Final Report: Mattole River 2017-2018 Adult Salmon and Steelhead Abundance Monitoring

A recently expired female Chinook salmon in Bear Creek reach #818 on January 14, 2018, Mattole River watershed.

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- This project would not have been possible without the support of the many landowners who allowed us to survey stream reaches on their properties. Their stewardship and interest is essential to the health and recovery of fish runs in the Mattole watershed.

Abstract

The Mattole Salmon Group (MSG) conducted spawning ground surveys in 22 stream reaches in the Mattole River watershed using the California Coastal Salmonid Monitoring Program (CMP) protocols (Adams et al. 2011). Potential survey reaches were all reaches in the watershed attributed as Chinook spawning reaches, based on maximum stream gradient and mean estimated discharge. A spatially-balanced random draw of reaches to be surveyed from the sample frame was made using the generalized random tessellation stratified (GRTS) algorithm, and landowners were contacted for access permission in reaches according to draw order.

From November 12, 2017 to February 27, 2018 a total of 162 surveys were completed. The number of surveys on each reach varied from four to nine, with a mean of 7.4. Data was collected using handheld Personal Digital Assistant (PDA) computer units loaded with DFW's CMP database-compatible software. 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. All analysis was done with the statistics program R, according to methods outlined in Adams et al. (2011) and Ricker et al. (2014 & 2015), and using code developed by Ricker and Ferreira (2016).

Survey personnel recorded a total of 3,009 adult salmon and steelhead over the survey period. This included 2764 Chinook salmon, zero coho salmon, 166 steelhead, and 77 unidentified salmonids. One-hundred seventy-seven Chinook carcasses, zero coho carcass, one steelhead, and eight unidentified carcasses were tallied. Surveyors recorded 834 unique redds. One-hundred fifty-three Chinook redds and five steelhead redds had fish associated with them. The estimate of total redd abundance by species in the Mattole River watershed for the 2017 survey season was 2,202 Chinook (95% CI 1,263 – 3,142), zero coho, and 471steelhead redds (310-633).

Introduction

The 2017-18 spawner survey season was the sixth 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 2017-18 spawning season, as well as a summary of results from 2012-2018 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 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. Sixty-two main reaches are attributed as Chinook and Coho spawning reaches, with 10 more reaches attributed as potential coho (but not Chinook reaches). All 72 reaches in the frame are considered potential steelhead spawning habitat. In 2017-2018 only reaches within the Chinook sample frame were surveyed. Due to the extremely low numbers of coho salmon returning to the Mattole watershed, spawning ground surveys are currently not an efficient or feasible method to determine coho salmon abundance. A steelhead-focused survey effort would require a much expanded survey frame, since steelhead routinely spawn in much higher gradient streams than either coho or Chinook.

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 to 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 2017-18 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, if not later), in addition to an expanded sample frame as mentioned previously, 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.

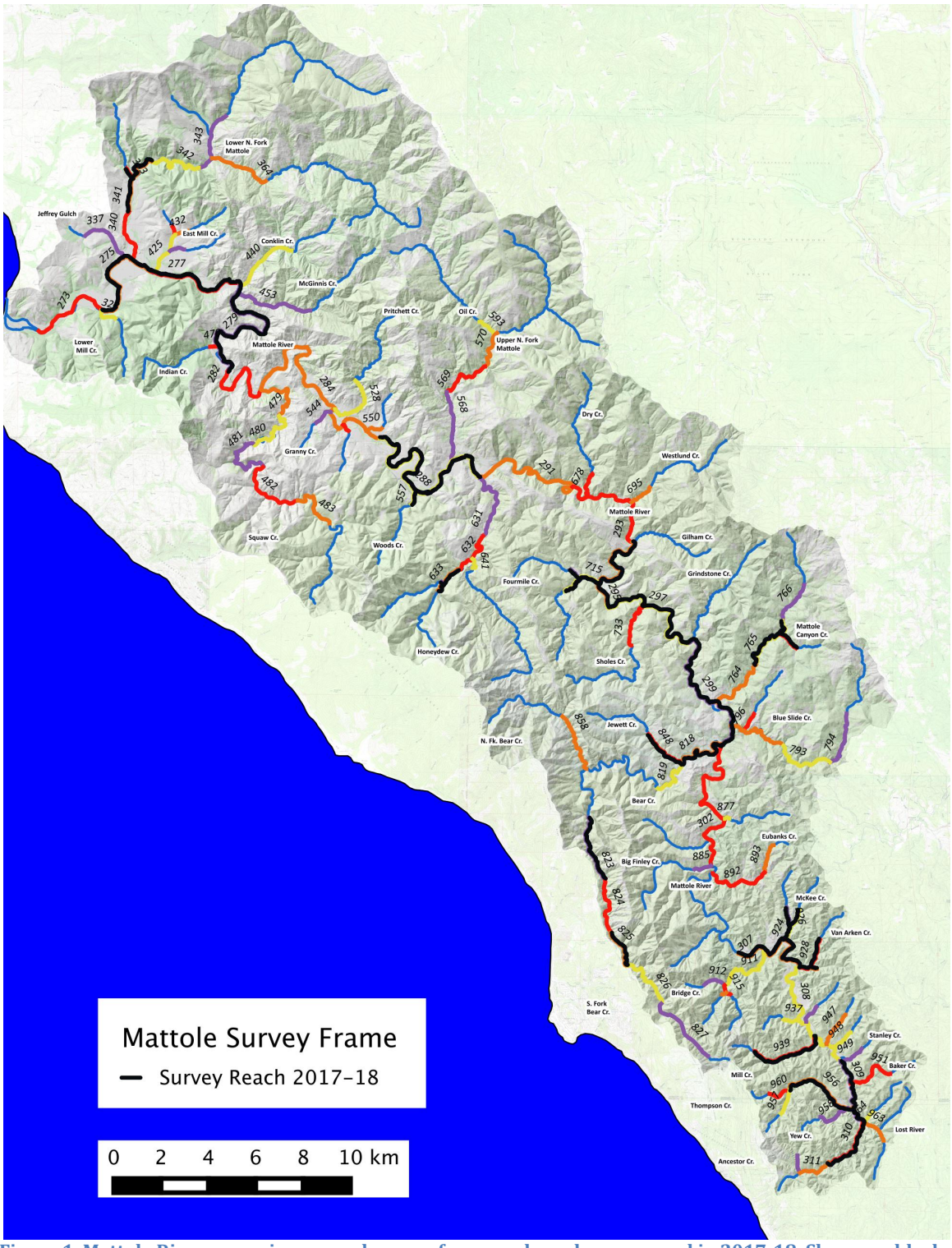

Figure 1. Mattole River spawning ground survey frame and reaches surveyed in 2017-18. Shown as black lines.

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) algorithm 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-two main reaches in the 2017-18 sample draw comprise 35% of the total sample reaches for Chinook salmon, and 30% of the reaches in the coho and steelhead sample frames. Seven of the main reaches were also connected to a sub-reach that was surveyed each occasion the main reach was surveyed. The 22 main reaches were surveyed a total of 162 times over the course of the survey season (Table 1).

Surveys began on 11/12/2017 and ended on 2/27/2018, a period of 107 days. The number of surveys on each reach varied from 4 to 9, with a mean of 7.4 (Table 1). The mean number of days between surveys ranged from 12 to 26, with an average of 15.

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	4	26
277	Mattole River	5	21
279	Mattole River	5	21
	Mattole River		
288	(+557 Woods Creek sub-reach)	7	15
295	Mattole River	8	13
297	Mattole River	8	13
299	Mattole River	9	12
307	Mattole River	9	12
309	Mattole River	8	13
310	Mattole River	9	12
	Lower North Fork Mattole River		
341	(+353 Grizzly Ck sub-reach)	5	21
	Honeydew Creek		
633	(+646 W. Fork Honeydew sub-reach)	7	15
	Fourmile Creek		
715	(+718 N. Fork Fourmile sub-reach)	8	13
	Mattole Canyon Creek		
765	(+770 Panther Ck sub-reach)	6	19
818	Bear Creek	8	13
823	South Fork Bear Creek	8	13
825	South Fork Bear Creek	9	12
848	Jewett Creek	8	13
924	McKee Creek (+926 Painter Creek)	8	13
	Van Arken Creek		
928	(+930 S. Fork Van Arken)	7	15
939	Mill Creek	7	15
956	Thompson Creek	8	13

Flow conditions allowed frequent surveys throughout most of the season, with a very wet November and then flows below average for most of the rest of the season (Figure 2), especially in December and February. Nearly all reaches except for the mainstem Mattole downstream of Honeydew are safe and clear enough to survey when flows at Petrolia are <1000 cfs. The last week and a half of January was the only extended period of time when surveys were only feasible in the smallest streams in the sample (McKee, Van Arken, and Jewett Creeks).

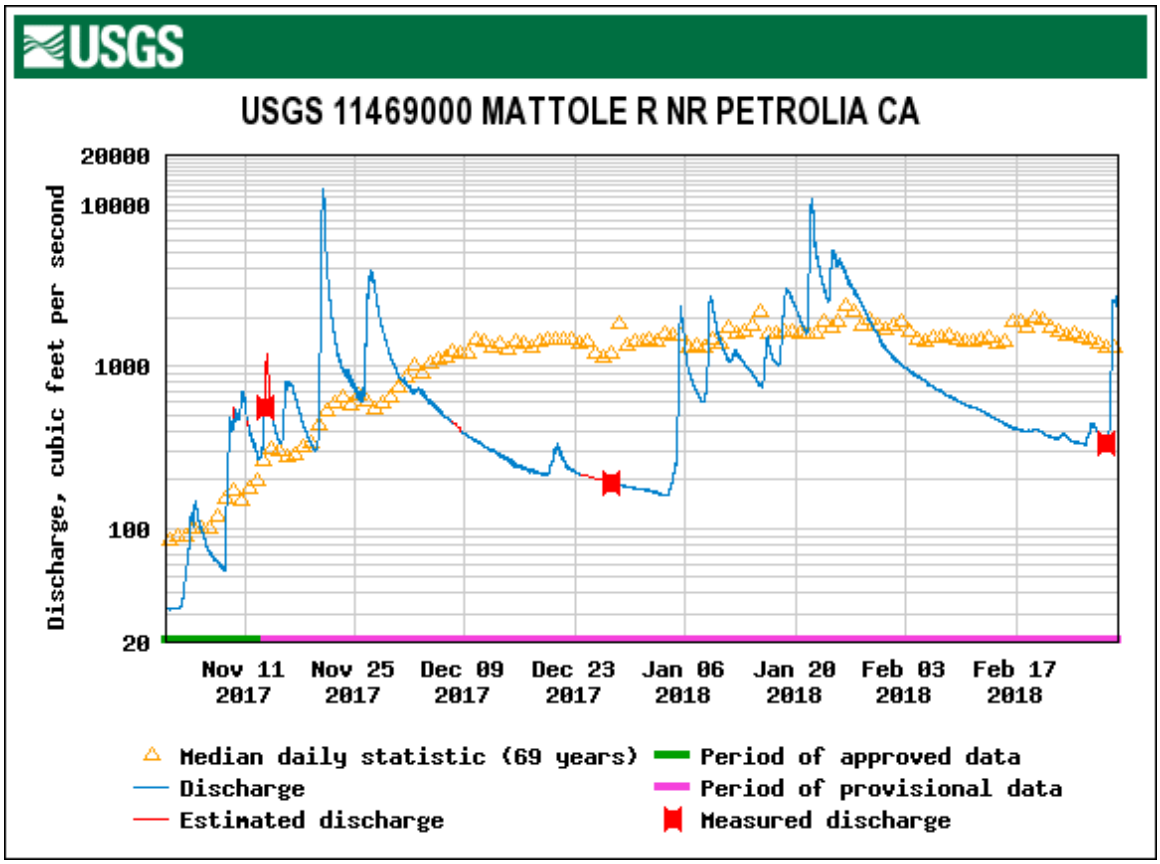

Figure 2. Streamflow from the Mattole River USGS gage at Petrolia, November 1, 2017 to March 1, 2018.

Fish Observations

Survey personnel recorded a total of 3,009 adult salmon and steelhead over the survey period. This included 2,764 Chinook salmon, zero coho salmon, 166 steelhead, and 77 unidentified salmonids (Table 2). One hundred seventy-seven Chinook, zero coho, one steelhead, and 9 unidentified carcasses were tallied (Table 3). The Chinook run appeared to end fairly abruptly in mid-January, with only seven new carcass recoveries on subsequent surveys and steelhead comprising nearly all live fish seen thereafter.

Table 2. Live fish observations by week and species.

Week Beginning	Chinook	coho	steelhead	unidentified
11/12/2017	0	0	0	1
11/19/2017	42	0	0	2
11/26/2017	170	0	0	3
12/3/2017	428	0	1	41
12/10/2017	665	0	1	0
12/17/2017	388	0	7	2
12/24/2017	624	0	1	0
12/31/2017	327	0	2	7
1/7/2018	63	0	11	2
1/14/2018	40	0	2	8
1/21/2018	0	0	0	1
1/28/2018	2	0	13	0
2/4/2018	1	0	4	3
2/11/2018	0	0	21	1
2/18/2018	1	0	102	6
2/25/2018	0	0	1	0
Total	2764	0	166	77

Table 3. Carcasses observations by week and species.

Week Beginning	Chinook	coho	steelhead	unidentified
11/12/2017	0	0	0	0
11/19/2017	0	0	0	0
11/26/2017	4	0	0	0
12/3/2017	13	0	0	1
12/10/2017	33	0	0	0
12/17/2017	28	0	0	0
12/24/2017	38	0	0	0
12/31/2017	24	0	0	8
1/7/2018	1	0	0	0
1/14/2018	29	0	0	0
1/21/2018	0	0	0	0
1/28/2018	6	0	0	0
2/4/2018	0	0	0	0
2/11/2018	1	0	1	0
2/18/2018	0	0	0	0
2/25/2018	0	0	0	0
Total	177	0	1	9

The greatest numbers of live Chinook were observed in mainstem reaches 288 and 299 (Table 4, Figure 3, Figure 4). Highest counts in these reaches occurred later in December when declining flow conditions appeared to prohibit or at least restrict upstream passage, and fish accumulated in these reaches, and large schools of 20-40 Chinook were present in multiple pools. Large numbers of Chinook were also observed in mainstem reaches 295, 297, 307, and 309, as well as Bear Creek 818, South Fork Bear Creek 823, and Thompson Creek 956.

Live Chinook were observed in all reaches except for 765 Mattole Canyon Creek, 848 Jewett Creek, 924 McKee Creek, 928 Van Arken Creek, and reach 277 in the mainstem Mattole. The lack of Chinook in these tributary reaches was likely a result of flow conditions – by the time the bulk of the Chinook run had arrived in the upper watershed in December, flows were already low enough that access to these tributaries was restricted. Mattole Canyon Creek is a much larger stream than the other three, but has a braided, shallow channel at its mouth that also probably prohibited passage of adult fish for most of December. Low December flows also appeared to restrict fish entry into mainstem reach 310, which is often the site of some of the highest densities of Chinook spawning in wet winters.

Most live steelhead observations occurred in the mainstem reach downstream of Honeydew (288) and the three reaches downstream of Ettersburg (295-299).

For the second year in a row no live or dead coho salmon were observed.

Chinook carcasses were most abundant in mainstem reach 307 (Thorn Junction), and Bear Creek reach 818, where 51 and 47 were recovered (Table 5). Notably low numbers of carcasses were recovered in several reaches where live fish were abundant, particularly in South Fork Bear 823 (3 carcasses, 111 live Chinook observed), and Thompson Creek 956 (1 carcass, 81 live Chinook observed). The lack of carcasses in these reaches was surprising, since we anticipated that with lower-than average flows through the spawning period and frequent surveys carcass recovery rates would be generally high. It is possible that the lack of carcasses in these two reaches may have been largely due to black bear activity, as scat and tracks were ubiquitous throughout these reaches, and in 823 in particular the shredding of redd flags by bears was an issue on nearly every survey.

No clipped or marked Chinook carcasses were recovered.

Only one steelhead carcass was recorded, in mainstem reach 309.

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

Location Code		Chinook salmon	coho salmon	steelhead	unknown species
275	Mattole River	1	0	0	5
277	Mattole River	0	0	1	0
279	Mattole River	5	0	4	7
288	Mattole River (+557 Woods Creek sub-reach)	514	0	20	36
295	Mattole River	260	0	18	14
297	Mattole River	416	0	72	0
299	Mattole River	598	0	23	2
307	Mattole River	221	0	8	6
309	Mattole River	305	0	5	0
310	Mattole River	23	0	0	2
341	Lower N. Fork Mattole River (+353 Grizzly Ck sub-reach)	1	0	0	0
633	Honeydew Creek (+646 W. Fork Honeydew sub-reach)	12	0	2	1
715	Fourmile Creek (+718 N. Fork Fourmile sub-reach)	7	0	2	0
765	Mattole Canyon Creek (+770 Panther Ck sub-reach)	0	0	0	0
818	Bear Creek	198	0	3	1
823	South Fork Bear Creek	111	0	5	0
825	South Fork Bear Creek	7	0	0	0
848	Jewett Creek	0	0	1	0
924	McKee Creek (+926 Painter Creek)	0	0	0	0
928	Van Arken Creek (+930 S. Fork Van Arken)	0	0	1	1
939	Mill Creek	4	0	0	0
956	Thompson Creek	81	0	1	2
Total		2764	0	166	26

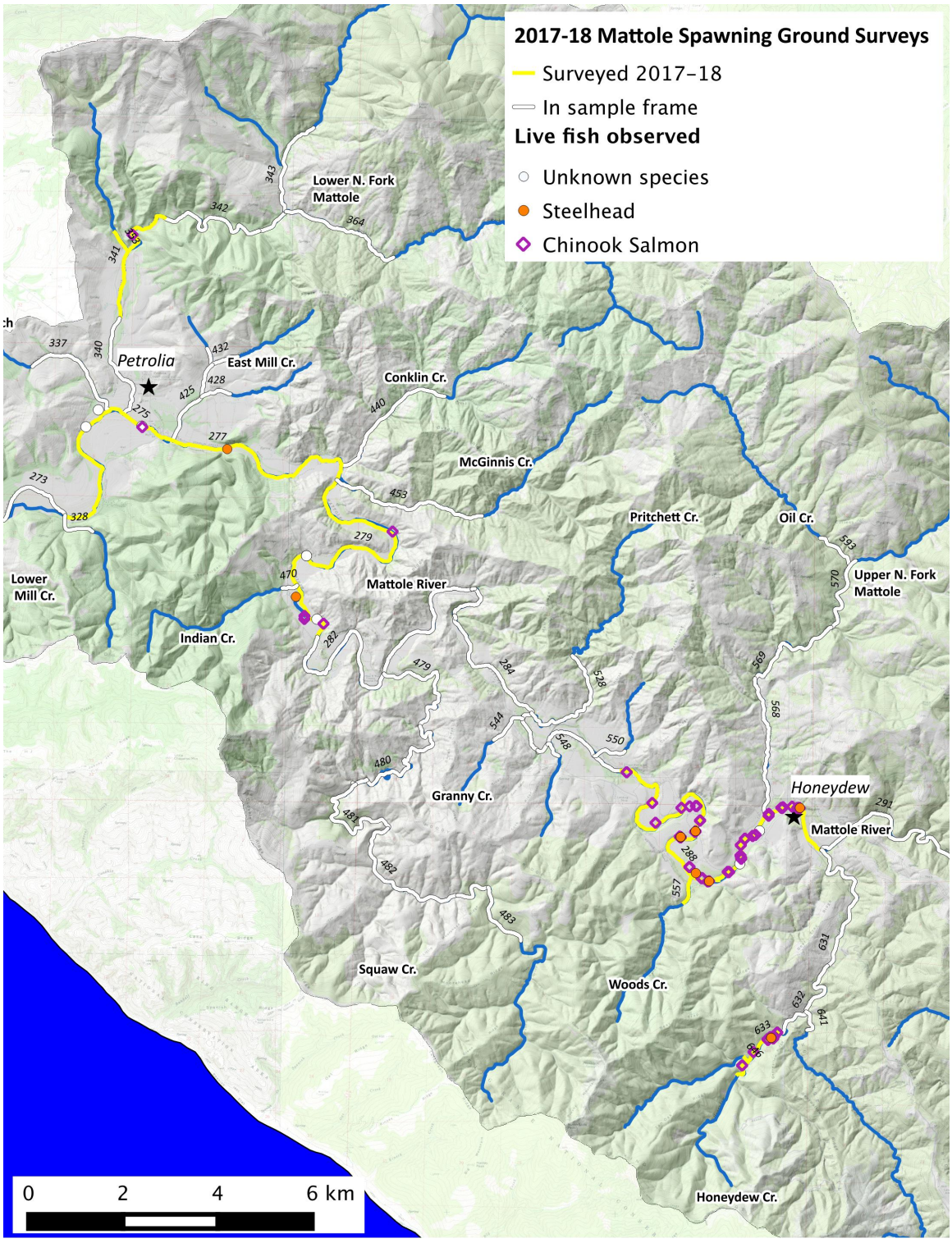

Figure 3. Locations of live fish observations by species, 2017-18 spawner surveys, northern half of the watershed (Honeydew Creek and downstream).

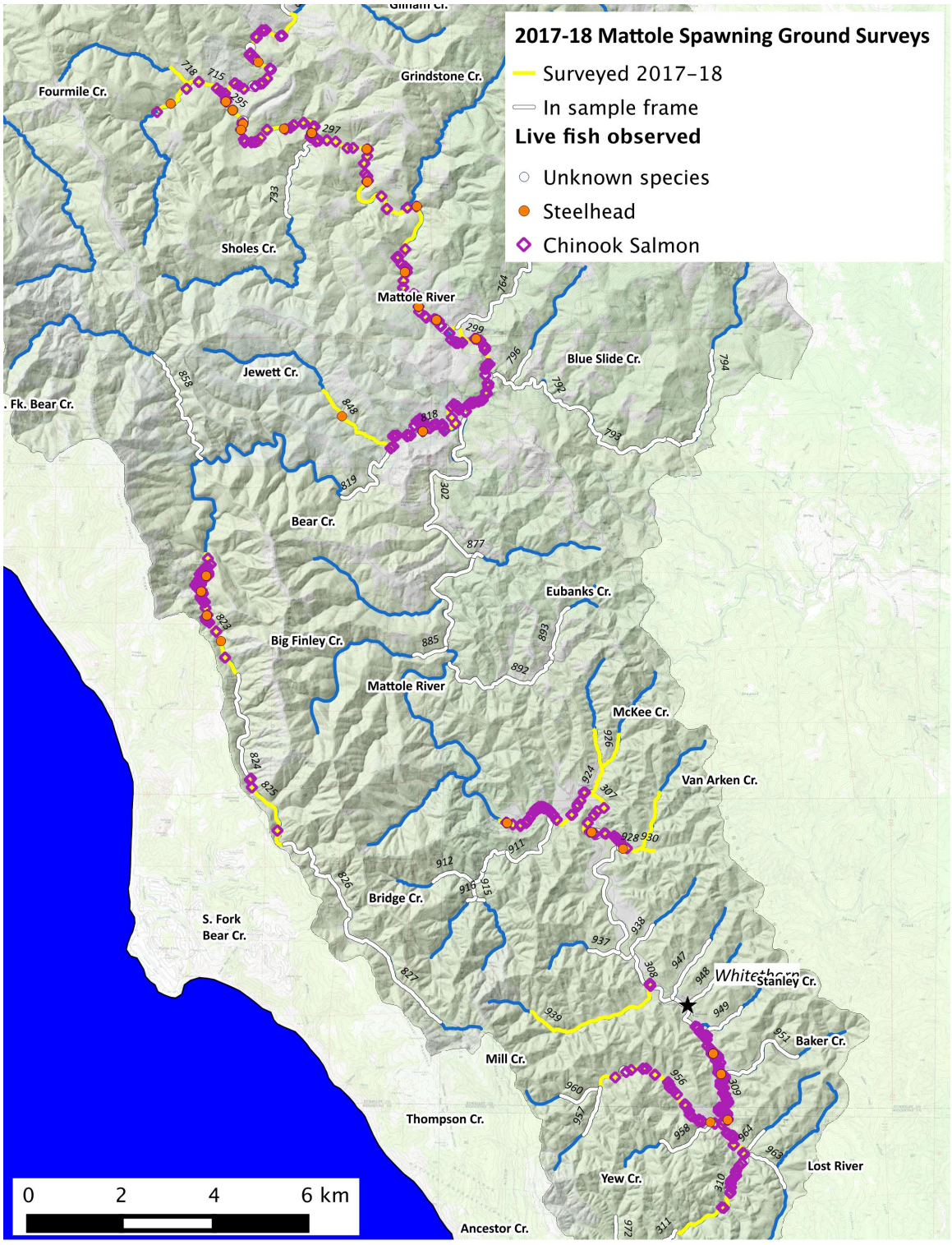

Figure 4. Locations of live fish observations by species, 2017-18 spawner surveys, southern half of the watershed (upstream of Honeydew Creek).

Table 5. Carcass observations by survey reach and species.

Location Code		Chinook salmon	coho salmon	steelhead	unknown species
275	Mattole River	0	0	0	0
277	Mattole River	0	0	0	0
279	Mattole River	0	0	0	0
288	Mattole River (+557 Woods Creek sub-reach)	5	0	0	0
295	Mattole River	7	0	0	0
297	Mattole River	6	0	0	0
299	Mattole River	27	0	0	1
307	Mattole River	51	0	0	8
309	Mattole River	24	0	1	0
310	Mattole River	4	0	0	0
341	Lower N. Fork Mattole River (+353 Grizzly Ck sub-reach)	0	0	0	0
633	Honeydew Creek (+646 W. Fork Honeydew sub-reach)	0	0	0	0
715	Fourmile Creek (+718 N. Fork Fourmile sub-reach)	0	0	0	0
765	Mattole Canyon Creek (+770 Panther Ck sub-reach)	0	0	0	0
818	Bear Creek	47	0	0	0
823	South Fork Bear Creek	3	0	0	0
825	South Fork Bear Creek	2	0	0	0
924	McKee Creek (+926 Painter Creek)	0	0	0	0
928	Van Arken Creek (+930 S. Fork Van Arken)	0	0	0	0
939	Mill Creek	0	0	0	0
956	Thompson Creek	1	0	0	0
Total		177	0	1	9

Redd Observations

Surveyors recorded 834 unique redds, and observed fish associated with 158 of these redds (Table 6). Of these known redds, 152 were associated with Chinook salmon and only six with steelhead. The very low number of steelhead actively spawning is not uncommon due to their generally cryptic behavior, especially in clear water conditions.

The greatest number of redds judged to be Chinook redds by surveyors in the field (based survey timing and redd morphology) were observed in mainstem reaches 299 (119 redds) and 309 (108 redds) (Table 6). In general, Chinook spawning activity in the mainstem was abundant in every survey reach from just downstream of Honeydew (reach 288) (Figure 5) to reach 310, upstream of Whitethorn in Mendocino County (Figure 6). Bear Creek reach 818, and 823 in South Fork of Bear Creek were also hotspots, with 73 and 54 redds, respectively, as was Thompson Creek 956 where 56 Chinook redds were observed (Table 6, Figure 6).

Steelhead spawning activity was distributed more evenly across more reaches in the frame, likely due in part to the slightly higher flows during late January and February when most steelhead activity was observed, allowing fish better access into smaller streams than earlier in the winter. Reaches with the greatest number of steelhead redds included mainstem reaches 299, 307, 309, and 310, and Thompson Creek 956 (Table 6, Figure 6).

The only three reaches where no redds were observed were mainstem Mattole reaches 275, 277, and 279, which cover the portion of river from lower Mill Creek, just downstream of Petrolia, to just downstream of A. Way County Park. (Table 6, Figure 6). Very few fish were observed in these reaches as well. Apparently flows were sufficiently high during the survey season that fish were not holding or spawning in this portion of the mainstem, choosing instead to continue upstream or into tributaries.

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. Number of redds occupied by fish is noted in parentheses.

Location Code		Chinook salmon	coho salmon	steelhead	unknown species
275	Mattole River	0	0	0	0
277	Mattole River	0	0	0	0
279	Mattole River	0	0	0	0
288	Mattole River (+557 Woods Creek sub-reach)	36 (9)	0	4	6
295	Mattole River	28 (4)	0	5	0
297	Mattole River	26 (5)	0	5	3
299	Mattole River	119 (13)	0	18	6
307	Mattole River	44 (7)	0	11	3
309	Mattole River	108 (49)	0	15 (2)	7
310	Mattole River	25 (4)	0	18	11
341	Lower N. Fork Mattole River (+353 Grizzly Ck sub-reach)	1	0	3	4
633	Honeydew Creek (+646 W. Fork Honeydew sub-reach)	19	0	0	0
715	Fourmile Creek (+718 N. Fork Fourmile sub-reach)	14 (2)	0	4 (1)	4
765	Mattole Canyon Creek (+770 Panther Ck sub-reach)	0	0	3	2
818	Bear Creek	73 (23)	0	6(1)	10
823	South Fork Bear Creek	54 (16)	0	6(1)	3
825	South Fork Bear Creek	15 (4)	0	1	6
848	Jewett Creek	0	0	3	2
924	McKee Creek (+926 Painter Creek)	1	0	3	2
928	Van Arken Creek (+930 S. Fork Van Arken)	1	0	1(1)	2
939	Mill Creek	4 (1)	0	8	4
956	Thompson Creek	56 (15)	0	12	9
Total		624(152)	0	126(6)	84

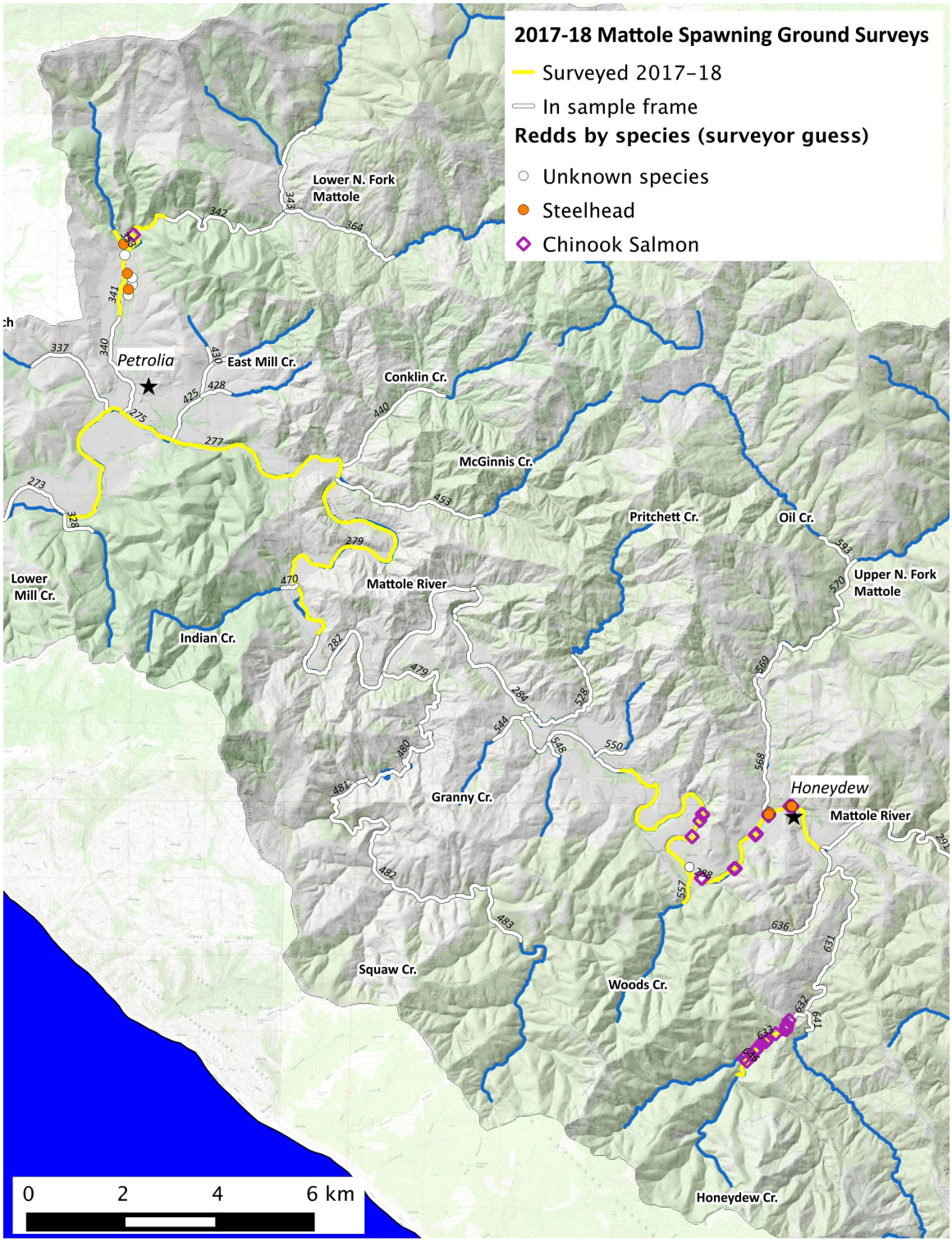

Figure 5. Locations of redd observations by species, 2017-18 spawner surveys, northern half of the watershed (Honeydew Creek and downstream).

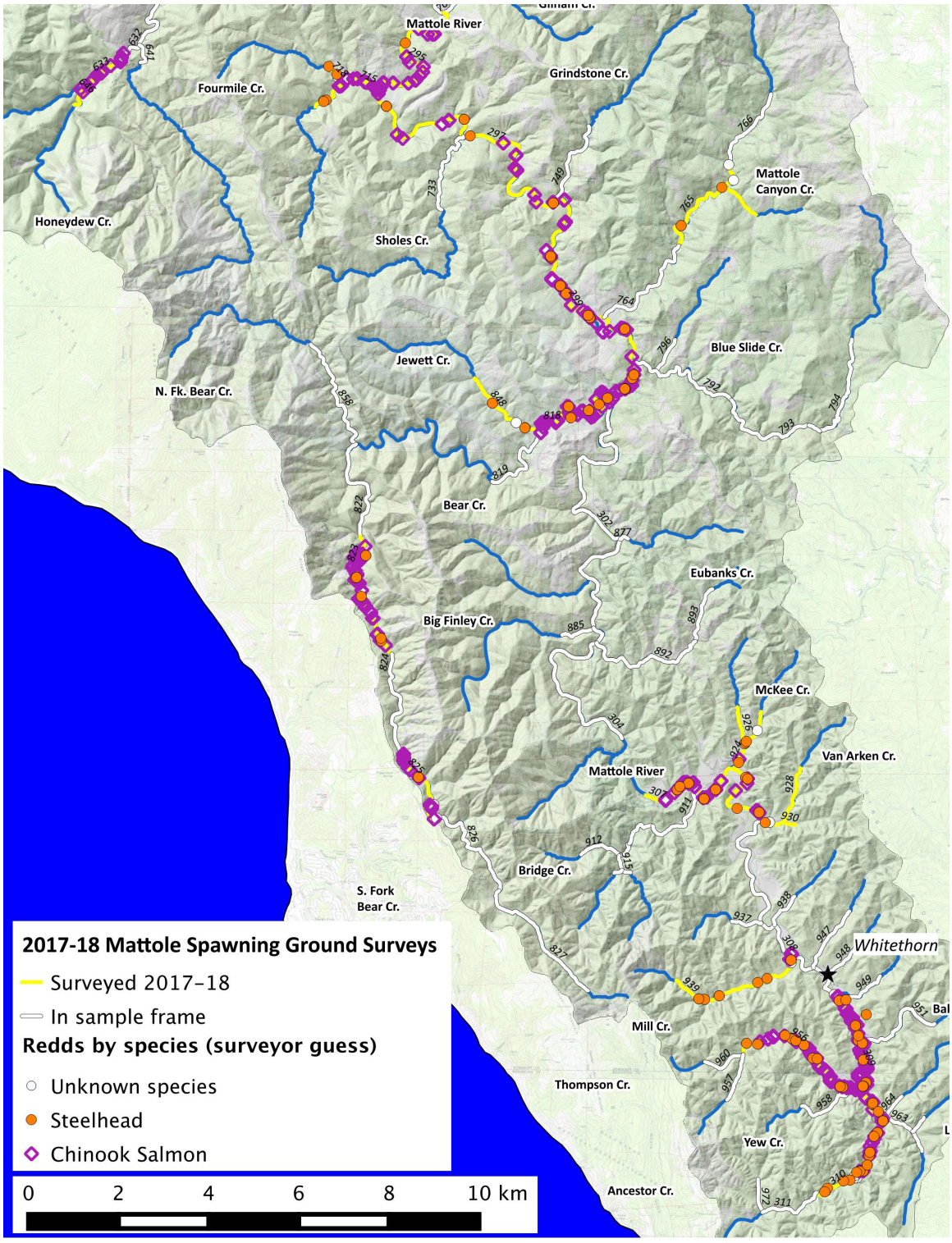

Figure 6. Locations of redd observations by species, 2017-18 spawner surveys, southern half of the watershed (Honeydew Creek and upstream).

Redd Abundance Estimates 2016-17

Of the 158 redds observed with fish on (known redds), the kNN classifier correctly classified 153 of them, or 97% (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 2,202 Chinook (95% CI 1263-3142), zero coho, and 471 steelhead redds (310-463) (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	149	0	2	151
	coho salmon	0	0	0	0
	steelhead	3	0	4	7
	Total Known	152	0	6	158

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)	2202 (1263 - 3142)	0	471 (310 – 633)
SE	451.6	0	77.7
Total Within Reach Variance	29.1	0	12.9
Total Between Reach Variance	1808.2	0	36.6
% Within	2%	0%	26%
% Between	98%	0%	74%
# sample reaches	22	22	22
# reaches in frame	62	72	72

Redd Abundance Estimates 2012-17

Over the past five years, the period when 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 7, Table 9). The mean Chinook redd abundance estimate in 2017-18 was 2,202, over twice as many as in the previous five seasons, while the mean estimate for steelhead of 471 is near the average for the time period.

Surveys only cover a portion of the steelhead run in both time and space – winter-run steelhead spawning continues through May (and perhaps later in wet years), and steelhead also commonly spawn in streams too steep for Chinook, so a significant amount of steelhead habitat exists outside of the Chinook and coho focused frame. Taking into account the potential spawning habitat outside of the current survey frame, and post-February spawning, we estimate that actual steelhead abundance is three-to-six times the estimate reported here. Snorkel surveys conducted in the summer confirm that steelhead parr are abundant and widespread throughout the watershed, appearing to occupy nearly all potential habitat (Queener 2018).

While we do not currently have any means of converting our redd abundance estimate to a fish abundance estimate, it seems likely that the number of adult Chinook approached or exceeded the Mattole population's recovery target of 4,000 fish (National Marine Fisheries Service 2016). This strong run of Chinook seems to offer evidence of a recovering watershed and species, although it seems prudent to see if abundance is similar in subsequent years to make sure the run of 2017-18 wasn't a chance event.

In contrast, the prospects for Mattole River coho look increasingly grim. This was the third straight year when no live adult coho salmon were observed in the Mattole watershed. Summer surveys for juveniles the last two summers have documented that YOY coho are present, but abundance and distribution appear to be declining, and distribution of parr in the summer of 2017 seemed to indicate that the previous winter's spawning activity consisted of only a few reaches in one short reach of the mainstem Mattole (Queener 2018).

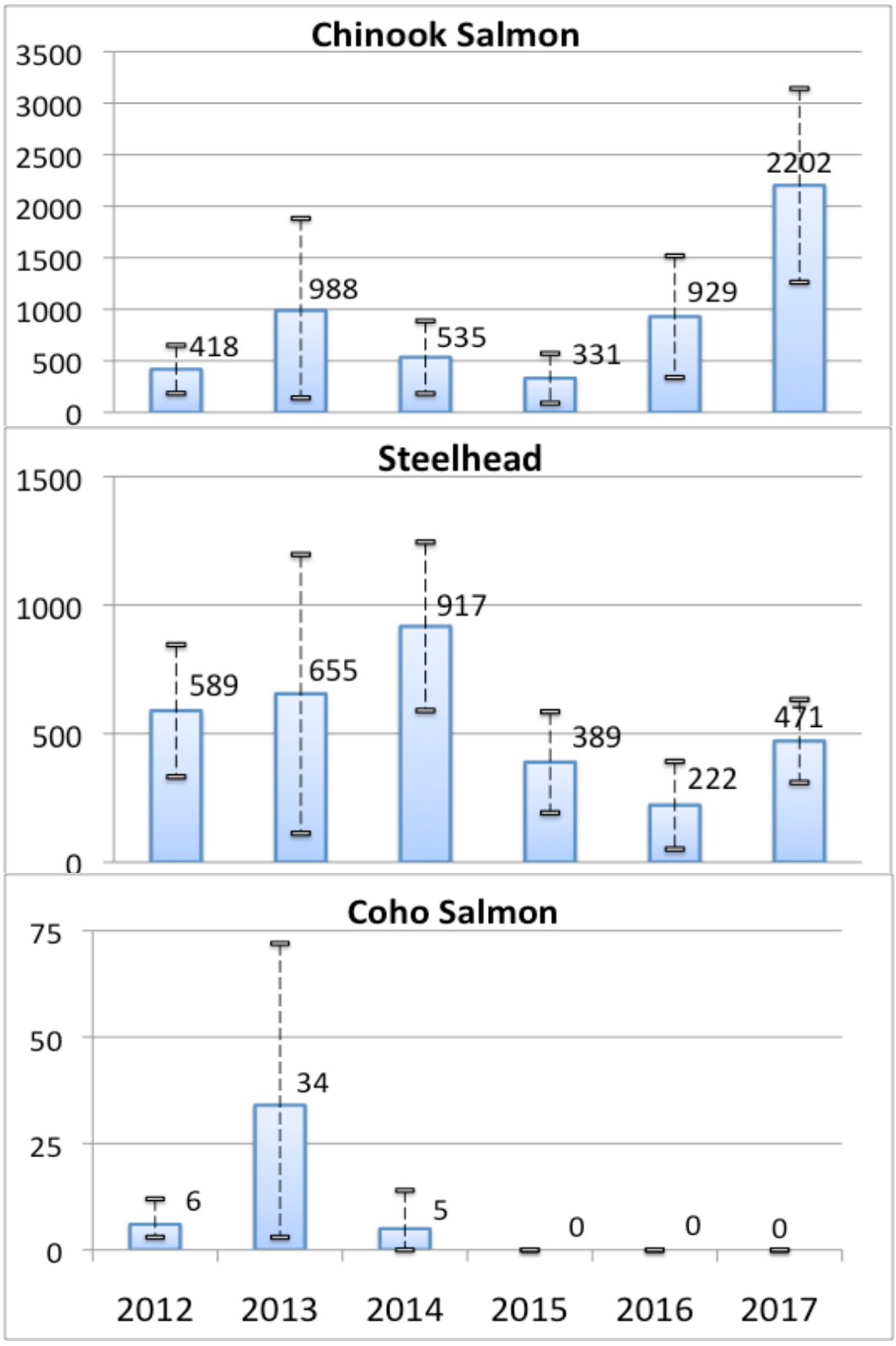

Figure 7. Redd population estimates for the Mattole watershed, 2012-2016. Numbers at top of columns are mean values for each species and year

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
2017	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
2017	Chinook Salmon	1263	2202	3142
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
2017	Steelhead	310	471	633

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