Final Report: Mattole River 2016-2017 Adult Salmon and Steelhead Abundance Monitoring

A pair of adult steelhead on a redd in Baker Creek reach #951, Mattole River watershed.

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Introduction

The 2016-17 spawner survey season was the fifth consecutive year the Mattole Salmon Group (MSG) conducted spawning ground surveys in the Mattole River watershed using in full the California Coastal Salmonid Monitoring Program (CMP) protocols (Adams et al. 2011). Spawning ground surveys with varying levels of survey effort have been conducted in the Mattole since 1981, using other protocols. The goal of the project was to collect data on fall-run Chinook Salmon *(Oncorhynchus tshawytscha),* Coho Salmon (*O. kisutch*), and Steelhead (*O. mykiss*) adult fish and redds, in order to determine population abundance estimates in order to support population and ESU-level evaluation of species viability.

This report describes survey setup, field methods, and data analysis, and presents results from the 2016-17 spawning season, as well as a summary of results from 2012-2017 and discussion of species abundance and distribution.

Methods

Sample Frame and Reach Selection

Potential survey reaches are all reaches in the watershed attributed as Chinook and/or coho spawning reaches, based on maximum stream gradient and mean estimated discharge as outlined in Garwood and Ricker (2008), modified based on local biologists' knowledge of fish use (Figure 1). The Mattole survey frame has been refined since its' initial creation in 2008 based on ground-truthing of reaches and increased access permission from private landowners. In 2016 the frame contained 72 main reaches, intended to cover all reaches in the watershed with potential Chinook or coho salmon spawning habitat that can be safely surveyed during the winter months. Sixty-two of those reaches were attributed as Chinook and Coho spawning reaches, plus 10 more reaches attributed as potential coho (but not Chinook reaches). All 72 reaches in the frame are considered potential steelhead spawning habitat. (See wa

All reaches within the sample frame were assigned numeric reach ID numbers, beginning with the downstream most reach of the mainstem Mattole, continuing upstream to the end of the mainstem, and then continuing with the downstream-most tributary stream and again continuing to the upstream (southern) portion of the watershed. This numerical ordering of the frame was then used to select a spatially-balanced random sample of survey reaches, via the General Randomized Tessellation Stratified (GRTS) routine (Adams et al. 2011). Survey reaches were chosen from the GRS draw of potential survey reaches in draw order, continuing down the list until the requisite number of sample reaches with landowner access had been achieved. Reaches less than 1 km in length ("tag" reaches or subreaches) are surveyed by implication if the main reach they attach too is in the sample draw.

Field Methods

Surveyors are trained in fish identification techniques and carcass handling using a salmon carcass as well as photos and videos of live fish, redds and carcasses from past survey seasons. For the 2016-17 season, a regional training led by DFW staff prior to the start of surveys focused on the use of the CMP protocol as well as fish identification and field safety. As in past years, on-the-job field training and quality control consisted of experienced surveyors accompanying new participants for multiple surveys until they demonstrate proficiency in protocol and fish identification.

Survey techniques followed Gallagher et al. (2007) and CDFG (2011). Two-person crews walked or boated reaches surveying for redds, live fish, and carcasses. Redd dimensions were measured, redds identified to species if possible, and flagged with a bearing and distance to avoid double counting. Live fish were tallied, identified to species, sexed if possible and length estimated. Carcasses were identified, tallied, sexed if possible, measured, and jaw tagged to ensure no double counting and track movement.

Reaches were surveyed every 7-14 days, weather and flow conditions permitting, throughout the coho and Chinook salmon spawning season. Surveys do not encompass the entirety of the winter-run steelhead spawning season, which would require a much longer survey season (into the month of May), which is currently not possible given available funding and ESU-level priorities.

Data was collected using handheld Personal Digital Assistant (PDA) computer units loaded with DFW's CMP database-compatible software. PDA data forms are programmed with front end data QA/QC filters allowing only appropriate ranges to be entered in numeric fields, drop down menus for categorical fields, and all required fields needed before data entry continuation. Location data was collected with Global Positioning System (GPS) units for all redds, live fish, and carcasses encountered. Following each survey day, or as soon as possible based on logistics, data was downloaded to the CMP database at the MSG office. Data error check routines were performed using validation tools in the CMP database.

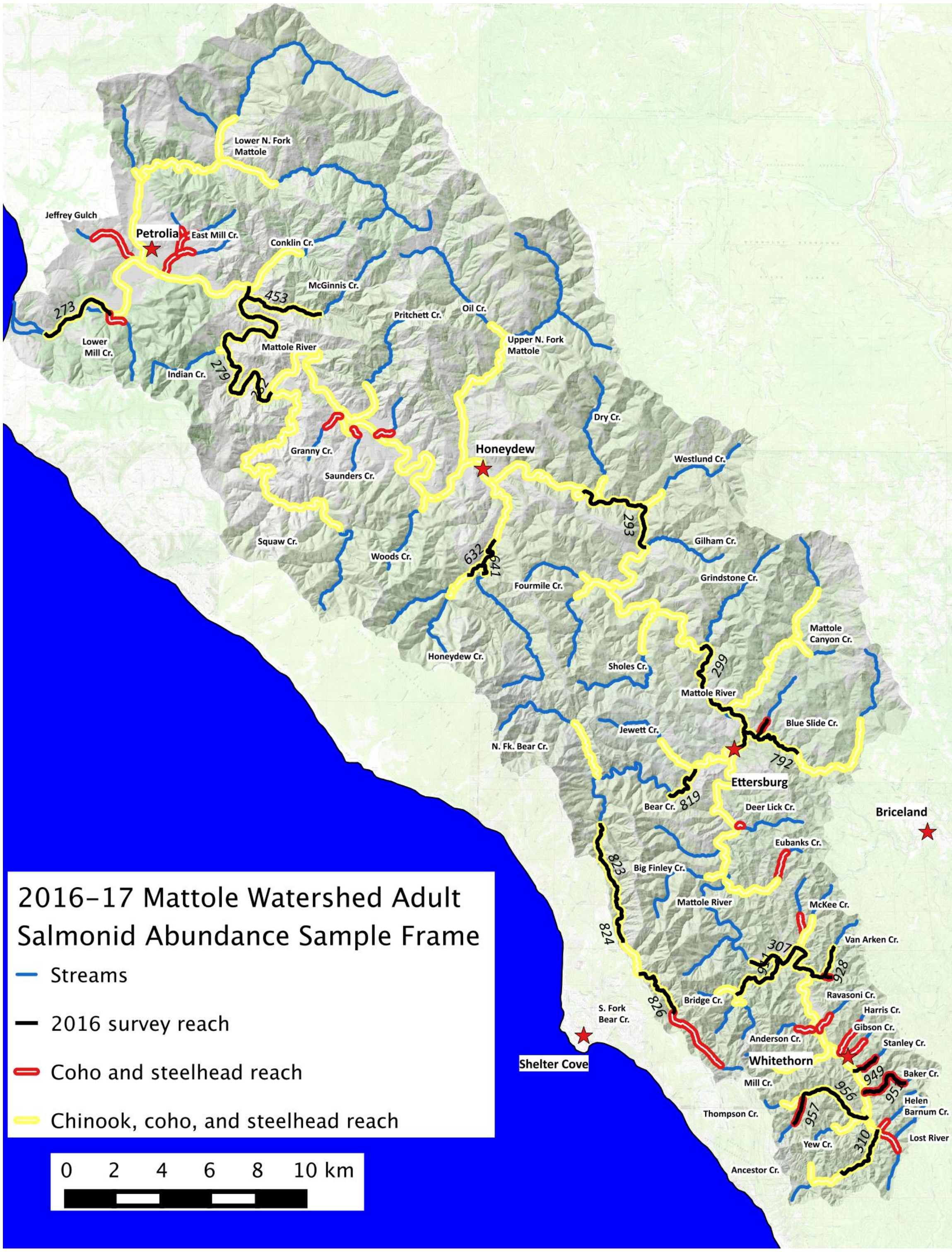


Figure 1. Mattole River spawning ground survey frame and reaches surveyed in 2016-17.

Data Analysis

After the end of the survey season, data was error-checked for common mistakes by sorting each data column to look for outliers or missing values, and plotting all redd, fish, and carcass locations in a GIS program to check for erroneous GPS coordinates. All analysis was done with the statistics program R (R Core Team 2015), according to methods outlined in Adams et al. (2011) and Ricker et al. (2014 & 2015), and using code developed by Ricker and Ferreira (2016). Methods are summarized briefly below, for more detail readers should refer to the aforementioned references. Analysis consists of three primary steps: (1) speciation of unknown redds based on proximity to positively identified live fish, (2) estimation of within reach redd abundance based on a mark-recapture model, and (3) expansions of reach estimates to the entire sample frame.

Speciation of Unknown Redds

To classify redds to species that were not observed with a positively identified fish on the redd, we used the K-nearest neighbor (kNN) algorithim to predict the species most likely to have constructed the redd, based on the proximity of positively identified live fish (using both those on redds and those not associated with redds) to the unknown redd in both space and time (Ricker et al. 2014 & 2015). Standardized values of Easting and Northing in UTMs, and date of observation as a Julian date, were used to calculate the Euclidean distance among observations. kNN selects classifications based on the shortest Euclidean distance, and in this case each unknown redd was classified based on the majority vote of the three nearest known neighbors (k=3).

Leave-one-out cross-validation (LOOCV) was used to evaluate the accuracy of the kNN model. In LOOCV, each redd is removed in turn from the dataset of known-species redds, the model is re-fit to the remaining data, and the removed redd is predicted to species. Overall model accuracy is assessed as the percentage of known redds correctly predicted to species by LOOCV divided by the total number of known redds (Ricker et al. 2014).

Estimation of Within-Reach Redd Abundance

Total redd construction within a survey reach is estimated using the theoretical basis of a mark-recapture experiment. All redds are marked with unique redd IDs applied to flagging placed on streamside vegetation near the redd, and redd survival from survey occasion i-1 to i, S_i is estimated as the proportion of redds newly observed and flagged ("marked") or previously flagged ("recaptured") on occasion i-1, M_{i-1}, that are still visible on survey occasion I, R_i:

$$\hat{S}_i = \frac{R_i}{M_{i-1}}$$ (Ricker et al. 2015)

New redds are recruited into the population when they are constructed, and redd "mortality" occurs when redds are obscured from view by substrate movement. Redd survival from all survey occasions are pooled to construct a reach and year-specific pooled survival used to estimate total redd construction within a given reach and years (Ricker et al. 2015). Redd recruitment is modeled as occurring at the mid-point between survey occasions.

Estimation of Total Redd Abundance in the Sample Frame

Redd abundance within the sample frame for the species-specific frame is estimated using a Simple Random Sample estimator for the total:

$$\hat{T} = N\left(\frac{\sum_{j=1}^{n} \hat{\tau}_j}{n}\right)$$ (Adams et al. 2011)

where *N* is the total number of reaches within the sample frame, *n* is the number of reaches in the sample, and T_j is the estimated total number of redds in sample reach *j* (Ricker et al. 2015). Standard error was also calculated using methods specified in Adams et al. (2011). Bootstrap resampling was used to estimate between- and within-reach variance, according to Ricker et al. (2015), and construct 95% confidence intervals.

Results

Survey Frequency and Timing

The twenty main reaches in the 2016-17 sample draw comprise 27% of the total number of sample reaches for both coho and Chinook. Frequent and heavy rain events beginning in October and continuing throughout the survey season severely limited our ability to revisit half the reaches in the sample draw at the desired survey interval. Seventeen main reaches and three sub-reaches were surveyed a total of 117 times over the course of the survey season (Table 1). Three reaches - 273, 279, and 282 on the mainstem Mattole downstream of Honeydew- were not surveyed even a single time through the course of the season due to persistent high flows and turbidity.

Surveys began on 11/9/2016 and ended on 2/28/2017, a period of 111 days. The number of surveys on each reach varied from 0 to 10, with a mean of five (Table 1). The mean number of days between surveys ranged from 11 to 111, with an average of 33. Reaches with a drainage area of less than 15 km^2 were able to be surveyed often enough to meet the desired survey return interval of less than 15 days. Larger reaches were unsafe to survey or too turbid to survey for multiple weeks at a time, multiple times during the season, resulting in fewer surveys than desired.

Table 1. Stream reaches surveyed, number of surveys, and mean number of days between survey occasions by reach.

Location Code	Stream Name	# of surveys	Mean # of days between surveys
273	Mattole River	0	111
279	Mattole River	0	111
282	Mattole River	0	111
293	Mattole River	3	35
299	Mattole River	4	28
307	Mattole River	5	22
310	Mattole River	10	11
453	McGinnis Creek	4	20
632	Honeydew Creek	2	55
641	Honeydew Creek, Lower East Fork (632 sub-reach)	2	55
792	Blue Slide Creek	3	28
796	Crooked Prairie Creek (792 sub-reach)	3	28
819	Bear Creek	4	27
823	South Fork Bear Creek	6	15
824	South Fork Bear Creek	7	13
826	South Fork Bear Creek	8	12
911	Bridge Creek	9	11
928	Van Arken Creek	9	11
930	Van Arken Creek, South Fork (928 sub-reach)	8	12
949	Stanley Creek	7	12
951	Baker Creek	7	11
956	Thompson Creek	8	13
957	Thompson Creek	8	12

Fish Observations

Survey personnel recorded a total of 816 adult salmon and steelhead over the survey period. This included 730 Chinook salmon, zero coho salmon, 60 steelhead, and 26 unidentified salmonids (Table 2). Fifty-seven Chinook carcasses, zero coho carcass, four steelhead, and 31 unidentified carcasses were tallied (Table 3).

Table 2. Live fish observations by week and species.

Week Beginning	Chinook	coho	steelhead	unidentified
2016-11-07	7	0	0	0
2016-11-14	0	0	0	1
2016-11-21	0	0	0	0
2016-11-28	257	0	0	2
2016-12-05	66	0	0	0
2016-12-12	162	0	5	3
2016-12-19	157	0	0	5
2016-12-26	53	0	0	2
2017-01-02	10	0	0	2
2017-01-09	1	0	1	2
2017-01-16	16	0	0	0
2017-01-23	1	0	14	3
2017-01-30	0	0	2	2
2017-02-06	0	0	13	3
2017-02-13	0	0	13	0
2017-02-20	0	0	7	0
2017-02-27	0	0	5	1
Total	730	0	60	26

Table 3. Carcasses observations by week and species.

Week Beginning	Chinook	coho	steelhead	unidentified
2016-11-07	0	0	0	0
2016-11-14	0	0	0	0
2016-11-21	0	0	0	0
2016-11-28	2	0	0	0
2016-12-05	4	0	0	0
2016-12-12	2	0	0	0
2016-12-19	9	0	0	0
2016-12-26	21	0	0	0
2017-01-02	4	0	0	3
2017-01-09	2	0	0	0
2017-01-16	4	0	0	1
2017-01-23	6	0	0	0
2017-01-30	3	0	0	0
2017-02-06	0	0	0	0
2017-02-13	0	0	1	0
2017-02-20	0	0	0	0
2017-02-27	0	0	1	0
Total	57	0	2	4

The greatest abundance of live Chinook (194) were observed in Mattole River reach 310, followed by Thompson Creek reach 956 (137) and South Fork Bear 824 (101) (Table 4). Many fewer steelhead were observed, as is typical, with the most documented in reaches without any Chinook observations – Baker Creek 951 and 826 in South Fork Bear Creek (Figure 2)

The greatest abundance of Chinook carcasses was also in Mattole River reach 310 (Table 5). In general, very few carcasses were recovered given the numbers of live Chinook encountered, probably due to the frequency of high flow events.

Among reaches with at least one survey, no fish or carcasses were observed in the following reaches: McGinnis Creek 453, Lower East Fork Honeydew Creek 641, Blue Slide Creek 792, and Stanley Creek 949.

Table 4. Live fish observations by survey reach and species.

Location Code		Chinook salmon	coho salmon	steelhead	unidentified species
293	Mattole River	0	0	0	1
299	Mattole River	55	0	0	0
307	Mattole River	58	0	2	2
310	Mattole River	194	0	9	3
632	Honeydew Creek	0	0	0	1
819	Bear Creek	4	0	0	0
823	South Fork Bear Creek	71	0	10	4
824	South Fork Bear Creek	101	0	8	1
826	South Fork Bear Creek	0	0	14	1
911	Bridge Creek	79	0	2	1
928	Van Arken Creek	28	0	0	1
949	Stanley Creek	0	0	0	0
951	Baker Creek	0	0	11	3
956	Thompson Creek	137	0	4	5
957	Thompson Creek	3	0	0	3
Total		730	0	60	26

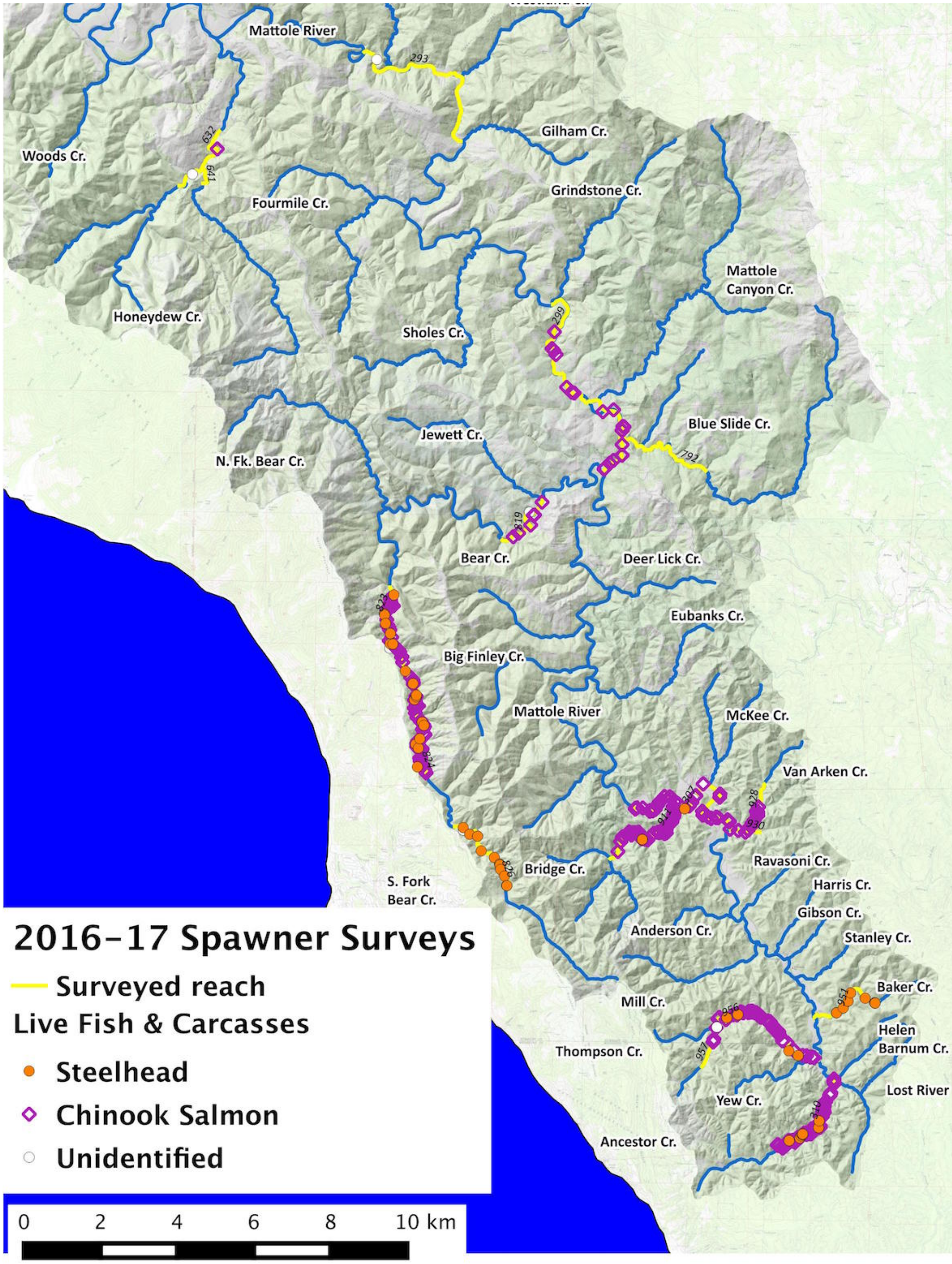


Figure 2. Locations of live and dead fish observations by species, 2016-17 spawner surveys. The northern third of the watershed downstream of Honeydew is not shown, since no live/dead fish were encountered in those reaches.

Table 5. Carcass observations by survey reach and species.

Location Code	Stream	Chinook	coho	steelhead	unidentified
299	Mattole River	9	0	0	0
307	Mattole River	11	0	0	0
310	Mattole River	14	0	0	3
632	Honeydew Creek	1	0	0	0
819	Bear Creek	1	0	0	0
823	South Fork Bear Creek	4	0	1	0
824	South Fork Bear Creek	3	0	1	0
911	Bridge Creek	10	0	0	1
928	Van Arken Creek	3	0	0	0
956	Thompson Creek	1	0	0	0
Total		57	0	2	4

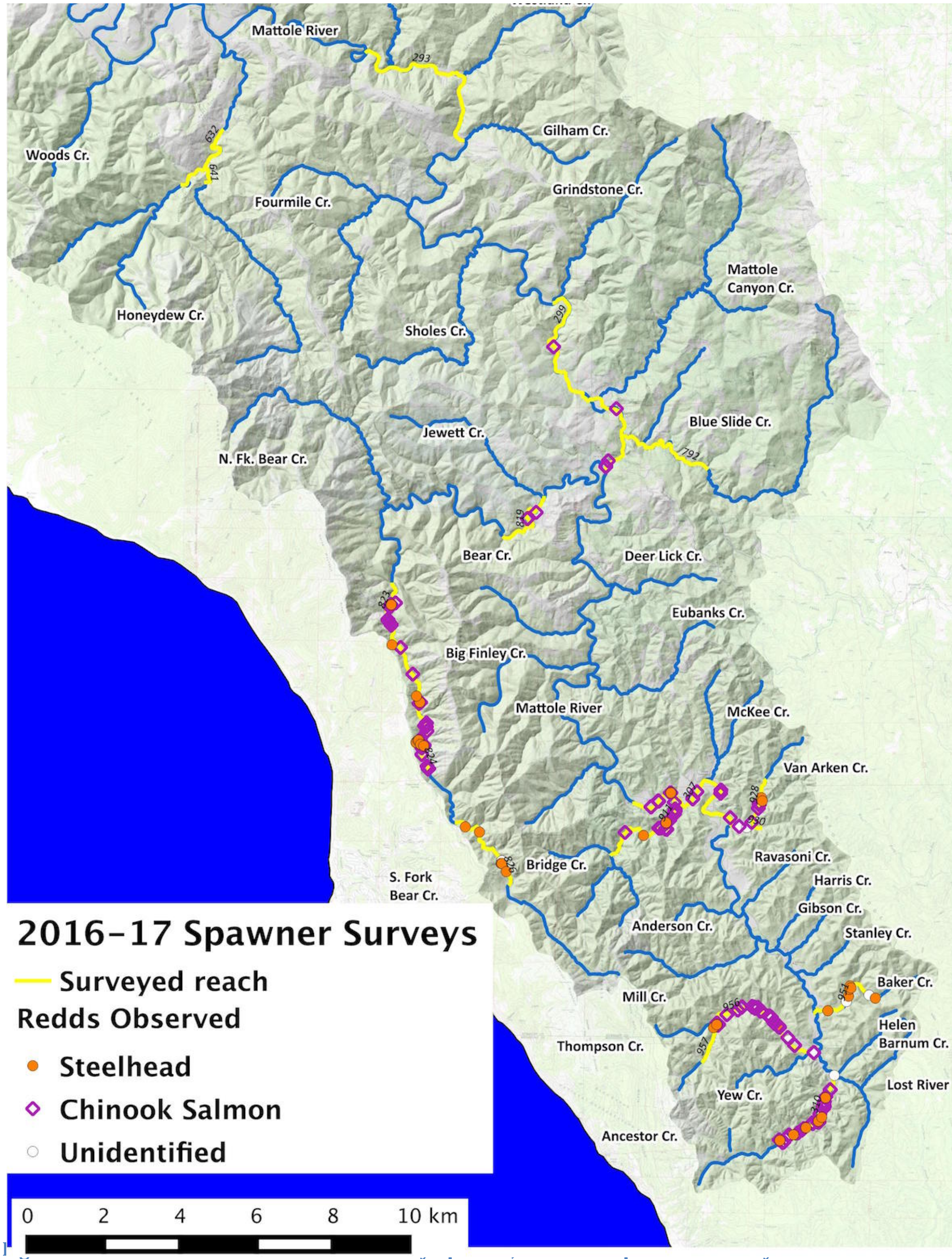
Redd Observations

Surveyors recorded 228 unique redds. Nearly half of these– 103 – were observed with fish present on the redd, an abnormally high percentage. Ninety-three Chinook redds and 10 steelhead redds had fish associated with them (Table 6).

Redd abundance by reach generally followed fish abundance, with the greatest number of redds recorded in Mattole River 310 (61), Thompson Creek 956 (44), and South Fork Bear Creek reach 824 (32) (Table 6). Among reaches where at least a single survey was conducted, no redds were observed in Mattole River 293, McGinnis Creek 453, Honeydew Creek 632, Lower East Fork Honeydew Creek 641, Blue Slide Creek 792, and Stanley Creek 949 (Figure 3). With the exception of Stanley Creek, these reaches were surveyed few times during the season due to unsafe conditions or turbidity, and the lack of detections of redds or fish is undoubtedly in part due to the fewer survey occasions.

Table 6. Number of redds observed by reach and species, when positively identified fish were associated with a redd. Redds listed as "unidentified" were observed with no fish present, or if a fish was on the redd, surveyors were unable to identify the individual(s) to species.

Location Code	Stream	Chinook	coho	steelhead	unidentified (no fish on redd)
299	Mattole River	2	0	0	3
307	Mattole River	9	0	0	9
310	Mattole River	25	0	0	36
819	Bear Creek	2	0	0	1
823	South Fork Bear Creek	7	0	0	6
824	South Fork Bear Creek	13	0	3	16
826	South Fork Bear Creek	0	0	3	3
911	Bridge Creek	8	0	1	11
928	Van Arken Creek	4	0	0	7
951	Baker Creek	0	0	3	6
956	Thompson Creek	22	0	0	22
957	Thompson Creek	1	0	0	5
Total		93	0	10	125



third of the watershed downstream of Honeydew is not shown, since no redds were encountered in those reaches

Redd Abundance Estimates 2016-17

Of the 103 redds observed with fish on (known redds), the kNN classifier correctly classified 102 of them, or 99% (Table 7), a very high degree of accuracy. The estimate of total redd abundance by species in the Mattole River watershed for the 2016 survey season was 875 Chinook (95% CI 320 - 1429), zero coho, and 210 steelhead redds (50-371) (Table 8).

Table 7. Confusion matrix showing number of actual known redds by species, and results of leave-one-out cross-validation predictions of species of known redds.

		Number of Actual Known Redds by Species			
	Species Predicted	Chinook salmon	coho salmon	steelhead	Total Predicted
Number of redds predicted by species	Chinook salmon	93	0	1	94
	coho salmon	0	0	0	0
	steelhead	0	0	9	9
	Total Known	93	0	10	

Table 8. Estimate of total number of redds by species in the sample frame, with standard errors and 95% confidence intervals., with components of variance.

	Chinook	coho	steelhead
Redd estimate (bounds of 95% CI)	875 (320 - 1429)	0	210 (50 – 371)
SE	259.2	0	77.2
Total Within Reach Variance	145.1	0	28.8
Total Between Reach Variance	413.9	0	31.0
% Within	26%	0%	48%
% Between	74%	0%	52%
# sample reaches	17	20	20
# reaches in frame	62	72	72

Redd Abundance Estimates 2012-16

Over the five years CMP spawner survey protocols have been fully implemented in the Mattole, redd abundance estimates within the Mattole watershed sample frame have ranged from 331 to 988 Chinook, 0 to 34 coho salmon, and 222 to 917 steelhead redds (Figure 4 Table 9). These numbers seem to indicate that both steelhead and Chinook populations are well above depensation thresholds, while coho salmon are on the brink of extirpation. While both 2015 and 2016 estimates for coho salmon are zero redds, in 2015 five coho carcasses were encountered by surveyors. In 2016, no live or dead coho were encountered.

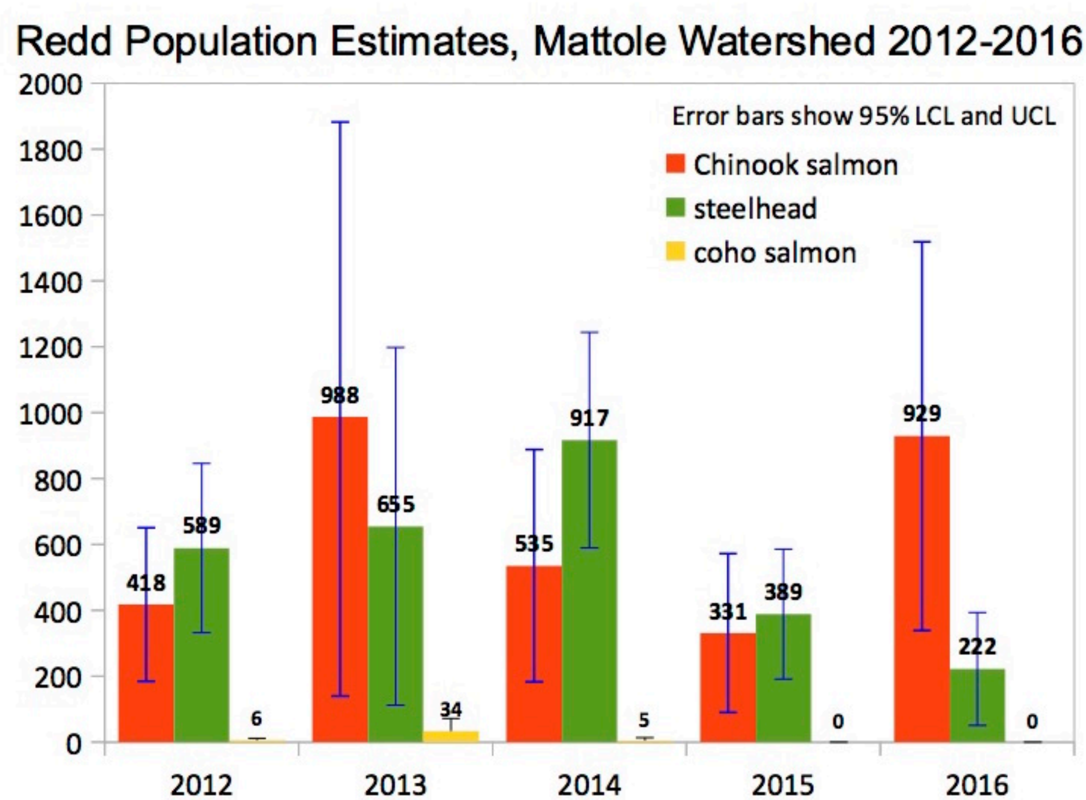


Figure 4. Redd population estimates for the Mattole watershed, 2012-2016. Numbers at top of columns are mean values for each species and year.

Table 9. Redd population estimates by species for the Mattole watershed, 2012-2016.

Survey Year	Species	95% lower confidence interval	Total Redd Estimate	95% upper confidence interval
2012	Coho Salmon	3	6	12
2013	Coho Salmon	3	34	72
2014	Coho Salmon	0	5	14
2015	Coho Salmon	0*	0*	0*
2016	Coho Salmon	0	0	0
2012	Chinook Salmon	185	418	651
2013	Chinook Salmon	140	988	1882
2014	Chinook Salmon	183	535	888
2015	Chinook Salmon	90	331	572
2016	Chinook Salmon	339	929	1519
2012	Steelhead	332	589	846
2013	Steelhead	112	655	1197
2014	Steelhead	590	917	1245
2015	Steelhead	192	389	585
2016	Steelhead	51	222	392

*While no live coho salmon were observed in 2015, five carcasses were tallied by surveyors and snorkel surveys documented coho parr distribution similar to the past three years in the summer of 2016.

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Appendix A: Sample Frame Map