1041	–	**20**	17	24
4/8/2013	2	1	0.1041	–	**20**	17	24
4/9/2013	5	0	0.1041	–	**48**	41	59
4/10/2013	3	1	0.1041	–	**30**	25	36
4/11/2013	0	1	0.1041	–	**1**	1	1
4/12/2013	3	3	0.1041	–	**32**	27	38
4/13/2013	4	9	0.1041	–	**44**	38	52
4/14/2013	4	9	0.1041	–	**44**	38	52
4/15/2013	4	9	0.1041	–	**44**	38	52
4/16/2013	5	7	0.1041	–	**55**	48	66
4/17/2013	5	14	0.1041	–	**62**	55	73
4/18/2013	6	26	0.1041	–	**84**	75	96
4/19/2013	7	25	0.1041	–	**92**	82	107
4/20/2013	11	30	0.1041	–	**135**	119	159
4/21/2013	11	30	0.1041	–	**135**	119	159
4/22/2013	11	30	0.1041	–	**135**	119	159
4/23/2013	16	17	0.1041	–	**171**	147	205
4/24/2013	18	35	0.1041	–	**208**	181	246
4/25/2013	14	60	0.0976	–	**203**	181	237
4/26/2013	12	127	0.0976	–	**250**	230	278
4/27/2013	25	175	0.0976	–	**431**	391	490
4/28/2013	20	233	0.0976	–	**439**	406	487
4/29/2013	20	233	0.0976	–	**439**	406	487
4/30/2013	20	233	0.0976	–	**439**	406	487
5/1/2013	27	260	0.0976	–	**537**	493	601
5/2/2013	24	235	0.0976	–	**481**	442	538
5/3/2013	19	538	0.0976	–	**733**	702	778
5/4/2013	23	1,600	0.0976	–	**1,831**	1,794	1,884
5/5/2013	23	1,600	0.0976	–	**1,831**	1,794	1,884
5/6/2013	23	1,600	0.0976	–	**1,831**	1,794	1,884
5/7/2013	23	2,862	0.0260	–	**3,746**	3,503	4,286
5/8/2013	20	1,960	0.0260	–	**2,728**	2,517	3,198
5/9/2013	22	3,745	0.0667	–	**4,075**	4,013	4,174
5/10/2013	42	3,680	0.0667	–	**4,310**	4,192	4,500
5/11/2013	37	2,758	0.0667	–	**3,306**	3,203	3,470
5/12/2013	37	2,758	0.0667	–	**3,306**	3,203	3,470
5/13/2013	37	2,758	0.0667	–	**3,306**	3,203	3,470
5/14/2013	48	2,799	0.0667	–	**3,519**	3,384	3,736
5/15/2013	40	2,694	0.0667	–	**3,294**	3,181	3,475
5/16/2013	47	1,670	0.0667	–	**2,375**	2,243	2,587
5/17/2013	36	3,183	0.0667	–	**3,723**	3,622	3,886
5/18/2013	39	1,725	0.0667	–	**2,310**	2,200	2,486
5/19/2013	39	1,725	0.0667	–	**2,310**	2,200	2,486
5/20/2013	39	1,725	0.0667	–	**2,310**	2,200	2,486
5/21/2013	22	619	0.0490	–	**1,068**	972	1,237
5/22/2013	39	1,152	0.0490	–	**1,948**	1,777	2,247

Appendix B continued

Date	GOLF catch	Bypass catch	GOLF efficiency	BYPASS efficiency	Downstream abundance estimate	95% Lower CI	95% Upper CI
5/23/2013	50	1,034	0.0290	–	**2,758**	2,303	3,722
5/24/2013	47	1,718	0.0290	–	**3,339**	2,911	4,245
5/25/2013	45	1,125	0.0290	–	**2,689**	2,276	3,563
5/26/2013	45	1,125	0.0290	–	**2,689**	2,276	3,563
5/27/2013	–	1,125	–	–	**1,125**	1,125	1,125
5/28/2013	–	1,125	–	–	**1,125**	1,125	1,125
5/29/2013	–	680	–	0.3700	**1,838**	1,601	2,156
5/30/2013	–	1,097	–	0.3700	**2,965**	2,583	3,479
5/31/2013	–	1,071	–	0.3700	**2,895**	2,522	3,396
6/1/2013	–	973	–	0.3700	**2,629**	2,291	3,084
6/2/2013	–	973	–	0.3700	**2,629**	2,291	3,084
6/3/2013	–	973	–	0.3700	**2,629**	2,291	3,084
6/4/2013	–	1,185	–	0.6200	**1,911**	1,756	2,097
6/5/2013	–	974	–	0.6200	**1,571**	1,443	1,724
6/6/2013	–	829	–	0.6200	**1,337**	1,228	1,467
6/7/2013	–	390	–	0.6200	**629**	578	690
6/8/2013	–	420	–	0.6200	**677**	622	742
6/9/2013	–	420	–	0.6200	**677**	622	742
6/10/2013	–	420	–	0.6200	**677**	622	742
6/11/2013	–	102	–	0.6200	**165**	151	181
6/12/2013	–	89	–	0.6200	**144**	132	158
6/13/2013	–	133	–	0.6200	**215**	197	235
6/14/2013	–	126	–	0.6200	**203**	187	223
6/15/2013	–	85	–	0.6200	**137**	126	151
6/16/2013	–	85	–	0.6200	**137**	126	151
6/17/2013	–	85	–	0.6200	**137**	126	151
6/18/2013	–	52	–	0.2700	**193**	162	237
6/19/2013	–	59	–	0.2700	**219**	184	268
6/20/2013	–	52	–	0.2700	**193**	162	237
6/21/2013	–	39	–	0.2700	**144**	122	177
6/22/2013	–	42	–	0.2700	**156**	132	192
6/23/2013	–	42	–	0.2700	**156**	132	192
6/24/2013	–	42	–	0.2700	**156**	132	192
6/25/2013	–	25	–	0.2933	**85**	72	103
6/26/2013	–	49	–	0.2933	**167**	142	203
6/27/2013	–	29	–	0.2933	**99**	84	120
6/28/2013	–	21	–	0.2933	**72**	61	87
6/29/2013	–	32	–	0.2933	**109**	93	132
6/30/2013	–	32	–	0.2933	**109**	93	132
7/1/2013	–	32	–	0.2933	**109**	93	132
7/2/2013	–	29	–	0.2933	**99**	84	120

Appendix C. Monthly totals of fish species caught at the upstream RST (VINO) on the lower Mokelumne river during the 2012/13 juvenile outmigration monitoring season.

Common Name	Genus	Species	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	Total
Black Bass	*Micropterus*	*sp.*	0	0	0	0	0	0	1	**1**
Black Crappie	*Pomoxis*	*nigromaculatus*	1	1	1	0	0	1	3	**7**
Bluegill	*Lepomis*	*macrochirus*	1	1	1	1	1	0	1	**6**
Channel Catfish	*Ictalurus*	*punctatus*	0	0	0	0	0	2	0	**2**
Chinook Salmon (Ad-Clip)	*Oncorhyhchus*	*tshawytscha*	0	1	0	1	13	3	0	**18**
Chinook Salmon (No Ad-Clip)	*Oncorhyhchus*	*tshawytscha*	52	8,447	38,582	4,225	87	263	13	**51,669**
Golden Shiner	*Notemigonus*	*crysoleucas*	0	1	1	0	0	0	1	**3**
Green Sunfish	*Lepomis*	*cyanellus*	0	0	0	0	0	0	1	**1**
Hitch	*Lavinia*	*exilicauda*	0	2	1	18	49	6	3	**79**
Kokanee Salmon	*Oncorhynchus*	*nerka kennerlyi*	1	0	0	0	2	0	0	**3**
Pacific Lamprey	*Lampetra*	*tridentata*	13	72	124	49	157	204	107	**726**
Prickly Sculpin	*Cottus*	*asper*	2	5	9	9	5	13	107	**150**
Redear Sunfish	*Lepomis*	*microlophus*	0	0	0	0	0	1	0	**1**
Sacramento Pikeminnow	*Ptychocheilus*	*grandis*	0	0	1	0	3	2	4	**10**
Sacramento Sucker	*Catostomus*	*occidentalis*	0	0	2	0	0	1	32	**35**
Spotted Bass	*Micropterus*	*punctulatus*	0	0	0	1	0	0	0	**1**
Steelhead (No Ad-Clip)	*Oncorhynchus*	*mykiss*	0	0	22	79	89	30	5	**225**
Tule Perch	*Hysterocarpus*	*traski*	1	1	6	10	21	7	0	**46**
Western Mosquitofish	*Gambusia*	*affinis*	1	2	2	0	0	0	0	**5**

Appendix D. Monthly totals of fish species caught at the downstream traps (GOLF and BYPASS) on the lower Mokelumne river during the 2012/13 juvenile outmigration monitoring season.

Common Name	**Genus**	**Species**	**Jan.**	**Feb.**	**Mar.**	**Apr.**	**May**	**June**	**July**	**Total**
American Shad	*Alosa*	*sapidissima*	0	0	0	0	2	0	0	**2**
Black Bass	*Micropterus*	*sp.*	0	27	0	95	8,877	14,185	153	**23,337**
Black Crappie	*Pomoxis*	*nigromaculatus*	1	50	2	1	0	379	14	**447**
Bluegill	*Lepomis*	*macrochirus*	0	513	14	7	7	2	0	**543**
Brown Bullhead	*Ameiurus*	*nebulosus*	0	0	0	1	1	0	0	**2**
Chinook Salmon (Ad-Clip)	*Oncorhyhchus*	*tshawytscha*	127	86	1	15	69	17	0	**315**
Chinook Salmon (No Ad-Clip)	*Oncorhyhchus*	*tshawytscha*	31	1,479	390	618	31,504	4,154	29	**38,205**
Common Carp	*Cyprinus*	*carpio*	0	4	0	1	5	0	0	**10**
Golden Shiner	*Notemigonus*	*crysoleucas*	0	23	4	4	0	1	0	**32**
Goldfish	*Carassius*	*auratus*	0	4	1	1	0	0	0	**6**
Green Sunfish	*Lepomis*	*cyanellus*	0	8	0	0	0	0	0	**8**
Hitch	*Lavinia*	*exilicauda*	0	2	3	1	0	0	0	**6**
Inland Silverside	*Menidia*	*beryllina*	1	0	0	3	0	0	0	**4**
Kokanee Salmon	*Oncorhynchus*	*nerka kennerlyi*	0	0	0	0	1	0	0	**1**
Largemouth Bass	*Micropterus*	*salmoides*	0	4	0	0	0	0	0	**4**
Pacific Lamprey	*Lampetra*	*tridentata*	11	18	5	4	54	4	0	**96**
Prickly Sculpin	*Cottus*	*asper*	81	117	37	868	3,119	83	3	**4,308**
Redear Sunfish	*Lepomis*	*microlophus*	1	0	0	1	0	0	0	**2**
Redeye Bass	*Micropterus*	*coosae*	0	1	0	0	0	0	0	**1**
Sacramento Pikeminnow	*Ptychocheilus*	*grandis*	0	0	0	1	0	0	0	**1**
Sacramento Sucker	*Catostomus*	*occidentalis*	2	7	1	2	3	0	0	**15**
Spotted Bass	*Micropterus*	*punctulatus*	0	2	0	0	0	0	0	**2**
Steelhead (Ad-Clip)	*Oncorhynchus*	*mykiss*	0	0	0	0	0	8	0	**8**
Steelhead (No Ad-Clip)	*Oncorhynchus*	*mykiss*	0	1	0	3	25	99	2	**130**
Striped Bass	*Morone*	*saxatilis*	0	0	0	1	0	0	0	**1**
Tule Perch	*Hysterocarpus*	*traski*	1	21	3	23	77	415	24	**564**
Western Mosquitofish	*Gambusia*	*affinis*	0	4	0	0	0	0	0	**4**
White Catfish	*Ameiurus*	*catus*	0	0	0	0	2	1	0	**3**