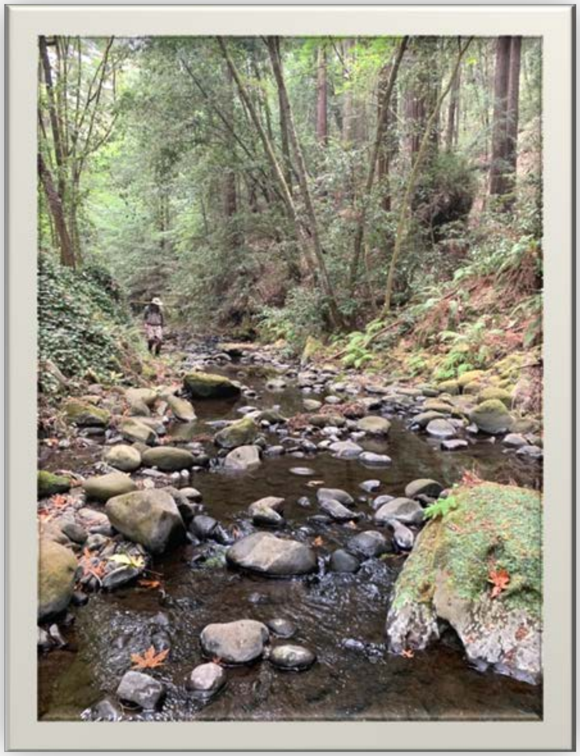
2021 Juvenile Steelhead Densities in the Corralitos Creek and Casserly Creek Watersheds



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:
Gary Kittleson, Kittleson Environmental Consulting

November 19, 2021

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. In 2020 and 2021, the City 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) plans to implement the College Lake Integrated Resources Management Project. The project will divert water 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 2021 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 on September 13-16, 2021. The sampling sites were selected to be 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

2019 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

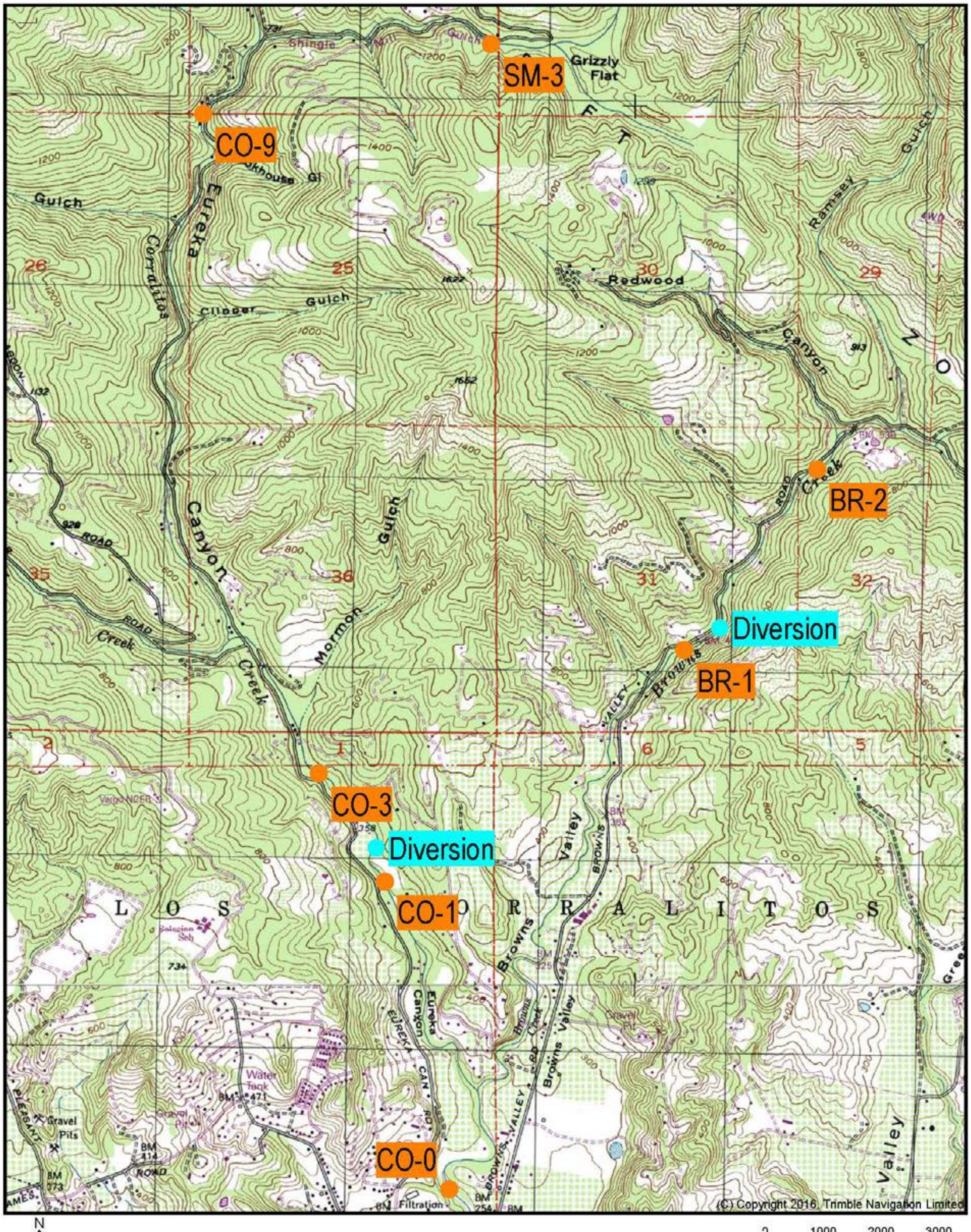
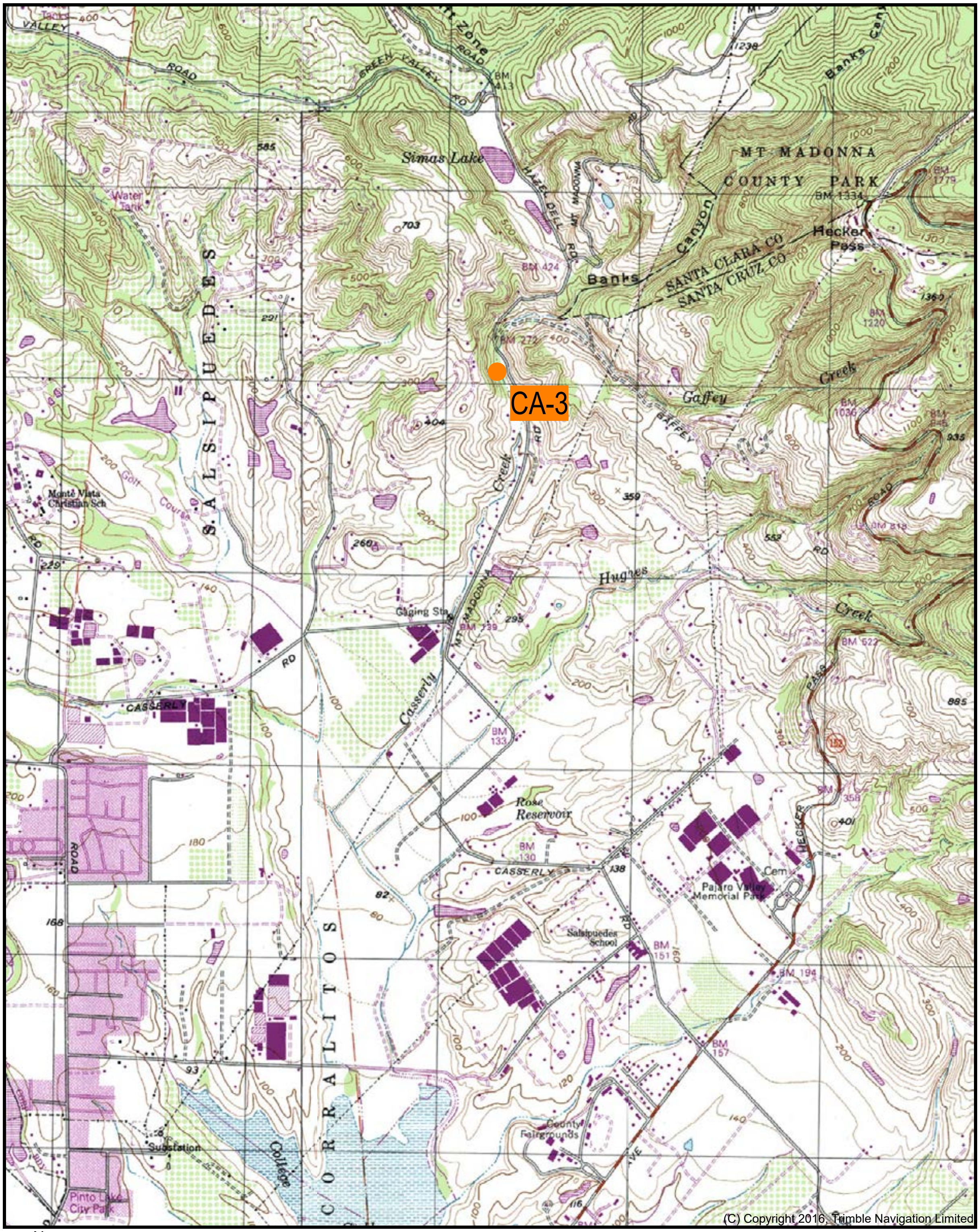


Figure 1. Sampling Sites in the Corralitos Creek Watershed



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 (e.g., gravel/cobble substrates with low levels of embeddedness) are appropriate.

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., bedrock).

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 creates 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 #15824-2R. 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., Shingle Mill Gulch #3), 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 researcher 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 2021 habitat assessments and fish surveys are presented below. Table 2 summarizes the results of basic water quality measurements collected immediately prior to fish sampling. 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 2021. The 2016 and 2017 density estimates are derived from Alley (2017, 2018). Absolute juvenile steelhead density estimates for 2018 through 2021 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 five sampling years accurately reflect actual population dynamics. Representative photographs of the sampling sites are provided in Appendix A.

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 2021 was 256 ft (Table 3). Based on percent total length, CO-0 consisted of 73% flatwater (step-run) and 27% 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 4,198 ft^2, essentially identical to the 2020 wetted area of 4,225 ft^2. Two Level II habitat units (one flatwater, one pool) were sampled at CO-0. The pool in this reach had a mean depth of 1.4 ft, a maximum depth of 1.7 ft, and a residual depth of 1.3 ft. In 2020, the pool tail-out had migrated several feet downstream since the prior year's survey and consisted of several concrete slabs forming the hydraulic control for this pool. In 2021, the concrete slabs remained, but most of the channel width now consists of a cobble tail-out with an embeddedness rating of 0-25%. The mean pool shelter rating was 40, representative of low shelter abundance, and consisted of bedrock ledge, some root mass, and terrestrial vegetation overhang. 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 40% and composed almost entirely (95%) of hardwood species.

The overall juvenile steelhead population estimate for CO-0 was 38, for a total juvenile steelhead density of 14.8 fish/100 ft (Table 4), an increase of approximately 15% over the 2020 estimate of 12.9 fish/100 ft. Of the juvenile steelhead captured at CO-0, 80.6% were age 0 fish (56.3% in 2020) and 19.4% were age 1+ fish (43.8% in 2020) (Figure 3). As such, estimated age class densities (Table 4) were 12.0 fish/100 ft for age 0 steelhead (7.3 fish/100 ft in 2020) and 2.9 fish/100 ft for age 1+ steelhead (5.7 fish/100 ft in 2020), representing a substantial increase in age 0+ densities while the age 1+ juvenile density was reduced by approximately 50%. The moderate increase in the total steelhead densities in 2021 was driven largely by the substantial increase in age 0 fish, indicative of at least some successful spawning in this lower reach of Corralitos Creek.

Sculpin (*Cottus* sp.) were again abundant at CO-0 and appeared to be represented by two species, riffle sculpin (*C. gulosus*) and coastrange sculpin (*C. aleuticus*). One California newt (*Taricha torosa*), a few Sacramento sucker (*Catostomus occidantalis*), and non-native signal crayfish (*Pacifastacus leniusculus*) were also present. Lamprey (*Lampetra* sp.) ammocoetes were captured at this site in 2020 but were absent in 2021.

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 2021 was 159 ft (Table 3). Based on percent total length, CO-1 consisted of 43% riffle and 57% 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 1,460 ft^2, comparable to the 2020 estimate of 1,347 ft^2. Four Level II habitat units (two riffles, two pools) were sampled at CO-1. The two pools in the reach had a combined mean depth of 1.2 ft, indicative of some aggradation since 2020. A large woody debris (LWD) accumulation present in 2019 has by now been entirely washed out, while a small woody debris (SWD) accumulation at the tail-out of the second pool again resulted in increased backwater depths. The maximum depth of the two pools was 2.3 ft with a maximum residual depth of 2.0 ft. Dominant pool tail-out substrates at the two pools consisted of boulders at one and bedrock at the other. As such, neither of the tail-outs provide suitable spawning habitat. The mean shelter rating for the two pools was 65, representative of relatively low shelter abundance, but the pool scoured by the previous LWD accumulation alone had a shelter rating of 100, a relatively high rating for the Corralitos Creek watershed. Sand was the dominant substrate type in the pools and large cobbles were the dominant substrate in the riffles. Canopy cover was estimated at 65% and composed almost entirely (90%) of hardwood species.

The overall juvenile steelhead population estimate for CO-1 was 26, and the total juvenile steelhead density was 16.4 fish/100 ft (Table 4), a 53% increase over the 2020 estimate of 10.7 fish/100 ft (Figure

5). Of the juvenile steelhead captured at CO-1, 87.5% were age 0 fish (26.7% in 2020) and 12.5% were age 1+ fish (73.3% in 2020) (Figure 3). As such, estimated age class densities were 14.3 fish/100 ft for age 0 steelhead (2.8 in 2020) and 2.0 fish/100 ft for age 1+ steelhead (7.8 in 2020) (Table 4). Similar to population trends at CO-0 discussed above, a large increase in the age 0 steelhead density at CO-1 in 2021 also resulted in an increase in the total steelhead density and suggests improved spawning success compared to 2020.

Sculpins were moderately abundant at CO-1. Several large (200+ mm SL) Sacramento suckers were also present. After a two-year absence of the species, one lamprey ammocoetes was observed at CO-1 in 2021.

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 2021 was 286 ft (Table 3). Based on percent total length, CO-3 consisted of 9% riffle, 41% flatwater, and 49% pool habitat. 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 3,776 ft^2, virtually identical to the 2019 estimate of 3,766 ft^2. Four Level II habitat units (one riffle, one flatwater, two pools) were sampled at CO-3. In 2018, two flatwater units and one pool were identified within this sampling reach (Podlech 2018), but by 2019, localized channel scour had modified (deepened) one of the flatwater units into a pool. The two pools in the 2021 sampling reach had a combined mean depth of 1.0 ft, a maximum depth of 2.2 ft, and a maximum residual depth of 1.5 ft. Pool depths were comparable to 2020. Dominant pool tail-out substrates at both pools consisted of large cobble with embeddedness ratings of 0-25% and 25-50%, representative of good and fair spawning conditions, respectively. The mean shelter rating for the pools was 40, representative of low shelter abundance. Shelter at CO-3 consisted of undercut banks and root masses providing relatively complex refuge habitat, but the relative proportion of the pool habitat with shelter availability is limited. Sand and large cobbles continue to be the dominant substrate types in the pools while the riffle and flatwater units are dominated by large cobble. Canopy cover was estimated at 75%, composed about equally of hardwood and conifer species.

The overall juvenile steelhead population estimate for CO-3 was 71, and the total juvenile steelhead density was 24.8 fish/100 ft (Table 4), a 61% increase over the 2020 estimate of 15.4 fish/100 ft (Figure 5). Of the juvenile steelhead captured at CO-3, 71.2% were age 0 fish (48.8% in 2020) and 28.8% were age 1+ fish (51.2% in 2020) (Figure 3). Estimated age class densities were 17.7 fish/100 ft for age 0 steelhead (7.5 in 2020) and 7.2 fish/100 ft for age 1+ steelhead (7.9 in 2020) (Table 4). Similar to CO-0 and CO-1, a large increase in age 0 densities suggest successful spawning in the vicinity of CO-3 in 2021. Combined with relatively stable age 1+ densities, the increase in age 0 densities resulted in the second highest total juvenile steelhead density of the eight sites sampled in 2021.

Sculpins were present in moderate numbers. Unlike previous years, no Sacramento sucker were observed at Co-3 in 2021, but non-native signal crayfish were abundant. Juvenile lamprey, which had been observed at CO-3 in low numbers in prior years, were not detected in 2020 or 2021.

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 (6%) is considerably steeper than at CO-0 through CO-3. The total channel length of the assessment reach in 2021 was 114 ft (Table 3). Based on percent total length, CO-9 consisted of 71% flatwater (step-run), and 29% pool habitat. 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 1,157 ft^2, comparable to the 2020 estimate of 1,097 ft^2. Two Level II habitat units (one flatwater, one pool) were sampled at CO-9. The pool in this reach had a mean depth of 1.4 ft (0.3 ft shallower than in 2020), a maximum depth of 2.5 ft (1.2 ft shallower than in 2020), and a residual depth of 2.4 ft (1.0 ft shallower than in 2020), indicative of substantial deposition during water year 2021. The pool tail-out in 2021 consisted of sand and therefore does not provide spawning habitat. The mean shelter rating for the pool was 70, representative of fair shelter abundance. 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 75%, composed almost entirely (90%) of hardwood species.

The overall juvenile steelhead population estimate for CO-9 was 44, and the total juvenile steelhead density was 38.6 fish/100 ft (Table 4), a 37% increase from the 2020 density of 28.0 fish/100 ft (Figure 5). This represents the third year in a row that CO-9 has had the highest total juvenile density of all eight sampling sites. Of the steelhead captured at CO-9 in 2021, 56.4% were age 0 fish (61.5% in 2020) and 43.6% were age 1+ fish (38.5% in 2020) (Figure 3). A relatively even distribution of age classes is typical for this sampling site. Estimated age class densities were 21.8 fish/100 ft for age 0 steelhead (17.3 in 2020) and 16.8 fish/100 ft for age 1+ steelhead (10.8 in 2020) (Table 4). The 2021 age 1+ density at CO-9 was the highest among all sampling sites for the fourth year in a row. The large pool at this site provides high quality habitat for older fish, some of which may assume a resident life history tactic.

Only one sculpin and one California newt were present at CO-9 in 2021.

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 2021 was 139 ft (Table 3). Based on percent total length, SM-3 consisted of 26% riffle and 74% pool habitat. 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 704 ft^2, comparable to the 2020 estimate of 711 ft^2. Three Level II habitat units (one riffle, two pools) were sampled at SM-3. The pools in the reach had a combined mean depth of 0.7 ft, a maximum depth of 1.6 ft, and a residual depth of 1.5 ft. Dominant pool tail-out substrates at the two pools consisted of large and small cobble with embeddedness ratings of 0-25% and 25-50%, representative of good and fair spawning conditions, respectively. The combined mean shelter rating for the pools was 27.5, substantially lower than the rating of 70 in 2020 and primarily the result of the winnowing of a woody debris accumulation in one of the pools over the past year. Gravel and small cobble were the dominant pool substrate types while the riffle was dominated by small cobble. Canopy cover was estimated at 90%, composed almost entirely (90%) of conifer species.

The overall juvenile steelhead population estimate for SM-3 was 5, and the total juvenile steelhead density was 3.6 fish/100 ft, a 25% decrease from the 2020 density of 4.8 fish/100 (Table 4). Of the juvenile steelhead captured at SM-3, 20.0% were age 0 fish (66.7% in 2020) and 80.0% were age 1+ fish (33.3% in 2020) (Figure 3). Estimated age class densities were 0.7 fish/100 ft for age 0 steelhead (3.2 in 2020) and 2.9 fish/100 ft for age 1+ steelhead (1.6 in 2020) (Table 4). Based on the very low density of age 0 fish at SM-3 (only one individual was captured in 2021), it appears that anadromous spawning likely did not occur this far up in the watershed in 2021 and that the Shingle Mill population may currently be sustained by low levels of resident trout spawning.

Seven larval California giant salamanders (*Dicamptodon ensatus*) and one California newt were observed at SM-3 in 2021. 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 2021 was 240 ft (Table 3). Based on percent total length, BR-1 consisted of 40% flatwater and 60% pool habitat. 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 2,333 ft^2, similar to the 2020 estimate of 2,418 ft^2. Three Level II habitat units (one flatwater, two pools) were sampled at BR-1. The two pools in this reach had a combined mean depth of 0.8 ft, a maximum depth of 2.1 ft, and a residual depth of 1.9 ft, indicative of a moderate amount (0.1-0.2 ft) of aggradation since 2020. The tail-outs at the 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 55, representative of low shelter abundance. The limited shelter was dominated by bedrock ledges in one pool and by a single root-wad in the other. Canopy cover was estimated at 75%, composed about equally of hardwood and conifer species.

The overall juvenile steelhead population estimate for BR-1 was 20, and the total juvenile steelhead density was 8.3 fish/100 ft (Table 4), a 42% decrease from the total density of 14.3 fish/100 ft in 2020. Juvenile densities have fluctuated widely at BR-1 since 2016 (Figure 5). Of the juvenile steelhead captured at BR-1, 40.0% were age 0 fish (32.0% in 2020) and 60.0% were age 1+ fish (68.0% in 2020) (Figure 3), similar to the age class structure observed in 2020. Estimated age class densities were 3.3 fish/100 ft for age 0 steelhead (4.6 in 2020) and 5.0 fish/100 ft for age 1+ steelhead (9.7 in 2020) (Table 4). Steelhead densities at BR-1 have declined substantially during two consecutive drought years.

Sculpins were moderately abundant, and some non-native signal crayfish were present at BR-1.

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 2020 was 228 ft (Table 3), approximately 40 ft less than in 2020. Based on percent total length, BR-2 consists of 61%

flatwater and 39% pool habitat. 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 2,642 ft^2, approximately 14% less than the 2020 estimate of 3,068 ft^2 as a result of the reduced reach length. 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 0.8 ft, a maximum depth of 1.9 ft, and a residual depth of 1.8 ft. The tail-outs at both pools consisted of large cobble with embeddedness ratings of 25-50%. The mean shelter rating for the pools was 37.5, representative of low shelter abundance. The limited shelter was dominated by boulders in one pool and by a 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 5, and the total juvenile steelhead density was 2.2 fish/100 ft (Table 4), an 83% decrease from the total density of 13.1 fish/100 ft in 2020 and the lowest density observed at this site in six years of sampling (Figure 5). Of the juvenile steelhead captured at BR-2, none were age 0 fish (59.4% in 2020) with 100% of captured fish in the age 1+ class (40.6% in 2020) (Figure 3). Estimated age class densities were 0.0 fish/100 ft for age 0 steelhead (7.8 in 2020) and 2.2 fish/100 ft for age 1+ steelhead (5.3 in 2020) (Table 4), indicative of essentially no 2021 spawning upstream of the City's diversion and representative of a near collapse of the population in this reach after two consecutive drought years.

However, sculpins were abundant at BR-2 in 2021.

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 2021 was 187 ft (Table 3), 20 ft less than in 2020. Surface flows were intermittent in 2021. Based on percent total length, CA-3 consisted of 33% riffles, 42% flatwater, and 25% pool habitat. 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 810 ft^2, a 15% decrease from the 2020 estimate of 951 ft^2 that is partially due to the shorter sampling reach but also due to the noticeably reduced wetted widths in 2021. Three Level II habitat units (one riffle, one flatwater, one pool) were sampled at CA-3. The pool in the reach had a mean depth of 0.7 ft, a maximum depth of 1.2 ft, and a residual depth of 1.1 ft. Dominant pool tail-out substrates consisted of large cobbles with a high embeddedness rating of 25-50%. The shelter rating for the pool was 80, reflective of the moderately high levels of cover provided by a root mass, undercut bank, and small woody debris. Sand and large cobble are the dominant substrate types in the pool, while sand dominated the flatwater and large cobbles were the dominant substrate in the riffle. Canopy cover was estimated at 50%, consisting of approximately 75% hardwood and 25% conifer species.

The overall juvenile steelhead population estimate for CA-3 was 12, and the total juvenile steelhead density was 6.4 fish/100 ft, representing a 57% decrease from the 2020 density of 15.0 fish/100 ft. Of

[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 did not change from 2019 to 2020 and 2021.

the juvenile steelhead captured at CA-3, 66.7% were age 0 fish (36.7% in 2020) and 33.3% were age 1+ fish (63.3% in 2020) (Figure 3). Estimated age class densities were 4.3 fish/100 ft for age 0 steelhead (5.5 in 2020) and 2.1 fish/100 ft for age 1+ steelhead (9.5 in 2020) (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). Similar to 2020, however, the 2021 relative abundance of age 0 fish was greatly reduced, a trend that is consistent with observations in upper Corralitos Creek and Browns Creek discussed above and indicative of limited adult migration opportunities in water year 2021 (Figure 7).

No other fish species, amphibians, 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. Most recently, 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 62-year average through the end of March, significantly limiting adult steelhead access to the watershed during the typical peak of 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).

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

Water year 2019 resulted in Corralitos Creek streamflows consistently remaining above the 62-year average through the entire adult steelhead migration and spawning season and smolt outmigration season. In fact, 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 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 (sustained, moderate spring flows), combined with the relatively low (<10 fish/100 ft) age 0 densities 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 (Figure 7) 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).

Water year 2021 marked the 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 Salsipuedes-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 over the past six years of monitoring (Figure 5).

It is important to note that the City of Watsonville did not operate its filter plant in 2020 or 2021. 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 and 2021 amounted to control years from the perspective of a fisheries effects analysis. As described above, both of the years the City did not divert were drought years, yet juvenile steelhead population trends differed based on differences in the timing of runoff events and the location of sampling sites.

TABLE 2

WATER QUALITY RESULTS AT EIGHT SAMPLING SITES IN THE CORRALITOS CREEK AND CASSERLY CREEK WATERSHEDS, SEPTEMBER 2021

Parameter	CO-0	CO-1	CO-3	CO-9	SM-3	BR-1	BR-2	CA-3
Date	9/16	9/15	9/16	9/13	9/13	9/14	9/14	9/15
Time	0950	1000	1410	1150	1010	1000	1245	1305
Weather	clear	clear	clear	clear	clear	clear	clear	clear
Air Temp (°C)	14.2	15.7	15.5	18.1	15.3	13.1	16.0	19.1
Water Temp (°C)	14.0	14.1	14.0	14.8	14.1	13.7	13.7	14.4
Conductivity (µmhos/cm)	433	428	431	541	426	589	651	576
DO Conc. (mg/l)	9.5	9.4	9.3	9.1	8.6	9.5	8.7	6.6
DO Sat. (%)	93	91	90	91	86	91	84	63
Streamflow* (cfs)	NA	1.48	NA	NA	NA	NA	NA	<0.01

*NOTES: = Preliminary streamflow estimates for CO-1 provided by the City of Watsonville;
CA-3 consisted of isolated wetted areas lacking surface connectivity and streamflow could not be measured. Qualitatively, streamflow on the day of the September 2021 survey was noticeably lower than in September 2020.

TABLE 3

SUMMARY OF HABITAT TYPES AND MEASURED PARAMETERS AT EIGHT SAMPLING SITES IN THE CORRALITOS CREEK AND CASSERLY CREEK WATERSHEDS, SEPTEMEBR 2021

Site ID	Habitat Unit Type	Number of Units Present	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 Rating	Mean Shelter Value
CO-0	P	1	68.0	27	15.3	1.4	1.7	1.3	1,040	SA	LC	1	40
	F	1	188.0	73	16.8	0.3	1.0	---	3,158	LC	---	---	---
	TOTAL		**256.0**						**4,198**				
CO-1	P	2	90.0	57	10.7	1.2	2.3	2.0	963	SA/BO	BR/BO	1	65
	R	2	69.0	43	7.2	0.4	1.2	---	497	LC	---	---	---
	TOTAL		**159.0**						**1,460**				
CO-3	P	2	141.0	49	14.8	1.0	2.2	1.5	2,087	SA/LC	LC	2.5	40
	F	1	118.0	41	11.8	0.6	1.4	---	1,392	LC	---	---	---
	R	1	27.0	9	11.0	0.3	0.6	---	297	LC	---	---	---
	TOTAL		**286.0**						**3,776**				
CO-9	P	1	33.0	29	12.0	1.4	2.5	2.4	396	SA	SA	NA	70
	F	1	81.0	71	9.4	0.5	0.9	---	761	BO	---	---	---
	TOTAL		**114.0**						**1,157**				
SM-3	P	2	103.0	74	5.4	0.7	1.6	1.5	556	GR/SC	GR	1.5	27.5
	R	1	36.0	26	4.1	0.1	0.2	---	148	SC	---	---	---
	TOTAL		**139.0**						**704**				
BR-1	P	2	144.0	60	8.2	0.8	2.1	1.9	1,181	BO/SA	LC/LC	1.5	55
	F	1	96.0	40	12.0	0.8	0.9	---	1,152	BO	---	---	---
	TOTAL		**240.0**						**2,333**				
BR-2	P	2	88.0	39	9.5	0.8	1.9	1.8	836	SA/BO	LC	2	37.5
	F	1	140.0	61	12.9	0.2	1.0	---	1,806	BO	---	---	---
	TOTAL		**228.0**						**2,642**				
CA-3	P	1	29.0	16	5.5	0.7	1.2	1.1	160	SA	LC	2	80
	F	1	88.0	47	5.0	0.3	1.0	---	440	SA	---	---	---
	R	1	70.0	37	3.0	0.1	0.4	---	210	LC	---	---	---
	TOTAL		**187.0**						**810**				

NOTE: Habitat unit codes: R = riffle; F = flatwater; P = pool.

NOTE: 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 2021

Metric	CO-0	CO-1	CO-3	CO-9	SM-3	BR-1	BR-2	CA-3
Total Density	14.8	16.4	24.8	38.6	3.6	8.3	2.2	6.4
Age 0 Density	12.0	14.3	17.7	21.8	0.7	3.3	0.0	4.3
Age 1+ Density	2.9	2.0	7.2	16.8	2.9	5.0	2.2	2.1

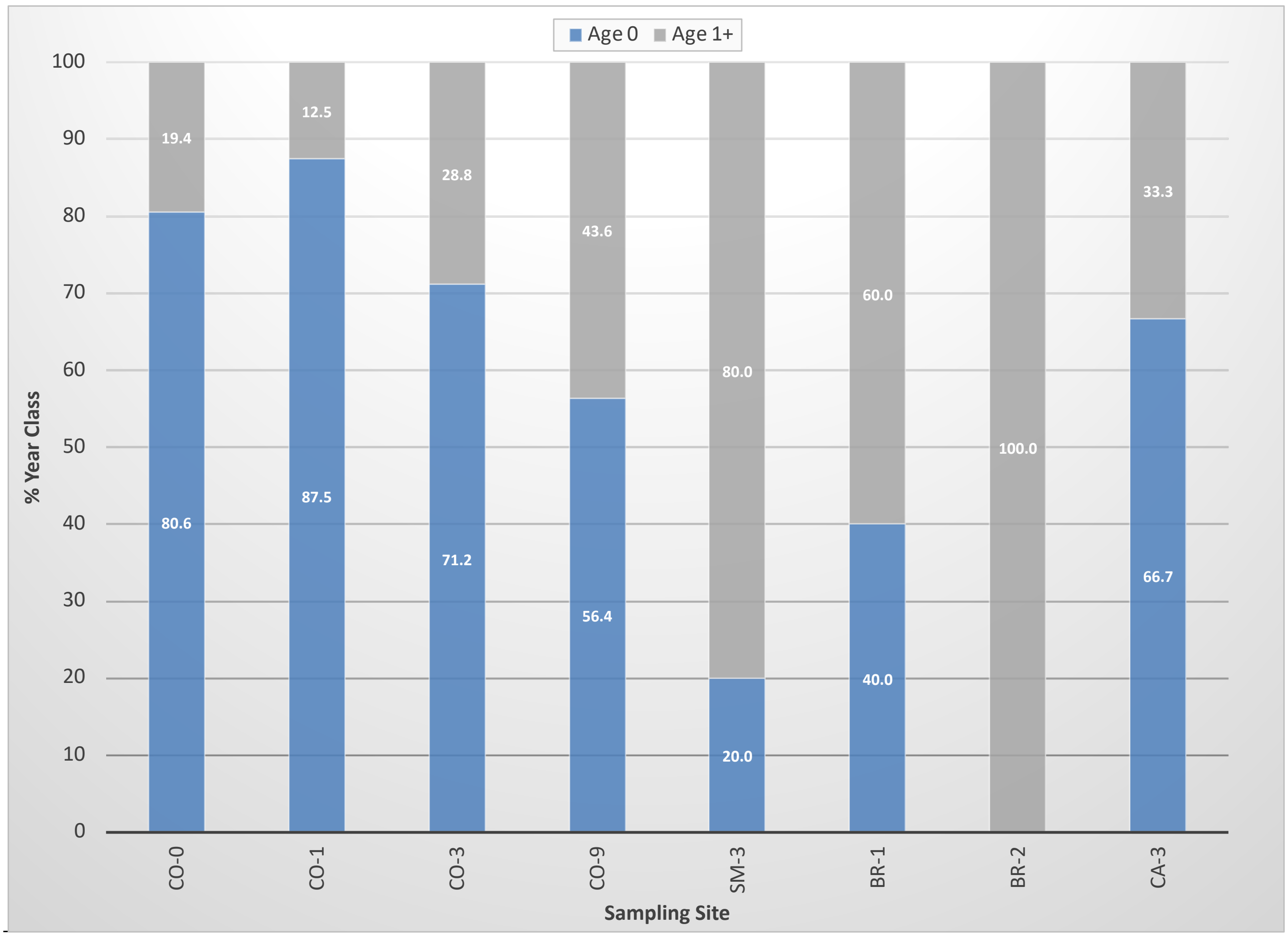
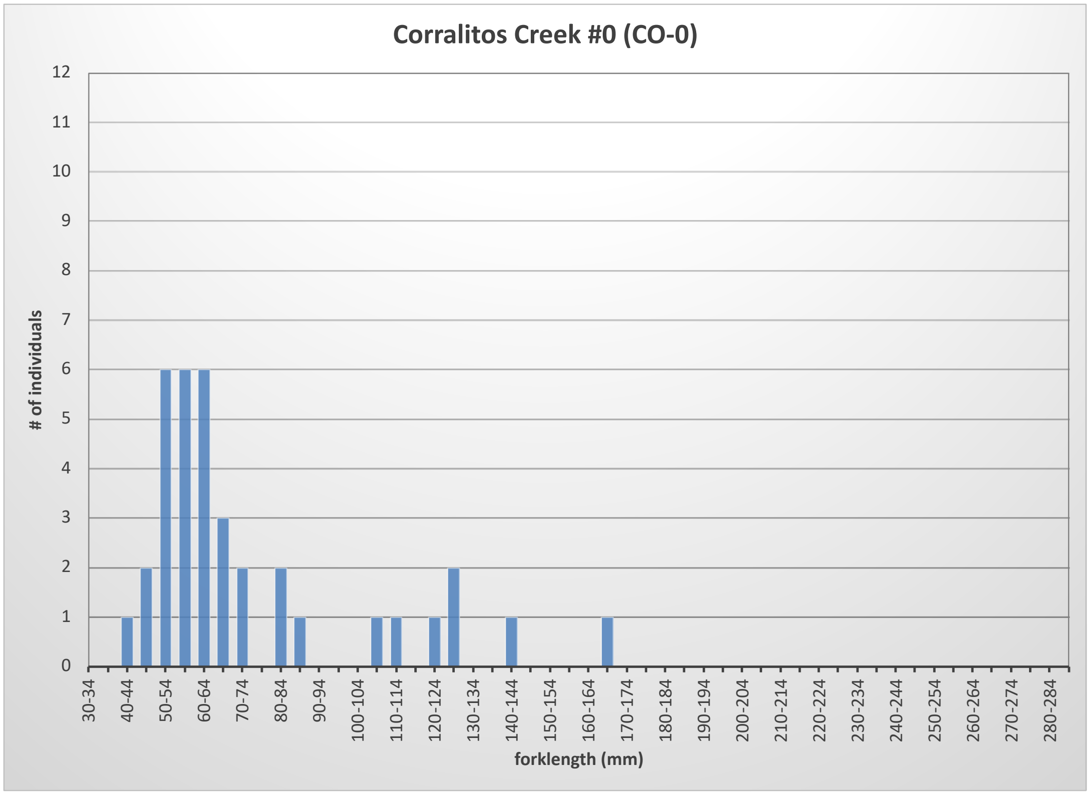


Figure 3. Relative Proportion (%) of Juvenile Steelhead Age Classes at Eight Sampling Sites in the Corralitos Creek and Casserly Creek Watersheds, September 2021



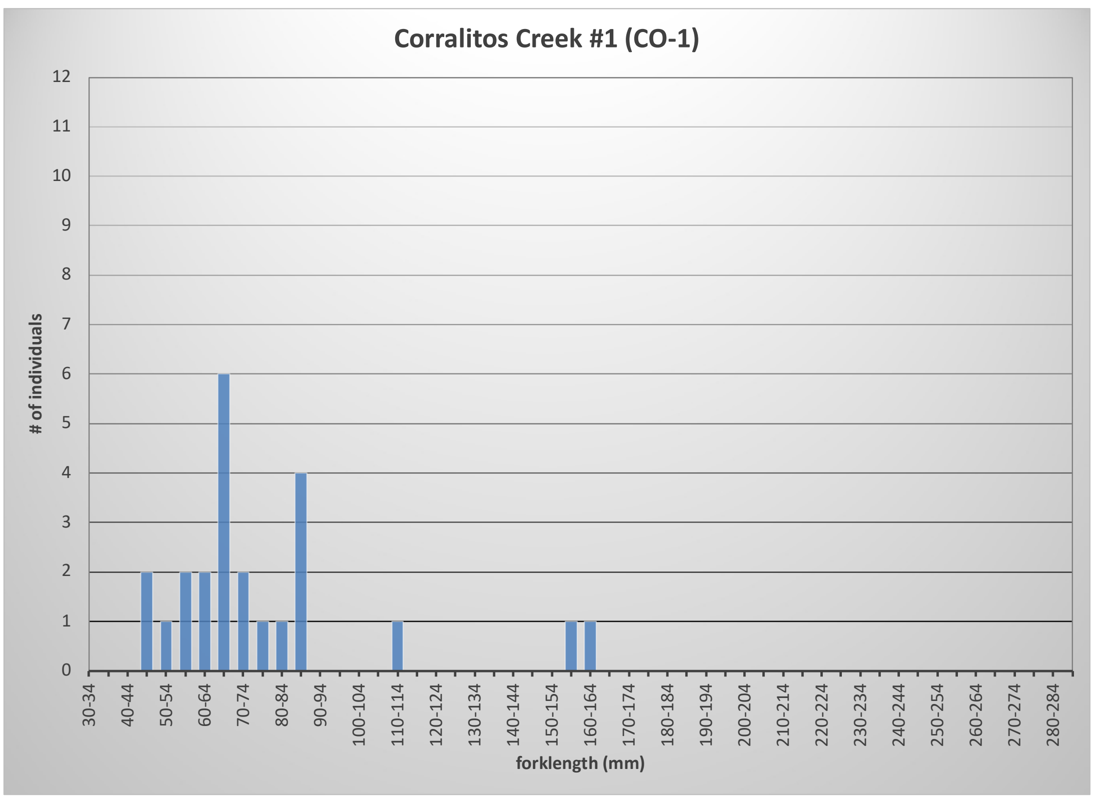
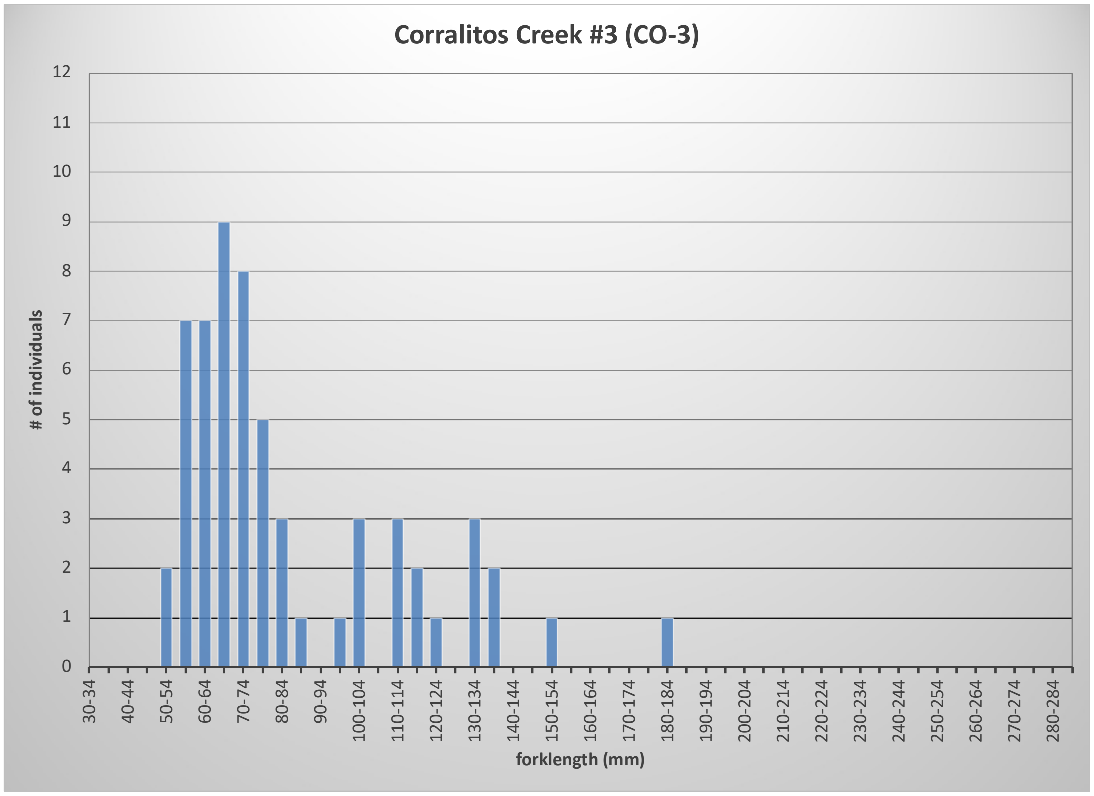


Figure 4. Forklength Distributions of Juvenile Steelhead at Eight Sampling Sites in the Corralitos Creek and Casserly Creek Watersheds, September 2021



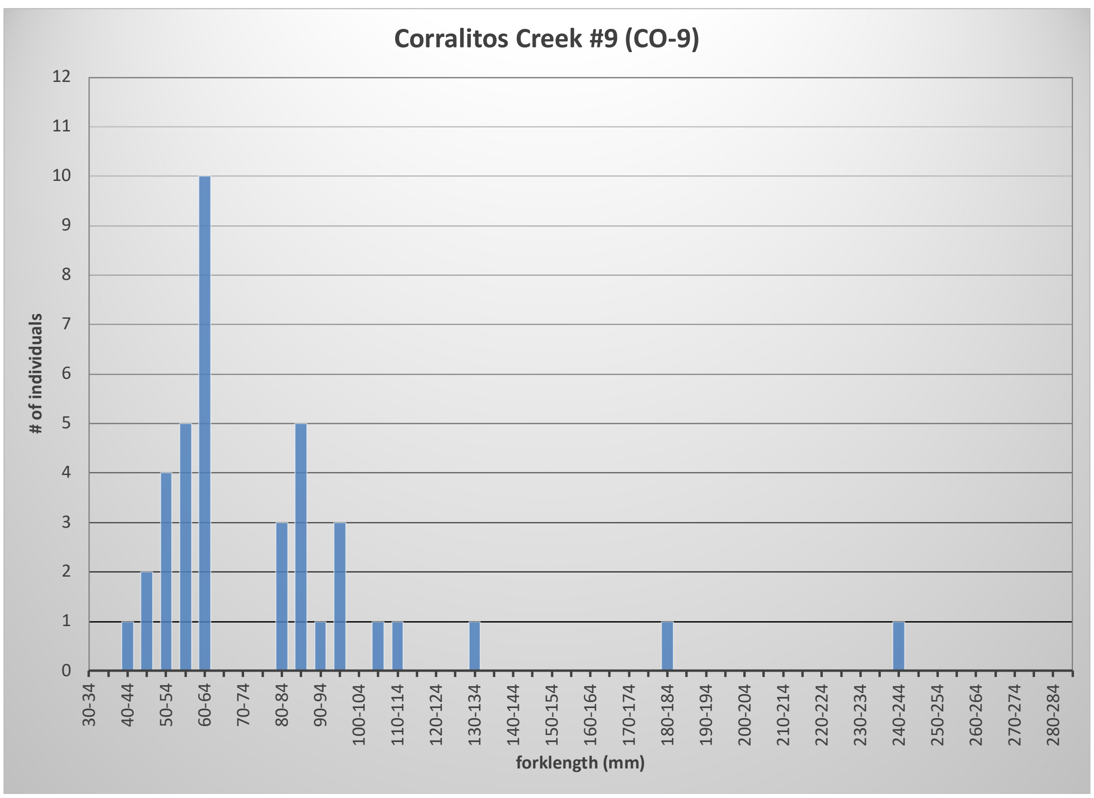
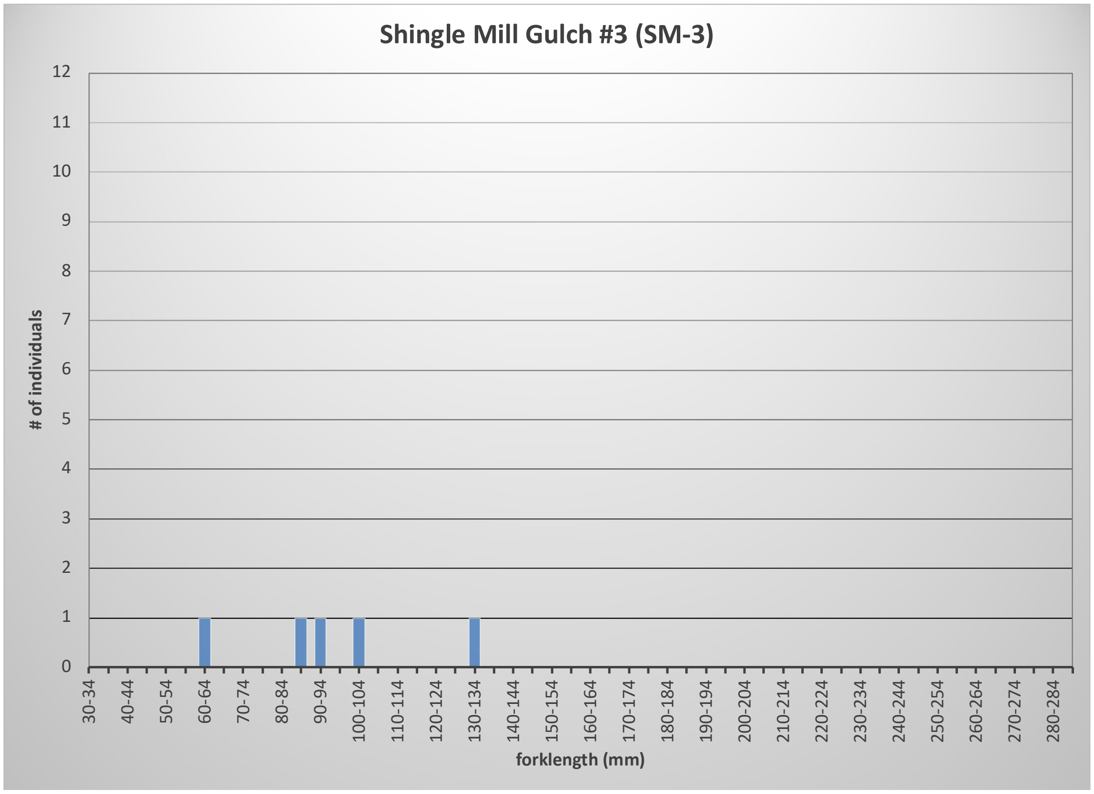


Figure 4 (cont.). Forklength Distributions of Juvenile Steelhead at Eight Sampling Sites in the Corralitos Creek and Casserly Creek Watersheds, September 2021



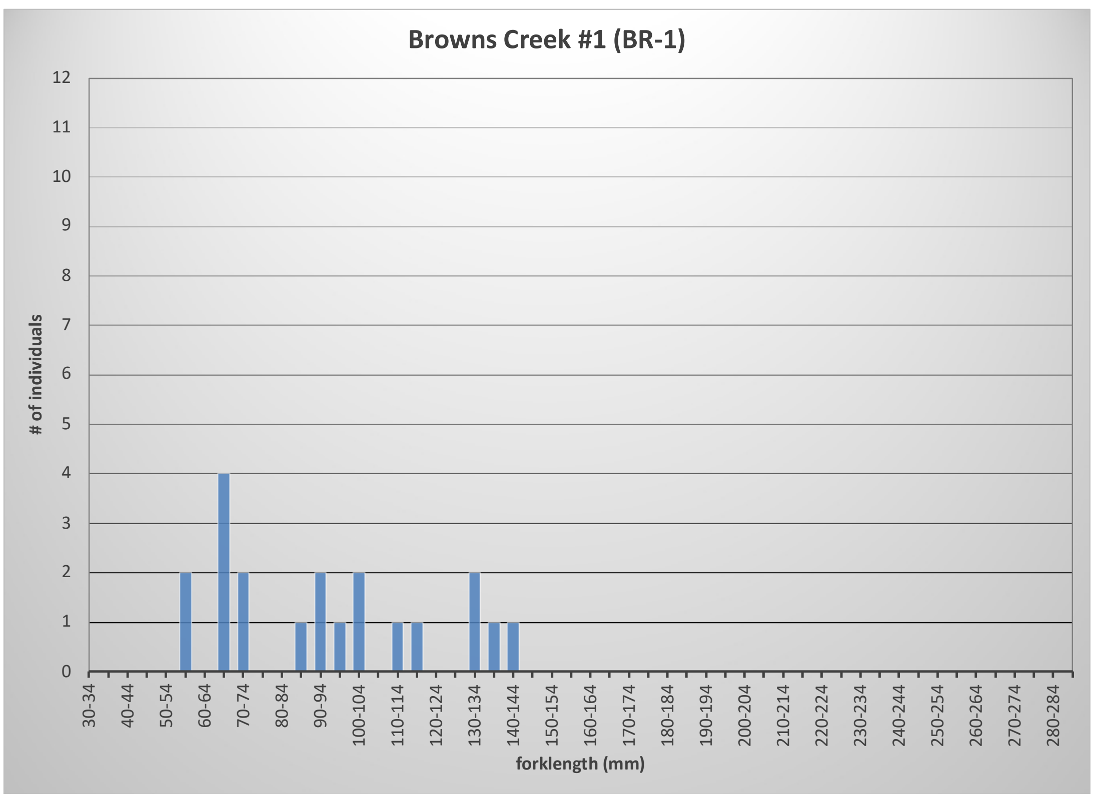
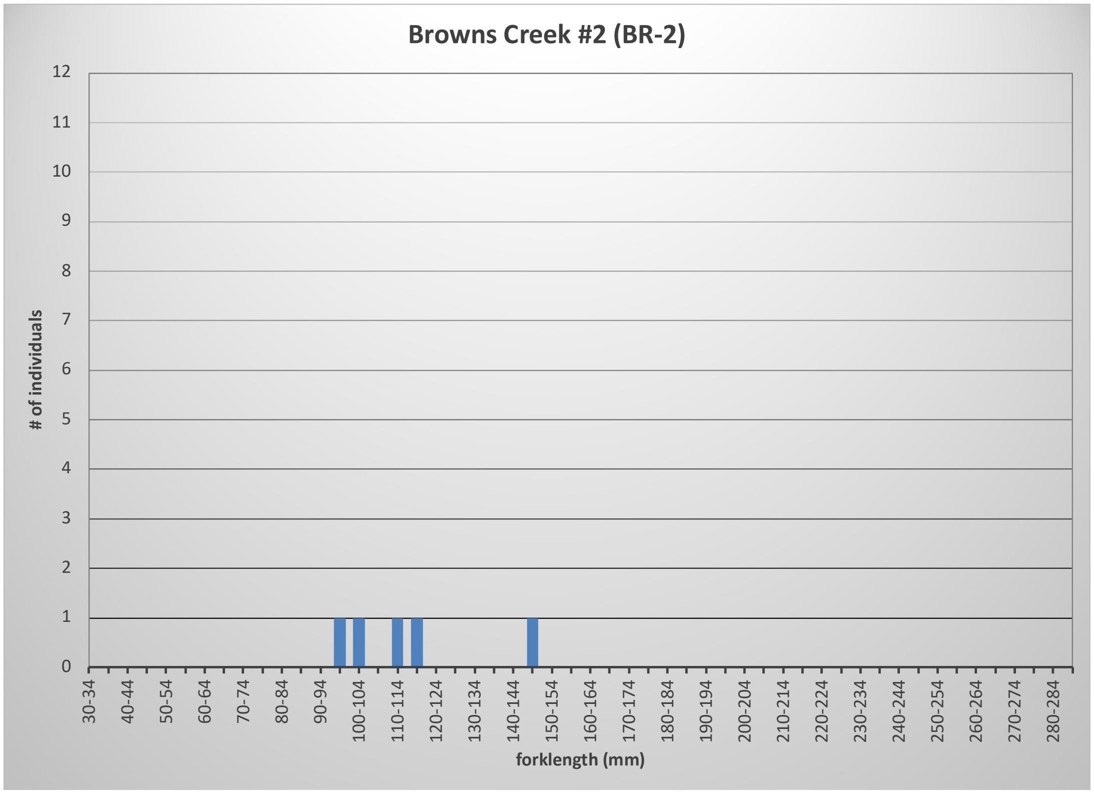


Figure 4 (cont.). Forklength Distributions of Juvenile Steelhead at Eight Sampling Sites in the Corralitos Creek and Casserly Creek Watersheds, September 2021



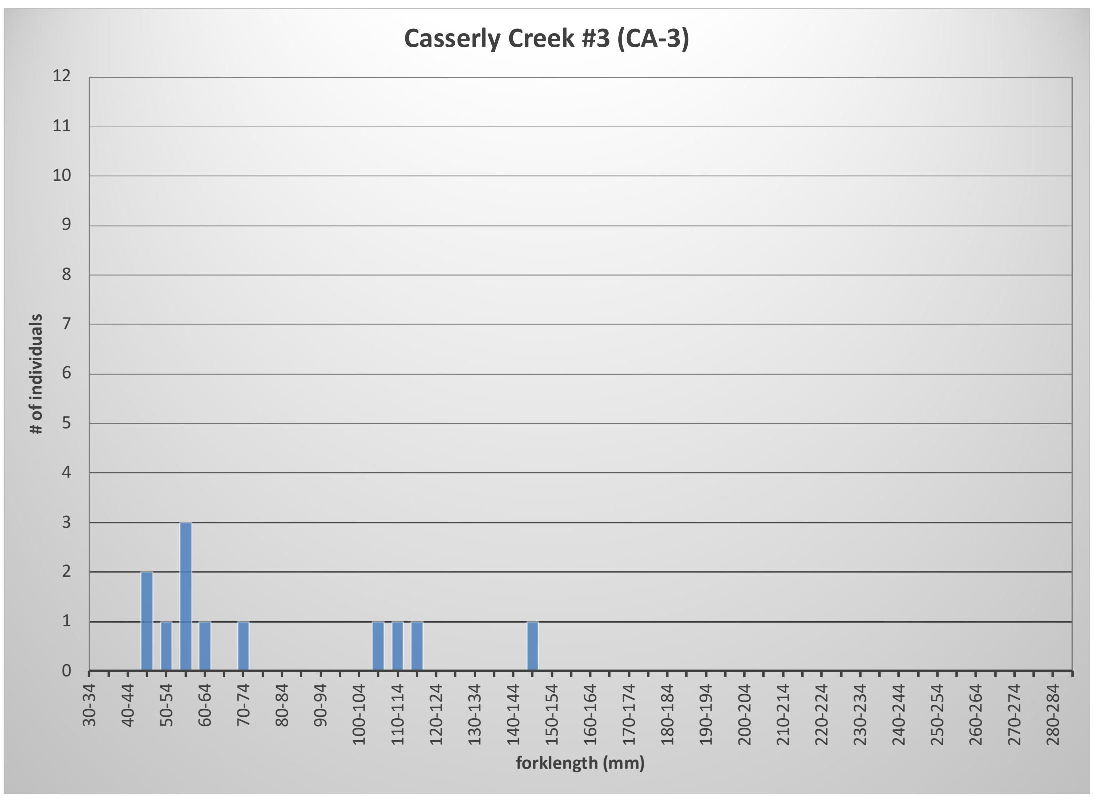
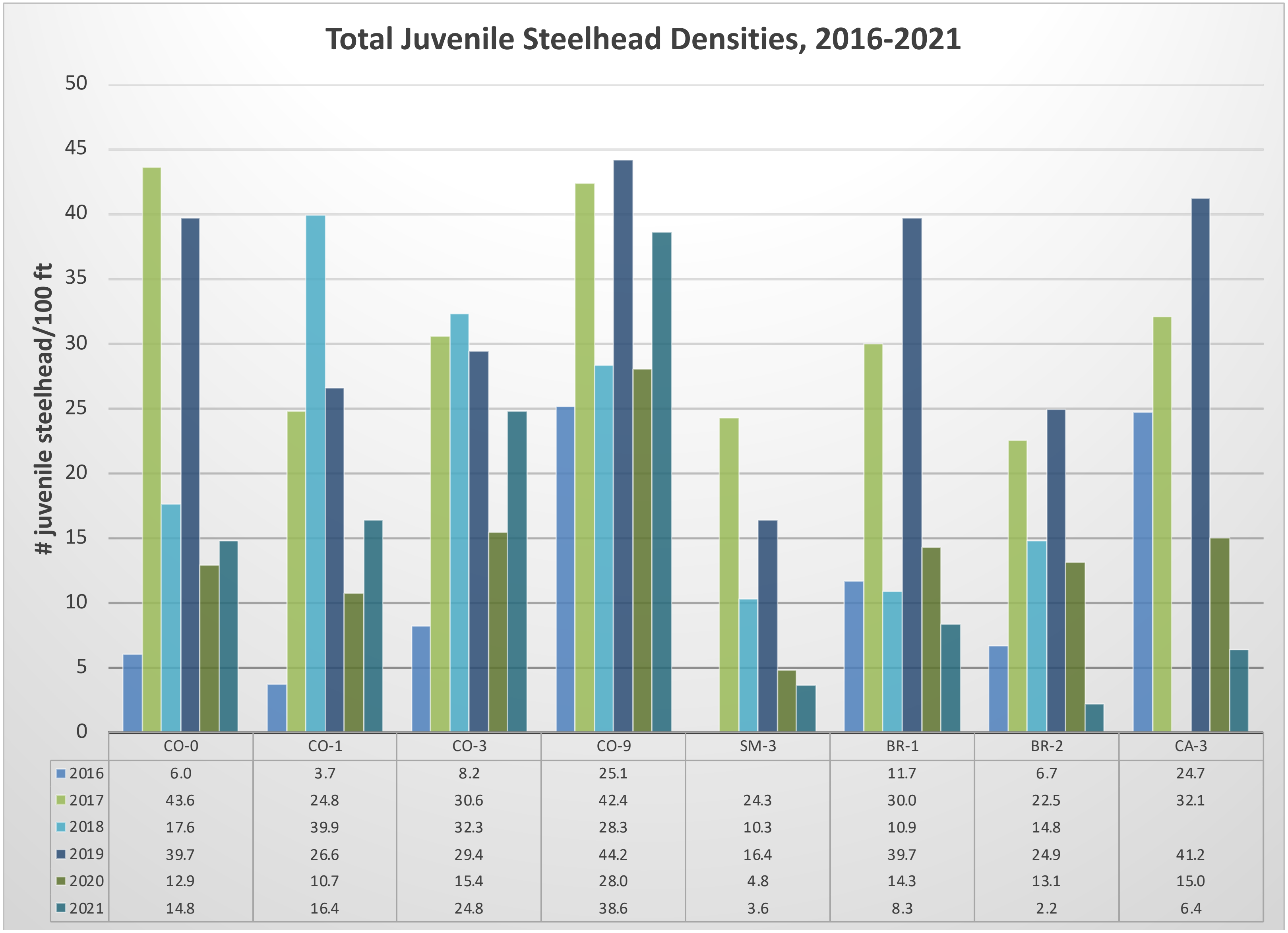


Figure 4 (cont.). Forklength Distributions of Juvenile Steelhead at Eight Sampling Sites in the Corralitos Creek and Casserly Creek Watersheds, September 2021

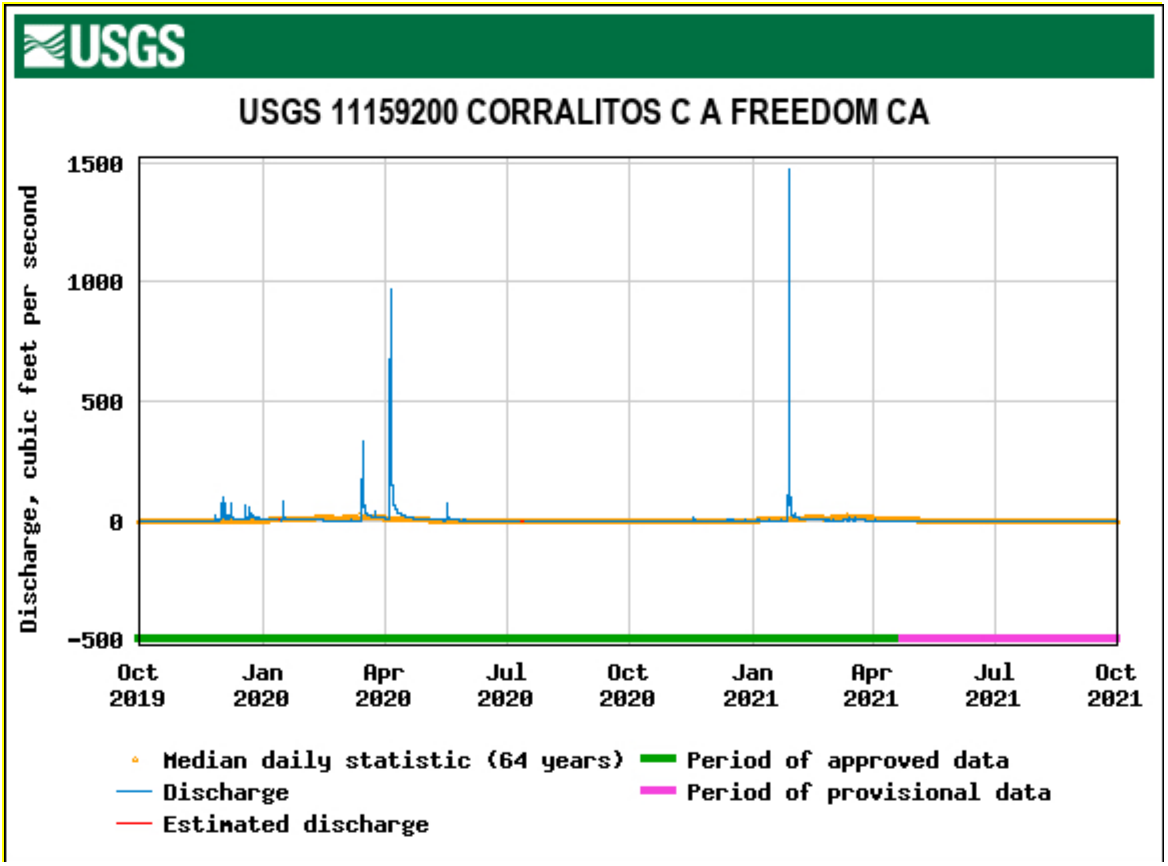


	CO-0	CO-1	CO-3	CO-9	SM-3	BR-1	BR-2	CA-3
2016	6.0	3.7	8.2	25.1		11.7	6.7	24.7
2017	43.6	24.8	30.6	42.4	24.3	30.0	22.5	32.1
2018	17.6	39.9	32.3	28.3	10.3	10.9	14.8	
2019	39.7	26.6	29.4	44.2	16.4	39.7	24.9	41.2
2020	12.9	10.7	15.4	28.0	4.8	14.3	13.1	15.0
2021	14.8	16.4	24.8	38.6	3.6	8.3	2.2	6.4

Figure 5. Total Juvenile Steelhead Densities at Eight Sampling Sites in the Corralitos Creek and Casserly Creek Watersheds, 2016-2021 (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

Figure 6. Age 0 Steelhead Densities at Eight Sampling Sites in the Corralitos Creek and Casserly Creek Watersheds, 2016-2021 (data for 2016-2017 adapted from Alley [2017, 2018])



SOURCE: U.S. Geological Survey, 2021

Figure 7. Mean Daily Discharge in Corralitos Creek at Freedom, USGS Gage 11159200, Water Years 2020-2021

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Appendix A

Photographs of Eight Sampling Sites in the Corralitos Creek and Casserly Creek Watersheds, September 2021

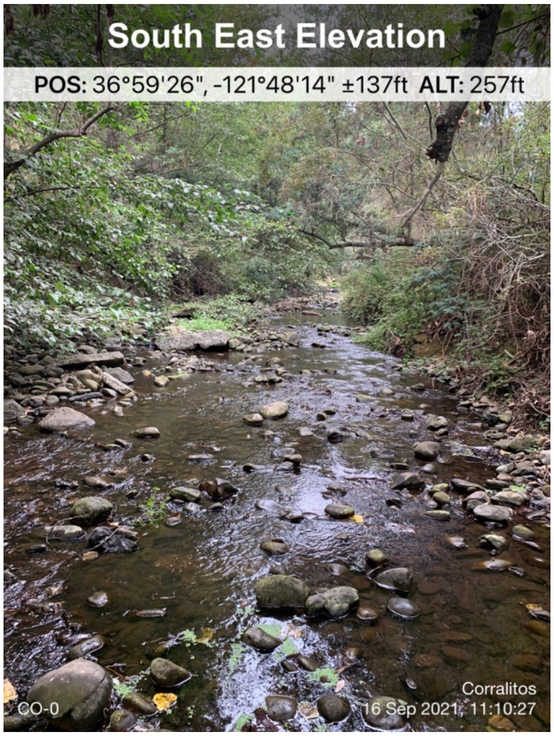

Photo 1. CO-0 flatwater-riffle transition, Sep. 16, 2021

Photo 2. CO-0 pool, Sep. 16, 2021

Photo 3. CO-1 riffle, Sep. 15, 2021

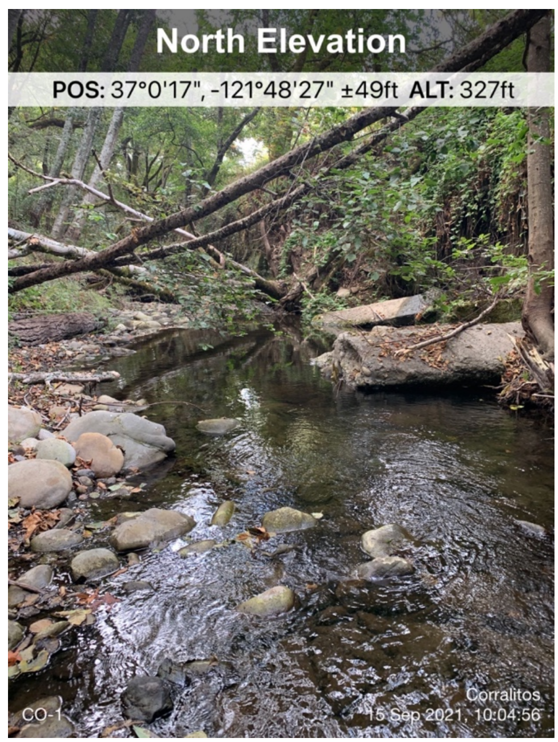

Photo 4. CO-1 pool with cover, Sep. 15, 2021

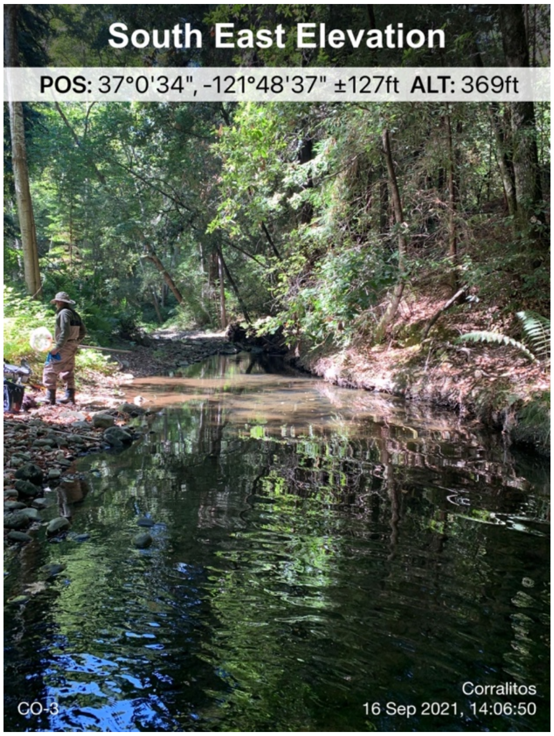

Photo 5. CO-3 pool, Sep. 16, 2021

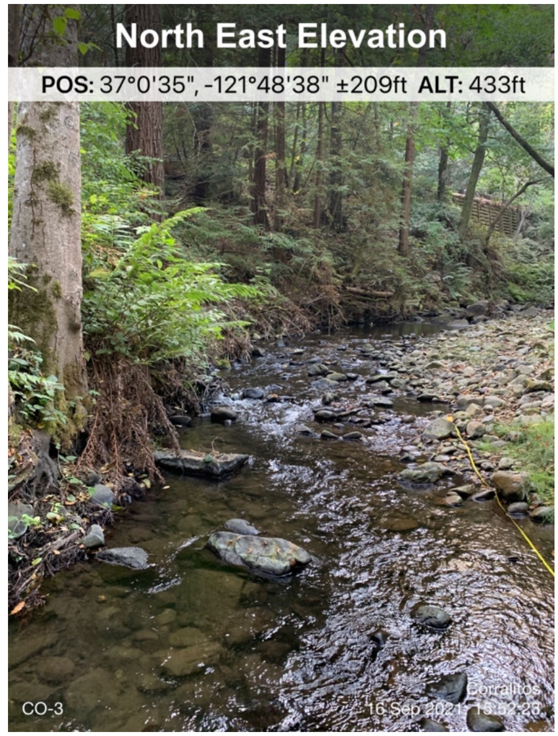

Photo 6. CO-3 riffle, Sep. 16, 2021

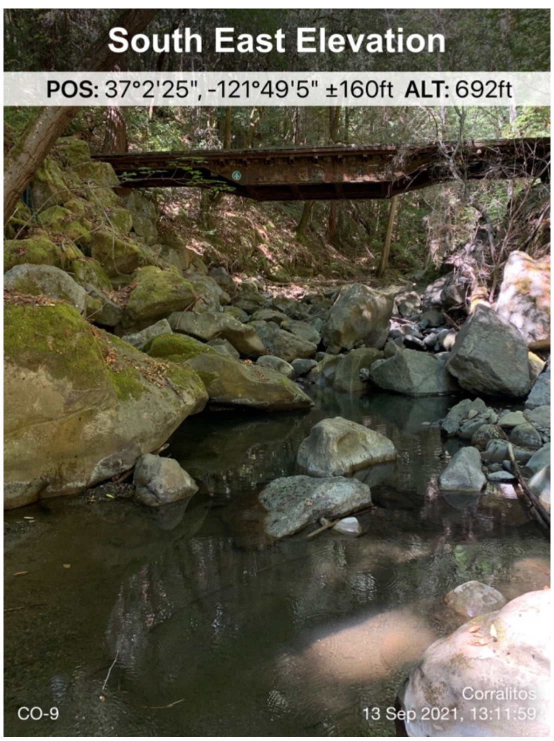

Photo 7. CO-9 pool, Sep. 13, 2021

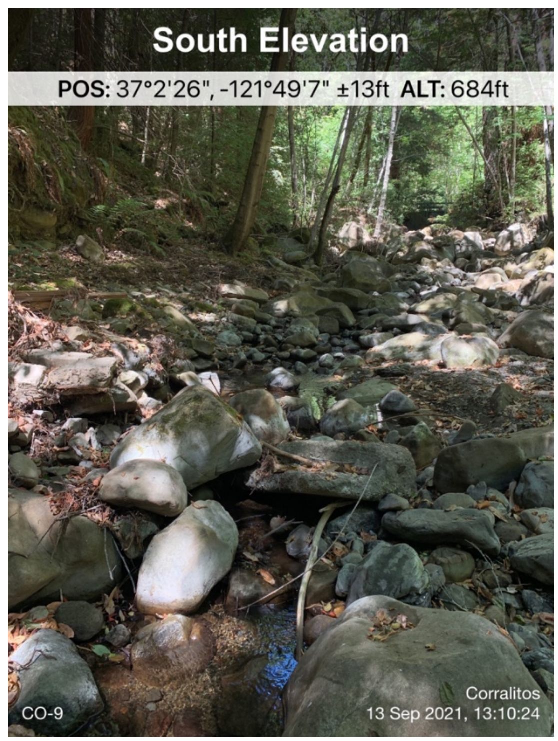

Photo 8. CO-9 flatwater, Sep. 13, 2021

Photo 9. SM-3 pool, Sep. 13, 2021

Photo 10. SM-3 riffle-pool transition, Sep. 13, 2021

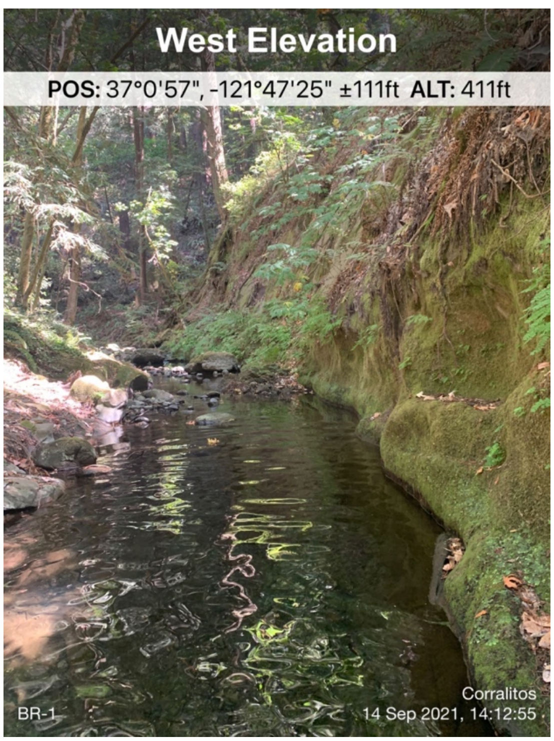

Photo 11. BR-1 pool, Sep. 14, 2021

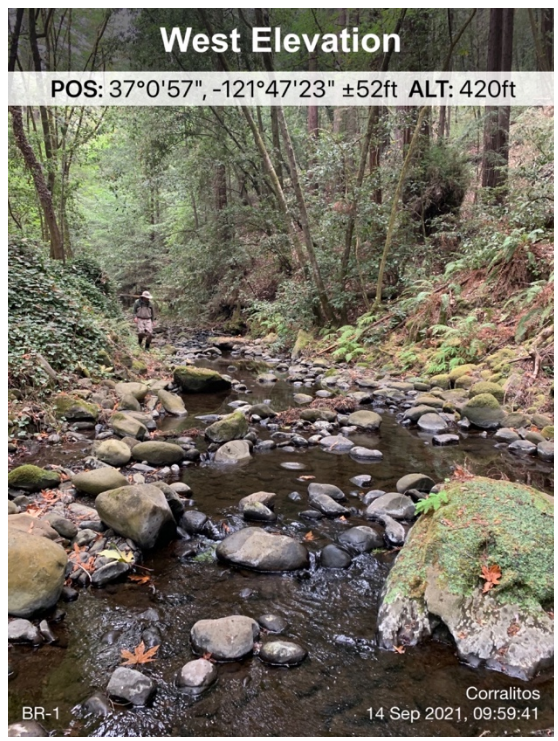

Photo 12. BR-1 flatwater, Sep. 14, 2021

Photo 13. BR-2 pool, Sep. 14, 2021

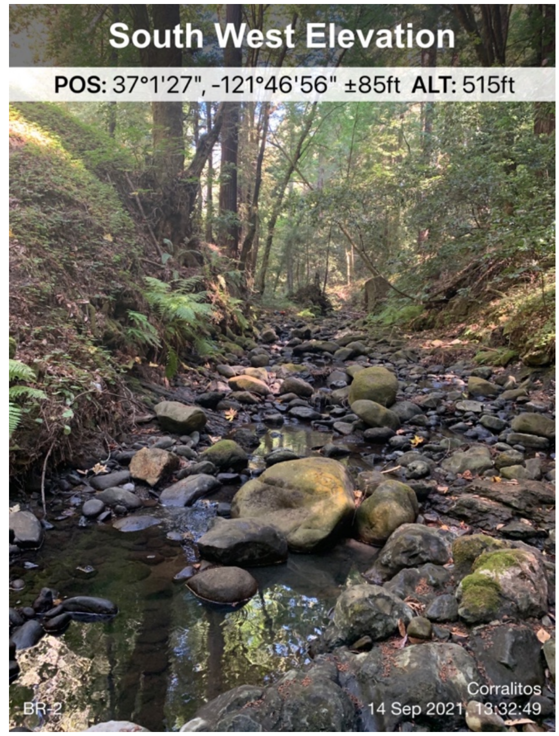

Photo 14. BR-2 flatwater, Sep. 14, 2021

Photo 15. CA-3 pool, Sep. 15, 2021

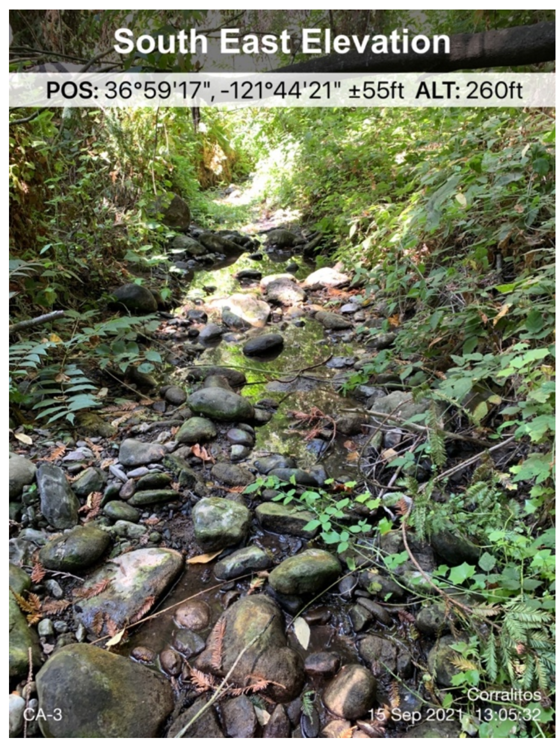

Photo 16. CA-3 riffle, Sep. 15, 2021