Emigration of Juvenile Chinook Salmon (*Oncorhynchus tshawytscha*) and Steelhead (*Oncorhynchus mykiss*) in the Lower Mokelumne River, December 2017 – July 2018

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SUMMARY

The emigration of juvenile Chinook salmon (*Oncorhynchus tshawytscha*) and steelhead (*Oncorhynchus mykiss*) on the lower Mokelumne River was monitored using two rotary screw traps (RST) and a bypass trap during the 2017/18 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 12 December 2017 to 29 June 2018. The downstream rotary screw trap (GOLF) was located just below the Lower Sacramento Road Bridge at rkm 61.8 and was operated from 3 January to 28 June 2018. The bypass trap (BYPASS), located at Woodbridge Irrigation District Dam (rkm 62.2), was operated from 3 April to 29 June 2018.

The first juvenile Chinook salmon was captured at the VINO RST on 29 December 2017. Including weekend estimates, the catch of naturally produced young-of-the-year (YOY) Chinook salmon was 38,778 during the monitoring period. Fourteen trap efficiency tests were conducted at VINO: four tests using naturally produced salmon and ten tests using hatchery produced salmon. The annual estimated emigration abundance of naturally produced YOY Chinook salmon at the VINO RST was 456,372 (95% CI: 380,500-532,243). Including weekend estimates, the catch of wild YOY steelhead was 558 at the VINO RST during the 2017/18 season. The estimated passage of wild YOY steelhead (based on trap calibrations using Chinook salmon) was 9,775 (95% CI: 6,886-12,663).

The first juvenile Chinook salmon was captured at the GOLF RST on 9 January 2018. Including weekend estimates, the catch of naturally produced YOY Chinook salmon was 7,266 during the monitoring period. Twelve trap efficiency tests were conducted at GOLF, all of which were conducted using hatchery produced salmon. The annual estimated emigration abundance of naturally produced YOY Chinook salmon at the GOLF RST was 32,851 (95% CI: 26,978-38,725). Including weekend estimates, the catch of wild YOY steelhead was 60 at the GOLF RST during the 2017/18 season. The estimated passage of wild YOY steelhead (based on trap calibrations using Chinook salmon) was 2,387 (95% CI: 1,427-3,347).

The first juvenile Chinook salmon was captured at the bypass trap (BYPASS) on 4 April 2018. Including weekend estimates, catch of naturally produced YOY Chinook salmon was 7,266 at the BYPASS during the monitoring period. The total downstream salmon emigration abundance estimate, calculated from adding the BYPASS trap catch to the GOLF RST abundance estimate, was 40,117 (95% CI: 34,244-45,991). Including weekend estimates, catch of wild YOY steelhead was 130 at the BYPASS during the 2017/18 season. The total downstream passage estimate of wild YOY steelhead, calculated from adding the BYPASS trap catch to the GOLF RST estimate, was 2,517 (95% CI: 1,557-3,477).

Although age 1+ steelhead are captured during trapping, abundance estimates were only calculated for YOY steelhead. Catch of other steelhead life stages are summarized below. At the VINO RST, six wild age 1+ steelhead were captured and classified as parr. At the downstream traps (GOLF and BYPASS), nine wild age 1+ steelhead were captured and classified as silvery parr, smolt, or adult. Steelhead catch at the downstream traps also consisted of 15 hatchery origin (adipose fin-clipped) age 1+ smolts and adults.

Twenty fish species were caught at the VINO RST during the survey period: eight native and twelve non-native species. Native fish species were more frequently caught than non-native species and Chinook salmon (no adipose fin-clip) was the most abundant species caught. At the downstream GOLF trap, 30 fish species were caught, made up of nine native and 21 non-native species. Numerically, native fish made up the majority of the catch and hatchery Chinook salmon (adipose fin-clip) was the most abundant species caught.

Average daily water releases from Camanche Reservoir ranged from 329 cubic feet per second (cfs) (9.3 m^3/s) to 2,501 cfs (70.8 m^3/s) during the monitoring period. During the trapping season, five water releases from Camanche Reservoir exceeded 1,000 cfs over a total of 27 days. From 1 October 2017 through 31 March 2018, East Bay Municipal Utility District (EBMUD) operated under a "Normal and Above" JSA water year type. From 1 April through 30 September 2018, EBMUD operated under a "Normal and Above" JSA water year type.

INTRODUCTION

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, Bilski et al. 2013). 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 the abundance and monitoring the emigration patterns of anadromous fish species in the LMR. This report presents the monitoring results for rotary screw trap operations from December 2017 through early July 2018.

METHODS

Environmental Data

Water quality measurements (turbidity, temperature, dissolved oxygen, and flow) were collected daily at each location during trap checks. Turbidity samples were collected by submerging a sample jar to a depth of 0.3 m 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), Victor (rkm 80.7), Golf (rkm 61.3), and Frandy (rkm 46.4) gauging stations (Figure 1).

Rotary screw traps

One 8-ft (cone diameter) rotary screw trap (E.G. Solutions, Inc.) was operated at upstream and downstream locations, respectively, on the lower Mokelumne River (Figure 1). The RST operated at the upstream location was near the Elliott Road Bridge, adjacent to property owned by Vino Farms, at rkm 87.4. The downstream location was operated just below Woodbridge Irrigation District Dam (WIDD), and adjacent to the Lodi Golf and Country Club at rkm 61.8. In this report, the upstream and downstream RST sites are referred to as VINO and GOLF, respectively.

During the 2017/18 monitoring season when traps were operational, RSTs were generally operated Monday through Friday, between December and June. During Monday through Friday operations, traps were taken out of service after each check on Friday afternoon and reset each Monday morning. Efforts were made to position RSTs in the thalweg of the river where water velocities were 0.6 m/s or greater (USFWS 2008). Water velocity was measured at the center of the trap cone, six inches below the water surface, at the beginning of each trap check. Rotations were measured using a stopwatch to record the time for three full rotations. Rotations per minute (RPMs) were calculated and recorded at each trap check. Efforts were made to maintain a rotational speed of 2 RPM or greater at both RSTs. 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. 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 2017/18 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 emigration period to provide an estimate of the proportion of juvenile Chinook salmon each RST was capturing. Naturally produced Chinook salmon were used for the trap efficiency trials when salmon catch was high enough to produce a group of test fish. Additional test salmon were provided by California Department of Fish and Wildlife at the Mokelumne River Fish Hatchery (MOKH). 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 and/or Bismark® brown dye were used to mark groups of test fish for the GOLF trap. The Bismark® brown dye was applied by holding test fish in an aerated tank of dye solution for approximately 30 minutes. Approximately 0.2g of dye was added to a 5 gallon bucket of river water to prepare the solution. 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

Daily catch estimates were generated for non-trapping days by taking an average of daily catch for three days preceding and following these periods (Appendix A). RST abundance estimates were generated for juvenile Chinook salmon and steelhead using a stratified mark-recovery approach with a single partial capture trap (Volkhardt et al. 2007). The number of marked fish released M_i and the number of marked fish recaptured m_i were applied to unmarked catch numbers over each trap efficiency period n_i to produce abundance estimates over that time $\hat{A}_i$:

$$\hat{A}_i = \frac{n_i(M_i + 1)}{m_i + 1}$$

where,

A_i = Estimated abundance of unmarked fish during period *i*
M_i = Number of fish marked and released during period *i*
n_i = Number of unmarked fish captured during period *i*
m_i = Number of marked fish captured during period *i*

Variance $V(\hat{A}_i)$ for abundance estimates was calculated as follows:

$$V(\hat{A}_i) = \frac{(M_i + 1)(n_i + m_i + 1)(M_i - m_i)n_i}{(m_i + 1)^2(m_i + 2)}$$

Total juvenile abundance $\hat{A}$ was calculated by the sum of *n* abundance estimates for each efficiency period $\hat{A}_i$:

$$\hat{A} = \sum_{i=1}^{n} \hat{A}_i$$

Variance associated with total juvenile abundance $V(\hat{A})$ was calculated using the same approach:

$$V(\hat{A}) = \sum_{i=1}^{n} V(\hat{A}_i)$$

The 95% confidence interval (CI) associated with total juvenile abundance was calculated as follows:

$$95\%\ CI = \hat{A} \pm 1.96\sqrt{V(\hat{A})}$$

Fish Handling and Condition Factors

Captured fish were processed in the field, 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 beginning of the season and later transferred to Woodbridge Dam when smolt-sized salmon were caught at the GOLF trap. A 20 mg/L solution of eugenol (AQUI-S®20E is 10% eugenol) was used to anesthetize salmonids, when needed. All sedation records were submitted to the USFWS Aquatic Animal Drug Approval Partnership (AADAP) Program as part of an ongoing Investigational New Animal Drug (INAD) permitted study. This will establish the effectiveness and safety of AQUI-S® 20E as an anesthetic/sedative for various fish species under a variety of environmental conditions. The AADAP suggested guidelines for preparing and using AQUI-S®20E as a sedative were followed. 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, additional fish of each species were plus counted. 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.

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.

Juvenile Chinook Salmon Survival

Chinook salmon egg to young-of-the-year (YOY) survival indices were calculated at the downstream trapping location based on the brood year (BY) 2017 redd count and BY 2017 average fecundity per female at the MOKH. The annual redd count was multiplied by the average fecundity per female to estimate the total production of YOY salmon at 100% survival. The Chinook salmon passage estimate at the downstream trapping location was divided by the total production estimate (at 100% survival) to calculate the survival index. Survival indices for BY 2017 were compared with previous years. The minimum and maximum survival indices were expected to range between 0.0 and 1.0, respectively.

Migration response

Generalized linear models were constructed to examine the relationship between daily salmon count (expressed as percent of annual count) and daily average flow, change in daily average flow, water temperature, and turbidity. 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 0.50 or greater were not used together in the same models. The minimum corrected Akaike Information Criterion (AICc) was used to select the best models. The top models at each trapping location were reported.

Spearman's rho correlation was used to examine the relationships between weekly salmon abundance and weekly salmon redd emergence at the upstream and downstream trapping locations. A weekly redd emergence timeline was constructed based on weekly salmonid redd surveys and a water temperature egg model developed by Vogel (1993) from Piper et al. (1992). Seven extra days were added to the date of predicted emergence at the downstream trap to account for travel time from the Chinook salmon spawning habitat to the downstream trap. 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).

Data Analysis

Graphics were created and data were analyzed using ArcMAP™ 10.2 (ESRI Inc.), JMP® 9.0.0 (SAS Institute Inc.), Microsoft® Office Access 2010 and Excel 2010. Statistical tests were considered significant if the P-value was ≤ 0.05. Trap abundance estimates were reported with 95% confidence intervals (CI).

RESULTS

Mokelumne River Flow, Water Temperature, and Turbidity

Average daily flow at the Victor Road gauging station (downstream of the VINO trapping site) ranged from 231 cfs (6.5 m^3/s) to 2,481 cfs (70.2 m^3/s) during the time when the VINO trap was operated (12 December 2017 through 29 June 2018). The mean flow during that time was 533 cfs (15.1 m^3/s). Water temperatures recorded at VINO ranged from 9.5 to 14.6°C, with a mean of 11.6°C. Water turbidity ranged from 1.4 to

14.5 Nephelometric Turbidity Units (NTU), with a mean of 2.9 NTU. Water dissolved oxygen ranged from 8.51 to 11.73 milligrams per liter (mg/l), with a mean of 10.38 mg/l.

Average daily flow at the Golf gauging station ranged from 109 cfs (3.1 m^3/s) to 2,360 cfs (66.8 m^3/s) during the time when the GOLF RST was operated (3 January through 29 June 2017). The average daily flow during that time was 487 cfs (13.8 m^3/s). Water temperatures recorded at GOLF ranged from 9.2 to 18.8°C, with a mean of 13.2°C. Water turbidity ranged from 2.0 to 81.6 NTU, with a mean of 4.3 NTU. Water dissolved oxygen ranged from 8.45 to 11.7 mg/l, with a mean of 10.8 mg/l.

During the time that the BYPASS trap was operated (3 April through 29 June 2018) average daily flow at the Golf gauging station ranged from 204 cfs (5.8 m^3/s) to 2,360 cfs (66.8 m^3/s), with a mean of 679 cfs (19.2 m^3/s). Flow at the Woodbridge Irrigation District Canal ranged from 37 cfs (1.0 m^3/s) to 190 cfs (5.4 m^3/s) and averaged 120 cfs (3.4 m^3/s). Water temperatures recorded at the BYPASS ranged from 12.5 to 18.9°C, with a mean of 15.5°C. Water turbidity at the BYPASS ranged from 2.2 to 6.6 NTU, with a mean of 3.4 NTU. Water dissolved oxygen ranged from 8.67 to 11.7 mg/l, with a mean of 10.0 mg/l. Figure 2 depicts average daily flow, water temperature and turbidity at locations between Camanche Dam and the GOLF gauging station in the lower Mokelumne River.

Trap Operations

The VINO RST was operated between 12 December 2017 and 29 June 2018. The cone was stopped by debris on 8 of 104 trap check days. Excluding days with trap stoppages, the minimum recorded cone rotation rate was 1.4 RPM and the maximum was 5.1 RPM. The mean rotation rate during the monitoring season was 3.0 RPM. The VINO trap met or exceeded a rotation speed of 2.0 RPMs on 123 of 125 (98.4%) operating days (excluding stoppage days). Water velocity entering the center of the trap cone ranged between 0.8 and 2.5 m/s, with a mean of 1.1 m/s.

The 8-ft RST at GOLF was operated from 3 January to 28 June 2018. Debris stopped the cone from rotating on 7 of 92 trap check days. Excluding trap stoppages, the minimum cone rotation rate was 1.3 RPM and the maximum rate was 5.1 RPM. Average rotational speed was 2.5 RPM. The 8-ft RST met or exceeded a rotation speed of 2.0 RPMs on 95 of 113 (84.1%) operating days (excluding stoppage days). Water velocity entering the center of the trap cone ranged between 0.5 and 1.3 m/s, with a mean of 0.8 m/s.

The BYPASS trap at WIDD was operated between 3 April and 29 June 2018. During this time frame the trap was checked on 51 days. Water velocity at the top of the trap ranged between 0.5 and 1.0 m/s and averaged 0.9 m/s.

RST Calibrations

Fourteen calibration tests were conducted for the VINO RST during the 2017/18 juvenile monitoring season (Table 1). Naturally produced Chinook salmon were used as test fish for four tests and Chinook salmon from the MOKH were used for ten tests. Trap efficiency tests 8 and 9 were not used to generate daily abundance estimates owing to trap stoppages and test 14 was not used due to insufficient recaptures to produce reliable 95% confidence intervals. Excluding tests 8, 9, and 14, trap efficiencies ranged from 1.1% to 18.2% and averaged 6.9% (n = 11).

Twelve calibration tests were conducted for the GOLF RST during the 2017/18 juvenile monitoring season (Table 1). Chinook salmon from the MOKH were used for all twelve tests. Trap efficiency tests 10 and 12 were not used to generate abundance estimates because of trap stoppages on the first day of potential recaptures during the estimation period. Excluding tests 10 and 12, trap efficiency ranged from 1.0% to 14.2%, with a mean of 6.5% (n = 10).

Chinook Salmon

<u>Catch and Abundance Estimates</u>

At the VINO RST, 19,548 naturally produced YOY Chinook salmon were captured between 12 December 2017 and 29 June 2018. Estimates for weekend catch and trap stoppages were added to the actual catch to produce an estimated count of 38,778 YOY Chinook salmon. Using trap efficiency data, the total estimated abundance of YOY salmon passing the upstream RST (VINO) was 456,372 (95% CI: 380,500-532,243). The highest period of estimated salmon abundance was recorded from 23 January to 30 January 2018 (Table 2).

At the GOLF RST, 785 naturally produced YOY Chinook salmon were captured between 3 January and 28 June 2018. Estimates for weekend catch and trap stoppages were added to the actual catch to produce an estimated count of 1,508 YOY Chinook salmon. Using trap efficiency data, the total downstream emigration abundance estimate of YOY Chinook salmon at the GOLF RST was 32,851 (95% CI: 26,978-38,725).

At the BYPASS trap, 3,835 naturally produced YOY Chinook salmon were captured between 4 April and 29 July 2018. Estimates for weekend catch were added to the actual catch to produce an estimated count of 7,266 YOY Chinook salmon. The total downstream emigration abundance estimate of 40,117 YOY Chinook salmon (95% CI: 34,244-45,991) was calculated by adding the BYPASS catch estimate to the GOLF RST abundance estimate. At the downstream traps (GOLF & BYPASS), the highest period of estimated salmon abundance was recorded from 8 May to 11 June (Table 2).

On 18 May 2018, the MOKH conducted two in-river releases of 200,000 marked (adipose fin-clipped) and tagged juvenile Chinook salmon. One release occurred directly adjacent to the MOKH, and the other release took place in the WID basin. Trap catch from these releases consisted of 451 hatchery-origin (adipose fin-clipped) Chinook salmon at the Vino RST (between 22 May and 29 June 2018), 543 adipose fin-clipped salmon at the GOLF RST (between 22 May and 28 June 2018), and 14,456 adipose fin-clipped salmon at the BYPASS trap (between 22 May and 29 June 2018). These captures were not part of the abundance estimates.

<u>Life stage, size and condition</u>

At the VINO RST, naturally produced Chinook salmon catch was classified as smolts (0.7%, n=135), fry (99.1%, n=19,308), parr (0.1%, n=22), and silvery parr (0.1%, n=23). In addition, 451 hatchery origin (adipose fin-clipped) Chinook salmon smolt were caught at the VINO RST. The size distribution by life stage of naturally produced Chinook salmon caught and measured at the VINO RST during the 2017/18 season is provided by Figure 3. Based on estimated Chinook salmon abundance, 94.4% (n=430,608) of the population moved past the upstream trap as fry and 5.6% (n=25,764) moved past the upstream trap as smolts.

At the downstream traps, naturally produced Chinook salmon catch was classified as smolts (89.4%, n=4,043), fry (9.9%, n=448), parr (0.2%, n=9), and silvery parr (0.5%, n=23). The size distribution by life stage of naturally produced Chinook salmon caught and measured at the downstream traps during the 2017/18 season is provided by Figure 3. Based on estimated Chinook salmon abundance, 26.3% (n=10,569) of the population moved past the downstream traps as fry and 73.7% (n=29,548) as smolts.

The monthly average condition factors by life stage for naturally produced Chinook salmon caught and measured at the upstream and downstream traps are presented in Figure 4. Monthly average condition factors were only reported if the number of observations by life stage was three or greater ($n>=3$). Hatchery smolts had an average condition factor of 1.11 (± 0.09 SD), whereas natural smolts had an average condition factor of 1.09 (± 0.27 SD).

Migration Response

The relationships between three environmental variables (average daily flow, water temperature and turbidity) and estimated daily salmon abundance or catch at the upstream and downstream traps during the 2017/18 monitoring season are presented graphically in Figures 5 and 6.

At the upstream trap, daily water turbidity and average daily flow (Victor, rkm 86.1) were the variables included in the generalized linear model (GLM) with the lowest AICc (Table 3). Flow and Turbidity had a significant negative relationship with daily salmon catch (parameter estimate = -0.0052 and -0.4565, respectively). Weekly salmon redd emergence and weekly salmon abundance had a significant positive correlation at the upstream trap ($r = 0.76$, $r < 0.0001$).

At the downstream traps, daily water turbidity was the variable included in the generalized linear model (GLM) with the lowest AICc (Table 3). None of the environmental variables analyzed had significant relationships with salmon abundance or catch. Weekly redd emergence and weekly salmon abundance had a significant negative correlation at the downstream traps ($r = -0.46$, $r = 0.0111$).

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

During the BY 2017 spawning season, 1,255 Chinook salmon redds were identified in the LMR. The BY 2017 average salmon fecundity estimate (per female spawned at the MOKH) was 4,162 eggs. The resulting estimated salmon production at 100% survival was 5,222,701 juveniles. The BY 2017 egg-to-YOY survival index for naturally produced YOY Chinook salmon at the VINO trap was 0.09 (95% CI: 0.07-0.10). At the downstream GOLF trap, the BY 2017 survival index was 0.01 (95% CI: 0.01-0.01). The BY 2017 upstream and downstream survival indices were lower than other brood years that experienced below normal water year types (Table 4).

Steelhead

Catch and Abundance Estimates

At the VINO RST, 239 wild YOY steelhead were captured between 23 January and 20 June 2018. Estimates for weekend catch were added to actual catch to produce an estimated count of 548 naturally produced steelhead. The estimated abundance of wild YOY steelhead (based on trap calibrations using Chinook salmon) was 9,775 (95% CI: 6,886-12,663). The largest monthly catch of wild steelhead (136) occurred at VINO in March.

At the GOLF RST, 33 wild YOY steelhead were captured between 13 March and 14 June 2018. Estimates for weekend catch and trap stoppages were added to actual catch to produce an estimated count of 60 naturally produced YOY steelhead. The estimated passage of wild YOY steelhead at GOLF (based on trap calibrations using Chinook salmon) was 2,387 (95% CI: 1,427-3,347). At the BYPASS, 62 YOY steelhead were captured between 5 April and 29 June 2018. Estimates for weekend catch were added to actual catch to produce an estimated count of 130 naturally produced YOY steelhead. The estimated abundance of wild YOY steelhead at the downstream traps, calculated from adding the BYPASS trap catch to the GOLF RST estimate, was 2,517 (95% CI: 1,557-3,477). The largest monthly catch of wild YOY steelhead (48) occurred at the downstream traps in June.

Life stage and size

At the VINO RST, 91.1% (n=245) of the naturally produced steelhead catch was classified as fry. The remaining wild steelhead catch was composed of parr (6.7%, n=18) and age 1+ parr (2.2%, n=6). No age 1+ smolts or adults were caught. Steelhead catch at the VINO RST also consisted of one hatchery-origin (adipose fin-clipped) smolt.

At the downstream traps, 77.7% (n=87) of the wild steelhead catch was classified as parr. The remaining wild steelhead catch was composed of fry (7.1%, n=8) and age 1+ parr (8.9%, n= 10), smolts (5.4%, n=6), and age 1+ adults (0.9 %, n=1).

The size distribution by life stage of all wild steelhead measured at the upstream and downstream traps is presented in Figure 7.

Species Composition

Twenty fish species were caught at the VINO RST during the survey period: eight native and twelve non-native species (Appendix C). Native fish species were more abundant than non-native species, comprising 99.3% of the total catch. Chinook salmon (no adipose fin-clip) was the most abundant species caught (92.4%), followed by hatchery-origin Chinook salmon (adipose fin-clip) (2.1%), steelhead (1.5%), and Pacific lamprey (*Entosphenus tridentatus)* (1.4%).

At the downstream traps (GOLF and BYPASS), thirty fish species were caught: nine native and twenty-one non-native species (Appendix D). Native fish species were more abundant than non-native species, comprising 96.2% of the total catch. This was driven by high catch of hatchery-origin Chinook salmon (adipose fin-clip) (47.8%), followed by prickly sculpin (*Cottus asper*) (38.2%), Chinook salmon (no adipose fin-clip) (12.9%), and Pacific lamprey (2.9%).

DISCUSSION

During the 2017/2018 juvenile outmigration monitoring season, the VINO RST was stopped by debris on eight of 104 operating days. Salmon catch was estimated at VINO on two of the eight days (4 and 5 April 2018) with trap stoppages, which occurred after the peak of juvenile salmon outmigration at the upstream trap. The GOLF RST was stopped by debris seven times throughout the monitoring season. Salmon catch was estimated at GOLF on two of the seven days (11 May and 5 June 2018) with trap stoppages, and occurred when moderate numbers of juvenile salmon were moving past the trap after the peak of outmigration. Catch was not estimated on stoppage days when rotation counts demonstrated that the trap functioned during most of the trapping period. These days may have led to a small, but not significant, underestimate of salmon abundance at the GOLF trap.

At the VINO RST, MOKH salmon fry were used as test fish for the first two trap efficiency trials and naturally produced salmon fry were used for four trap efficiency trials that took place early in the monitoring season. Conversely, near the middle and the end of the season (April through June), trap efficiency trials were conducted using larger parr and smolt-sized salmon from the MOKH. The results of the efficiency trials were consistent with previous seasons. When the trap was operated at relatively stable low flows, trap efficiencies steadily declined as salmon fork length increased. The decreased capture efficiency was likely due to the improved swimming ability of larger salmon. Also, trap efficiencies decreased during peirods of increased flows, and efficiencies increased as flows receeded. Three tests (8, 9, and 14) were not used due to trap stoppages or an inadequate number of recaptures that were needed to generate reliable 95% confidence intervals. In future monitoring seasons, it is recommended to increase the size of trap efficiency release groups towards the end of the season, when smolt-sized salmon are used as the test fish.

At the GOLF RST, all twelve trap efficiency trials were run using groups of salmon from the MOKH. Ten of the twelve tests were considered successful this season and used to create population estimates. Tests 10 and 12 were not successful due to trap stoppages. Trap efficiencies appeared high (between 2.3% and 18.2%) until Camanche releases increased above 400 cfs and parr/smolt-sized salman were used. All successful efficiency trials were run when Camanche releases ranged from 238 to 2,306 cfs.

The upstream juvenile salmon abundance estimate of 456,372 Chinook salmon, ranked the 6th highest (of 10) on record since the trap site was initiated in the 2007/08 juvenile outmigration season. The downstream juvenile salmon abundance estimate of 40,117 ranked the 4th lowest (of 26) on record since the 1992/93 season. The annual juvenile salmon abundance estimate for the downstream trap was below average, relative to previous estimates. Compared to previous below normal water year types, the BY 2017 downstream survival index was also below average. Factors that may have contributed to the mortality of juvenile Chinook salmon in the LMR include predation by native and non-native fish species, egg losses 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), warm incubation water temperatures averaging 14.0°C during periods when the progression of embryonic development occurred, limited rearing habitat, 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.

At the upstream trap, daily water turbidity and average daily flow at Victor were the variables included in the GLM with the lowest AICc. Flow and turbidity had a significant negative relationship with daily salmon abundance, establishing that most of the salmon passed the upstream trap when flows and turbidity were low. Camanche releases were relatively low when 94.3% of the estimated emigrating salmon moved past the ustream trap as fry. Large Camanche releases up to 2,500 cfs coinsided with the parr/smolt emigration period, after the majority of salmon had already moved past the upstream trap. In previous seasons, a significant positive relationship between weekly redd emergence and Chinook salmon abundance has also been established (Bilski et al. 2013), indicating that the majority of juvenile salmon pass the upstream trap as fry and rear below Elliot Road. This season was no different, weekly redd emergence and weekly salmon abundance had a significant positive correlation at the upstream trap.

At the downstream traps, none of the environmental factors analyzed had significant relationships with daily salmon catch or salmon abundance. In addition, weekly redd emergence and weekly salmon abundance had a moderate negative correlation at the downstream traps. This could suggest that a large proportion of the juvenile Chinook salmon spent time rearing upstream of the GOLF RST and/or the BYPASS and emigrated past the downstream traps as smolts (73.7% estimated abundance) or did not survive.

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Table 1. Summary of trap efficiency tests conducted at trapping locations on the lower Mokelumne River during the 2017/2018 trapping season. Abbreviations are as follows: MOKH = Mokelumne River Fish Hatchery.

VINO (UPSTREAM RST)

Test #	Release Date	Origin of Test Salmon	Flow (cfs)	Ave. FL of Test Salmon (mm)	# Released	# Recaptured	% Recaptured	Used for abundance estimate?
1	08-Jan-18	MOKH	263	31	1,011	81	8.0%	Yes
2	22-Jan-18	MOKH	377	38	778	18	2.3%	Yes
3	30-Jan-18	WILD	372	33	297	54	18.2%	Yes
4	06-Feb-18	WILD	364	35	550	62	11.3%	Yes
5	21-Feb-18	WILD	296	35	612	88	14.4%	Yes
6	06-Mar-18	WILD	317	35	346	39	11.3%	Yes
7	20-Mar-18	MOKH	314	39	503	15	3.0%	Yes
8	03-Apr-18	MOKH	852	42	500	1	0.2%	No
9	09-Apr-18	MOKH	2,383	45	503	3	0.6%	No
10	16-Apr-18	MOKH	514	48	510	11	2.2%	Yes
11	30-Apr-18	MOKH	495	60	1,005	17	1.7%	Yes
12	14-May-18	MOKH	1,161	61	1,013	29	2.9%	Yes
13	29-May-18	MOKH	574	77	1,017	11	1.1%	Yes
14	18-Jun-18	MOKH	396	88	885	3	0.3%	No

GOLF (DOWNSTREAM RST)

Test #	Release Date	Origin of test salmon	Flow (cfs)	Ave. FL of test salmon (mm)	# Released	# Recaptured	% Recaptured	Used for abundance estimate?
1	16-Jan-18	MOKH	321	36	1,009	99	9.8%	Yes
2	29-Jan-18	MOKH	307	35	1,013	144	14.2%	Yes
3	13-Feb-18	MOKH	306	35	1,032	88	8.5%	Yes
4	26-Feb-18	MOKH	308	35	995	61	6.1%	Yes
5	12-Mar-18	MOKH	238	37	1,026	62	6.0%	Yes
6	26-Mar-18	MOKH	237	41	1,019	114	11.2%	Yes
7	09-Apr-18	MOKH	2,306	46	502	5	1.0%	Yes
8	23-Apr-18	MOKH	434	51	1,002	45	4.5%	Yes
9	07-May-18	MOKH	1,048	58	1,012	25	2.5%	Yes
10	04-Jun-18	MOKH	332	80	1,017	0	0.0%	No
11	11-Jun-18	MOKH	243	78	1,500	21	1.4%	Yes
12	25-Jun-18	MOKH	212	90	1,163	2	0.2%	No

Table 2. Expanded monthly catch, juvenile abundance estimates, and percent passage for Chinook salmon captured at the upstream and downstream trapping locations on the lower Mokelumne River during the 2017/2018 trapping season. 95% confidence intervals (LCI and UCI) are calculated for the annual abundance estimates.

Upstream (VINO FARMS)			
Time Frame	Estimated Catch	Abundance	Percent Passage
12/12-1/22	3,076	**37,962**	8.3%
1/23-1/30	3,685	**151,085**	33.1%
1/31-2/6	5,807	**31,463**	6.9%
2/7-2/21	17,064	**149,242**	32.7%
2/22-3/6	7,222	**49,743**	10.9%
3/7-3/20	1,281	**11,113**	2.4%
3/21-4/16	375	**11,825**	2.6%
4/17-4/30	47	**2,001**	0.4%
5/1-5/14	59	**3,297**	0.7%
5/15-5/29	100	**3,380**	0.7%
5/30-6/29	62	**5,260**	1.2%
	38,778	**456,372**	100.0%
		95% CI (380,500-532,243)	

Downstream (GOLF and BYPASS)			
Time Frame	Estimated Catch	Abundance	Percent Passage
1/3-1/29	18	**182**	0.5%
1/30-2/13	201	**1,406**	3.5%
2/14-2/26	204	**2,363**	5.9%
2/27-3/12	125	**2,008**	5.0%
3/13-3/26	203	**3,309**	8.2%
3/27-4/9	152	**1,301**	3.2%
4/10-4/23	64	**4,206**	10.5%
4/24-5/7	456	**5,761**	14.4%
5/8-6/11	6307	**17,126**	42.7%
6/12-6/29	1044	**2,456**	6.1%
	8,774	**40,117**	100.0%
		95% CI (34,244-45,991)	

Table 3. Generalized linear models for juvenile Chinook salmon abundance at the upstream and downstream trapping locations based on environmental variables on the lower Mokelumne River during the 2017/18 juvenile outmigration monitoring season.

Upstream (VINO FARMS)

Model 1						
AICc	df	*P*	Independent Variable(s)	df	X^2	*P*
59.9754	1, 129	**0.0235**				
			Flow (Victor)	1	13.34881	**0.0003**
			Turbidity	1	3.388667	0.0656

Model 2						
AICc	df	*P*	Independent Variable(s)	df	X^2	*P*
64.6043	1, 130	**0.0042**				
			Turbidity	1	8.201401	**0.0042**

Downstream (GOLF and BYPASS)

Model 1						
AICc	df	*P*	Independent Variable(s)	df	X^2	*P*
157.27	1, 114	**0.4282**				
			Turbidity	1	0.06276	**0.4282**

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 Chinook salmon naturally produced 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 Hatchery (MOKH). JSA = 1998 Mokelumne River Joint Settle Agreement.

BY	Trap(s) used	Chinook salmon redd count	Estimated production (at 100% survival)	Abundance Estimate	95% LCI	95% UCI	Survival index (LCI - UCI)	JSA water year type (Apr.-Sept.)
				Upstream (rkm 87.4)				
2009	Vino Farms	248	1,208,444	124,279	93,555	199,950	0.10 (0.08-0.17)	Below Normal
2010	Vino Farms	314	1,601,627	842,570	631,115	2,039,099	0.53 (0.39-1.27)	Normal & Above
2011	Vino Farms	564	2,983,439	202,772	152,937	312,856	0.07 (0.05-0.10)	Dry
2012	Vino Farms	1,287	6,509,206	1,203,754	958,664	1,724,580	0.18 (0.15-0.26)	Dry
2013	Vino Farms	1,823	10,098,958	595,070	437,148	955,327	0.06 (0.04-0.09)	Dry
2014	Vino Farms	911	4,520,382	431,677	338,021	769,057	0.10 (0.07-0.17)	Critically Dry
2015	Vino Farms	1,359	5,760,801	856,127	689,152	1,201,359	0.15 (0.11-0.21)	Below Normal
2016	Vino Farms	405	1,859,301	No Estimate				Normal & Above
2017	Vino Farms	1,255	5,222,701	456,372	380,500	532,243	0.09 (0.07-0.10)	Below Normal
				Downstream (rkm 62)				
2005	Golf	2170	10,348,580	432,874	274,012	1,527,356	0.04 (0.03-.15)	Normal & Above
2006	Golf	755	3,387,149	1,197,778	883,225	2,174,338	0.35 (0.26-0.64)	Normal & Above
2007	Golf & Bypass	306	1,609,575	39,938	35,395	62,117	0.02 (0.02-0.04)	Normal & Above
2008	Golf	63	338,899	18,347	14,513	25,152	0.05 (0.04-0.07)	Below Normal
2009	Golf & Bypass	248	1,208,444	67,349	39,512	283,914	0.06 (0.03-0.23)	Below Normal
2010	Golf & Bypass	314	1,601,627	281,500	186,249	606,084	0.18 (0.12-0.38)	Normal & Above
2011	Golf & Bypass	564	2,983,439	51,799	42,063	70,631	0.02 (0.01-0.02)	Dry
2012	Golf & Bypass	1,287	6,509,206	147,590	130,342	176,579	0.02 (0.02-0.03)	Dry
2013	Golf & Bypass	1,823	10,098,958	169,864	134,673	287,964	0.02 (0.01-0.03)	Dry
2014	Golf & Bypass	911	4,520,382	61,305	57,120	74,069	0.01 (0.01-0.02)	Critically Dry
2015	Golf & Bypass	1,359	5,760,801	134,593	112,836	183,706	0.02 (0.02-0.03)	Below Normal
2016	Golf	405	1,859,301	326,455	217,992	434,918	0.18 (0.12-0.23)	Normal & Above
2017	Golf & Bypass	1,255	5,222,701	40,117	34,244	45,991	0.01 (0.01-0.01)	Below Normal

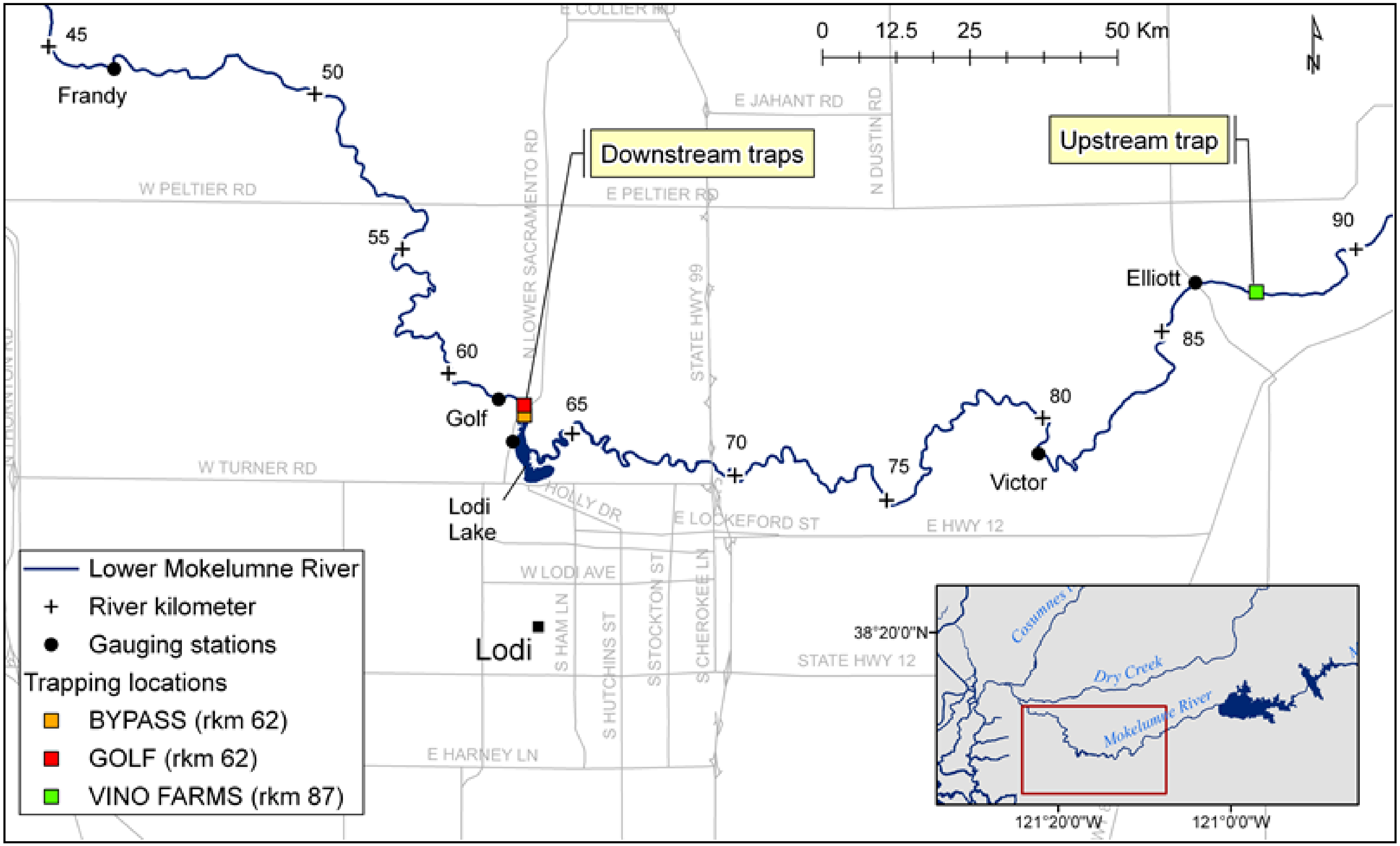

Figure 1. Trapping sites used for juvenile emigration monitoring on the lower Mokelumne River during the 2017/18 season.

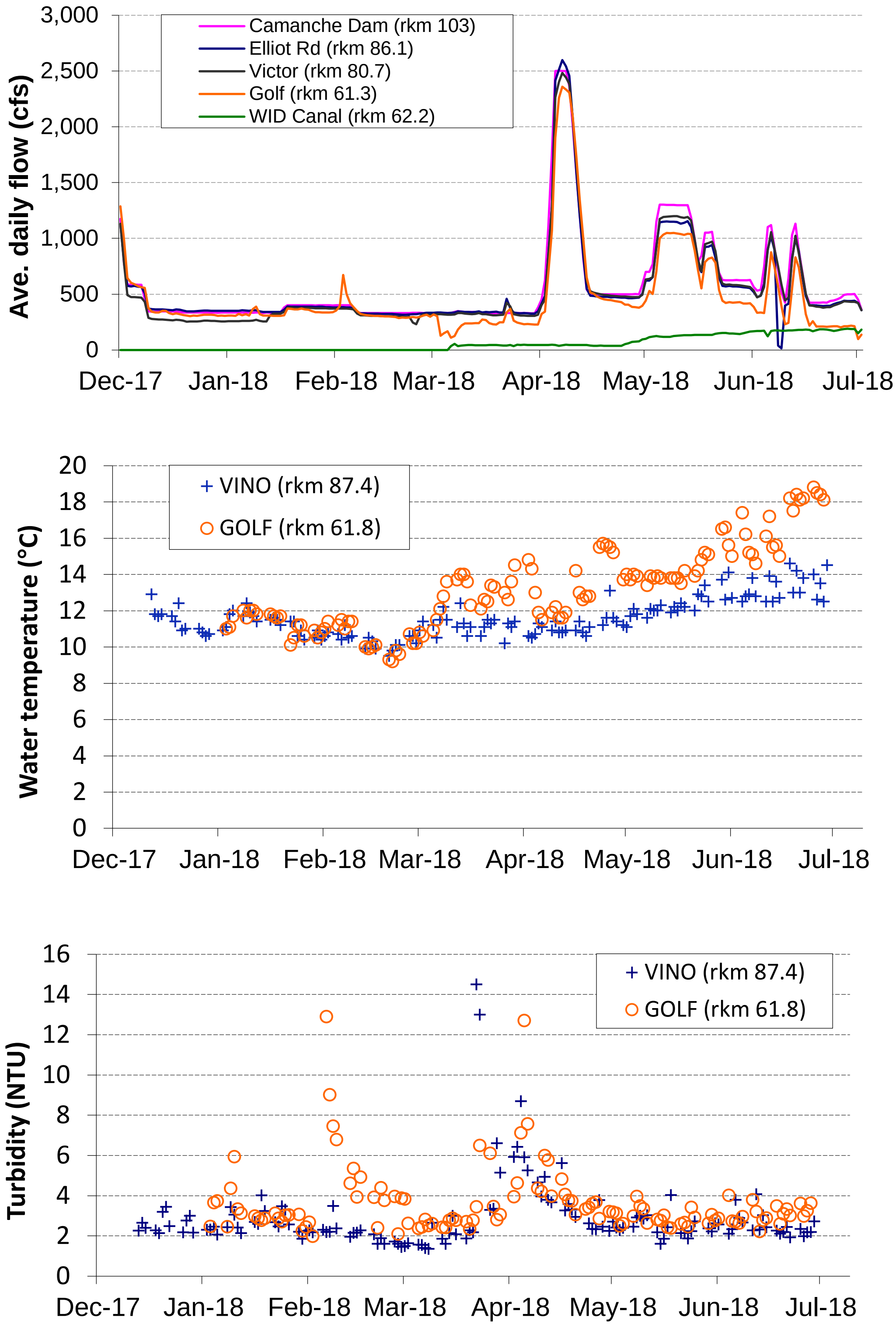

Figure 2. Average daily flow, water temperature, and turbidity on the lower Mokelumne River between Camanche Dam (rkm 103) and Golf (rkm 61.3) during the 2017/18 juvenile emigration monitoring season.

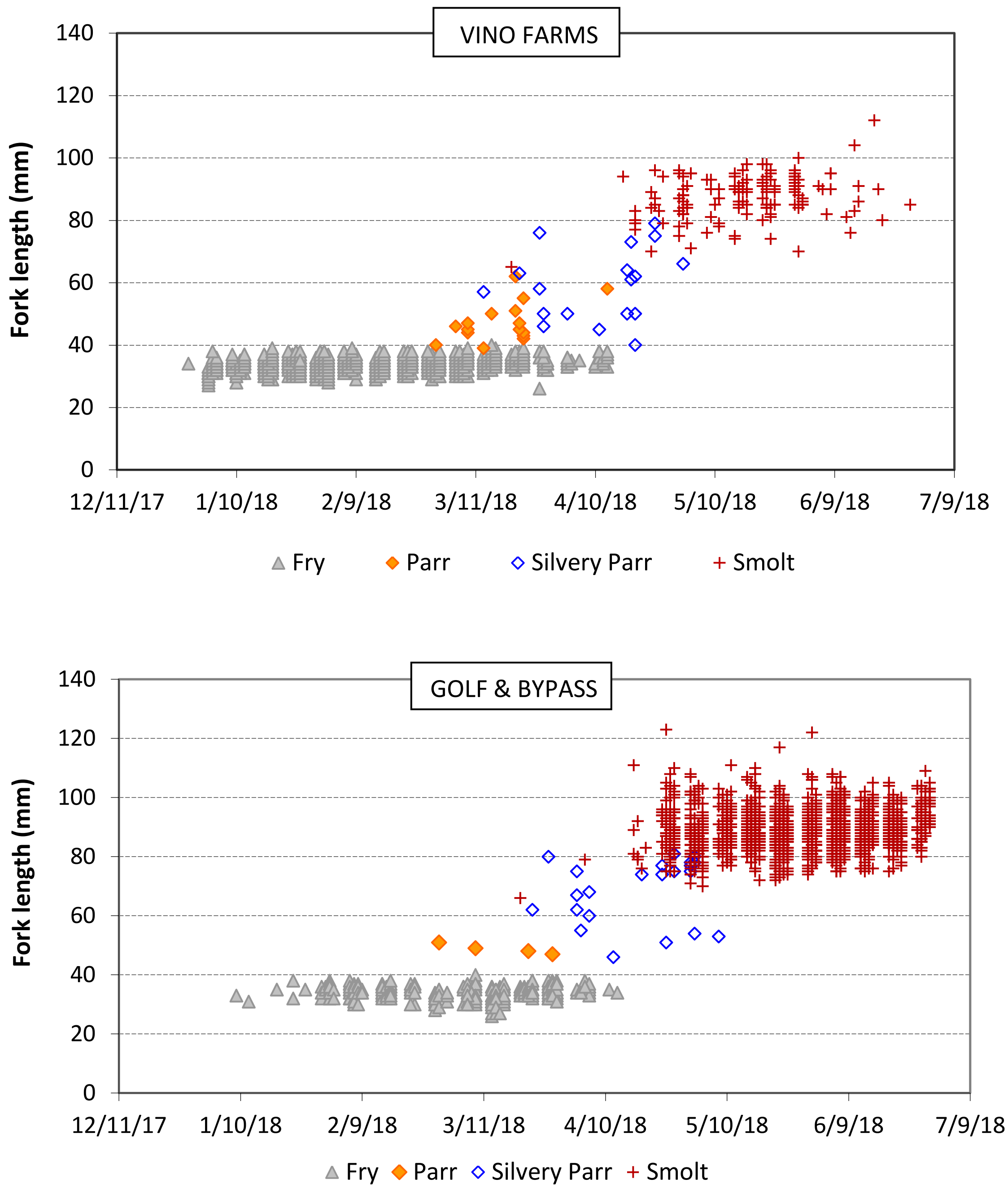

Figure 3. Size distribution by life stage of measured wild juvenile Chinook salmon at the upstream (VINO FARMS) and downstream (GOLF) trapping locations during the 2017/18 juvenile emigration season on the lower Mokelumne River.

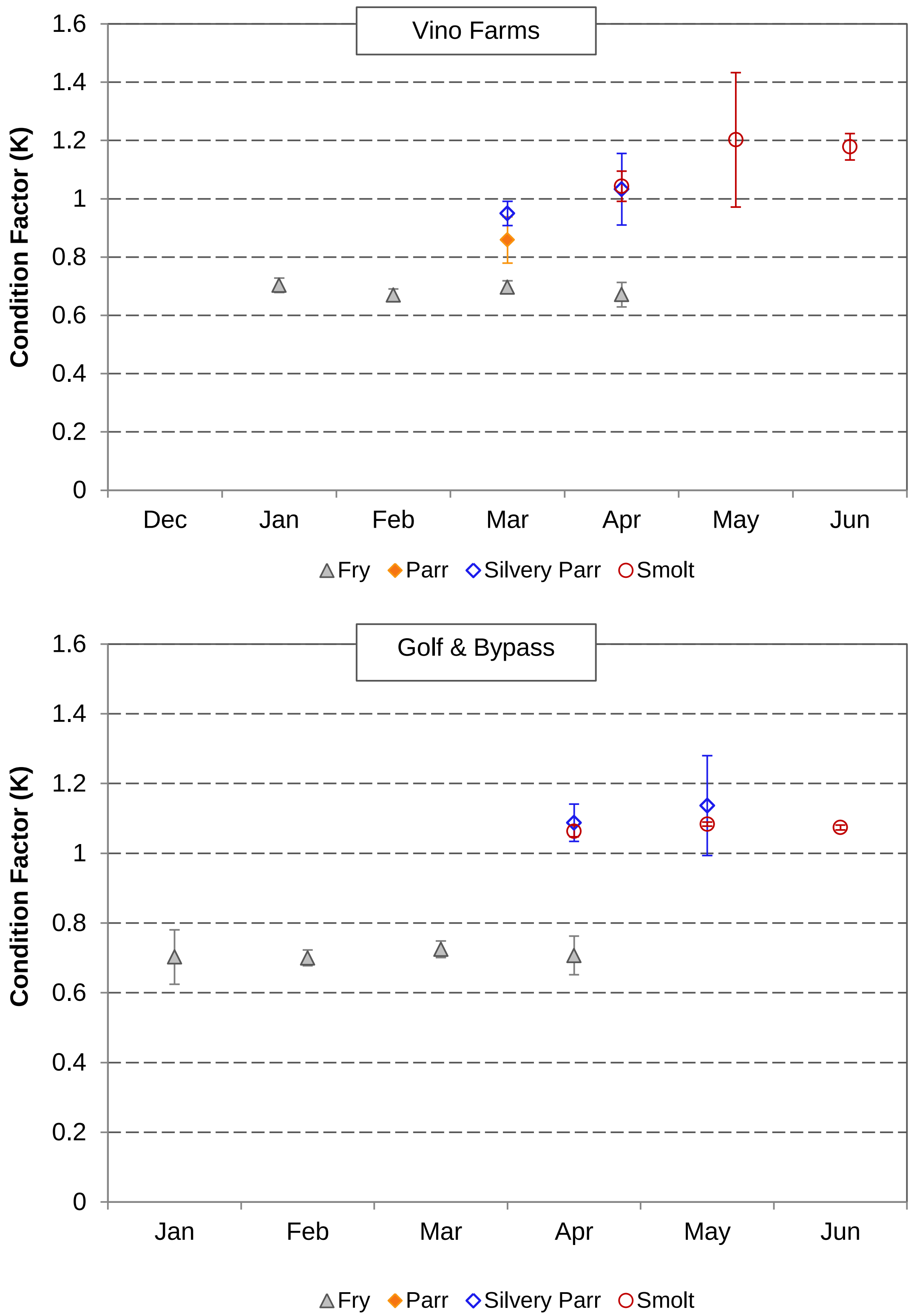

Figure 4. Monthly average condition factor ± 2 SE (vertical lines) of measured wild juvenile Chinook salmon at the upstream (VINO FARMS) and downstream (GOLF & BYPASS) trapping locations during the 2017/18 juvenile emigration monitoring season on the lower Mokelumne River.

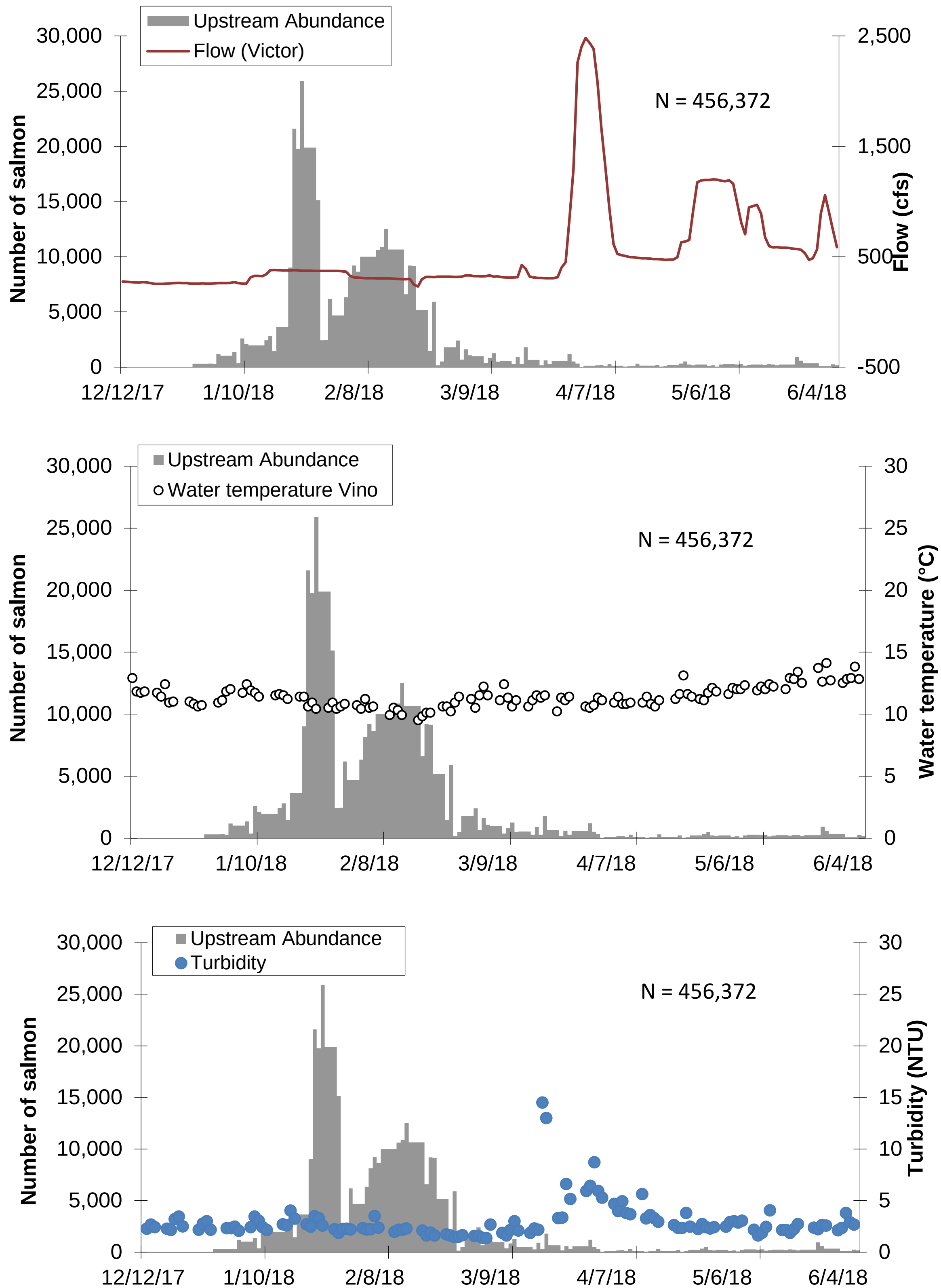

Figure 5. The relationships between estimated daily Chinook salmon abundance and flow (top), water temperature (middle), and turbidity (bottom) at the VINO RST (upstream trapping location) during the 2017/18 juvenile emigration monitoring season.

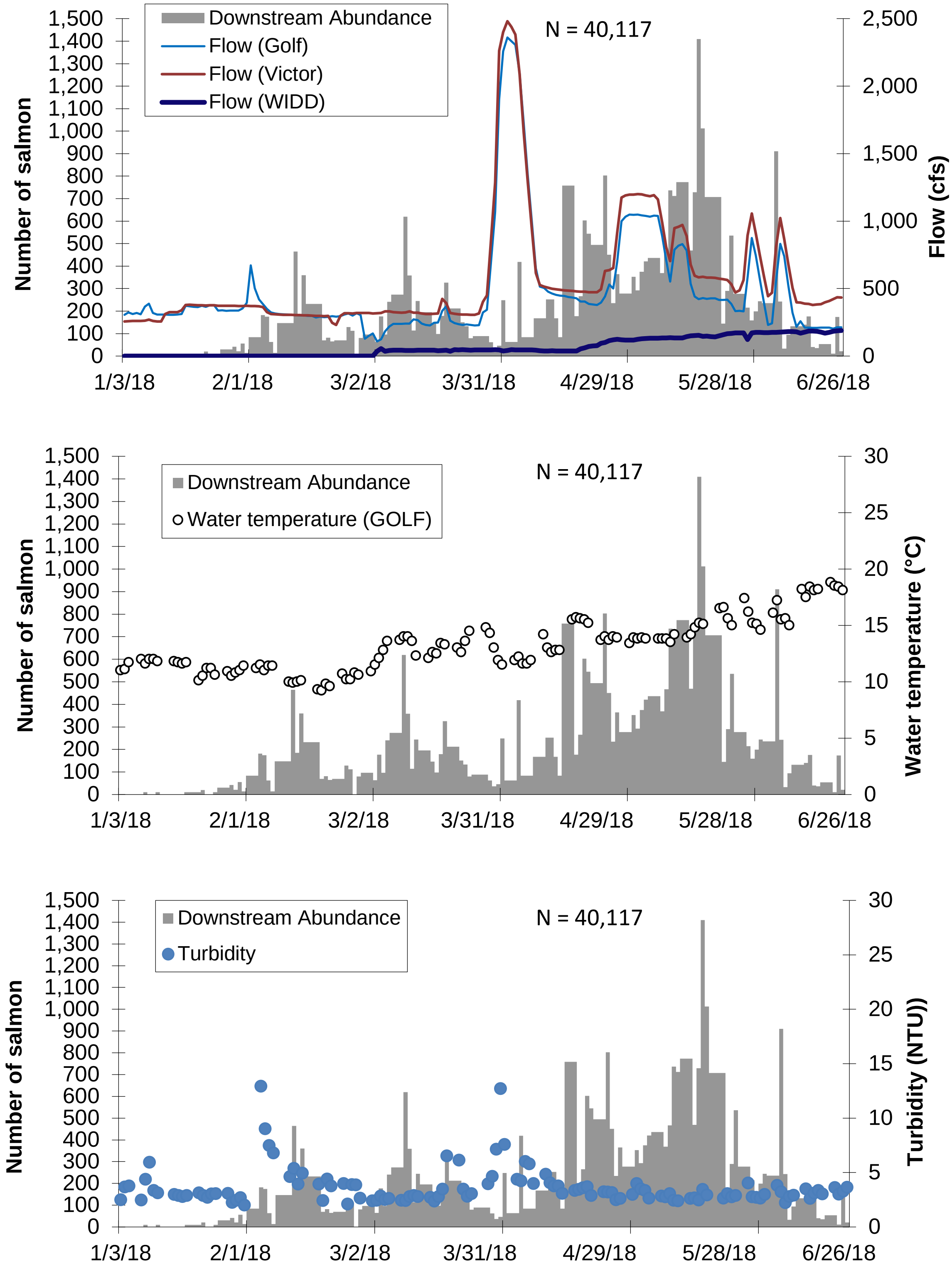

Figure 6. The relationships between estimated daily Chinook salmon abundance and flow (top), water temperature (middle), and turbidity (bottom) at the downstream trapping location (GOLF) during the 2017/18 juvenile emigration monitoring season.

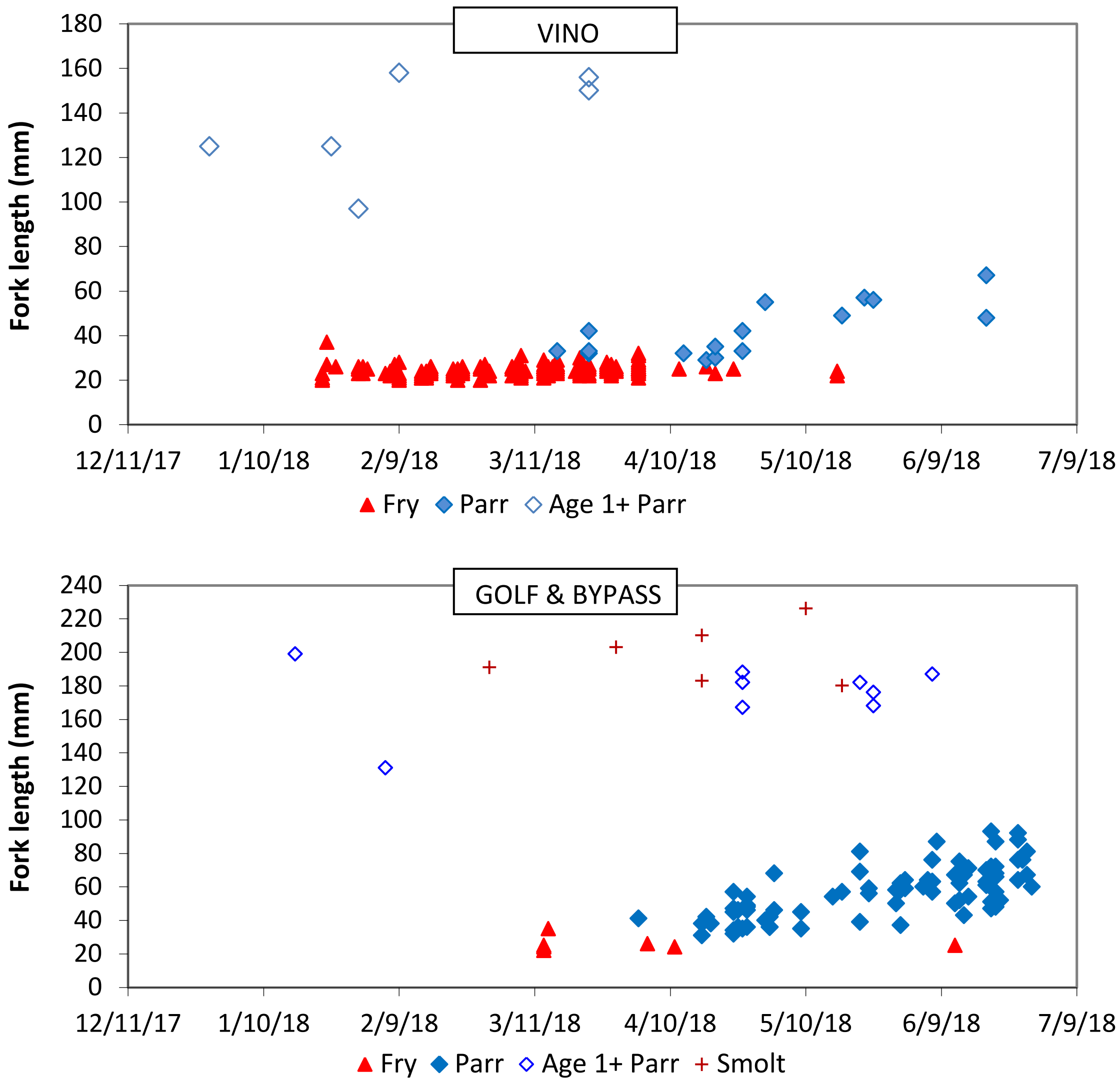

Figure 7. Size and life stage distribution of measured wild steelhead at the downstream upstream (Vino) and Downstream (Golf and Bypass) trapping locations during the 2017/18 juvenile emigration monitoring season on the lower Mokelumne River. One age 1+ adult was also captured at the Golf location, but not depicted.

Appendix A. Daily trap catch, period trap efficiency, abundance estimates, and 95% confidence intervals (CI) of juvenile Chinook salmon at the upstream trap (VINO) on the lower Mokelumne River during the 2017/18 monitoring period. Shaded areas represent non-trapping days with trap stoppages where catch was estimated.

Date	GOLF catch (u)	Marked (M)	Recaptured (m)	Upstream abundance estimate (U)	SD
12/12/2017					
12/13/2017	0	1,011	81		
12/14/2017	0	1,011	81		
12/15/2017	0	1,011	81		
12/16/2017	0	1,011	81		
12/17/2017	0	1,011	81		
12/18/2017	0	1,011	81		
12/19/2017	0	1,011	81		
12/20/2017	0	1,011	81		
12/21/2017	0	1,011	81		
12/22/2017	0	1,011	81		
12/23/2017	0	1,011	81		
12/24/2017	0	1,011	81		
12/25/2017	0	1,011	81		
12/26/2017	0	1,011	81		
12/27/2017	0	1,011	81		
12/28/2017	0	1,011	81		
12/29/2017	1	1,011	81		
12/30/2017	24	1,011	81		
12/31/2017	24	1,011	81		
1/1/2018	24	1,011	81		
1/2/2018	24	1,011	81		
1/3/2018	26	1,011	81		
1/4/2018	23	1,011	81		
1/5/2018	96	1,011	81		
1/6/2018	83	1,011	81		
1/7/2018	83	1,011	81		
1/8/2018	83	1,011	81		
1/9/2018	110	1,011	81		
1/10/2018	29	1,011	81		
1/11/2018	211	1,011	81		
1/12/2018	171	1,011	81		
1/13/2018	159	1,011	81		
1/14/2018	159	1,011	81		
1/15/2018	159	1,011	81		
1/16/2018	159	1,011	81		
1/17/2018	197	1,011	81		
1/18/2018	228	1,011	81		
1/19/2018	118	1,011	81		
1/20/2018	295	1,011	81		
1/21/2018	295	1,011	81		
1/22/2018	295	1,011	81		
Period Summary	**3,076**	**1,011**	**81**	**37,962**	
1/23/2018	220	778	18		
1/24/2018	527	778	18		
1/25/2018	482	778	18		

Appendix A continued

1/26/2018	632	778	18	
1/27/2018	485	778	18	
1/28/2018	485	778	18	
1/29/2018	485	778	18	
1/30/2018	369	778	18	
Period Summary	**3,685**	**778**	**18**	**151,085**
1/31/2018	448	297	54	
2/1/2018	452	297	54	
2/2/2018	1,142	297	54	
2/3/2018	866	297	54	
2/4/2018	866	297	54	
2/5/2018	866	297	54	
2/6/2018	1,167	297	54	
Period Summary	**5,807**	**297**	**54**	**31,463**
2/7/2018	931	550	62	
2/8/2018	1,053	550	62	
2/9/2018	988	550	62	
2/10/2018	1,144	550	62	
2/11/2018	1,144	550	62	
2/12/2018	1,144	550	62	
2/13/2018	1,144	550	62	
2/14/2018	1,215	550	62	
2/15/2018	1,242	550	62	
2/16/2018	1,433	550	62	
2/17/2018	1,218	550	62	
2/18/2018	1,218	550	62	
2/19/2018	1,218	550	62	
2/20/2018	1,218	550	62	
2/21/2018	754	550	62	
Period Summary	**17,064**	**550**	**62**	**149,242**
2/22/2018	1,336	612	88	
2/23/2018	1,328	612	88	
2/24/2018	752	612	88	
2/25/2018	752	612	88	
2/26/2018	752	612	88	
2/27/2018	215	612	88	
2/28/2018	859	612	88	
3/1/2018	22	612	88	
3/2/2018	73	612	88	
3/3/2018	261	612	88	
3/4/2018	261	612	88	
3/5/2018	261	612	88	
3/6/2018	350	612	88	
Period Summary	**7,222**	**612**	**88**	**49,743**
3/7/2018	77	346	39	
3/8/2018	187	346	39	
3/9/2018	125	346	39	
3/10/2018	112	346	39	

Appendix A continued

3/11/2018	112	346	39	
3/12/2018	112	346	39	
3/13/2018	43	346	39	
3/14/2018	96	346	39	
3/15/2018	146	346	39	
3/16/2018	56	346	39	
3/17/2018	61	346	39	
3/18/2018	61	346	39	
3/19/2018	61	346	39	
3/20/2018	32	346	39	
Period Summary	**1,281**	**346**	**39**	**11,113**
3/21/2018	29	503	15	
3/22/2018	9	503	15	
3/23/2018	57	503	15	
3/24/2018	21	503	15	
3/25/2018	21	503	15	
3/26/2018	21	503	15	
3/27/2018	5	503	15	
3/28/2018	19	503	15	
3/29/2018	9	503	15	
3/30/2018	18	503	15	
3/31/2018	18	503	15	
4/1/2018	18	503	15	
4/2/2018	18	503	15	
4/3/2018	38	503	15	
4/4/2018	16	503	15	
4/5/2018	10	503	15	
4/6/2018	1	503	15	
4/7/2018	4	503	15	
4/8/2018	4	503	15	
4/9/2018	4	503	15	
4/10/2018	5	503	15	
4/11/2018	6	503	15	
4/12/2018	3	503	15	
4/13/2018	9	503	15	
4/14/2018	4	503	15	
4/15/2018	4	503	15	
4/16/2018	4	503	15	
Period Summary	**375**	**503**	**15**	**11,825**
4/17/2018	1	510	11	
4/18/2018	2	510	11	
4/19/2018	2	510	11	
4/20/2018	7	510	11	
4/21/2018	3	510	11	
4/22/2018	3	510	11	
4/23/2018	3	510	11	
4/24/2018	3	510	11	
4/25/2018	5	510	11	

Appendix A continued

4/26/2018	1	510	11	
4/27/2018	2	510	11	
4/28/2018	5	510	11	
4/29/2018	5	510	11	
4/30/2018	5	510	11	
Period Summary	**47**	**510**	**11**	**2,001**
5/1/2018	6	1,005	17	
5/2/2018	9	1,005	17	
5/3/2018	4	1,005	17	
5/4/2018	3	1,005	17	
5/5/2018	4	1,005	17	
5/6/2018	4	1,005	17	
5/7/2018	4	1,005	17	
5/8/2018	2	1,005	17	
5/9/2018	3	1,005	17	
5/10/2018	1	1,005	17	
5/11/2018	4	1,005	17	
5/12/2018	5	1,005	17	
5/13/2018	5	1,005	17	
5/14/2018	5	1,005	17	
Period Summary	**59**	**1,005**	**17**	**3,297**
5/15/2018	7	1,013	29	
5/16/2018	8	1,013	29	
5/17/2018	4	1,013	29	
5/18/2018	6	1,013	29	
5/19/2018	7	1,013	29	
5/20/2018	7	1,013	29	
5/21/2018	7	1,013	29	
5/22/2018	6	1,013	29	
5/23/2018	8	1,013	29	
5/24/2018	7	1,013	29	
5/25/2018	5	1,013	29	
5/26/2018	7	1,013	29	
5/27/2018	7	1,013	29	
5/28/2018	7	1,013	29	
5/29/2018	7	1,013	29	
Period Summary	**100**	**1,013**	**29**	**3,380**
5/30/2018	11	1,017	11	
5/31/2018	7	1,017	11	
6/1/2018	4	1,017	11	
6/2/2018	4	1,017	11	
6/3/2018	4	1,017	11	
6/4/2018	4	1,017	11	
6/5/2018	1	1,017	11	
6/6/2018	1	1,017	11	
6/7/2018	1	1,017	11	
6/8/2018	3	1,017	11	
6/9/2018	2	1,017	11	

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6/10/2018	2	1,017	11		
6/11/2018	2	1,017	11		
6/12/2018	1	1,017	11		
6/13/2018	1	1,017	11		
6/14/2018	2	1,017	11		
6/15/2018	2	1,017	11		
6/16/2018	1	1,017	11		
6/17/2018	1	1,017	11		
6/18/2018	1	1,017	11		
6/19/2018	1	1,017	11		
6/20/2018	1	1,017	11		
6/21/2018	1	1,017	11		
6/22/2018	0	1,017	11		
6/23/2018	1	1,017	11		
6/24/2018	1	1,017	11		
6/25/2018	1	1,017	11		
6/26/2018	0	1,017	11		
6/27/2018	0	1,017	11		
6/28/2018	1	1,017	11		
6/29/2018	0	1,017	11		
Period Summary	**62**	**1,017**	**11**	**5,260**	
Annual Totals	**38,778**			**456,372**	**38,710**
				(95% CI 380,500 - 532,243)	

Appendix B. Daily trap catch, period trap efficiency, abundance estimates, and 95% confidence intervals (CI) of juvenile Chinook salmon at the downstream traps (GOLF & BYPASS) on the lower Mokelumne River during the 2017/18 monitoring period. Shaded areas represent non-trapping days with trap stoppages where catch was estimated.

Date	GOLF catch (u)	Marked (M)	Recaptured (m)	Golf abundance estimate (U)	BYPASS catch	Downstream abundance estimate	SD
1/3/2018	0	1,009	99		0		
1/4/2018	0	1,009	99		0		
1/5/2018	0	1,009	99		0		
1/6/2018	0	1,009	99		0		
1/7/2018	0	1,009	99		0		
1/8/2018	0	1,009	99		0		
1/9/2018	1	1,009	99		0		
1/10/2018	0	1,009	99		0		
1/11/2018	0	1,009	99		0		
1/12/2018	1	1,009	99		0		
1/13/2018	0	1,009	99		0		
1/14/2018	0	1,009	99		0		
1/15/2018	0	1,009	99		0		
1/16/2018	0	1,009	99		0		
1/17/2018	0	1,009	99		0		
1/18/2018	0	1,009	99		0		
1/19/2018	1	1,009	99		0		
1/20/2018	1	1,009	99		0		
1/21/2018	1	1,009	99		0		
1/22/2018	1	1,009	99		0		
1/23/2018	2	1,009	99		0		
1/24/2018	0	1,009	99		0		
1/25/2018	0	1,009	99		0		
1/26/2018	1	1,009	99		0		
1/27/2018	3	1,009	99		0		
1/28/2018	3	1,009	99		0		
1/29/2018	3	1,009	99		0		
Period Summary	**18**	**1,009**	**99**	**182**	**0**	**182**	
1/30/2018	6	1,013	144		0		
1/31/2018	3	1,013	144		0		
2/1/2018	8	1,013	144		0		
2/2/2018	2	1,013	144		0		
2/3/2018	12	1,013	144		0		
2/4/2018	12	1,013	144		0		
2/5/2018	12	1,013	144		0		
2/6/2018	26	1,013	144		0		
2/7/2018	25	1,013	144		0		
2/8/2018	9	1,013	144		0		
2/9/2018	2	1,013	144		0		
2/10/2018	21	1,013	144		0		
2/11/2018	21	1,013	144		0		
2/12/2018	21	1,013	144		0		
2/13/2018	21	1,013	144		**0**		
Period Summary	**201**	**1,013**	**144**	**1,406**		**1,406**	
2/14/2018	40	1,032	88		**0**		
2/15/2018	16	1,032	88		0		

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2/16/2018	31	1,032	88		0	
2/17/2018	20	1,032	88		0	
2/18/2018	20	1,032	88		0	
2/19/2018	20	1,032	88		0	
2/20/2018	20	1,032	88		0	
2/21/2018	6	1,032	88		0	
2/22/2018	7	1,032	88		0	
2/23/2018	6	1,032	88		0	
2/24/2018	6	1,032	88		0	
2/25/2018	6	1,032	88		0	
2/26/2018	6	1,032	88		0	
Period Summary	**204**	**1,032**	**88**	**2,363**		**2,363**
2/27/2018	8	995	61		0	
2/28/2018	7	995	61		0	
3/1/2018	0	995	61		0	
3/2/2018	5	995	61		0	
3/3/2018	6	995	61		0	
3/4/2018	6	995	61		0	
3/5/2018	6	995	61		0	
3/6/2018	4	995	61		0	
3/7/2018	11	995	61		0	
3/8/2018	6	995	61		0	
3/9/2018	15	995	61		0	
3/10/2018	17	995	61		0	
3/11/2018	17	995	61		0	
3/12/2018	17	995	61		0	
Period Summary	**125**	**995**	**61**	**2,008**		**2,008**
3/13/2018	38	1,026	62		0	
3/14/2018	22	1,026	62		0	
3/15/2018	7	1,026	62		0	
3/16/2018	15	1,026	62		0	
3/17/2018	12	1,026	62		0	
3/18/2018	12	1,026	62		0	
3/19/2018	12	1,026	62		0	
3/20/2018	9	1,026	62		0	
3/21/2018	6	1,026	62		0	
3/22/2018	11	1,026	62		0	
3/23/2018	20	1,026	62		0	
3/24/2018	13	1,026	62		0	
3/25/2018	13	1,026	62		0	
3/26/2018	13	1,026	62		0	
Period Summary	**203**	**1,026**	**62**	**3,309**		**3,309**
3/27/2018	17	1,019	114		0	
3/28/2018	15	1,019	114		0	
3/29/2018	9	1,019	114		0	
3/30/2018	10	1,019	114		0	
3/31/2018	10	1,019	114		0	
4/1/2018	10	1,019	114		0	

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4/2/2018	10	1,019	114		0	
4/3/2018	7	1,019	114		0	
4/4/2018	4	1,019	114		1	
4/5/2018	5	1,019	114		2	
4/6/2018	28	1,019	114		0	
4/7/2018	7	1,019	114		1	
4/8/2018	7	1,019	114		1	
4/9/2018	7	1,019	114		1	
Period Summary	**146**	**1,019**	**114**	**1,295**	**6**	**1,301**
4/10/2018	5	502	5		0	
4/11/2018	1	502	5		0	
4/12/2018	1	502	5		0	
4/13/2018	1	502	5		0	
4/14/2018	2	502	5		0	
4/15/2018	2	502	5		0	
4/16/2018	2	502	5		0	
4/17/2018	3	502	5		1	
4/18/2018	3	502	5		1	
4/19/2018	2	502	5		0	
4/20/2018	1	502	5		0	
4/21/2018	9	502	5		4	
4/22/2018	9	502	5		4	
4/23/2018	9	502	5		4	
Period Summary	**50**	**502**	**5**	**4,192**	**14**	**4,206**
4/24/2018	8	1,002	45		3	
4/25/2018	12	1,002	45		4	
4/26/2018	27	1,002	45		14	
4/27/2018	24	1,002	45		21	
4/28/2018	22	1,002	45		15	
4/29/2018	22	1,002	45		15	
4/30/2018	22	1,002	45		15	
5/1/2018	36	1,002	45		18	
5/2/2018	20	1,002	45		15	
5/3/2018	10	1,002	45		17	
5/4/2018	16	1,002	45		16	
5/5/2018	12	1,002	45		16	
5/6/2018	12	1,002	45		16	
5/7/2018	12	1,002	45		16	
Period Summary	**255**	**1,002**	**45**	**5,560**	**201**	**5,761**
5/8/2018	9	1,012	25		2	
5/9/2018	7	1,012	25		20	
5/10/2018	9	1,012	25		24	
5/11/2018	10	1,012	25		31	
5/12/2018	10	1,012	25		47	
5/13/2018	10	1,012	25		47	
5/14/2018	10	1,012	25		47	
5/15/2018	8	1,012	25		57	
5/16/2018	10	1,012	25		77	

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5/17/2018	17	1,012	25		74		
5/18/2018	13	1,012	25		205		
5/19/2018	14	1,012	25		228		
5/20/2018	14	1,012	25		228		
5/21/2018	14	1,012	25		228		
5/22/2018	10	1,012	25		80		
5/23/2018	10	1,012	25		339		
5/24/2018	21	1,012	25		591		
5/25/2018	13	1,012	25		506		
5/26/2018	9	1,012	25		356		
5/27/2018	9	1,012	25		356		
5/28/2018	9	1,012	25		356		
5/29/2018	9	1,012	25		356		
5/30/2018	2	1,012	25		67		
5/31/2018	1	1,012	25		251		
6/1/2018	4	1,012	25		380		
6/2/2018	3	1,012	25		160		
6/3/2018	3	1,012	25		160		
6/4/2018	3	1,012	25		160		
6/5/2018	3	1,012	25		98		
6/6/2018	2	1,012	25		81		
6/7/2018	3	1,012	25		82		
6/8/2018	4	1,012	25		88		
6/9/2018	4	1,012	25		80		
6/10/2018	4	1,012	25		80		
6/11/2018	4	1,012	25		80		
Period Summary	**285**	**1,012**	**25**	**11,104**	**6,022**	**17,126**	
6/12/2018	11	1,500	21		160		
6/13/2018	3	1,500	21		38		
6/14/2018	0	1,500	21		33		
6/15/2018	1	1,500	21		26		
6/16/2018	1	1,500	21		64		
6/17/2018	1	1,500	21		64		
6/18/2018	1	1,500	21		64		
6/19/2018	1	1,500	21		72		
6/20/2018	0	1,500	21		176		
6/21/2018	0	1,500	21		40		
6/22/2018	0	1,500	21		36		
6/23/2018	0	1,500	21		54		
6/24/2018	0	1,500	21		54		
6/25/2018	0	1,500	21		54		
6/26/2018	0	1,500	21		11		
6/27/2018	2	1,500	21		37		
6/28/2018	0	1,500	21		21		
6/29/2018	0	1,500	21		19		
Period Summary	**21**	**1,500**	**21**	**1,433**	**1,023**	**2,456**	
Annual Totals	**1508**			**32,851**		**40,117**	**2,997**
				(95% CI 26,978 - 38,725)		**(95% CI 32,244 - 45,991)**	

Appendix C. Monthly totals of species caught at the upstream RST (VINO) on the lower Mokelumne river during the 2017/18 juvenile outmigration monitoring season.

Common Name	**Genus**	**Species**	**Dec.**	**Jan.**	**Feb.**	**Mar.**	**Apr.**	**May**	**June**	**Total**
black bass	*Micropterus*	*spp.*	0	0	2	0	0	0	0	**2**
black crappie	*Pomoxis*	*nigromaculatus*	15	2	27	0	1	0	0	**45**
blue gill	*Lepomis*	*macrochirus*	0	0	125	8	1	1	1	**136**
channel catfish	*Ictalurus*	*punctatus*	0	1	2	0	1	1	0	**5**
Chinook salmon (ad-clip)	*Oncorhyhchus*	*tshawytscha*	0	0	0	0	0	181	270	**451**
Chinook salmon (no ad-clip)	*Oncorhyhchus*	*tshawytscha*	1	3,887	14,115	1,335	89	101	20	**19,548**
common carp	*Cyprinus*	*carpio*	1	0	4	0	0	0	0	**5**
golden shiner	*Notemigonus*	*crysoleucas*	0	0	0	25	4	0	1	**30**
goldfish	*Carassius*	*auratus*	0	0	0	0	1	0	0	**1**
hitch	*Lavinia*	*exilicauda*	3	2	7	17	6	3	4	**42**
Pacific lamprey	*Lampetra*	*tridentata*	26	37	30	136	26	21	29	**305**
prickly sculpin	*Cottus*	*asper*	2	7	6	12	111	19	12	**169**
redear sunfish	*Lepomis*	*microlophus*	0	0	1	1	0	0	0	**2**
Sacramento pikeminnow	*Ptychocheilus*	*grandis*	0	0	1	9	1	0	1	**12**
Sacramento sucker	*Catostomus*	*occidentalis*	0	0	1	1	0	0	0	**2**
steelhead (no ad-clip)	*Oncorhynchus*	*mykiss*	2	13	83	138	43	34	3	**316**
threadfin shad	*Dorosoma*	*petenense*	0	1	0	0	1	0	0	**2**
tule perch	*Hysterocarpus*	*traski*	2	8	1	14	2	3	1	**31**
warmouth	*Lepomis*	*gulosus*	0	0	0	1	0	0	0	**1**
white catfish	*Ameiurus*	*catus*	2	2	3	4	4	5	10	**30**
western mosquitofish	*Gambusia*	*affinis*	0	1	0	1	11	1	0	**14**

Appendix D. Monthly totals of fish species caught at the downstream RST (GOLF) and Bypass trap on the lower Mokelumne river during the 2017/18 juvenile outmigration monitoring season.

Common Name	**Genus**	**Species**	**Jan.**	**Feb.**	**Mar.**	**Apr.**	**May**	**June**	**Total**
american shad	*Alosa*	*sapidissima*	0	0	0	0	0	1	**1**
bigscale logperch	*Percina*	*macrolepida*	0	1	3	0	1	0	**5**
black bass	*Micropterus*	*spp.*	2	97	0	0	13	213	**325**
black crappie	*Pomoxis*	*nigromaculatus*	4	159	6	1	0	0	**170**
bluegill	*Lepomis*	*macrochirus*	1	447	110	34	27	39	**658**
brown bullhead	*Ameiurus*	*nebulosus*	0	0	0	0	0	1	**1**
channel catfish	*Ictalurus*	*punctatus*	0	4	1	0	0	0	**5**
Chinook salmon (ad-clip)	*Oncorhyhchus*	*tshawytscha*	0	0	0	0	5,480	9,519	**14,999**
Chinook salmon (no ad-clip)	*Oncorhyhchus*	*tshawytscha*	15	190	210	174	2,602	1,429	**4,620**
common carp	*Cyprinus*	*carpio*	1	11	1	5	1	1	**20**
fathead minnow	*Pimephales*	*promelas*	0	0	0	0	1	0	**1**
golden shiner	*Notemigonus*	*crysoleucas*	3	7	16	8	1	2	**37**
green sunfish	*Lepomis*	*cyanellus*	0	8	0	1	1	2	**12**
hitch	*Lavinia*	*exilicauda*	0	3	0	0	1	1	**5**
inland silverside	*Menidia*	*beryllina*	0	1	1	1	0	0	**3**
largemouth bass	*Micropterus*	*salmoides*	1	3	1	0	0	0	**5**
lepomis hybrid	*Lepomis*	*spp.*	0	0	1	0	0	0	**1**
Pacific lamprey	*Entosphenus*	*tridentatus*	5	43	493	389	41	63	**1,034**
prickly sculpin	*Cottus*	*asper*	11	65	150	80	1,518	11,901	**13,725**
redear sunfish	*Lepomis*	*microlophus*	1	6	0	2	8	11	**28**
redeye bass	*Micropterus*	*coosae*	0	0	1	1	0	2	**4**
Sacramento pikeminnow	*Ptychocheilus*	*grandis*	0	1	0	1	1	0	**3**
Sacramento sucker	*Catostomus*	*occidentalis*	0	0	0	0	0	1	**1**
spotted bass	*Micropterus*	*punctulatus*	0	1	0	0	0	0	**1**
steelhead (no ad-clip)	*Oncorhynchus*	*mykiss*	2	2	7	25	27	49	**112**
striped Bass	*Morone*	*saxatilis*	0	0	0	0	2	7	**9**
threadfin shad	*Dorosoma*	*petenense*	1	0	0	1	0	0	**2**
tule perch	*Hysterocarpus*	*traski*	0	2	1	7	5	27	**42**
warmouth	*Lepomis*	*gulosus*	0	13	18	2	10	0	**43**
white catfish	*Ameiurus*	*catus*	0	6	1	0	0	4	**11**
western mosquitofish	*Gambusia*	*affinis*	2	13	0	2	1	0	**18**