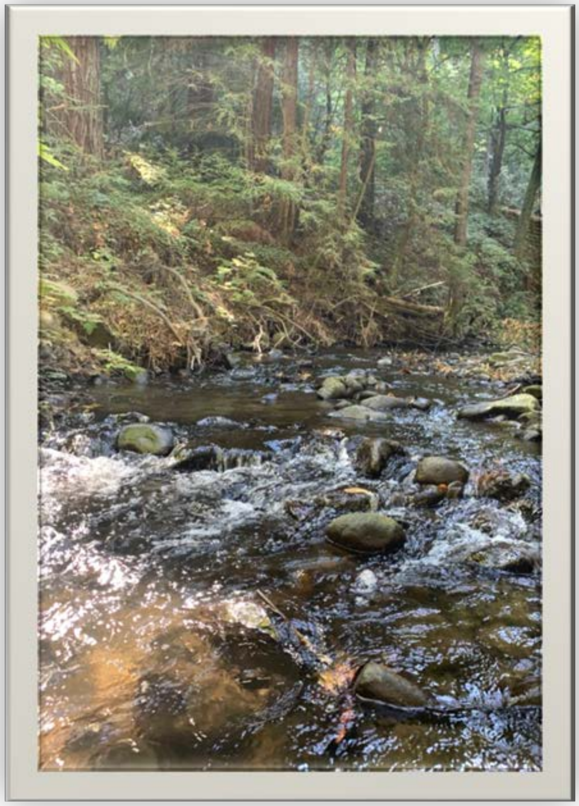
2020 Juvenile Steelhead Densities in the Corralitos Creek and Casserly Creek Watersheds



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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, 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 subwatersheds. 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 elected to again fund fish surveys in 2020 at a previously sampled site on Casserly Creek.

This report summarizes the results of the 2020 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 23, 24, 25, and 29, 2020. 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

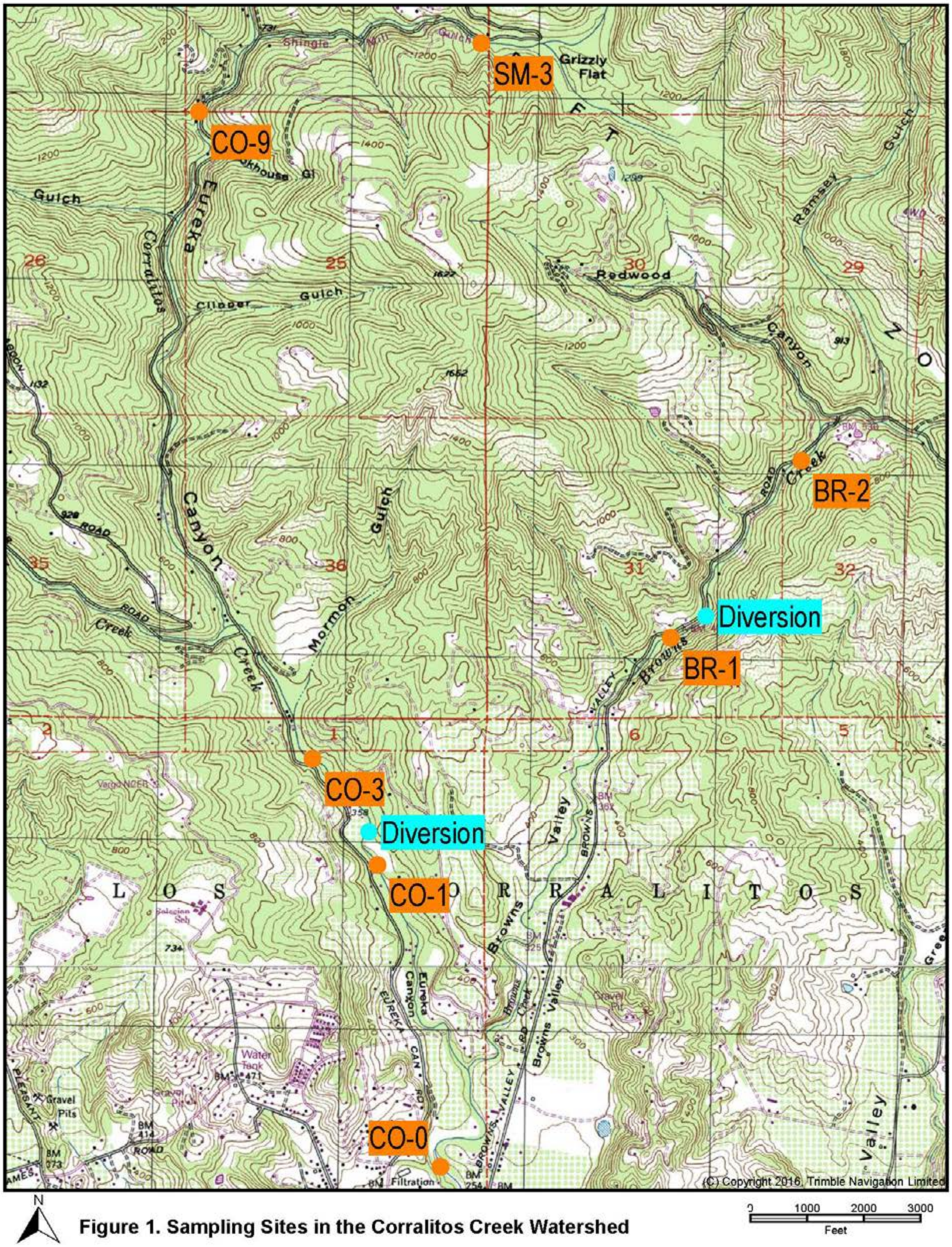


Figure 1. Sampling Sites in the Corralitos Creek Watershed

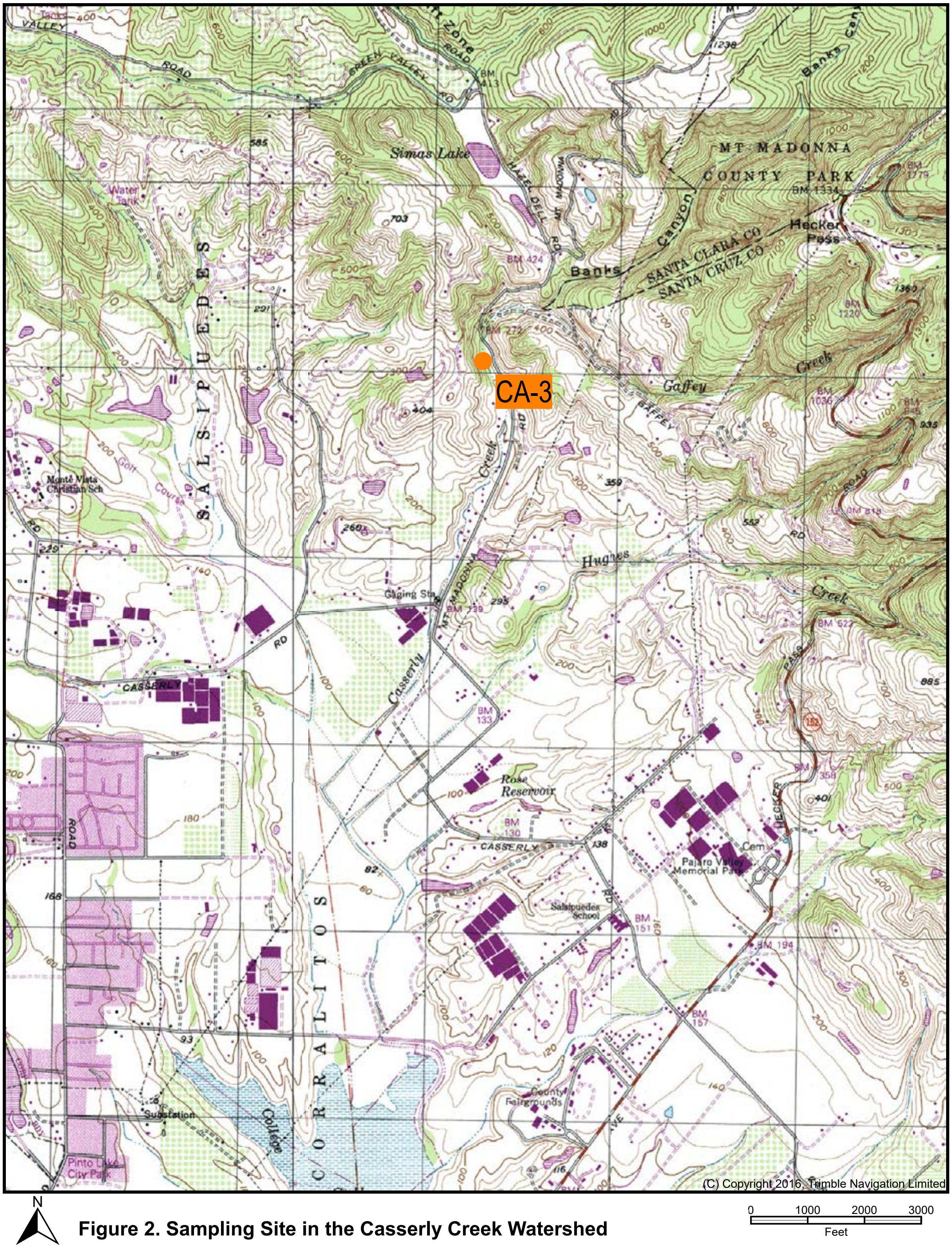


Figure 2. Sampling Site in the Casserly Creek Watershed

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. For the 2018 and 2020 steelhead assessments, standard lengths (SL) of all captured steelhead were also measured for comparison to previous sampling conducted by Alley (2017). In 2019, only a small subsample of steelhead was measured for both FL and SL at each sampling site (Podlech 2019).

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 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[1], but in the more shaded upper watershed sites (i.e., Corralitos Creek #9, Shingle Mill Gulch #3, and Brown Creek #1 and #2), 85 mm FL was used as the breakpoint between age 0 and age 1+. This age classification scheme compares favorably to the bimodal distributions of standard length (SL) 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.

Results

The results of the September 2020 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. Figure 5 compares juvenile steelhead densities for 2016 through 2020. The 2016 and 2017 density estimates are derived from Alley (2017, 2018). Absolute juvenile steelhead density estimates for 2018 through 2020 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 most likely 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 2020 was 263 ft (Table 3). Based on percent total length, CO-0 consisted of 59% flatwater (step-run) and 41% 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 4,225 ft^2, which represents an approximately 32% increase from the 2019 wetted area of 3,210 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 1.0 ft, a maximum depth of 1.6 ft, and a residual depth of 1.4 ft. The pool

[1] In 2019, one juvenile steelhead each at CO-0 and CO-1 measured 91 mm. Based on bimodal size distributions (Figure 4) and the proximity of the measurements to the 90 mm age class cutoff, these two fish were considered to be age 0 juveniles.

tail-out had migrated several feet downstream since the prior year's survey and is now dominated by several concrete slabs forming the hydraulic control for this pool. Tail-out embeddedness not estimated due to the unsuitable adult steelhead spawning conditions. The mean pool shelter rating was 20, representative of very low shelter abundance, and consisted entirely of a bedrock ledge. 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 of hardwood species.

The overall juvenile steelhead population estimate for CO-0 was 33, for a total juvenile steelhead density of 12.9 fish/100 ft (Table 4), a decrease of approximately 68% from the 2019 estimate of 39.7 fish/100 ft. Of the steelhead captured at CO-0, 56.3% were age 0 fish (83.7% in 2019) and 43.8% were age 1+ fish (16.3% in 2018) (Figure 3). As such, estimated age class densities (Table 4) were 7.3 fish/100 ft for age 0 steelhead (33.3 fish/100 ft in 2019) and 5.7 fish/100 ft for age 1+ steelhead (6.5 fish/100 ft in 2019), representing a drastic decrease in age 0+ densities while the age 1+ juvenile density remained largely unchanged. The large decrease in total and age 0 steelhead densities in 2020 is even more significant considering the large increase in estimated wetted surface area compared to 2019.

Sculpin (*Cottus* sp.) were relatively abundant at CO-0 and appeared to be represented by two species, riffle sculpin (*C. gulosus*) and coastrange sculpin (*C. aleuticus*). Two lamprey (*Lampetra* sp.) ammocoetes were captured. Non-native signal crayfish (*Pacifastacus leniusculus*) were also present.

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 2022 was 150 ft (Table 3). Based on percent total length, CO-1 consisted of 40% riffle 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 1,347 ft^2, an approximately 20% reduction from the 2019 estimate of 1,689 ft^2, resulting primarily from sampling a 27-ft shorter reach in 2020. 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 1.6 ft, identical to 2019. A large woody debris (LWD) accumulation present in 2019 has been washed out almost entirely, 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 residual depth of 1.7 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 provided suitable spawning habitat. The mean shelter rating for the two pools was 55, representative of relatively low shelter abundance, but the pool scoured by the previous LWD accumulation alone had a shelter rating of 90, 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 16, and the total juvenile steelhead density was 10.7 fish/100 ft (Table 4), a 60% decrease from the 2019 estimate of 26.6 fish/100 ft (Figure 5). Of the juvenile steelhead captured at CO-1, 26.7% were age 0 fish (54.5% in 2019) and 73.3% were age 1+ fish (45.5% in 2019) (Figure 3). As such, estimated age class densities were 2.8 fish/100 ft for age

0 steelhead (14.5 in 2019) and 7.8 fish/100 ft for age 1+ steelhead (12.1 in 2019) (Table 4). As in 2019, the dominance of relatively deep pool habitat and available shelter at CO-1 appears to favor larger (age 1+) steelhead that may outcompete and/or preyed upon smaller age 0 steelhead.

Sculpins were present in low numbers at CO-1. Several large (200+ mm SL) Sacramento suckers (*Catostomus occidantalis*) and non-native signal crayfish were also present. Unlike in 2018, lamprey ammocoetes were not observed at CO-1 in 2019 or 2020.

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 2020 was 305 ft (Table 3). Based on percent total length, CO-3 consisted of 15% riffle, 34% flatwater, and 51% 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 3,766 ft^2, a slight (6%) decrease from the 2019 estimate of 3,992 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 2020 sampling reach had a combined mean depth of 1.1 ft, a maximum depth of 1.9 ft (0.5 ft less than the 2019 maximum depth), and a residual depth of 1.6 ft. Dominant pool tail-out substrates at one of the pools consisted of large cobble with an embeddedness rating of 50-75%, representative of suboptimal spawning conditions; the other pool tail-out consisted of boulders and does not provide spawning habitat. The mean shelter rating for the pools was 55, 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 pools with shelter availability is limited. Sand and large cobbles was the dominant substrate type in the pools while the riffle and flatwater units were 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 47, and the total juvenile steelhead density was 15.4 fish/100 ft (Table 4), a 48% decrease from the 2019 estimate of 29.4 fish/100 ft (Figure 5). Of the juvenile steelhead captured at CO-3, 48.8% were age 0 fish (78.5% in 2019) and 51.2% were age 1+ fish (21.5% in 2019) (Figure 3). Estimated age class densities were 7.5 fish/100 ft for age 0 steelhead (23.0 in 2019) and 7.9 fish/100 ft for age 1+ steelhead (6.3 in 2019) (Table 4). The large decrease in age 0 densities and relatively stable age 1+ densities are similar trends observed at CO-0. It should be noted, however, that prior to the 2019 survey, staff from the California Department of Fish and Wildlife (CDFW) and the County released 358 rescued age 0 steelhead in Corralitos Creek approximately 0.5 miles upstream of CO-3 and 33 age 1+ rescued steelhead approximately 750 ft downstream of CO-3 (Jankovitz, pers. comm.). As such, 2019 density estimates at CO-3 may have been artificially high if some of the released steelhead dispersed into the sampling reach prior to the survey. CDFW and the County did not conduct fish rescues on Corralitos Creek in 2020.

Sculpins were present in moderate numbers. Sacramento sucker and non-native signal crayfish were present in low numbers. Juvenile lamprey, which had been observed at CO-3 in low numbers in prior years, were not detected in 2020.

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 2020 was 107 ft (Table 3). Based on percent total length, CO-9 consisted of 70% flatwater (step-run), and 30% 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 1,097 ft^2, a minor (7%) increase over the 2019 estimate of 1,026 ft^2, even though the survey reach was 13 ft (11 %) shorter in 2020. Two Level II habitat units (one flatwater, one pool) were sampled at CO-9. The pool in this reach had a mean depth of 1.7 ft (0.5 ft deeper than in 2019), a maximum depth of 3.7 ft (1.1 ft deeper than in 2019), and a residual depth of 3.4 ft (1.4 ft deeper than in 2019), indicative of significant scour during water year 2020. The pool tail-out consists of boulders and therefore does not provide spawning habitat. The mean shelter rating for the pool was 100, representative of suitable shelter abundance. Shelter consisted entirely of large boulders that, combined with the significant depth of the pool, provided high quality habitat for age 1+ steelhead. Canopy cover was estimated at 80%, composed almost entirely (90%) of hardwood species.

The overall juvenile steelhead population estimate for CO-9 was 30, and the total juvenile steelhead density was 28.0 fish/100 ft (Table 4), the highest total density of the eight sampling sites in 2020 but a 37% decrease from the 2019 density of 44.2 fish/100 ft (Figure 5). Of the juvenile steelhead captured at CO-9, 61.5% were age 0 fish (52.2% in 2019) and 38.5% were age 1+ fish (47.8% in 2019) (Figure 3). Estimated age class densities were 17.3 fish/100 ft for age 0 steelhead (23.0 in 2019) and 10.8 fish/100 ft for age 1+ steelhead (21.1 in 2019) (Table 4). Although about 50% lower than in 2019, the 2020 age 1+ density at CO-9 was the highest among all sampling sites for the third year in a row.

Sculpins were present in low numbers. One California newt (*Taricha torosa*) was present in 2018, but none were observed in 2019 or 2020.

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 2020 was 125 ft (Table 3). Based on percent total length, SM-3 consisted of 24% riffle and 76% 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 711 ft^2, a 15% decrease from the 2019 estimate of 833 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 0.9 ft, a maximum depth of 1.4 ft, and a residual depth of 1.0 ft. Dominant pool tail-out substrates at the two pools consisted of large and small cobble with embeddedness ratings of 50-75% at both, representative of suboptimal spawning conditions. The combined mean shelter rating for the pools was 70, substantially higher than the rating of 23 in 2019 and primarily the result of the recent formation of a woody debris accumulation associated with a previously present root mass. In fact, this feature may have resulted in an underestimation of juvenile steelhead densities in 2020 as the electrofishing capture efficiency within the debris accumulation appeared to be suboptimal. Gravel and large cobble were the dominant pool substrate types while the riffle was dominated by small cobble. Canopy cover was estimated at 80%, composed almost entirely (95%) of conifer species.

The overall juvenile steelhead population estimate for SM-3 was 6, and the total juvenile steelhead density was 4.8 fish/100 ft, a 71% decrease from the 2019 density of 16.4 fish/100, and again the lowest among all sites sampled (Table 4). Of the juvenile steelhead captured at SM-3, 66.7% were age 0 fish (94.1% in 2019) and 33.3% were age 1+ fish (5.9% in 2019) (Figure 3). Estimated age class densities were 3.2 fish/100 ft for age 0 steelhead (15.4 in 2019) and 1.6 fish/100 ft for age 1+ steelhead (1.0 in 2019 (Table 4).

Two larval California giant salamanders (*Dicamptodon ensatus*) were observed at SM-3 in 2020 and non-native signal crayfish were also present.

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 2020 was 231 ft (Table 3). Based on percent total length, BR-1 consisted of 41% flatwater and 59% 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 2,418 ft^2, similar to the 2019 estimate of 2,340 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 0.9 ft, a maximum depth of 2.3 ft, and a residual depth of 2.1 ft, indicating largely unchanged conditions from 2019. 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 45, representative of low shelter abundance. The limited shelter was dominated by bedrock ledges in one pool and by a root-wad 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-1 was 33, and the total juvenile steelhead density was 14.3 fish/100 ft (Table 4), a 64% decrease from the total density of 39.7 fish/100 ft in 2019 Juvenile densities have fluctuated widely at BR-1 since 2016 (Figure 5). Of the juvenile steelhead captured at BR-1, 32.0% were age 0 fish (only 78.8% in 2019) and 68.0% were age 1+ fish (21.2% in 2019) (Figure 3), an almost complete reversal in age class structure compared to 2019 but comparable to the relative distribution observed in 2018. Estimated age class densities were 4.6 fish/100 ft for age 0 steelhead (31.3 in 2019) and 9.7 fish/100 ft for age 1+ steelhead (8.4 in 2019) (Table 4). The large decrease in age 0 juvenile densities and stable age 1+ densities reflect the same age class trend as observed in Corralitos Creek.

Sculpins were moderately abundant, and 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 268 ft (Table 3). Based on percent total length, BR-2 consists of 54% flatwater and 46% 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 3,068 ft^2, similar to the 2019 estimate of 3,119 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 0.9 ft, a maximum depth of 1.5 ft, and a residual depth of 1.4 ft, again indicative of relatively stable conditions. The tail-out at one pool consisted of boulders and does not provide spawning habitat, while the other tail-out was dominated by large cobble with an embeddedness rating of 50-75%. The mean shelter rating for the pools was 25, 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 70%, composed about equally of hardwood and conifer species.

The overall juvenile steelhead population estimate for BR-2 was 35, and the total juvenile steelhead density was 13.1 fish/100 ft (Table 4), a 47% decrease from the total density of 24.9 fish/100 ft in 2019 but comparable to the 2018 density (Figure 5). Of the juvenile steelhead captured at BR-2, 59.4% were age 0 fish (76.3% in 2019) and 40.6% were age 1+ fish (23.7% in 2019) (Figure 3). Estimated age class densities were 7.8 fish/100 ft for age 0 steelhead (19.0 in 2019) and 5.3 fish/100 ft for age 1+ steelhead (5.9 in 2019) (Table 4), again indicative of the large decrease in age 0 densities and stable age 1+ densities.

Sculpins were moderately abundant, and non-native signal crayfish were present.

Casserly Creek #3 (CA-3)[2]

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 2020 was 207 ft (Table 3). 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 951 ft^2, a 12% decrease from the 2019 estimate of 1,075 ft^2. Four Level II habitat units (one riffle, one flatwater, two pools) were sampled at CA-3. The two pools in the reach had a combined mean depth of 0.5 ft (0.9 ft in 2019), a maximum depth of 1.0 ft (1.5 ft in 2019), and a maximum residual depth of 0.9 ft (1.4 ft in 2019). Dominant pool tail-out substrates at one of the pools consisted of large cobbles with a high embeddedness rating of 75-100% and the other consisted of gravel with an estimated embeddedness of 25-50%. The mean shelter rating for the two pools was 70. One of the two pools had an individual shelter rating of 80, comprised of an undercut bank and root mass that supported numerous juvenile steelhead. Sand and large cobble were the dominant substrate types in the pools, while silt dominated the flatwater and large cobbles were the dominant substrate in the riffle. Canopy

[2] 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.

cover was estimated at 50%, consisting of approximately 75% hardwood and 25% conifer species.

The overall juvenile steelhead population estimate for CA-3 was 31, and the total juvenile steelhead density was 15.0 fish/100 ft, representing a 64% decrease from the 2019 density of 41.2 fish/100 ft, but nevertheless the third highest juvenile steelhead density of all sites sampled in 2020 (Table 4). Of the juvenile steelhead captured at CA-3, 36.7% were age 0 fish (83.3% in 2019) and 63.3% were age 1+ fish (16.7% in 2019) (Figure 3). Estimated age class densities were 5.5 fish/100 ft for age 0 steelhead (34.3 in 2019) and 9.5 fish/100 ft for age 1+ steelhead (6.9 in 2019) (Table 4). The high proportion and density of age 0 steelhead in 2019 suggested successful spawning in Casserly Creek, and therefore successful adult migration through College Lake. In 2020, the relative abundances of age 0 fish were greatly reduced, a trend that is consistent with observations in Corralitos Creek and Browns Creek discussed above and indicative of the limited adult migration opportunities in water year 2020 (Figure 6).

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 adult steelhead.

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[3] 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

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

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 62-year average through the entire adult steelhead migration and spawning season and smolt outmigration season (Figure 6). 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 (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 6) 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 is 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 5).

It is important to note that the City of Watsonville did not operate its filter plant in 2020. Lower creek flows combined with a lack of late rain events and a lack of overall total rain accumulation, rendered extended diversion periods unlikely. Moreover, COVID work restrictions (confined space and close work proximity tasks were limited to emergency purposes) prevented the City from completing tasks needed to prepare the facility. For these reasons, the City chose not to divert streamflow at its Corralitos Creek and Browns Creek facilities in 2020. As such, 2020 amounted to a control year from the perspective of a fisheries effect analysis. The drastic decrease in age 0 juvenile densities combined with essentially unchanged age 1+ densities in the absence of City surface water diversions provide strong evidence that the natural hydrologic regime is likely the primary factor affecting population trends in the Corralitos Creek watershed.

TABLE 2

WATER QUALITY RESULTS AT EIGHT SAMPLING SITES IN THE CORRALITOS CREEK AND CASSERLY CREEK WATERSHEDS, SEPTEMBER 2020

Parameter	CO-0	CO-1	CO-3	CO-9	SM-3	BR-1	BR-2	CA-3
Date	9/29	9/25	9/29	9/23	9/23	9/24	9/24	9/25
Time	0930	0945	1200	1130	0945	1215	0945	1215
Weather	clear	clear	clear	clear	clear	clear	clear	clear
Air Temp (°C)	16.3	16.1	19.6	16.9	16.2	17.0	16.4	19.2
Water Temp (°C)	15.1	15.0	15.4	14.3	13.6	14.9	14.4	14.9
Conductivity (µmhos/cm)	426	424	429	478	418	559	553	941
DO Conc. (mg/l)	8.6	8.8	8.9	9.4	9.5	8.8	8.5	7.9
DO Sat. (%)	86	87	89	92	91	88	83	78
Streamflow* (cfs)	NA	1.80	NA	NA	NA	~ 0.80	NA	<0.02

*NOTES: = Preliminary streamflow estimates for CO-1 and BR-1 (approximate) provided by the City of Watsonville; Streamflow at CA-3 was visually only a trickle and could not be measured accurately. Qualitatively, streamflow on the day of the September 2020 survey was noticeably lower than the 0.02 cfs measured on the day of the September 2019 survey.

TABLE 3

SUMMARY OF HABITAT TYPES AND MEASURED PARAMETERS AT EIGHT SAMPLING SITES IN THE CORRALITOS CREEK AND CASSERLY CREEK WATERSHEDS, SEPTEMEBR 2020

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	77.0	41	16.7	1.0	1.6	1.4	1,286	SA	rip-rap	NA	20
	F	1	186.0	59	15.8	0.3	0.9	---	2,939	LC	---	---	---
	TOTAL		**263.0**						**4,225**				
CO-1	P	2	90.0	60	10.5	1.6	2.3	1.7	945	SA	BO	NA	55
	R	2	60.0	40	6.7	0.4	0.8	---	402	LC	---	---	---
	TOTAL		**150.0**						**1,347**				
CO-3	P	2	156.5	51	12.7	1.1	1.9	1.6	1,988	SA/LC	LC/BO	3	55
	F	1	104.5	34	12.8	0.7	1.4	---	1,338	LC	---	---	---
	R	1	44.0	15	10.0	0.4	0.7	---	440	LC	---	---	---
	TOTAL		**305.0**						**3,766**				
CO-9	P	1	32.0	30	13.2	1.7	3.7	3.4	422	BO	BO	NA	100
	F	1	75.0	70	9.0	0.4	1.2	---	675	BO	---	---	---
	TOTAL		**107.0**						**1,097**				
SM-3	P	2	95.0	76	5.9	0.9	1.4	1.0	561	GR/LC	SC/GR	3.0	70
	R	1	30.0	24	5.0	0.1	0.2	---	150	SC	---	---	---
	TOTAL		**125.0**						**711**				
BR-1	P	2	136.0	59	8.0	0.9	2.3	2.1	1,088	LC/SA	LC/LC	3	45
	F	1	95.0	41	14.0	0.5	1.1	---	1,330	BO	---	---	---
	TOTAL		**231.0**						**2,418**				
BR-2	P	2	123.0	46	10.2	0.9	1.5	1.4	1,255	SI/BO	BO/SC	3	25
	F	1	145.0	54	12.5	0.4	1.0	---	1,813	BO	---	---	---
	TOTAL		**268.0**						**3,068**				
CA-3	P	2	51.0	25	4.5	0.5	1.0	0.9	230	LC/SA	LC/GR	3	100
	F	1	87.0	42	5.5	0.3	1.4	---	479	SI	---	---	---
	R	1	69.0	33	3.5	0.2	0.3	---	242	LC	---	---	---
	TOTAL		**207.0**						**951**				

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 2020

Metric	CO-0	CO-1	CO-3	CO-9	SM-3	BR-1	BR-2	CA-3
Total Density	12.9	10.7	15.4	28.0	4.8	14.3	13.1	15.0
Age 0 Density	7.3	2.8	7.5	17.3	3.2	4.6	7.8	5.5
Age 1+ Density	5.7	7.8	7.9	10.8	1.6	9.7	5.3	9.5

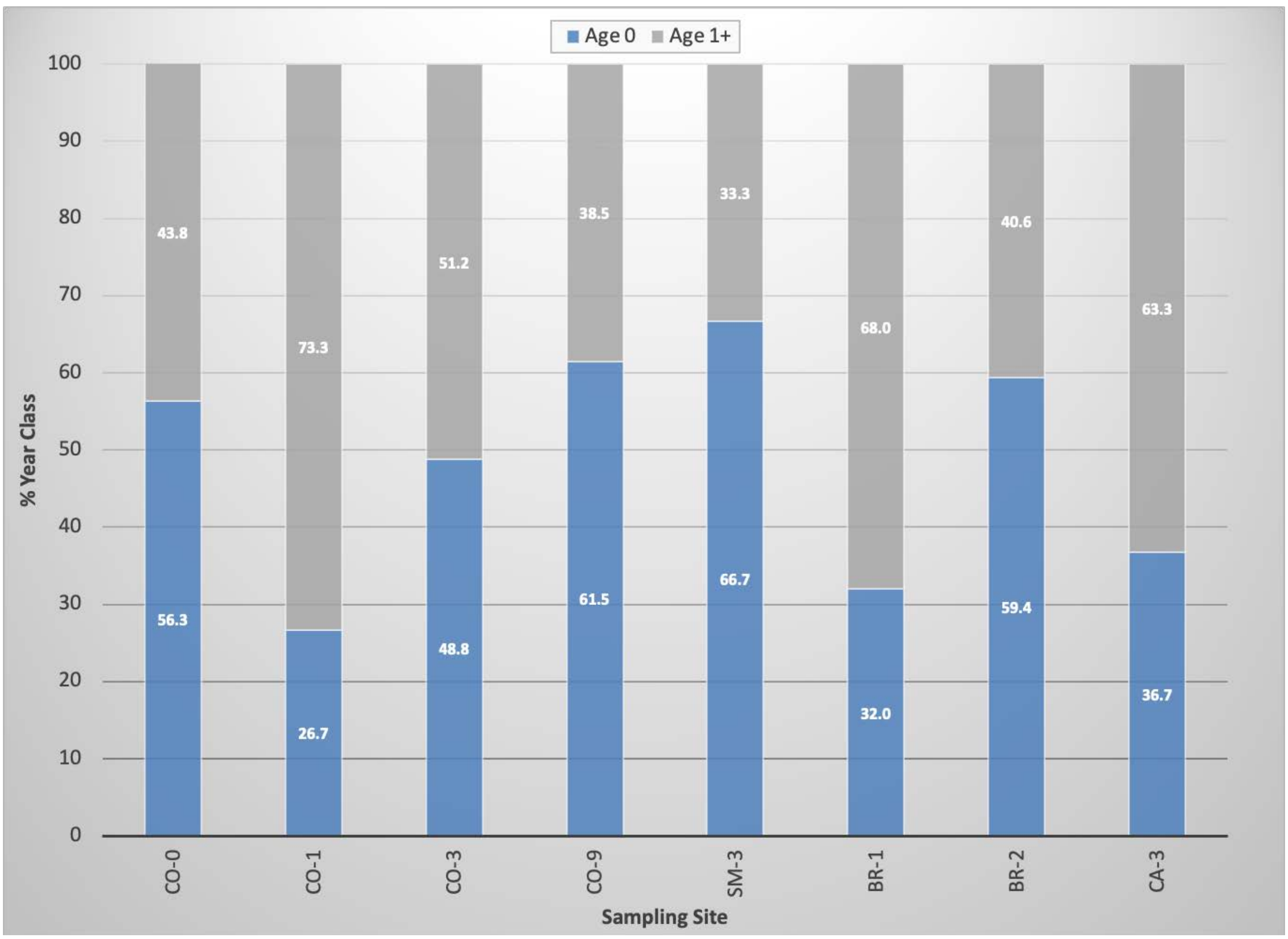
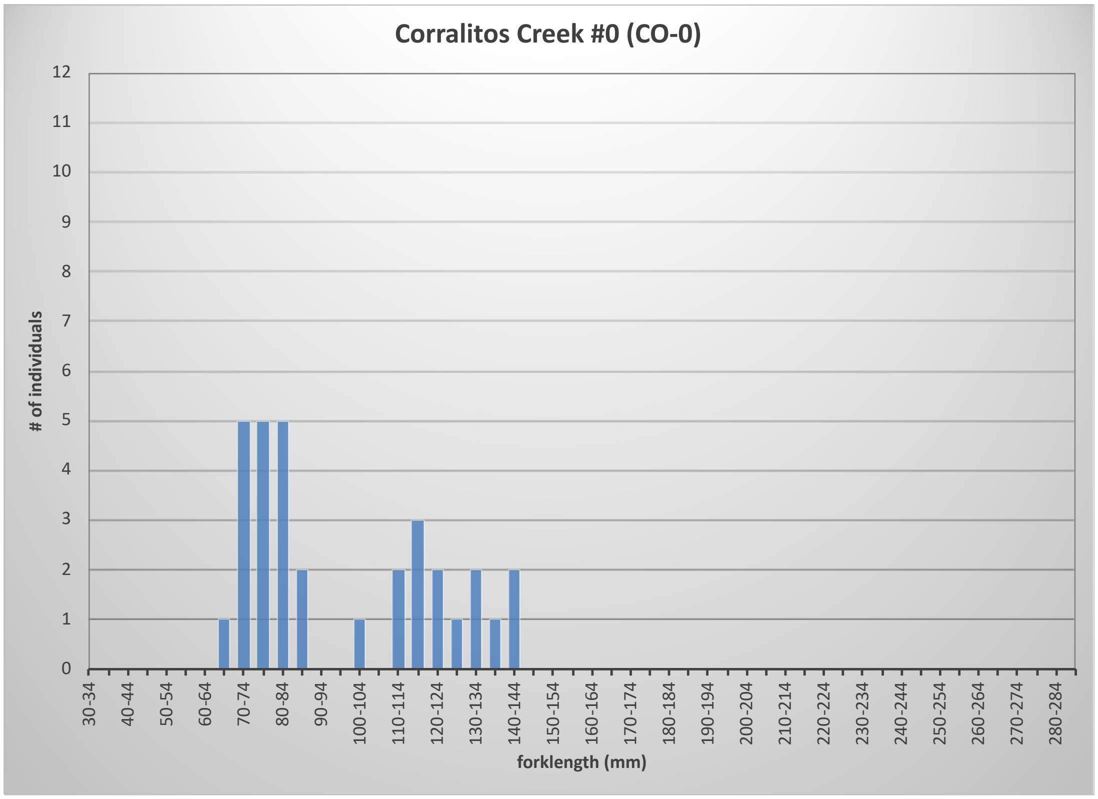


Figure 3. Relative Proportion (%) of Juvenile Steelhead Age Classes at Eight Sampling Sites in the Corralitos Creek and Casserly Creek Watersheds, September 2020



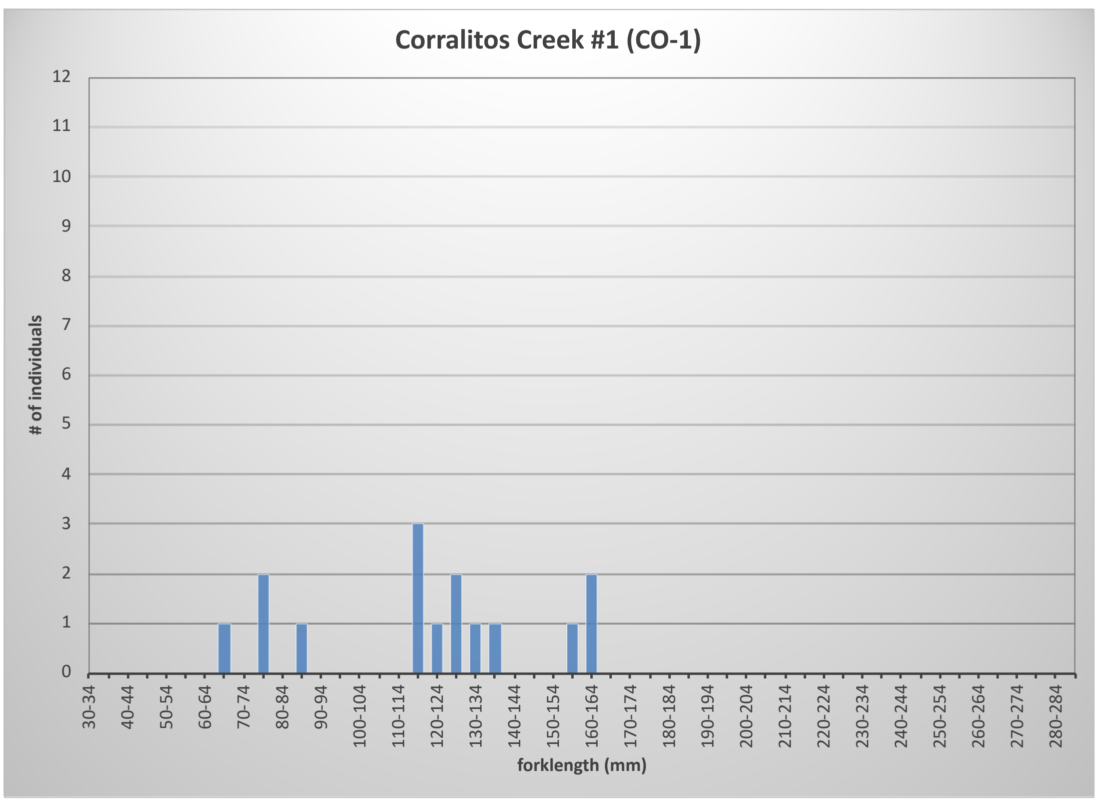
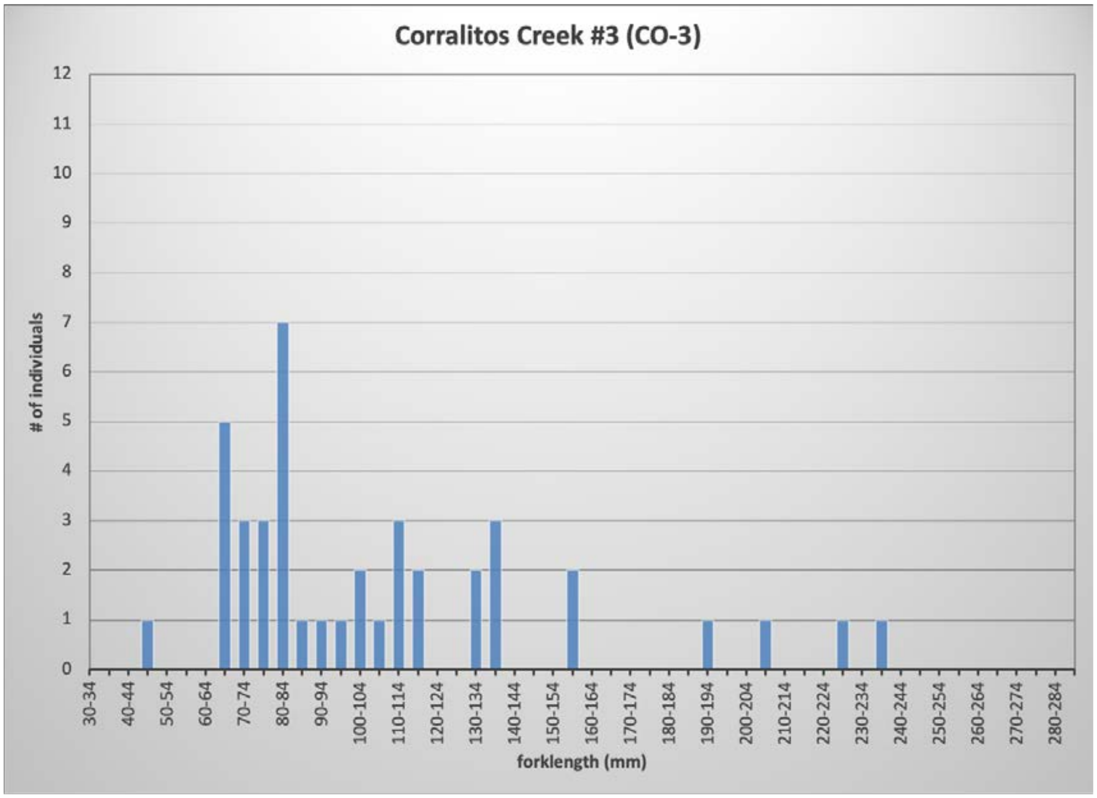


Figure 4. Forklength Distributions of Juvenile Steelhead at Eight Sampling Sites in the Corralitos Creek and Casserly Creek Watersheds, September 2020



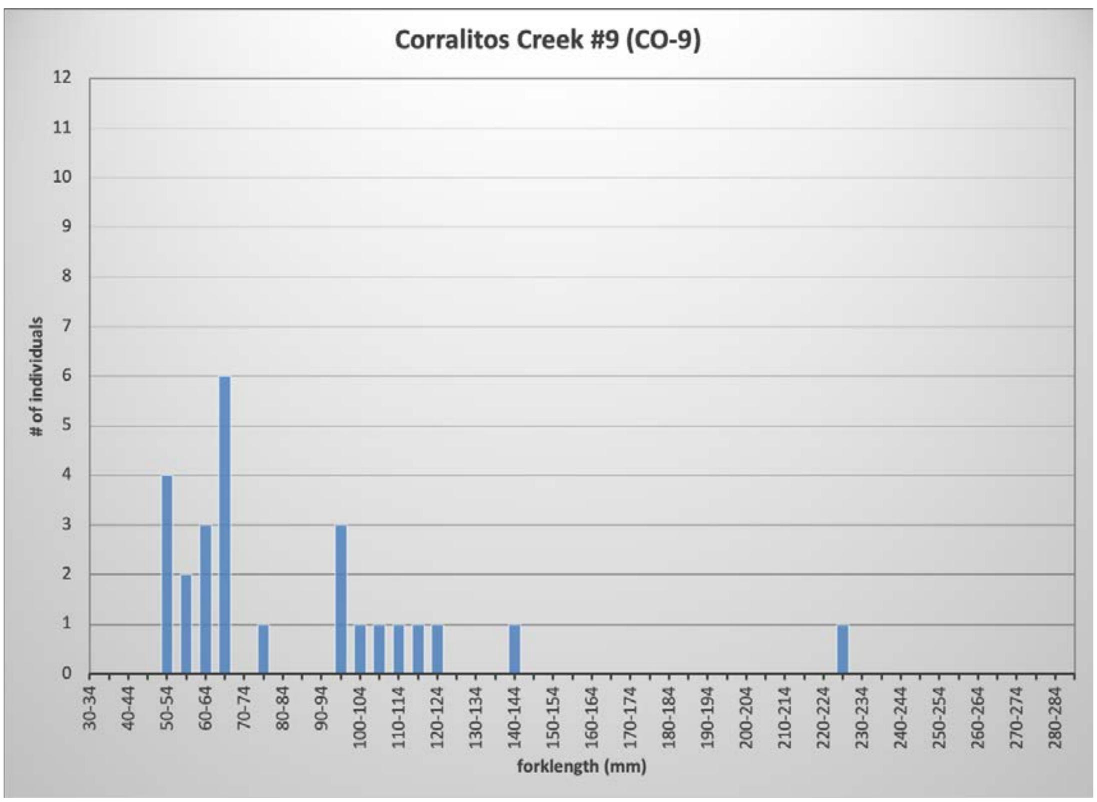
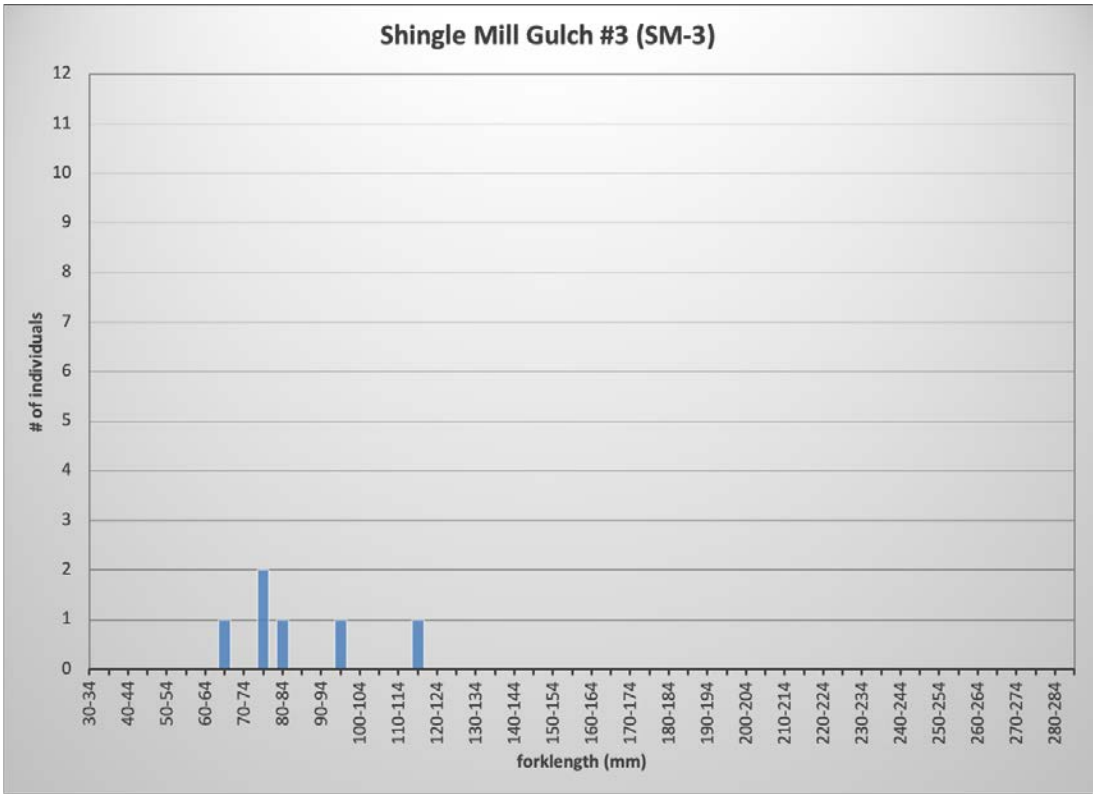


Figure 4 (cont.). Forklength Distributions of Juvenile Steelhead at Eight Sampling Sites in the Corralitos Creek and Casserly Creek Watersheds, September 2020



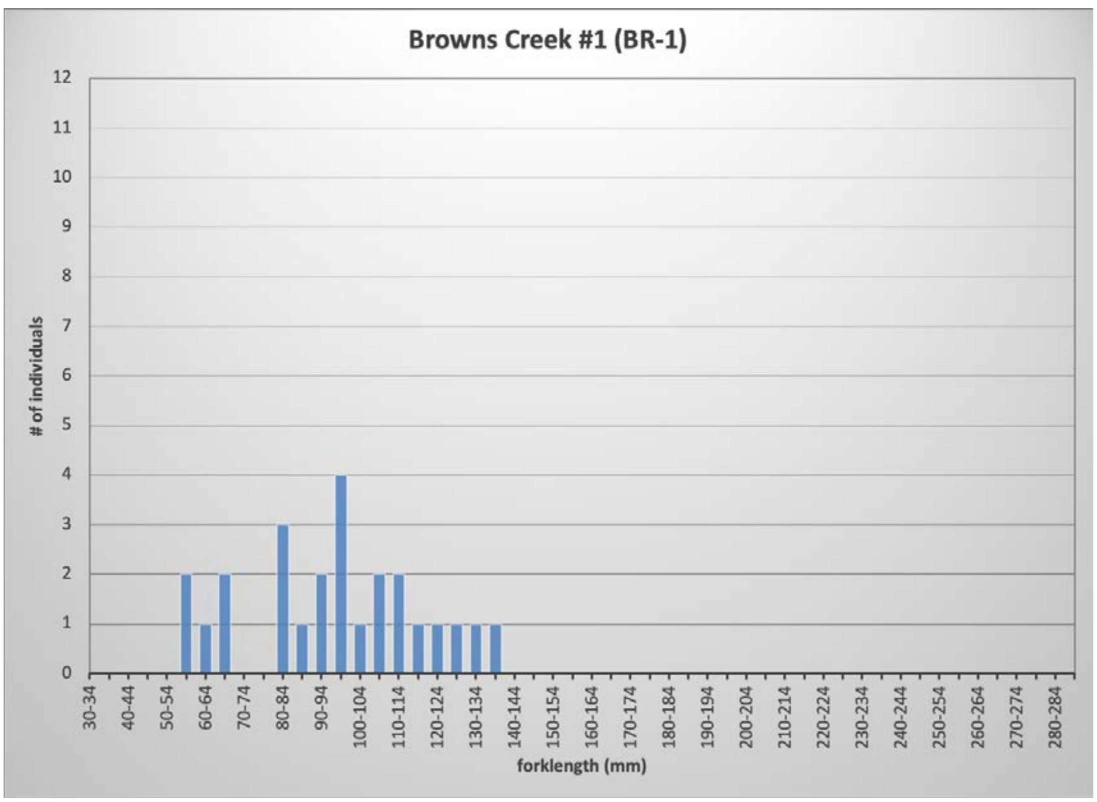
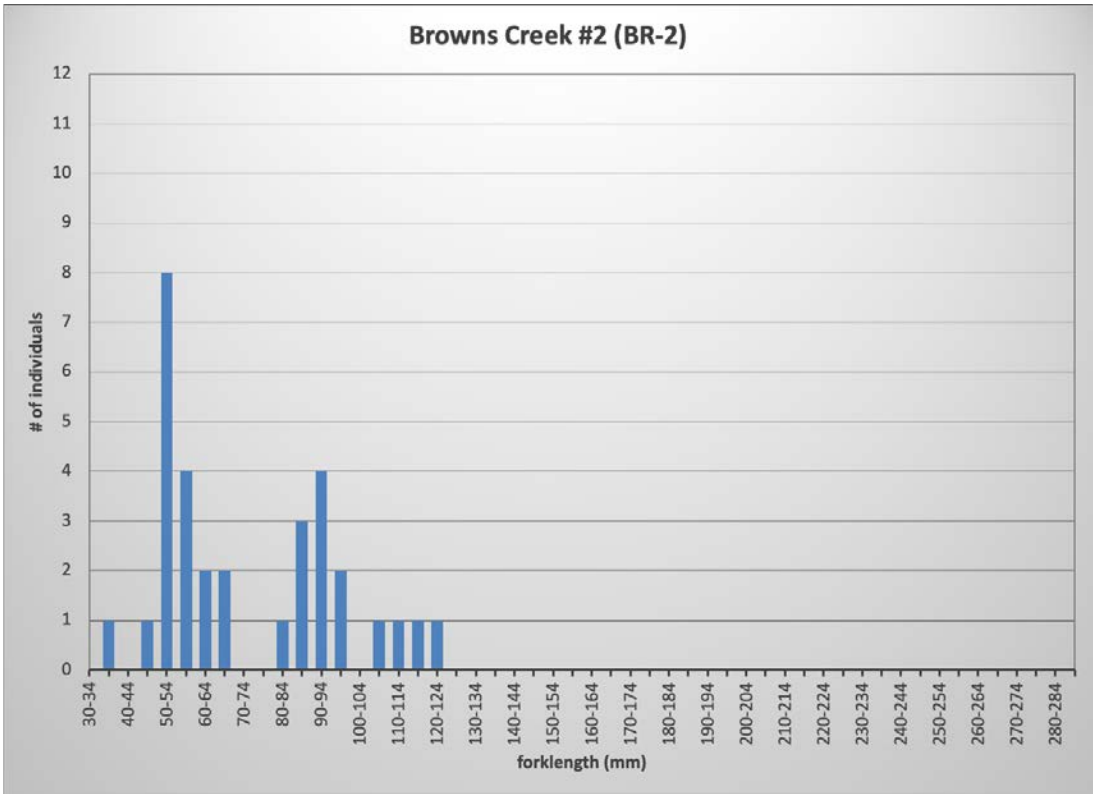


Figure 4 (cont.). Forklength Distributions of Juvenile Steelhead at Eight Sampling Sites in the Corralitos Creek and Casserly Creek Watersheds, September 2029



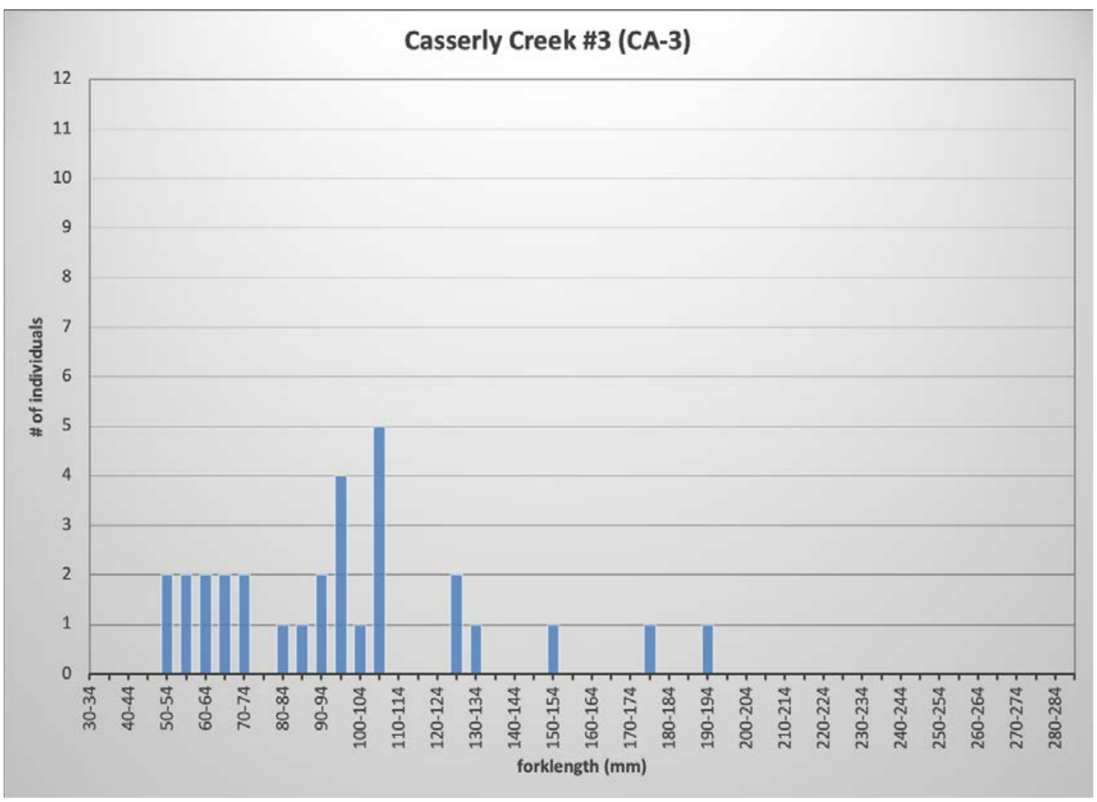
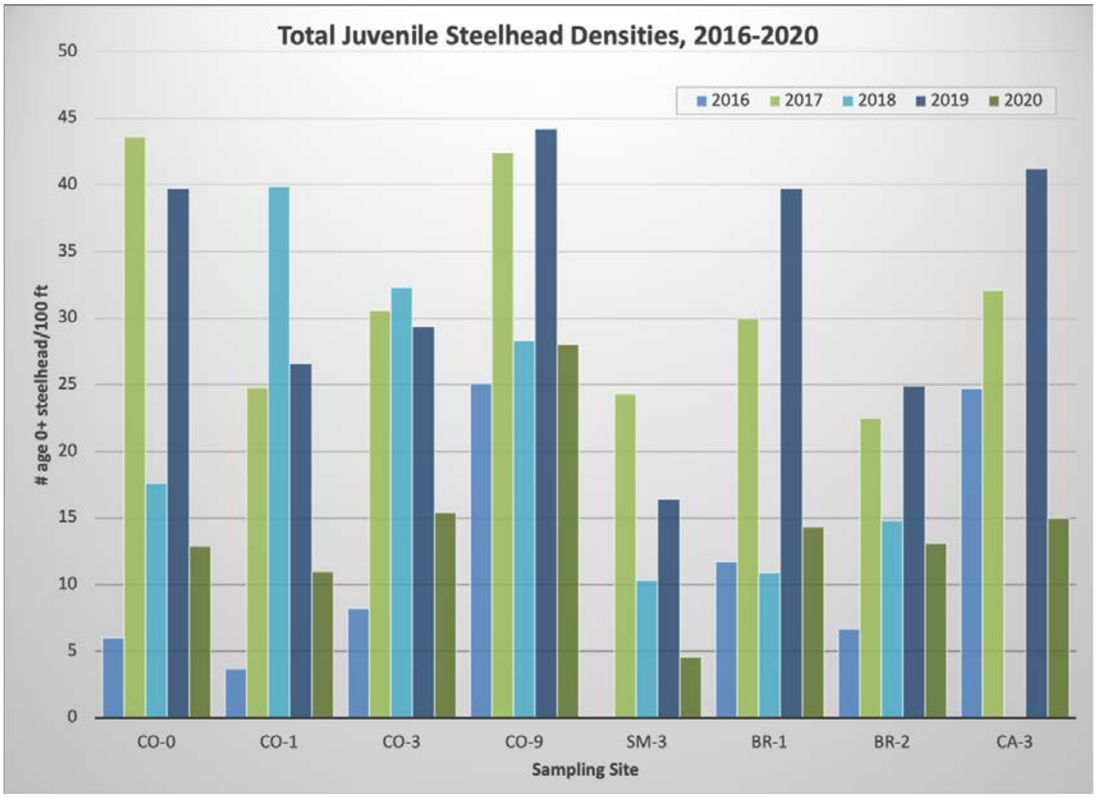


Figure 4 (cont.). Forklength Distributions of Juvenile Steelhead at Eight Sampling Sites in the Corralitos Creek and Casserly Creek Watersheds, September 2020



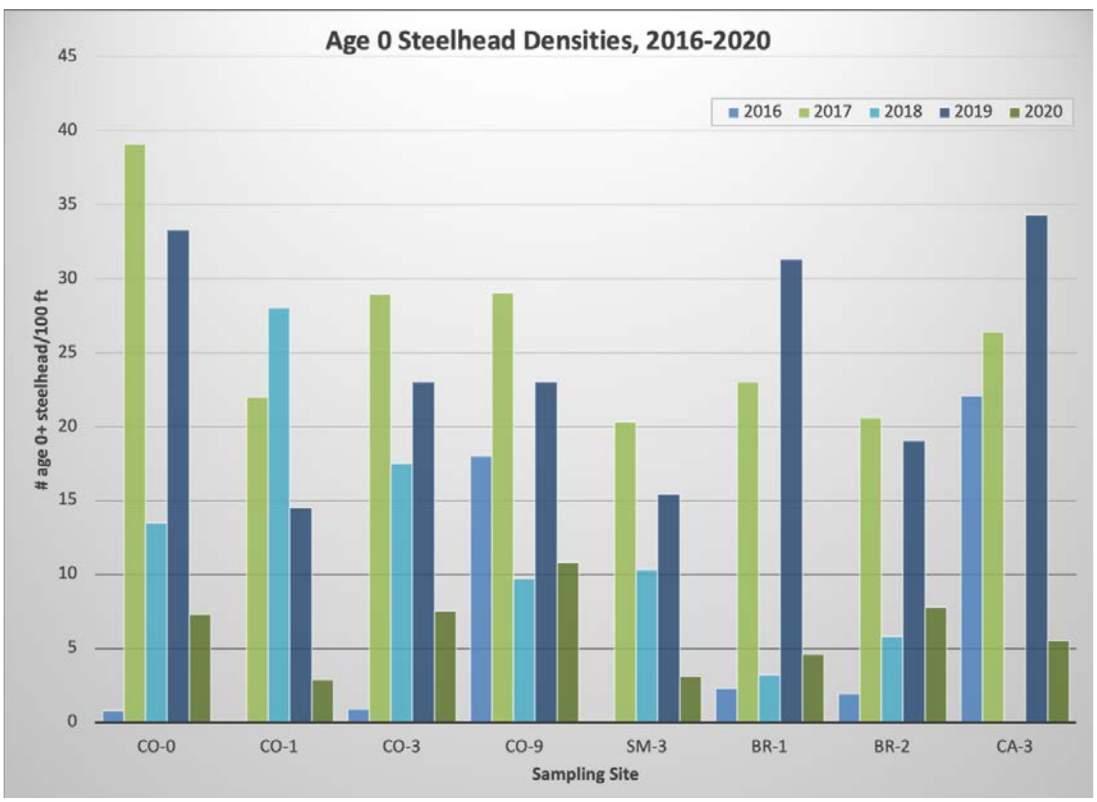
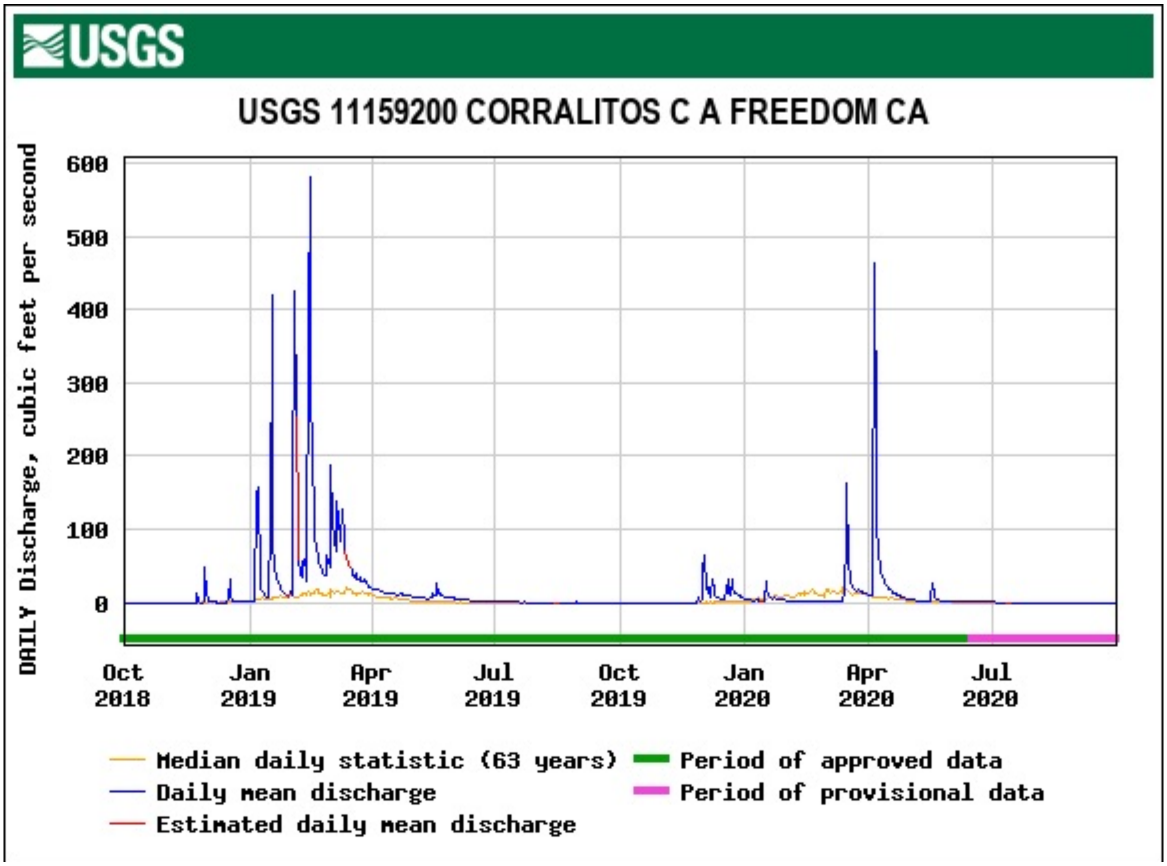


Figure 5. Total and Age 0 Juvenile Steelhead Densities at Eight Sampling Sites in the Corralitos Creek and Casserly Creek Watersheds, 2016-2020 (data for 2016-2017 adapted from Alley [2017, 2018])



SOURCE: U.S. Geological Survey, 2020

Figure 6. Mean Daily Discharge in Corralitos Creek at Freedom, USGS Gage 11159200, Water Years 2019-20020

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Appendix A

Photographs of Eight Sampling Sites in the Corralitos Creek and Casserly Creek Watersheds, September 2020

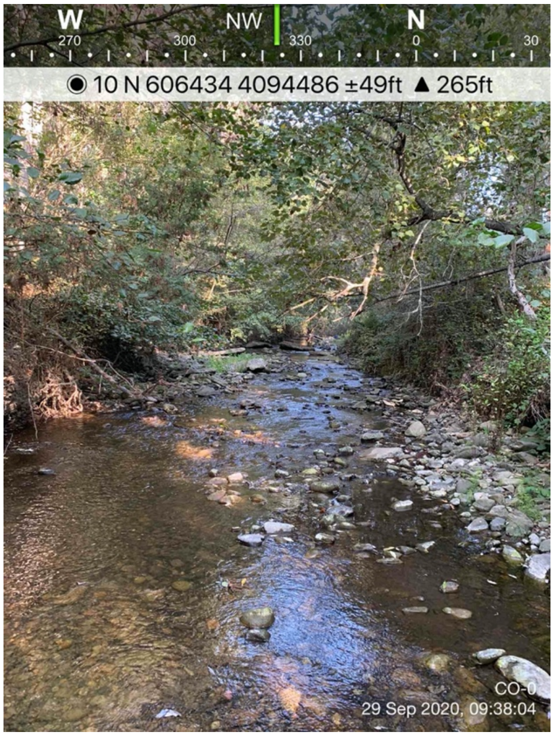

Photo 1. CO-0 flatwater-riffle transition, Sep. 29, 202

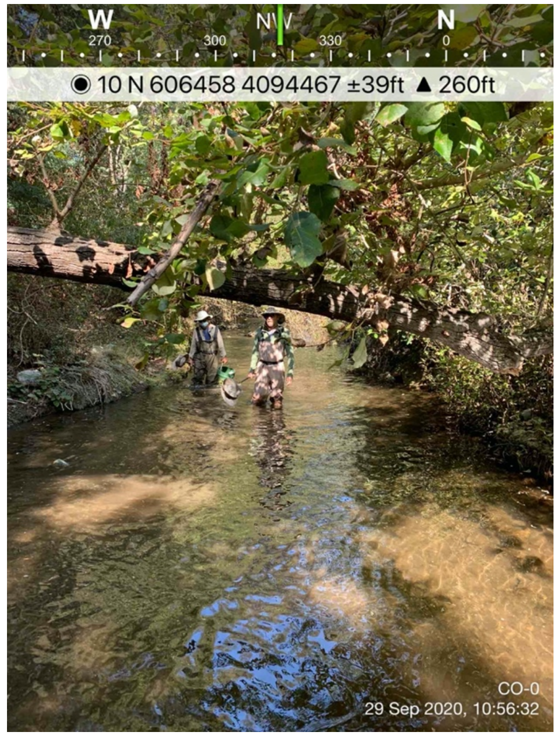

Photo 2. CO-0 pool, Sep. 29, 2020

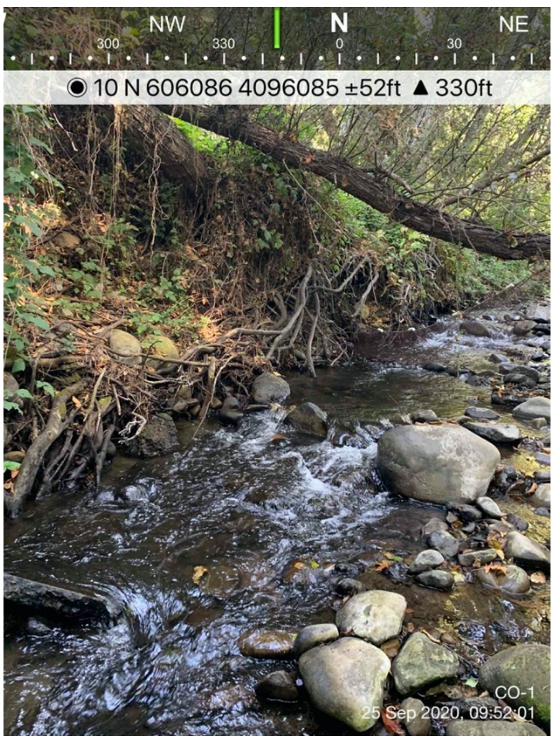

Photo 3. CO-1 riffle, Sep. 25, 2020

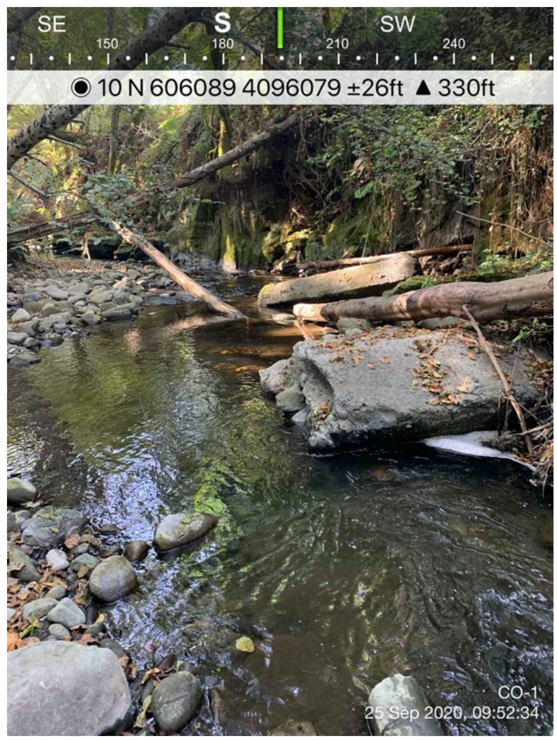

Photo 4. CO-1 pool with cover, Sep. 25, 2020

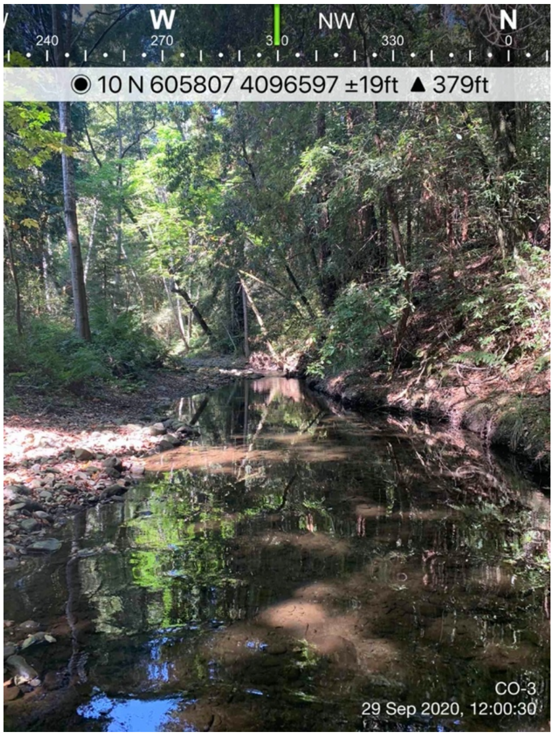

Photo 5. CO-3 pool, Sep. 29, 2020

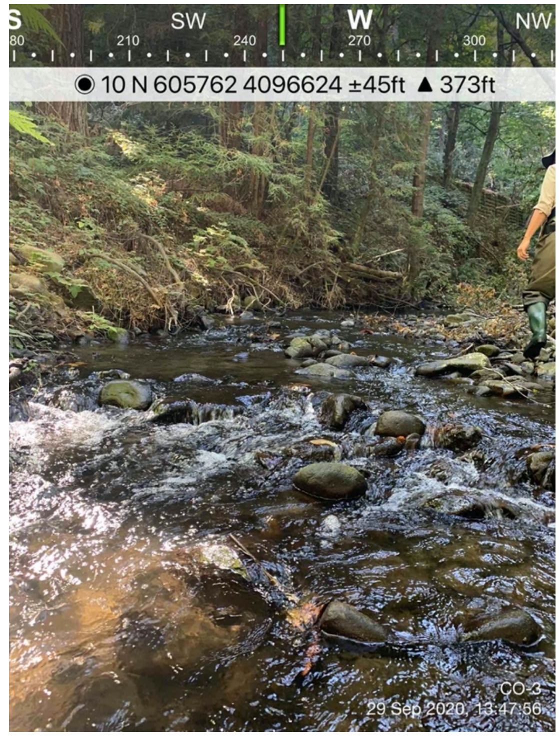

Photo 6. CO-3 riffle, Sep. 29, 2020

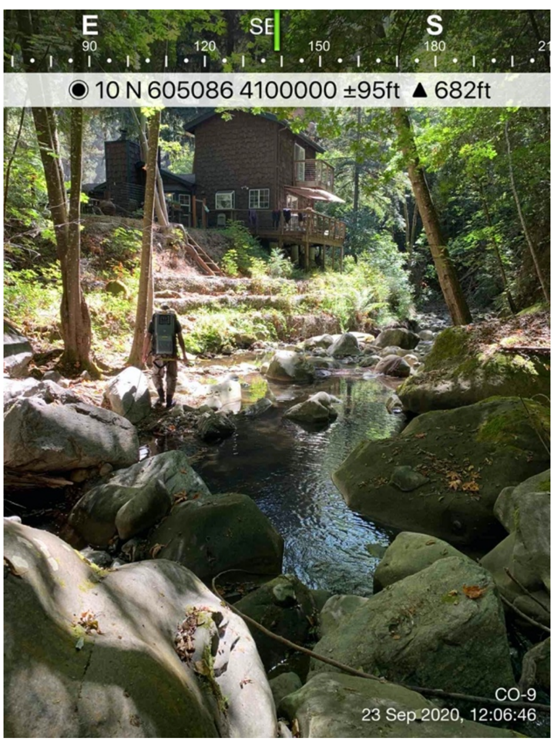

Photo 7. CO-9 pool, Sep. 23, 2020

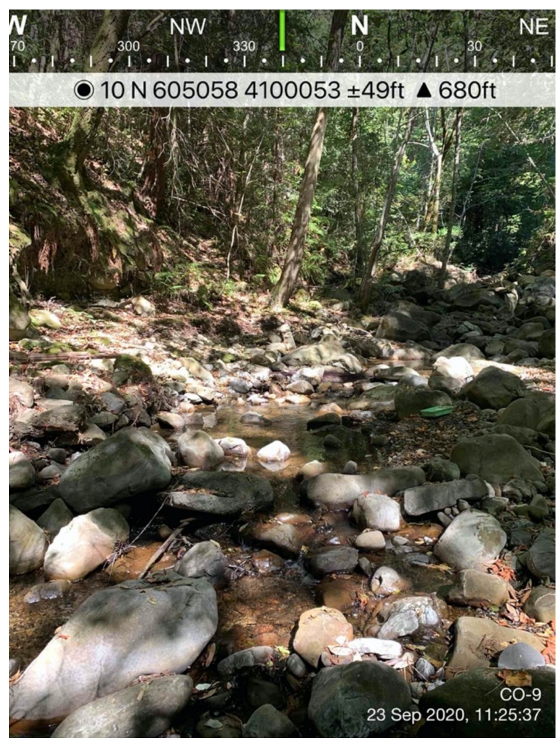

Photo 8. CO-9 flatwater, Sep. 23, 2020

Photo 9. SM-3 pool, Sep. 23, 2020

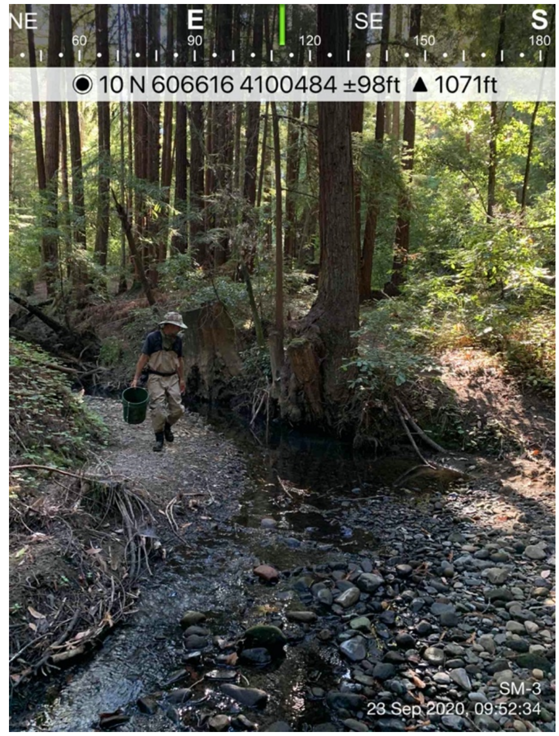

Photo 10. SM-3 riffle-pool transition, Sep. 23, 2020

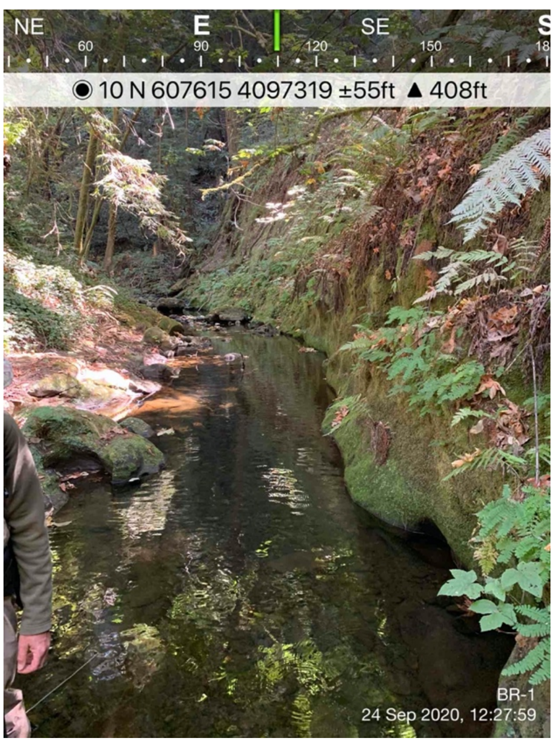

Photo 11. BR-1 pool, Sep. 24, 2020

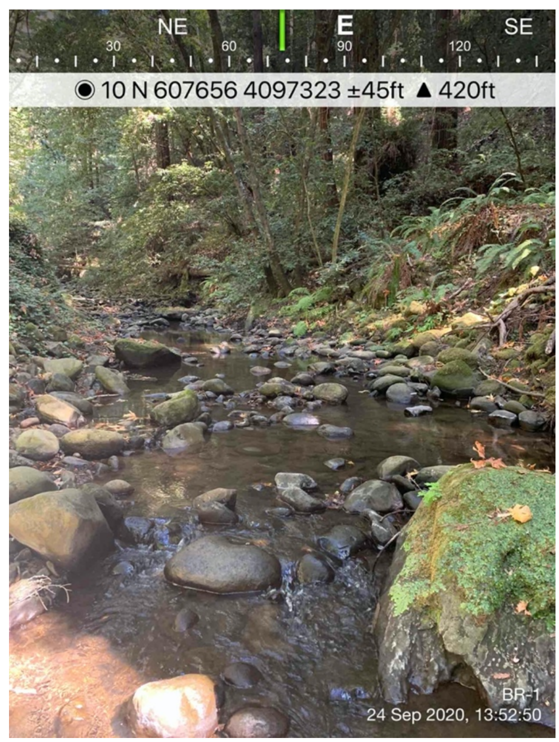

Photo 12. BR-1 flatwater, Sep. 24, 2020

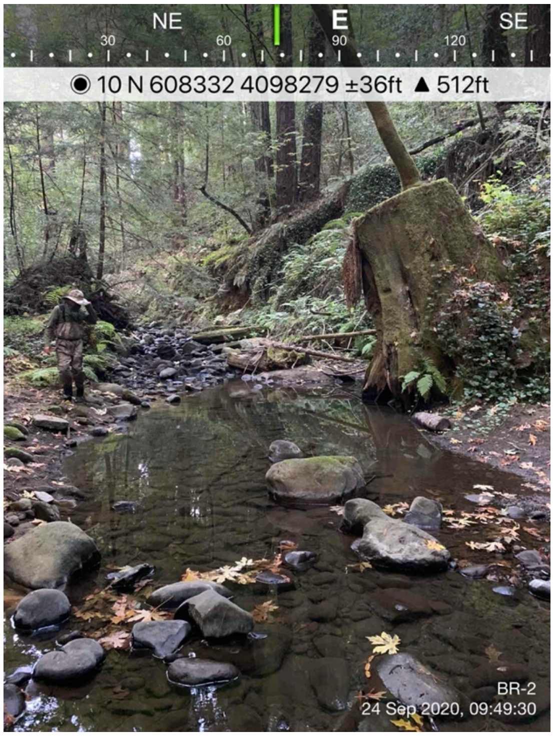

Photo 13. BR-2 pool, Sep. 24, 2020

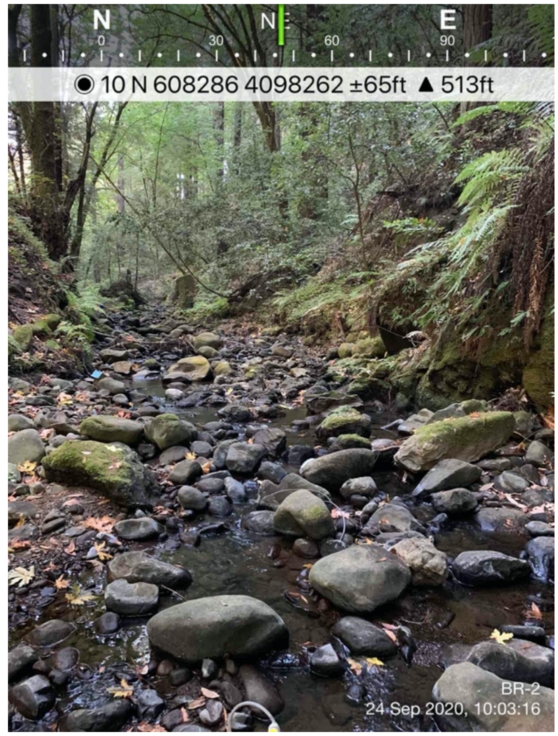

Photo 14. BR-2 flatwater, Sep. 24, 2020

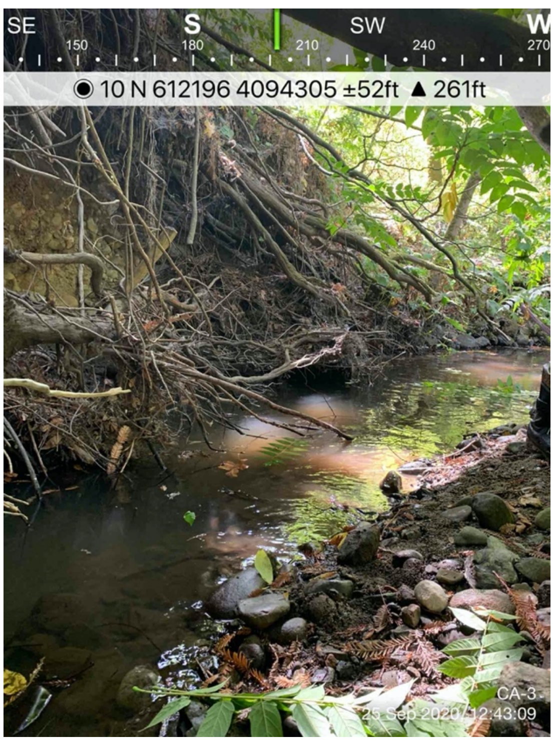

Photo 15. CA-3 pool, Sep. 25, 2020

Photo 16. CA-3 riffle, Sep. 25, 2020