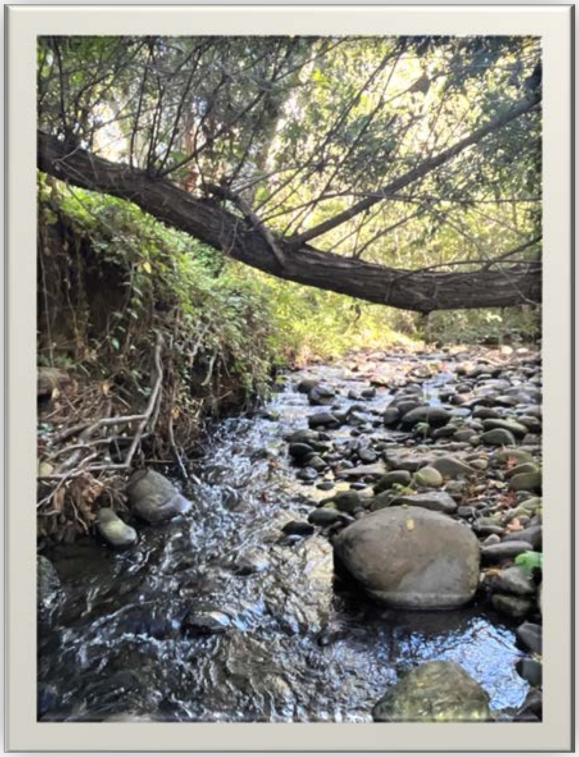
2022 Juvenile Steelhead Densities in the Corralitos Creek and Casserly Creek Watersheds



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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. Since 2020, the City has voluntarily continued its commitment toward monitoring fish populations in the watershed and thereby contribute toward countywide steelhead monitoring efforts.

The Pajaro Valley Water Management Agency (PV Water) plans to implement the College Lake Integrated Resources Management Project. The project will divert up to 3,000 acre-feet of water annually from College Lake, located on Salsipuedes Creek, for treatment, transmission, and distribution for agricultural irrigation. College Lake is a naturally occurring, seasonally wet depression that receives water inflows from the Green Valley, Casserly, and Hughes creeks sub-watersheds. College Lake provides seasonal juvenile steelhead rearing habitat (Podlech, 2011) and Casserly Creek is known to support a steelhead population (Smith, 2010; Alley 2017). In an effort to build upon existing baseline steelhead population data upstream of College Lake, PV Water has been funding fish surveys at a previously sampled site on Casserly Creek since 2020. This report summarizes the results of the 2022 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 26 and 28-30, 2022. 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

2022 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

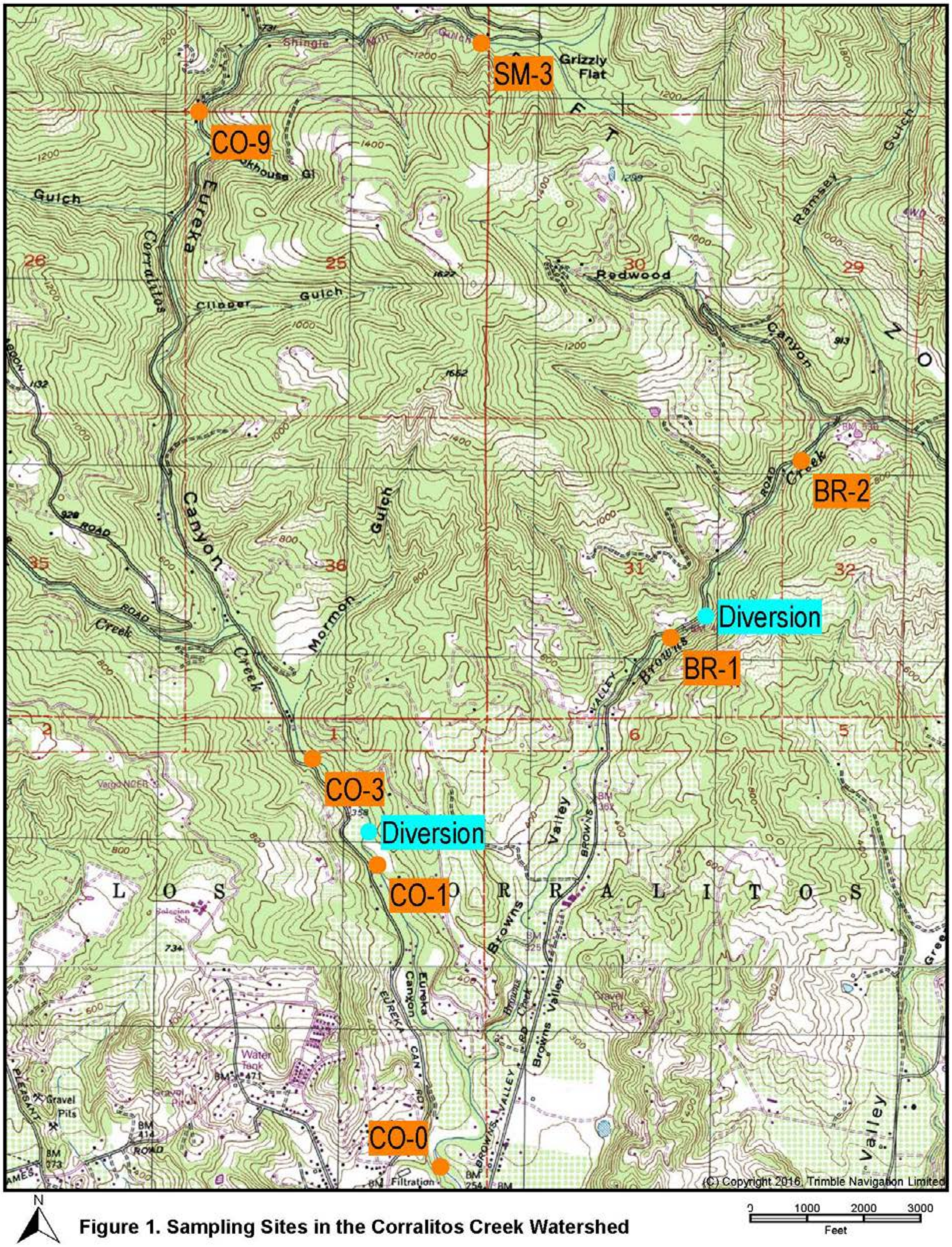


Figure 1. Sampling Sites in the Corralitos Creek Watershed

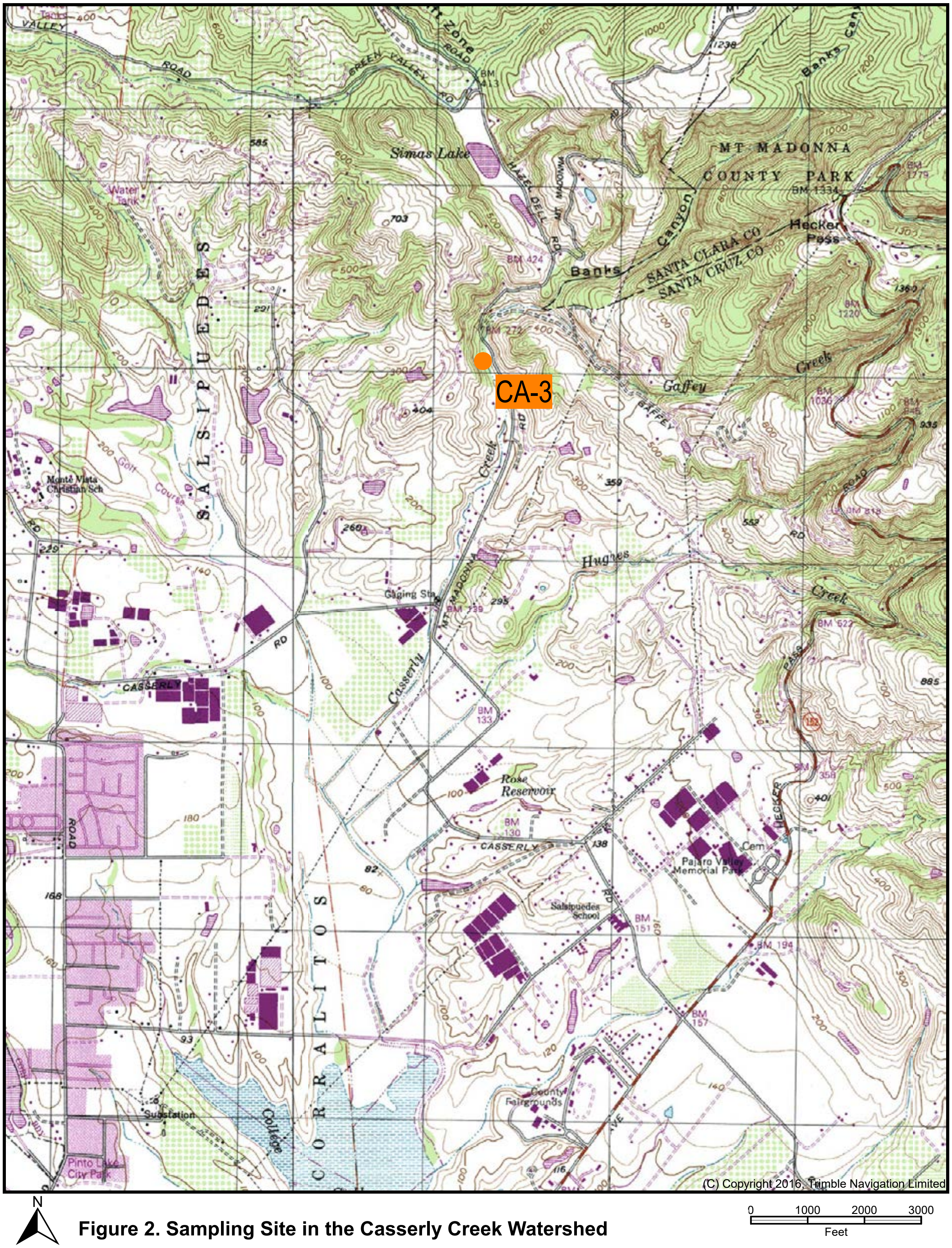


Figure 2. Sampling Site in the Casserly Creek Watershed

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. 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 2022 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 2022. The 2016 and 2017 density estimates are derived from Alley (2017, 2018). Absolute juvenile steelhead density estimates for 2018 through 2022 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 seven sampling years accurately reflect actual population dynamics. Representative photographs of the sampling sites are provided in Appendix A.

Early-season precipitation occurred along the central California coast in mid-September 2022, approximately 7-10 days prior to the surveys, raising streamflows above summer baseflow levels. As such, the habitat assessment results presented below may not be representative of critical drought conditions local streams and fish populations experienced in 2022.

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 2022 was 226 ft (Table 3). Based on percent total length, CO-0 consisted of 68% flatwater (step-run) and 32% 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 3,814 ft^2, approximately 9% less than the 2021 wetted area of 4,198 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 0.9 ft, a maximum depth of 1.4 ft, and a residual depth of 1.1 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 and 2022, the concrete slabs remained, but most of the channel width now consists of a cobble-dominated tail-out with an embeddedness rating of 0-25%. The mean pool shelter rating was 20, 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 65% and composed entirely (100%) of hardwood species.

The overall juvenile steelhead population estimate for CO-0 was 25, for a total juvenile steelhead density of 11.1 fish/100 ft (Table 4), representing a 25% decrease from the 2021 estimate of 14.8 fish/100 ft but comparable to the 2020 estimate of 12.9 11.1 fish/100 ft. Of the juvenile steelhead captured at CO-0, 45.5% were age 0 fish (80.6% in 2021) and 54.5% were age 1+ fish (19.4% in 2021) (Figure 3). Estimated age class densities (Table 4) were 5.0 fish/100 ft for age 0 steelhead (12.0 fish/100 ft in 2021) and 6.0 fish/100 ft for age 1+ steelhead (2.9 fish/100 ft in 2021), representing a substantial decrease in age 0 densities while the age 1+ juvenile density roughly doubled since 2021. As such, the observed decrease in total steelhead densities in 2022 was driven by the substantial decrease in age 0 fish, suggesting limited 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*). Two lamprey (*Lampetra* sp.) ammocoetes were captured at this site in 2022 after the species was absent from this site in 2021. However, unlike prior years, no Sacramento sucker (*Catostomus occidantalis*) were captured in 2022. Non-native signal crayfish (*Pacifastacus leniusculus*) were again present, but of greater concern was the discovery of invasive New Zealand mudsnails (*Potamopyrgus antipodarum*) at this site.

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 168 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 1,821 ft^2, a 25% increase over the 2021 estimate of 1,460 ft^2 that was the result of wider mean wetted widths in the riffle sections of the assessment reach. 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 0.9 ft, indicative of continued aggradation within the site's primary pool unit. 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 in the two pools was 1.8 ft with a maximum residual depth of 1.5 ft, representative of a 0.5 ft decrease in depth. Dominant pool tail-out substrates consisted of boulders at one pool 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 28, with most of the decrease over prior years resulting from the loss of LWD. 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 13, and the total juvenile steelhead density was 7.7 fish/100 ft (Table 4), a 53% decrease from the 2021 estimate of 16.4 fish/100 ft (Figure 5) but only slightly lower than the 2020 estimate of 10.7 fish/100 ft. Of the juvenile steelhead captured at CO-1 in 2022, only 16.7% were age 0 fish and 83.3% were age 1+ fish (Figure 3), an almost complete reversal from the 2021 distribution of 87.5% age 0 fish and 12.5% age 1+ fish. Estimated age class densities in 2022 were 1.3 fish/100 ft for age 0 steelhead (14.3 in 2021) and 6.4 fish/100 ft for age 1+ steelhead (2.0 in 2021) (Table 4). Similar to population trends at CO-0 discussed above, the significant decrease in the age 0 steelhead density at CO-1 in 2022 resulted in a substantial decrease in the total steelhead density and suggests poor spawning success compared to 2021.

Sculpins were moderately abundant at CO-1. Three large (200+ mm SL) Sacramento suckers were also present. One lamprey ammocoete was observed at CO-1 in 2021, but the species appeared to be absent in 2022. Unfortunately, New Zealand mudsnails were also observed at this site, albeit in lower numbers than at CO-0.

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 2022 was 268 ft (Table 3). Based on percent total length, CO-3 consisted of 14% riffle, 34% flatwater, and 52% 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 3,592 ft^2, comparable to the 2021 estimate of 3,776 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 2022 sampling reach had a combined mean depth of 1.1 ft, a maximum depth of 2.0 ft, and a maximum residual depth of 1.6 ft, indicative of relatively unchanged conditions since 2021. Dominant pool tail-out substrates at both pools consisted of large cobble with embeddedness ratings of 50-75% and 75-100%, representative of relatively spawning conditions. The mean shelter rating for the pools was 48, 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%, consisting of approximately 60% hardwood and 40% conifer species.

The overall juvenile steelhead population estimate for CO-3 was 33, and the total juvenile steelhead density was 12.3 fish/100 ft (Table 4), a 50% decrease from the 2021 estimate of 24.8 fish/100 ft (Figure 5). Of the juvenile steelhead captured at CO-3, 24.1% were age 0 fish and 75.9% were age 1+ fish (Figure 3). Similar to CO-1 above, this distribution is a near full reversal from the 71.2% age 0 to 28.8% age 1+

distribution in 2021. Estimated age class densities in 2022 were 3.0 fish/100 ft for age 0 steelhead (17.7 in 2021) and 9.3 fish/100 ft for age 1+ steelhead (7.2 in 2020) (Table 4). Similar to CO-0 and CO-1, a large decrease in age 0 densities suggest low spawning activity in the vicinity of CO-3 in 2022. Nevertheless, partly due to the modest increase in the age 1+ density, CO-3 had the second highest total juvenile steelhead density of the eight sites sampled in 2022.

Sculpins were present in moderate numbers, one Sacramento sucker, and one lamprey ammocoete were observed at CO-3 in 2022. Non-native signal crayfish were also present.

It should be noted that staff from CDFW and the Monterey Bay Salmon and Trout Project (MBSTP) conducted a juvenile steelhead rescue operation within a dry-back reach of lower Corralitos Creek in early June 2022 and released 110 mostly age 0 steelhead in Corralitos Creek at the Las Colinas Drive crossing, located approximately 1,000 ft downstream of the CO-3 sampling site, and 266 juvenile steelhead in vicinity of Rider Creek confluence, approximately 0.5 mile upstream of CO-3 (Cochran, pers. comm.). While density estimates at CO-3 may have been affected if some of the released steelhead dispersed into the sampling reach prior to the survey, the likelihood of this appears to be low considering the exceedingly low densities of age 0 steelhead captured at CO-3 in 2022.

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 2022 was 107 ft (Table 3). Based on percent total length, CO-9 consisted of 76% flatwater (step-run), and 31% 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 836 ft^2, approximately 28% lower than the 2021 estimate of 1,157 ft^2. The reduction in wetted surface area was the result of an almost 3-ft decrease in the width of the pool unit. Two Level II habitat units (one flatwater, one pool) were sampled at CO-9. The pool in this reach had a mean depth of 1.1 ft (0.3 ft shallower than in 2021), a maximum depth of 2.5 ft and a residual depth of 2.3 ft (comparable to 2021), suggesting continued deposition in much of the pool during water year 2022. The pool tail-out in 2022 consisted of boulders and therefore does not provide spawning habitat. The mean shelter rating for the pool was 100, representative of fair shelter availability. Shelter consisted entirely of large boulders that, combined with the still significant depth of the pool, provided high quality habitat for age 1+ steelhead. Canopy cover was estimated at 70%, composed almost entirely (95%) of hardwood species.

The overall juvenile steelhead population estimate for CO-9 was 15, and the total juvenile steelhead density was 14.0 fish/100 ft (Table 4), a 64% decrease from the 2021 density of 38.6 fish/100 ft (Figure 5). This represents the fourth consecutive year that CO-9 had the highest total juvenile density of the eight sampling sites. Of the steelhead captured at CO-9 in 2021, only 6.7% were age 0 fish (56.4% in 2021) while 93.3% were age 1+ fish (43.6% in 2021) (Figure 3), representing a significant departure from the typically even age classes distribution at this sampling site. Estimated age class densities were 0.9 fish/100 ft for age 0 steelhead (21.8 in 2021) and 13.1 fish/100 ft for age 1+ steelhead (16.8 in 2021) (Table 4). The 2022 age 1+ density at CO-9 was the highest among all sampling sites for the fifth 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. The exceedingly low density of age 0 fish, however, provides further indication of poor adult migration and/or spawning success in the Corralitos Creek watershed in water year 2022.

No other fish species were present at CO-9 in 2022, but one California giant salamander (*Dicamptodon ensatus*) larva was observed.

Shingle Mill Gulch #3 (SM-3)

Sampling site SM-3 is located on Shingle Mill Gulch, tributary to Corralitos Creek, upstream of the third Eureka Canyon Road crossing and downstream of Grizzly Flat (Figure 1). Although located in the upper Corralitos Creek watershed, the gradient of the sampling reach is relatively low at approximately 2%. The total channel length of the assessment reach in 2022 was 139 ft (Table 3). Based on percent total length, SM-3 consisted of 38% riffle and 62% 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 601 ft^2, a modest decrease from the 2021 estimate of 704 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 0.6 ft, a maximum depth of 1.9 ft, and a residual depth of 1.8 ft. Dominant pool tail-out substrates at both pools consisted of gravels with embeddedness ratings of 0-25%, representative of good spawning conditions. The combined mean shelter rating for the pools was 33, similar to the 2021 rating of 27.5. Gravel was the dominant substrate type in the pools and the riffle. Canopy cover was estimated at 90%, composed almost entirely (85%) 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 (Table 4), identical to the 2021 density. Of the juvenile steelhead captured at SM-3, 20.0% were age 0 fish and 80.0% were age 1+ fish (Figure 3), also identical to 2021. Estimated age class densities were 0.7 fish/100 ft for age 0 steelhead and 2.9 fish/100 ft (Table 4), again identical to 2021. Based on the very low density of age 0 fish at SM-3 (only one individual was captured in 2021 and 2022), it appears that anadromous spawning may not extend this far up in the watershed in drought years and that the Shingle Mill population may currently be sustained by low levels of resident trout spawning.

Several larval California giant salamanders and four California newt were observed at SM-3 in 2022. 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 2022 was 236 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 2,396 ft^2, comparable to the 2021 estimate of 2,333 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 2.4 ft, and a residual depth of 2.2 ft, indicative of a moderate amount of scour (0.3 ft) since 2021. 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 single 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 11, and the total juvenile steelhead density was 4.7 fish/100 ft (Table 4), a 43% decrease from the total density of 8.3 fish/100 ft in 2021. Juvenile densities have fluctuated widely at BR-1 since 2016 (Figure 5). Of the juvenile steelhead captured at BR-1 in 2022, 36.4% were age 0 fish (40.0% in 2020) and 63.6% were age 1+ fish (60.0% in 2020) (Figure 3), similar to the age class structure observed in 2020 and 2021. Estimated age class densities in 2022 were 1.7 fish/100 ft for age 0 steelhead (3.3 in 2020) and 3.0 fish/100 ft for age 1+ steelhead (5.0 in 2020) (Table 4). Steelhead densities at BR-1 have declined substantially during three consecutive drought years (Figure 5).

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 2022 was 229 ft (Table 3). Based on percent total length, BR-2 consists of 58% flatwater and 42% 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 2,650 ft^2, essential identical to the 2021 estimate of 2,642 ft^2. Three Level II habitat units (one flatwater, two pools) were sampled at BR-2. The pools in this reach had a combined mean depth of 1.0 ft, a maximum depth of 2.2 ft, and a residual depth of 2.1 ft. The tail-outs at both pools consisted of very large cobbles and boulders that are not suitable for spawning by adult steelhead. The mean shelter rating for the pools was 60, representative of low shelter abundance. The limited shelter was dominated by boulders in one pool and by a complex root mass in the other. Canopy cover was estimated at 80%, composed about equally of hardwood and conifer species.

The overall juvenile steelhead population estimate for BR-2 was 12, and the total juvenile steelhead density was 5.2 fish/100 ft (Table 4), a 136% increase from the total density of 2.2 fish/100 ft in 2021 and the only sampling site where the juvenile density increased over the prior year (Figure 5). Of the juvenile steelhead captured at BR-2, 90% were age 0 fish (0% in 2021) with 10% of captured fish in the age 1+ class (100% in 2021) (Figure 3). Estimated age class densities were 4.7 fish/100 ft for age 0 steelhead (0.0 in 2020) and 0.5 fish/100 ft for age 1+ steelhead (2.2 in 2021) (Table 4), suggestive of some spawning success upstream of the City's diversion in 2022.

Sculpins were again abundant at BR-2 in 2022 and California giant salamander larvae were present too.

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 2022 was 171 ft (Table 3). Unlike in 2021, surface flow was continuous on the day of 2022 survey but likely intermittent or largely dry prior to the early season rainfall that occurred approximately 10 days prior to the survey. Based on percent total length, CA-3 consisted of 33% riffles, 51% flatwater, and 16% 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 880 ft^2, a 8% increase over the 2021 estimate of 810 ft^2 that is primarily the result of slightly increased wetted widths in 2022. 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 0.6 ft, a maximum depth of 1.1 ft, and a residual depth of 1.0 ft. Dominant pool tail-out substrates consisted of large cobbles with a high embeddedness rating of 50-75%. The shelter rating for the pool was 45, reflective of decreased cover availability compared to prior years. Sand is the dominant substrate type in the pool, while gravel dominated the flatwater and boulders were the dominant substrate in the riffle. Canopy cover was estimated at 50%, consisting of approximately 90% hardwood and 10% conifer species.

The overall juvenile steelhead population estimate for CA-3 was 9, and the total juvenile steelhead density was 5.3 fish/100 ft, representing a 17% decrease from the 2021 density of 6.4 fish/100 ft. Of the juvenile steelhead captured at CA-3, only one (11.1%) was an age 0 fish (66.7% in 2021) and all others (88.9%) were age 1+ fish (33.3% in 2021) (Figure 3). Estimated age class densities were 0.6 fish/100 ft for age 0 steelhead (4.3 in 2021) and 4.7 fish/100 ft for age 1+ steelhead (2.1 in 2021) (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 and 2021, however, the 2022 relative abundance of age 0 fish was greatly reduced, a trend that is consistent with observations in Shingle Mill Creek discussed above and indicative of limited adult migration opportunities in water year 2022 (Figure 7).

No other fish species or crayfish were observed at CA-3. One frog was briefly observed in the pool but evaded subsequent detection and identification.

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

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

factor in maturation and recruitment of adults.

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

For salmonids, the timing of runoff events is more important than the total or mean annual discharge. In water year 2018, only one minor runoff event occurred in early January 2018, then streamflows in Corralitos Creek remained below the 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).

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. Hydrologically, 2019 was an almost ideal water year for steelhead as streamflows remained elevated but did not reach levels that would be expected to result in redd (egg nest) scour and/or significant flushing of age 0 fish. It appears that higher flows in water year 2019 provided adult steelhead access higher up in the watershed, as reflected by substantial increases in age 0 juvenile densities at CO-9, SM-3, BR-1, and BR-2 compared to 2018 (Figure 5). Conversely, age 1+ densities decreased moderately at most sites and substantially in Shingle Mill Gulch (SM-3). The favorable 2019 smolt outmigration conditions (i.e., sustained, moderate spring flows), combined with the relatively low age 0 densities (<10 fish/100 ft) in 2018 likely resulted in the weaker age 1+ densities at these sites in 2019 (Podlech 2019).

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

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

Water year 2021 marked a second consecutive drought year. In contrast to water year 2020, however, the only significant adult migration opportunity of water year 2021 occurred in late January during the peak steelhead migration and spawning season. This relatively brief event appears to have enabled adult steelhead to enter the 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 in six years of monitoring (Figure 5) (Podlech 2021).

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

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

TABLE 2

WATER QUALITY RESULTS AT EIGHT SAMPLING SITES IN THE CORRALITOS CREEK AND CASSERLY CREEK WATERSHEDS, SEPTEMBER 2022

Parameter	CO-0	CO-1	CO-3	CO-9	SM-3	BR-1	BR-2	CA-3
Date	9/29	9/30	9/29	9/26	9/26	9/28	9/28	9/30
Time	1030	1040	1325	1135	1000	1300	1030	1335
Weather	clear	clear	clear	clear	clear	clear	clear	clear
Air Temp (°C)	17.0	19.7	22.7	16.9	14.9	16.7	15.6	21.2
Water Temp (°C)	14.8	15.0	15.6	14.8	14.0	14.5	13.9	15.4
Conductivity (µmhos/cm)	447	440	444	508	455	582	590	N/A
DO Conc. (mg/l)	9.9	9.1	8.7	9.4	8.8	8.3	9.0	7.8
DO Sat. (%)	95	93	85	98	86	86	91	68

TABLE 3

SUMMARY OF HABITAT TYPES AND MEASURED PARAMETERS AT EIGHT SAMPLING SITES IN THE CORRALITOS CREEK AND CASSERLY CREEK WATERSHEDS, SEPTEMEBR 2022

Site ID	Habitat Unit Type	# of Units	Total Length (ft.)	% of Reach Length	Mean Width (ft.)	Mean Depth (ft.)	Max. Depth (ft.)	Residual Pool Depth (ft.)	Estimated Total Area (sq. ft.)	Dominant Substrate Types	Dominant Pool Tail Substrate	Mean Tail Embedded-ness	Mean Shelter Value
CO-0	P	1	72	32	14.9	0.9	1.4	1.1	1,073	SA	LC	1.0	20
	F	1	154	68	17.8	0.3	0.7	---	2,741	LC	---	---	---
	TOTAL		**226**						**3,814**				
CO-1	P	2	72	43	10.1	0.9	1.8	1.5	727	SA/LC	BR/BO	NA	28
	R	2	96	57	11.4	0.4	1.2	---	1,094	LC	---	---	---
	TOTAL		**168**						**1,821**				
CO-3	P	2	139	52	15.0	1.1	2.0	1.6	2,085	SA/LC	LC	3.5	48
	F	1	92	34	12.2	0.6	1.5	---	1,122	LC	---	---	---
	R	1	37	14	10.4	0.3	0.6	---	385	LC	---	---	---
	TOTAL		**268**						**3,592**				
CO-9	P	1	31	29	12.0	1.1	2.5	2.3	372	BO	BO	NA	50
	F	1	76	71	6.1	0.4	1.6	---	464	BO	---	---	---
	TOTAL		**107**						**836**				
SM-3	P	2	86	62	4.9	0.6	1.9	1.8	421	GR	GR	1.0	33
	R	2	53	38	3.4	0.1	0.3	---	180	GR	---	---	---
	TOTAL		**139**						**601**				
BR-1	P	2	140	59	8.2	0.9	2.4	2.2	1,148	BO/LC	BO/BO	NA	45
	F	1	96	41	13.0	0.4	0.8	---	1,248	BO	---	---	---
	TOTAL		**236**						**2,396**				
BR-2	P	2	97	42	11.4	1.0	2.2	2.1	1,106	SA/BO	BO/BO	NA	60
	F	1	132	58	11.7	0.3	0.9	---	1,544	BO	---	---	---
	TOTAL		**229**						**2,650**				
CA-3	P	1	27	16	6.2	0.6	1.1	1.0	167	SA	LC	3	45
	F	1	88	51	4.6	0.4	1.3	---	405	GR	---	---	---
	R	1	56	33	5.5	0.2	0.4	---	308	BO	---	---	---
	TOTAL		**171**						**880**				

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 2022

Metric	CO-0	CO-1	CO-3	CO-9	SM-3	BR-1	BR-2	CA-3
Total Density	11.1	7.7	12.3	14.0	3.6	4.7	5.2	5.3
Age 0 Density	5.0	1.3	3.0	0.9	0.7	1.7	4.7	0.6
Age 1+ Density	6.0	6.4	9.3	13.1	2.9	3.0	0.5	4.7

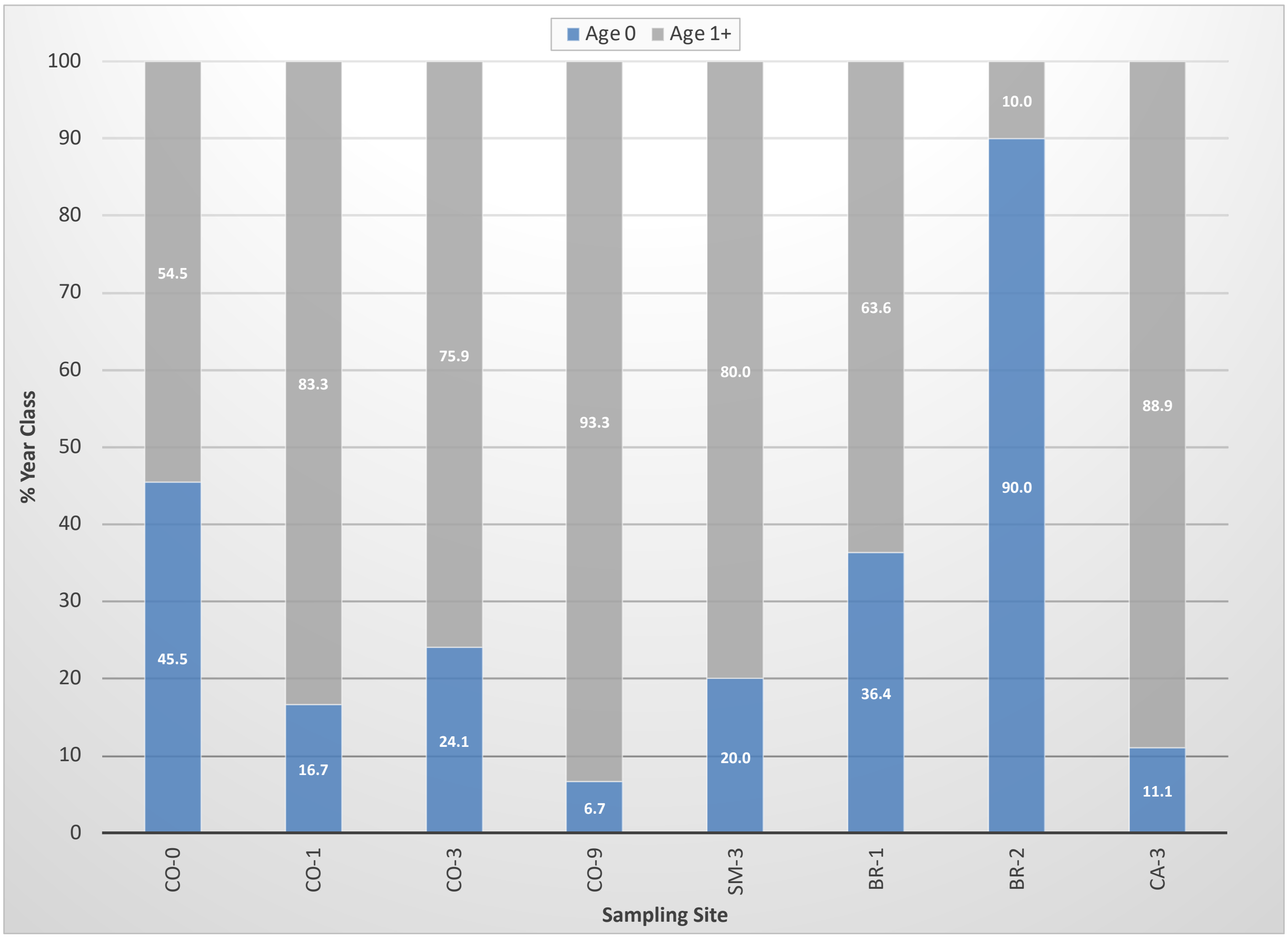
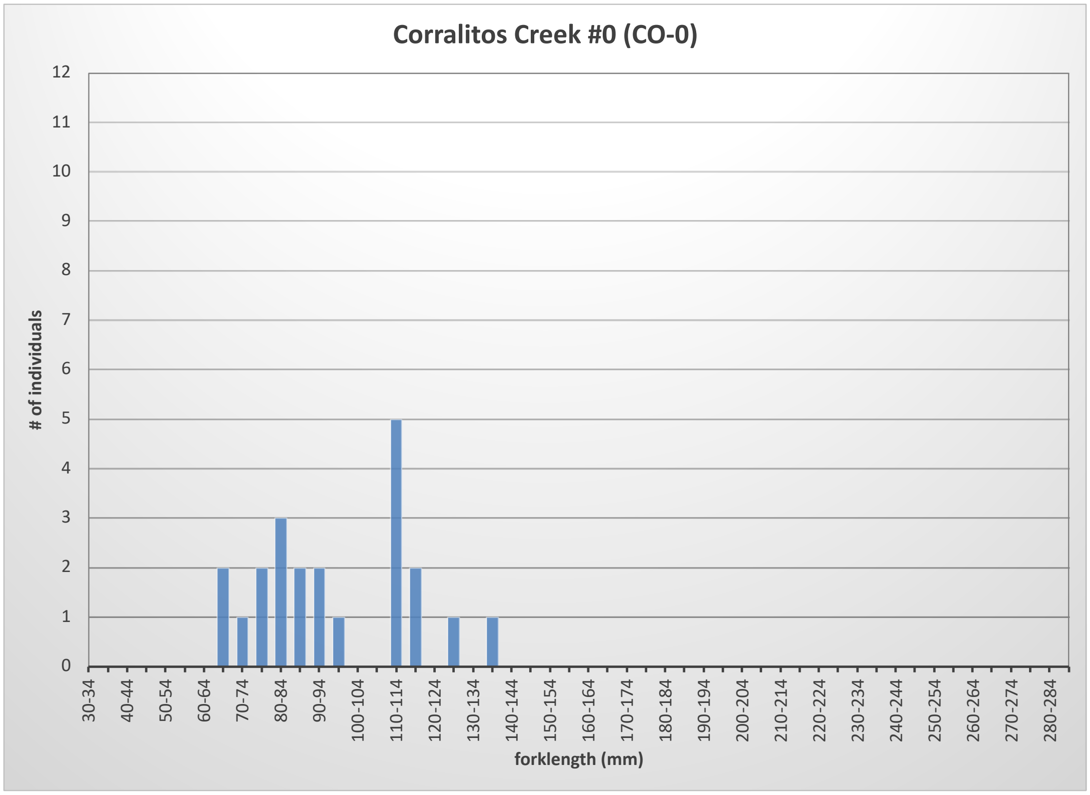


Figure 3. Relative Proportion (%) of Juvenile Steelhead Age Classes at Eight Sampling Sites in the Corralitos Creek and Casserly Creek Watersheds, September 2022



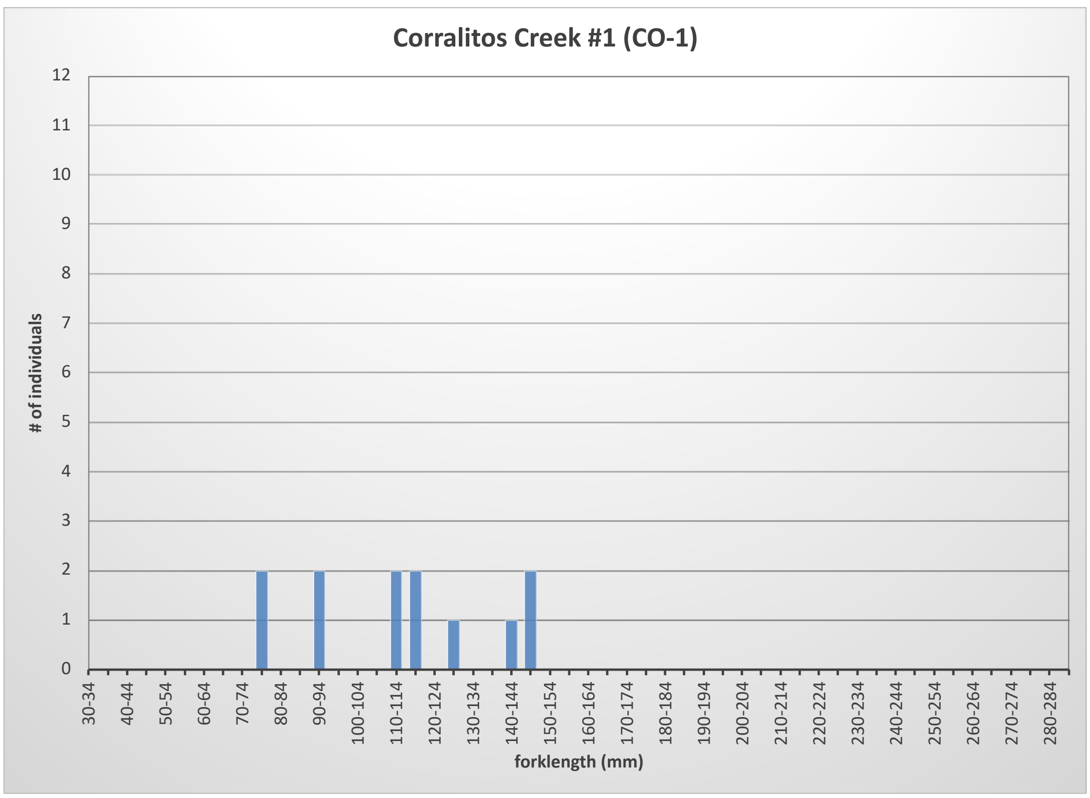
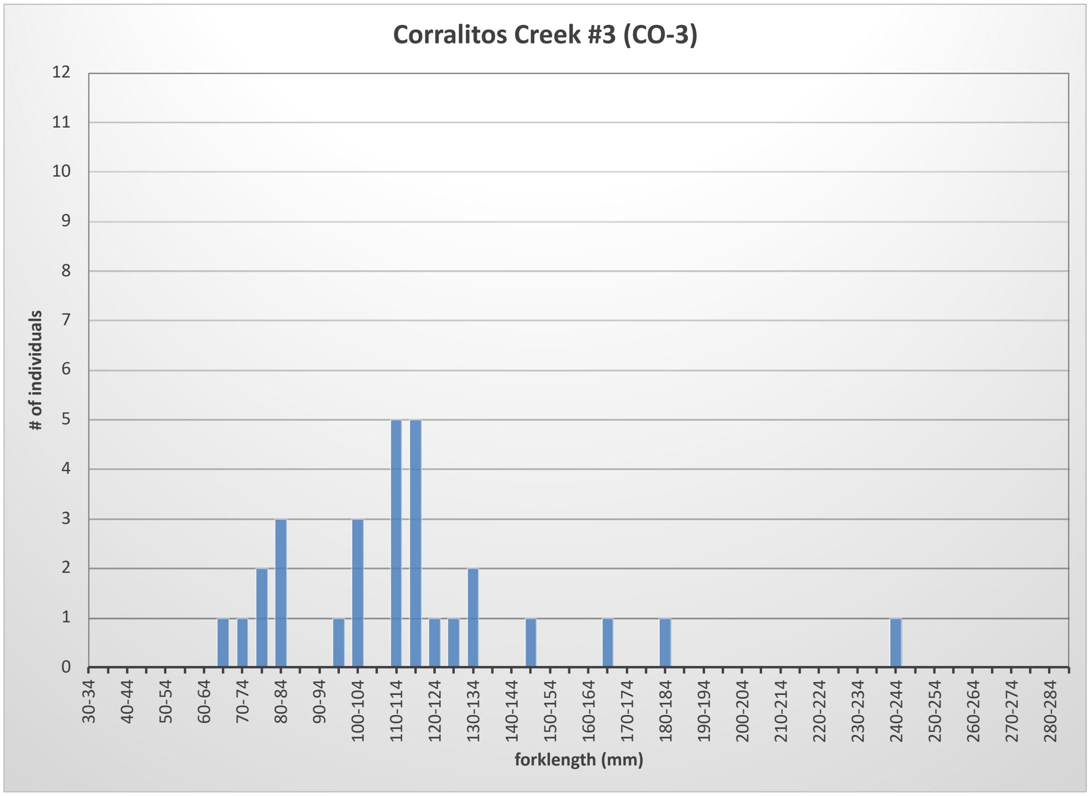


Figure 4. Forklength Distributions of Juvenile Steelhead at Eight Sampling Sites in the Corralitos Creek and Casserly Creek Watersheds, September 2022



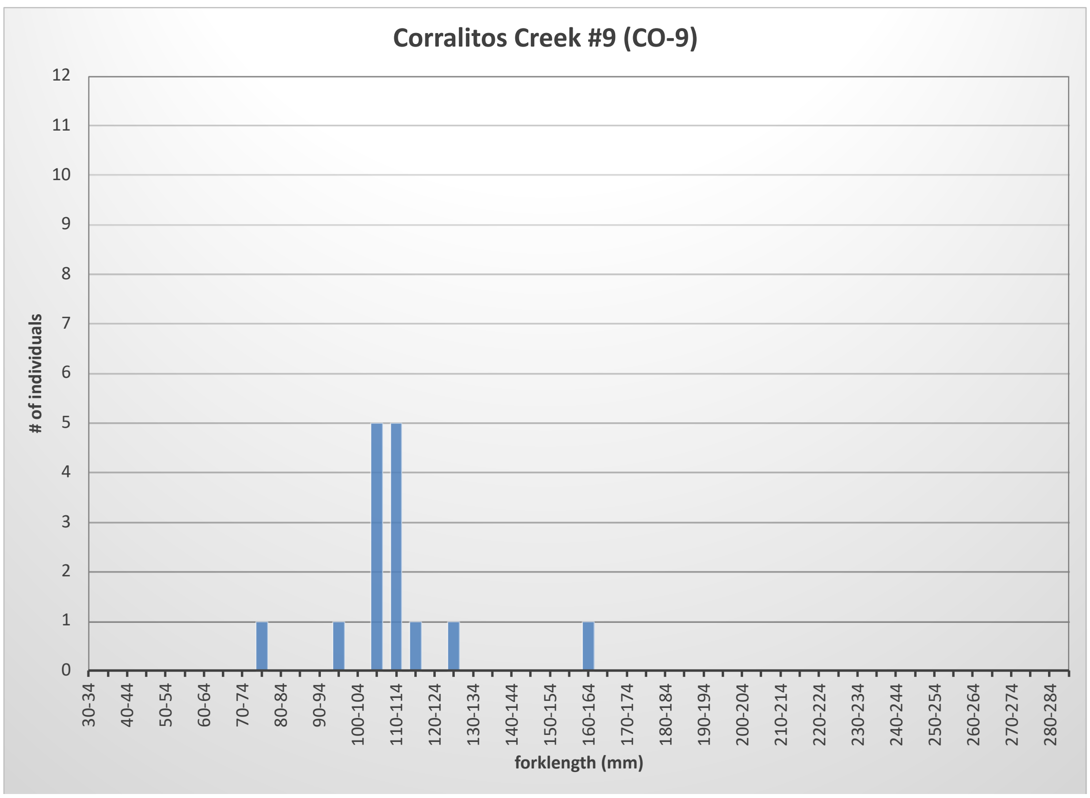
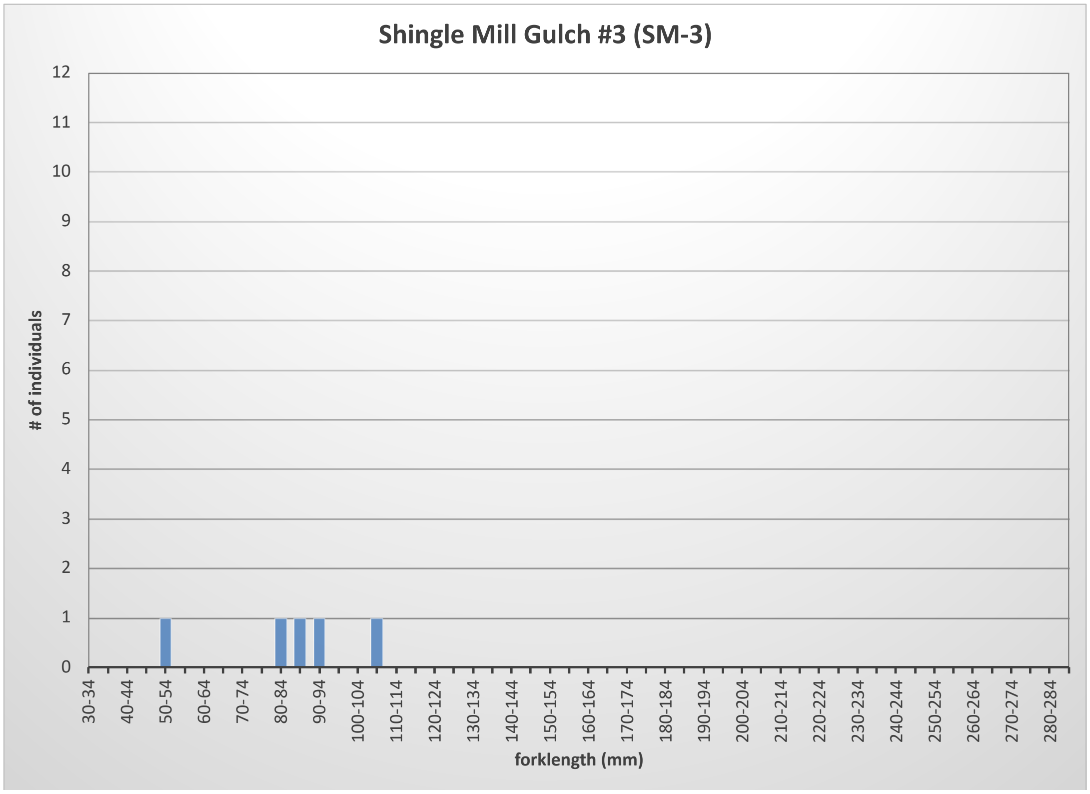


Figure 4 (cont.). Forklength Distributions of Juvenile Steelhead at Eight Sampling Sites in the Corralitos Creek and Casserly Creek Watersheds, September 2022



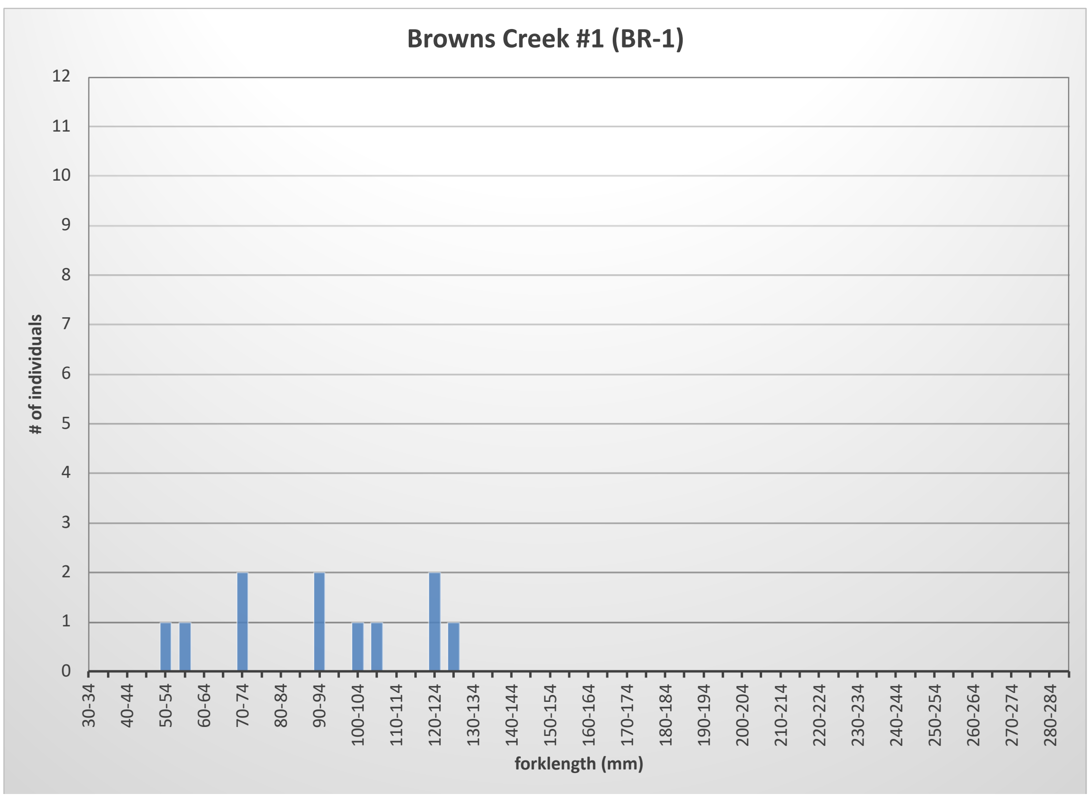
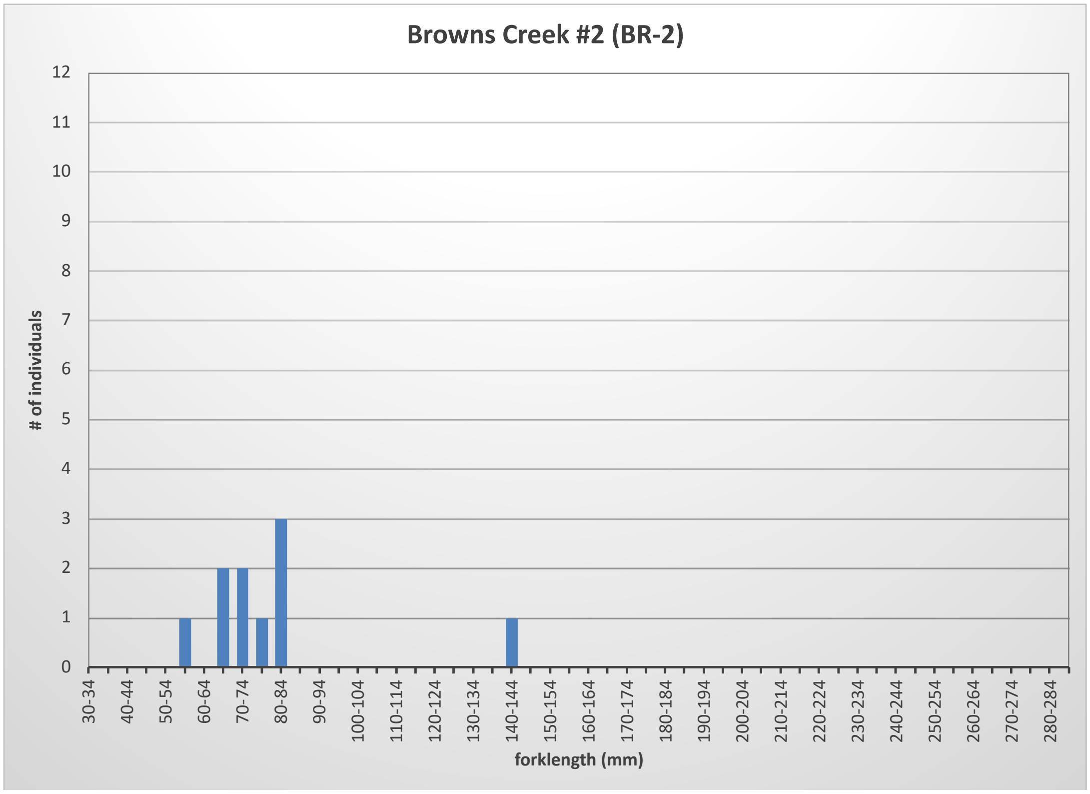


Figure 4 (cont.). Forklength Distributions of Juvenile Steelhead at Eight Sampling Sites in the Corralitos Creek and Casserly Creek Watersheds, September 2022



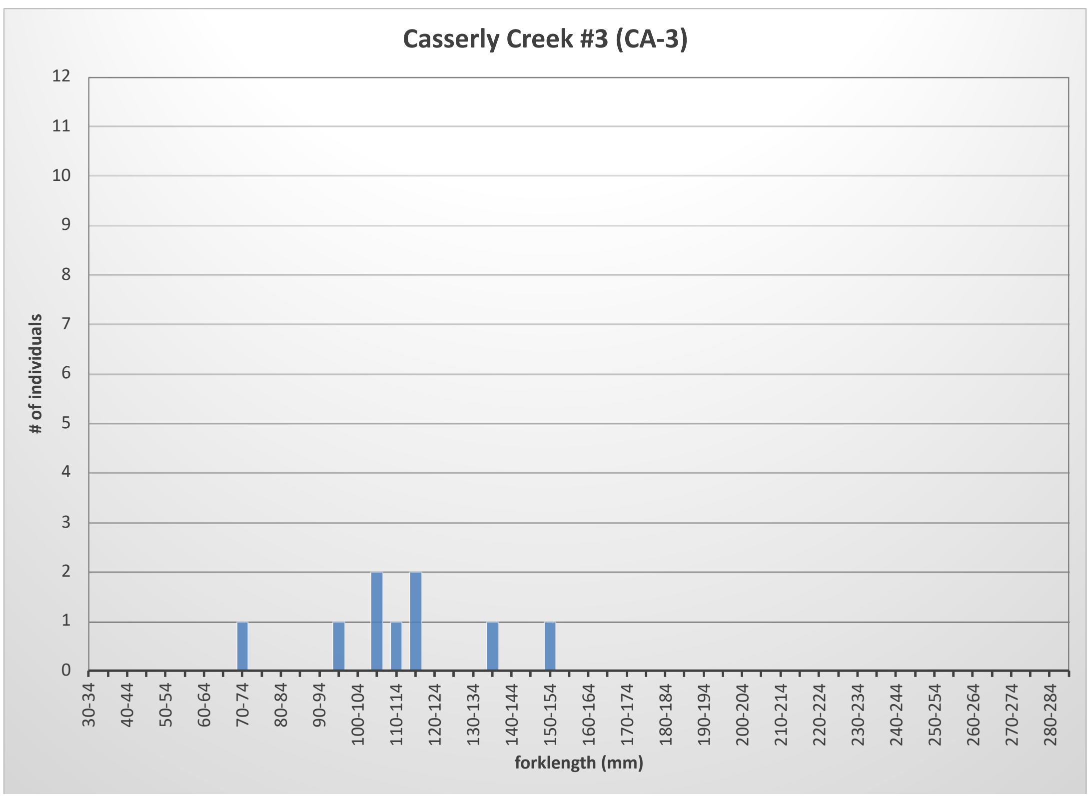
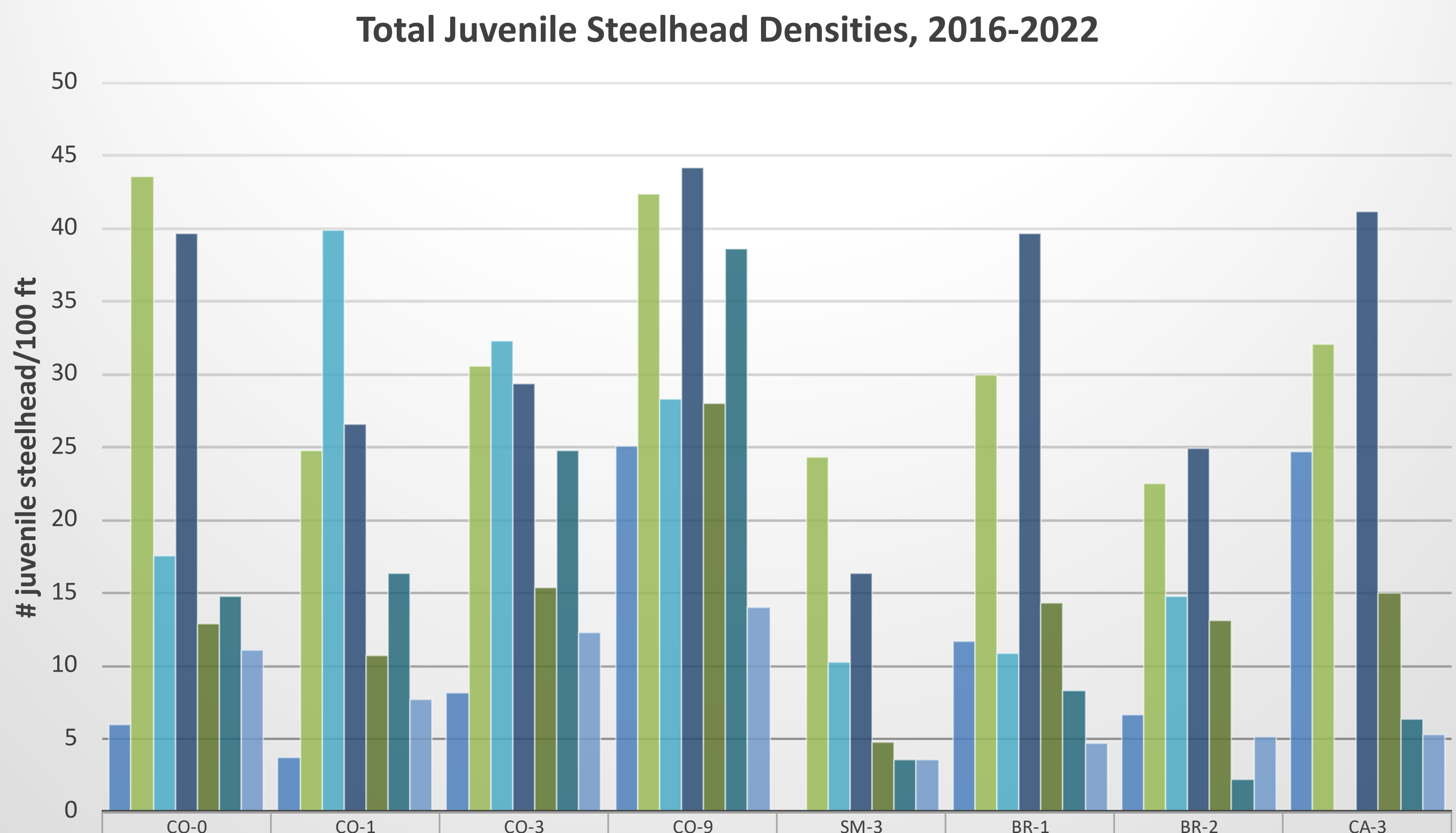
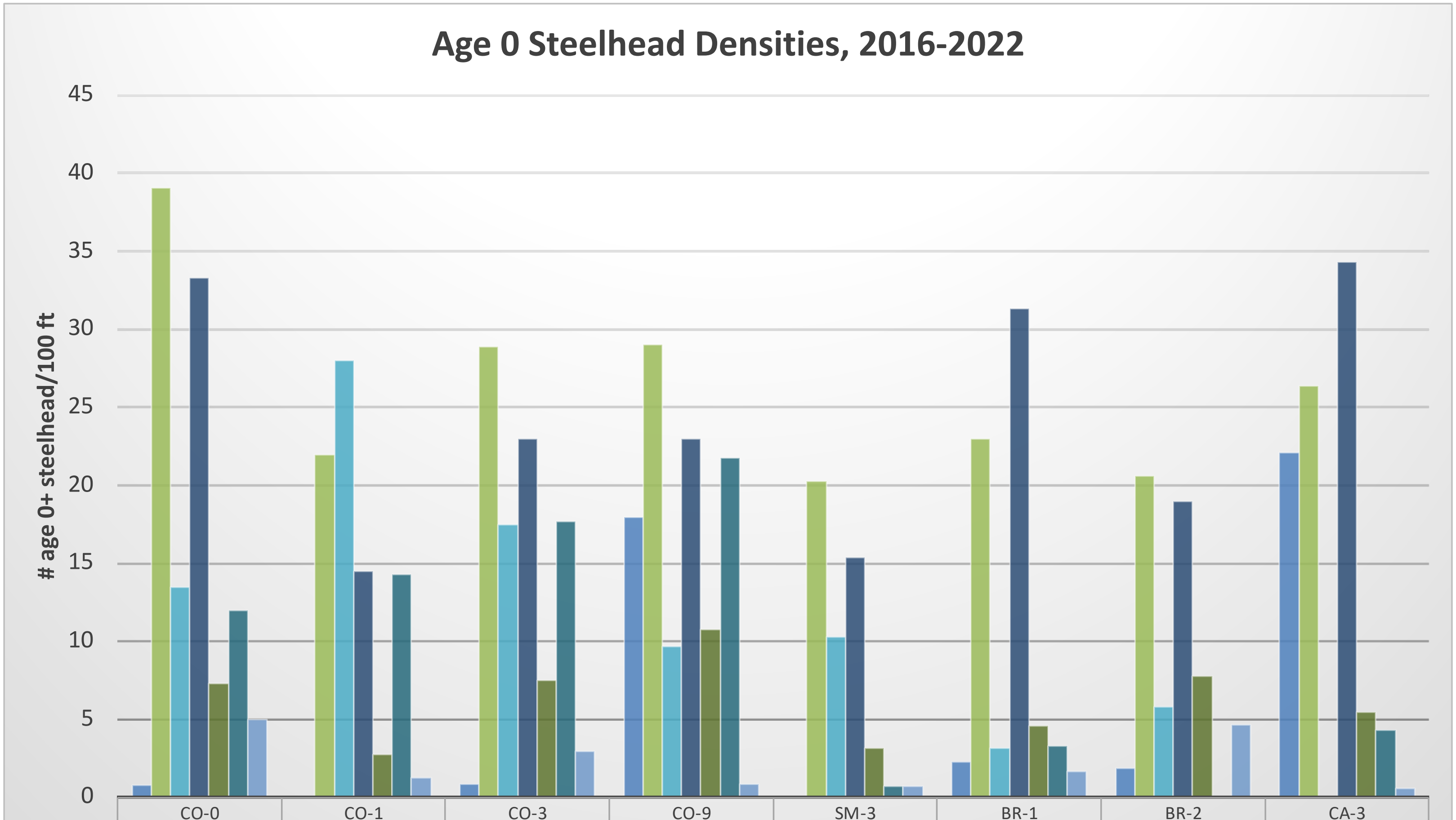


Figure 4 (cont.). Forklength Distributions of Juvenile Steelhead at Eight Sampling Sites in the Corralitos Creek and Casserly Creek Watersheds, September 2022



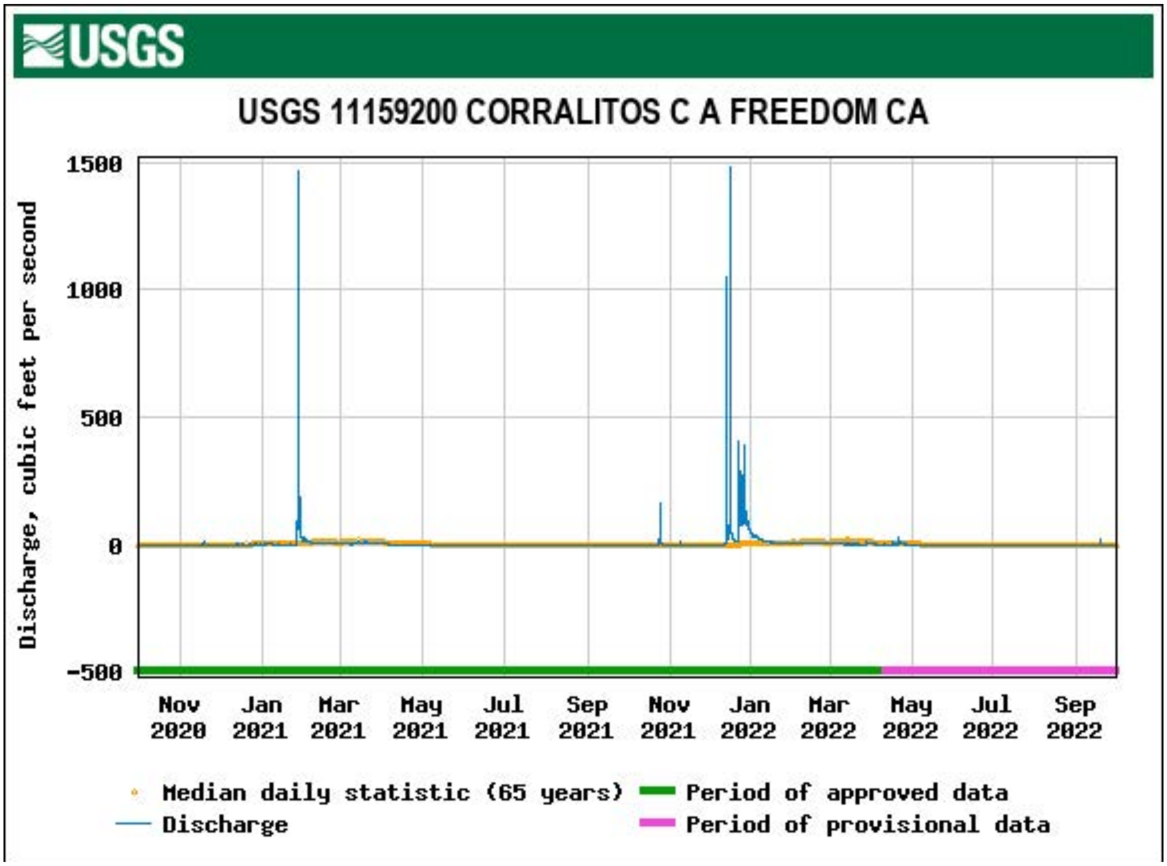
	CO-0	CO-1	CO-3	CO-9	SM-3	BR-1	BR-2	CA-3
2016	6.0	3.7	8.2	25.1		11.7	6.7	24.7
2017	43.6	24.8	30.6	42.4	24.3	30.0	22.5	32.1
2018	17.6	39.9	32.3	28.3	10.3	10.9	14.8	
2019	39.7	26.6	29.4	44.2	16.4	39.7	24.9	41.2
2020	12.9	10.7	15.4	28.0	4.8	14.3	13.1	15.0
2021	14.8	16.4	24.8	38.6	3.6	8.3	2.2	6.4
2022	11.1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

Figure 5. Total Juvenile Steelhead Densities at Eight Sampling Sites in the Corralitos Creek and Casserly Creek Watersheds, 2016-2022 (data for 2016-2017 adapted from Alley [2017, 2018])



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

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, 2022

Figure 7. Mean Daily Discharge in Corralitos Creek at Freedom, USGS Gage 11159200, Water Years 2021-2022

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Appendix A

Photographs of Eight Sampling Sites in the Corralitos Creek and Casserly Creek Watersheds, September 2022

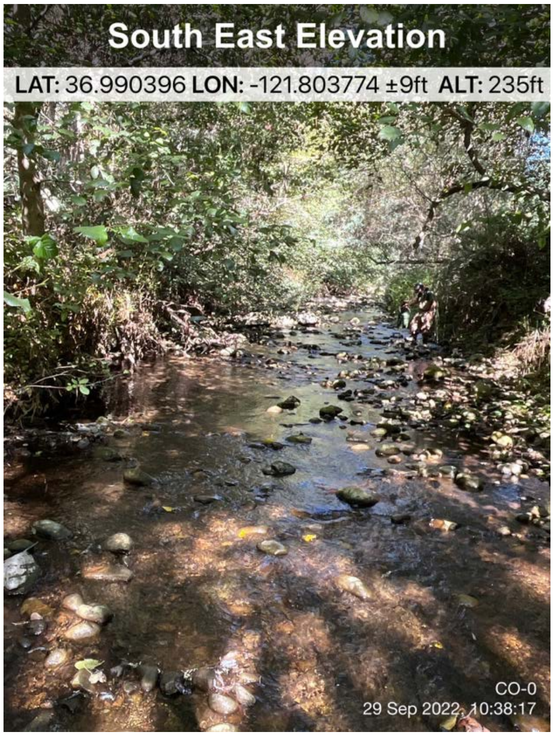

Photo 1. CO-0 flatwater-riffle transition, Sep. 29, 2022

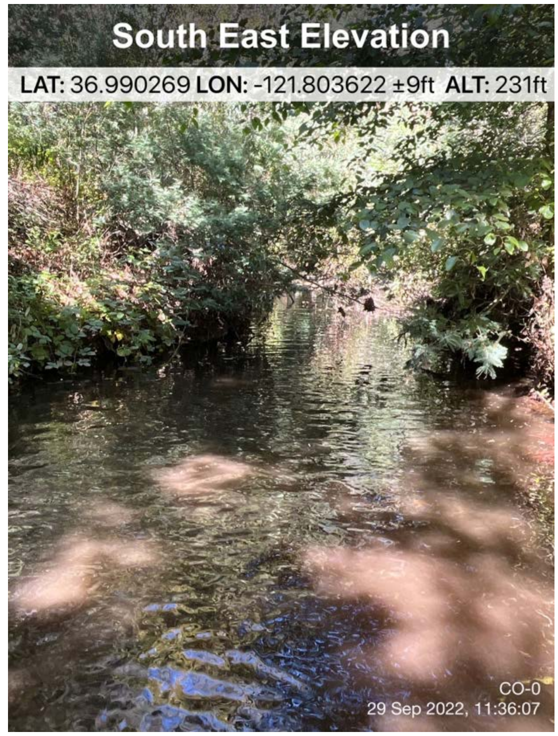

Photo 2. CO-0 pool, Sep. 29, 2022

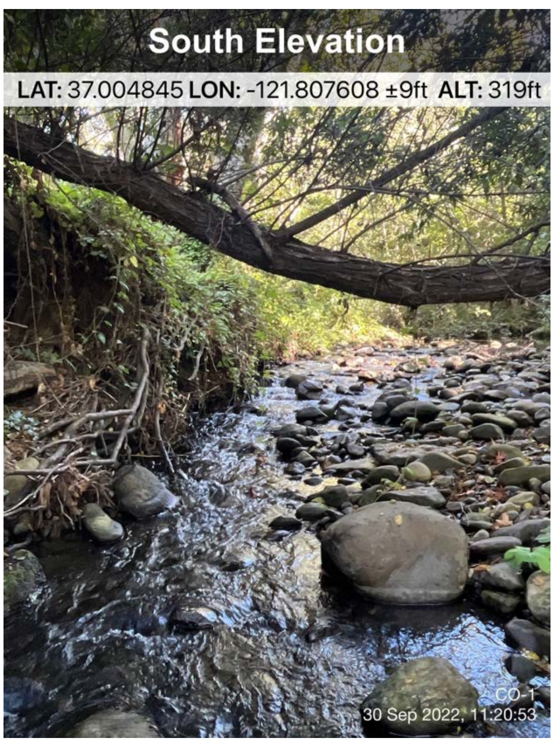

Photo 3. CO-1 riffle, Sep. 30, 2022

Photo 4. CO-1 pool with cover, Sep. 30, 2022

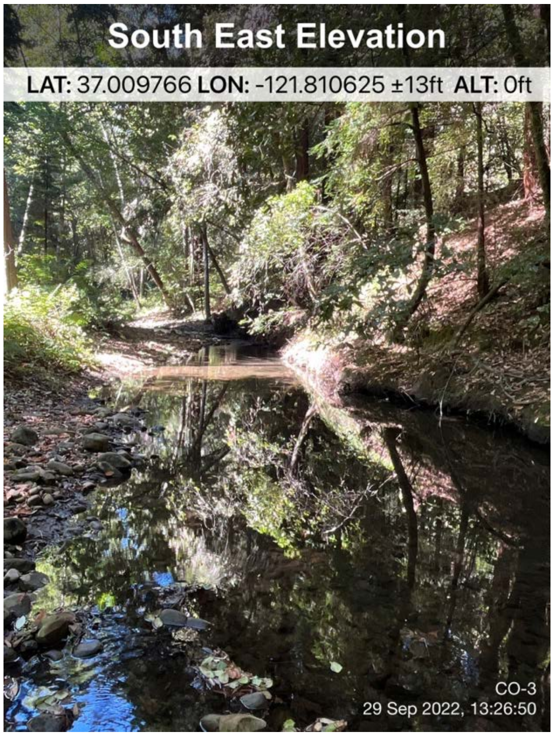

Photo 5. CO-3 pool, Sep. 29, 2022

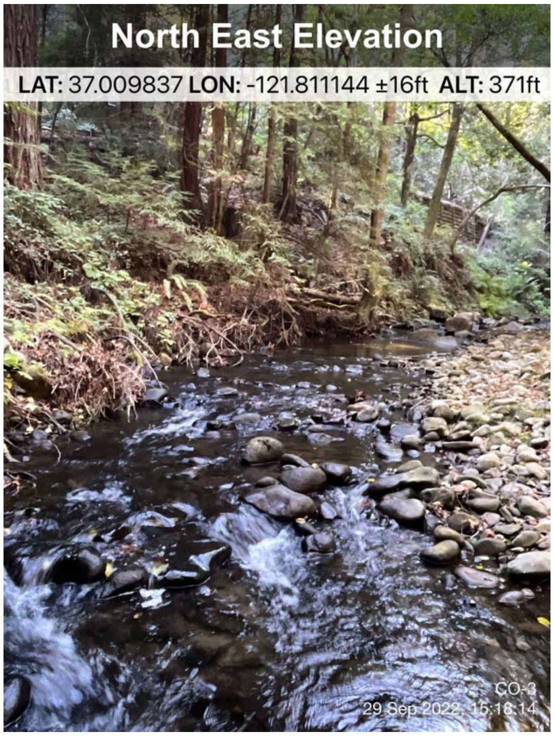

Photo 6. CO-3 riffle, Sep. 29, 2022

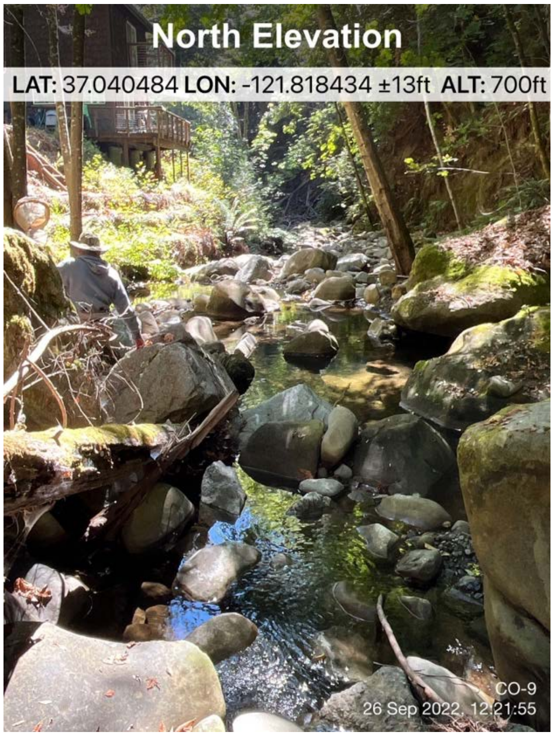

Photo 7. CO-9 pool, Sep. 26, 2022

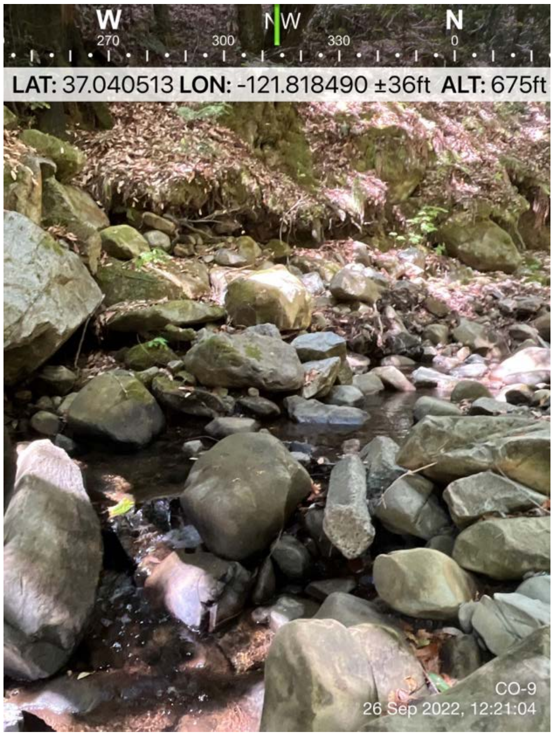

Photo 8. CO-9 flatwater, Sep. 26, 2022

Photo 9. SM-3 pool, Sep. 26, 2022

Photo 10. SM-3 riffle-pool transition, Sep. 26, 2022

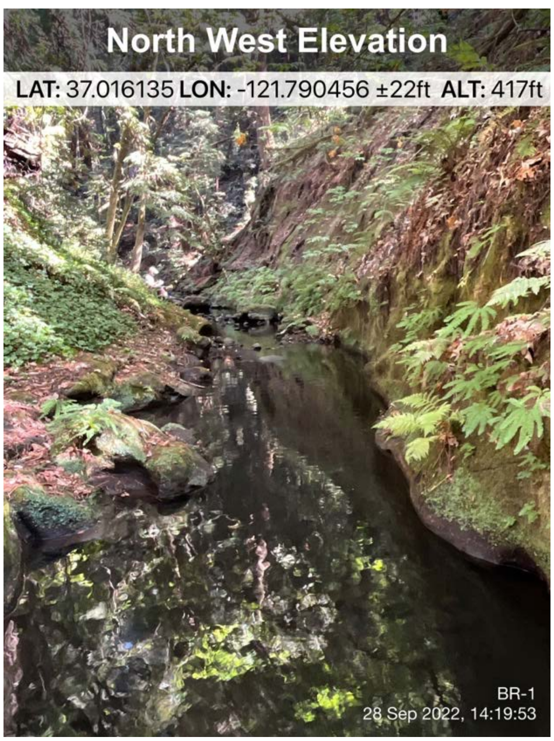

Photo 11. BR-1 pool, Sep. 28, 2022

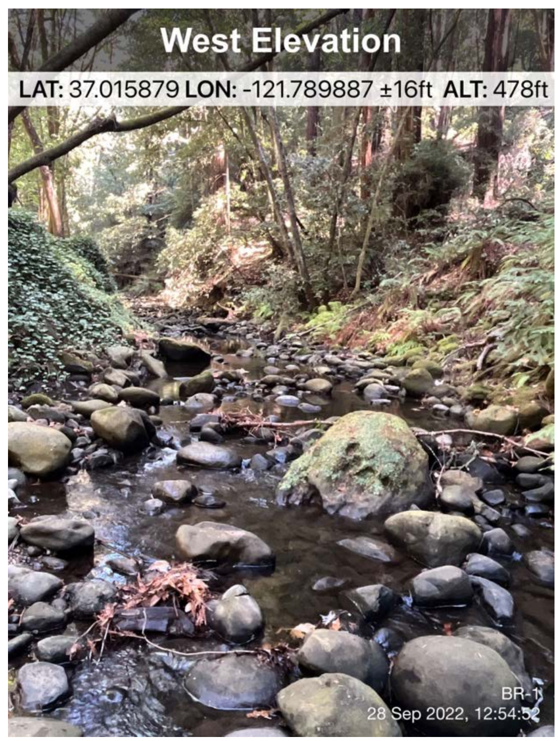

Photo 12. BR-1 flatwater, Sep. 28, 2022

Photo 13. BR-2 pool, Sep. 28, 2022

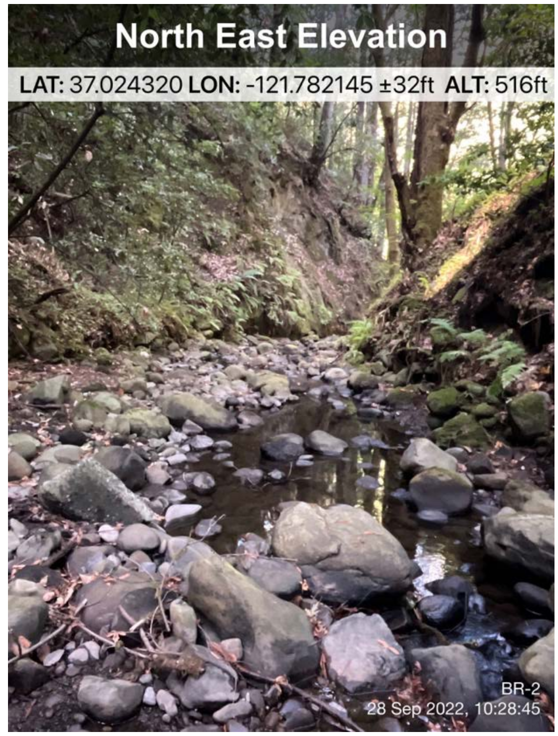

Photo 14. BR-2 flatwater, Sep. 28, 2022

Photo 15. CA-3 pool, Sep. 30, 2022

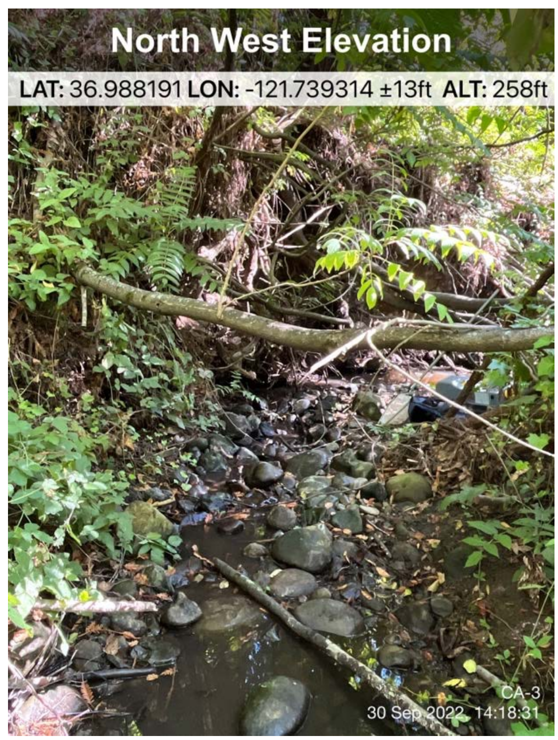

Photo 16. CA-3 riffle, Sep. 30, 2022