Mattole River Watershed 2014-2015 Spawning Ground Surveys and Redd Population Estimate

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Introduction

The 2014-15 spawner survey season was the fifth consecutive year the Mattole Salmon Group (MSG) conducted spawning ground surveys in the Mattole River watershed using the California Coastal Salmonid Monitoring Program (CMP) protocols (Adams et al. 2011). 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 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 2014-15 spawning season. A more complete report, presenting survey data and analysis for the 2013-14 and 2015-16 survey seasons, which were also made possible by funding from the Bureau of Land Management Arcata Field Office, is in preparation, and will contain discussion of all three survey seasons' results. This report will be completed in summer of 2016.

Methods

Sample Frame and Reach Selection

Potential survey reaches are all reaches 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. 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, and in the 2014 survey season the frame contained 59 reaches attributed as Chinook and coho spawning habitat, and an additional 10 reaches attributed as potential coho reaches (Figure 1). All 69 reaches in the frame are considered potential steelhead spawning habitat.

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) are surveyed by implication if the main reach they attach too is in the sample draw.

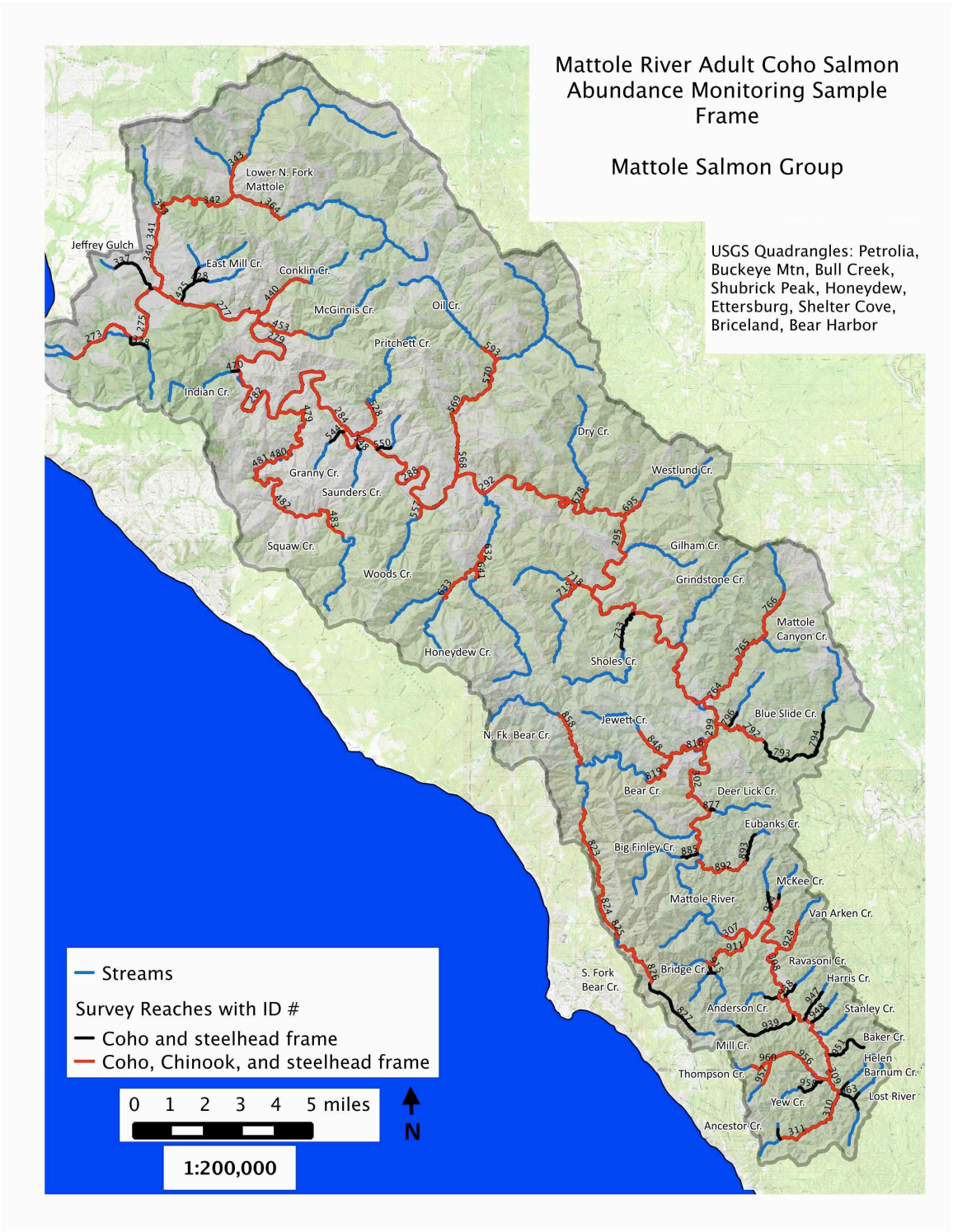

Figure 1. Mattole River spawning ground survey frame.

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 2014-15 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 7-10 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.

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 with 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

Fifteen main reaches and five tag reaches, covering 65.5 km of stream length and comprising 22% of the total number of sample reaches for both coho and Chinook were surveyed 2014. The total number of surveys was 153 and covered 449 accumulated km of stream length.

Surveys began on 11/4/2014 and ended on 2/26/2015, a period of 114 days. Frequent large storms beginning in mid-December and continuing to the end of the survey season rendered mainstem Mattole River reaches 275, 284, and 288 (and associated tag reaches 544, 548, and 557) un-surveyable due to turbidity for much of the season. The number of surveys on each reach varied from two to 12, with a mean of eight (Table 1). The mean number of days between surveys ranged from 10 to 57, with an average of 18.

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
275	Mattole River	3	38
284	Mattole River	4	29
288	Mattole River	6	19
299	Mattole River	8	14
307	Mattole River	7	16
311	Mattole River	11	10
328	Lower Mill Creek	10	11
340	Lower North Fork Mattole River	7	16
544	Granny Creek	4	29
548	Saunders Creek	2	57
557	Woods Creek	6	19
632	Honeydew Creek	9	13
633	Honeydew Creek	8	14
641	Lower East Fork Honeydew Creek	9	13
733	Sholes Creek	11	10
764	Mattole Canyon Creek	7	16
824	South Fork Bear Creek	9	13
827	South Fork Bear Creek	11	10
957	Thompson Creek	12	10
972	Ancestor Creek	11	10

Fish Observations

Survey personnel recorded a total of 615 adult salmon and steelhead over the survey period. This included 434 Chinook salmon, four coho salmon, 143 steelhead, and 34 unidentified salmonids (Table 2). One hundred sixty four Chinook carcasses, one 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
2014-11-03	103	0	1	5
2014-11-10	54	1	3	4
2014-11-17	46	1	0	1
2014-11-24	129	0	0	9
2014-12-01	9	0	0	1
2014-12-08	46	1	2	2
2014-12-15	15	0	0	1
2014-12-22	9	0	0	1
2014-12-29	12	1	0	1
2015-01-05	7	0	4	2
2015-01-12	0	0	19	3
2015-01-19	1	0	12	0
2015-01-26	0	0	19	0
2015-02-02	1	0	53	2
2015-02-09	1	0	6	0
2015-02-16	0	0	5	0
2015-02-23	1	0	19	2
Total	434	4	143	34

Table 3. Carcasses observations by week and species.

Week Beginning	Chinook	coho	steelhead	unidentified
2014-11-03	0	0	0	0
2014-11-10	0	0	0	0
2014-11-17	0	0	0	0
2014-11-24	1	0	0	0
2014-12-01	1	0	0	0
2014-12-08	11	0	0	0
2014-12-15	0	0	0	0
2014-12-22	8	1	0	4
2014-12-29	54	0	0	7
2015-01-05	43	0	0	12
2015-01-12	3	0	0	0
2015-01-19	25	0	0	6
2015-01-26	7	0	2	0
2015-02-02	11	0	0	1
2015-02-09	0	0	0	0
2015-02-16	0	0	1	1
2015-02-23	0	0	1	0
Total	164	1	4	31

The greatest abundance of live Chinook were observed in Mattole River reaches 288 and 299, due in large part to surveys that coincided with periods when Chinook were schooling in larger pools prior to significant rainfall (Table 4). Large numbers of live and dead Chinook were also observed in the South Fork of Bear Creek, and mainstem reach 307 (Table 4 and Table 5).

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

Location Code		Chinook salmon	coho salmon	steelhead	unidentified species
275	Mattole River	3	0	0	1
284	Mattole River	44	0	1	2
288	Mattole River	105	1	30	10
299	Mattole River	113	1	72	7
307	Mattole River	39	1	21	7
311	Mattole River	11	1	5	3
632	Honeydew Creek	5	0	0	0
633	Honeydew Creek	0	0	2	0
641	Honeydew Creek	8	0	0	0
733	Sholes Creek	20	0	5	1
824	South Fork Bear Creek	81	0	1	2
827	South Fork Bear Creek	0	0	3	0
957	Thompson Creek	0	0	3	0
972	Ancestor Creek	5	0	0	1
Total		434	4	143	34

Table 5. Carcass observations by survey reach and species.

Location Code	Stream	Chinook	coho	steelhead	unidentified
284	Mattole River	1	0	0	0
299	Mattole River	37	0	0	5
307	Mattole River	53	0	1	20
311	Mattole River	14	1	2	2
340	Lower North Fork Mattole River	1	0	0	0
632	Honeydew Creek	3	0	1	0
633	Honeydew Creek	2	0	0	1
641	Honeydew Creek	2	0	0	0
733	Sholes Creek	12	0	0	3
824	South Fork Bear Creek	39	0	0	0
827	South Fork Bear Creek	0	0	0	0
Total		164	1	4	31

Redd Observations

Surveyors recorded 257 unique redds. Of these, the vast majority, 208, were observed with no fish on the redd (unidentified redds in Table 6). Forty-one Chinook redds, one coho redd, and seven steelhead redds had fish associated with them (Table 6).

The greatest number of redds was recorded in South Fork Bear Creek reach 824 (43), Sholes Creek reach 733 (32), and Mattole River reaches 299 and 311 (31 each). The abundance of both steelhead and especially Chinook in Sholes Creek was surprising, as this stream has been little surveyed in past years and not been thought to be particularly productive.

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)
288	Mattole River	1	0	0	8
299	Mattole River	8	0	1	22
307	Mattole River	6	0	0	20
311	Mattole River	4	1	2	24
328	Lower Mill Creek	0	0	0	8
340	Lower North Fork Mattole River	0	0	0	2
557	Woods Creek	0	0	0	1
632	Honeydew Creek	2	0	0	6
633	Honeydew Creek	0	0	1	4
641	Honeydew Creek	3	0	0	7
733	Sholes Creek	6	0	1	25
764	Mattole Canyon Creek	0	0	0	9
824	South Fork Bear Creek	10	0	0	33
827	South Fork Bear Creek	0	0	1	21
957	Thompson Creek	0	0	1	13
972	Ancestor Creek	1	0	0	5
Total		41	1	7	208

Redd Abundance Estimates

Of the 49 redds recorded with fish on (known redds), the kNN classifier correctly classified 47 of them, or 96% (Table 7), a high degree of accuracy.

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	41	1	1	43
	coho salmon	0	0	0	0
	steelhead	0	0	6	6
	Total Known	41	1	7	

The estimate of total redd abundance by species in the Mattole River watershed for the 2014 survey season was 525 Chinook (95% CI 184-865), five coho (0-13), and 930 steelhead redds (623-1238) (Table 8).

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)	525 (184 - 865)	5 (0-13)	930 (623 – 1238)
SE	149.856	3.740	105.692
Total Within Reach Variance	26.381	0	43.854
Total Between Reach Variance	96.620	0.077	60.696
% Within	21%	0%	42%
% Between	79%	100%	58%
# sample reaches	12	15	15
# reaches in frame	59	69	69

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