A Summary of Carpinteria Creek and the Ventura River Spawning Ground Surveys 2016 – 2018

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

ABSTRACT

This study is a continuation of monitoring efforts initiated by the Pacific States Marine Fisheries Commission in 2013 to ascertain the abundance and spatial structure of southern California steelhead (*Oncorhynchus mykiss*) via spawning ground surveys. Due to sampling concerns related to the low abundance of *O. mykiss* in southern California watersheds and the potential for patchy distribution, surveys were conducted as a complete census of available spawning habitat in in the Ventura River, Ventura County, and Carpinteria Creek, Santa Barbara County. Both of these watersheds are a high priority for steelhead recovery action (Core 1; NMFS 2012). During the 2016-2017 and 2017-2018 winter seasons, surveys were conducted from January through May on a bi-weekly basis when environmental conditions allowed. Four reaches covering 7.36 stream miles were surveyed in Carpinteria and sixteen reaches covering 41 stream miles were surveyed in the Ventura River. No *O. mykiss* or redds were observed in Carpinteria Creek for the duration of the project period. During the 2016-2017 season, a total of 11 redds and 273 individual *O. mykiss* were observed in the Ventura River. Of the 11 redds observed, 9 were found in anadromous waters, and three were located in the upper watershed above the Matilija Dam. Of all redds discovered, only a single redd was identified as likely derived from an anadromous *O.* mykiss due to its measured dimensions, substrate composition, and location within the watershed. The size structure of the fish found in the Ventura River watershed indicated a relatively young population. Most of the individual *O. mykiss* observed were 0 to 2 inches in length and located in the upper watershed. During the 2017 – 2018 survey season, zero redds were observed and just two *O. mykiss* were observed. Both trout were seen in the uppermost reach of Upper Matilija Creek, and visually estimated to be 4 – 6 inches in length. Surveys conducted during this season were hindered by a massive wildfire and subsequent flow events that limited site access and surveyor effectiveness due to poor water clarity. Multiyear comparisons were performed for visibility during surveys, redd life (i.e., the duration of time redds remained detectable), redd area, total redd count, total number of bankside observations and spatial distribution of *O. mykiss* in the Ventura River basin. Visibility, redd life, and redd area varied significantly across years included in the analyses. Post hoc tests were performed to determine which years varied significantly from others.

INTRODUCTION

A dramatic decline in southern California steelhead (*Oncorhynchus mykiss*) populations over the past century, due primarily to anthropogenic factors, has resulted in the southern California distinct population segment being listed under the Endangered Species Act (ESA). Recovery of the species, as outlined in the ESA-mandated recovery plan (NMFS 2012), aims to ensure the long-term persistence of viable, self-sustaining populations of anadromous *O. mykiss*. Guidelines for meeting monitoring goals listed in the National Marine Fisheries Service (NMFS) recovery plan were put forth by the California Department of Fish and Wildlife in Fish Bulletin 180 (Adams et al. 2011; NMFS 2012) as the California Coastal Monitoring Plan (CMP). This plan calls for intensive monitoring in key recovery watersheds within southern California, where *O. mykiss* populations are characterized by low numbers and patchy distribution.

To address these challenges, steelhead monitoring in the southern California currently focuses on conducting redd surveys as a complete census of available spawning habitat in high priority watersheds (i.e., Core 1 systems; NMFS 2012). Redd surveys can provide an index of population size and are the best available means of obtaining spatial and temporal redd data for target watersheds (Gallagher 2007). Furthermore, previous studies using redd surveys have demonstrated that steelhead and resident trout redds can be distinguished by redd size (Zimmerman and Reeves 2000). This information can provide insight into the complex interplay between resident and anadromous life history strategies in focal watersheds. This report summarizes data collected from redd surveys conducted during the 2016 – 2017 and 2017 – 2018 *O. mykiss* spawning seasons in the Carpinteria Creek and Ventura River Basins. Both of these stream systems are identified as high priority for steelhead recovery efforts.

METHODS

Survey Area

Carpinteria Creek

The Carpinteria Creek Basin consists of a high gradient upper watershed that transitions into a low elevation coastal terrace before reaching the Pacific Ocean (NMFS 2012). It drains approximately 15 square miles and has a total stream length of 35.1 miles, 7.0 miles of which are accessible to anadromous *O. mykiss* (Cachuma Conservation District and the Carpinteria Creek Watershed Coalition 2005). We sampled the anadromous waters up to the limit of anadromy (i.e., natural waterfalls), of the two principal creeks within the Carpinteria Creek Basin, which are Carpinteria Creek main stem for 4.1 miles and Gobernador Creek for 3.2 miles (CalFish 2018).

Ventura River

The Ventura River watershed consists of mountainous, high peak elevations that transition into a lower elevation coastal terrace before reaching the Pacific Ocean (NMFS 2012). It drains roughly 227 square miles and contains approximately 35 miles of anadromous water (NMFS 2012). Both the Casitas and Matilija dams act as total barriers to steelhead passage and prevent migration to spawning and rearing habitat in the upper watershed (NMFS 2012) (Figure 2). The Robles Diversion, located on the Ventura main stem 1.5 miles downstream of the confluence of Matilija and North Fork Matilija Creeks, diverts flow from the Ventura River to Lake Casitas and contains a fish-passage facility (NMFS 2012).

Data Collection

Spawning ground surveys were conducted in accordance with standardized protocols developed by California Department of Fish and Wildlife (CDFW) scientists for southern California as part of the CMP (McLaughlin and Christianson 2016). Surveys were conducted from December through May of each year. In the Carpinteria Creek watershed, four reaches comprising seven miles of potential spawning habitat were surveyed (Figure 1). In the Ventura River watershed, 16 reaches encompassing 41 stream miles of potential spawning habitat were surveyed (Figure 2). Of these, 34.5 miles were accessible to anadromous adults, while 8.2 miles were above the Matilija Dam where resident populations are known to exist. Recent studies have demonstrated the genetic similarity between populations above and below fish passage barriers within the same system (Abadía-Cardoso et al. 2016; Clemento et al. 2009). We therefore considered these above-dam resident populations to be important to steelhead monitoring efforts.

Individual reach designations were determined by the sampling frame currently under development by CDFW CMP and Fisheries Branch biologists. Reaches began and ended at easily identifiable landmarks (e.g. bridges or stream confluences) and were designed to be completed in a single day. These reaches ranged in length from 1.3 to 4.5 stream miles with a mean of 2.5 $\pm$ 0.17 miles (mean ± SE).

Surveys were conducted every two weeks throughout the survey season when stream flows, and weather permitted. Two weeks is the minimum amount of time redds remain detectable in southern California stream systems (R. Bush, National Marine Fisheries Service, unpublished data). Teams of two to three surveyors walked reaches in an upstream direction recording observations on handheld data recorders. All fish observed were identified to species. For each *O. mykiss* observation, a total length estimate (in 2-inch size bins), location, and life history stage (when possible) were recorded.

When redds were first observed, measurements were taken for pot and tail spill dimensions. For pot dimensions, we measured pot length, width, and depth relative to the adjacent streambed. For tail spill dimensions, we measured tails spill length and width measurements were taken at 1/3 and 2/3 the distance from the upstream end of the tail spill. Dominant substrate size was also recorded for both the pot and tail spill. Redds were identified with a flag denoting the redd record number, distance and bearing of the redd from the flag location, date the redd was first identified, and redd age. Redd ages were categorized as the following: 1 - New since last survey, 2 - Previously identified and still measureable, 3 - No longer measureable but still visible, and 4 - No redd apparent. Redd ages were updated and recorded during subsequent observations. Redds were re-measured when pot and tail spill dimensions had noticeably changed following their initial observation.

Data Analysis

To examine survey frequency, we calculated the mean $\pm$ SE number of days between surveys. Water visibility was examined as a metric for redd detectability. Visibility measurements were classified as either “clear” (i.e., visibility = 100%) or “not clear” (visibility < 100%) for each survey. The mean $\pm$ SE number of surveys where visibility was 100% was calculated by reach and by watershed for each year.

We mapped the distribution of redds observed during the spawning season using ArcGIS 10.1 (ESRI, Redlands, California) and R Software (R Core Team. 2016). To examine all redd observations, we calculated area and total redd length for each redd. Redd area was calculated as the sum of pot and tail spill areas per Gallagher et al. (2007). Total redd length was calculated as the sum of the pot and tail spill lengths. Redd dimensions and area were used to compare the relative sizes of all redds observed and to indicate those produced by anadromous *O. mykiss*. Due to low sample size, we reported the mean ± SE dimensions across all redds, regardless of their location or hypothesized origin (anadromous or non-anadromous). Finally, we examined trout observation counts by size class and their spatial distribution by mapping observation locations.

To characterize any potential changes over time, we compared data collected from surveys conducted in the Ventura River in 2017 and 2018 with data collected from 2013 through 2016. We examined redd counts, redd area, redd life (i.e., the duration of time redds remained detectable), O. *mykiss* bankside observation totals and visibility versus year for trends per Gallagher (2005). When evaluating redd and trout count data, comparisons were drawn from data where survey effort was consistent (i.e., years 2015 – 2018). Analyses of redd life by year were only performed for redds in years where a final status indicating that they were no longer visible (i.e., redd age 4) was recorded. All redds recorded from 2013 – 2018 were included in our examination of redd area versus year due to low sample size. Visibility comparisons were also drawn between all years from 2013 – 2018. All analyses were completed using R software.

RESULTS

Carpinteria Creek

2016 – 2017

Twenty-five redd surveys were conducted over four reaches in the Carpinteria Creek Basin from December 14, 2016 to May 24, 2017. During the survey season, above-average rainfall led to periods of high flow and extended periods of low visibility due to high turbidity. These conditions affected sampling frequency in some cases (

Table 1). The mean ± SE number of days between surveys was 16.3 ± 0.86 days and 92% of surveys were completed with 100% visibility. No redds or *O. mykiss* were observed in either Carpinteria or Gobernador Creeks during the 2016–2017 spawning season.

2017 – 2018

Twenty-five redd surveys were conducted over four reaches in the Carpinteria Creek Basin from January 3, 2018 to April 4, 2018 during the 2017 – 2018 spawning season. A large-scale wildfire, the Thomas Fire, burned 50% of watershed in December of 2017 (Klose 2018) (Figure 4). A high intensity storm event immediately following the fire lead to widespread mobilization of soil and burn debris. The combined impacts of these events lead to long-term road closures and high levels of sustained turbidity in Carpinteria Creek. These factors limited surveyor effectiveness due to restricted access and high turbidity. The mean ± SE number of days between surveys was 15.86 ± 0.79 days and 72% of surveys were completed with 100% visibility. No redds or *O. mykiss* were observed in either Carpinteria or Gobernador Creeks during the 2017–2018 spawning season.

Ventura River

2016 – 2017

One hundred and fifty redd surveys were conducted over 16 reaches from December 21, 2016 to May 25, 2017 during the 2016–2017 spawning season. During this time, above-average rainfall led to periods of flow exceeding safe surveying conditions for some reaches. These conditions had a direct effect on sampling frequency, particularly in the upper watershed including reaches in Matilija Creek (Table 2). The time between surveys was typically greater than 14 days with a mean ± SE number of days between surveys of 18.36 ± 1.32 days. With regards to water clarity 87% of surveys were completed with 100% visibility.

A total of eleven redds were observed during the 2016–2017 spawning season. All redds were initially detected in February and March. The first was observed on February 13, 2017, and the last on March 30, 2017. Redds were detected in six reaches, most of which were in the upper watershed (Figure 2). Eight of the 11 redds observed were in anadromous waters (Figure 2).

The redd in closest proximity to the Pacific Ocean was observed nine miles upstream of the Ventura River mouth in San Antonio Creek (Figure 2). The pot dimensions recorded for this redd were 28 inches for length, 20 inches for width and 4 inches for depth. These dimensions were the largest of all redds observed (Table 3). All other redds located in anadromous reaches (n=7) were observed in North Fork Matilija Creek upstream of the Robles Diversion and more than 18 miles from the Pacific Ocean. All redds observed upstream of the Matilija Dam (n=3) were all found on the upper-most reach of Matilija Creek (i.e., Upper Matilija 3) (Figure 2). The estimated redd life (i.e., the duration of time redds remained detectable) was of 21 ± 3.07 days (mean ± SE). Redd lifespan was only calculated for redds where a final status indicating that they were no longer visible (i.e., redd age 4) was recorded (n= 7).

A total of 270 bankside observations of *O. mykiss* were recorded. A total of 202 trout were observed in non-anadromous reaches above the Matilija Dam, and 68 were observed in North Fork Matilija Creek. Estimated trout lengths ranged from 0 – 2 inches to 10 - 12 inches with the majority of observations (n = 147) (54%) falling in the 0 to 2-inch size class (Figure 3).

2017 – 2018

One hundred and four redd surveys were conducted over 18 reaches from December 28, 2017 to May 9, 2018 during the 2017–2018 spawning season in the Ventura River basin. Similar to what occurred in Carpinteria Creek; the Thomas Fire burned 80% of the Ventura River watershed (Klose 2018) (Figure 4). The previously described storm event had similar effects on data collection efforts in the Ventura River basin in the form of access limitations and high turbidity. The number of days between surveys was typically greater than 14 with a mean ± SE of 19.90 ± 1.07 days. With regards to water clarity 54% of surveys were completed with 100% visibility.

No redds were observed in the Ventura River watershed during the 2017 – 2018 survey season. Two *O. mykiss* were observed bankside. Both trout were observed on April 24, 2018 in the uppermost reach of Upper Matilija Creek (i.e., Upper Matilija 3), and were both estimated to be 4 – 6 inches in length.

Multiyear Comparisons

The proportion of surveys where visibility was 100% varied significantly in the Ventura River watershed among years 2013 – 2018 ($\chi 2 = 46.26$; d.f. = 5; $p < 0.001$) (Figure 5). Post-hoc pairwise testing revealed that 2018 alone differed significantly from all other years ($p < 0.001$).

An analysis of variance showed there was a significant effect on estimated redd life by survey year from 2014 – 2017 in the Ventura River basin (ANOVA: f = 6.1; d.f. = 1, 30; $p < .05$) (Figure 6). A pairwise t-test conducted using Bonferroni adjusted alpha levels ($\alpha = .008$), showed that estimated redd life only varied significantly between years 2015 and 2017 ($p = 0.004$).

Redd area was found to vary significantly between years 2013 – 2018 in the Ventura River (ANOVA: $f = 9.26$; d.f. = 4, 122; $p < .01$) (Figure 7). Post hoc analysis indicated that 2017 was the only year where redd area was significantly different from all other years, with the exception of 2013 (Tukey multiple comparisons test, $p < 0.05$) (Table 6).

Total redd count and survey year were strongly negatively correlated for years 2015 – 2018 in the Ventura River ($r = -0.967$; $n = 4$; $p < 0.05$) (Table 7). However, our small sample size yielded a relatively low level of statistical power (0.65) for this test.

The mean $\pm$ SE total number of bankside observations for years 2015 – 2017 was 281 $\pm$ 39 trout in the Ventura River. The total number of *O. mykiss* bankside observations decreased by two orders of magnitude in 2018 ($n = 2$) and was less than 1% of the mean number of observations for the previous three years (Table 8).

Spatial distribution of *O. mykiss* bankside observations across all years in the Ventura River (i.e., 2013 – 2018), show the majority of observations (i.e., 94%) were recorded in the upper watershed (i.e., upstream of the confluence of North Fork Matilija Creek and Upper Matilija Creek) (Figure 9). Redd observations recorded during the same timeframe exhibited a similar distribution pattern with 88% of redds being observed in the upper watershed (Figure 10).

DISCUSSION

The 2016–2017 spawning season was characterized by above-average rainfall, resulting in peak flows exceeding 21,000 $ft^3\ s^{-1}$ in the Ventura River main stem and 1,000 $ft^3\ s^{-1}$ in the Carpinteria Creek main stem (USGS 2018). Elevated flows led to persistent turbidity and increased depths throughout both watersheds, preventing the completion of scheduled surveys during the months of February and March. This interruption in sampling coincided with what has historically been an active spawning period in the Ventura River watershed (Figure 8) and may have influenced redd counts.

Only 11 redds were recorded for the entire season in the Ventura River basin in 2016 - 2017. It is likely that the previously described storm events obscured or destroyed redds during peak flows in February and March. Due to flow impacts and overall low redd count, it was impossible to draw any meaningful conclusions regarding redd distribution or lifespan. However, increased flow led to more connectivity in the lower watershed than in previous years. Migration corridors allowing anadromous individuals to reach spawning habitat in San Antonio Creek and North Fork Matilija Creek remained passable into late spring. Unfortunately, despite the increased opportunity for anadromous adults to enter the system, no anadromous adults were observed.

The redd dimensions observed in 2017 generally coincided with what would be expected for smaller resident individuals in the Ventura River watershed (California Department of Fish and Wildlife, unpublished data). The mean total length of redds observed in the Ventura River Basin was 12.24 inches, which is substantially smaller than those documented in the Pacific Northwest, which regularly exceed 80 inches (Zimmerman and Reeves 2000). A single redd was recorded in San Antonio Creek with a pot length of 27.5 inches, which was appreciably larger than both the mean size of all redds (12.2 inches) and size of the next largest redd (length of 14 inches). Notably, the redd's substrate composition was also substantially larger than all other observed redds, with particles sized at 2.4 inches compared to the mean

0.45 (±SE) inches. Together, these observations suggest that the redd in San Antonio was constructed by a larger female compared to those that constructed redds elsewhere. While there is a possibility this redd could have been built by a large resident female, the difference in size suggests the redd was constructed by an anadromous female.

For all *O. mykiss* observations in the Ventura River watershed in 2017, none exceeded 12 inches in estimated length. This falls well below the California Department of Fish and Wildlife's listed minimum steelhead length of 16 inches (California Department of Fish and Wildlife 2017). Additionally, trout were only observed in the upper watershed, at least 16.7 river miles from the Pacific Ocean. Both size and location data strongly suggest that all *O. mykiss* observed were resident forms. Of the 270 *O. mykiss* recorded in 2017, 147 were estimated as 0–2 inches in length. This size class represents what would be expected for trout born within the past year (i.e., young of the year). Of the six reaches where 0–2 inch trout were observed in 2017, three of them corresponded to reaches where redds were observed. The presence of trout this size suggests successful *O. mykiss* spawning occurred in three reaches where redds were not detected. This may be explained by the lower sampling frequency for reaches in the upper watershed due to increased flow and reduced visibility.

Elevated turbidities were consistently problematic throughout the 2017 – 2018 survey season. In the Ventura River watershed, turbidity was particularly challenging and lead to a sizeable number of surveys (n = 48) being completed under sub-optimal conditions. The prevalence of limited visibility may have negatively biased redd counts due to missed observations. However, the absence of 0-2 inch *O. mykiss* observations (i.e., the size corresponding to young of the year) supports a lack of spawning activity in Ventura River watershed during the 2017 – 2018 season. The degree to which poor water clarity influenced surveys in 2017 – 2018 is further emphasized when compared this data with previous years via a chi-square test of independence. A post-hoc pairwise test showed that 2018 was the only year where the proportion of surveys where visibility was < 100% differed from all other years. We surmise that this significant change in turbidity was a secondary effect of the Thomas Fire due to destabilization of stream hillslopes resulting from loss of vegetation to the fire (Klose 2018). Additional years of data are needed to further explore the long-term effects of wildfires on redd survey efficacy in southern California watersheds.

The 95% CI [36.60, 50.90] of the mean estimated redd life (43.8 ± 3.51 [mean ± SE]) for all redds observed from 2014 – 2017 suggests a survey frequency of two weeks should allow for detection of new redds before they degrade to an extent where they are no longer visible. In practice; however, this is complicated by high flow events that may erase redds before they can be observed. In cases where high flow events were anticipated, we attempted to survey reaches where the risk for redds to be obscured was highest (i.e., reaches where stream gradient and wildfire burn severity were both relatively high). Continued tracking of redd life in subsequent years will further increase our understanding of redd longevity in southern California systems and its implications for survey methodology.

Mean redd areas observed in the Ventura River from 2013 to 2017 ranged from 1.54 ft^2 to 3.39 ft^2. These sizes are much smaller than the areas of steelhead redd observed in northern California (e.g., 19.15 ft^2) (Gallagher and Gallagher 2005). Based on our findings, and with the support of evidence provided by a sonar count station operated in the lower Ventura River concurrently with redd survey efforts, we believe that all redds observed in the Ventura River from 2013 – 2017 with the potential exception of a single redd in 2017 were produced by resident rainbow trout.

When comparing data collected in Ventura River from the 2016-2017 spawning season to data collected during the 2017-2018 season, there are considerable differences in *O. mykiss* redd and bankside observations. Our data show that in 2018, the total number of bankside observations of trout decreased by > 99%. The 2017 – 2018 season also represents the first time since redd surveys were initiated in the Ventura River by National Marine Fisheries staff in 2009 that zero redds were observed (R. Bush, National Marine Fisheries Service, unpublished data). These results are likely due to the combined effects of the Thomas Fire and persistent drought conditions. Mean annual rainfall for the past five years has been 62% and 65% of historical averages for the Carpinteria Creek and Ventura River watersheds respectively (Santa Barbara County Public Works Department 2018, Ventura Watershed Protection District 2018). The negative synergistic effects of wildfire and drought have likely lead to the depressed number of *O. mykiss* in the Ventura River basin and the apparent absence of *O. mykiss* in the Carpinteria Creek watershed. Continued monitoring of these systems that have been assigned a high priority for recovery action via redd surveys will be a critical step toward better understanding of southern California steelhead recovery in response to extreme environmental conditions (NMFS 2012).

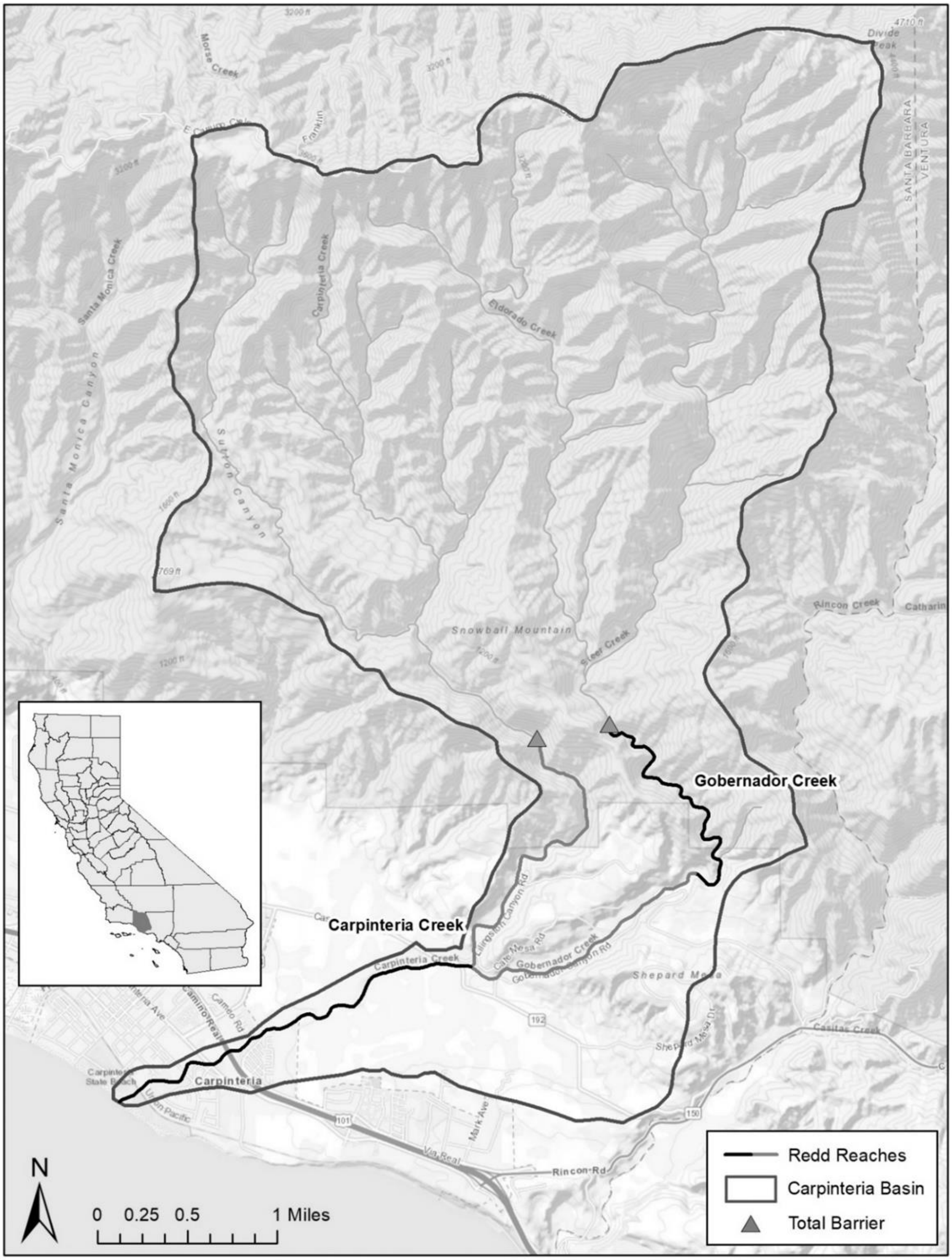

Figure 1. The Carpinteria Creek watershed with survey reaches indicated.

Figure 2. The Ventura River watershed with survey reaches and redd observations recorded in 2016 – 2017 indicated.

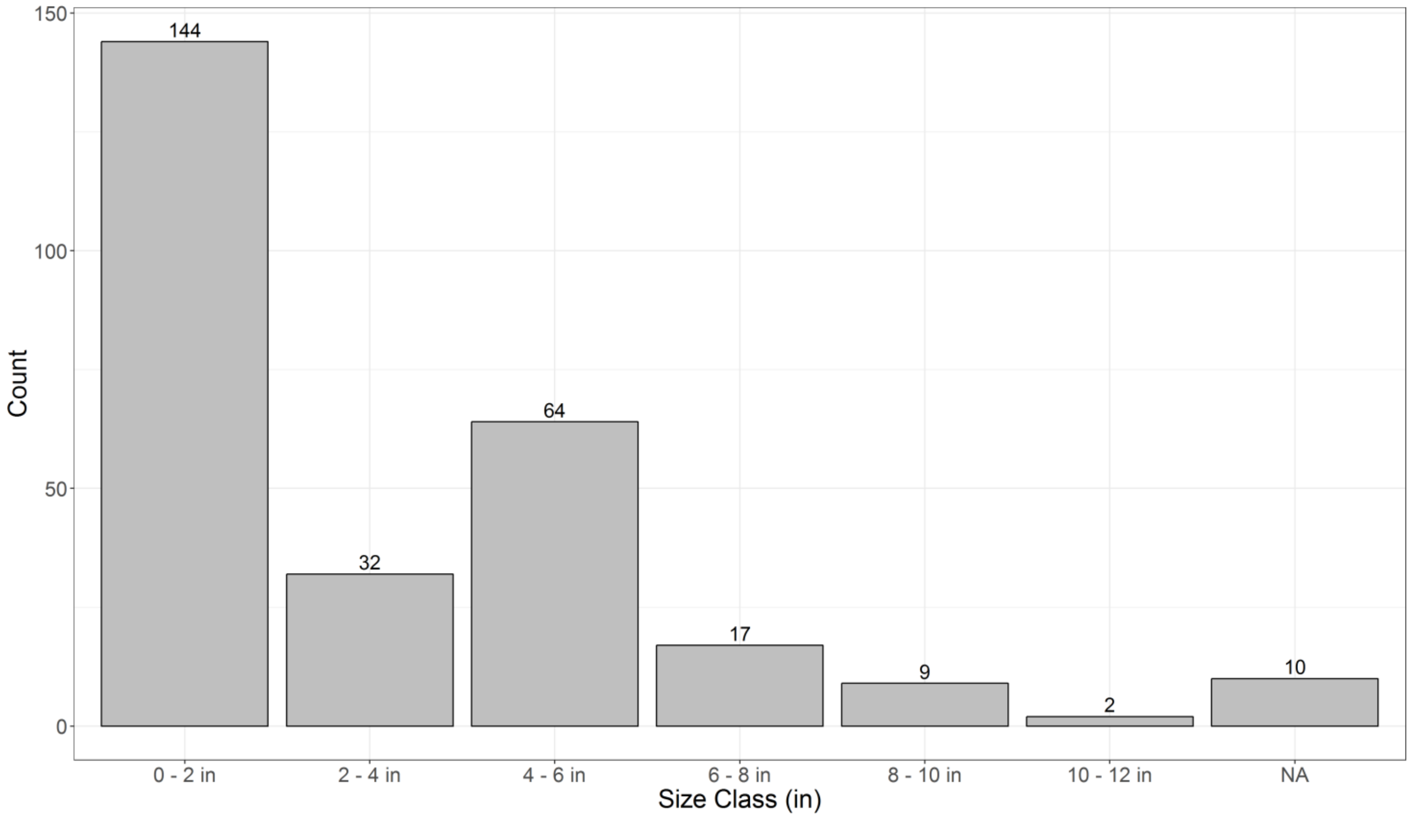

Figure 3. *Oncorhynchus mykiss* observation totals for the Ventura River in 2016 – 2017 binned into 2-inch size classes. NA indicates observations where length data were not recorded.

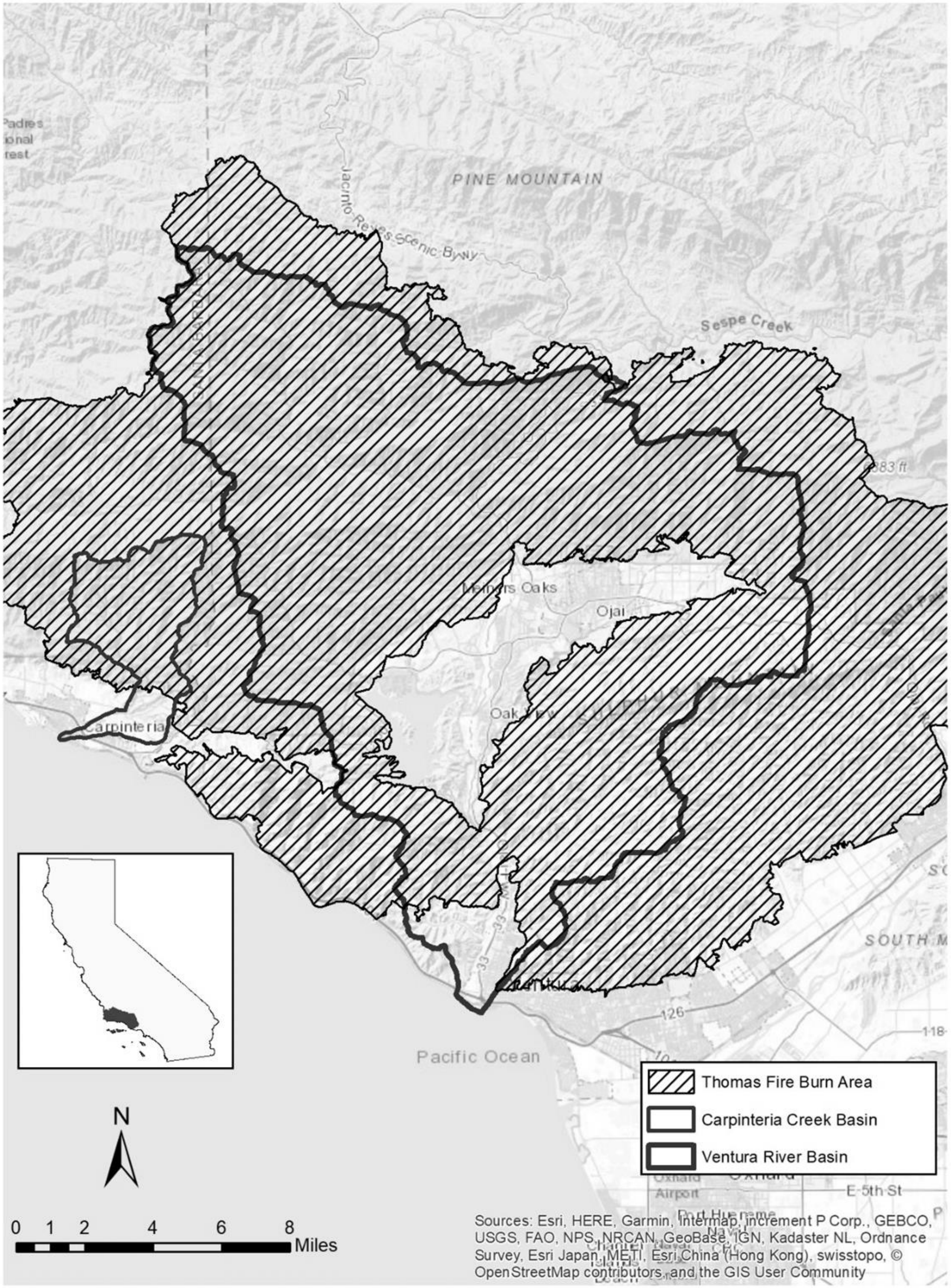

Figure 4. The Carpinteria Creek and Ventura River basin boundaries overlaid by the area affected by the Thomas Fire.

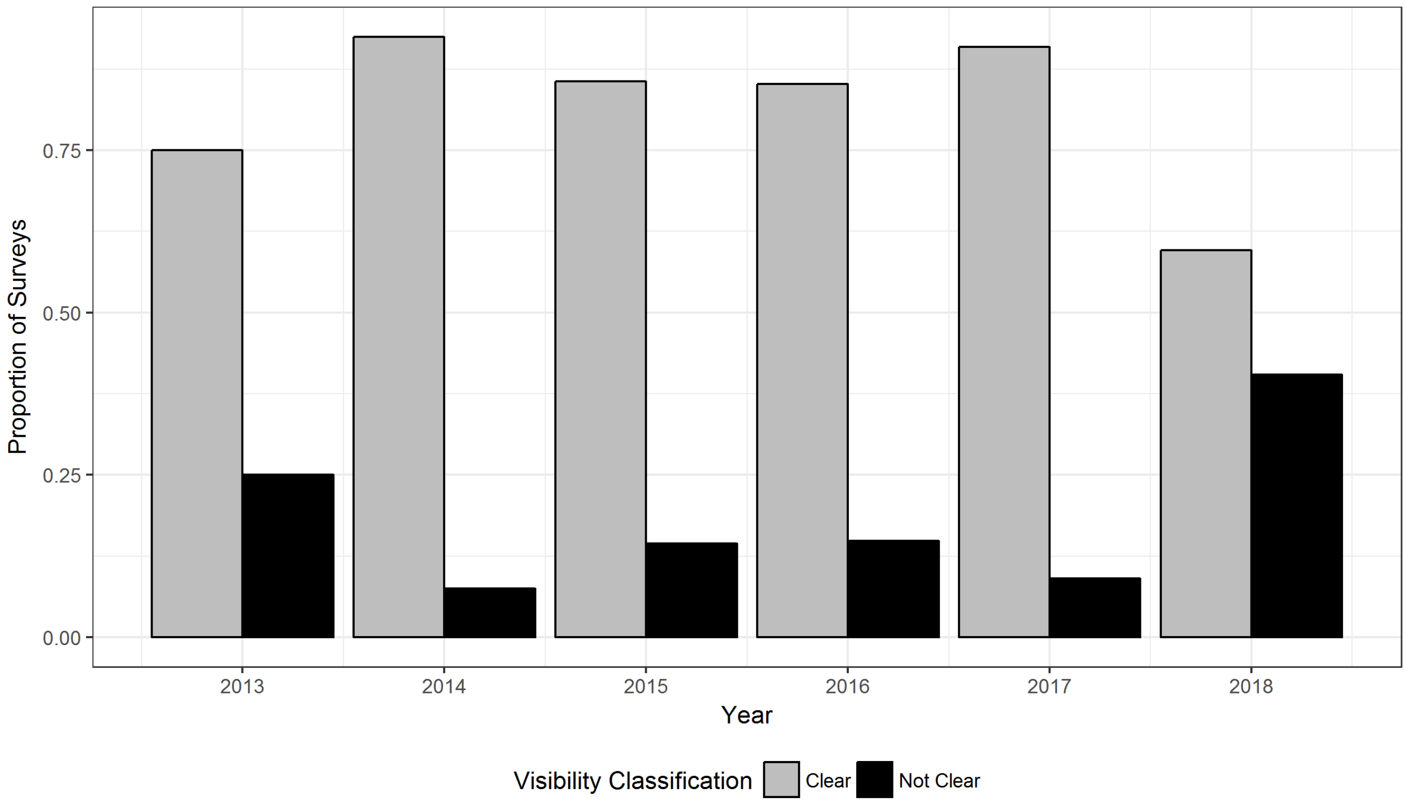

Figure 5. The proportion of surveys where visibility was 100% (i.e., Clear) compared with those where visibility was less than 100% (i.e., Not Clear) for years 2013 to 2018 in the Ventura River basin.

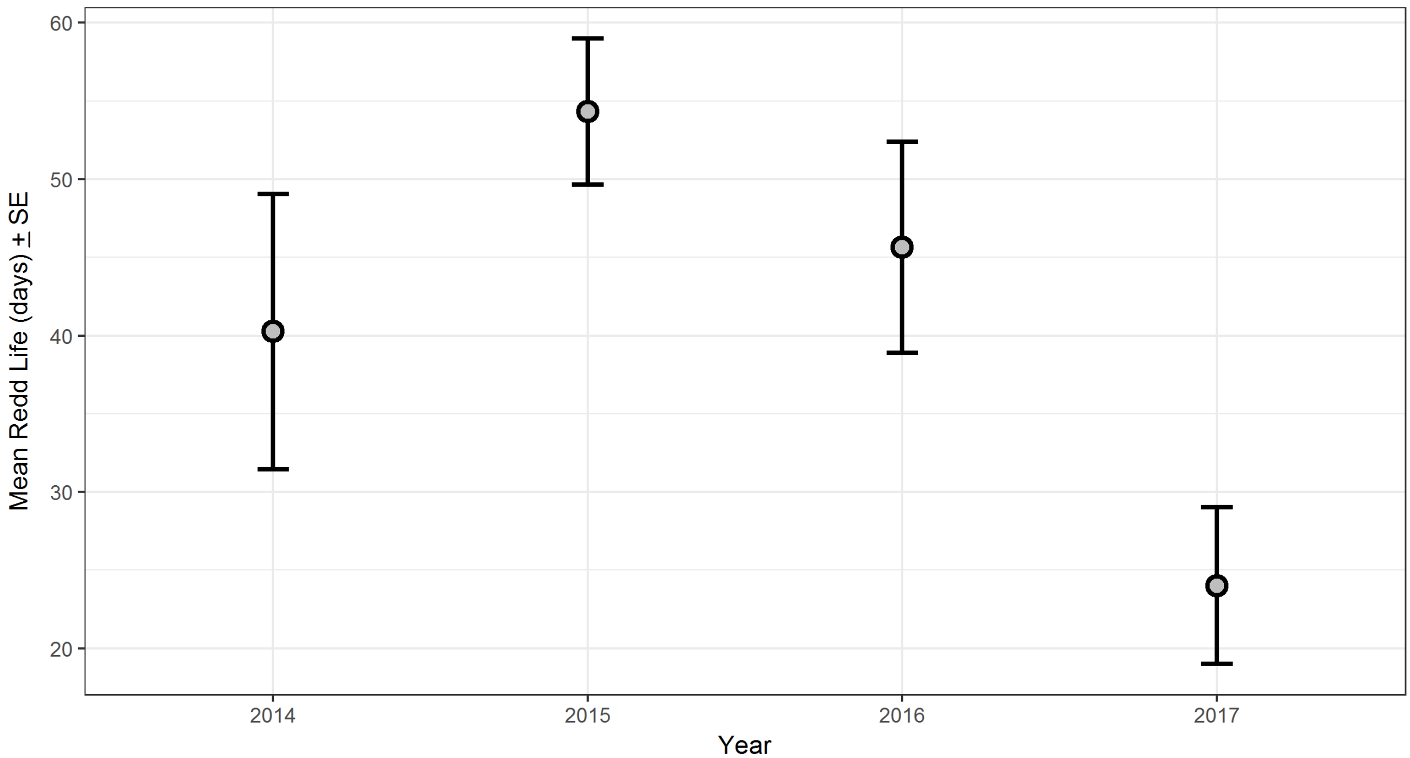

Figure 6. Mean estimated *Oncorhynchus mykiss* redd life in days by year in the Ventura River basin. Vertical bars indicate standard error.

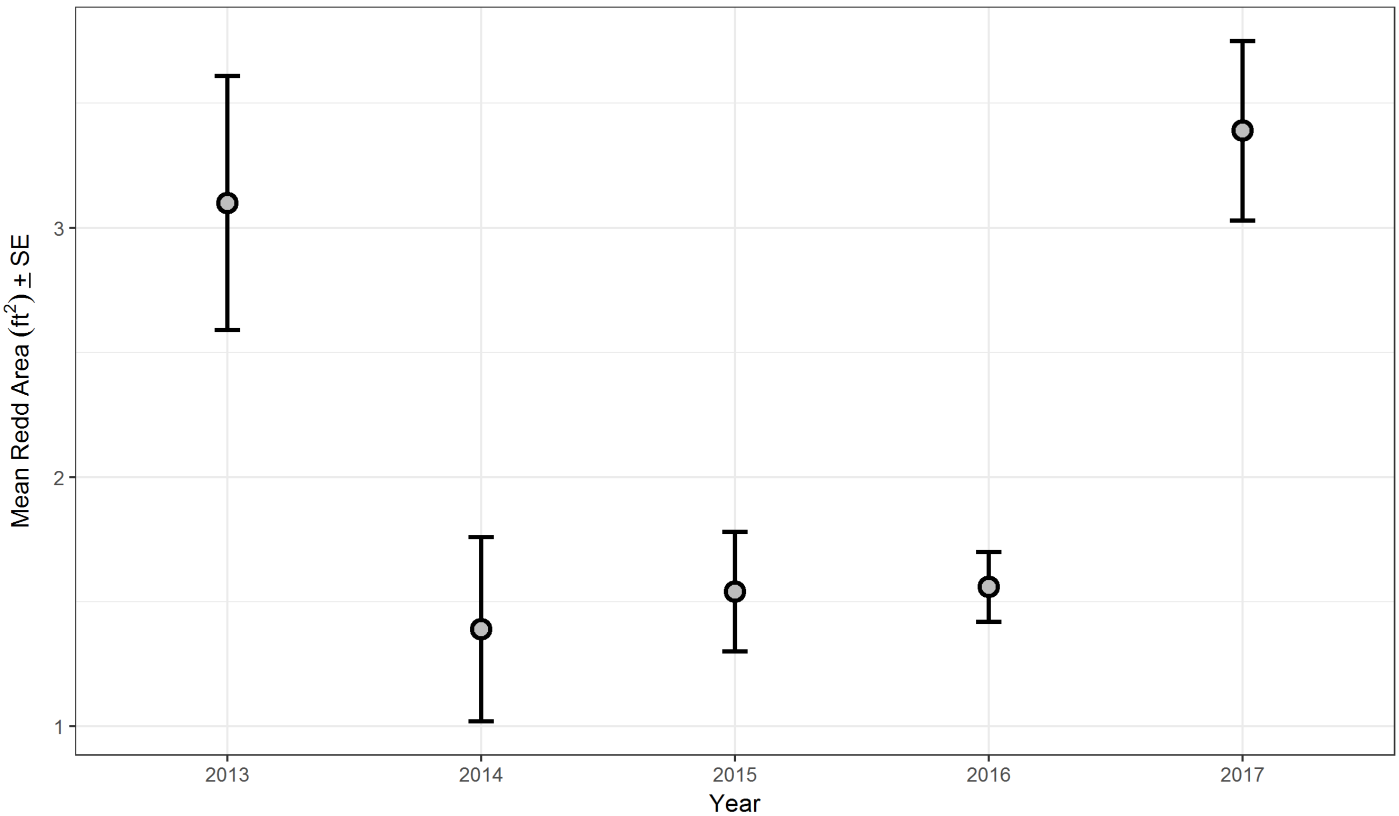

Figure 7. Mean *Oncorhynchus mykiss* redd area in ft^2 versus year in the Ventura River basin. Vertical bars indicate standard error.

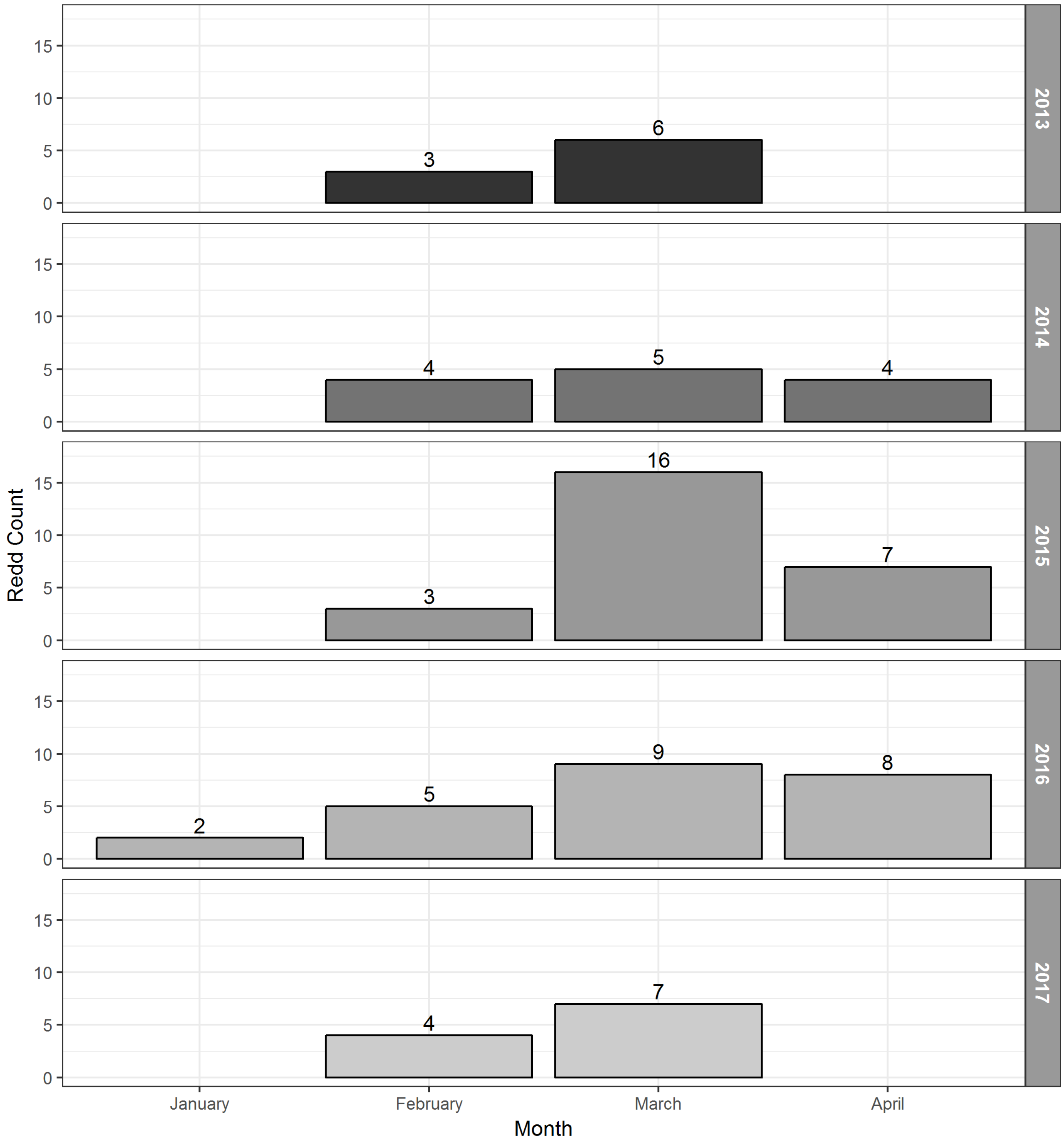

Figure 8. Monthly redd counts for years 2013 – 2017 in the Ventura River watershed.

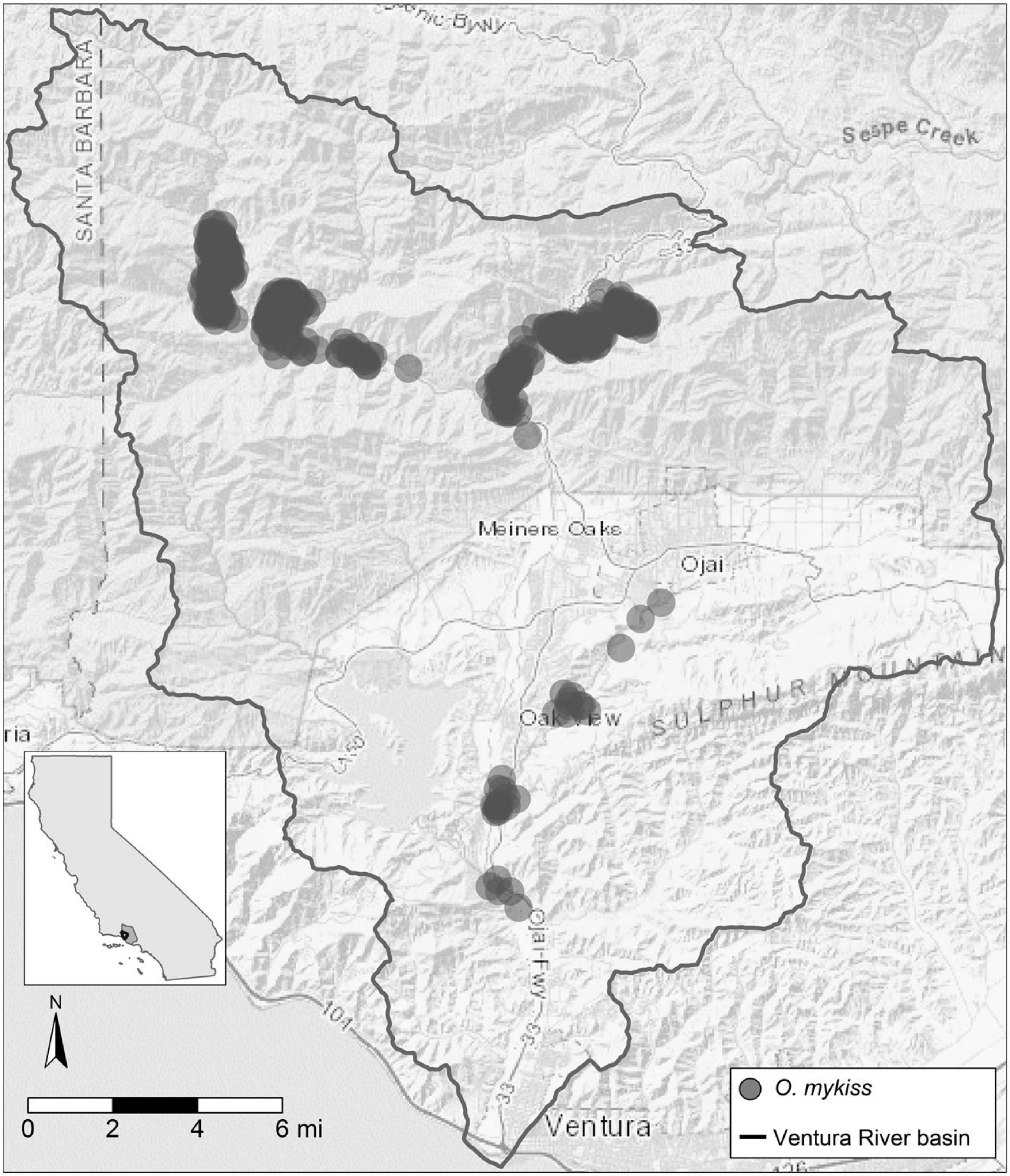

Figure 9. Bankside *Oncorhynchus mykiss* observation locations from 2013 – 2018. Random noise has been added to observation positions to offset overlapping points.

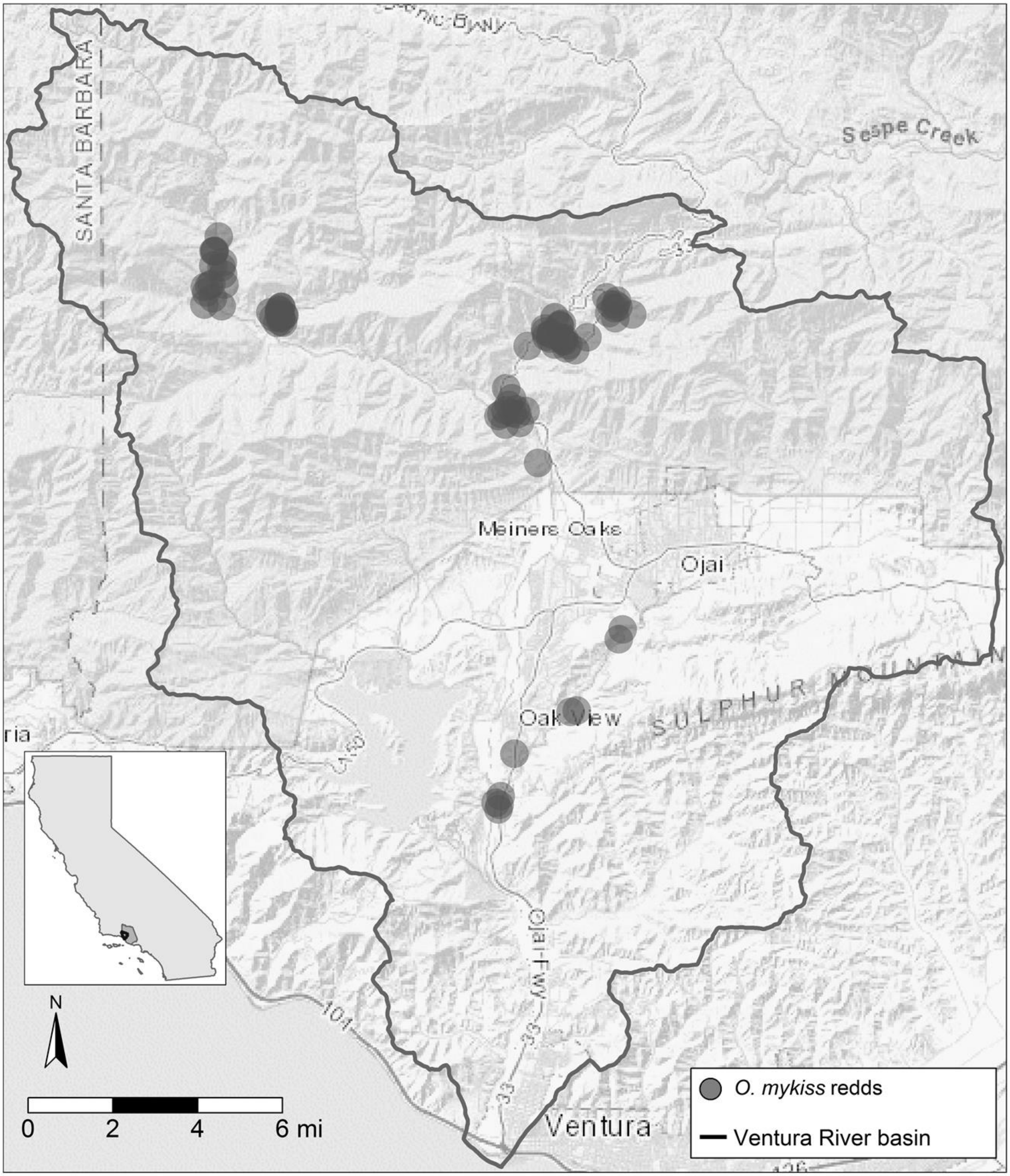

Figure 10. *Oncorhynchus mykiss* redd locations recorded from 2013 – 2017. Random noise has been added to observation positions to offset overlapping points.

Table 1. Redd survey frequency by reach in the Carpinteria Creek watershed for 2016 - 2017.

Reach	*N*	*Mean (days)*	*SE*
Carpinteria Creek 1	5	13.75	1
Carpinteria Creek 2	10	17.11	2
Gobernador Creek 1	5	17.25	4
Gobernador Creek 2	5	17.25	4

Table 2. Redd survey frequency by reach in Ventura River watershed for 2016 - 2017.

Reach	*N*	*Mean (days)*	*SE*
Bear Creek	11	15.5	0.91
North Fork Matilija 1	10	14.56	1.83
North Fork Matilija 2	9	15.62	2.15
North Fork Matilija 3	2	61	NA
Upper Matilija Creek 1	6	29.4	12.21
Upper Matilija Creek 2	6	30.2	12.54
Upper Matilija Creek 3	9	18.88	6.21
Upper North Fork	8	22	6.76
Lion Creek	8	18.86	2.86
San Antonio Creek 1	11	14.5	1.06
San Antonio Creek 2	11	14.5	1.06
San Antonio Creek 3	7	23.5	4.7
Ventura River 1	10	15.44	0.94
Ventura River 2	10	15.44	0.85
Ventura River 3	11	14	1.04
Ventura River 4	11	14.1	1.08
Ventura River 5	9	17.25	3.2

Table 3. Mean ± SE measurements for redds observed in the Ventura River watershed in 2016 - 2017.

Measurement	*Mean (in.)*	*SE*
Pot Depth	1.83	0.38
Pot Length	11.6	1.99
Pot Substrate	1.07	0.17
Pot Width	11.49	2.11
Tail Spill Length	17.97	2.24
Tail Spill Substrate	0.5	0.08
Tail Spill Width 1	13.1	1.83
Tail Spill Width2	9.34	1.38
Total Length	29.56	3.65

Table 4. Redd survey frequency by reach in the Carpinteria Creek watershed for 2017 - 2018.

Reach	*N*	*Mean (Days)*	*SE*
Carpinteria Creek 1	7	17.5	2.11
Carpinteria Creek 2	6	15.2	1.3
Gobernador Creek 1	6	15.2	1.3
Gobernador Creek 2	6	15.2	1.3

Table 5. Redd survey frequency by reach in the Ventura River watershed for 2017 - 2018.

Reach	*N*	*Mean (Days)*	*SE*
Bear Creek	4	24	10
Matilija Creek 1	4	30	15
Matilija Creek 2	5	22.5	4.5
Matilija Creek 3	5	22.5	4.52
North Fork Matilija 1	4	23.33	7.84
North Fork Matilija 2	4	23.33	7.84
Upper North Fork	4	27.67	9.94
Lion Creek	6	23.8	6.46
San Antonio Creek 1	8	17.57	1.76
San Antonio Creek 2	9	15.38	2.03
San Antonio Creek 3	6	25.2	4.44
Stewart Creek	7	19.83	2.41
Ventura River 1	8	18.14	2.63
Ventura River 2	8	17.86	2.56
Ventura River 3	8	16.86	2.61
Ventura River 4	8	16.57	3.39
Ventura River 5	3	12.5	1.5
Ventura River 5.1	3	12.5	1.5

Table 6. Mean *O. mykiss* redd area for years 2013 – 2017 in the Ventura River watershed. Means followed by the same letter did not differ significantly (Tukey test, $p < 0.05$).

Year	*Mean Redd Area* (ft^2)	*SE*
2013	3.1 AB	0.51
2014	1.39 B	0.37
2015	1.54 B	0.24
2016	1.56 B	0.14
2017	3.39 A	0.36

Table 7. Total *Oncorhynchus mykiss* redd counts for years 2015 to 2018 in the Ventura River watershed.

Year	*Redd Count*
2015	26
2016	24
2017	11
2018	0

Table 8. Total *Oncorhynchus mykiss* bankside observations for years 2015 to 2018 in the Ventura River watershed.

Year	*O. mykiss Observations*
2015	357
2016	227
2017	260
2018	2

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