Pacific States Marine Fisheries Commission

*in partnership with the*

State of California
Department of Fish and Wildlife

California Coastal Salmonid Monitoring Program Annual Report prepared in partial fulfillment of CDFW Fisheries Restoration Grant Program
Grantee Agreement Number: P1510507

# Results of regional spawning ground surveys and estimates of total salmonid redd construction in the South Fork Eel River, Humboldt County California, 2016.

Prepared by:

Brian Starks[1], Sharon Powers[1], Scott Monday[2]

April 4, 2017

[1] Pacific States Marine Fisheries Commission
[2] Corresponding author. California Department of Fish and Wildlife, Scott.Monday@wildlife.ca.gov

## ABSTRACT

During year seven of the South Fork Eel River Adult Salmonid Redd Abundance Monitoring Project, 227 spawning ground surveys were conducted over 40 spatially balanced, randomly selected reaches in the South Fork Eel River Watershed from November 3, 2016 to March 9, 2017. Each reach was surveyed an average of 5.6 times, and the average interval between surveys over all reaches was 19.7 days. During the 2016-2017 survey season, crews observed 102 live coho salmon, 360 live Chinook salmon, 8 live steelhead, and 36 unidentified salmonids. Crews encountered 6 coho salmon carcasses, 102 Chinook salmon carcasses, 1 steelhead carcass, and 9 unidentified salmonid carcasses. A total of 320 redds were detected, of which 86 redds were observed to be associated with a specific salmonid species while in the field. The remaining 234 redds were assigned a species using a k-Nearest Neighbors algorithm. The number of redds observed in sample reaches was expanded to estimate the number of redds constructed across the entire South Fork Eel River sample frame. Redd abundance estimates for the 2016-2017 spawning season in the South Fork Eel River, including 95% confidence intervals, were 465 (98,831) coho salmon redds, 1,458 (923,1,992) Chinook salmon redds, and 54 (9,111) steelhead redds.

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# 1 INTRODUCTION

## 1.1 BACKGROUND

Coho salmon (*Oncorhynchus kisutch*) in the Southern Oregon/Northern California Coast (SONCC) Evolutionarily Significant Unit (ESU) were listed as threatened under the federal Endangered Species Act in 1997 (62 FR 24588); and their listing was reaffirmed in 2005 (70 FR 37160). The SONNC coho salmon ESU was also listed as threatened under the California Endangered Species Act in 2002 (CDFG 2002). Both the California Department of Fish and Wildlife (CDFW) and the National Marine Fisheries Service (NMFS) have developed recovery plans for coho salmon outlining recovery goals, prioritizing recovery actions, and offering criteria that must be met in order to delist the species (CDFW 2004, NMFS 2014). Long-term population monitoring is an essential component of these recovery plans, as metrics are needed to assess recovery actions and track the species' progress towards recovery.

The 2011 CDFW "*Fish Bulletin 180 California Coastal Salmonid Monitoring Plan*" (CMP) established the approach for monitoring ESA/CESA listed anadromous salmonid population(s) status and trend in California. In the CMP's Northern California area, adult salmonid population abundance will be monitored using extensive spawning ground surveys to estimate total redd escapement within a survey area/sample frame. Each year spawning ground surveys are conducted on a random and spatially balanced sample of survey reaches, drawn from a survey frame encompassing all potential spawning habitat available to anadromous salmonid specie(s) within the designated study area. Georeferenced live salmonids, salmonid carcasses, and redd observation data are collected in each reach. The number of redds per salmonid species identified by observation and data analysis within the sample reaches is then be expanded to estimate total redd escapement for the entire sample frame (Adams et al. 2011).

## 1.2 STUDY AREA

The South Fork Eel River flows through Humboldt and Mendocino counties and is a significant tributary within California's third largest watershed (see Figure 1). The South Fork Eel River's confluence with the Eel River is located approximately three miles north of the town of Weott, CA and approximately 40 river miles upstream from the Eel River's confluence with the Pacific Ocean, near the town of Loleta, CA. The South Fork Eel River Basin is the second largest sub-basin in the Eel River Watershed and covers approximately 690 square miles, 19% of the Eel River Basin. The South Fork Eel River is approximately 100 miles long and the basin contains a total of 683 miles of perennial blue line streams according to the USGS 7.5 Minute U.S. Geological Survey (USGS) Quadrangle maps (CDFW 2014). The predominant land uses throughout the basin are timber harvest, livestock grazing, and dispersed rural development. In 1998, the South Fork Eel River was listed as an impaired water body by the federal

Environmental Protection Agency due to high levels of sedimentation and high water temperature (CDFW 2014).

Historically, the South Fork Eel River was the most productive major tributary of the Eel River Basin for anadromous salmonids, supporting runs of coho salmon, Chinook salmon (*O. tshawytscha*), and steelhead/rainbow trout (*O. mykiss*). In 1947, a high of 25,289 returning adult coho salmon were counted at the Benbow Dam (Taylor, 1978). However, Pacific salmon runs in the South Fork Eel River have markedly declined since the mid-twentieth century. In 1994, a status review of South Fork Eel River coho salmon estimated the returning population at approximately 1,320 adults (Brown et al. 1994).

South Fork Eel River coho salmon are considered a core population under the federal SONCC Coho Recovery Plan and as such constitute an important demographic for long-term SONCC coho salmon ESU monitoring needs (NMFS 2014). The South Fork Eel River Adult Salmonid Redd Abundance Monitoring Project was initiated by the Pacific States Marine Fisheries Commission (PSMFC), in partnership with CDFW, in 2010 as a long-term effort to provide estimates of adult coho salmon redd abundance in the South Fork Eel River Watershed. This report presents the results of the 2016-2017 spawning survey season, the seventh year of the project. Previous annual reports for years 2010 through 2015 are available in the CDFW Document Library: https://nrm.dfg.ca.gov/documents/.


Figure 1**.** Map of the South Fork Eel River Watershed and its location within the Eel River Watershed.

# 2 METHODS

## 2.1 SAMPLE FRAME

A sample frame was established for the South Fork Eel River using five parameters: (1) documented salmonid distributions, (2) stream gradient and stream size where salmonid distributions are unknown, (3) fish passage barrier data, (4) expert knowledge of salmonid distribution and migration barriers, and (5) field reconnaissance (Garwood and Ricker 2011). These data were compiled within a Geographic Information System (GIS) to develop species-specific (coho, Chinook and steelhead) spawning distributions (sample frames).

As the focus of this project is adult coho salmon, streams within the identified coho-specific sample frame were segmented into one to three kilometer reaches, with start and end points at identifiable landmarks (e.g. tributaries) and upstream extents at barriers to anadromy, both known and model-derived. All reaches were assigned a numeric identification, known as the location code, starting at the lower-most reach and moving upstream from north to south (Figures 2-4). Reaches that are less than one kilometer long (sub-reaches) are surveyed together with the main reach that they flow into. All data collected in these sub-reaches are combined with that of their associated main reach (Garwood and Ricker 2011).

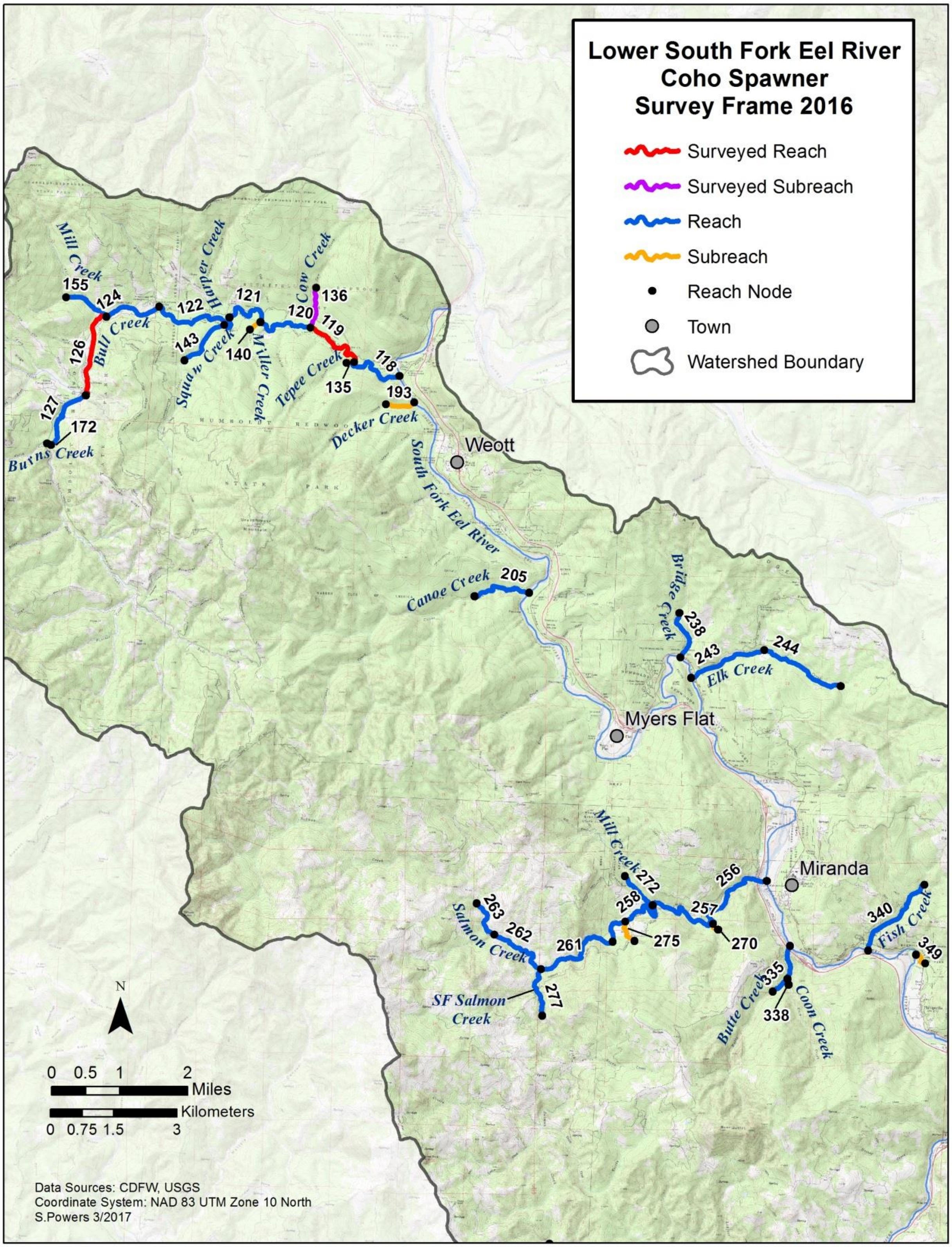


Figure 2**.** Map of the lower South Fork Eel River coho-specific spawner survey frame. Reaches surveyed during the 2016-2017 spawner survey season are red; associated subreaches are purple. Unsurveyed sample frame reaches are blue; associated sub-reaches are yellow. Each reach is labelled with its numeric location code.

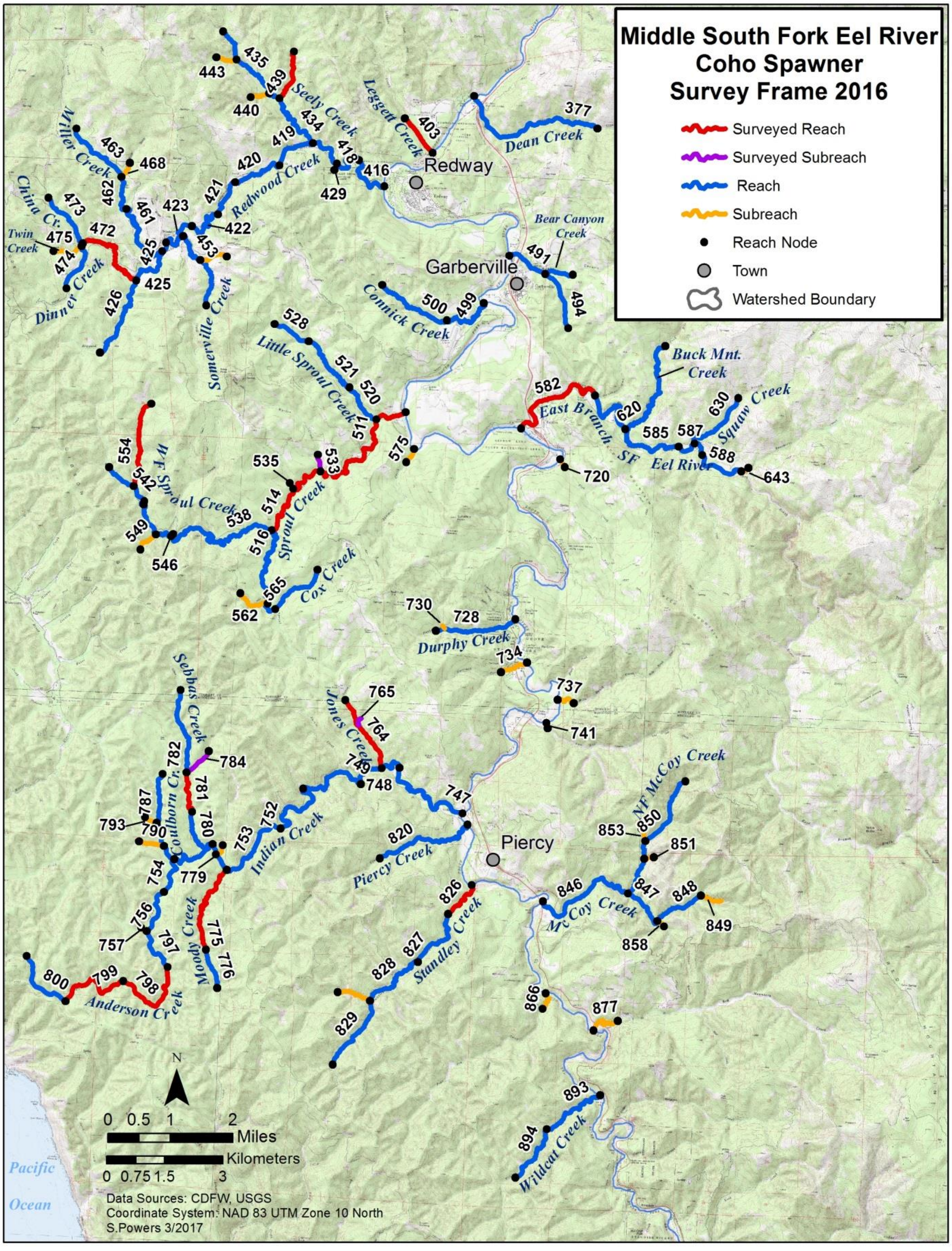


Figure 3**.** Map of the middle South Fork Eel River coho-specific spawner survey frame. Reaches surveyed during the 2016-2017 spawner survey season are red; associated subreaches are purple. Unsurveyed sample frame reaches are blue; associated sub-reaches are yellow. Each reach is labelled with its numeric location code.

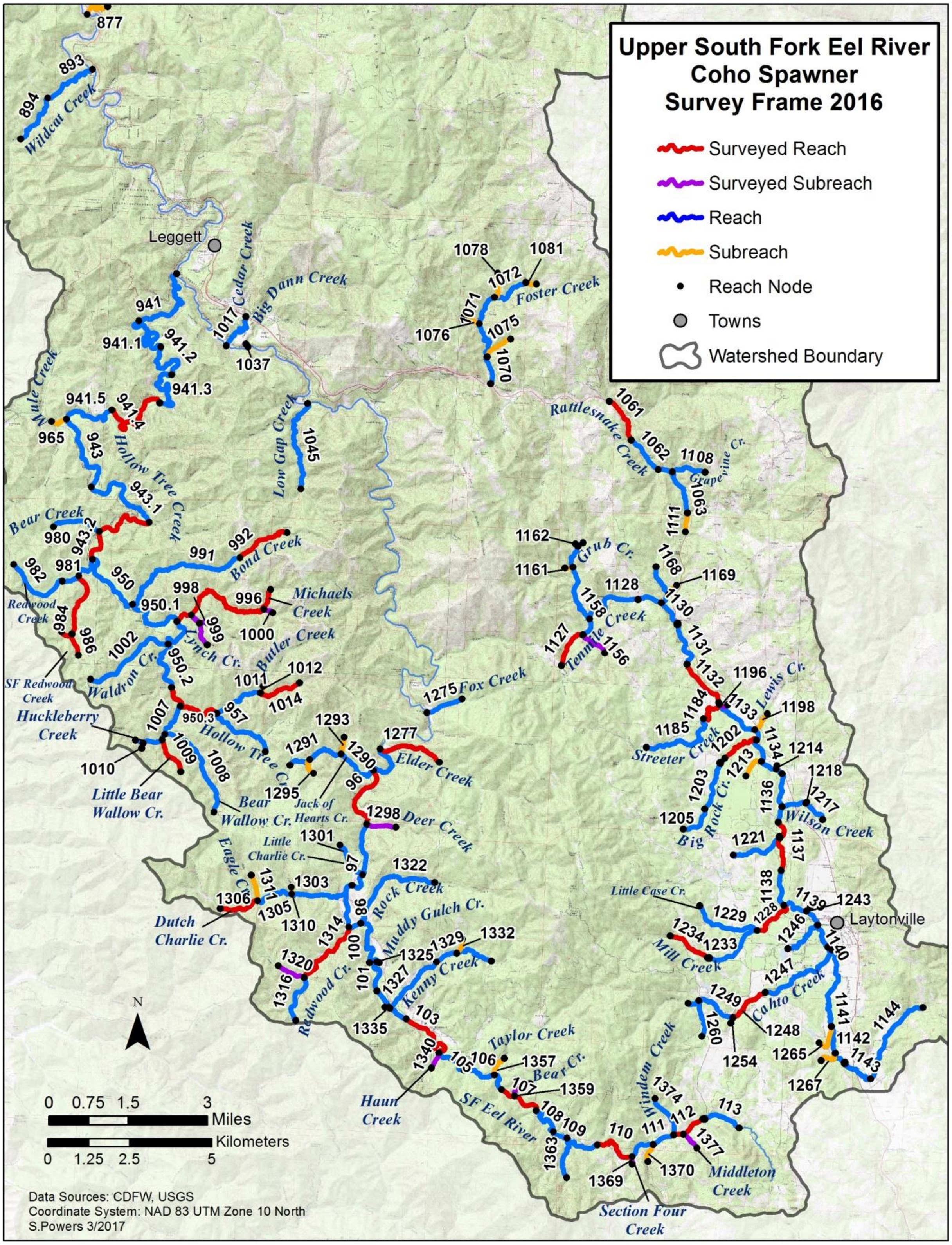


Figure 4. Map of the upper South Fork Eel River coho-specific spawner survey frame. Reaches surveyed during the 2016-2017 spawner survey season are red; associated subreaches are purple. Unsurveyed sample frame reaches are blue; associated sub-reaches are yellow. Each reach is labelled with its numeric location code.

## 2.2 SAMPLE REACH SELECTION

Spawning ground surveys were conducted periodically on a spatially balanced, random sample of 40 stream reaches drawn from the coho-specific sample frame of 204 potential reaches (Table 1). A General Randomized Tessellation Stratified (GRTS) routine (McDonald 2003) was used to create a randomized reordering of the survey frame from which the 40 reaches were drawn. Since much of the South Fork Eel River is under private ownership, a reach's inclusion on the list of 40 sample reaches is dependent on gaining stream access permission from the relevant landowners. If permission was denied or if a landowner did not respond in time for the start of the spawning season, the reach was skipped for the year and the next stream in order was added to the survey list.

## 2.3 REACH SURVEY PROTOCOL

Spawning ground surveys were conducted following the methods of ground survey and data capture outlined in Gallagher et al. 2014 and Adams et al. 2011. The surveys were conducted during the coho salmon and Chinook salmon spawning season (roughly mid-November to late February/early March during an average rainfall year) by a two person team, either by foot in smaller streams, or by inflatable kayak in larger streams. Each reach is intended to be surveyed once every 7 to 14 days, or as weather, flow, and turbidity conditions allow.

Live fish and carcasses were identified to species and sex if possible and X-Y coordinates are acquired with a handheld Global Positioning System (GPS) unit. Carcasses were assigned a condition code ranging from 1 to 5 based on freshness, measured to fork length if possible, and marked as "captured" with a uniquely numbered jaw tag. If a carcass was recovered with a jaw tag on a subsequent survey it was considered "re-captured".

Redds were attributed a species if an identifiable fish was observed actively digging or guarding the redd. If no fish was observed on the redd, its species was left as unidentified. The location of all newly observed redds was geo-referenced by acquiring X-Y coordinates with a GPS unit and marked with flagging labelled with that redd's unique record number. All new redds encountered were assigned an age of (1) new since last survey. On subsequent surveys, encountered flags were matched with their associated redds, which were then re-assigned a new age of (2) still visible and measurable, (3) visible, but not measurable, (4) not visible, or (5) unknown due to poor visibility. If a new redd was unattended or an old redd was not previously measured, physical measurements were taken, including length and width of pot and tailspill, substrate size of pot and tailspill, and depth of the pot relative to the surrounding substrate.

## 2.4 ESTIMATION OF TOTAL REDD ABUNDANCE WITHIN SURVEY FRAME

The redd data collected over the course of the spawning season was expanded to estimate total coho salmon redd abundance over the entire survey frame using the steps outlined in Ricker et al.

2014. To estimate total redd abundance, (1) all redds were assigned a species, (2) within-reach redd abundance was estimated, and (3) within-reach redd abundance was expanded to estimate total redd abundance across the entire survey frame.

### 2.4.1 ASSIGNING SPECIES TO REDDS

Only redds directly associated with a live fish building or guarding them were considered unambiguously known to species. In order to assign a species to the redds labelled in the field as "unidentified species," a k-Nearest Neighbor (kNN) model was used to predict which species (coho, Chinook, or steelhead) was most likely to have constructed the redd (Ricker et al. 2013). Both known species redds and live fish observations were used as known elements in the training set of data in the kNN model. The standardized z-scores of X and Y coordinates and julian date of observation were used as feature attributes and each redd was classified by the majority vote of the three nearest neighbors (known redds and live fish) in Euclidean distance. Leave-one-out-cross-validation (LOOCV) of the known redds in the survey was then used to evaluate the performance of the kNN model. All calculations were performed using the program R with the "class" package (Venables and Ripley 2002) and the "caret" package (Kuhn 2013). Only known species fish and redds from the current survey year were chosen for use in the training data available to make predictions.

### 2.4.2 ESTIMATION OF WITHIN-REACH ABUNDANCE

High stream discharge and time between repeated surveys may scour or flatten redds and therefore obscure them from potential counting (Jones, 2012). To account for the unseen fraction of redds deposited then subsequently obscured from view between repeated surveys, the total number of redds constructed within a survey reach was estimated using a flag-based mark-recapture model. The total count of individually observed and flagged redds for a given reach is divided by the square root of the seasonally pooled redd survival rate. Redd survival is calculated as the fraction of re-observed and still identifiable flagged redds ("recaptures" assigned age 2 or 3) to the total number of flagged redds available to for potential re-observation ("marked"). Taking the square root of this fraction assumes the deposition of redds occurs at the midpoint between survey intervals (see below) (Schwarz et al. 1993). Bootstrap resampling from an assumed binomial distribution was used to represent the uncertainty of the pooled seasonal redd survival term in the estimator of total number of redds within the reach. The variance of the estimated total number of redds within a reach is calculated as the variance of the resultant bootstrap distribution (Manly 1997, Ricker et al. 2014). Additional assumptions applied to this model are as follows:

1. Surveyors correctly identify all redds and no redds are missed during each survey.
2. Once a redd has been classified as "not visible" it does not become visible at a later occasion.
3. All redd flags are re-observed, identifiable, and recorded.

4. All marked redds have the same probability of survival, regardless of species or age and across all occasions.
5. New redds are constructed at the mid-point between survey intervals

### 2.4.3 ESTIMATION OF TOTAL REDD ABUNDANCE

A Simple Random Sample estimator is used to expand the number of redds in the sample reaches to an estimated total over the entire sample frame. The estimated total is calculated as the product of the total number of reaches in the sample frame and the mean number of redds of the sample reaches. The total variance is the sum of the within reach variance of the sample reaches and the between sample reach variance (Adams et al. 2011).

Table 1. Survey frequency by reach. Reaches are listed by stream name and location code (location codes listed in parentheses are subreaches). Mean indicates the average number of days between surveys, Max is the maximum number of days between surveys, and N is the total number of surveys.

| Location Code | Stream Name | Mean (Days) | Max (Days) | N (Surveys) |
|---|---|---|---|---|
| 96(1298) | South Fork Eel River | 37.50 | 62 | 3 |
| 103(1340) | South Fork Eel River | 25.00 | 33 | 4 |
| 107(1359) | South Fork Eel River | 14.83 | 21 | 7 |
| 110(1369) | South Fork Eel River | 15.00 | 21 | 7 |
| 112(1377) | South Fork Eel River | 14.67 | 18 | 7 |
| 119(136) | Bull Creek | 13.50 | 19 | 3 |
| 126 | Bull Creek | 27.00 | 27 | 2 |
| 403 | Leggett Creek | 27.75 | 64 | 5 |
| 439 | Unnamed Tributary to Seely Creek | 28.25 | 45 | 5 |
| 472 | China Creek | 13.75 | 18 | 9 |
| 511 | Sproul Creek | 20.75 | 38 | 5 |
| 514(533,535) | Sproul Creek | 17.40 | 38 | 6 |
| 554 | Unnamed Trib to WF Sproul Creek | 13.83 | 25 | 7 |
| 582 | East Branch South Fork Eel River | 15.00 | 23 | 3 |
| 764(765) | Jones Creek | 27.00 | 33 | 5 |
| 775 | Moody Creek | 16.00 | 33 | 7 |
| 781(784) | Sebbas Creek | 19.20 | 28 | 6 |
| 798 | Anderson Creek | 16.50 | 23 | 7 |
| 799 | Anderson Creek | 16.17 | 22 | 7 |
| 826 | Standley Creek | 26.75 | 35 | 5 |
| 941.4 | Hollow Tree Creek | 34.50 | 55 | 3 |
| 943.2 | Hollow Tree Creek | 34.33 | 69 | 4 |
| 950.3 | Hollow Tree Creek | 14.29 | 36 | 8 |
| 984(986) | South Fork Redwood Creek | 12.25 | 29 | 9 |
| 992 | Bond Creek | 10.50 | 14 | 7 |
| 996(998,999,1000) | Michaels Creek | 18.60 | 27 | 6 |
| 1009 | Little Bear Wallow Creek | 13.20 | 17 | 6 |
| 1014 | Unnamed Tributary to Butler Creek | 13.60 | 16 | 6 |
| 1061 | Rattlesnake Creek | 24.67 | 41 | 4 |
| 1127(1156) | Tenmile Creek | 24.33 | 33 | 4 |
| 1132(1196) | Tenmile Creek | 25.33 | 33 | 4 |
| 1137 | Tenmile Creek | 24.67 | 33 | 4 |
| 1184 | Streeter Creek | 17.00 | 26 | 7 |
| 1202 | Big Rock Creek | 22.50 | 41 | 5 |
| 1228 | Little Case Creek | 17.60 | 27 | 6 |
| 1234 | Mill Creek | 15.00 | 26 | 6 |
| 1248(1254) | Cahto Creek | 15.00 | 20 | 7 |
| 1277 | Elder Creek | 17.50 | 22 | 3 |
| 1306 | Dutch Charlie Creek | 14.13 | 25 | 9 |
| 1314(1320) | Redwood Creek | 12.50 | 17 | 9 |
| | All Reaches | 19.68 | 30.83 | 5.68 |

# 3 RESULTS

## 3.1 SAMPLE FRAME CHANGES AND STATUS

Field reconnaissance of the South Fork Eel River sampling frame is now considered complete and appropriate updates transferred to the state-wide CMP Geo database in Sacramento and the luLocation table of the CMP Aquatic Survey's Survey Management Switchboard. Sample frame updates included changes to reach lengths, start stop locations, and total number of reaches. Reach additions resulted from the splitting of reaches on Hollow Tree Creek (Location Codes 943 and 950) into multiple shorter reaches that better fit field protocols and reach length criteria for the CMP. Primary main reaches in the South Fork Eel headwaters region above Dutch Charlie Creek were removed from the sample frame for the 2011-12 survey season then added back in for the 2012 and future years after physical access for survey crews was deemed available and reasonable using boating survey methods. The lower most reach in Rattlesnake Creek above the canyon (Location Code 1060) was removed in 2011 due to inaccessibility and surveyor safety concerns. There were additional instances of shortening reaches at the terminus at the upstream extents of distribution. Smaller sub-reaches were added and or subtracted, but the manipulation of sub-reaches did not change the total number of main reaches in the sample frame. In 2015, the South Fork Eel River coho salmon sampling frame was considered finalized and remains static for the continuation of the project into future years. The finalized coho salmon sample frame consists of 204 main survey reaches (Figures 2, 3, and 4). Given this progress, the adoption of a fixed, rotating panel revisit design will be proposed to the CMP Science Team Sample Frame group for adoption and implementation.

## 3.2 SURVEY STATISTICS

Survey crews conducted a total of 227 spawning ground surveys from November 3, 2016 to March 9, 2017 over the 40 randomly selected stream reaches within the South Fork Eel River Watershed. Each reach was visited between 2 and 9 times over the survey season (average number of visits per reach was 5.6). The average interval between surveys over all reaches was 19.7 days (Table 1). Figure 5 presents the stream discharge measured at the South Fork Eel River USGS gauging station near Miranda, CA relative to the number of surveys completed per day over the survey season.

## 3.3 FISH OBSERVATIONS

A total of 102 coho salmon, 360 Chinook salmon, 8 steelhead, and 36 unidentified fish were observed over the survey period. Six coho salmon carcasses, 102 Chinook salmon carcasses, 1 steelhead carcass, and 9 unidentified carcasses were counted. Peak coho observations occurred from the week beginning December 19, 2016 to the week beginning January 16, 2017. Peak Chinook salmon observations occurred from the week beginning November 14, 2016 to the week beginning December 19, 2016 (Figure 6). Table 2 summarizes live fish observations by location code. Table 3 summarizes observations of live fish and carcasses by survey week.

In addition to coho salmon, Chinook salmon, and steelhead, one Pacific lamprey (*Lampetra tridentata*) carcass was observed in Tenmile Creek, location code 1137, on November 29, 2016.

## 3.4 REDD OBSERVATIONS

Surveyors identified 14 known coho salmon redds, 69 known Chinook salmon redds, and 1 known steelhead redd (Tables 2 and 3, Figure 6). Cross validation of the 86 known redds resulted in the kNN model correctly assigning 83 known redds to the respective species. Two hundred thirty-three redds were not field identified to species and kNN predictions of the species most likely to have constructed them were made.

## 3.5 TOTAL REDD ABUNDANCE

Sufficient flag marking and re-observation data was available to apply the within-reach estimation model in eight sample reaches where known or predicted coho salmon redds were observed. Aggregate counts of individual known and predicted redds by species were used in the remaining 32 reaches where no reach level expansion was available. The total redd abundance estimate for coho salmon for the 2016-2017 South Fork Eel River spawning season, with 95% confidence intervals, is 465 (98, 831). The total redd abundance estimates for Chinook salmon and steelhead are 1,458 (923, 1,992) and 54 (9, 111), respectively (Table 4).

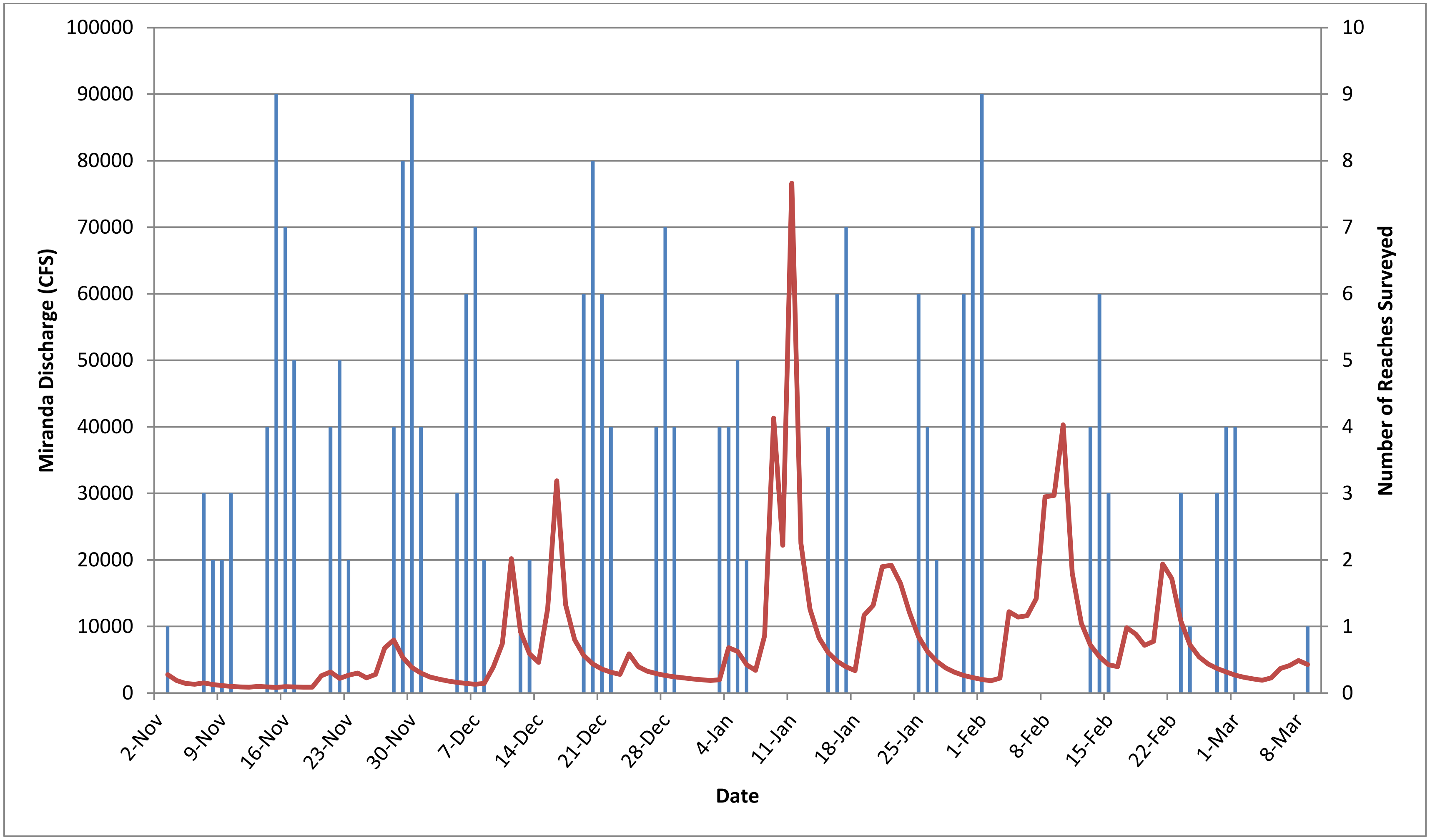


Figure 5. Discharge of the South Fork Eel River near Miranda compared to number of surveys conducted each day over the survey period November 3rd, 2016 to March 9th, 2017. Discharge (in cubic feet per second, cfs) as recorded at midnight on each day is presented on the primary y-axis (red line); the number of reaches surveyed per day is presented on the secondary y-axis (blue lines).

Table 2. Counts of observed live fish and redds by location code.

| Location Code | Live Chinook | Known Chinook Redds | Live Coho | Known Coho Redds | Live Steelhead | Known Steelhead Redds | Live Unidentified | Unidentified Redds |
|---|---|---|---|---|---|---|---|---|
| 96 | 6 | 1 | 0 | 0 | 0 | 0 | 1 | 2 |
| 103 | 8 | 5 | 0 | 0 | 0 | 0 | 0 | 9 |
| 107 | 21 | 7 | 2 | 0 | 0 | 0 | 0 | 2 |
| 110 | 37 | 6 | 0 | 0 | 2 | 1 | 0 | 19 |
| 112 | 7 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| 119 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 3 |
| 126 | 7 | 2 | 0 | 0 | 0 | 0 | 0 | 2 |
| 403 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 439 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 472 | 35 | 11 | 2 | 0 | 1 | 0 | 1 | 20 |
| 511 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 7 |
| 514 | 24 | 3 | 0 | 0 | 0 | 0 | 0 | 8 |
| 554 | 5 | 1 | 12 | 3 | 0 | 0 | 2 | 4 |
| 582 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 |
| 764 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 775 | 0 | 0 | 3 | 0 | 0 | 0 | 2 | 2 |
| 781 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 |
| 798 | 49 | 4 | 27 | 4 | 2 | 0 | 8 | 36 |
| 799 | 0 | 0 | 20 | 2 | 0 | 0 | 2 | 15 |
| 826 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 2 |
| 941.4 | 6 | 0 | 0 | 0 | 0 | 0 | 0 | 5 |
| 943.2 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 11 |
| 950.3 | 6 | 2 | 0 | 0 | 0 | 0 | 2 | 14 |
| 984 | 0 | 0 | 5 | 1 | 3 | 0 | 0 | 6 |
| 992 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 996 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 4 |
| 1009 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 1014 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 1061 | 10 | 3 | 0 | 0 | 0 | 0 | 0 | 1 |
| 1127 | 2 | 1 | 0 | 0 | 0 | 0 | 2 | 1 |
| 1132 | 3 | 2 | 2 | 1 | 0 | 0 | 1 | 3 |
| 1137 | 22 | 3 | 0 | 0 | 0 | 0 | 0 | 7 |
| 1184 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 1202 | 24 | 6 | 0 | 0 | 0 | 0 | 0 | 5 |
| 1228 | 30 | 4 | 0 | 0 | 0 | 0 | 0 | 16 |
| 1234 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 1248 | 48 | 8 | 0 | 0 | 0 | 0 | 0 | 4 |
| 1277 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 1306 | 0 | 0 | 3 | 0 | 0 | 0 | 3 | 2 |
| 1314 | 3 | 1 | 26 | 4 | 0 | 0 | 12 | 16 |
| Total | 360 | 70 | 102 | 15 | 8 | 1 | 36 | 231 |

Table 3. Counts of observed live fish, carcasses and redds by week over the survey season, November 3, 2016 to March 9, 2017.

| First Day of Week | Live Chinook | Live Coho | Live Steelhead | Live Unidentified | Chinook carcasses | Coho carcasses | Steelhead carcasses | Unidentified carcasses | Known Chinook Redds | Known Coho Redds | Known Steelhead Redds | Unidentified Redds |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 31-Oct | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 7-Nov | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 3 |
| 14-Nov | 56 | 2 | 0 | 4 | 31 | 0 | 0 | 0 | 15 | 1 | 0 | 30 |
| 21-Nov | 9 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 2 | 0 | 0 | 18 |
| 28-Nov | 226 | 0 | 0 | 9 | 23 | 0 | 0 | 1 | 41 | 0 | 0 | 71 |
| 5-Dec | 30 | 0 | 0 | 0 | 6 | 0 | 0 | 0 | 3 | 0 | 0 | 28 |
| 12-Dec | 5 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 3 |
| 19-Dec | 26 | 16 | 0 | 8 | 19 | 0 | 0 | 2 | 5 | 3 | 0 | 31 |
| 26-Dec | 2 | 1 | 0 | 1 | 14 | 0 | 0 | 0 | 1 | 0 | 0 | 15 |
| 2-Jan | 0 | 38 | 0 | 5 | 1 | 4 | 0 | 0 | 0 | 4 | 0 | 10 |
| 9-Jan | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| 16-Jan | 2 | 44 | 1 | 3 | 2 | 0 | 0 | 0 | 0 | 7 | 1 | 7 |
| 23-Jan | 0 | 1 | 2 | 2 | 1 | 1 | 0 | 1 | 0 | 0 | 0 | 2 |
| 30-Jan | 0 | 0 | 0 | 0 | 4 | 1 | 1 | 2 | 0 | 0 | 0 | 4 |
| 6-Feb | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 13-Feb | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 |
| 20-Feb | 0 | 0 | 5 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 27-Feb | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 6 |
| 6-Mar | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| Total: | 360 | 102 | 8 | 36 | 102 | 6 | 1 | 9 | 70 | 15 | 1 | 231 |

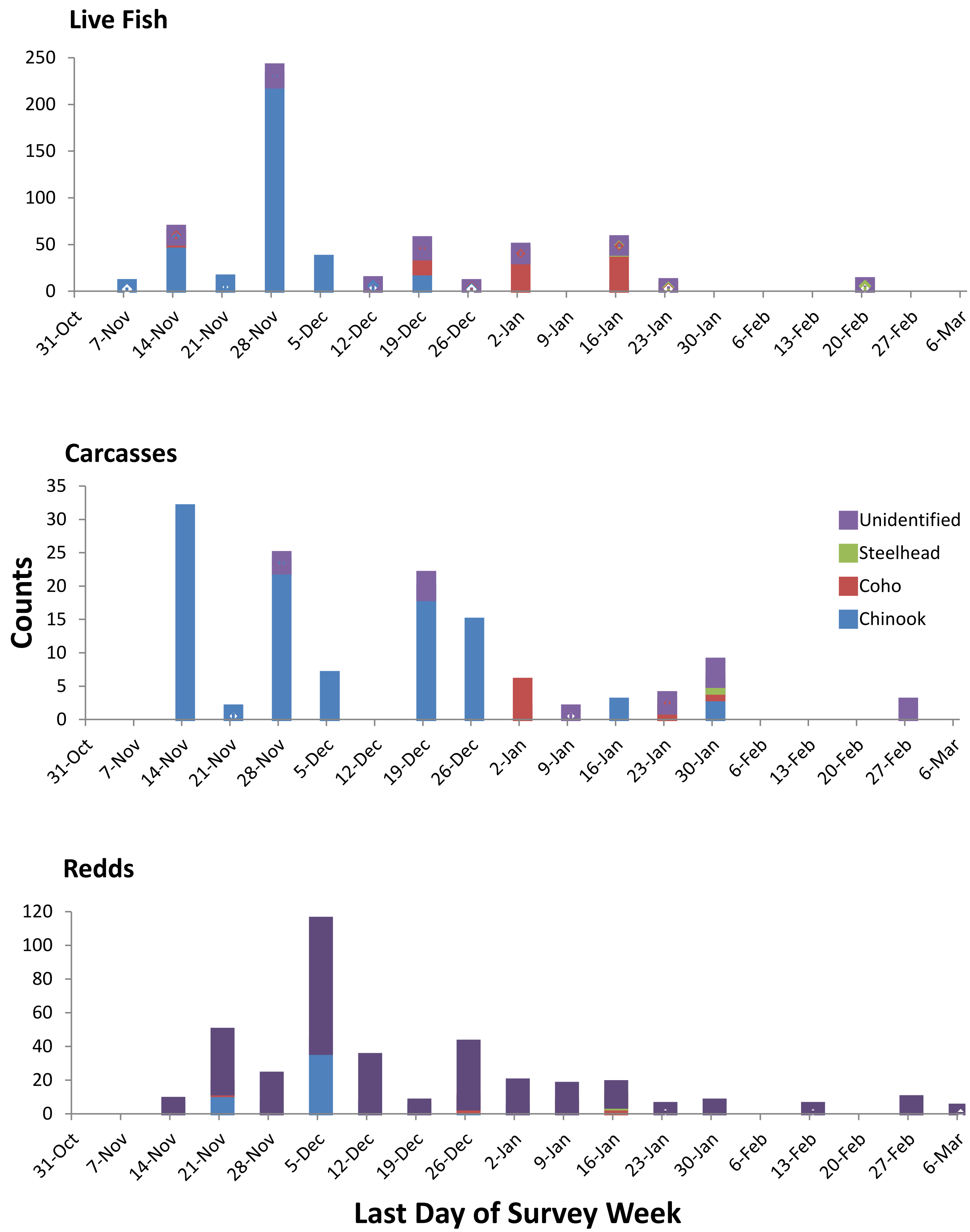


Figure 6. Stacked barplot of observed live fish, carcasses, and redds by week over the survey season, November 3, 2016 to March 9, 2017.

Table 4. Estimated total redd abundance by species with 95% confidence intervals.

| | Chinook | Coho | Steelhead |
|---|---|---|---|
| Estimated number of redds | 1458 | 465 | 54 |
| 95% Confidence Intervals | 923, 1992 | 98, 831 | 9, 111 |

# 4 DISCUSSION

The South Fork Eel River Adult Redd Salmonid Abundance Monitoring Project was initiated in 2010 as a long-term effort to provide estimates of adult coho salmon redd abundance in the South Fork Eel River Watershed over time. As the primary focus of this project is coho salmon, spawning ground surveys are conducted over the spatial extent and time period deemed ideal for coho data capture. Estimates of total redd construction for Chinook salmon and steelhead presented herein are likely underestimates because the spatial extent of Chinook salmon and steelhead spawning habitats are greater than the spatial extent of the coho salmon sampling frame, and because the duration of the steelhead spawning run extends beyond the coho spawning run. The estimates of total redd abundance for Chinook salmon and steelhead presented in this report are representative only of those occurring within the coho-specific sampling frame and within the observation period, November 3, 2016 to March 9, 2017.

The 2016-2017 survey season was characterized by frequent and heavy rainfall. The first significant event came in late October which allowed Chinook salmon to reach the upper parts of the South Fork Eel River Watershed much earlier than normal. After the early run of Chinook salmon, there was a strong second run of Chinook salmon, peaking the week of November 28 when 226 live Chinook salmon were observed. Survey coverage during most of the Chinook salmon season was excellent, with only a short gap in mid-December due to a minor rain event. In January there was a large flood event that prevented crews from surveying the week of January 9, while a subsequent event prevented surveys from January 18 to January 24. A third large rain event prevented crews from surveying February 2 to February 14. These rain events occurred during the peak of the coho season, which likely resulted in many missed field observations. In addition to preventing surveys due to high flows and turbidity, the heavy and consistent rain during January and February damaged many of the main roads that are used to access the sample reaches. For example, Highway 1, which is used to access the Hollow Tree Creek and Indian Creek watersheds, was closed February 3 through the end of the survey season due to a landslide. This impacted the ability to adequately survey all sample reaches for the last month of the survey season.

The South Fork Eel River is a large and complex system. As such, survey intervals and the number of visits per reach are more influenced by the unique discharge and turbidity characteristics of the individual reaches than by conditions basin wide. For example, Hollow

Tree Creek and Indian Creek have low turbidity rates during storm events and tend to present a flashy behavior with quick rise and fall of stream flows, making it easier to conduct surveys within three to five days after a significant rain event. Bull Creek and East Branch South Fork Eel River are very high turbidity streams and can take weeks before conditions are clear enough to survey. Consequently, some reaches within the sample frame will be more heavily sampled during a season. Each reach was visited between two and nine times over the survey season (the average number of visits per reach was 6), and the maximum number of days between visits ranged from 10 to 37 (the average survey interval was 20). Three reaches, two on Bull Creek and one on East Branch South Fork Eel River, were surveyed in early December and were never revisited due to high turbidity.

Due to significant gaps in the survey that occurred due to weather and flow, the South Fork Eel River 2016-2017 redd abundance estimate is likely an underestimate of actual coho redd abundance for this spawning year. Frequent and significant flow events prevented repeat survey recapture of previously observed redds throughout the sampled reaches due to redds becoming obscured between surveys. The lack of redd recapture and live fish observations reduced within-reach redd abundance estimates. Monitoring during the peak of Chinook salmon and steelhead spawning was less hampered by persistent high flow and turbidity and allowed for regular surveys, fish and redd observation, and redd recapture.

Data obtained from operation of a salmonid life cycle monitoring station (LCM) in a sub-basin of the South Fork Eel River would provide a ratio of redd abundance to adult salmonid spawning escapement within the South Fork Eel River Watershed. Until a South Fork Eel River LCM derived, or other appropriate index of annual redd/adult ratio is available, redd estimates developed from South Fork Eel River surveys 2010-2011, 2011-2012, 2012-2013, 2013-2014, 2014-2015, 2015-2016, and 2016-2017 should be evaluated together with the achieved annual survey frequency and flow conditions that occurred in those years. Table 5 summarizes survey statistics and redd estimates for the last seven years of the project.

Table 5. Summary of the prior seven years of South Fork Eel River Coho Population Monitoring Project redd estimates and 95% confidence intervals. *The estimated number of salmonids redds for survey years 2010-2011 through 2014-2015 were adjusted in the 2015-2016 annual report following new data analysis techniques. The estimates presented in this table are the most current and should be used for future analysis.

| Survey Year | Number of reaches surveyed | Total Number of Surveys | Average Survey Interval | Average number of surveys per reach | Estimated number of coho redds | Estimated number of Chinook redds | Estimated number of steelhead redds |
|---|---|---|---|---|---|---|---|
| 2010-2011* | 31 | 151 | 21 | 5 | 1284 (159, 2543) | 1829 (679, 2980) | 288 (35, 255) |
| 2011-2012* | 40 | 204 | 22 | 5 | 1873 (1253, 2493) | 68 (15, 148) | 379 (58, 818) |
| 2012-2013* | 40 | 229 | 16 | 6 | 1340 (658, 2022) | 855 (293, 1418) | 761 (471, 1051) |
| 2013-2014* | 39 | 247 | 27 | 6 | 939 (304, 1574) | 223 (40, 423) | 1055 (359, 1751) |
| 2014-2015* | 40 | 248 | 19 | 6 | 2069 (1342, 2795) | 781 (310, 1253) | 967 (541, 1393) |
| 2015-2016 | 40 | 190 | 26 | 5 | 416 (117, 715) | 418 (76, 892) | 1125 (686, 1563) |
| 2016-2017 | 40 | 227 | 20 | 6 | 465 (98, 831) | 1458 (923, 1992) | 54 (9, 111) |

# 5 ACKNOWLEDGEMENTS

Funding for the 2016-2017 PSMFC South Fork Eel River Adult Salmonid Redd Abundance Monitoring Project was provided by the CDFW Fisheries Restoration Grant Program: Grantee Agreement Number P1510507.

We would like to thank our project partners: the California Department of Fish and Wildlife and the California Conservation Corps AmeriCorps Watershed Stewards Program. Additional thanks to Allan Renger and David Kajtaniak (CDFW) for report editing. Thank you to the project field technicians: Ryan Bernstein, Kaydee Boozel, Angela Cruz, Josh Gruver, Jon Guczek, Sylvia Gwozdz, Maddelyn Harden, Jason Held, Maddie Hicks, Rachel Karlov, Dave Lam, Isaac Mikus, Scott Monday, Chad Moura, Matt Rice, Kori Roberts, Brian Starks, and Sydney Stewart.

This project was possible thanks to the many willing landowners who granted the project team their land and stream access permission throughout the South Fork Eel River Watershed.

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