Emigration of Juvenile Chinook Salmon (*Oncorhynchus tshawytscha*) and Steelhead (*Oncorhynchus mykiss*) in the Lower Mokelumne River, December 2016 – July 2017

November 2017

Ed Rible, Robyn Bilski, and Matt Saldate
East Bay Municipal Utility District, 1 Winemasters Way, Unit K, Lodi, CA

Key Words: Chinook salmon, emigration, juvenile monitoring, lower Mokelumne River, steelhead

---

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) during the 2016/17 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 13 December 2016 to 4 January 2017. The downstream rotary screw trap (GOLF) was located just below the Lower Sacramento Road Bridge at rkm 61.8 and was operated from 9 January to 7 July 2017.

The first juvenile Chinook salmon was captured at the VINO RST on 17 December 2016. Due to high flood control releases from Lake Camanche (>3,500 cubic feet per second) the VINO RST was only operated for 23 days. Including weekend estimates, the catch of naturally produced young-of-the-year (YOY) Chinook salmon was 124 during the truncated monitoring period. No trap efficiency tests were conducted, and no annual abundance estimates of naturally produced YOY Chinook salmon or wild YOY steelhead were calculated during the 2016/17 season at the VINO RST due to the short duration of sampling.

The first juvenile Chinook salmon was captured at the downstream RST (GOLF) on 12 January 2017. Including weekend estimates, the catch of naturally produced YOY Chinook salmon was 1,557 during the monitoring period. Eleven 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 326,455 (95% CI: 217,992-434,918). Including weekend estimates, the catch of wild YOY steelhead was 191 at the GOLF RST during the 2016/17 season. The estimated passage of wild YOY steelhead (based on trap calibrations using Chinook salmon) was 20,675 (95% CI: 11,300-30,050).

The bypass trap (BYPASS), located at Woodbridge Irrigation District Dam (rkm 62.2), was completely inundated with water from high Mokelumne river flows (> 2,300 cfs) and was never operated.

Although ages 1+ steelhead are captured during trapping, abundance estimates are only calculated for YOY steelhead. Catch of other steelhead life stages are summarized below. At the downstream GOLF trap, four wild age 1+ steelhead smolts were captured and two age 1+ adults were captured.

Ten fish species were caught at the VINO RST during the survey period: four native and six non-native species. Native fish species were more frequently caught than non-native species and Pacific lamprey (*Entosphenus tridentatus)* was the most abundant species caught. At the downstream GOLF trap, 26 fish species were caught, made up of eight native and 18 non-native species. Numerically, native fish made up the majority of the catch and Prickly sculpin (*Cottus asper*) was the most abundant species caught.

Average daily water releases from Camanche Reservoir ranged from 701 cfs (19.9 m^3/s) to 4,989 cfs (141.3 m^3/s) during the monitoring period. The trapping season had 71 days with releases larger than 4,900 cfs and 148 consecutive days with releases above 3,000 cfs. From 1 October 2016 through 31 March 2017, EBMUD operated under a "Normal and Above" JSA water year type. From 1 April through 30 September 2017, EBMUD operated under a "Normal and Above" 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, 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 2016 through early July 2017.

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), 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

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 8-ft rotary screw trap (RST) was operated at the upstream location near the Elliott Road Bridge, adjacent to property owned by Vino Farms, at rkm 87.4. At the downstream location, an 8-ft RST 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 2016/17 monitoring season when traps were operational, RSTs were generally operated Monday through Friday, between December and July. 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, just 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 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.

Calibrations

Multiple trap efficiency tests were conducted at the GOLF RST throughout the emigration period to provide an estimate of the proportion of juvenile Chinook salmon it was capturing. Test salmon provided by California Department of Fish and Wildlife at the Mokelumne River Fish Hatchery (MOKH) were used for trap efficiency trials. A lower caudal fin clip and/or Bismark® brown dye were used to mark groups of test fish for the GOLF trap. 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. The test fish were distributed proportionally to the flow across the river.

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 to 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) 2016 redd count and BY 2016 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 2016 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 downstream trapping location. 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 (Setka 2004) to the downstream trap

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 Elliot Road gauging station (just downstream of the VINO trapping site) ranged from 872 cfs (24.7 m^3/s) to 1,493 cfs (42.3 m^3/s) during the time when the VINO trap was operated (13 December 2016 through 4 January 2016). The mean flow during that time was 1,235 cfs (35.0 m^3/s). Water temperatures recorded at VINO ranged from 11.0 to 13.4°C, with a mean of 12.0°C. Water turbidity ranged from 2.5 to 8.4 Nephelometric Turbidity Units (NTU), with a mean of 4.1 NTU. Water dissolved oxygen ranged from 9.26 to 12.35 milligrams per liter (mg/l), with a mean of 10.42 mg/l.

Average daily flow at the Golf gauging station ranged from 497 cfs (14.1 m^3/s) to 4,827 cfs (136.7 m^3/s) during the time when the GOLF RST was operated (9 January through 7 July 2017). The average daily flow during that time was 3,647 cfs (103.3 m^3/s). Water temperatures recorded at GOLF ranged from 9.0 to 19.0°C, with a mean of 12.2°C. Water turbidity ranged from 3.1 to 22.9 NTU, with a mean of 7.9 NTU. Water dissolved oxygen ranged from 9.32 to 16.24 mg/l, with a mean of 11.30 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 13 December 2016 and 4 January 2017. The cone was stopped by debris on 3 of 12 trap check days. Excluding days with trap stoppages, the minimum recorded cone rotation rate was 2.7 RPM and the maximum was 3.9 RPM. The mean rotation rate during the monitoring season was 3.5 RPM. The VINO trap met or exceeded a rotation speed of 2.0 RPMs on 100% of all operating days (excluding stoppage days). Water velocity entering the center of the trap cone ranged between 0.8 and 1.0 m/s, with a mean of 1.0 m/s. The VINO trap was taken out of operations due to high flows on January 4th. At flows over 3,500 cfs, the VINO trap location becomes unusable due to high water submerging the static line.

The 8-ft RST at GOLF was operated from 9 January to 7 July 2017. Debris stopped the cone from rotating on 17 of 95 trap check days. Excluding trap stoppages, the minimum cone rotation rate was 2.2 RPM and the maximum rate was 5.1 RPM. Average rotational speed was 3.9 RPM. The 8-ft RST met or exceeded a rotation speed of 2.0 RPMs on 100% of all operating days (excluding stoppage days). Water velocity entering the center of the trap cone ranged between 0.7 and 1.4 m/s, with a mean of 1.1 m/s.

RST Calibrations

No calibration tests were conducted for the VINO RST during the 2016/17 juvenile monitoring season due to the short duration of sampling (Table 1).

Thirteen calibration tests were conducted for the GOLF RST during the 2016/17 juvenile monitoring season (Table 1). Chinook salmon from the MOKH were used for all thirteen tests. Trap efficiency test 1 was not used to generate abundance estimates because of a trap stoppage on the estimation day, and efficiency test 13 was not used because there were insufficient recaptures to produce reliable 95% confidence intervals. Excluding tests 1 and 13, trap efficiency ranged from 0.1% to 1.2%, with a mean of 0.5% (n = 11).

Chinook Salmon

<u>Catch and Abundance Estimates</u>

At the VINO RST, 51 naturally produced YOY Chinook salmon were captured between 20 December 2016 and 4 January 2017. Estimates for weekend catch and trap stoppages were added to the actual catch to produce an estimated count of 124 YOY Chinook salmon (Table 2). No abundance estimate was calculated.

At the GOLF RST, 841 naturally produced YOY Chinook salmon were captured between 9 January and 7 July 2017. Estimates for weekend catch and trap stoppages were added to the actual catch to produce an estimated count of 1,557 YOY Chinook salmon. Using trap efficiency data, the total downstream emigration abundance estimate of YOY Chinook salmon at the GOLF RST was 326,455 (95% CI: 217,992-434,918). The highest period of estimated salmon abundance was recorded from 15 February to 27 February 2017 (Table 2). On 15 June 2017, the MOKH conducted two in-river Chinook salmon releases of 200,000 marked and tagged juveniles. One release was directly adjacent to the hatchery, and the other was in the WID basin. As a result of these releases, 6 hatchery origin (adipose fin-clipped) Chinook salmon smolts were caught at the GOLF trap between 21 June 2017 and 30 June 2017. These captures were not part of the population estimate.

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

At the VINO RST, 100% (n=51) of the naturally produced Chinook salmon catch was classified as fry. The size distribution by life stage of naturally produced Chinook salmon caught and measured at the VINO RST during the 2016/17 season is provided in Figure 3.

At the downstream trap, naturally produced Chinook salmon catch was classified as smolts (64.1%, n=539), fry (35.1%, n=295), parr (0.1%, n=1), and silvery parr (0.7%, n=6). The size distribution by life stage of naturally produced Chinook salmon caught and measured at the downstream trap during the 2016/17 season is provided by Figure 3. Based off Chinook salmon estimated abundance 46.1% (n=153,255) moved past the downstream trap as fry and 53.1% (173,200) as smolt.

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). Interestingly, hatchery smolts had a condition factor of 1.22 on average, whereas natural smolts were 1.12.

Migration Response

The relationships between three environmental variables (average daily flow, water temperature and turbidity) and estimated daily salmon count at the upstream and downstream traps during the 2016/17 monitoring season are presented graphically in Figures 5 and 6.

At the downstream trap, daily water turbidity was the only variable included in the GLM with the lowest AICc (Table 3). Turbidity had a significant negative relationship with daily salmon catch (parameter estimate = -0.0669). Weekly redd emergence and weekly salmon catch had a significant positive correlation at the downstream trap (r = 0.89, r < 0.0001).

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

During the BY 2016 spawning season, 405 Chinook salmon redds were identified in the LMR. The BY 2016 average salmon fecundity estimate (per female spawned at the MOKH) was 4,591 eggs. The resulting estimated salmon production at 100% survival was 1,859,301 juveniles. The BY 2016 egg-to-YOY survival index for naturally produced YOY Chinook salmon at the upstream VINO trap was not calculated due to an incomplete sample period. At the downstream GOLF trap, the BY 2016 survival index was 0.18 (95% CI: 0.12-0.23). The BY 2016 downstream survival index was above average (0.16), compared to other brood years that experienced normal and above water year types, (Table 4) BY 2005-2007, 2010, 2016.The result of large Camanche releases greater than 1,000 cfs ended the BY 2016 spawning survey early in Julian week 51. Based off previous spawning surveys with normal and above water year types, 3% of Chinook salmon redds were constructed after Julian week 51. An adjusted possible estimated survival index (0.17) would also be above average (0.16).

Steelhead

Catch and Abundance Estimates

At the VINO RST, there were no wild YOY steelhead captured between 13 December 2016 and 4 January 2017.

At the GOLF RST, 97 wild YOY steelhead were captured between 16 May and 7 July 2017. Estimates for weekend catch and trap stoppages were added to actual catch to produce an estimated count of 191 naturally produced YOY steelhead. The estimated passage of wild YOY steelhead at GOLF (based on trap calibrations using Chinook salmon) was 20,675 (95% CI: 11,300-30,050). The largest monthly catch of wild YOY steelhead (90) occurred at the downstream traps in June.

Life stage and size

At the VINO RST, there were no wild YOY steelhead captured between 13 December 2016 and 4 January 2017.

At the downstream trap, 93.2% (n=96) of the wild steelhead catch was classified as parr. The remaining wild steelhead catch was composed of fry (1%, n=1) and age 1+ smolts (3.9%, n=4, and age 1+ adults (1.9 %, n=2).

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

Species Composition

Ten fish species were caught at the VINO RST during the survey period: four native and six non-native species. Native fish species were more abundant than non-native species, comprising 95.1% of the total catch. Pacific lamprey was the most abundant species caught (75.8%), followed by Chinook salmon (no adipose fin-clip) (17.9%), and western mosquitofish (*Gambusia affinis*) (2.1%).

At the downstream GOLF trap, twenty-six fish species were caught: eight native and eighteen non-native species. Native fish species were more abundant than non-native species, comprising 76.7% of the total catch. This was driven primarily by high abundance of Prickly sculpin which was the most abundant species caught (71.4%), followed by juvenile black bass (*Micropterus spp.)* (10.9%), common carp (*Cyprinus carpio*) (8.2%), and Chinook salmon (no adipose fin-clip) (4.7%).

DISCUSSION

During the 2016/2017 juvenile outmigration monitoring season, the VINO RST was stopped by debris on three of 12 operating days. Salmon catch was not estimated at VINO on any of the three days with trap stoppages. The GOLF RST was stopped by debris seventeen times throughout the monitoring season. Salmon catch was estimated at GOLF on one (19 June) of the seventeen days with trap stoppages, when trap revolutions were low and moderate numbers of salmon were moving past the trap. During the other days when the GOLF trap was stopped, salmon catch was not estimated because trap stoppages occurred outside of peak salmon outmigration periods. These days may have led to a small, but not significant, underestimate of salmon abundance at the GOLF trap. The bypass trap (BYPASS), located at Woodbridge Irrigation District Dam (rkm 62.2), was completely inundated with water from high flows (over 2,300 cfs) and was never operated.

At the VINO RST, no efficiency trials took place during the monitoring season. The trap was only operated for 11 days at the beginning of the season. Mokelumne river flows exceeded 3,500 cfs, resulting in the VINO RST removal on January 4th 2017.

At the GOLF RST, all thirteen trap efficiency trials were run using groups of salmon from the MOKH. Eleven of the thirteen tests were considered successful this season and used to create population estimates. Test 1 was not successful due to a trap stoppage the day after the release and Test 13 was omitted because of a small release group resulting in poor confidence intervals. Trap efficiencies were very low ($\leq$ 1.2%) throughout the season. All successful efficiency trials were run when Camanche releases ranged from 3,354 to 4,746 cfs. Low trap efficiencies were likely due to an increased wetted area, resulting in a smaller proportion of the total volume of water sampled while providing more migration routes around the trap.

No upstream juvenile abundance estimate was calculated for the VINO trap site. The VINO trap is not operable when Camanche Dam releases exceed 3,000 cfs. Beginning on 5 January 2017 releases exceeded 3,000 cfs for 148 consecutive days. Flows did not recede to operable levels until 2 June 2017, after the majority of juvenile Chinook salmon would have emigrated past Vino.

The downstream juvenile salmon abundance estimate of 326,455 ranked the 7th highest (of 25) on record since the 1992/93 season. The annual juvenile salmon abundance estimate for the downstream trap was above average, relative to previous estimates. Compared to previous normal and above water year types, the BY 2016 downstream survival index was also above average. Factors that could have helped survival were good incubation water temperatures, averaging 11.2°C during periods when the progression of embryonic development occurred (Merz et al. 2004). An extremely wet winter and spring may have tempered water diversion rates while reducing the cumulative impact that small diversions have on fish populations indicated by Moyle and Isreal (2005). Near flood stage Camanche releases significantly increased LMR velocities and possibly reduced juvenile Chinook salmon entrainment of unscreened water diversions. Increasing sweeping water velocities over unscreened water diversion pipes and reducing diversion rates in non-turbid water has shown reduced entrainment (Mussen et al. 2013). High LMR flows could have diluted predation effects by increasing wetted area and providing more refuge and migration routes.

At the downstream traps, turbidity was the only variable included in the GLM with the lowest AICc. Turbidity had a significant negative relationship with daily salmon catch indicating that many juvenile salmon emigrated past the downstream traps when turbidity was low. In addition, weekly redd emergence and weekly salmon count had a significant positive correlation at the downstream trap. This confirmed a large proportion of the juvenile Chinook salmon emigrated past the downstream trap as fry (46.9% estimated abundance).

ACKNOWLEDGEMENTS

We would like to thank Charles Hunter, Jason Shillam, Samantha Linhardt, Kenneth Robbins, Casey Del Real, and James Jones for field support and Terry Cummings for assistance with data entry and QA/QC. We also thank Michelle Workman for her assistance, review, and support. Thanks to Woodbridge Irrigation District for help with access at downstream trapping sites. We thank Bill Smith, Darrick Baker, and hatchery staff from the California Department of Fish and Wildlife who provided Mokelumne River hatchery origin Chinook salmon to use as test fish for trap efficiency tests.

LITERATURE CITED

Bagenal, T. B. and F. W. Tesch. 1978. Age and growth. Pages 101-136 *in* T. B. Bagenal (editor). Methods for Assessment of Fish Production in Fresh Waters. IBP Handbook No. 3. Blackwell Scientific Publications. Oxford, England.

Bianchi, E.W., W. Walsh, and C. Marzuola. 1992. Task reports of fisheries studies on the Mokelumne River 1990-1992. (Appendix A of the Lower Mokelumne River Management Plan). Report to East Bay Municipal Utility District, Oakland, California. BioSystems Analysis, Inc., Tiburon, California.

Bilski, R., J. Shillam, C. Hunter, M. Saldate, and E. Rible. 2013. Emigration of Juvenile Chinook Salmon (*Oncorhynchus tschawytscha*) and Steelhead (*Oncorhynchus mykiss*) in the Lower Mokelumne River, December 2012 through July 2013. East Bay Municipal Utility District, Lodi, California.

Marine, K. 2000. Lower Mokelumne River Fisheries Monitoring Program 1999-2000. Downstream Migration Monitoring at Woodbridge Dam During December 1999 through July 2000. Report to East Bay Municipal Utility District, Oakland, California. Natural Resource Scientists, Inc.

Merz, J.E., J.D. Setka, G.B. Pasternack, and J.M. Wheaton. 2004. Predicting benefits of spawning-habitat rehabilitation to salmonid (*Oncorhynchus* spp.) fry production in a regulated California river. Canadian Journal of Fisheries and Aquatic Sciences 61:1433-1446.

Moyle, P.B. and J.A. Israel. 2005. Untested assumptions: effectiveness of screening diversions for conservation of fish populations. Fisheries 30(5):20-28.

Mussen, T.D., D. Cocherell, Z. Hockett, A. Ercan, H. Bandeh, M. L. Kavvas, J.J. Cech, and N.A. Fangue. 2013. Assessing Juvenile Chinook Salmon Behavior and Entrainment Risk near Unscreened Water Diversions: Large Fume Simulations, Transactions of the American Fisheries Society, 142:1, 130-142, DOI: 10.1080/00028487.2012.720633.

Piper, R.G., I.B. McElwain, L.E. Orme, J.P. McCraren, L.G. Fowler, J.R. Leonard. 1992. Fish Hatchery Management. USDI. Fish and Wildlife Service. Washington D.C.

Setka, J. 2004. Summary of fall-run chinook salmon and steelhead trout spawning in the lower Mokelumne River, CA 1996-2003. East Bay Municipal Utility District, Orinda, California.

Schroder, S.L., C. M. Knudsen, T. N. Pearsons, T. W. Kassler, S. F. Young, C. A. Busack, D. E. Fast. 2008. Breeding Success of Wild and First-Generation Hatchery Female Spring Chinook Salmon Spawning in an Artificial Stream, Transactions of the American Fisheries Society 137: 1475-1489.

USFWS. 2008. DRAFT CVPIA Comprehensive Assessment and Monitoring Program (CAMP). Rotary Screw Trap Protocol for Estimating Production of Juvenile Chinook Salmon. US Fish and Wildlife Service, Sacramento, California.

Volkhardt, G.C., S.L. Johnson, B.A. Miller, T.E. Nickelson, and D.E. Seiler. 2007. Rotary Screw Traps and Inclined Plane Screen Traps. Pages 235-266, *In* Salmonid Field Protocols Handbook: Techniques for Assessing Status and Trends in Salmon and Trout Populations. American Fisheries Society, Bethesda, Maryland.

Vogel, D. 1993. Model for predicting Chinook fry emergence from gravel. Natural Resource Scientists, Inc., Red Bluff, California.

Workman, M. L., C. E. Hunter, M. S. Saldate and J. L. Shillam. 2007. Downstream Fish Migration Monitoring at Woodbridge Irrigation District Dam Lower Mokelumne River, December 2006 through July 2007. East Bay Municipal Utility District, Lodi, California.

Table 1. Summary of trap efficiency tests conducted at trapping locations on the lower Mokelumne River during the 2016/201 trapping season. Abbreviations are as follows: MOKH = Mokelumne River Fish Hatchery, LMR = lower Mokelumne River.

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 abundanc estimate?
1	9-Jan-17	4309	MOKH	31	984	6	**0.6%**	No
2	17-Jan-17	4232	MOKH	35	1004	12	**1.2%**	Yes
3	23-Jan-17	4746	MOKH	35	1018	12	**1.2%**	Yes
4	6-Feb-17	3890	MOKH	37	1017	8	**0.8%**	Yes
5	14-Feb-17	4714	MOKH	42	1016	1	**0.1%**	Yes
6	27-Feb-17	4726	MOKH	38	1018	4	**0.4%**	Yes
7	13-Mar-17	4681	MOKH	39	1018	1	**0.1%**	Yes
8	3-Apr-17	4655	MOKH	48	1048	2	**0.2%**	Yes
9	17-Apr-17	3866	MOKH	68	1500	13	**0.9%**	Yes
10	2-May-17	3786	MOKH	73	1515	7	**0.5%**	Yes
11	15-May-17	3778	MOKH	79	1502	6	**0.4%**	Yes
12	30-May-17	3354	MOKH	88	1508	14	**0.9%**	Yes
13	12-Jun-17	1055	MOKH	91	692	1	**0.1%**	No

Table 2. Expanded monthly catch, juvenile abundance estimates. , and percent passage for Chinook salmon captured at the downstream trapping location on the lower Mokelumne River during the 2016/2017 trapping season. 95% confidence interval (LCI and UCI) is calculated for the season total.

Upstream (VINO FARMS)			
Time Frame	Estimated Catch	Abundance Estimate	Percent Passage (%)
12/13-1/4	124	**NA**	NA
Trap pulled			

Downstream (GOLF)			
Time Frame	Estimated Catch	Abundance Estimate	Percent Passage (%)
1/10-1/23	11	**902**	0.3%
1/24-2/6	82	**6388**	2.0%
2/7-2/14	57	**6410**	2.0%
2/15-2/27	116	**58986**	18.1%
2/28-3/13	216	**44021**	13.5%
3/14-4/3	72	**36548**	11.2%
4/4-4/17	29	**14948**	4.6%
4/18-5/2	71	**7569**	2.3%
5/3-5/15	214	**40458**	12.4%
5/16-5/30	357	**76725**	23.5%
5/31-7/7	333	**33500**	10.3%
Total	**1,557**	**326,455**	**100%**
		95% CI (217,992-434,918)	

Table 3. Generalized linear models for juvenile Chinook salmon abundance at the downstream trapping location based on environmental variables on the lower Mokelumne River during the 2016/17 juvenile outmigration monitoring season.

Downstream (GOLF)

Model 1						
AICc	df	*P*	Independent Variable(s)	df	X^2	*P*
166.735	1, 116	**0.0109**				
			Turbidity	1	6.476906	**0.0109**

Model 2						
AICc	df	*P*	Independent Variable(s)	df	X^2	*P*
167.285	2, 115	**0.0374**				
			Turbidity	1	4.079897	**0.0434**
			Flow (Golf)	1	0.153659	0.6951

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 Installation (MRFI). 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	--	--	--	--	Normal & Above
				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

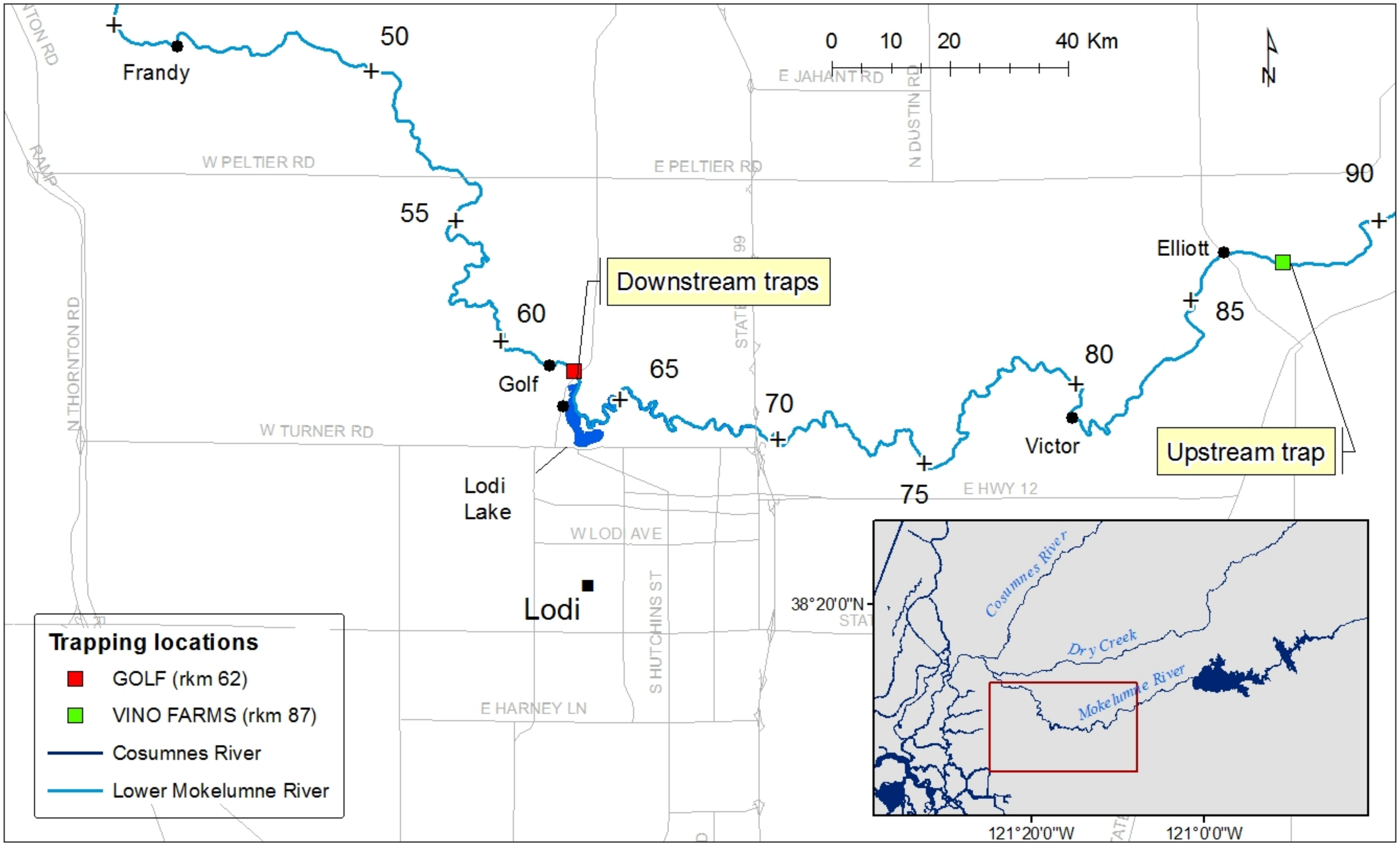

Figure 1. Trapping sites used for juvenile emigration monitoring on the lower Mokelumne River during the 2016/17 season.

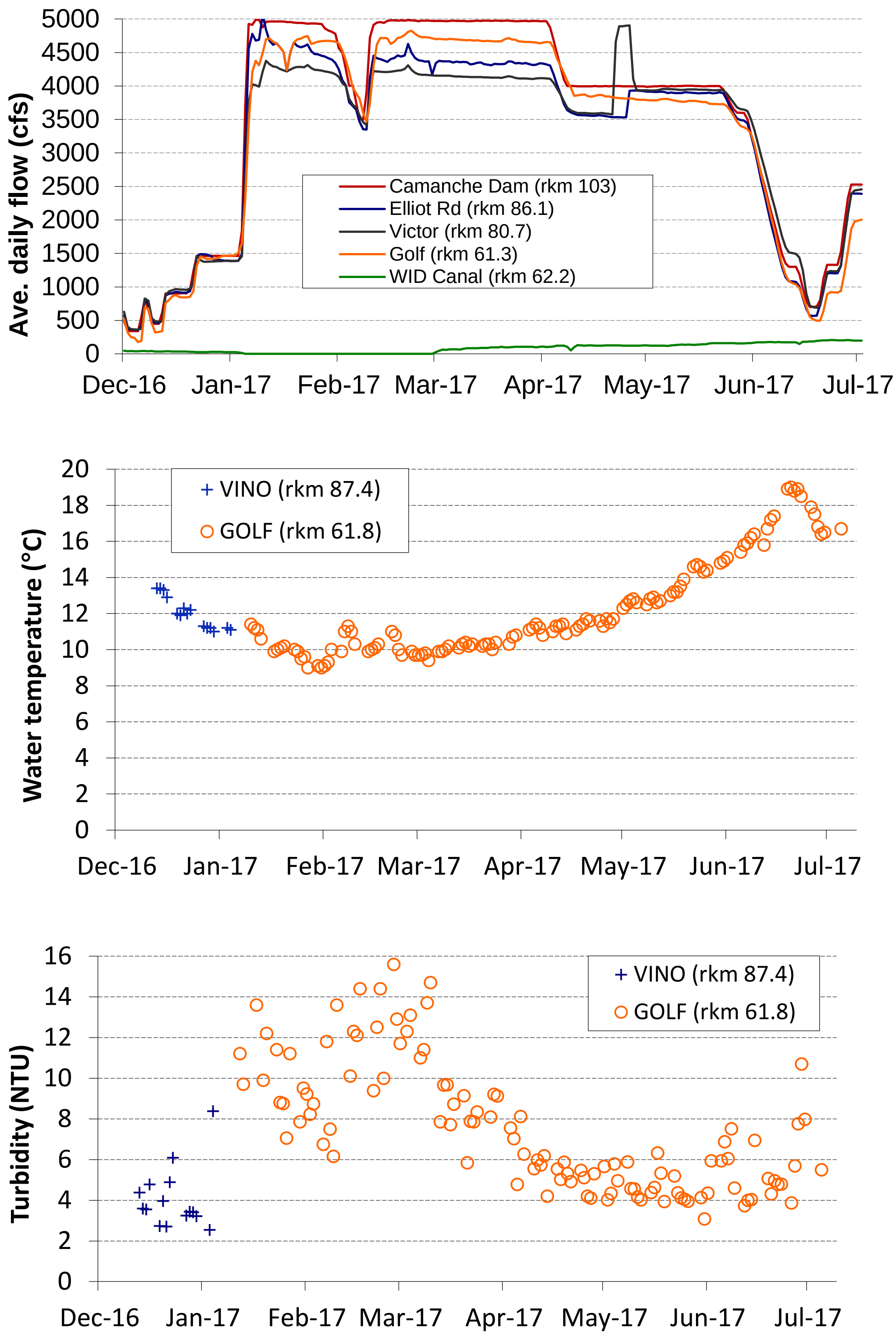

Figure 2. Average daily flow, water temperature, and turbidity on the lower Mokelumne River between Camanche Dam (rkm 103) and Golf (rkm 61.3) during the 2016/17 juvenile emigration monitoring season.

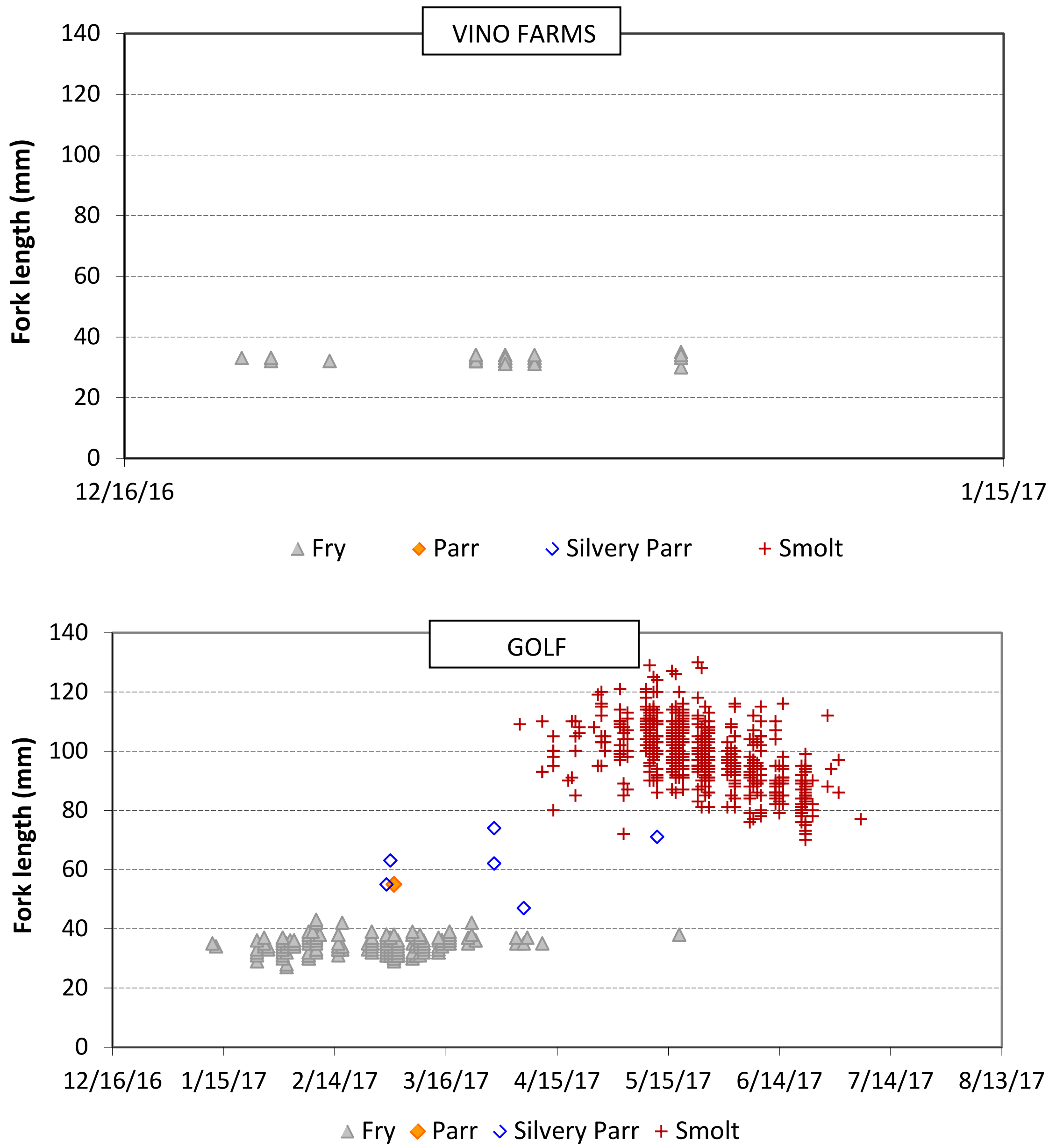

Figure 3. Size distribution by life stage of measured wild juvenile Chinook salmon at the upstream (VINO FARMS) and downstream (GOLF) trapping locations during the 2016/17 juvenile emigration season on the lower Mokelumne River.

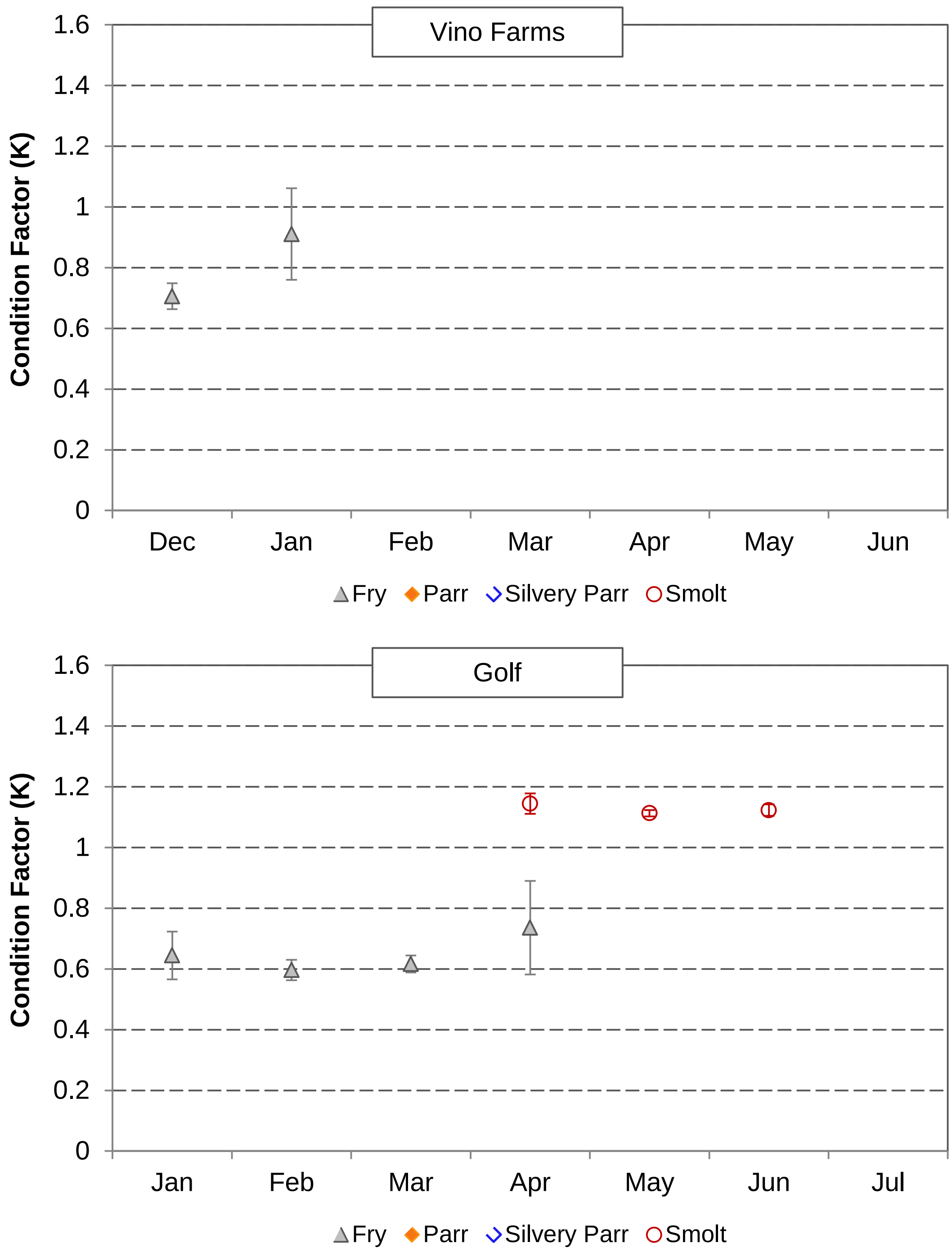

Figure 4. Monthly average condition factor ± 2 SE (vertical lines) of measured wild juvenile Chinook salmon at the upstream (VINO FARMS) and downstream (GOLF & BYPASS) trapping locations during the 2016/17 juvenile emigration monitoring season on the lower Mokelumne River.

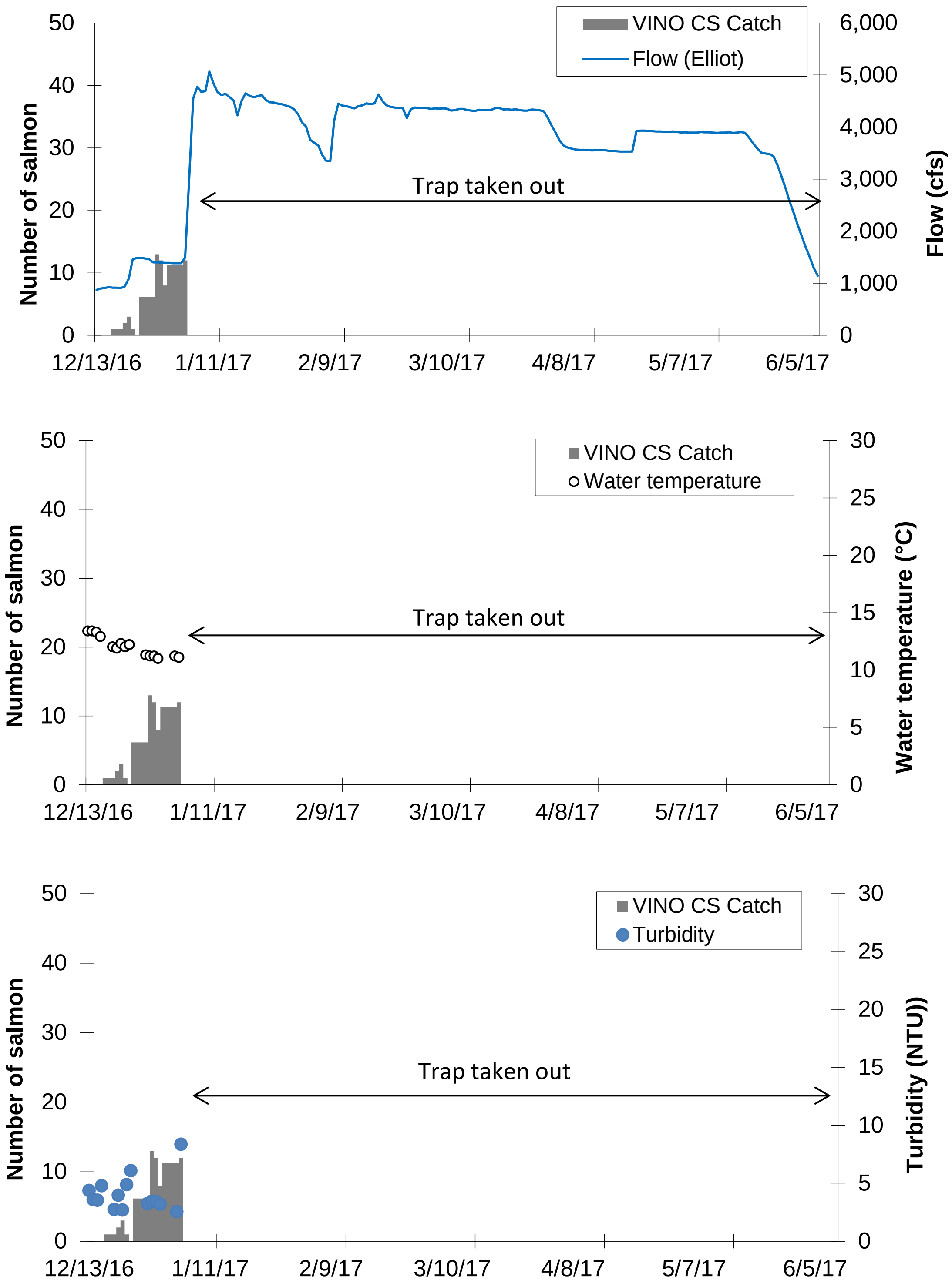

Figure 5. The relationships between estimated daily Chinook salmon catch and flow (top), water temperature (middle), and turbidity (bottom) at the VINO RST (upstream trapping location) during the 2016/17 juvenile emigration monitoring season.

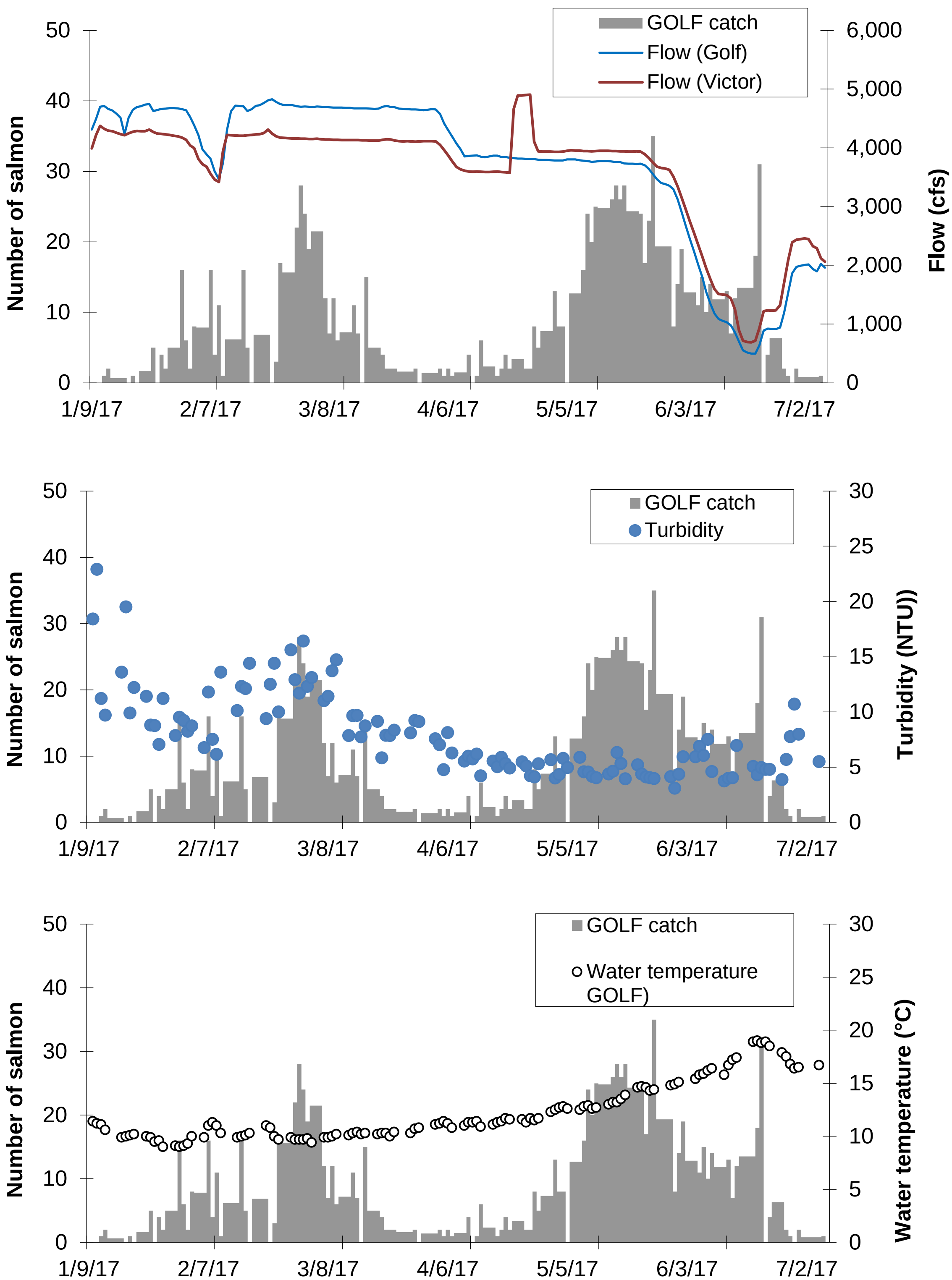

Figure 6. The relationships between estimated daily Chinook salmon catch and flow (top), water temperature (middle), and turbidity (bottom) at the downstream trapping location (GOLF) during the 2016/17 juvenile emigration monitoring season.

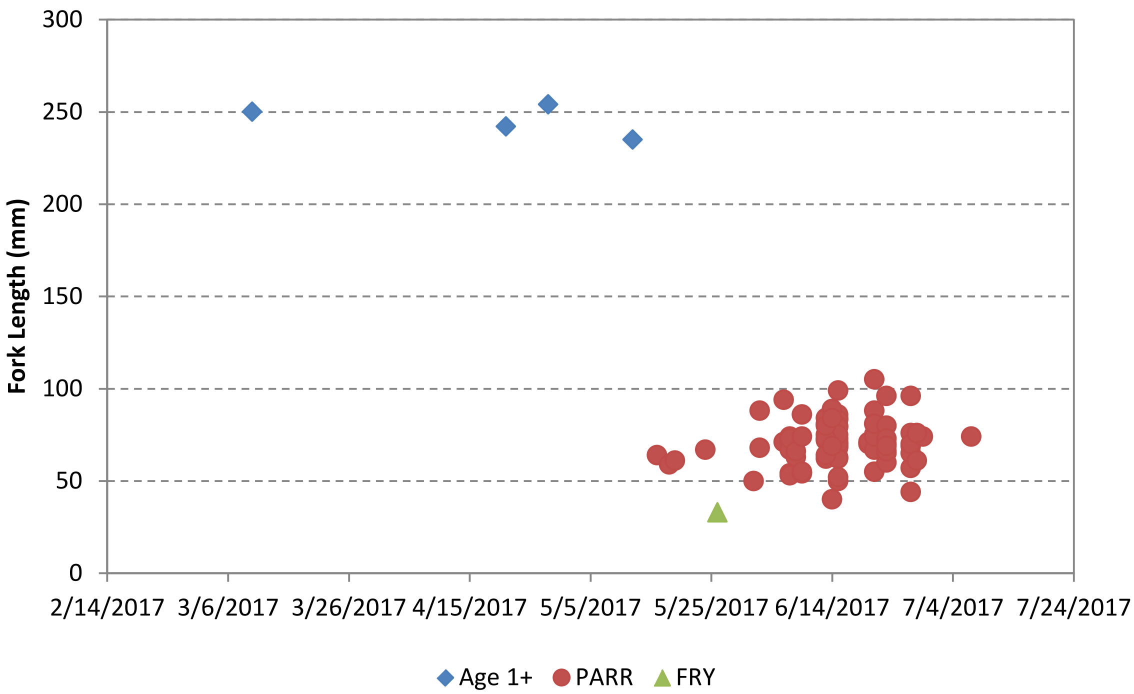

Figure 7. Size and life stage distribution of measured wild steelhead at the downstream GOLF trapping location during the 2016/17 juvenile emigration monitoring season on the lower Mokelumne River. Two age 1+ adults were also captured and released without length measurements.

Appendix A. Daily trap catch, period trap efficiency, abundance estimates, and 95% confidence intervals (CI) of juvenile Chinook salmon at the downstream trap (GOLF) on the lower Mokelumne River during the 2016/17 monitoring period. Shaded areas represent non-trapping days with trap stoppages where catch was estimated.

Date	GOLF CS catch (u)	Marked (M)	Recaptured (m)	Salmon Abundance (U)	SD
1/9/2017	set				
1/10/2017	0	1,004	**12**		
1/11/2017	0	1,004	**12**		
1/12/2017	1	1,004	**12**		
1/13/2017	2	1,004	**12**		
1/14/2017	1	1,004	**12**		
1/15/2017	1	1,004	**12**		
1/16/2017	1	1,004	**12**		
1/17/2017	1	1,004	**12**		
1/18/2017	0	1,004	**12**		
1/19/2017	1	1,004	**12**		
1/20/2017	0	1,004	**12**		
1/21/2017	2	1,004	**12**		
1/22/2017	2	1,004	**12**		
1/23/2017	2	1,004	**12**		
Period Summary	**12**	**1,004**	**12**	**902**	
1/24/2017	5	1,018	12		
1/25/2017	0	1,018	12		
1/26/2017	4	1,018	12		
1/27/2017	2	1,018	12		
1/28/2017	5	1,018	12		
1/29/2017	5	1,018	12		
1/30/2017	5	1,018	12		
1/31/2017	16	1,018	12		
2/1/2017	6	1,018	12		
2/2/2017	2	1,018	12		
2/3/2017	8	1,018	12		
2/4/2017	8	1,018	12		
2/5/2017	8	1,018	12		
2/6/2017	8	1,018	12		
Period Summary	**82**	**1,018**	**12**	**6,388**	
2/7/2017	16	1,017	8		
2/8/2017	4	1,017	8		
2/9/2017	11	1,017	8		
2/10/2017	1	1,017	8		
2/11/2017	6	1,017	8		
2/12/2017	6	1,017	8		
2/13/2017	6	1,017	8		
2/14/2017	6	1,017	8		
Period Summary	**57**	**1,017**	**8**	**6,410**	
2/15/2017	16	1,016	**1**		
2/16/2017	5	1,016	**1**		
2/17/2017	0	1,016	**1**		
2/18/2017	7	1,016	**1**		
2/19/2017	7	1,016	**1**		

Appendix A continued

Date	GOLF CS catch (u)	Marked (M)	Recaptured (m)	Salmon Abundance (U)	SD
2/20/2017	7	1,016	**1**		
2/21/2017	7	1,016	**1**		
2/22/2017	0	1,016	**1**		
2/23/2017	3	1,016	**1**		
2/24/2017	17	1,016	**1**		
2/25/2017	16	1,016	**1**		
2/26/2017	16	1,016	**1**		
2/27/2017	16	1,016	**1**		
Period Summary	**116**	**1,016**	**1**	**58,986**	
2/28/2017	22	1,018	**4**		
3/1/2017	28	1,018	**4**		
3/2/2017	24	1,018	**4**		
3/3/2017	19	1,018	**4**		
3/4/2017	22	1,018	**4**		
3/5/2017	22	1,018	**4**		
3/6/2017	22	1,018	**4**		
3/7/2017	12	1,018	**4**		
3/8/2017	7	1,018	**4**		
3/9/2017	12	1,018	**4**		
3/10/2017	6	1,018	**4**		
3/11/2017	7	1,018	**4**		
3/12/2017	7	1,018	**4**		
3/13/2017	7	1,018	**4**		
Period Summary	**216**	**1,018**	**4**	**44,021**	
3/14/2017	11	1,018	**1**		
3/15/2017	7	1,018	**1**		
3/16/2017	0	1,018	**1**		
3/17/2017	15	1,018	**1**		
3/18/2017	5	1,018	**1**		
3/19/2017	5	1,018	**1**		
3/20/2017	5	1,018	**1**		
3/21/2017	4	1,018	**1**		
3/22/2017	2	1,018	**1**		
3/23/2017	2	1,018	**1**		
3/24/2017	2	1,018	**1**		
3/25/2017	2	1,018	**1**		
3/26/2017	2	1,018	**1**		
3/27/2017	2	1,018	**1**		
3/28/2017	2	1,018	**1**		
3/29/2017	2	1,018	**1**		
3/30/2017	0	1,018	**1**		
3/31/2017	1	1,018	**1**		
4/1/2017	1	1,018	**1**		
4/2/2017	1	1,018	**1**		
4/3/2017	1	1,018	**1**		
Period Summary	**72**	**1,018**	**1**	**36,548**	

Appendix A continued

Date	GOLF CS catch (u)	Marked (M)	Recaptured (m)	Salmon Abundance (U)	SD
4/4/2017	2	1,048	**1**		
4/5/2017	1	1,048	**1**		
4/6/2017	2	1,048	**1**		
4/7/2017	1	1,048	**1**		
4/8/2017	2	1,048	**1**		
4/9/2017	2	1,048	**1**		
4/10/2017	2	1,048	**1**		
4/11/2017	4	1,048	**1**		
4/12/2017	0	1,048	**1**		
4/13/2017	1	1,048	**1**		
4/14/2017	6	1,048	**1**		
4/15/2017	2	1,048	**1**		
4/16/2017	2	1,048	**1**		
4/17/2017	2	1,048	**1**		
Period Summary	**29**	**1,048**	**1**	**14,948**	
4/18/2017	1	1,500	13		
4/19/2017	2	1,500	13		
4/20/2017	4	1,500	13		
4/21/2017	2	1,500	13		
4/22/2017	3	1,500	13		
4/23/2017	3	1,500	13		
4/24/2017	3	1,500	13		
4/25/2017	2	1,500	13		
4/26/2017	2	1,500	13		
4/27/2017	8	1,500	13		
4/28/2017	5	1,500	13		
4/29/2017	7	1,500	13		
4/30/2017	7	1,500	13		
5/1/2017	7	1,500	13		
5/2/2017	13	1,500	13		
Period Summary	**71**	**1,500**	**13**	**7,569**	
5/3/2017	8	1,515	7		
5/4/2017	8	1,515	7		
5/5/2017	0	1,515	7		
5/6/2017	13	1,515	7		
5/7/2017	13	1,515	7		
5/8/2017	13	1,515	7		
5/9/2017	16	1,515	7		
5/10/2017	24	1,515	7		
5/11/2017	20	1,515	7		
5/12/2017	25	1,515	7		
5/13/2017	25	1,515	7		
5/14/2017	25	1,515	7		
5/15/2017	25	1,515	7		
Period Summary	**214**	**1,515**	**7**	**40,458**	

Appendix A continued					
Date	GOLF CS catch (u)	Marked (M)	Recaptured (m)	Salmon Abundance (U)	SD
5/16/2017	26	1,502	**6**		
5/17/2017	28	1,502	**6**		
5/18/2017	26	1,502	**6**		
5/19/2017	28	1,502	**6**		
5/20/2017	24	1,502	**6**		
5/21/2017	24	1,502	**6**		
5/22/2017	24	1,502	**6**		
5/23/2017	24	1,502	**6**		
5/24/2017	17	1,502	**6**		
5/25/2017	23	1,502	**6**		
5/26/2017	35	1,502	**6**		
5/27/2017	19	1,502	**6**		
5/28/2017	19	1,502	**6**		
5/29/2017	19	1,502	**6**		
5/30/2017	19	1,502	**6**		
Period Summary	**357**	**1,502**	**6**	**76,725**	
5/31/2017	8	1,508	14		
6/1/2017	14	1,508	14		
6/2/2017	19	1,508	14		
6/3/2017	13	1,508	14		
6/4/2017	13	1,508	14		
6/5/2017	13	1,508	14		
6/6/2017	11	1,508	14		
6/7/2017	15	1,508	14		
6/8/2017	10	1,508	14		
6/9/2017	14	1,508	14		
6/10/2017	12	1,508	14		
6/11/2017	12	1,508	14		
6/12/2017	12	1,508	14		
6/13/2017	13	1,508	14		
6/14/2017	7	1,508	14		
6/15/2017	12	1,508	14		
6/16/2017	14	1,508	14		
6/17/2017	14	1,508	14		
6/18/2017	14	1,508	14		
6/19/2017	14	1,508	14		
6/20/2017	18	1,508	14		
6/21/2017	31	1,508	14		
6/22/2017	0	1,508	14		
6/23/2017	4	1,508	14		
6/24/2017	6	1,508	14		
6/25/2017	6	1,508	14		
6/26/2017	6	1,508	14		
6/27/2017	2	1,508	14		
6/28/2017	1	1,508	14		
6/29/2017	0	1,508	14		

Appendix A continued

Date	GOLF CS catch (u)	Marked (M)	Recaptured (m)	Salmon Abundance (U)	SD
6/30/2017	2	1,508	14		
7/1/2017	1	1,508	14		
7/2/2017	1	1,508	14		
7/3/2017	1	1,508	14		
7/4/2017	1	1,508	14		
7/5/2017	1	1,508	14		
7/6/2017	1	1,508	14		
7/7/2017	0	1,508	14		
Period Summary	**333**	**1,508**	**14**	**33,500**	
Annual Totals	**1,557**			**326,455**	**55,338**
				(95% CI 217,992 - 434,918)	

Appendix B. Monthly totals of species caught at the upstream RST (VINO) on the lower Mokelumne river during the 2016/17 juvenile outmigration monitoring season.

Common Name	**Genus**	**Species**	**Dec.**	**Jan.**	**Feb.**	**Mar.**	**Apr.**	**May**	**June**	**July**	**Total**
black crappie	*Pomoxis*	*nigromaculatus*	2		0	0	0	0	0	0	**2**
channel catfish	*Ictalurus*	*punctatus*	1		0	0	0	0	0	0	**1**
Chinook salmon (no ad-clip)	*Oncorhyhchus*	*tshawytscha*	39	12	0	0	0	0	0	0	**51**
Pacific lamprey	*Lampetra*	*tridentata*	212	4	0	0	0	0	0	0	**216**
prickly sculpin	*Cottus*	*asper*	2		0	0	0	0	0	0	**2**
redear sunfish	*Lepomis*	*microlophus*	1		0	0	0	0	0	0	**1**
threadfin shad	*Dorosoma*	*petenense*	3		0	0	0	0	0	0	**3**
tule perch	*Hysterocarpus*	*traski*	1	1	0	0	0	0	0	0	**2**
white catfish	*Ameiurus*	*catus*	1								**1**
western mosquitofish	*Gambusia*	*affinis*	6		0	0	0	0	0	0	**6**

Appendix C. Monthly totals of fish species caught at the downstream RST (GOLF) on the lower Mokelumne river during the 2016/17 juvenile outmigration monitoring season.

Common Name	**Genus**	**Species**	**Jan.**	**Feb.**	**Mar.**	**Apr.**	**May**	**June**	**July**	**Total**
black bass	*Micropterus*	*spp.*	20	14	0	0	110	2,019	10	**2,173**
black crappie	*Pomoxis*	*nigromaculatus*	37	6	2	1	18	36	2	**102**
bluegill	*Lepomis*	*macrochirus*	48	24	5	17	30	48	2	**174**
brown bullhead	*Ameiurus*	*nebulosus*	0	1	0	0	1	2	0	**4**
channel catfish	*Ictalurus*	*punctatus*	0	0	0	2	6	0	0	**8**
Chinook salmon (ad-clip)	*Oncorhyhchus*	*tshawytscha*	0	0	0	0	0	6	0	**6**
Chinook salmon (no ad-clip)	*Oncorhyhchus*	*tshawytscha*	61	121	156	58	356	175	1	**928**
common carp	*Cyprinus*	*carpio*	0	0	0	53	388	1,186	3	**1,630**
golden shiner	*Notemigonus*	*crysoleucas*	140	1	1	2	2	115	3	**264**
goldfish	*Carassius*	*auratus*	1	1	0	0	2	0	0	**4**
green sunfish	*Lepomis*	*cyanellus*	0	0	0	0	1	0	0	**1**
hitch	*Lavinia*	*exilicauda*	0	0	0	0	0	1	0	**1**
kokanee	*Oncorhynchus*	*nerka kennerlyi*	0	0	0	0	1	0	0	**1**
largemouth bass	*Micropterus*	*salmoides*	12	3	1	1	1	0	0	**18**
lepomis hybrid	*Lepomis*	*spp.*	6	2	0	0	2	2	0	**12**
Pacific lamprey	*Entosphenus*	*tridentatus*	0	1	0	0	1	4	0	**6**
prickly sculpin	*Cottus*	*asper*	2	0	1	577	5,522	8,031	101	**14,234**
redear sunfish	*Lepomis*	*microlophus*	11	2	1	5	11	4	0	**34**
redeye bass	*Micropterus*	*coosae*	0	0	0	0	1	0	0	**1**
Sacramento pikeminnow	*Ptychocheilus*	*grandis*	0	0	2	0	0	1	0	**3**
Sacramento sucker	*Catostomus*	*occidentalis*	0	0	1	0	2	5	0	**8**
spotted bass	*Micropterus*	*punctulatus*	13	3	0	0	0	0	0	**16**
steelhead (no ad-clip)	*Oncorhynchus*	*mykiss*	0	2	1	2	7	90	1	**103**
striped Bass	*Morone*	*saxatilis*	0	0	0	0	1	1	0	**2**
threadfin shad	*Dorosoma*	*petenense*	17	13	5	2	0	0	0	**37**
tule perch	*Hysterocarpus*	*traski*	0	0	0	2	4	14	0	**20**
warmouth	*Lepomis*	*gulosus*	2	0	0	0	1	1	0	**4**
white catfish	*Ameiurus*	*catus*	0	0	0	4	12	40	3	**59**
western mosquitofish	*Gambusia*	*affinis*	41	22	12	4	1	3	0	**83**