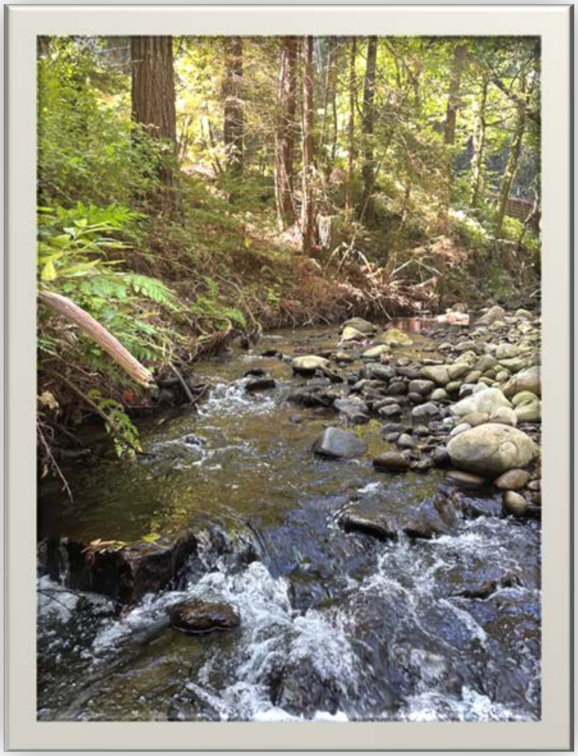
2023 Juvenile Steelhead Densities in the Corralitos Creek and Casserly Creek Watersheds



Prepared for:

City of Watsonville,
275 Main Street, Suite 400
Watsonville, CA 95076

Pajaro Valley Water Management Agency
36 Brennan Street
Watsonville, CA 95076

Prepared by:
Mike Podlech, Aquatic Ecologist

With Field Assistance From:
Kittleson Environmental Consulting

December 4, 2023

Background

The City of Watsonville (City) owns and operates water diversion facilities on Corralitos Creek and one of its tributaries, Browns Creek, in the Salsipuedes Creek watershed, tributary to the Pajaro River in Santa Cruz County. As part of prior permit obligations for the operation of the diversion facilities, the City has been funding annual assessments of juvenile steelhead (*Oncorhynchus mykiss*) densities in the watershed. Since 2020, the City has voluntarily continued its commitment toward monitoring fish populations in the watershed and thereby contribute toward countywide steelhead monitoring efforts.

The Pajaro Valley Water Management Agency (PV Water) is currently constructing the College Lake Integrated Resources Management Project. The project will divert up to 3,000 acre-feet of water annually from College Lake, located on Salsipuedes Creek, for treatment, transmission, and distribution for agricultural irrigation. College Lake is a naturally occurring, seasonally wet depression that receives water inflows from the Green Valley, Casserly, and Hughes creeks sub-watersheds. College Lake provides seasonal juvenile steelhead rearing habitat (Podlech, 2011) and Casserly Creek is known to support a steelhead population (Smith, 2010; Alley 2017). In an effort to build upon existing baseline steelhead population data upstream of College Lake, PV Water has been funding fish surveys at a previously sampled site on Casserly Creek since 2020. This report summarizes the results of the 2023 juvenile steelhead densities assessments in the Corralitos Creek and Casserly Creek watersheds.

Methods

Sampling Sites

Fish surveys were conducted at seven sampling sites in the Corralitos Creek watershed and one site in the Casserly Creek watershed between September 25 and October 4, 2023. Sampling sites were selected in 2018 and are located in the vicinity of sites previously sampled by D. W. Alley & Associates (Alley) as part of the annual *Juvenile Steelhead Densities in the San Lorenzo, Soquel, Aptos and Pajaro Watersheds* monitoring program conducted for the County of Santa Cruz (County) and its partners. Individual sampling sites were selected to be representative of overall stream reach characteristics. Sampling site locations are summarized in Table 1 and depicted in Figures 1 and 2.

TABLE 1

2023 SAMPLING SITES IN THE CORRALITOS CREEK AND CASSERLY CREEK WATERSHEDS

Sampling Site	Site ID	Coordinates (UTM)	Alley Site ID
Corralitos Creek below Browns Creek confluence	**CO-0**	10 N 0606456 4094453	Corralitos #0
Corralitos Creek downstream of diversions site	**CO-1**	10 N 0606093 4096068	Corralitos #1
Corralitos Creek upstream of diversions site	**CO-3**	10 N 0605739 4096633	Corralitos #3
Corralitos Creek downstream of Shingle Mill Gulch	**CO-9**	10 N 0605083 4100092	Corralitos #9
Browns Creek downstream of diversions site	**BR-1**	10 N 0607660 4097304	Browns Valley #1
Browns Creek upstream of diversions site	**BR-2**	10 N 0608348 4098264	Browns Valley #2
Shingle Mill Gulch downstream of Grizzly Flat	**SM-3**	10 N 0606599 4100478	Shingle Mill #3
Casserly Creek downstream of Mt Madonna Rd.	**CA-3**	10 N 0612189 4094311	Casserly #3

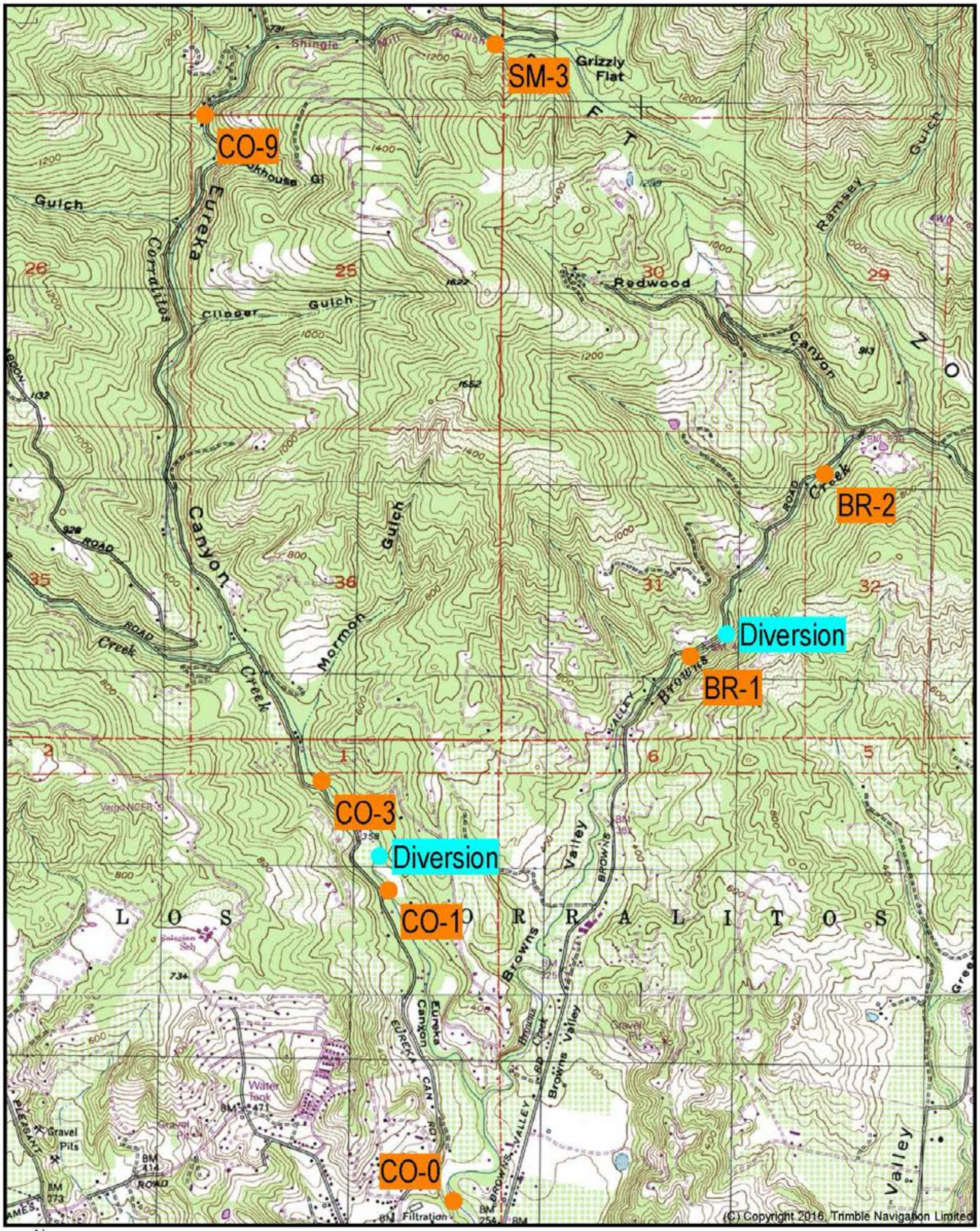
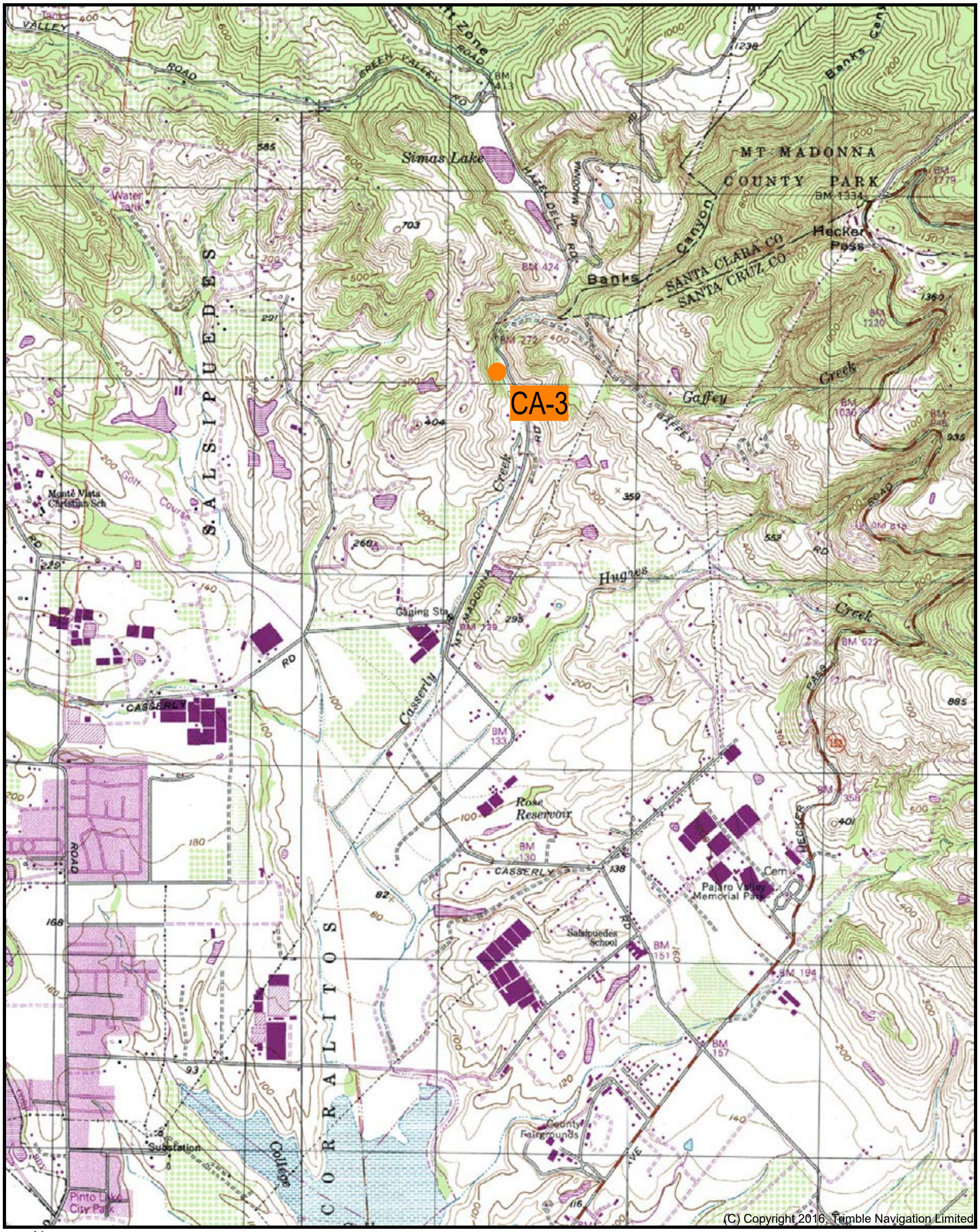


Figure 1. Sampling Sites in the Corralitos Creek Watershed



N

Figure 2. Sampling Site in the Casserly Creek Watershed

0 1000 2000 3000
Feet

Habitat Assessments

Basic aquatic habitat assessments were conducted at each site using the Level II habitat typing protocol described in the *California Salmonid Stream Habitat Restoration Manual* (Flosi *et al.* 2010). Level II habitat typing simply classifies habitat units into riffles, flatwater, and pools, which are the three broad habitat types offering different ecological function for fisheries resource (see *Habitat Type and Stream Dimension* below).

Habitat Type and Stream Dimension

The habitat inventory assesses the amount and quality of different habitat types within each reach. Habitat dimensions (depth, area) and type (pool, riffle, flatwater) influence the ability of a stream to support salmonid populations. Riffle habitats are important for production of aquatic insects and other organisms used as food sources. Riffles can also provide habitat for younger age classes of salmonids and can be good foraging areas if they are sufficiently deep. Flatwater runs and glides can also be used for foraging and can support greater numbers of rearing juveniles depending on depth and cover characteristics. Flatwater habitats also tend to have areas where velocity and substrate characteristics are suitable for spawning. Pools are important because they provide habitat during the summer low flow period and during periodic droughts. Deeper pools with good cover characteristics provide important habitat for adult resident trout and yearling-and-older juvenile steelhead. Although these fish may inhabit pools with mean depths in the range of 0.5 to 1.5 ft in small streams, they generally occur at greater densities in streams with more pools in the 1.5 to 2.5-ft or deeper mean depth range. Pool tail-outs serve as important spawning sites if conditions are suitable (i.e., gravel/cobble substrates with low levels of embeddedness).

Shelter Characteristics

There are numerous potential predators on juvenile salmonids inhabiting streams, and the presence of adequate cover, or shelter, can greatly influence survival rates. Instream and overhead cover in the form of undercut banks, tree trunks and branches (whether alive or dead), grasses, herbs, and shrubs, floating or rooted aquatic vegetation, cobbles and boulders, bedrock ledges, and surface turbulence can inhibit the ability of predators to see and capture juvenile salmonids. The proportion of each pool unit that was influenced by some type of shelter was estimated as a percentage of the total surface area of the unit. A standard qualitative shelter value of 0 (none), 1 (low), 2 (medium), or 3 (high) was assigned according to the complexity of the cover. The shelter rating is calculated for each pool by multiplying shelter value and percent cover. Thus, shelter ratings can range from 0-300 and are expressed as mean values by habitat types within a stream. A pool shelter rating of at least 100 is desirable for salmonids.

Substrate Conditions

Substrate conditions influence spawning and egg incubation, cover for juveniles, and production of aquatic invertebrates important in the aquatic food chain. Steelhead rely on relatively loose, clean gravel substrate with low amounts of fine sediments for reproduction. Larger substrate such as cobbles and boulders can provide hiding areas for juveniles of many species including trout. Fine sediments (silt and sand) present in excessive amounts fill spaces between the larger substrate elements and reduce its ability to support invertebrate production, spawning, and escape cover. A number of criteria are used to describe substrate compositions occurring in streams and assess suitability for different life stages of anadromous salmonids. The most detailed methods involve bulk sampling of the streambed and characterization of the complete range of sediment size classes. A simpler method, included in the Flosi *et al.* (2010) habitat assessment protocol, involves estimating cobble embeddedness, which is defined as the average proportion of individual cobbles embedded in fine substrate materials. Embeddedness is typically estimated in pool tail-outs, the preferred spawning location of adult salmonids. Fish density, particularly for juvenile salmonids, is generally reduced as embeddedness increases, but steelhead appear to be less sensitive than some other species. Embeddedness is rated on a scale of 1 to 4 in 25% ranges. Embeddedness measured to be 25% or less (i.e., rating of 1) is considered best for the spawning needs of steelhead. Additionally, a value of 5 is assigned to tail-outs deemed unsuited for spawning due to inappropriate substrate particle size (e.g., boulder).

Riparian Conditions

The condition of the riparian corridor adjacent to a stream is an important factor in salmonid habitat quality. Riparian vegetation helps support some of the insects consumed by juveniles, provides cover from predators, and limits solar radiation to streams, keeping water temperatures cool. Tree roots stabilize streambanks and create habitat structure, and fallen trees create instream cover and refugia for juvenile fish to reside during high velocity flows. During the habitat assessment, the proportion of the channel shaded by deciduous and coniferous tree canopy was estimated. In general, canopy densities of 80% or more are desirable. However, limited openings in the canopy provide important foraging habitat, particularly for salmonid fry.

Fish Surveys

Fish surveys were conducted using standard electrofishing techniques (e.g., Temple and Pearsons 2007) and in accordance with the *Guidelines for Electrofishing Water Containing Salmonids Listed Under the Endangered Species Act* (NMFS 2000) and conditions set forth in the County's Endangered Species Act Section 10(a)(1)(a) scientific research permit #15824-3R. Block nets were set at the upstream and downstream ends of the sampling reaches, and standard water quality parameters (water temperature, dissolved oxygen, and specific conductivity) were measured using a YSI model 85 digital multipurpose meter. Using a standard multi-pass depletion method, repeated (2-3) electrofishing passes were made with a Smith-Root Model LR-24 backpack electrofisher and dipnets. Captured fish were placed in 5-gallon buckets containing stream water and battery-powered aerators. All captured salmonids were counted, measured to fork length (FL), and returned to the same stream reach where they were caught. Qualitative abundance estimates were noted for non-salmonid fish and amphibian species. Standard lengths (SL) of all captured steelhead were also measured for comparison to previous sampling conducted by Alley (2017).

Statistical population estimates for each sampling site were calculated using the Microfish 3.0 software (Van Deventer and Platts 1989). Total densities (number of fish/100 ft of channel) of juvenile steelhead were calculated based on the statistical population estimates and sampling site lengths. Densities of age 0 (young-of-the-year) and age 1+ (yearling-and-older) steelhead were calculated from the statistical population estimates based on their respective proportion (percentage) of occurrence within the sample.

Accurate age determinations of juvenile salmonids require scale analysis, which was beyond the scope of this effort. However, age class thresholds can also be determined fairly accurately from bimodal length-frequency distributions if a sufficiently large sample size is available. As this was not the case at some sites (e.g., Browns Creek #2), age class cutoffs were determined based on a combination of bimodal length-frequency distributions, professional experience conducting other long-term steelhead monitoring programs, and methods applied by other researchers in Santa Cruz County (e.g., Alley 2017; Sogard *et al.* 2009). For example, Alley (2017) generally classifies juvenile steelhead from non-mainstem San Lorenzo River sites as age 0 if SL is less than 75 mm. In a multi-year study of seasonal patterns of abundance, growth, and site fidelity of juvenile steelhead in the Soquel Creek watershed, Sogard *et al.* (2009) found that age 0 steelhead were generally less than 90 mm FL in October. Based on our observed length-frequency distributions and Sogard *et al.* (2009), we classified juvenile steelhead in the more open, low-gradient sites (i.e., Corralitos Creek #0 through #3) as age 0 if they were less than 90 mm FL, but in the more shaded upper watershed sites (i.e., Shingle Mill Gulch #3, and Brown Creek #1 and #2), 85 mm FL was generally used as the breakpoint between age 0 and age 1+ unless clear bimodal distributions suggested otherwise. This age classification scheme compares favorably to the bimodal distributions of standard-length frequencies and the Alley (2017) 75 mm SL breakpoint. In most cases, there was a clear demarcation between size modes of age 0 and age 1+ fish, but a small number of fish may have been incorrectly aged. Due to limited sample sizes, no attempt was made to segregate older fish into age 2 or age 3 categories and these fish were instead classified into the age 1+ category.

Results

The results of the September/October 2023 habitat assessments and fish surveys are presented below. Table 2 summarizes the results of basic water quality measurements collected immediately prior to fish sampling at each site. Table 3 summarizes habitat conditions at the sampling sites, and Table 4 lists juvenile steelhead density estimates. Figure 3 depicts the relative proportions of age 0 and age 1+ steelhead captured at each site, and Figure 4 presents length-frequency histograms for each site. Figures 5 and 6 compare total juvenile and age 0 densities, respectively, for 2016 through 2023. The 2016 and 2017 density estimates are derived from Alley (2017, 2018). Absolute juvenile steelhead density estimates for 2018 through 2023 may not be directly comparable to 2016-2017 estimates due to slight differences in sampling methodology and site locations, but overall density trends across the eight sampling years accurately reflect actual population dynamics. Representative photographs of the sampling sites are provided in Appendix A.

Water year 2023 was characterized by substantial amounts of precipitation and concomitant streamflows in the Monterey Bay region. The California Data Exchange Center (CDEC 2023) Watsonville Water (WTW) site reports a total of 36.62 inches of precipitation for the water year. PV Water (2022) classifies water years with total precipitation of 32.38 inches or more as “very wet”. As a result of multiple atmospheric rivers, streamflows in Corralitos Creek well above long-term averages during much of December 2022 through spring and summer 2023.

Corralitos Creek #0 (CO-0)

Sampling site CO-0 is located on Corralitos Creek downstream of the Browns Creek confluence (Figure 1) at the head of a low-gradient (1-2%) alluvial valley that typically dries out during summer months. The total channel length of the assessment reach in 2023 was 183 ft (Table 3). Based on percent total length, CO-0 consisted of 63% flatwater (step-run) and 37% pool habitat. Based on the total length and mean widths of the habitat units, the total wetted area of the sampling site at the time of the assessment was estimated at 2,431 ft^2, approximately 36% less than the 2022 wetted area of 3,814 ft^2 but this year-over-year decrease was largely due to the shorter reach length sampled in 2023. Two Level II habitat units (one flatwater, one pool) were sampled at CO-0. The pool in this reach had a mean depth of 0.8 ft, a maximum depth of 0.9 ft, and a residual depth of 0.6 ft. These measurements are representative of substantial aggradation (sediment deposition) within the pool compared to prior sampling years. The pool's cobble-dominated tail-out was highly embedded with a rating of 75-100%. The mean pool shelter rating was 25, representative of low shelter abundance consisting of minor amounts of boulders, bedrock ledge, and some root mass. Sand was the dominant substrate type in the pool, and large cobbles were the dominant substrate in the flatwater step-run. Canopy cover was estimated at 50% and composed entirely (100%) of hardwood species.

The overall juvenile steelhead population estimate for CO-0 was 6, for a total juvenile steelhead density of 3.3 fish/100 ft (Table 4), representing a 70% decrease from the 2022 estimate of 11.1 fish/100 ft and the lowest density recorded at this site in eight years of sampling (Figure 5). Of the juvenile steelhead captured at CO-0, 33.3% were age 0 fish (45.5% in 2022) and 66.7% were age 1+ fish (54.5% in 2022) (Figure 3). Estimated age class densities (Table 4) were 1.1 fish/100 ft for age 0 steelhead (5.0 fish/100 ft in 2022) and 2.2 fish/100 ft for age 1+ steelhead (6.0 fish/100 ft in 2022), representing a substantial decrease in both age class densities. The decline in steelhead densities likely resulted from a combination of factors, including potentially excessive streamflows during the spawning and incubation period resulting in redd scour and/or flushing of fry in the lower watershed as well as the loss of summer rearing habitat in the form of significant sediment deposition within the pool of this sampling reach.

Sculpins (*Cottus* sp.) were relativley abundant at CO-0 and appeared to be represented by two species, riffle sculpin (*C. gulosus*) and coastrange sculpin (*C. aleuticus*). Unlike during prior years, no lamprey (*Lampetra* sp.) ammocoetes or Sacramento sucker (*Catostomus occidantalis*) were captured in 2023. Non-native signal crayfish (*Pacifastacus leniusculus*) were again present at CO-0.

Corralitos Creek #1 (CO-1)

Sampling site CO-1 is located within a low-gradient (1-2%) reach of Corralitos Creek downstream of the City's diversion facility (Figure 1). The total channel length of the assessment reach in 2023 was 203 ft (Table 3). CO-1 underwent significant morphological changes during the prior wet season. One pool that previously contained abundant cover had become entirely filled with sediment and is now a flatwater, while a prior riffle was extensively scoured to become part of what is now a large, broad pool at the downstream end of the sampling reach. Based on percent total length, CO-1 now consists of 20% riffle, 17% flatwater, and 63% pool habitat. Based on the total length and mean widths of the habitat units, the wetted area of the reach at the time of the assessment was estimated at 3,048 ft^2, a 67% increase over the 2022 estimate of 1,821 ft^2 resulting from a 2-5 ft increase in wetted widths across all habitat units as well as a 34 ft increase in reach length. Three Level II habitat units (one riffle, one flatwater, one pool) were sampled at CO-1. The large pool had a mean depth of 1.7 ft, a maximum depth of 3.3 ft, and a residual depth of 2.8 ft, indicative of significant scour since 2022. The dominant pool tail-out substrate now consists of spawning-sized gravel with 25-50% embeddedness. Although large and deep, the pool's shelter rating (15) is lower than during prior years and consists primarily of shallow bedrock ledges and limited root mass. Sand was the dominant substrate type in the pool and large cobbles were the dominant substrate in the flatwater and riffle. Canopy cover was estimated at 60% and composed almost entirely (90%) of hardwood species.

The overall juvenile steelhead population estimate for CO-1 was 20, and the total juvenile steelhead density was 9.9 fish/100 ft (Table 4), a 29% increase over the 2022 estimate of 7.7 fish/100 ft (Figure 5), but lower than the 2017 through 2021 estimates. Most notably, no age 0+ steelhead were captured at CO-1 in 2023 (Figure 3), which may be indictive of poor spawning success (possibly due to scouring/flushing streamflows) but could also be the result of predation by older juvenile steelhead within the large pool lacking shelter and low invertebrate food productivity due to the abundance of sandy substrates.

Sculpins were moderately abundant at CO-1. Several large (200+ mm SL) Sacramento suckers and two lamprey ammocoetes were also present. Approximately 10% of the steelhead captured showed low levels of blackspot disease infection, which had not been noted at any sampling site in prior years.

Corralitos Creek #3 (CO-3)

Sampling site CO-3 is located within a moderate gradient (2-3%) reach of Corralitos Creek upstream of the City's diversion facility (Figure 1). The total channel length of the assessment reach in 2023 was 270 ft (Table 3). Based on percent total length, CO-3 consisted of 18% riffle, 18% flatwater, and 64% pool habitat. Although a portion of the flatwater unit underwent moderate scour, thereby expanding pool habitat within the sampling reach, the channel morphology of CO-3 remained largely unchanged from 2022. Based on the total length and mean widths of the habitat units, the total wetted area of the reach at the time of the assessment was estimated at 3,613 ft^2, comparable to the 2022 estimate of 3,592 ft^2. Five Level II habitat units (two riffles, one flatwater, two pools) were sampled at CO-3. The two pools in the 2023 sampling reach had a combined mean depth of 1.5 ft, a maximum depth of 3.1 ft, and a maximum residual depth of 2.5 ft, indicative of moderate scour. Dominant pool tail-out substrates at the pools consisted of small and large cobble with embeddedness ratings of 50-75%, representative of suboptimal spawning conditions. The mean shelter rating for the pools was 35, representative of low shelter abundance. Shelter at CO-3 consisted of undercut banks and root masses providing complex refuge habitat where present, but the relative proportion of pool habitat with shelter availability is limited. Sand was the dominant substrate type in the pools while the riffle and flatwater units are dominated by large cobble and boulders. Canopy cover was estimated at 80%, consisting of approximately 60% hardwood and 40% conifer species.

The overall juvenile steelhead population estimate for CO-3 was 15, and the total juvenile steelhead density was 5.6 fish/100 ft (Table 4), a 55% decrease from the 2022 estimate of 12.3 fish/100 ft (Figure 5) and the lowest density recorded at this site in eight years of sampling (Figure 5). Of the juvenile steelhead captured at CO-3, only 13.3% were age 0 fish and the remainder (86.7%) were age 1+ fish (Figure 3). Estimated age class densities in 2023 were 0.7 fish/100 ft for age 0 steelhead (3.0 in 2022) and 4.8 fish/100 ft for age 1+ steelhead (9.3 in 2022) (Table 4). Similar to CO-0 and CO-1, a large decrease in age 0 densities likely resulted from a combination of factors, including potentially excessive streamflows during January and March 2023, corresponding to peak spawning and incubation periods, respectively.

Sculpins were present in moderate numbers and the relative abundance of Sacramento suckers was low. No lamprey ammocetes were observed at CO-3 in 2023. Non-native signal crayfish were present.

It should be noted that staff from the National Marine Fisheries Service (NMFS) and the Monterey Bay Salmon and Trout Project (MBSTP) conducted a juvenile steelhead rescue operation within a dry-back reach of lower Corralitos Creek in September 2023 and released a total of 78 juvenile steelhead and 8 lamprey ammocetes in Corralitos Creek at the Las Colinas Drive crossing, located approximately 1,000 ft downstream of the CO-3 sampling site, and in vicinity of Rider Creek confluence, approximately 0.5 mile upstream of CO-3, with approximately half of the relocated fish being released at each site (Casagrande, pers. comm.). Similar to age class distributions noted above, age 0 steelhead also accounted for only about 25% of the fish relocated by NMFS/MBSTP (Casagrande, pers. comm.).While density estimates at CO-3 may have been affected if some of the released steelhead dispersed into the sampling reach prior to the survey, the likelihood of this appears to be low considering the exceedingly low densities of steelhead captured at CO-3 in 2023.

Corralitos Creek #9 (CO-9)

Sampling site CO-9 is located in the upper Corralitos Creek watershed approximately 0.3 miles downstream of the Shingle Mill Gulch confluence (Figure 1). The gradient in this reach is considerably steeper (6%) than at CO-0 through CO-3. The total channel length of the assessment reach in 2023 was 121 ft (Table 3). Based on percent total length, CO-9 consisted of 56% flatwater (step-run), and 44% pool habitat. The total wetted area of the reach at the time of the assessment was estimated at 1,444 ft^2, approximately 73% higher than the 2022 estimate of 836 ft^2. The increase in wetted surface area was the result of an approximately 4-ft increase in average channel width compared to 2022. Two Level II habitat units (one flatwater, one pool) were sampled at CO-9. The pool in this reach had a mean depth of 0.9 ft (0.2 ft shallower than in 2022), a maximum depth of 2.0 ft and a residual depth of 1.6 ft (0.5 ft and 0.7 ft shallower, respectively, than in 2022), suggesting continued deposition in much of the pool during water year 2023. The pool tail-out continues to be comprised of boulders and therefore does not provide spawning habitat. The mean shelter rating for the pool was 45, representative of low shelter availability. Shelter consisted entirely of large boulders that, combined with the still significant depth of the pool, provided high quality habitat for age 1+ steelhead. Canopy cover was estimated at 70%, composed almost entirely (90%) of hardwood species.

The overall juvenile steelhead population estimate for CO-9 was 15, and the total juvenile steelhead density was 40.5 fish/100 ft (Table 4), a 189% increase over the 2022 density of 14.0 fish/100 ft (Figure 5). This represents the fifth consecutive year that CO-9 has had the highest total juvenile density of the eight sampling sites. Of the steelhead captured at CO-9 in 2023, 77.3% were age 0 fish (6.7% in 2022) and 22.7% were age 1+ fish (93.3% in 2022) (Figure 3), representing a notable increase in the relative abundance of age 0+ steelhead at this site. Estimated age class densities were 31.3 fish/100 ft for age 0 steelhead (0.9 in 2022) and 9.2 fish/100 ft for age 1+ steelhead (13.1 in 2022) (Table 4). The 2023 age 0+

density at CO-9 was the highest among all sampling sites. The large pool at this site provides high quality habitat for older fish, some of which may assume a resident life history tactic. The observed increase in the density of age 0 fish, however, suggests adult steelhead migration and spawning success in the upper Corralitos Creek watershed in water year 2023.

Sculpins were present in very low numbers at CO-9 in 2023, and one California giant salamander (*Dicamptodon ensatus*) larva was observed.

Shingle Mill Gulch #3 (SM-3)

Sampling site SM-3 is located on Shingle Mill Gulch, tributary to Corralitos Creek, upstream of the third Eureka Canyon Road crossing and downstream of Grizzly Flat (Figure 1). Although located in the upper Corralitos Creek watershed, the gradient of the sampling reach is relatively low at approximately 2%. The total channel length of the assessment reach in 2023 was 135 ft (Table 3). Based on percent total length, SM-3 consisted of 11% riffle, 36% flatwater, and 53% pool habitat. In past years, a long riffle separated two pools, but much of this riffle was deepened into a flatwater in 2023. Based on the total length and mean widths of the habitat units, the total wetted area of the reach at the time of the assessment was estimated at 855 ft^2, a 42% increase over the 2022 estimate of 601 ft^2. Four Level II habitat units (one riffle, one flatwater, two pools) were sampled at SM-3. The pools in the reach had a combined mean depth of 1.0 ft, a maximum depth of 2.0 ft, and a residual depth of 1.9 ft. Dominant pool tail-out substrates at both pools consisted of gravel and small cobble with embeddedness ratings of 25-50%, representative of fair spawning conditions. The combined mean shelter rating for the pools was 53, comprised primarily of root masses and small woody debris. Coarse substrates dominated the riffle and flatwater while sand was the dominant substrate type in the pools. Canopy cover was estimated at 85%, composed primarily (75%) of conifer species.

The overall juvenile steelhead population estimate for SM-3 was 21, and the total juvenile steelhead density was 15.6 fish/100 ft, a 333% increase over the 2022 density of 3.6 fish/100 ft (Table 4). Of the juvenile steelhead captured at SM-3, 89.5% were age 0 fish (20.0% in 2022) and 10.5% were age 1+ fish (80.0% in 2022) (Figure 3). Estimated age class densities were 13.9 fish/100 ft for age 0 steelhead (0.7 in 2022) and 1.6 fish/100 ft (2.9 in 2022) (Table 4). Age 0 densities at SM-3 were very low in 2021 and 2022 (only one individual each year), suggesting that anadromous spawning may not extend this far up in the watershed in drought years and that the Shingle Mill population may have been sustained by low levels of resident trout spawning during those years. The substantial increase in age 0 abundance and density in 2023, a near-record setting water year, suggests that anadromous spawning likely extended this far up in the watershed in 2023.

Two larval California giant salamanders and one California newt were observed at SM-3 in 2023. Non-native signal crayfish were also present in low numbers.

Browns Creek #1 (BR-1)

Sampling site BR-1 is located on a moderate gradient (2-3%) reach of Browns Creek downstream of the City's diversion facility (Figure 1). The total channel length of the assessment reach in 2023 was 216 ft (Table 3). Based on percent total length, BR-1 consisted of 76% flatwater and 24% pool habitat.

Compared to prior years, significant sediment deposition in 2023 resulted in the near-complete filling of a previously large bedrock-dominated pool at the downstream end of the survey reach as well as the complete filling of a previously shallow, smaller pool at the upstream end of the reach. As a result, flatwater habitat availability increased by about 75% in 2023 and pool habitat decreased by a similar margin. Based on the total length and mean widths of the habitat units, the total wetted area of the reach at the time of the 2023 assessment was estimated at 2,603 ft^2, comparable to the 2022 estimate of 2,396 ft^2. Three Level II habitat units (two flatwaters, one pool) were sampled at BR-1. The remaining pool in this reach had a mean depth of 1.4 ft, a maximum depth of 2.6 ft, and a residual depth of 1.9 ft, indicative of a moderate amount of scour since 2022. The tail-out at the pool consisted of small cobbles with 50-75% embeddedness, providing suboptimal adult steelhead spawning conditions. The shelter rating for the pool was 10, representative of exceedingly low shelter within this habitat unit. The limited shelter was dominated by boulders and bedrock ledges. Canopy cover was estimated at 65%, composed almost entirely (80%) of hardwood species.

The overall juvenile steelhead population estimate for BR-1 was 17, and the total juvenile steelhead density was 7.9 fish/100 ft (Table 4), a 68% increase from the total density of 4.7 fish/100 ft in 2022. Juvenile densities have fluctuated widely at BR-1 since 2016 (Figure 5), but the 2023 estimate represents the second lowest during that 8-year period. Of the juvenile steelhead captured at BR-1 in 2023, 64.7% were age 0 fish (36.4% in 2022) and 35.3% were age 1+ fish (63.6% in 2022) (Figure 3), representative of a reversal of the age class structure observed in 2022. Estimated age class densities in 2023 were 5.1 fish/100 ft for age 0 steelhead (1.7 in 2022) and 2.8 fish/100 ft for age 1+ steelhead (3.0 in 2022) (Table 4). Steelhead densities at BR-1 declined substantially during the 2020-2022 drought years and 2023 represents a slight increase (Figure 5).

Sculpins were moderately abundant, and some non-native signal crayfish were present at BR-1. One California newt was also observed.

Browns Creek #2 (BR-2)

Sampling site BR-2 is located on a moderate gradient (2-3%) reach of Browns Creek upstream of the City's diversion facility (Figure 1). The total channel length of the assessment reach in 2023 was 211 ft (Table 3). Based on percent total length, BR-2 consisted of 56% flatwater and 44% pool habitat, which is largely unchanged from 2022. The total wetted area of the reach at the time of the 2023 assessment was estimated at 2,327 ft^2, only slightly lower than the 2022 estimate of 2,650 ft^2. Three Level II habitat units (one flatwater, two pools) were sampled at BR-2. The pools in this reach had a combined mean depth of 1.2 ft, a maximum depth of 2.4 ft, and a residual depth of 2.1 ft. The tail-outs at both pools consisted of very large cobbles and boulders that are not suitable for spawning by adult steelhead. The mean shelter rating for the pools was 45, representative of low shelter abundance. The limited shelter was dominated by boulders in one pool and by a complex root mass in the other. Canopy cover was estimated at 80%, composed about equally of hardwood and conifer species.

The overall juvenile steelhead population estimate for BR-2 was 10, and the total juvenile steelhead density was 4.7 fish/100 ft (Table 4), a 10% decrease from the total density of 5.2 fish/100 ft in 2022. Of the juvenile steelhead captured at BR-2, 30% were age 0 fish (90% in 2022) and 70% of captured fish were classified as age 1+ (10% in 2022) (Figure 3). Estimated age class densities were 1.4 fish/100 ft for age 0 steelhead (4.7 in 2022) and 3.3 fish/100 ft for age 1+ steelhead (0.5 in 2022) (Table 4), suggestive of limited spawning success upstream of the City's diversion in 2023. Storm damage to the diversion structure may have impeded adult fish passage at some flows during the migration and spawning season.

Sculpins were moderately abundant and some non-native signal crayfish were present at BR-2. One California newt was also observed.

Casserly Creek #3 (CA-3)[1]

Sampling site CA-3 is located within a moderate-gradient (3%) reach of Casserly Creek approximately 250 ft downstream of Mt. Madonna Road bridge and 2.5 miles upstream of College Lake (Figure 2). The total channel length of the assessment reach in 2023 was 195 ft (Table 3). Based on percent total length, CA-3 consisted of 90% flatwater and 10% shallow pool habitat in 2023. This habitat distribution represents a substantial shift from prior years when flatwater only accounted for roughly half of the assessment reach while riffles extended across approximately one third of the site. Extended high flows in winter/spring 2023 appear to have scoured riffles and filled parts of the pools, resulting in fairly homogenous flatwater habitat characteristics. Based on the total length and mean widths of the habitat units, the total wetted area of the reach at the time of the 2023 assessment was estimated at 1,005 ft^2, a moderate increase over the 2022 estimate of 880 ft^2. Two Level II habitat units (one flatwater, one pool) were sampled at CA-3. The pool in the reach had a mean depth of 0.6 ft, a maximum depth of 1.0 ft, and a residual depth of 0.9 ft. While these depths are comparable to 2022 conditions, the overall surface area extent of the habitat unit decreased by about a third in 2023. Dominant pool tail-out substrates in 2023 consisted of large cobbles with a high embeddedness rating of 50-75%. The shelter rating for the pool was 50, reflective of decreased cover availability compared to pre-2022 years. Large cobble is the dominant substrate type in the pool. Considering that this pool used to be dominated by sandy substrates, it is evident that coarse bed materials from a riffle that used to be located upstream of the pool were mobilized and transported into the pool. Canopy cover was estimated at 40%, consisting of approximately 90% hardwood and 10% conifer species.

The overall juvenile steelhead population estimate for CA-3 was 4, and the total juvenile steelhead density was 2.1 fish/100 ft, a 60% decrease from the 2022 density of 5.3 fish/100 ft and the lowest density observed at this site in seven years of sampling (Figure 5). Of the juvenile steelhead captured at CA-3, only one (25.0%) was an age 0 fish (also only one in 2022) and the three others (75.0%) were age 1+ fish (88.9% in 2022) (Figure 3). Estimated age class densities were 0.5 fish/100 ft for age 0 steelhead (0.6 in 2021) and 1.5 fish/100 ft for age 1+ steelhead (4.7 in 2022) (Table 4). In 2019, the high proportion and density of age 0 steelhead suggested successful spawning in Casserly Creek, and therefore successful adult migration through College Lake (Podlech 2019). However, in 2020 through 2022, the relative abundances of age 0 fish were greatly reduced, a trend that was consistent with observations in Shingle Mill Creek during that period and indicative of limited adult migration opportunities during drought years (Podlech 2022). In 2023, however, the population decline at CA-3 was in stark contracts to the substantial

[1] Note that the *2019 Juvenile Steelhead Densities in the Corralitos Creek and Casserly Creek Watershed* report (Podlech 2019) misidentified this sampling site as "Casserly Creek #1 (CA-1)" due to inconsistencies in site-naming in Alley (2017). However, the location of the Casserly Creek sampling site has remained consistent during all survey years.

increase at SM-3, and may have been the result of channel bed scour/deposition in Casserly Creek and/or challenging fish passage conditions at Paulson Road on the north side of College Lake where the bridge crossing became almost entirely plugged with sediment and levee failures resulted in Casserly Creek flowing across agricultural fields and the road.

No other fish species or crayfish were observed at CA-3.

Discussion

Many factors influence intra- and interannual fish population fluctuations. These include among others the magnitude and timing of streamflows, water quality conditions, the ability of adult steelhead to pass natural barriers, spawning success, food production (i.e., benthic macroinvertebrate abundance), and sedimentation. Direct cause-and-effect relationships are difficult to establish since fish populations, even in an undisturbed area, can fluctuate due to natural variations in the biotic and abiotic components of the environment. For anadromous salmonids such as steelhead, ocean conditions also play an important factor in maturation and recruitment of adults.

Droughts create low-flow conditions that are positively correlated with overall population declines, especially in age 0 juvenile salmonids. Low flows impede upstream migration of adult steelhead, limit streambed substrate for spawning, and tend to result in higher water temperatures that may adversely affect summer survival. Low juvenile steelhead densities in the Corralitos Creek watershed were reported by Alley (2018) in 2014 and 2016. After experiencing near-record precipitation and stream discharges during water year 2017, and a concomitant improvement in juvenile steelhead densities in the Corralitos Creek watershed (Alley 2018), water year 2018 saw a return to below-average rainfall in coastal central California and juvenile steelhead densities decreased at all sampling sites in the Corralitos Creek watershed[2] except CO-1, where a high density of age 0 juveniles accounted for the highest total juvenile density (Figure 5).

For salmonids, the timing of runoff events is more important than the total or mean annual discharge. In water year 2018, only one minor runoff event occurred in early January 2018, then streamflows in Corralitos Creek remained below the long-term average through the end of March, significantly limiting adult steelhead access to the watershed during the typical peak of the spawning migration season, before several additional moderate runoff events occurred in March in early April toward the tail end of the adult migration and spawning season. The fact that only the lower watershed sites of CO-0 and CO-1 supported high proportions of age 0 steelhead in 2018, while age 1+ fish were far more abundant than age 0 fish in the upper watershed sites of CO-9, BR-1, and BR-2, supported the hypothesis that the late arrival of adult migration opportunities largely limited adult access to the lower watershed (Podlech 2018).

Water year 2019 resulted in Corralitos Creek streamflows consistently remaining above the long-term average through the entire adult steelhead migration and spawning season and smolt outmigration season. Hydrologically, 2019 was an almost ideal water year for steelhead as streamflows remained elevated but did not reach levels that would be expected to result in redd (egg nest) scour and/or

[2] Casserly Creek (CA-3) was not sampled in 2018.

significant flushing of age 0 fish. It appears that higher flows in water year 2019 provided adult steelhead access higher up in the watershed, as reflected by substantial increases in age 0 juvenile densities at CO-9, SM-3, BR-1, and BR-2 compared to 2018 (Figure 5). Conversely, age 1+ densities decreased moderately at most sites and substantially in Shingle Mill Gulch (SM-3). The favorable 2019 smolt outmigration conditions (i.e., sustained, moderate spring flows), combined with the relatively low age 0 densities (<10 fish/100 ft) in 2018 likely resulted in the weaker age 1+ densities at these sites in 2019 (Podlech 2019).

Water year 2020 was similar to 2018. After a few minor precipitation events in December, streamflows remained low throughout most of the peak adult steelhead migration period until another minor event occurred in late March, followed by a major discharge peak in early April at the tail-end of the migration season. The infrequent and untimely migration opportunities likely limited adult steelhead access, and therefore spawning success, in the Corralitos Creek and Casserly Creek watersheds in 2020. This lack of migration and spawning flows was the most likely cause of the marked decreases in age 0 juvenile steelhead densities observed at every sampling site in 2020 compared to 2019 (Figure 6) (Podlech 2020).

Water year 2021 marked a second consecutive drought year. In contrast to water year 2020, however, the only significant adult migration opportunity of water year 2021 occurred in late January during the peak steelhead migration and spawning season. This relatively brief event appears to have enabled adult steelhead to enter the Corralitos Creek basin and spawn in the lower reaches of the watershed (CO-0, CO-1, CO-3) where age 0 steelhead densities increased substantially in 2021 compared to 2020 (Figure 6). The increase in age 0 fish at these sites was large enough to also result in increased total juvenile densities compared to 2020 (Figure 7) even though age 1+ densities decreased at each of the sites. At the upper watershed sites (e.g., SM-3, CA-3, BR-1, BR-2), however, age 0 densities decreased further in 2021 from already depressed levels in 2020 (Figure 6). In fact, no age 0 steelhead were observed at BR-2. Combined with decreased age 1+ densities at most of those sites (except SM-3), total juvenile steelhead densities in Shingle Mill Creek, Browns Creek, and Casserly Creek were the lowest recorded in six years of monitoring at that time (Figure 5) (Podlech 2021).

Water year 2022 was characterized by continued drought conditions. Although a few significant storm events occurred late December 2021 (Figure 7), the associated increases in streamflows occurred prior to the peak adult steelhead migration and spawning period. As in 2018 and 2020, essentially no additional precipitation occurred until late March 2022 at the tail-end of the spawning season. Age 0 steelhead densities that year were some of the lowest observed at the eight sampling sites since 2016 (Figure 6). Although age 1+ densities increased somewhat at most sites compared to the very low numbers observed in 2021, total juvenile steelhead densities in Shingle Mill Creek, upper Corralitos Creek (CO-9), lower Browns Creek (BR-1), and Casserly Creek (CA-3) were the lowest recorded in seven years of monitoring (Figure 5). In lower Corralitos Creek (CO-0, CO-1, CO-3) and upper Browns Creek (BR-2), total juvenile densities were the second lowest observed in seven years, with only the 2016 densities lower (Figure 5).

It is important to note that the City of Watsonville did not operate its filter plant in 2020, 2021, or 2022. Lower creek flows combined with a lack of late rain events and a lack of overall total rain accumulation, rendered extended diversion periods infeasible. As such, 2020 through 2022 amount to control years from the perspective of a fisheries effects analysis. As described above, the three non-diversion years were drought years, yet juvenile steelhead population trends differed based on differences in the timing of runoff events and the location of sampling sites.

As noted above, water year 2023 was characterized by substantial extended precipitation and concomitant streamflows. Multiple atmospheric rivers maintained streamflows along the central California coast well above long-term averages during much of December 2022 through spring and summer 2023 (Figure 8). These elevated flows likely provided numerous and prolonged migration and spawning opportunities for adult steelhead throughout much of the Corralitos-Casserly Creek subbasin. However, several peak flow events in Corralitos Creek in late December and mid-January approached or exceeded 2,000 cubic feet per second (cfs) (Figure 8), resulting in major sediment transport events as evidenced by substantial geomorphic changes at some sampling sites. Significant sediment transport events have the potential to scour or burry active spawning redds, resulting in loss of incubating eggs and/or alevins. In March 2023, a time when newly emerged fry are present in the streams, streamflows remained above 100 cfs for much of the month and again peaked at approximately 2,000 cfs (Figure 8). In addition to potentially flushing fry, turbidity and suspended sediment levels were qualitatively very high throughout this time. High and prolonged turbidity concentrations can lower dissolved oxygen in the water column, reduce respiratory function, disrupt normal feeding behavior and efficiency, reduce growth rates, lower disease tolerance, and cause fish mortality. These effects are more pronounced in smaller fish such as steelhead fry. The lower portion of a watershed typically experiences higher flow rates and turbidity/suspended sediment levels, and age 0 steelhead densities at sites CO-0, CO-1, and CO-3 in 2023 were among the lowest recorded during the past eight years (Figure 6). Casserly Creek (CA-3) underwent substantial geomorphic changes, including the loss of feeding (riffle) and rearing (pool) habitat. Densities of total and age 0 juveniles thus remained as low as during recent drought years. Conversely, upper watershed sites such as CO-9 and SM-3 saw among the highest total juvenile densities recorded at these sites (Figure 5), driven largely by substantial increases in age 0 densities (Figure 6). In Browns Creek, the lower site (BR-1) had the highest density of age 0 steelhead in the past four years while the upper site (BR-2) had the second lowest density in the past eight years even though total densities remained largely unchanged. As noted above, damage to a weir at the Browns Valley diversion site may have adversely affected adult fish passage opportunities through the fish ladder.

TABLE 2

WATER QUALITY RESULTS AT EIGHT SAMPLING SITES IN THE CORRALITOS CREEK AND CASSERLY CREEK WATERSHEDS, SEPTEMBER/OCTOBER 2023

Parameter	CO-0	CO-1	CO-3	CO-9	SM-3	BR-1	BR-2	CA-3
Date	10/04	10/02	10/04	9/25	9/25	9/29	9/29	10/02
Time	1245	930	945	1215	945	1200	930	1230
Weather	clear	clear	clear	clear	clear	clear	clear	clear
Air Temp (°C)	23.8	12.6	15.3	15.9	13.3	15.3	13.9	16.1
Water Temp (°C)	15.3	13.1	13.5	13.1	12.5	14.1	13.7	15.0
Conductivity (µmhos/cm)	425	412	412	442	421	500	460	1097
DO Conc. (mg/l)	9.5	9.7	9.3	9.8	9.2	8.9	9.8	8.9
DO Sat. (%)	95	93	89	98	87	87	95	93

TABLE 3

SUMMARY OF HABITAT TYPES AND MEASURED PARAMETERS AT EIGHT SAMPLING SITES IN THE CORRALITOS CREEK AND CASSERLY CREEK WATERSHEDS, SEPTEMEBR/OCTOBER 2023

Site ID	Habitat Unit Type	# of Units	Total Length (ft.)	% of Reach Length	Mean Width (ft.)	Mean Depth (ft.)	Max. Depth (ft.)	Residual Pool Depth (ft.)	Estimated Total Area (sq. ft.)	Dominant Substrate Types	Dominant Pool Tail Substrate	Mean Tail Embedded-ness	Mean Shelter Value
CO-0	P	1	67	37	15.5	0.8	0.9	0.6	1,039	SA	LC	4.0	25
	F	1	116	63	12.0	0.4	1.4	---	1,392	LC	---	---	---
	TOTAL		**183**						**2,431**				
CO-1	P	1	128	63	16.0	1.7	3.3	2.8	2,048	SA	GR	2.0	15
	F	1	34	17	14.1	0.9	1.5	---	479	LC	---	---	---
	R	1	41	20	12.7	0.4	1.4	---	521	LC	---	---	---
	TOTAL		**203**						**3,048**				
CO-3	P	2	172	64	13.2	1.5	3.1	2.5	2,270	SA	SC	3.0	35
	F	1	49	18	12.2	0.8	1.2	---	598	LC	---	---	---
	R	2	49	18	15.2	0.4	0.8	---	745	LC/BO	---	---	---
	TOTAL		**270**						**3,613**				
CO-9	P	1	53	44	13.4	0.9	2.0	1.6	710	BO	BO	NA	45
	F	1	68	56	10.8	0.6	1.0	---	734	BO	---	---	---
	TOTAL		**121**						**1,444**				
SM-3	P	2	71	53	7.2	1.0	2.0	1.9	511	SA	GR/SC	2.0	53
	F	1	48	36	6.0	0.3	0.4	---	288	SC	---	---	---
	R	1	16	11	3.5	0.2	0.2	---	56	GR	---	---	---
	TOTAL		**135**						**855**				
BR-1	P	1	51	24	9.3	1.4	2.6	1.9	474	LC	SC	3.0	10
	F	2	165	76	12.9	0.4	1.1	---	2129	LC	---	---	---
	TOTAL		**216**						**2,603**				
BR-2	P	2	93	44	12.2	1.2	2.4	2.1	1,135	SA/BO	BO/BO	NA	45
	F	1	118	56	10.1	0.5	1.3	---	1,192	BO	---	---	---
	TOTAL		**211**						**2,327**				
CA-3	P	1	20	10	5.6	0.6	1.0	0.9	112	LC	LC	3.0	50
	F	1	175	90	5.1	0.3	0.9	---	893	LC	---	---	---
	TOTAL		**195**						**1,005**				

NOTE: Habitat type codes: R = riffle; F = flatwater; P = pool.
Substrate type codes: SI =silt; SA = sand; GR = gravel; SC = small cobble; LC = large cobble; BO = boulder; BR = bedrock.

TABLE 4

JUVENILE STEELHEAD DENSITIES (# FISH/100 FT) AT EIGHT SAMPLING SITES IN THE CORRALITOS CREEK AND CASSERLY CREEK WATERSHEDS, SEPTEMBER/OCTOBER 2023

Metric	CO-0	CO-1	CO-3	CO-9	SM-3	BR-1	BR-2	CA-3
Total Density	3.3	9.9	5.6	40.5	21.0	7.9	4.7	2.1
Age 0 Density	1.1	0.0	0.7	31.3	13.9	5.1	1.4	0.5
Age 1+ Density	2.2	9.9	4.8	9.2	1.6	2.8	3.3	1.5

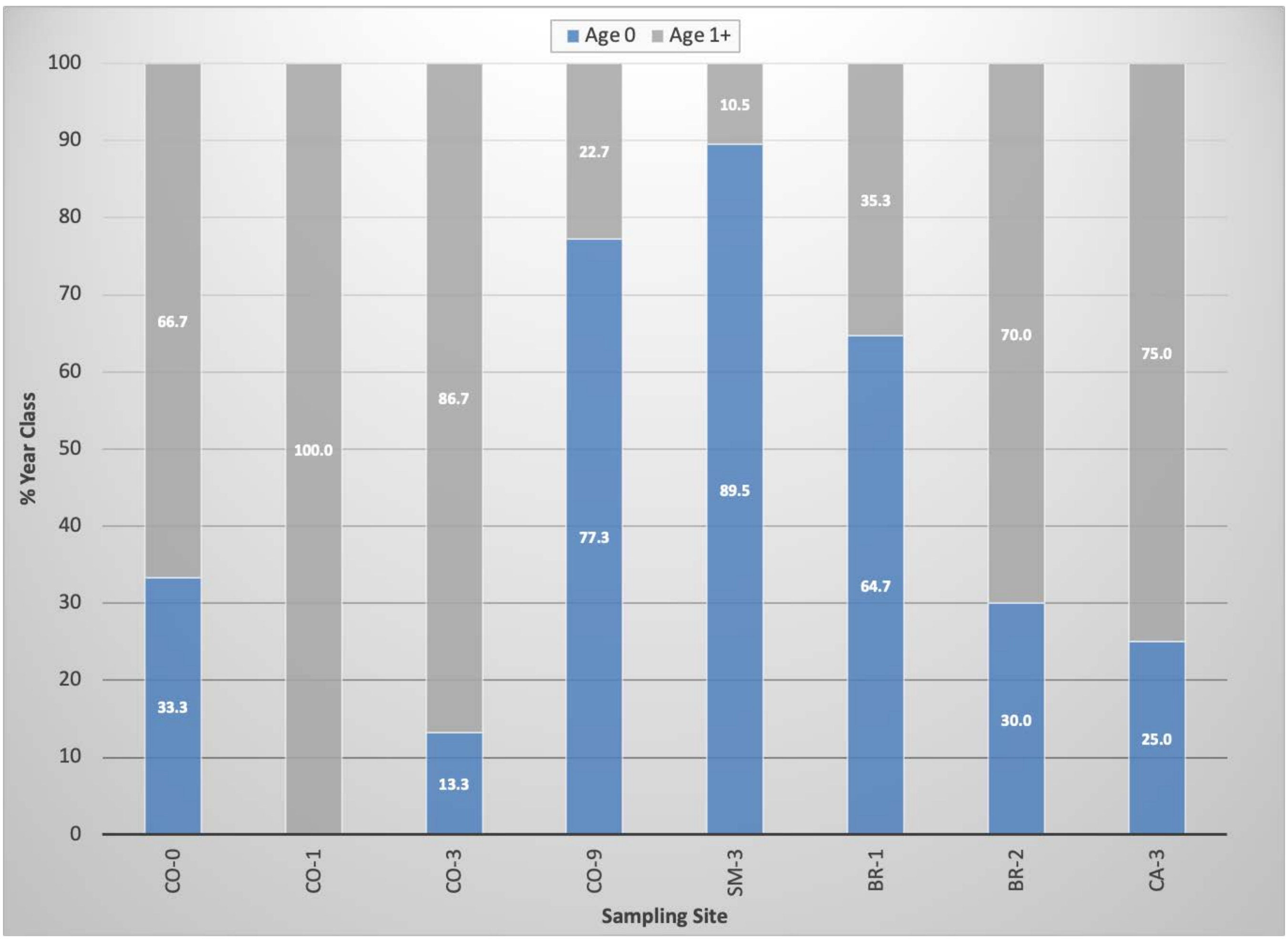
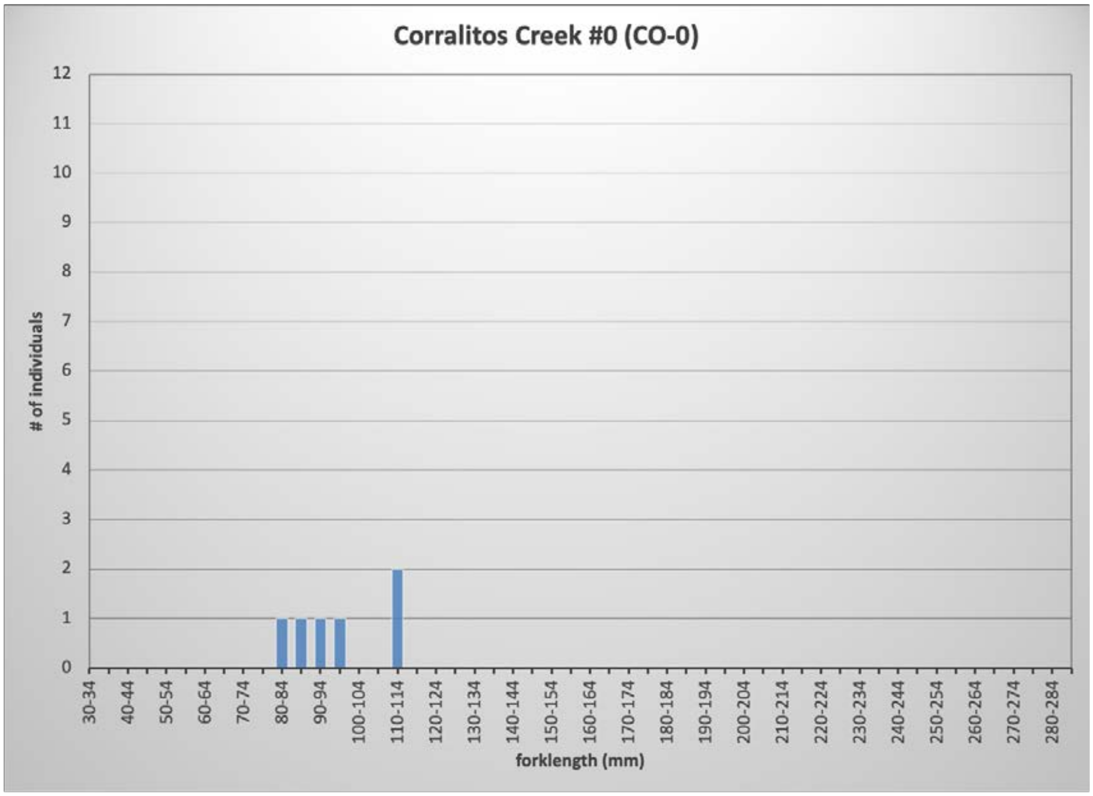


Figure 3. Relative Proportion (%) of Juvenile Steelhead Age Classes at Eight Sampling Sites in the Corralitos Creek and Casserly Creek Watersheds, September/October 2023



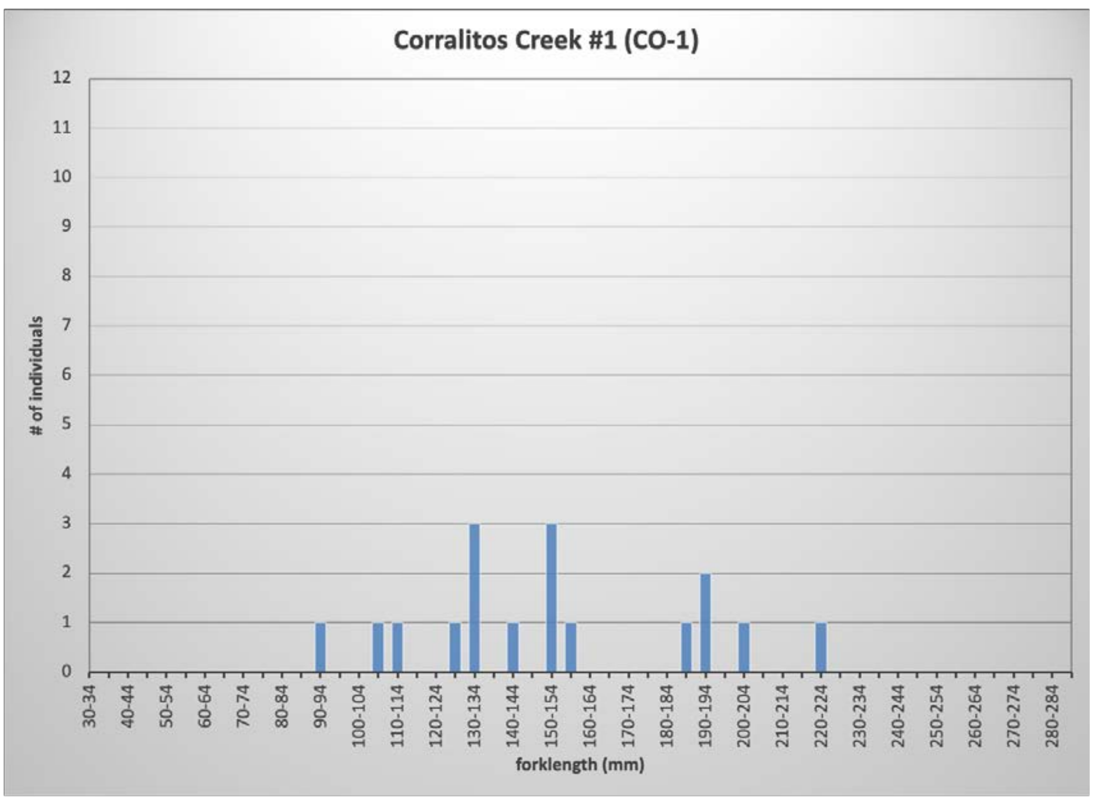
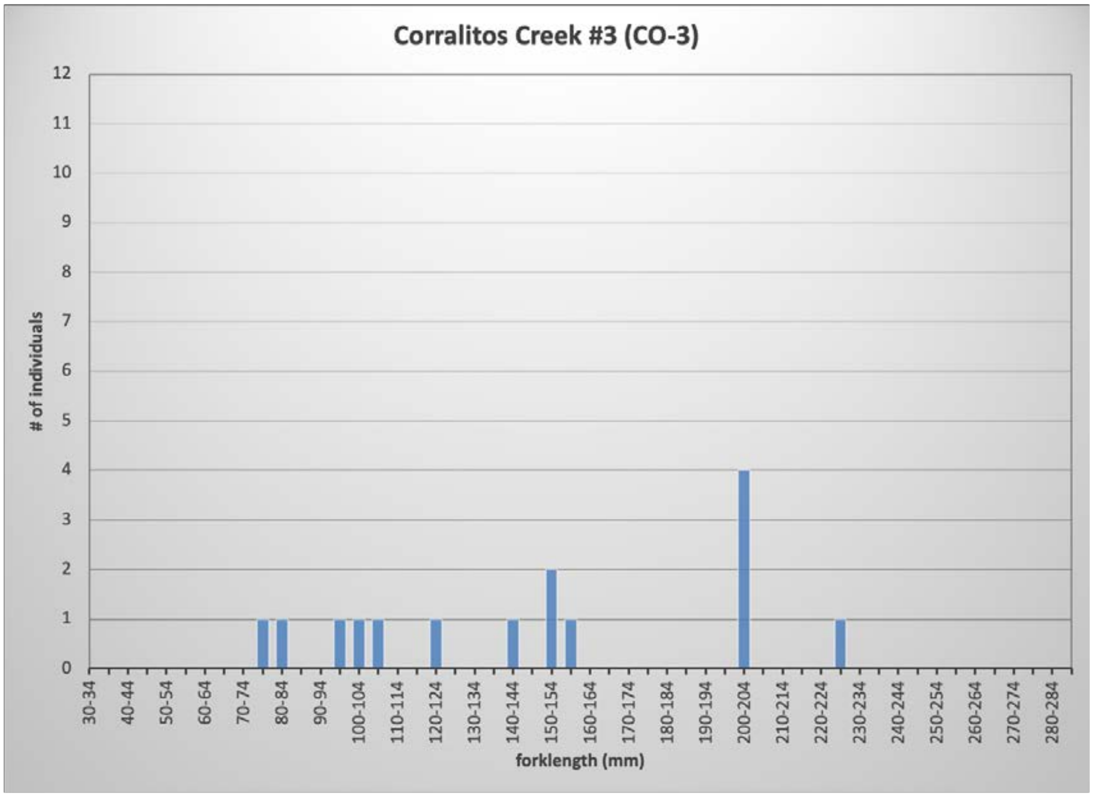


Figure 4. Forklength Distributions of Juvenile Steelhead at Eight Sampling Sites in the Corralitos Creek and Casserly Creek Watersheds, September/October 2023



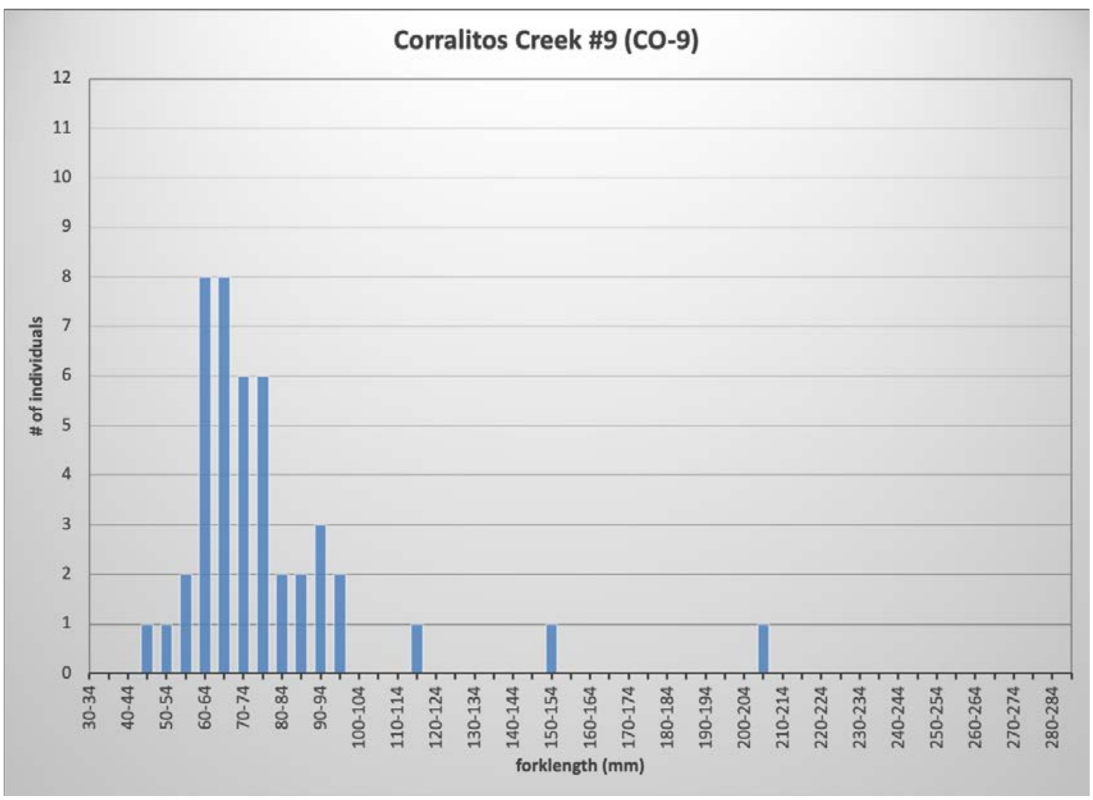
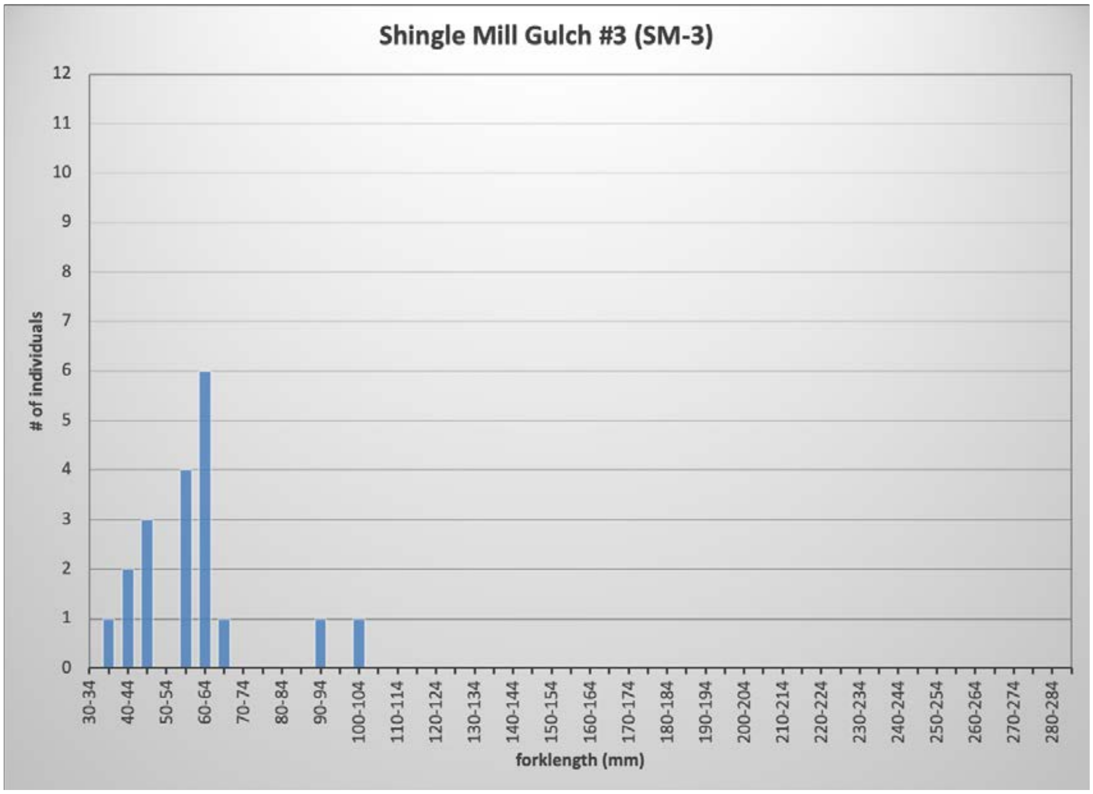


Figure 4 (cont.). Forklength Distributions of Juvenile Steelhead at Eight Sampling Sites in the Corralitos Creek and Casserly Creek Watersheds, September/October 2023



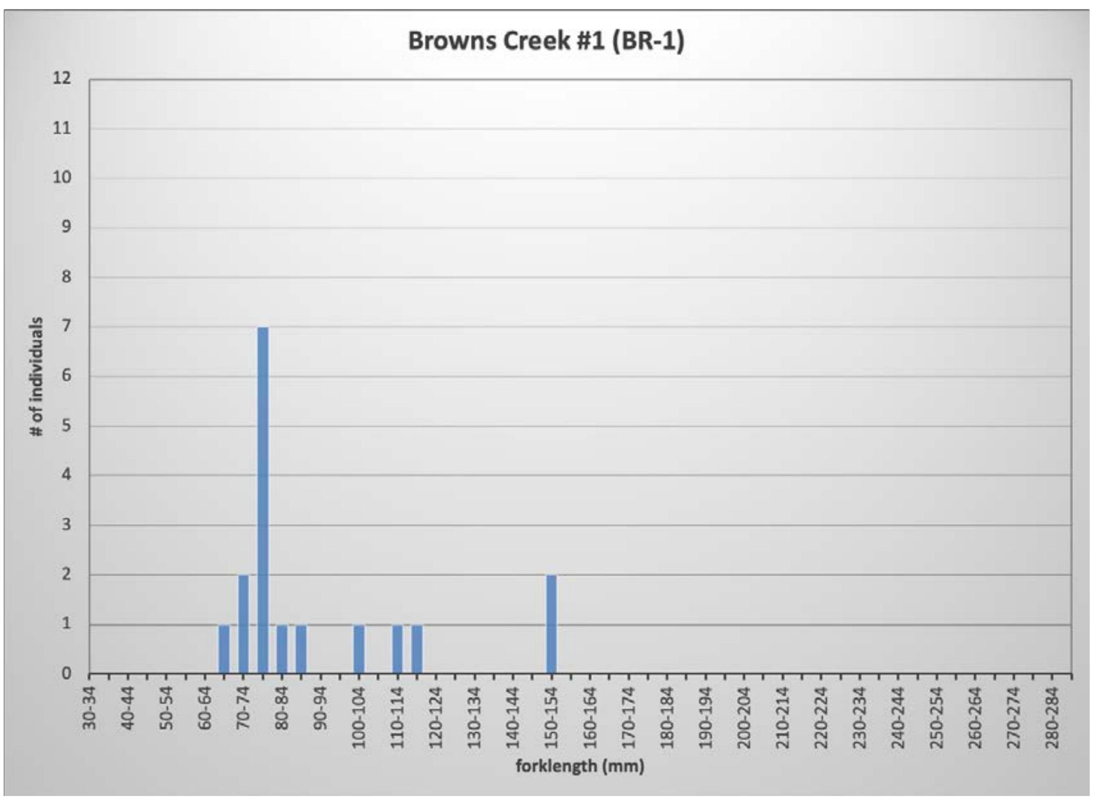
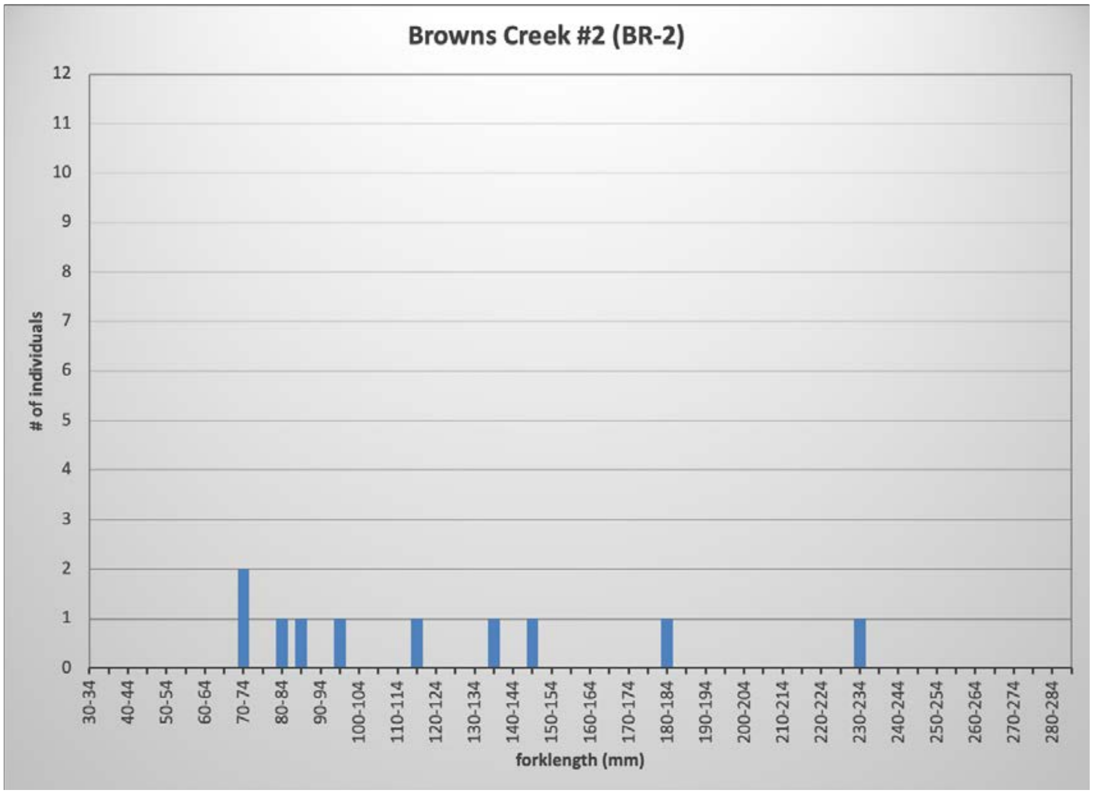


Figure 4 (cont.). Forklength Distributions of Juvenile Steelhead at Eight Sampling Sites in the Corralitos Creek and Casserly Creek Watersheds, September/October 2023



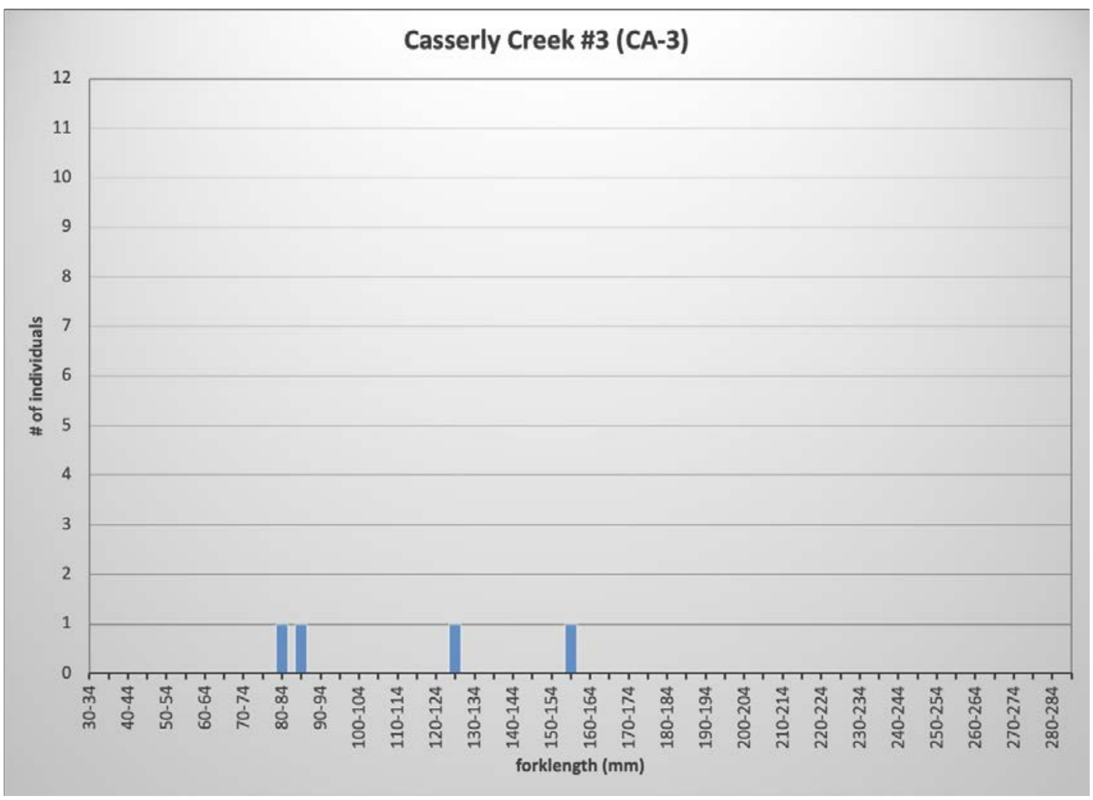
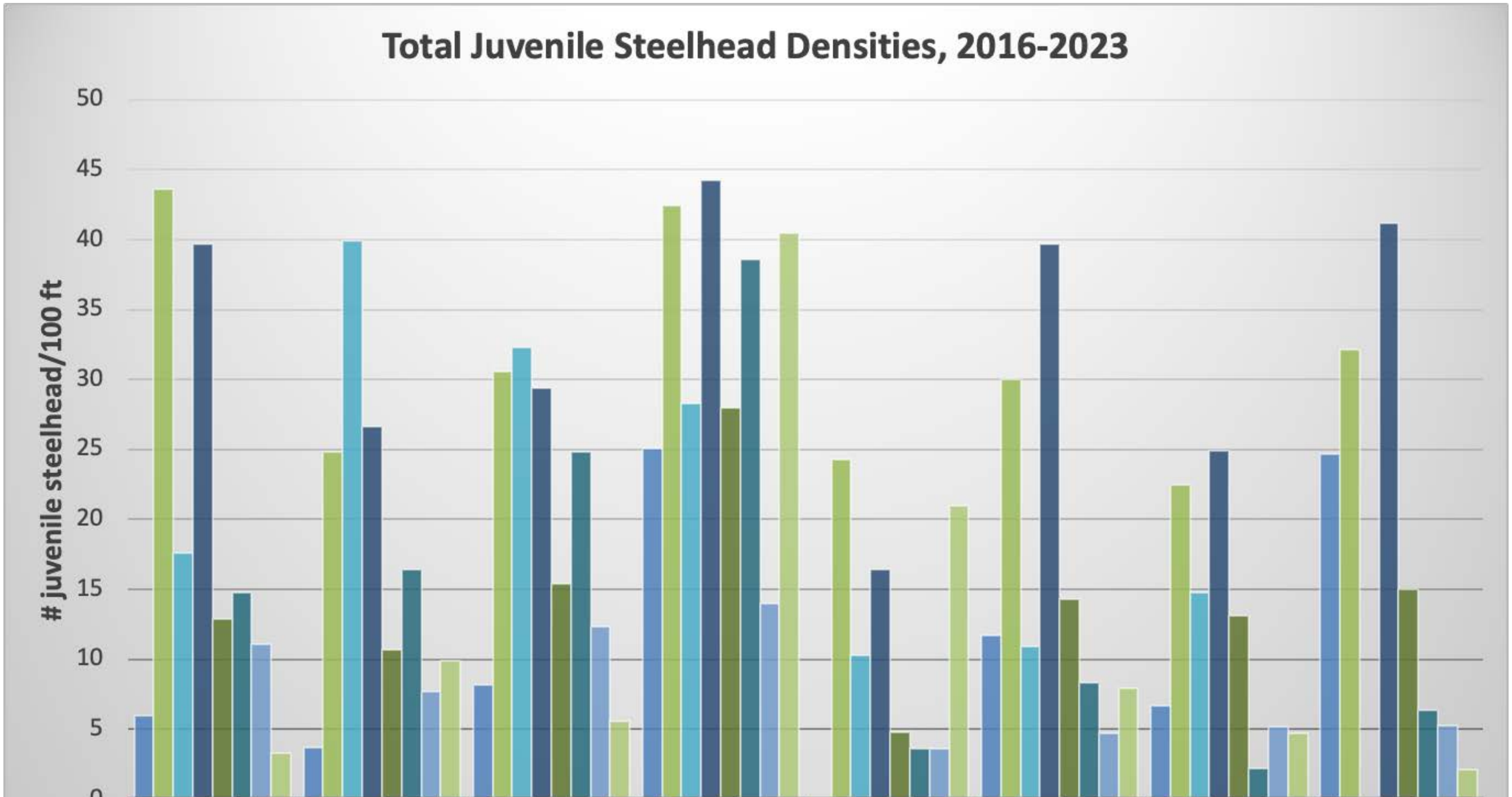
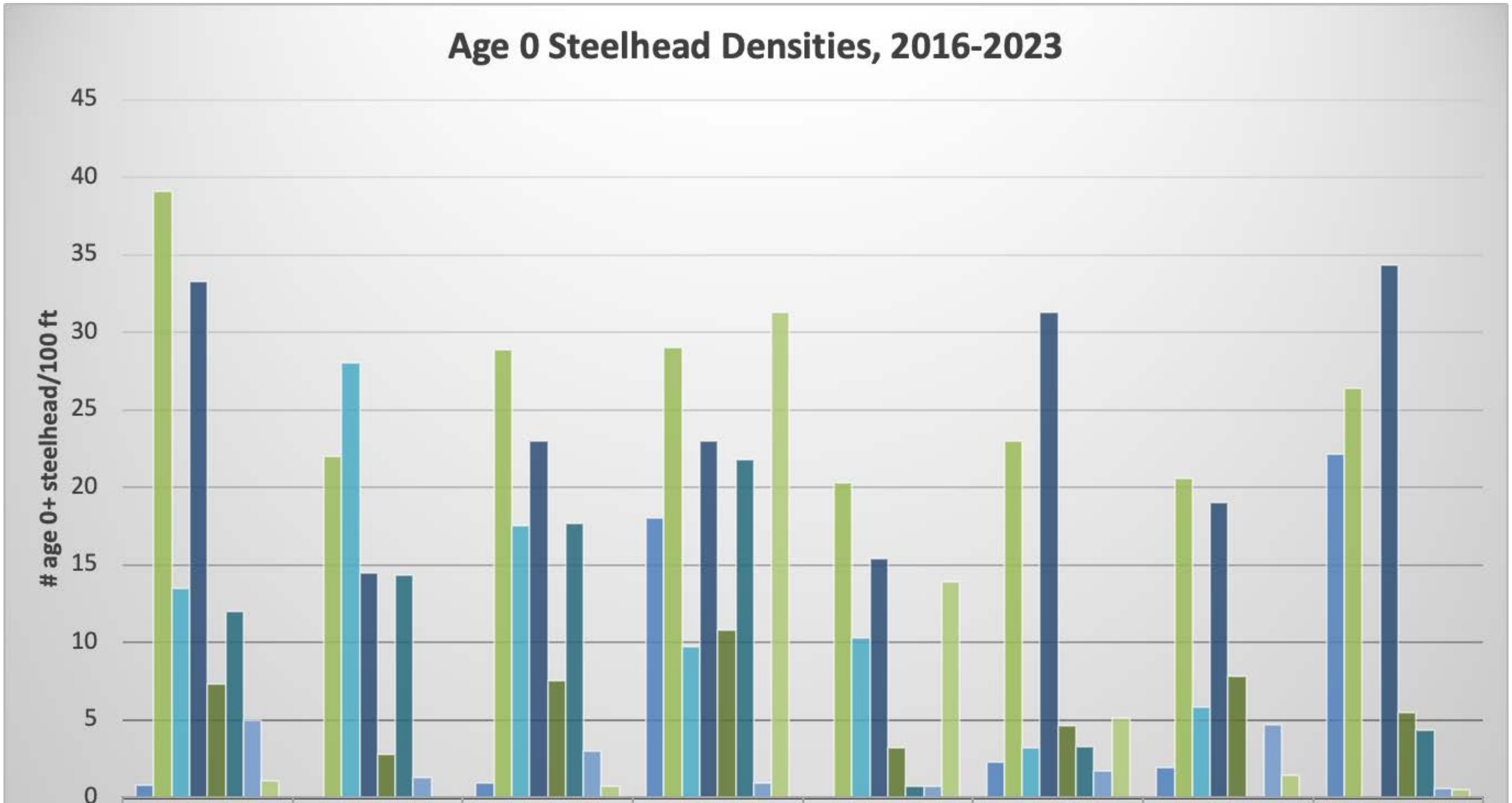


Figure 4 (cont.). Forklength Distributions of Juvenile Steelhead at Eight Sampling Sites in the Corralitos Creek and Casserly Creek Watersheds, September/October 2023



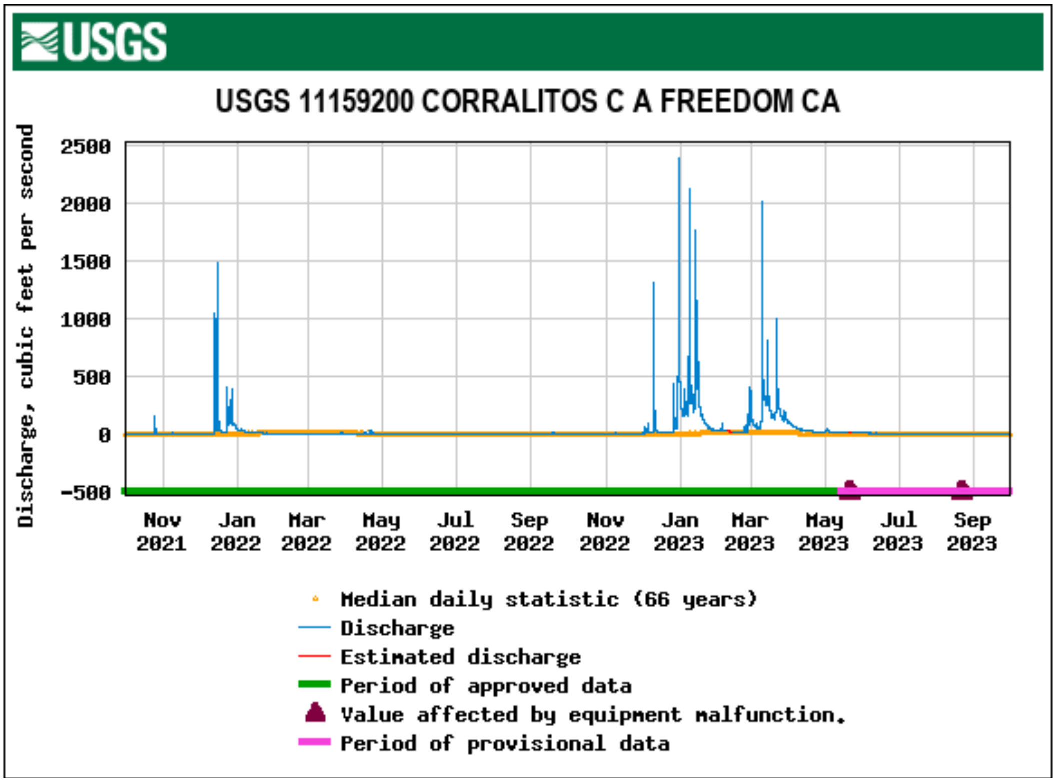
	CO-0	CO-1	CO-3	CO-9	SM-3	BR-1	BR-2	CA-3
2016	6.0	3.7	8.2	25.1		11.7	6.7	24.7
2017	43.6	24.8	30.6	42.4	24.3	30.0	22.5	32.1
2018	17.6	39.9	32.3	28.3	10.3	10.9	14.8	
2019	39.7	26.6	29.4	44.2	16.4	39.7	24.9	41.2
2020	12.9	10.7	15.4	28.0	4.8	14.3	13.1	15.0
2021	14.8	16.4	24.8	38.6	3.6	8.3	2.2	6.4
2022	11.1	7.7	12.3	14.0	3.6	4.7	5.2	5.3
2023	3.3	9.9	5.6	40.5	21.0	7.9	4.7	2.1

Figure 5. Total Juvenile Steelhead Densities at Eight Sampling Sites in the Corralitos Creek and Casserly Creek Watersheds, 2016-2023 (data for 2016-2017 adapted from Alley [2017, 2018])



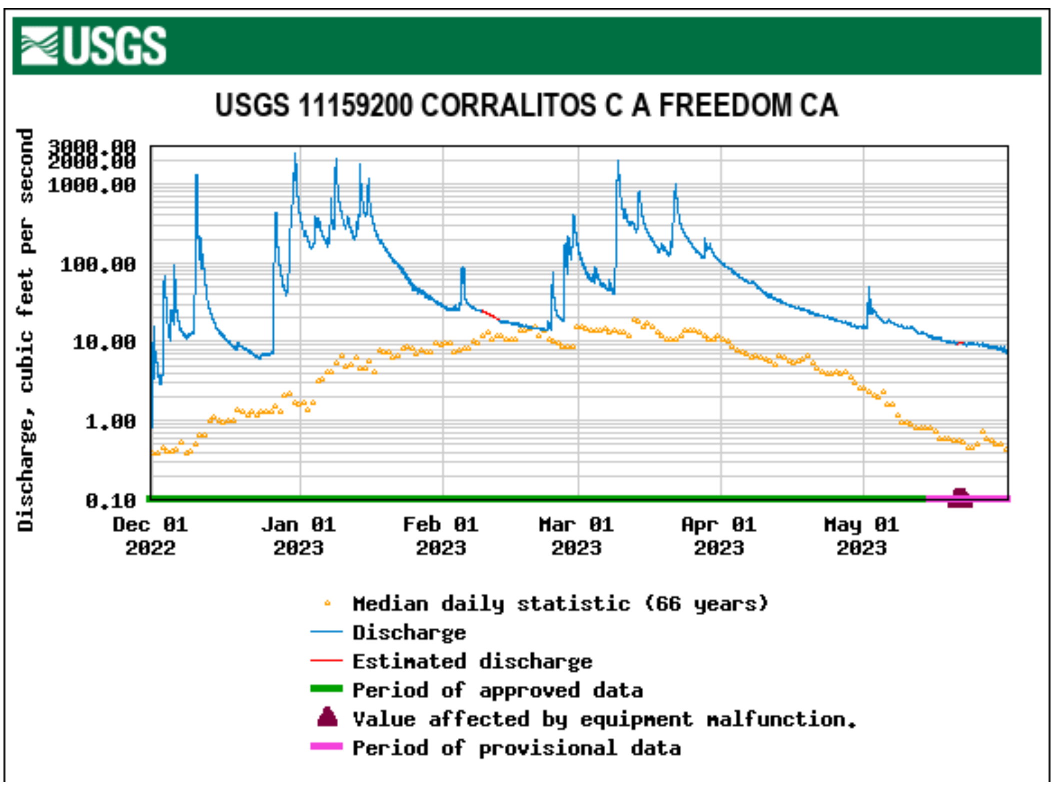
	CO-0	CO-1	CO-3	CO-9	SM-3	BR-1	BR-2	CA-3
2016	0.8	0.0	0.9	18.0		2.3	1.9	22.1
2017	39.1	22.0	28.9	29.0	20.3	23.0	20.6	26.4
2018	13.5	28.0	17.5	9.7	10.3	3.2	5.8	
2019	33.3	14.5	23.0	23.0	15.4	31.3	19.0	34.3
2020	7.3	2.8	7.5	10.8	3.2	4.6	7.8	5.5
2021	12.0	14.3	17.7	21.8	0.7	3.3	0.0	4.3
2022	5.0	1.3	3.0	0.9	0.7	1.7	4.7	0.6
2023	1.1	0.0	0.7	31.3	13.9	5.1	1.4	0.5

Figure 6. Age 0 Steelhead Densities at Eight Sampling Sites in the Corralitos Creek and Casserly Creek Watersheds, 2016-2023 (data for 2016-2017 adapted from Alley [2017, 2018])



SOURCE: U.S. Geological Survey, 2023

Figure 7. Mean Daily Discharge in Corralitos Creek at Freedom, USGS 11159200, Water Years 2022-2023



SOURCE: U.S. Geological Survey, 2023

Figure 8. Mean Daily Discharge in Corralitos Creek at Freedom, USGS 11159200, December 2022-May 2023

References

Alley, D.W. 2018. 2017 Summary Report − Juvenile Steelhead Densities in the San Lorenzo, Soquel, Aptos and Pajaro Watersheds, Santa Cruz County, CA. Prepared for Santa Cruz County.

Alley, D.W. 2017. 2016 Summary Report − Juvenile Steelhead Densities in the San Lorenzo, Soquel, Aptos and Pajaro Watersheds, Santa Cruz County, CA. Prepared for Santa Cruz County.

Bond, M.H., S.A. Hayes, C.V. Hanson, and R.B. MacFarlane. 2008. Marine survival of steelhead (*Oncorhynchus mykiss*) enhanced by a seasonally closed estuary. Canadian Journal of Fisheries and Aquatic Sciences, 65(10): 2242-2252.

California Data Exchange Center (CDEC). 2023. Watsonville Water (WTW). Available at https://cdec.water.ca.gov/dynamicapp/QueryMonthly?s=WTW&end=2023-09.

Casagrande, J. 2010. Distribution, abundance, growth and habitat use of steelhead in Uvas Creek, California. M.S. Thesis, San Jose State University, San Jose, CA. 160 pp.

Casagrande, Joel, Fisheries Biologist, National Marine Fisheries Services, personal communication on October 10, 2023.

Flosi, G., S. Downie, J. Hopelain, M. Bird, R. Coey, and B. Collins. 2010. California Salmonid Stream Habitat Restoration Manual. 4th edition, California Department of Fish and Game, Inland Fisheries Division. Sacramento, CA.

National Marine Fisheries Service (NMFS). 2000. Guidelines for Electrofishing Waters Containing Salmonids Listed Under the Endangered Species Act, June.

Pajaro Valley Water Management Agency (PV Water). 2022. Pajaro Valley Subbasin Water Year 2021 Annual Report. Available at: https://www.pvwater.org/images/about-pvwma/assets/annual_reports_assets/SGMA-WY/PVWater_AR_SGMA3-002.01WY2021.pdf

Podlech, M. 2011. College Lake Smolt Outmigrant Study – Spring 201 1. Prepared for the Resource Conservation District of Santa Cruz County, Capitola, CA.

Podlech, M. 2018. 2018 Juvenile Steelhead Densities in the Corralitos Creek Watershed. Prepared for the City of Watsonville, Watsonville, CA.

Podlech, M. 2019. 2019 Juvenile Steelhead Densities in the Corralitos Creek and Casserly Creek Watersheds. Prepared for the City of Watsonville and Pajaro Valley Water Management Agency, Watsonville, CA.

Podlech, M. 2020. 2020 Juvenile Steelhead Densities in the Corralitos Creek and Casserly Creek Watersheds. Prepared for the City of Watsonville and Pajaro Valley Water Management Agency, Watsonville, CA.

Podlech, M. 2021. 2021 Juvenile Steelhead Densities in the Corralitos Creek and Casserly Creek Watersheds. Prepared for the City of Watsonville and Pajaro Valley Water Management Agency, Watsonville, CA.

Podlech, M. 2022. 2022 Juvenile Steelhead Densities in the Corralitos Creek and Casserly Creek Watersheds. Prepared for the City of Watsonville and Pajaro Valley Water Management Agency, Watsonville, CA.

Sogard, S.M., T.H. Williams, and H. Fish. 2009. Seasonal Patterns of Abundance, Growth, and Site Fidelity of Juvenile Steelhead in a Small Coastal California Stream, Transactions of the American Fisheries Society, 138:3, 549-563.

Temple, G. M. and T. N. Pearsons. 2007. Electrofishing: Backpack and drift boat. Pages 95–132 in D. H. Johnson, B. M. Shrier, J. S. O'Neal, J. A. Knutzen, X. Augerot, T. A. O'Neil, and T. N. Pearsons, editors. Salmonid field protocols handbook: techniques for assessing status and trends in salmon and trout populations. American Fisheries Society, Bethesda, Maryland.

US Geological Survey (USGS). 2023. National Water Information System website. Current and historical discharge data for the Corralitos Creek at Freedom USGS gage 11159200; https://nwis.waterdata.usgs.gov/ca/nwis/uv/?ts_id=14686&format=img_stats&site_no=11159200&begin_date=20211001&end_date=20230930.

Van Deventer, S. J. and W. S. Platts. 1989. Microcomputer software system for generating population statistics *in* Electrofishing data user's guide for MicroFish 3.0. Gen Tech Rep INT-254. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Research Station. 29 p.

Appendix A

Photographs of Eight Sampling Sites in the Corralitos Creek and Casserly Creek Watersheds September/October 2023

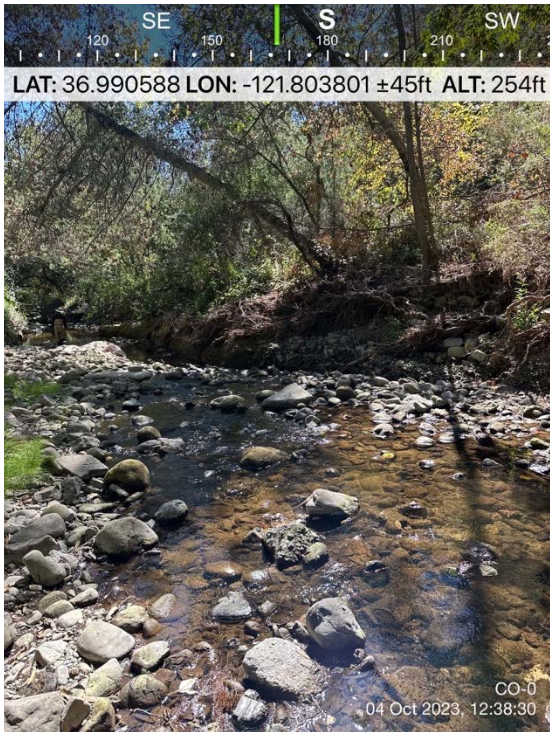


Photo 1. CO-0 flatwater-riffle transition, Oct. 4, 2023

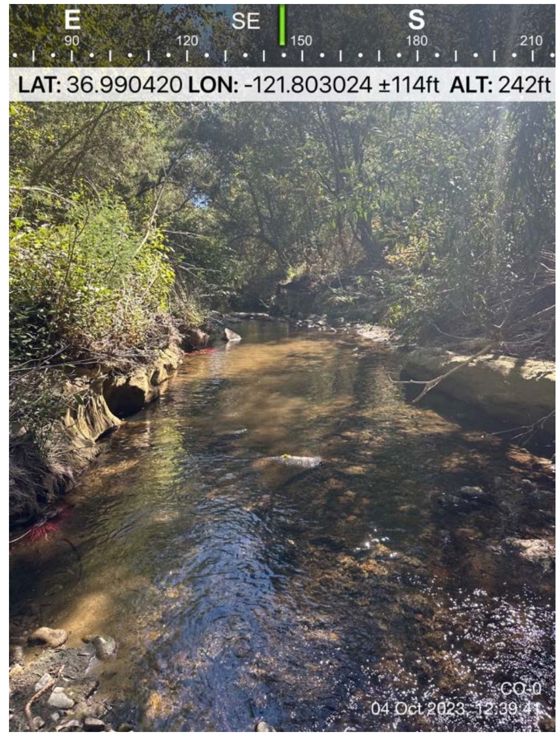


Photo 2. CO-0 pool, Oct. 4, 2023

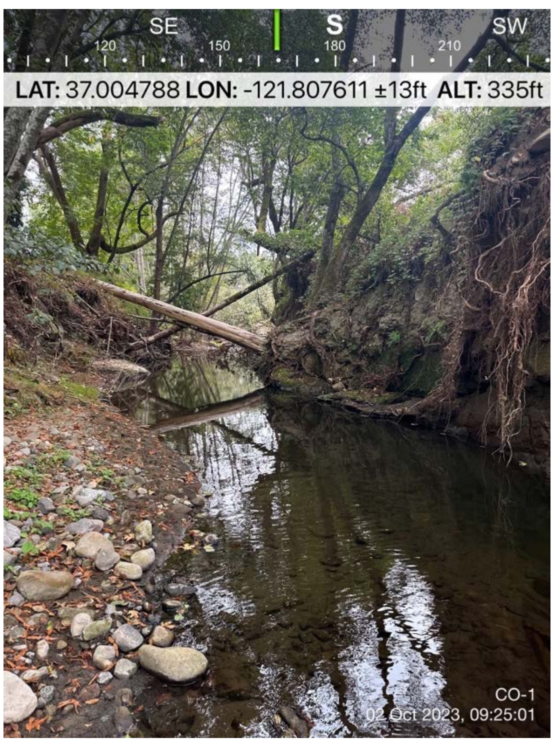


Photo 3. CO-1 pool, Oct. 2, 2023

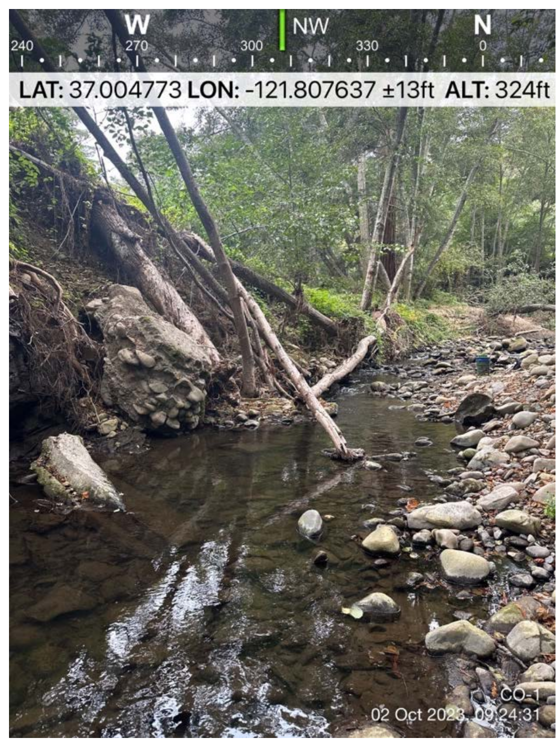


Photo 4. CO-1 flatwater (previously pool), Oct. 2, 2023

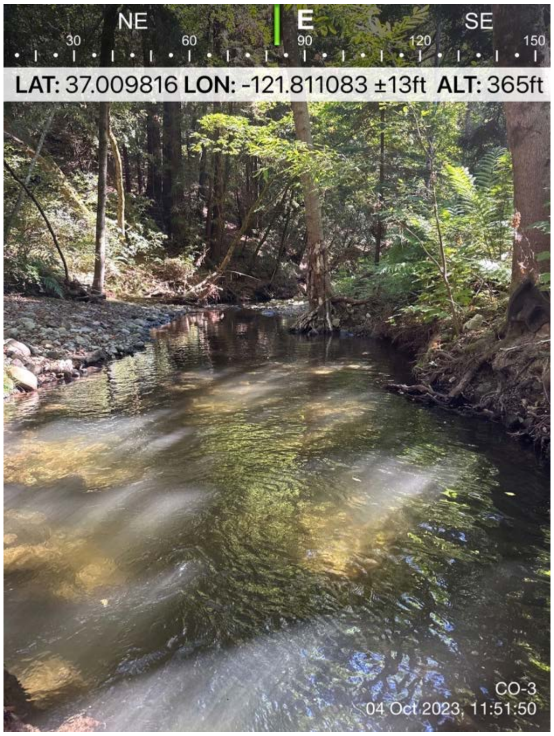


Photo 5. CO-3 pool, Oct. 4, 2023

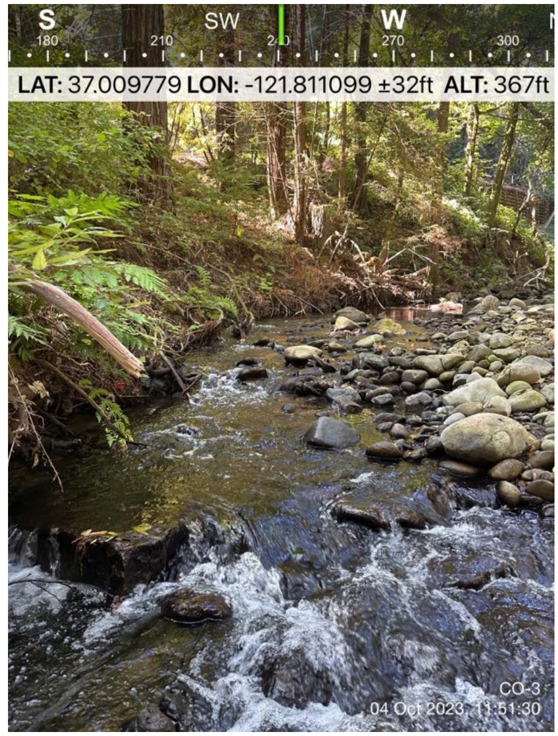


Photo 6. CO-3 riffle, Oct. 4, 2023

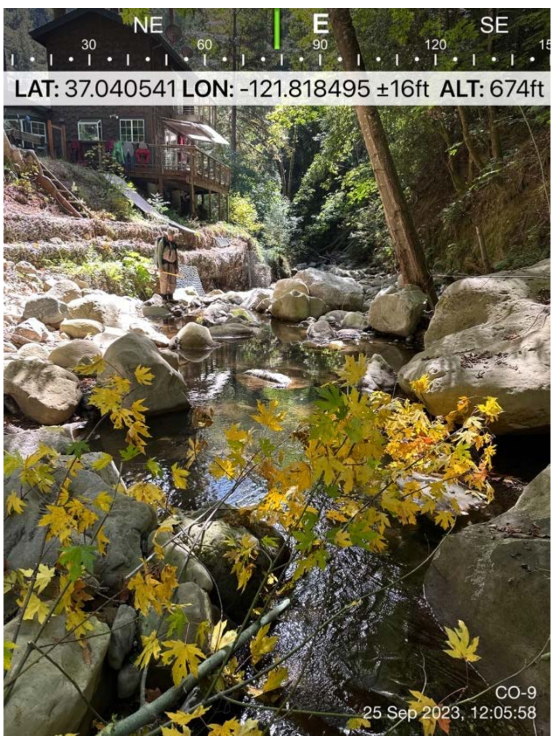


Photo 7. CO-9 pool, Sep. 25, 2023

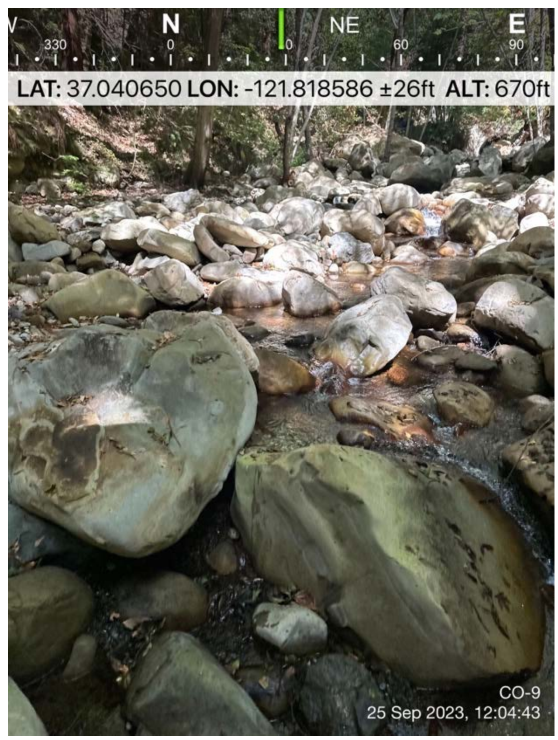


Photo 8. CO-9 flatwater, Sep. 25, 2023

Photo 9. SM-3 pool, Sep. 25, 2023

Photo 10. SM-3 flatwater-pool transition, Sep. 25, 2023

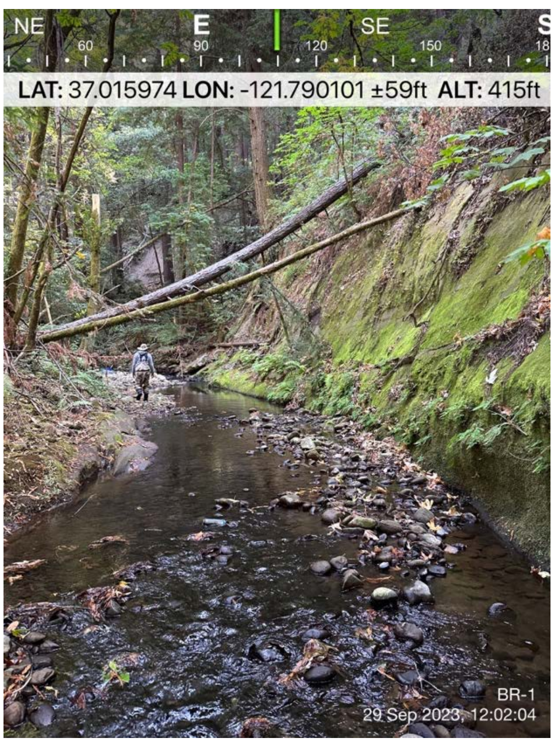


Photo 11. BR-1 flatwater/riffle (previously pool), Sep. 29, 2023

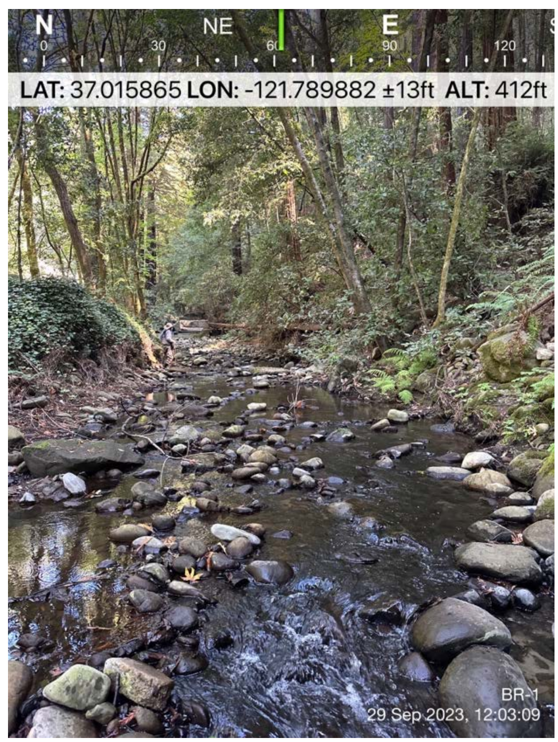


Photo 12. BR-1 flatwater, Sep. 29, 2023

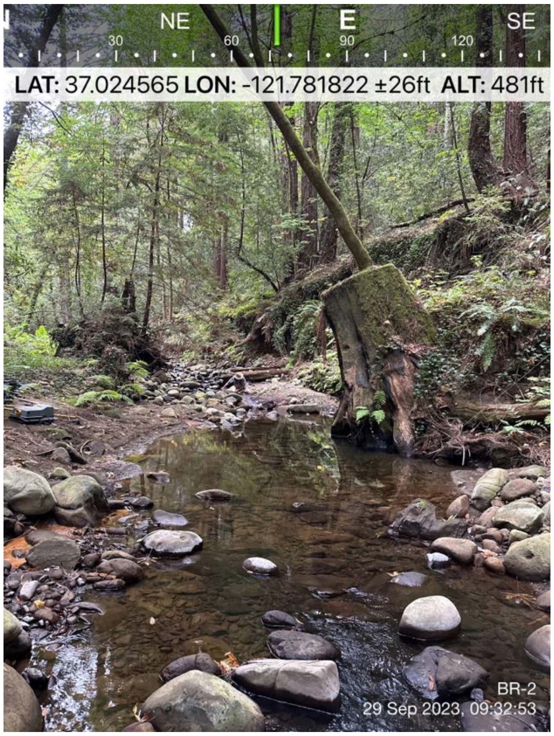


Photo 13. BR-2 pool, Sep. 29, 2023

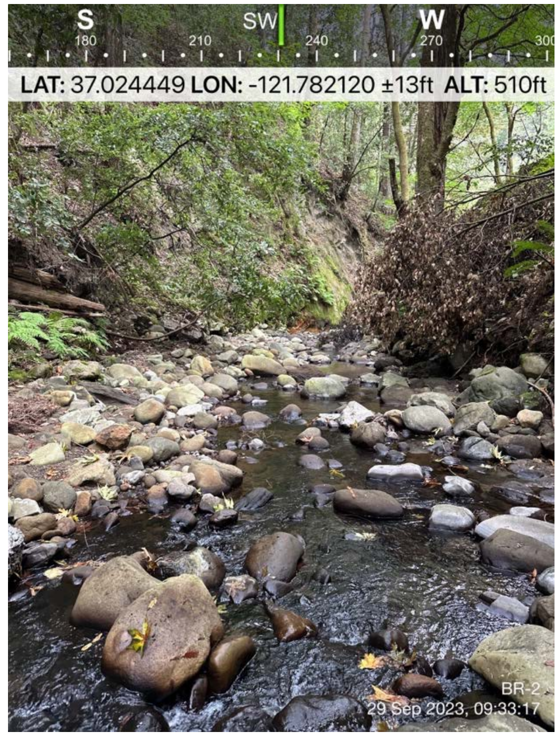


Photo 14. BR-2 flatwater, Sep. 29, 2023

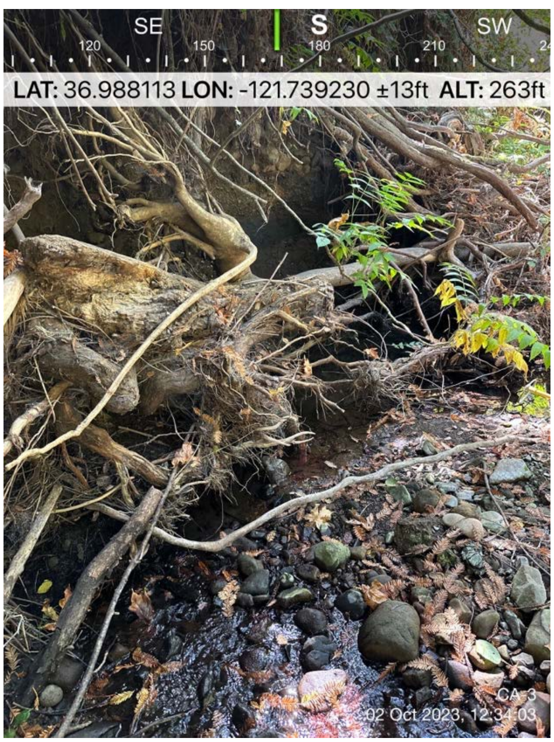


Photo 15. CA-3 pool, Oct. 2, 2023

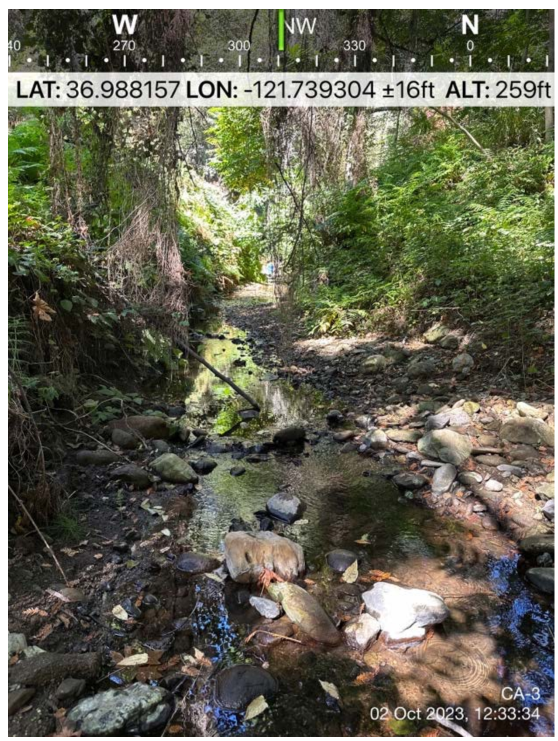


Photo 16. CA-3 flatwater, Oct. 2, 2023