D.W. ALLEY & Associates aquatic biology

# 2019 SUMMARY REPORT− Juvenile Steelhead Densities in the San Lorenzo, Soquel and Aptos Watersheds, Santa Cruz County, CA

**Adult Steelhead, San Lorenzo River Gorge. (Photo by Ed Morrison)**

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***Prepared for the*** **City of Santa Cruz Water Department**,
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**Cities of Santa Cruz and Capitola, Soquel Creek Water District, San Lorenzo Valley Water District, Scotts Valley Water District, and the County of Santa Cruz**
**(Sampling for Tidewater Goby under USFWS Endangered Species Recovery Permit TE-793645-4)**

**April 2020** **Project # 200-17**

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**Juvenile Steelhead (*Oncorhynchus mykiss*) reared in the San Lorenzo River. Sep 2019. (Photo by Tyler Suttle)**

# A. EXECUTIVE SUMMARY

WY2019 baseflow was above the median flow statistic, unlike the drier WY2018, making 8 of the last 13 water years below median flow (**Figures 4 and 21**). Williams et al. (**2020**) examined hydrological modeling and tree-ring reconstructions of summer soil moisture to show that from 2000 to 2018 was the driest 19-year span in the southwestern United States and northern Mexico since the late 1500s and the second driest since 800 CE. Locally, the 5 to 6 more than bankfull stormflows and other lesser ones during the wet season, 2018-2019, provided ample adult steelhead access to upper sites in our sampled watersheds. However, spawning redds laid prior to bankfull events between January and 15 March may have been scoured or smothered by sediment during stormflows. Good spawning success and YOY survival were evident in fall sampling, with generally high densities of small YOY in the Size Class I category (<75 mm SL) except in relatively fast growth sites in the lower San Lorenzo mainstem, Soquel mainstem and the lagoons, where a significant portion of YOY grew into the larger Size Class II ( =>75 mm SL to <150 mm SL). When 2019 rearing habitat conditions were compared with 2018 and pre-2017 conditions (2015-2016), they had improved with increased baseflow (more food), increased depth (except in lower Zayante and Aptos creeks) and generally similar or increased escape cover. Percent fine sediment and embeddedness were generally similar to 2018 conditions or increased (primarily in fastwater habitat). Substantial overwinter sediment transport was evident from significant pool deepening in the San Lorenzo and especially Soquel watersheds but not Aptos. In Bear Creek, a significant sediment source in the past within the San Lorenzo watershed, the pool depths at sampling sites in 2019 were similar to those in 2018.

Total juvenile densities were above average at 7 of 10 mainstem sites in the San Lorenzo drainage (averaging 35 juveniles/100 ft), with the exception of 2 middle mainstem sites below average and the lowermost mainstem Site 0a near average (**Figure 8**). Total juvenile densities were above average at 11 of 16 tributary sites (averaging 68 juveniles/100 ft). YOY densities were above average at 8 of 10 mainstem sites (averaging 33 YOY/100 ft) and were above average at 14 of 16 tributary sites (averaging 63 YOY/100 ft), with YOY densities below average at Zayante 13d and upper Fall 15b and just a little above average densities at Bean 14b and Boulder 17a sites (**Figure 9**). 2019 YOY average density increased from 2018 (statistically significant) and at all 10 mainstem sites and at 13 of 15 tributary sites, excepting upper Zayante 13d and upper Bean 14c-2 sites (**Figure 10**). Three factors may explain the above average densities of primarily small YOY in Size Class I at the majority of sites in 2019 (lower mainstem sites with higher proportion of Size Class II YOY than tributary sites). The main factor may have been higher than usual adult returns. Supportively, adult returns to Scott Creek indicated a relatively large adult steelhead return there (**Figure 11**). Indications of higher adult returns may have resulted from more favorable ocean rearing conditions than other recent years, combined with good adult recruitment from high Size Class II/III juvenile densities produced during the high flow 2017 year and their returning after only one year ocean. A second factor may have been poor egg survival prior to the more than bankfull events occurring before 15 March and better egg survival after 15 March from nests spread out through a very accessible watershed for spawning adults. The third factor was the above average baseflow that provided more food and rearing habitat to increase YOY survival from late spawners, albeit a shorter growing season to reach Size Class II with increased intraspecific competition for food between abundant YOY.

Size Class II and III juvenile densities were above average at the lower 5 mainstem San Lorenzo sites and below average at the upper 5 mainstem sites (averaging 9.7 fish/100 ft) (**Figure 13**). They were below average at 14 of 16 tributary sites (averaging 7.5 fish/100 ft), consistent with smaller YOY than typically occur during a high baseflow year. Yearling densities were also below average at 12 of 16 tributary sites (**Figure 12**). The average 5-site mainstem trend in soon-to-smolt-densities increased for the mainstem San Lorenzo (**Figure 16**) (19-year average 7.3 fish/ 100 ft). The 10- mainstem site average increased from 5.2 in 2018 to 9.7 fish/ 100 ft in 2019. The average 7-site tributary trend in the San Lorenzo decreased in 2019 (**Figure 17**) (22-year average of 11.5 fish/ 100 ft for 7 sites). The 16-tributary site average decreased slightly from 8.1 in 2018 to 7.5 fish/ 100 ft in 2019. A positive correlation was evident in 2019 between average mainstem densities of these larger juveniles and the 5-month baseflow average. But average tributary densities declined in 2019 despite higher baseflow (**Figures 18 and 19**). In the past, when baseflow was relatively high in tributaries, more YOY typically reached

Size Class II than occurred in 2019. Atypically, Size Class II densities declined in lower and middle Zayante Creek and middle Bean Creek in 2019. Typically, in wetter years the average length of juveniles was greater than in drier years because higher baseflow in spring and summer provided more food for faster growth. Also, in wetter years after 1998, there were fewer juveniles that reduced food competition (2006, 2011 and 2017). But YOY were more abundant and smaller in 2019 (**Figure 20**).

In Soquel Creek, spawning and egg survival from a likely larger than usual adult steelhead population was better than usual after 15 March. With above median baseflow, total and YOY juvenile steelhead densities in Soquel Creek were above average at 5 of 8 sites in 2019 (averaging 55.8 total juveniles/100 ft and 53.5 YOY/100 ft) (**Figures 22 and 23**) but still much below average at Site 16 on the East Branch. Total and YOY density increased at all 8 sites from 2018 to 2019 (statistically significant), especially at upper mainstem Sites 10 and 12 and East Branch Site 13a (**Figure 24**). The 6-site trend in total site densities (consisting mostly of YOY) increased in 2019 and was the 4$^{th}$ highest average in 22 years. Size Class II and III densities were above average at 4 of 8 sites in 2019 (especially at fast growing mainstem Sites 1, 10 and 12) but were still much below average at sediment- laden mainstem Site 4 and East Branch 13a below Mill Pond (**Figure 25**). Though good YOY growth with some YOY reaching Size Class II occurred in the mainstem, fewer YOY reached Size Class II in the Branches than would be expected from a high baseflow year. This was due to higher YOY densities coming from late spawning success that increased intraspecific competition for food in a shortened growing season. In 2019, the 6-site long-term trend in Size Class II and III densities increased substantially from 2018 (**Figure 28**). This trend in 2019 positively correlated with average 5-month baseflow (**Figure 29**). The 8-site Size Class II/III density doubled from 4.8 fish/100 ft in 2018 to 10 fish/100 ft in 2019. The lagoon steelhead population estimate was 3,322 (YOY smaller sized than usual but most still in Size Class II) and 4$^{th}$ highest in 27 years.

Total and YOY steelhead densities were above average at all 4 Aptos watershed sites (averaging 46.2 total juveniles/100 ft and 40.7 YOY/100 ft) (**Figures 30 and 31**). Yearling and older densities and Size Class II/III densities were above average at Valencia 3 site and below average at the other 3 sites (averaging 7.1 Size Class II/III juveniles/100 ft) **(Figure 34**). Total and YOY densities increased in 2019 from 2018 at all sites (statistically significant) (**Figure 32**). Yearling and older densities and Size Class II/III densities increased at Valencia Creek sites and decreased at Aptos Creek sites in 2019 (**Figure 34**). The 4-site long-term trend in total density increased in 2019 (**Figure 35**). The density of Size Class II/III juveniles increased slightly in 2019 from an average site density of 6.5 fish/ 100 ft in 2018 to 7.1 fish/ 100 ft in 2019 (below multi-year average of 9.6) (**Figure 36**). The Aptos Estuary steelhead population estimate was 707, the highest so far (**Figure 37**). The size histogram indicated a bimodal size distribution of age classes (**Figure 38**). The much larger Aptos estuary steelhead population of mostly Size Class II and III juveniles in 2019 offered potential for overall population sustainability, though densities of these soon-to-smolt fish were still below average above the estuary.

# B. INTRODUCTION

***i. Scope of Work***

In fall 2019, 3 Santa Cruz County watersheds were sampled for juvenile steelhead to primarily compare juvenile abundance at multiple stratified sites in each watershed with past years to assess trends and compare habitat conditions in habitat typed segments and at sampling sites with those in 2018 and past years in selected reaches of the San Lorenzo, Soquel and Aptos watersheds (**Figures 1−3**). Results from steelhead and habitat monitoring guide watershed management and planning (including implementation of public works projects) and enhancement for species recovery. Refer to the Santa Cruz County Environmental Health website http://scceh.com/steelhead.aspx for the database. Hydrographs of all previous sampling years are also available at the website. Methods of data collection and tables of habitat conditions and steelhead density by size and age class since 1997 are available upon request, and past reports that include the methods are available at the county website. Sampling sites represented average habitat conditions regarding escape cover and water depth within reaches, based on systematic and consistent habitat typing of ½-mile segments within.

***ii. Study Area***

***San Lorenzo River.*** The mainstem San Lorenzo River and 8 tributaries were sampled at 26 sites (10 mainstem and 16 tributary sites) (**Figure 1**). Sampled tributaries included Branciforte, Zayante, Bean, Fall, Newell, Boulder and Bear creeks. Eight half-mile segments were habitat typed in the San Lorenzo system to assess habitat conditions and select habitats of average quality to sample for fish density. For the remaining 18 sites, the 2018 sites were replicated for fish sampling. Depth, cover, percent fines, embeddedness and percent tree canopy were measured at sampling sites.

***Soquel Creek.*** Soquel Creek and its branches were sampled at 8 sites (4 mainstem and 4 branch sites). Three half-mile segments were habitat typed to assess habitat conditions and select habitats of average quality to sample for fish density (**Figures 2**). For the remaining 5 sites, the 2018 sites were replicated for fish sampling. Depth, cover, percent fines, embeddedness and percent tree canopy were measured at sampling sites.

***Aptos Creek and Lagoon/Estuary.*** Aptos watershed was sampled for steelhead at two Aptos and two Valencia creek sites, as well as the lagoon/estuary (**Figure 3**). After habitat typing of the 2 Aptos segments, new sites were chosen with some overlap at Aptos Site 3. The 2 Valencia Creek sites were replicated at the 2018 locations for fish sampling. Depth, cover, percent fines, embeddedness and percent tree canopy were measured at all sampling sites. Water quality conditions were measured during estuary sampling. The juvenile steelhead population was estimated in the Aptos Lagoon/Estuary by mark and recapture on 2 days in October, using a beach seine with a central bag.

***Pajaro River Lagoon/ Estuary.*** The Pajaro River Estuary was sampled in late September/ early October for steelhead and tidewater goby. Water quality conditions were measured during sampling. Results are presented in a separate report to the county flood control district.

**Coast Range Sculpin (*Cottus aleuticus*) reared in the San Lorenzo River. (Photo by Jessica Wheeler)**

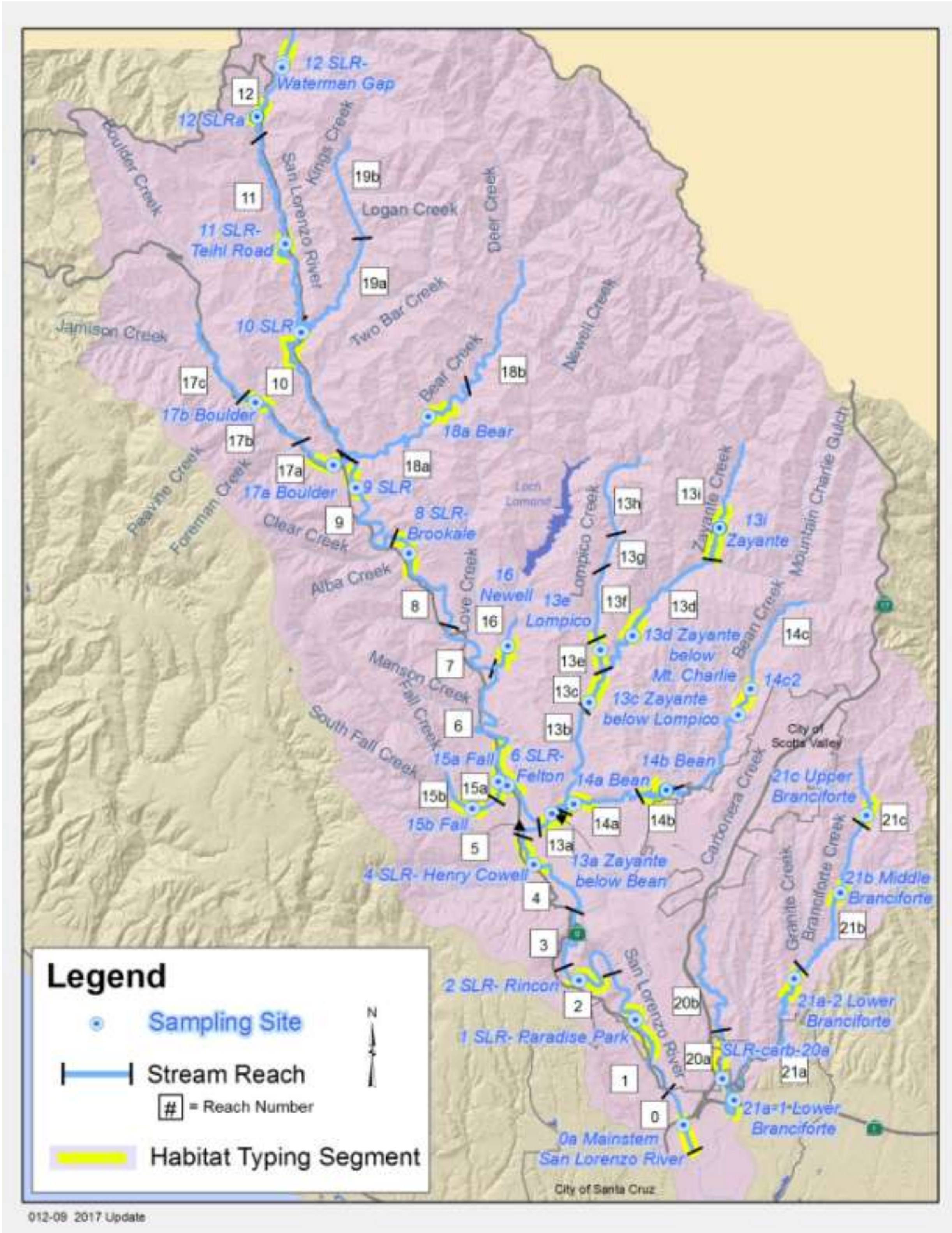



**Figure 1. San Lorenzo River Watershed− Sampling Sites and Reaches.**

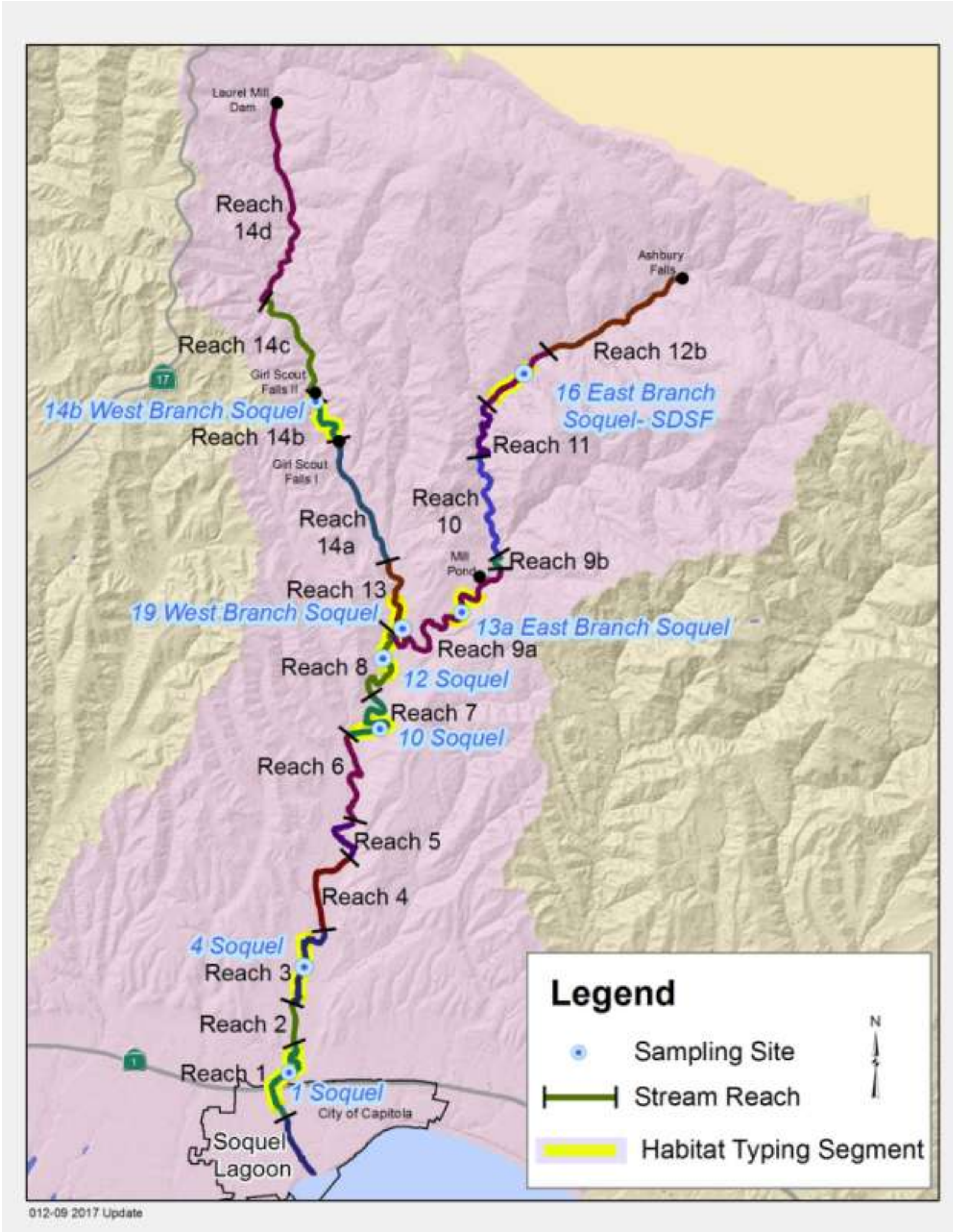



**Figure 2. Soquel Creek Watershed.**

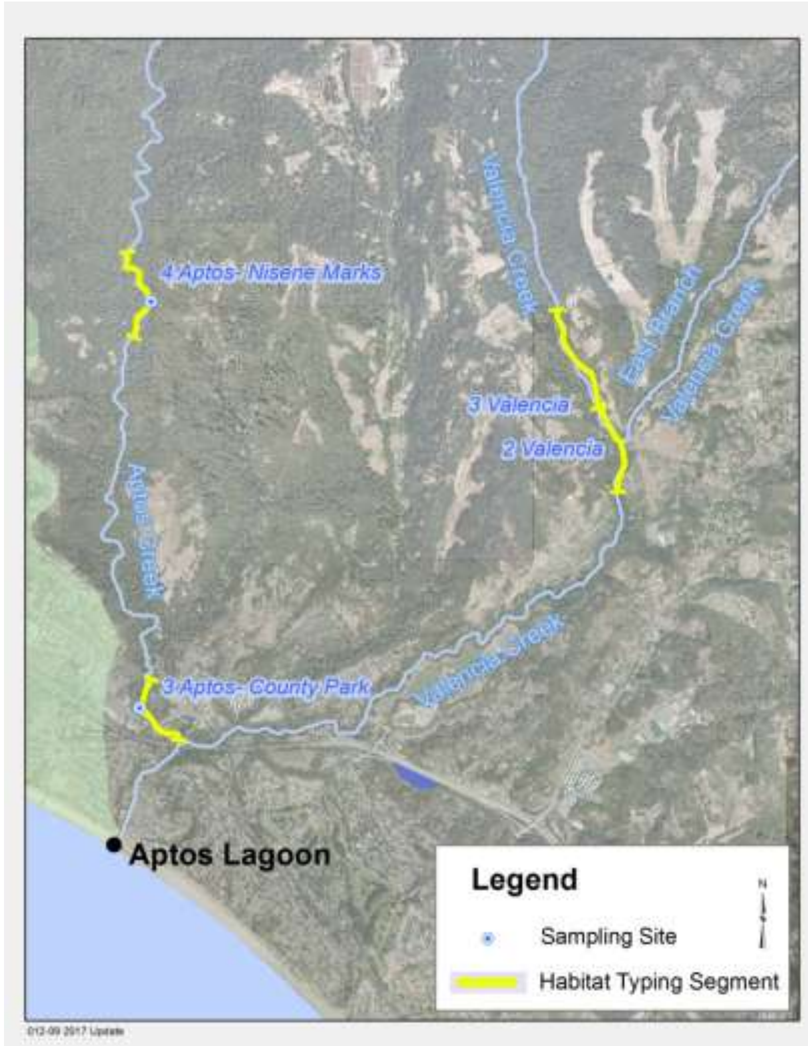



**Figure 3. Aptos Creek Watershed.**

# C. RESULTS

## *i. Steelhead Abundance and Habitat Conditions in the San Lorenzo River Watershed*

**1.** WY2019 streamflows in spring-summer-fall were above the median flow statistic, unlike the below median WY2018, making 8 of the last 13 water years below median flow (**Figure 4**). Good adult steelhead spawning access to the upper watershed was provided by 6 stormflows greater than bankfull (4,000+ cfs) from January to March 15, with 2 prior stormflows in November and December and one as late as May. However, some spawning redds laid prior to March 15 before the bankfull events may have been destroyed or smothered with sediment moved by those stormflows. YOY steelhead were relatively abundant at uppermost sites in the mainstem, Zayante, Bean, Bear, Boulder and Branciforte creeks. However, below average YOY densities were found at uppermost Fall 15b and Zayante 13d. Baseflow well above the 23-year average provided improved rearing conditions and potential for YOY steelhead growth rate in 2019 compared to the low baseflow 2018 (**Figure 5**). However, a high proportion of YOY reaching Size Class II occurred only at lower mainstem sites below Zayante Creek, though 2019 YOY densities were much increased at all but 2 sites compared to 2018, dominated by relatively small YOY (**Figure 10**). Bullfrog tadpoles were only at Boulder 17b in 2019, indicating poorer survival than the previous year.

2. ***In the mainstem in 2019***, rearing habitat conditions improved in reaches and sites when compared to 2018 conditions, with increased food (more surface area and water velocity associated with higher baseflow) and increased depth. But escape cover was similar to 2018 or less for mainstem 0a, mainstem 2a and mainstem 10 (**Tables 2 and 3**). More escape cover was available in most mainstem fastwater habitat downstream of Boulder Creek confluence. However, most of these mainstem sites/segments had increased percent fines in fastwater habitat. 2019 embeddedness in mainstem sites/segments below Boulder Creek was mostly similar to 2018 except increased in the mainstem 0a pool, mainstem Site 1 riffle and mainstem Site 6 run habitat. In Reach 2, the channel remained split into 3 channels as occurred in 2017 after the abrupt Rincon bend and above the Rincon riffle, likely continuing to make the Rincon riffle challenging to migrating adult steelhead. The middle of the ½-mile habitat typed segment still had one channel. But at the upper and lower end of the segment, the channel remained split into 3 instead of the previous 2 channels. In 2019 in the Rincon 2a segment, escape cover decreased in riffles (consistent with increased percent fines), and depth increased in fastwater habitat. Sand and gravel bars that had formed during the 2016-2017 winter at tails of pools in the mainstem were scoured away.

3. As in the mainstem, 2019 habitat conditions in ***upper mainstem and tributary sites/reaches*** in 2019 improved compared to 2018, with increased food and depth (**Tables 2 and 3**). But pool escape cover was similar to 2018 for Zayante 13i, Bean 14a, Fall 15a, Bear 18a and 18b and Branciforte 21a-2. Pool escape cover declined for mainstem Site 10, Zayante 13c and 13d, Bean 14b, Boulder 17a and Branciforte 21b (compared to 2016). Pool escape cover increased in mainstem 11 and 12b, lower Zayante 13a, upper Bean 14c-2, upper Fall 15b, upper Boulder 17b and Branciforte 21a-2. In the Zayante 13d segment in 2019, pool escape cover declined slightly, and water depth increased (**Figures 6 and 7**). Fine sediment in 2019 tributaries was similar to or higher than in 2018. Embeddedness in 2019 tributaries remained similar to 2018 or increased except for improvement in pools at mainstem Site 11, Zayante 13d and Bean 14c-2.

4. ***Total juvenile densities in mainstem sites*** were above average at 7 of 10 sites, averaging 35.1 juveniles/100 ft (***YOY densities*** were above average at 8 of 10 mainstem sites, averaging 33.3 YOY/100 ft) (**Figures 8 and 9**). YOY steelhead were abundant with good growth in lower mainstem but were near average or below in the middle mainstem. 2019 YOY densities increased from 2018 at all 10 mainstem sites (**Figure 10**). Higher YOY densities throughout the watershed were consistent with a possibly larger adult return over the winter/spring compared to recent years. This was supported by the large adult steelhead return estimate of 547 from Scott Creek (**J. Kiernan, pers. comm.**) (**Figure 15**). Smith (**2019**) found that 2019 average YOY densities were 1) similarly low to the 2018 average in Gazos Creek (27/100 ft), with likely adult spawning access problems from log jams; 2) were substantially greater than the 2018 average for Waddell Creek but low (21/100 ft); 3) were substantially greater than the 2018 average for Scott Creek and second highest in the last 15 years (54/100 ft).

5. ***Mainstem yearling densities*** were below average at 9 of 10 sites (2019 average= 1.9/100 ft) after low recruitment from below average YOY densities in 2018 and 6 bankfull events before 15 March in 2019 that may have encouraged out-migration of larger yearlings (**Figure 12**). Site 11 was slightly above average.

6. ***Mainstem densities of Size Class II/III soon-to-smolt juveniles*** were above average at the lower 5 sites but below average at the upper 5 mainstem sites, averaging 9.7 fish/100 ft (**Figure 13**). This was due to increased growth rate of YOY in the lower mainstem and more YOY at 8 of 10 mainstem sites in 2019 but dominated by small Size Class I YOY at mid-mainstem and upper mainstem sites. There were below average numbers of yearlings to contribute to these Size Class II and III juveniles in 2019. Four of the 10 mainstem sites were rated "poor" to "below average" with their low soon-smolt-densities and preponderance of small Size Class I fish (**Table 2**).

7. ***Total densities at tributary sites*** were above average at 12 of 16 sites, averaging 68.1 fish/100 ft (***YOY densities*** above average at 14 of 16 tributary sites, averaging 62.9 YOY/100 ft) (**Figures 8 and 9**). YOY

density was especially high at Zayante 13a and 13c and Bear 18b, though tributary sites were dominated by small YOY with few reaching Size Class II. The 2 sites with below average YOY densities were Zayante 13d and upper Fall 15b. 2019 YOY densities were up at 13 of 15 tributary sites compared to 2018, the exceptions being Zayante 13d and Branciforte 21a-2 (**Figure 10**).

8. ***Tributary yearling densities*** were below average at 12 of 16 tributary sites (2019 average= 5.6/100 ft and slightly less than 2018) after low recruitment from below average YOY densities in 2018 sites and 6 bankfull events before 15 March that may have encouraged out-migration of larger yearlings (**Figure 8**). The tributary sites with above average yearling density were upper Bean 14c-2, Fall 15a and 15b, and upper Boulder 17b. Smith (**2019**) found 2019 yearling densities to be higher than most years in Gazos Creek (8/100 ft) but less than in 2018; to be similar to 2017 and 2018 in Scott Creek (7/100 ft). Yearlings are the primary source of Size Class II/III steelhead in these smaller, shaded streams.

9. ***Densities of Size Class II/III soon-to-smolt juveniles at tributary sites*** were below average at 14 of 16 tributary sites, averaging 7.5 fish/100 ft (**Figure 13**), with likely worse than average overwinter survival of yearlings and encouragement for larger yearlings to smolt during a wet winter. Six of 16 tributary sites were rated "poor" to "below average" in soon-to-smolt densities (**Table 2**).

10. Three factors may explain the above average densities of primarily small YOY in Size Class I at the majority of sites (noting lower mainstem sites with higher proportion of Size Class II YOY than other sites). The main factor in 2019 may have been higher than usual adult returns. Adult returns to Scott Creek indicated a relatively large adult steelhead return there (**Figure 11**). A second factor may have been poor egg survival in redds laid prior to the 6 bankfull events occurring prior to 15 March and eggs spawned in redds after 15 March surviving better. The third factor was the above average baseflow that provided more food and rearing habitat to increase YOY survival from the late spawners, albeit a shorter growing season to reach Size Class II and increased intraspecific competition for food between abundant YOY before baseflows naturally declined in summer to slow growth everywhere but in the lower mainstem, downstream of Zayante Creek confluence and the lagoon.

11. The 5-site, long term ***trend in average mainstem site total density*** (consisting of mostly YOY) increased in 2019 (**Figure 14**). The 10-site mainstem average total density more than doubled from 16 in 2018 to 35 juveniles/100 ft in 2019. The 10-site mainstem average YOY density nearly tripled from 12 in 2018 to 33 juveniles/100 ft in 2019. The 8-site, long term ***trend in average total density at tributary sites*** (consisting of mostly YOY) also increased in 2019 (**Figure 15**). The 16-site tributary average total density increased from 38 in 2018 to 68 juveniles/100 ft in 2019. The 16-site tributary average YOY density more than doubled from 28 in 2018 to 63 YOY/100 ft in 2019.

12. Causes for 19 of 26 sites to have below average Size Class II and III densities, despite the high baseflow, include that most egg survival likely occurred late in the spawning season with higher numbers of adults than usual spawning late, with high spawning success and good YOY survival late in the spawning season. This resulted in high densities of small YOY to compete heavily for food, coupled with a shortened growing season at most upper mainstem and tributary sites. This prevented most YOY from reaching Size Class II. Sites that typically produce a higher proportion of Size Class II YOY in wet years with typically lower YOY densities did not produce a higher proportion in 2019. Those sites included mainstem Sites 8 and 9, Zayante 13a and 13c, Bean 14b and Newell 16. Also, there were below average densities of yearlings at 21 of 26 sites to contribute to Size Class II and III densities. Larger yearlings were encouraged to smolt early with the multiple bankfull events during the wet winter and spring.

13. Regarding the ***trend in Size Class II/III soon-to-smolt densities***, the 5-site, long-term mainstem San Lorenzo average increased in 2019 (**Figure 16**). The 10-mainstem site average nearly doubled from 5.2 in 2018 to 9.7 juveniles/100 ft in 2019. The 8-site, long term San Lorenzo tributary average decreased in 2019

(**Figure 17**). The 16-tributary site average decreased slightly from 8.1 in 2018 to 7.5 juveniles/100 ft in 2019. A positive correlation was evident between average site densities of these larger juveniles at mainstem sites and the 5-month baseflow average but not for tributary sites in 2019 (**Figure 18**). A similar positive correlation was evident at 2 middle mainstem sites 6 and 8, though densities were much reduced from those in 1997 and 1998 (**Figure 19**). In the past in tributaries, when baseflow was relatively high in the April to June growth period, more YOY typically reached Size Class II than occurred in 2019. This was atypically not evident at lower and middle Zayante Creek sites and the middle Bean Creek site in 2019. Typically in wetter years that were calculated after 1998, the average length of juveniles was greater than in drier years because more baseflow provided more food for faster growth in wetter years, and in wetter years there tends to be fewer juveniles, which reduces competition for food (2006, 2011 and 2017) (**Figures 14 and 15**). But this was not the case in 2019 (**Figure 20**). YOY densities increased in 2019, providing the potential for good recruitment into the yearling age class and Size Class II/III in 2020.

**14.** The increases in total and YOY densities from 2018 to 2019 in the San Lorenzo system were statistically significant at the p=0.01 level, using the paired t-test for replicated sites (**Table 8** (section iv at the end of the report). The increase in Size Class II and III densities was statistically significant at the p=0.0507 level.

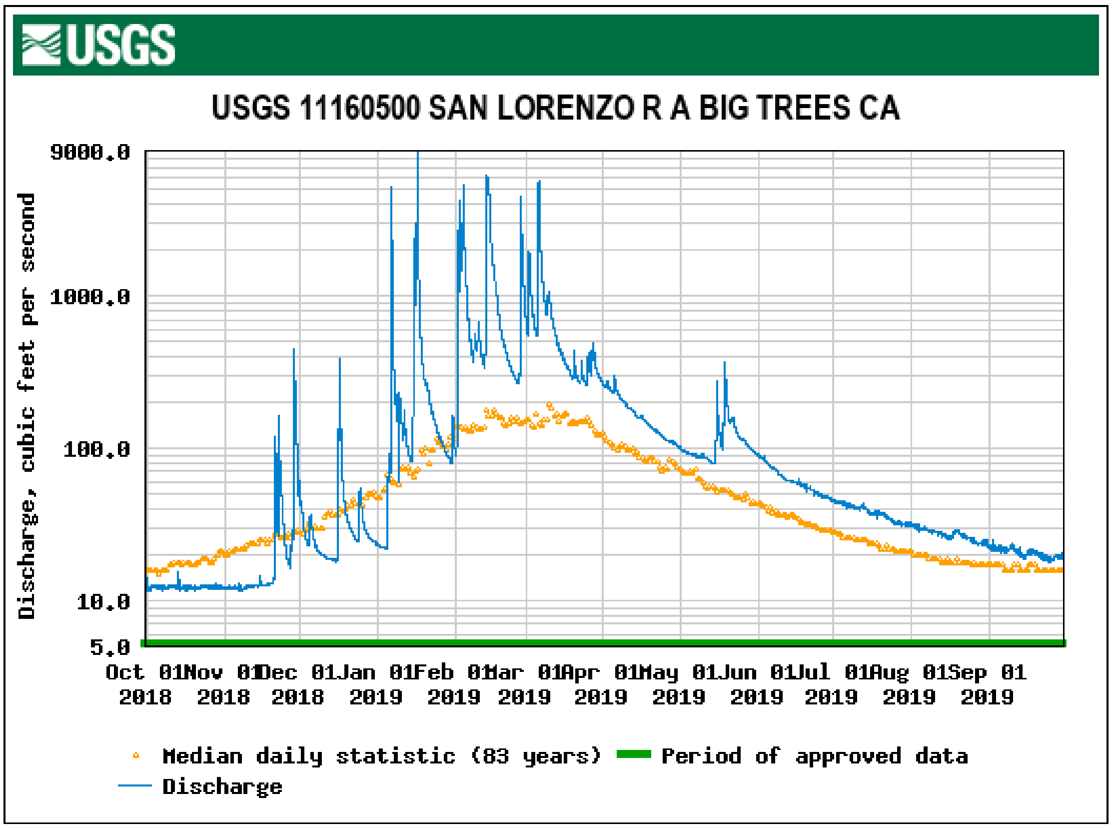



**Figure 4. The 2019 Discharge Flow of Record for the USGS Gage on the San Lorenzo River at Big Trees.**

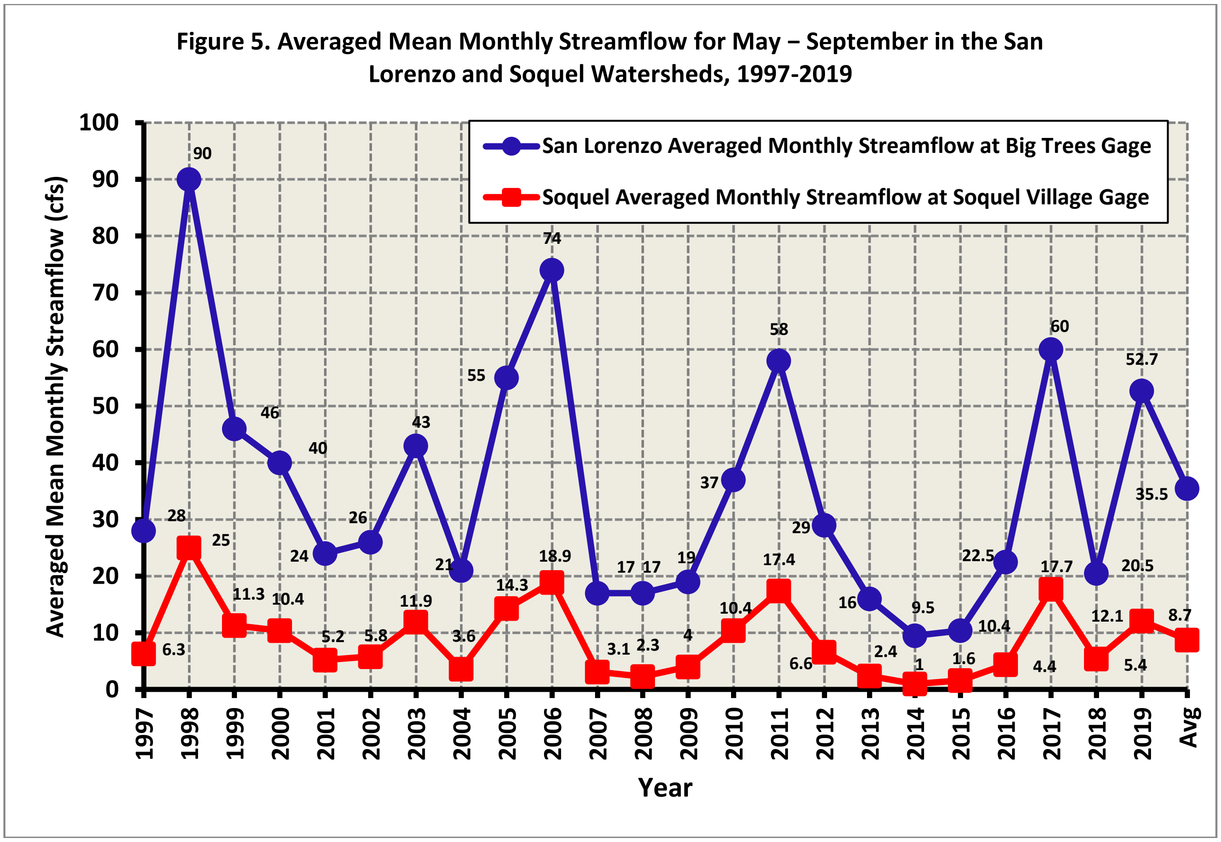



**Figure 5. Averaged Mean Monthly Streamflow for May−September in San Lorenzo and Soquel Watersheds, 1997-2019.**

**Juvenile Sacramento Sucker (*Catostomus occidentalis*) , Soquel Creek. September 2008. (Photo by Chad Steiner)**

**Table 1. Fall STREAMFLOW (cubic feet/ sec) measured by D.W. ALLEY & Associates at SAN LORENZO sampling sites before fall storms (or in 2011 when summer baseflow had resumed after early storm).**

| Site # / Location | 1995 | 1996 | 1998 | 1999 | 2000 | 2001 | 2003 | 2004 | 2005 | 2006 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1- SLR/ Paradise Pk | 22.9 | 25.5 | 34.3 | 26.2 | 21.7 | 19.6 | | | | 26.2 | 18.7 | 27.6 | 17.2 | 12.9 | 8.0 | 7.81 | | 22.6 | 13.5 | 22.8 |
| 2- SLR/ Rincon | | | | 24.0 | 21.1 | 17.2 | | | | | | | | | | | | | | |
| 3-SLR Gorge | 23.3 | 20.5 | | | | | | | | | | | | | | | | | | |
| 4-SLR/ Henry Cowell | 18.7 | | 32.7 | 23.3 | 21.8 | 15.5 | | | | 24.1 | | | | | | | | | | |
| 5- SLR/ Below Zay. | | | 31.9 | | | | | | | | | | | | | | | | | |
| 6- SLR/ Below Fall | 14.6 | | 23.4 | 12.8 | 11.6 | 9.4 | 10.6 | 8.8 | 18.9 | 14.3 | | | | | 3.7 | 3.25 | 6.99 | 12.9 | 6.68 | |
| 7- SLR/ Ben Lomond | 5.8 | | | | 5.4 | 3.7 | 5.4 | 3.7 | 8.1 | | | | | | | | | | | |
| 8- SLR/ Below Clear | 4.2 | | 10.3 | 4.9 | 4.2 | 3.1 | 4.2 | 2.7 | 7.1 | 6.4 | 4.0 | | 2.8 | 1.7 | 0.95 | 1.11 | 2.35 | 4.71 | 2.61 | 4.53 |
| 9- SLR/ Below Bould. | 4.6 | | 7.2 | 3.5 | | 3.0 | 3.7 | 2.1 | 5.8 | | | | | | 0.80 | 0.88 | 1.82 | 4.02 | 1.43 | 4.36 |
| 10- SLR/ Below Kings | | | | 3.0 | 1.1 | 1.3 | 0.6 | 0.52 | 1.4 | | | | | | | | | | | |
| 11- SLR/ Teihl Rd | | | 1.7 | 0.8 | 0.8 | 0.4 | 0.9 | 0.63 | 1.5 | | 0.94 | 1.10 | 0.40 | 0.38 | 0.13 | 0.21 | | 1.07 | 0.35 | 0.87 |
| 12a-b SLR/ Lower Waterman | | | 1.0 | 0.7 | | | | | | | | | | 0.33 | 0.10 | 0.22 | | 0.85 | 0.39 | 0.78 |
| 13a/ Zayante below Bean | | | 8.5 | 6.3 | 5.2 | 4.7 | 5.4 | 5.1 | 7.4 | 7.8* | 4.9 | 7.2 | 4.4 | 3.9 | 3.2 | 2.9 | | 8.27 | 4.04 | 5.96 |
| 13b/ Zayante above Bean | | | 3.9 | 2.9 | 2.8 | 1.9 | 2.1 | 1.7 | 3.2 | 2.8 | | | | | | | | | | |
| 14b/Bean bel Lockhart G | 1.5 | | 1.1 | 1.1 | 1.0 | 1.1 | 1.1 | 0.77 | 1.0 | 1.1 | | | | | | 0.62 | | | | |
| 14c/Bean abv MacKenzie | | | | | | | | | | | 0.03 | 0.11 | Dry | Dry | Dry | Dry | Dry | 0.07 | Dry | Wet |
| 14c-2/Bean abv MacKenzie | | | | | | | | | | | | | | | | | | | 0.02 | 0.06 |
| 15a–b/ Fall | 2.0 Above Div | | 3.4 Above Div. | 2.2 Above Div | 1.7 Above Div | 1.7 Above Div | | | | | | | | | 1.0 below div. Bal | 0.32 Bel div Bal | 1.39 Below div. | 2.80 Bel div. | 1.00 Bel div. | |
| 16/ Newell | 1.6 | | | | 0.51 | | | | | | 1.2 | 0.92 | 0.78 | 0.78 | 0.08 | 0.04 | | 1.05 | 0.87 | |
| 17a/ Boulder | 2.0 | | 2.2 | | 1.1 | 1.0 | 1.25 | 0.9 | 1.6 | 1.7 | 1.6 | 2.2 | 1.1 | 1.1 | 0.76 Bal | 0.66 Bal | 1.39 Bal | 1.76 | 0.94 | 1.45 |
| 18a/ Bear abv Hopkins G | | | | 0.45 | 0.61 | 0.34 | 0.6 | 0.51 | 0.90 | 1.1 | 0.68 | 1.3 | 0.23 | 0.16 | 0.03 | 0.02 | | 0.90 | 0.21 | 0.70 |
| 19a/ Lower Kings | | | 1.1 | 0.11 | 0.17 | 0.02 | | | | | | | | | | | | | | |
| 20a/ Lower Carbonera | 0.33 | 0.36 | | | | | | | | | | | | | | | | | | |
| 21a-2/ Branciforte | | | 0.80 | | | | | | | | 0.44 | 0.81 | 0.32 | 0.29 | | 0.13 | | | 0.37 | 0.38 |

***Streamflow in lower Zayante Creek done 3 weeks earlier in 2006 than usual and before other locations.**

**Table 2. 2019 Sampling Sites Rated by Potential Smolt-Sized Juvenile Density (=>75 mm SL) and Average Smolt Size, with Physical Habitat Change Since Previous Reach or Site Measurements.** (Red denotes ratings of 1−3 below average or negative habitat change; purple denotes ratings of 5−7. Methods for assessing ratings and habitat change are in previous years' reports and available upon request. Average size affects rating.)

| Site | Multi-Year Avg. Potential Smolt Density Per 100 ft/ Avg Pot. Smolt Size Since 2006 | 2019 Potential Smolt Density (per 100 ft)/ Avg Pot. Smolt Size SL | 2019 Symbolic Rating (1 to 7) | 2018 Potential Smolt Density (per 100 ft)/ Avg Pot. Smolt Size SL | Physical Habitat Change by Reach/Site (Since Previous Measure) |
|---|---|---|---|---|---|
| Low. San Lorenzo #0a | 8.3/ 121 mm | 8.4/ 124 mm | @@@@@ Good | 6.7/ 152 mm | Site + (Since 2018) |
| Low. San Lorenzo #1 | 7.8/ 111 mm | 15.5/ 95 mm | @@@@ Fair | 6.1/ 104 mm | Site + (Since 2018) |
| Low. San Lorenzo #2 | 13.7/ 101 | 24.6/ 92 mm | @@@@@ Good | 4.4/ 104 mm | Reach + (Since 2018) |
| Low. San Lorenzo #4 | 12.7/ 89 mm | 16.2/ 88 mm | @@@ Below Average | 6.4/ 85 mm | Site + (Since 2018) |
| Mid. San Lorenzo #6 | 3.7/ 88 mm | 6.4/ 129 mm | @@@@ Fair | 0.3/ 92 mm | Site + (Since 2018) |
| Mid. San Lorenzo #8 | 5.1/ 90 mm | 4.4/ 86 mm | @@ Poor | 1.6/ 102 mm | Reach + (Since 2018) |
| Mid. San Lorenzo #9 | 5.7/ 90 mm | 3.7/ 93 mm | @@ Poor | 0.9/ 95 mm | Site + (Since 2018) |
| Up. San Lorenzo #10 | 5.3/ 99 mm | 3.7/ 102 mm | @@@ Below Average | 2.2/ 117 mm | Site + (Since 2018) |
| Up. San Lorenzo #11 | 6.1/ 103 mm | 5.7/ 103 mm | @@@@ Fair | 5.4/ 105 mm | Site + (Since 2018) |
| Up. San Loren #12b | 13.8/ 100 | 8.7/ 105 mm | @@@@@ Good | 17.5/ 87 mm | Site + (Since 2018) |
| Zayante #13a | 8.7/ 98 mm | 6.9/ 107 mm | @@@@ Fair | 0.9/ 118 mm | Site + (Since 2018) |
| Zayante #13c | 15.5/ 92 mm | 6.0/ 99 mm | @@@ Below Average | 8.2/ 98 mm | Site + (Since 2018) |
| Zayante #13d | 16.2/ 101 mm | 9.6/ 101 mm | @@@@ Fair | 22.1/ 99 mm | Reach + (Since 2018) |
| Zayante #13i | 8.9/ 105 mm | 6.1/ 116 mm | @@@@ Fair | 10.4/ 98 mm | Reach + (Since 2018) |
| Bean #14a | 4.5/ 90 mm | 3.6/ 97 mm | @@ Poor | 1.5/ 90 mm | Site + (Since 2018) |
| Bean #14b | 11.3/ 103 mm | 6.6/ 102 mm | @@@@ Fair | 10.5/ 94 mm | Reach + (Since 2018) |
| Bean #14c-2 | 9.2/ 105 mm (14c-1 & 14c-2) | 10.9/ 107 mm | @@@@@ Good | 13.5/ 96 mm | Site + (Since 2018) |
| Fall #15a | 7.4/ 102 mm | 12.6/ 106 mm | @@@@@ Good | 7.1/ 98 mm | Reach + (Since 2018) |
| Fall #15b | 11.8/ 106 mm | 11.3/ 111 mm | @@@@@ Good | 10.1/ 98 mm | Site + (Since 2018) |
| Newell #16 | 12.2/ 94 mm | 11.7/ 94 mm | @@@@ Fair | 5.5/ 106 mm | Site + (Since 2018) |
| Boulder #17a | 10.4/ 107 mm | 5.3/ 95 mm | @@@ Below Average | 7.0/ 112 mm | Reach + (Since 2018) |
| Boulder #17b | 10.3/ 97 mm | 9.0/ 90 mm | @@@@ Fair | 11.8/ 100 mm | Site + (Since 2018) |
| Bear #18a | 8.3/ 102 mm | 3.1/ 105 mm | @@@ Below Average | 2.2/ 114 mm | Reach + (Since 2016) |
| Bear #18b | 12.0/ 103 mm | 7.2/ 100 mm | @@@ Below Average | 3.7/ 113 mm | Site + (Since 2018) |
| Branciforte #21a-2 | 8.7/ 103 mm | 4.7/ 96 mm | @@@ Below Average | 6.7/ 101 mm | Site + (Since 2018) |

| Site | Multi-Year Avg. Potential Smolt Density Per 100 ft/ Avg Pot. Smolt Size Since 2006 | 2019 Potential Smolt Density (per 100 ft)/ Avg Pot. Smolt Size SL | 2019 Symbolic Rating (1 to 7) | 2018 Potential Smolt Density (per 100 ft)/ Avg Pot. Smolt Size SL | Physical Habitat Change by Reach/Site (Since Previous Measure) |
|---|---|---|---|---|---|
| **Branciforte 21b** | **11.8/ 101 mm** | **4.7/ 108 mm** | **@@@@ Fair** | **Not Sampled** | **Reach + (Since 2016)** |
| **Soquel #1** | **3.8/ 105 mm** | **10.2/ 95 mm** | **@@@@ Fair** | **2.3/ 105 mm** | **Reach + (Since 2016)** |
| **Soquel #4** | **7.3/ 104 mm** | **3.9/ 90 mm** | **@@ Poor** | **0.7/ 124 mm** | **Site + (Since 2018)** |
| **Soquel #10** | **9.7/ 93 mm** | **18.6/ 86 mm** | **@@@@ Fair** | **11.4/ 91 mm** | **Reach + (Since 2015)** |
| **Soquel #12** | **8.4/ 96 mm** | **19.1/ 87 mm** | **@@@@ Fair** | **7.1/ 85 mm** | **Site + (Since 2018)** |
| **East Branch Soquel #13a** | **9.5/ 100 mm** | **4.7/ 96 mm** | **@@@ Below Average** | **2.3/ 105 mm** | **Reach + (Since 2016)** |
| **East Branch Soquel #16** | **9.7/ 98 mm** | **8.6/ 88 mm** | **@@@ Below Average** | **3.9/ 111 mm** | **Site + (Since 2018)** |
| **West Branch Soquel #19** | **6.0/ 95 mm** | **4.0/ 88 mm** | **@@ Poor** | **2.9/ 97 mm** | **Site + (Since 2018)** |
| **West Branch Soquel #21** | **10.0/ 97 mm** | **7.8/ 119 mm** | **@@@@ Fair** | **11.2/ 88 mm** | **Site + (Since 2018)** |
| **Aptos #3** | **8.6/ 107 mm** | **8.6/ 110 mm** | **@@@@@ Good** | **7.5/ 103 mm** | **Reach + (Since 2018)** |
| **Aptos #4** | **9.2/ 103 mm** | **4.0/ 91 mm** | **@@@ Below Average** | **6.4/ 115 mm** | **Reach + (Since 2018)** |
| **Valencia #2** | **8.2/ 96 mm** | **5.0/ 91 mm** | **@@@ Below Average** | **4.2/ 116 mm** | **Site – (Since 2018)** |
| **Valencia #3** | **11.2/ 102 mm** | **12.2/ 111 mm** | **@@@@@ Good** | **6.8/ 106 mm** | **Site + (Since 2018)** |

**Speckled Dace reared in San Lorenzo River. 26 September 2019. (Photo by Tyler Suttle)**

**Table 3. Habitat Change in the SAN LORENZO MAINSTEM AND TRIBUTARIES from most recent years' reach averages compared to 2019, or site comparisons when reach averages were unavailable.**

| Reach or (Site Only) Comparison To Previous Years | 2019 Baseflow Comparison (Most Important Factor May-September) | Pool Depth / Fastwater Habitat Depth in Mainstem below Boulder Creek | Fine Sediment Pool/ Fastwater | Embed-dedness Pool/ Fastwater | Pool Escape Cover/ Fastwater Habitat Cover | Overall Habitat Change |
|---|---|---|---|---|---|---|
| (Mainstem Site 0a) (Since 2018) | + | + /+ | − / Same | − / Sim | − (slightly) / − | + (more food, depth in fastwater) |
| (Mainstem Site 1) (Since 2018) | + | / + | / − | / Sim run − riffle | / + | + (more food, depth & cover in fastwater) |
| Mainstem Reach 2 (Since 2018) | + | + / + | − / − | + / Sim | / − | + (more food and depth in fastwater) |
| (Mainstem Site 4) (Since 2018) | + | / + | / − riffle Same run | / + riffle Same run | / + | + (more food, depth and cover in fastwater) |
| (Mainstem Site 6) (Since 2018) | + | / − runs + riffle | / − | / − run Same riff | / + | + (in fastwater - more food, depth and cover) |
| Mainstem Reach 8 (Since 2018) | + | + / + | − / Sim | Sim / Sim | − / + | + (more food, depth and cover in fastwater) |
| (Mainstem Site 9) (Since 2018) | + | / + | / − | / Sim | / + | + (more food, depth and cover in fastwater) |
| (Mainstem Site 10) (Since 2018) | + | + / + | − / − riffle Sim run | + / + | − / Sim | + (more food and depth but less pool cover) |
| (Mainstem Site 11) (Since 2018) | + | + /+ | + / + | − / + run | + / − | + (more food, depth and cover in pools) |
| (Mainstem Site 12b) (Since 2018) | + | + / + | Same / − run Same riff | Sim /−run Sim riff | + / Sim | + (more food, depth and cover in pools) |
| (Zayante Site 13a) (Since 2018) | + | − / − | − / − | + / + | + / | + (more food and cover in pools, more fines and shallower) |
| (Zayante Site 13c) (Since 2018) | + | + / + | Sim / Sim | Same / NA | − / | + (more food, and depth but less cover in pools) |
| Zayante Reach 13d (Since 2018) | + | + / + | − / Sim | + / Sim riff + run | − / + | + (more food, and depth overall but less cover) |

| Reach or (Site Only) Comparison To Previous Years | 2019 Baseflow Comparison (Most Important Factor May-September) | Pool Depth / Fastwater Habitat Depth in Mainstem below Boulder Creek | Fine Sediment Pool/ Fastwater | Embed-dedness Pool/ Fastwater | Pool Escape Cover/ Fastwater Habitat Cover in Mainstem below Boulder Creek | Overall Habitat Change |
|---|---|---|---|---|---|---|
| **Zayante Reach 13i (Since 2018)** | **+** | **+ / +** | **Sim / Sim** | **Sim / Sim** | **Sim / −** | **+ (more food and depth in pools and fastwater)** |
| **(Bean Site 14a) (Since 2018)** | **+** | **+ / +** | **Sim / Sim riff − run** | **− / Sim** | **Sim /** | **+ (more food, and depth with similar cover)** |
| **Bean Reach 14b (Since 2018)** | **+** | **Sim / Same riff + runs** | **− / + runs Sim riffles** | **Sim / Sim riff − run** | **− / +** | **+ (more food and deeper runs but less cover in pools)** |
| **(Bean Site 14c-2) (Since 2018)** | **+** | **+ / + riffles − runs** | **Sim / Same** | **+ / − riff Sim run** | **+ /** | **+ (more depth and cover in pools)** |
| **Fall Reach 15a (Since 2018)** | **+** | **+ / +** | **− / + runs Sim riff** | **Sim / Sim riff − run** | **Sim / Sim** | **+ (more food and depth with similar cover)** |
| **(Fall Site 15b) (Since 2018)** | **+** | **+ / + riffle − run** | **Sim / − runs Sim riff** | **− / + riff** | **+ /** | **+ (more food, depth & cover)** |
| **(Newell Site 16) ((Since 2018)** | **+** | **+ / +** | **Similar / −** | **Same / − riff Sim run** | **+ /** | **+ (more food and depth & more cover in pools)** |
| **Boulder Reach 17a (Since 2018)** | **+** | **+ / +** | **− / −** | **Sim / Sim** | **− / −** | **+ (more food and depth but less cover and more fine sediment)** |
| **(Boulder Site 17b) (Since 2018)** | **+** | **Sim / Sim riff + runs** | **Sim / Sim** | **Sim / Sim** | **+ /** | **+ (more food and cover)** |
| **(Bear Site 18a) (Since 2018)** | **+** | **Sim/ +** | **Sim / −** | **− / −** | **Sim /** | **+ (more food; more depth in fastwater)** |
| **(Bear Site 18b) (Since 2018)** | **+** | **+ / +** | **+ / − riff Sim run** | **Sim / +** | **Sim /** | **+ (more food and depth, similar pool cover)** |
| **(Branciforte Site 21a-2) (Since 2018)** | **+** | **− max depth Same mean depth / Sim** | **Sim / Same** | **− / Same** | **+ /** | **+ (more food and cover in pools)** |
| **Branciforte Reach 21b (Since 2016)** | **+** | **+ / +** | **Sim / Sim** | **Same / − riff Sim run** | **− / −** | **+ (more food and depth, less cover)** |

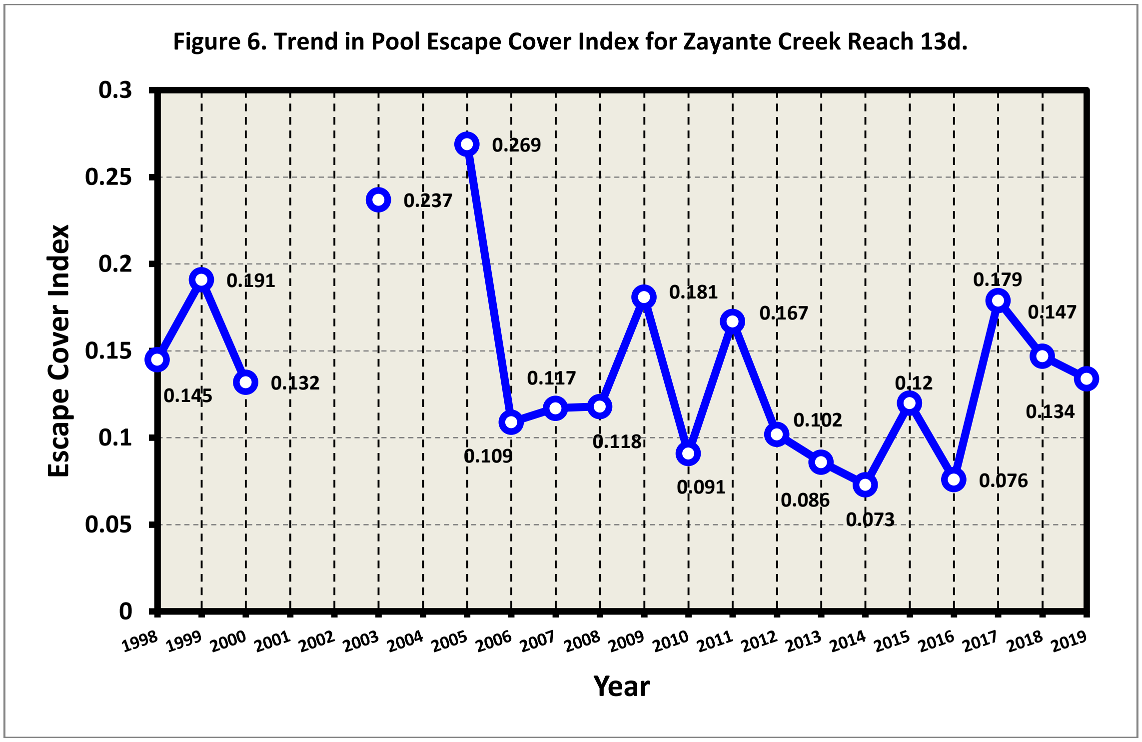



**Figure 6. Trend in Pool Escape Cover Index for Zayante Creek, Reach Segment 13d.**

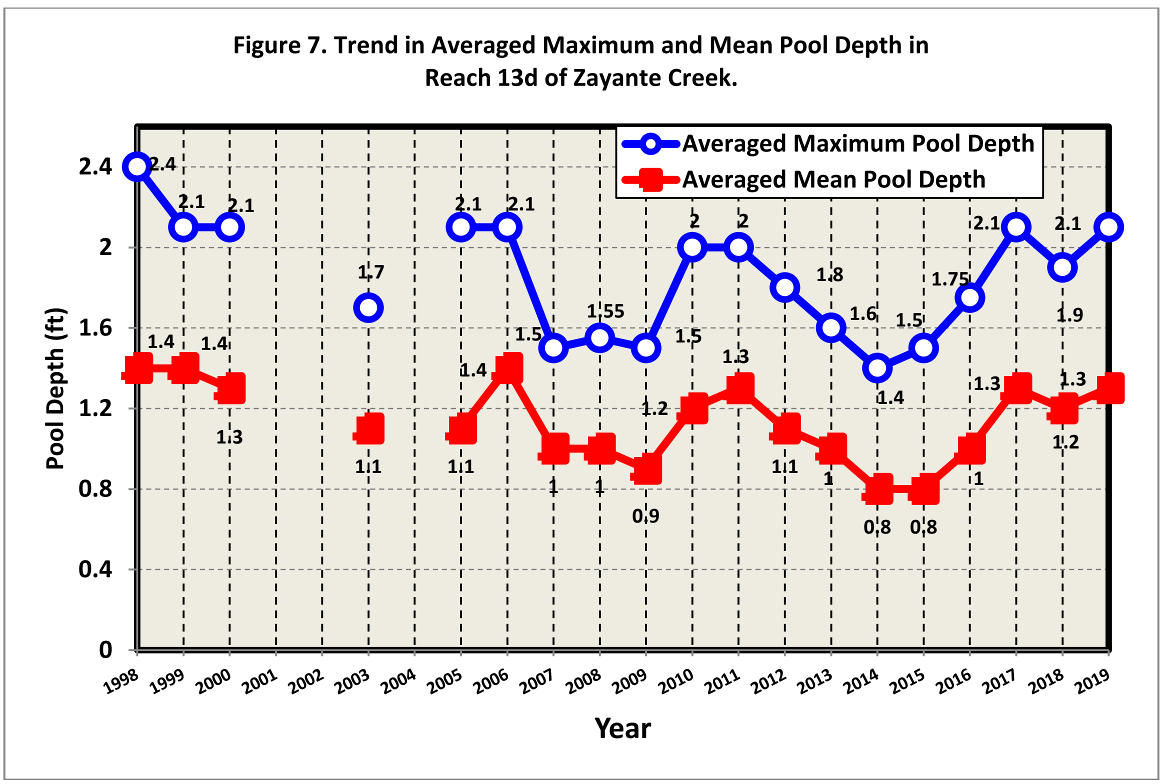



**Figure 7. Trend in Averaged Maximum and Mean Pool Depth in Reach Segment 13d of Zayante Creek.**

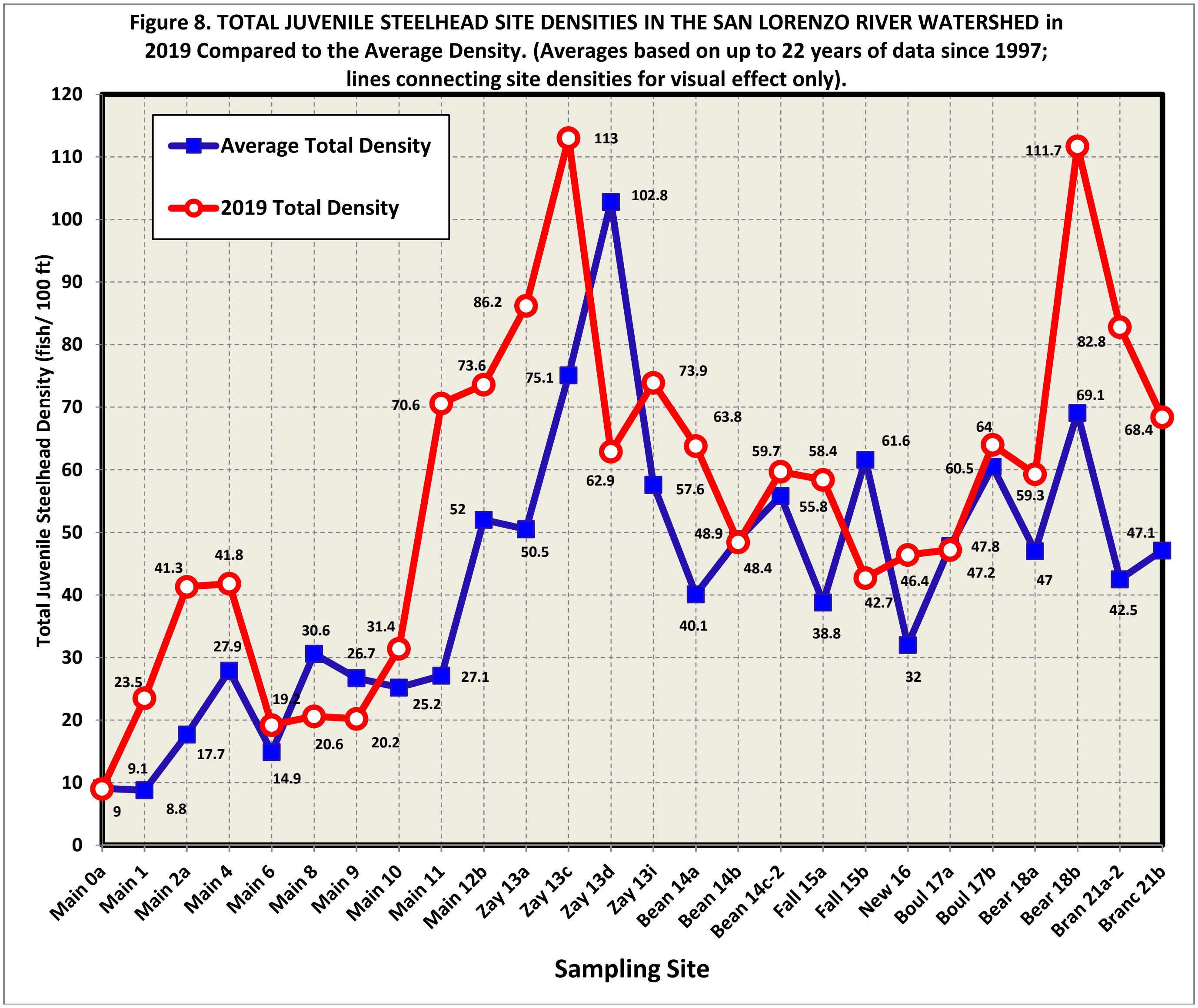



**Figure 8. Total Juvenile Steelhead Site Densities in the San Lorenzo River in 2019 Compared to Average Density. (Averages based on up to 22 years of data.)**

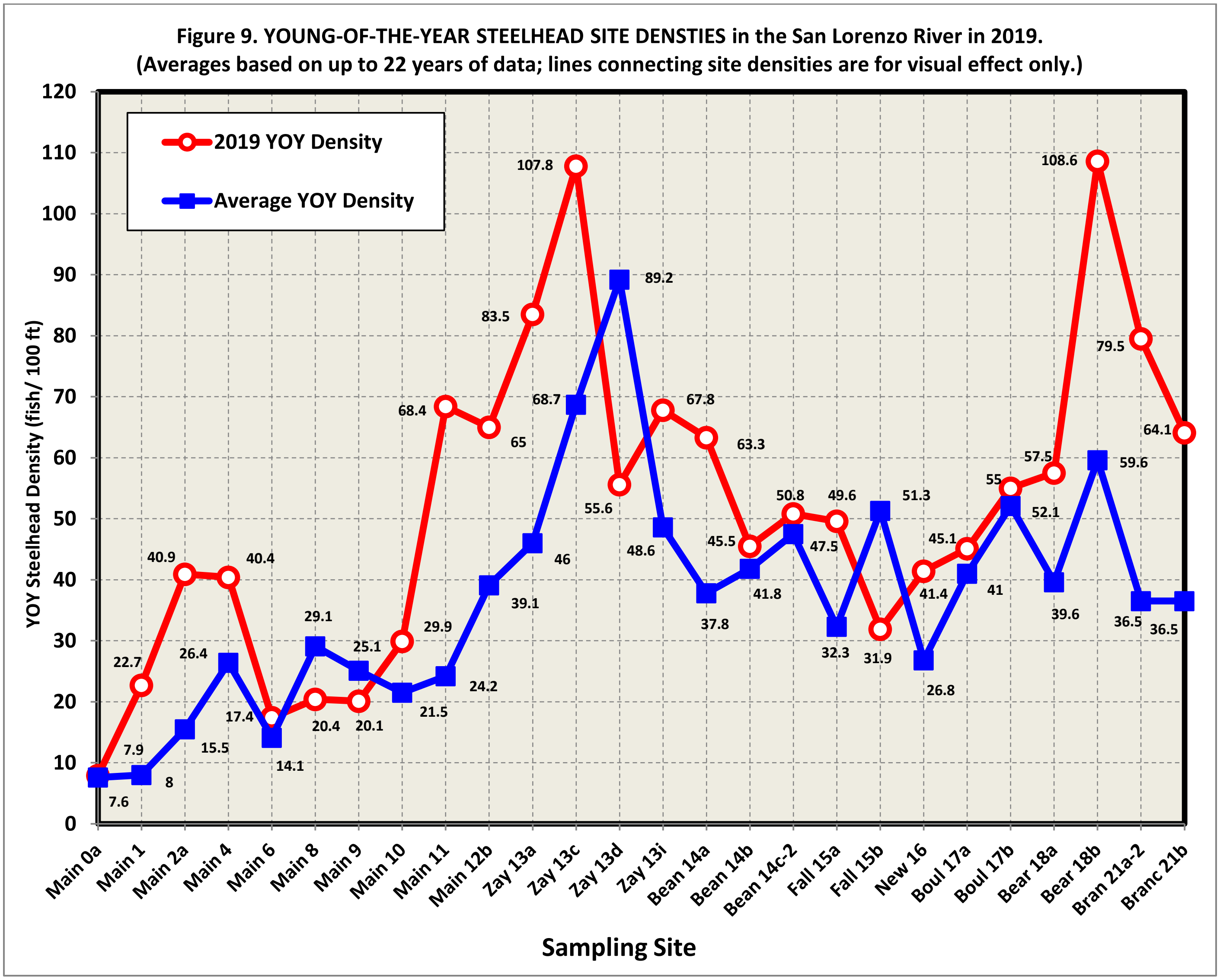



**Figure 9. Young-of-the-Year Steelhead Site Densities in the San Lorenzo River in 2019 Compared to Average Density. (Averages based on up to 22 years of data.)**

**Figure 10. Young-of-the-Year Steelhead Site Densities in the San Lorenzo River in 2019 Compared to 2018. (Lines connecting site densities are for visual effect only.)**

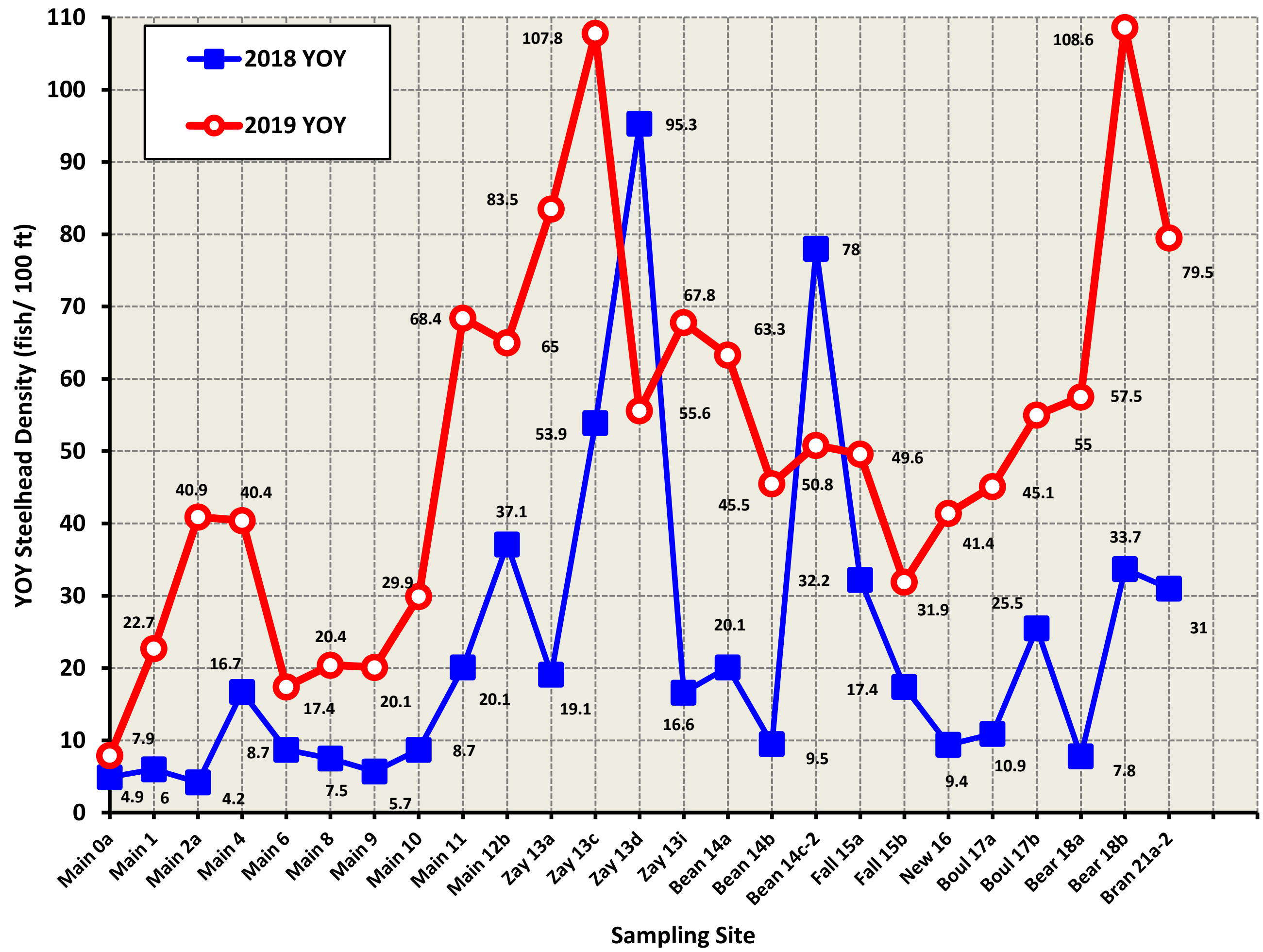



**Figure 10. Young-of-the-Year Site Densities in the San Lorenzo Watershed Comparing 2019 to 2018.**

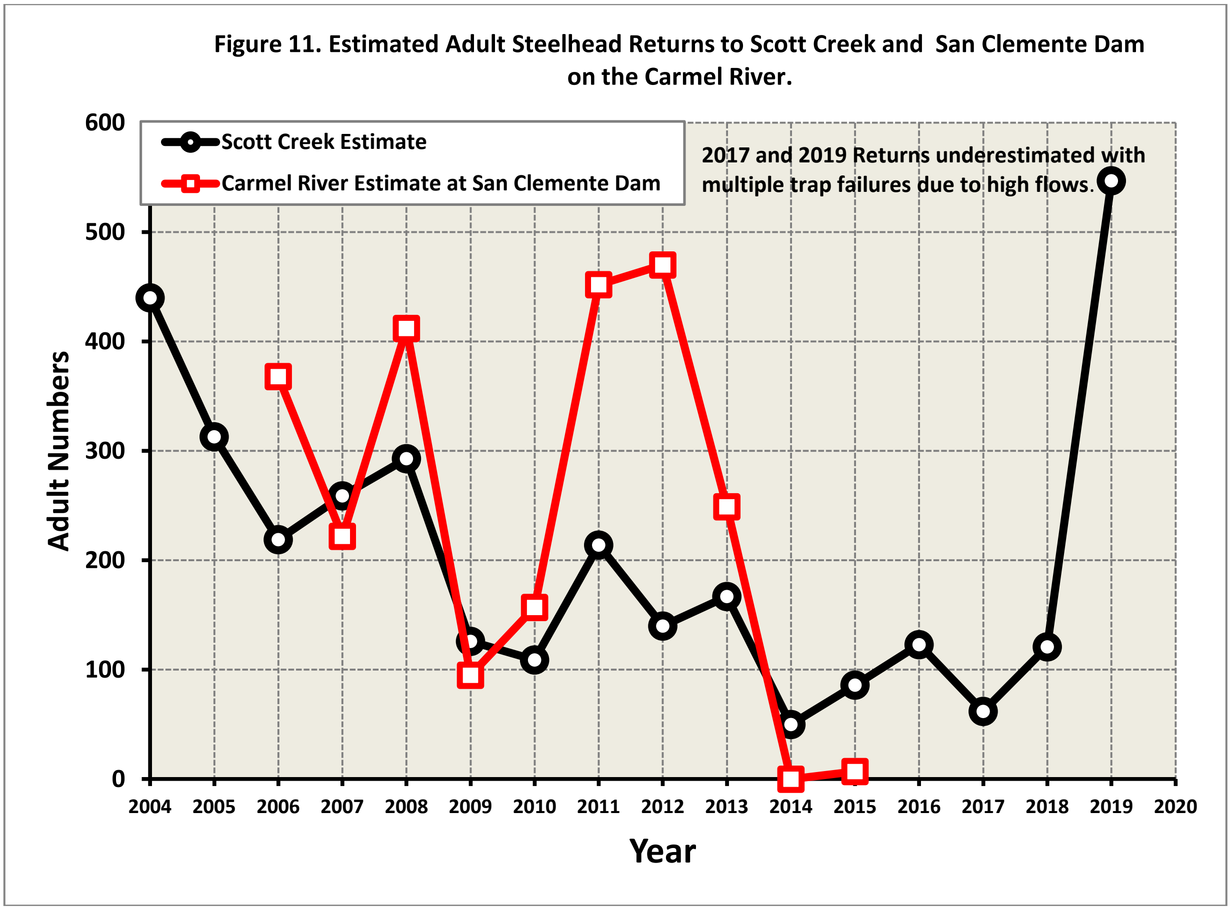



**Figure 11. Estimated Adult Steelhead Returns to Scott Creek and San Clemente Dam on the Carmel River.**

**Immature Pacific Lamprey (*Entosphenus tridentatus*), San Lorenzo River. Sep 2019. (Photo by Tyler Suttle)**

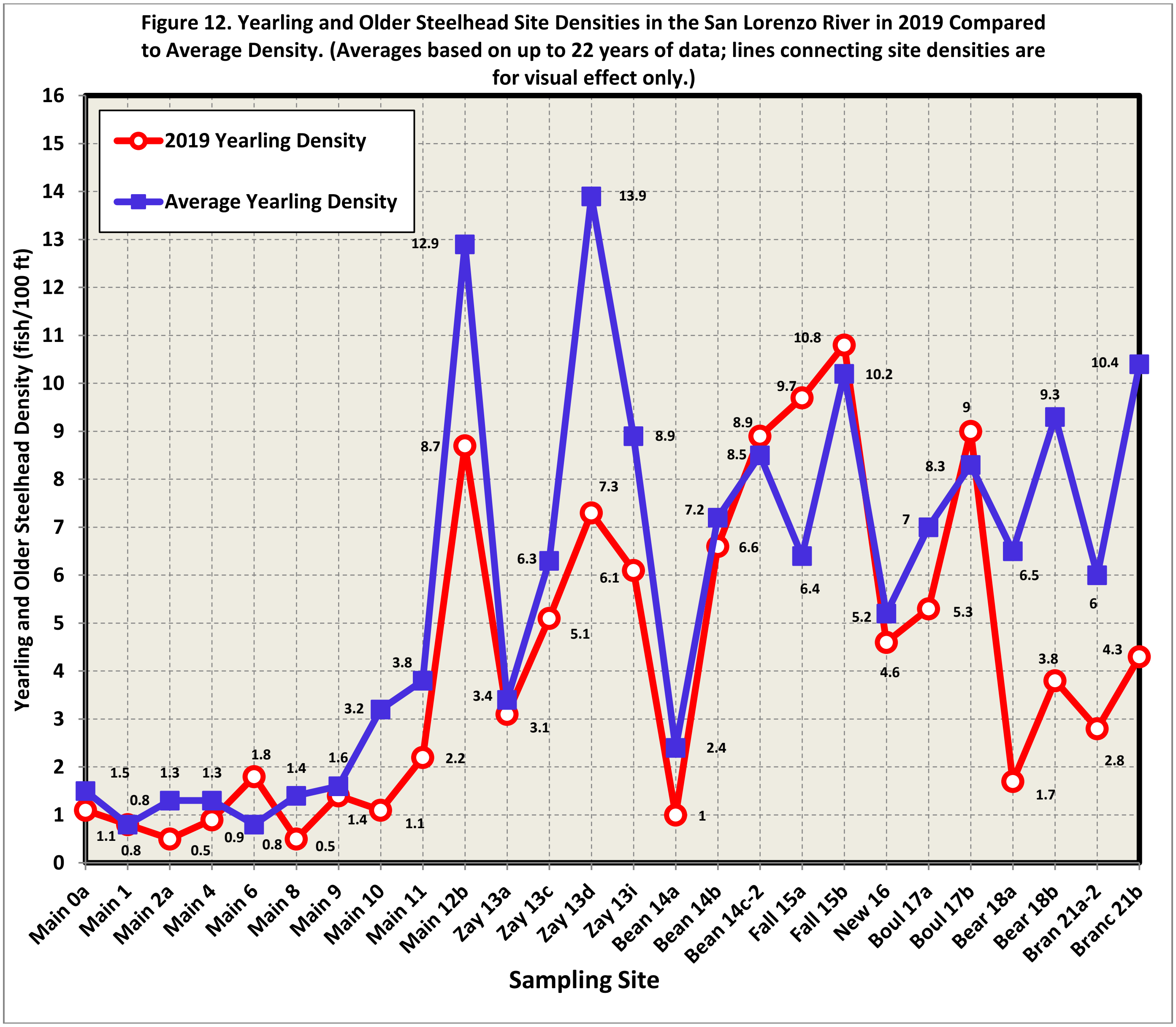



**Figure 12. Yearling Steelhead Site Densities in the San Lorenzo River in 2019 Compared to Average Density. (Averages based on up to 22 years of data.)**

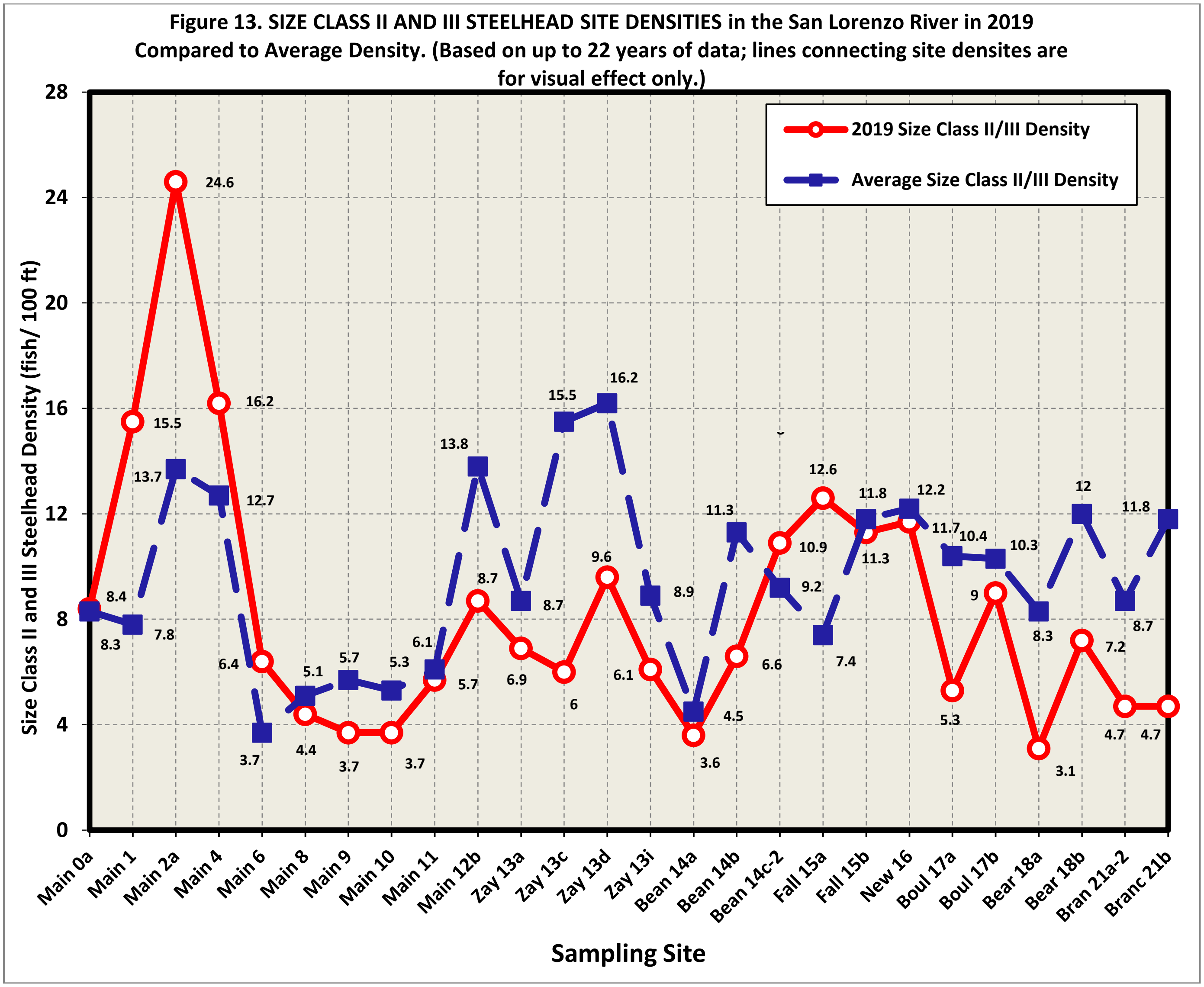



**Figure 13. Size Class II and III Steelhead Site Densities in the San Lorenzo River in 2019 Compared to Average Density. (Averages based on up to 22 years of data.)**

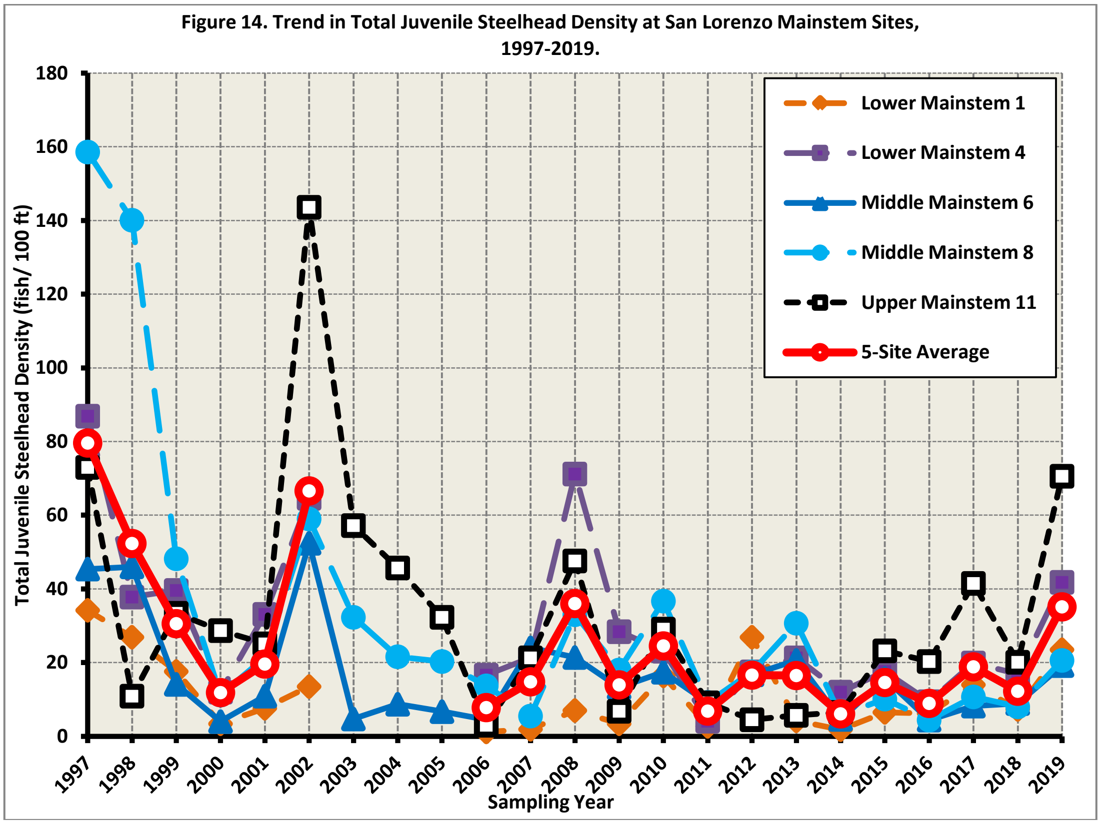



**Figure 14. Trend in Total Juvenile Steelhead Density at San Lorenzo Mainstem Sites, 1997-2019.**

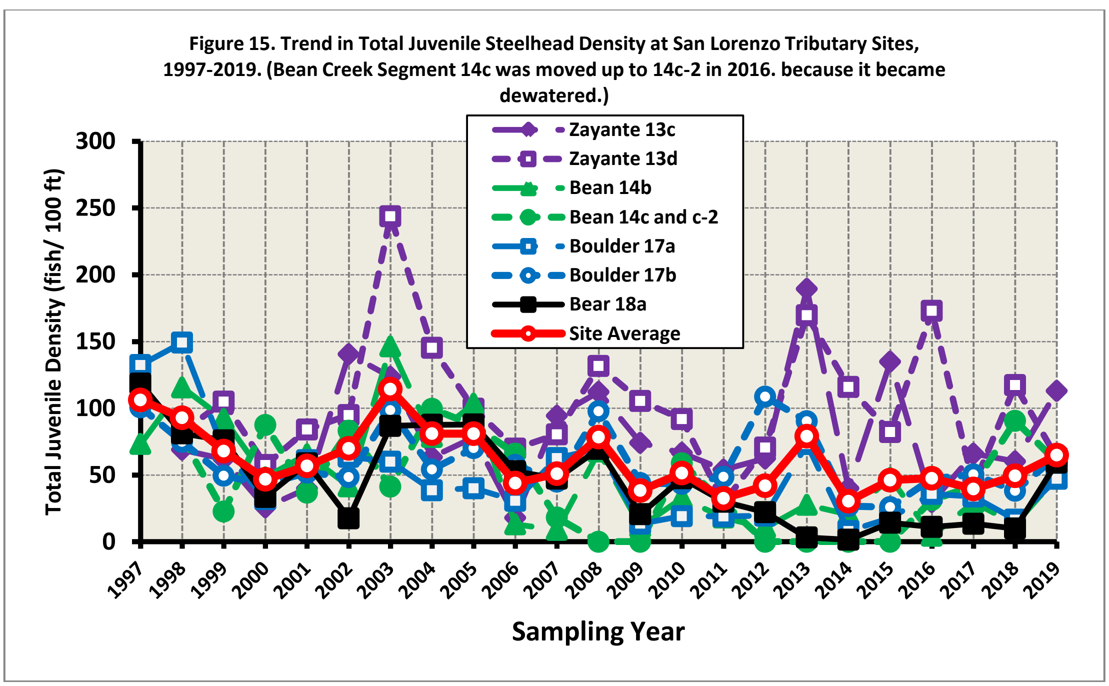



**Figure 15. Trend in Total Juvenile Steelhead Density at San Lorenzo Tributary Sites, 1997-2019.**

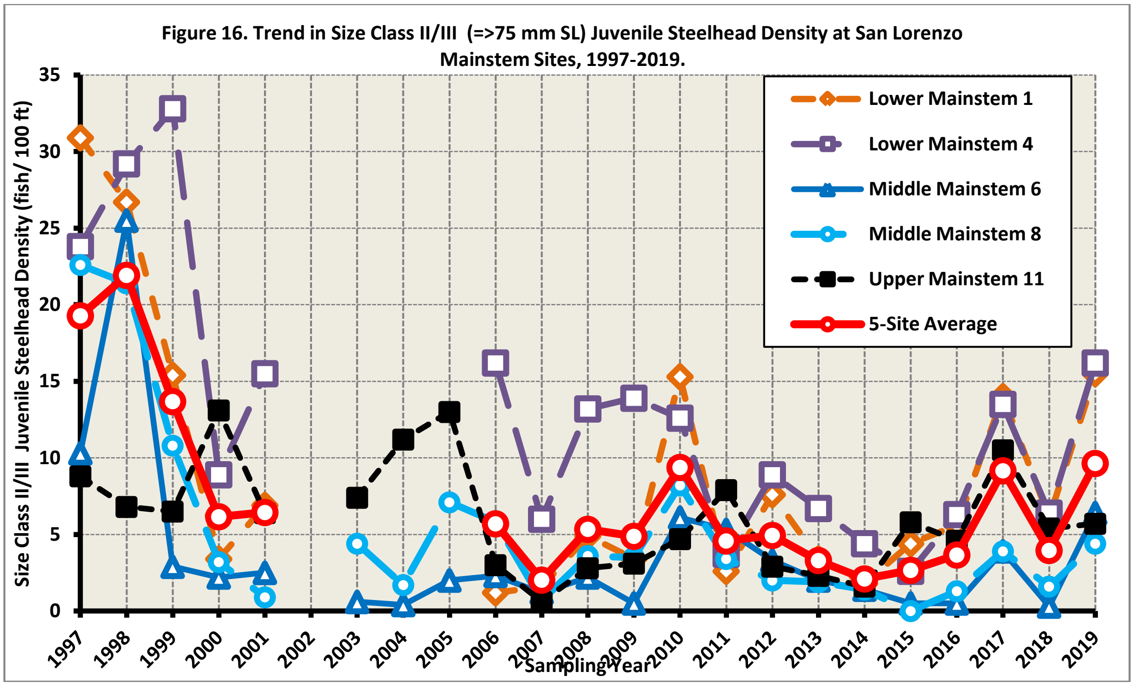



**Figure 16. Trend in Size Class II/III Juvenile Steelhead Density at San Lorenzo Mainstem Sites, 1997-2019.**

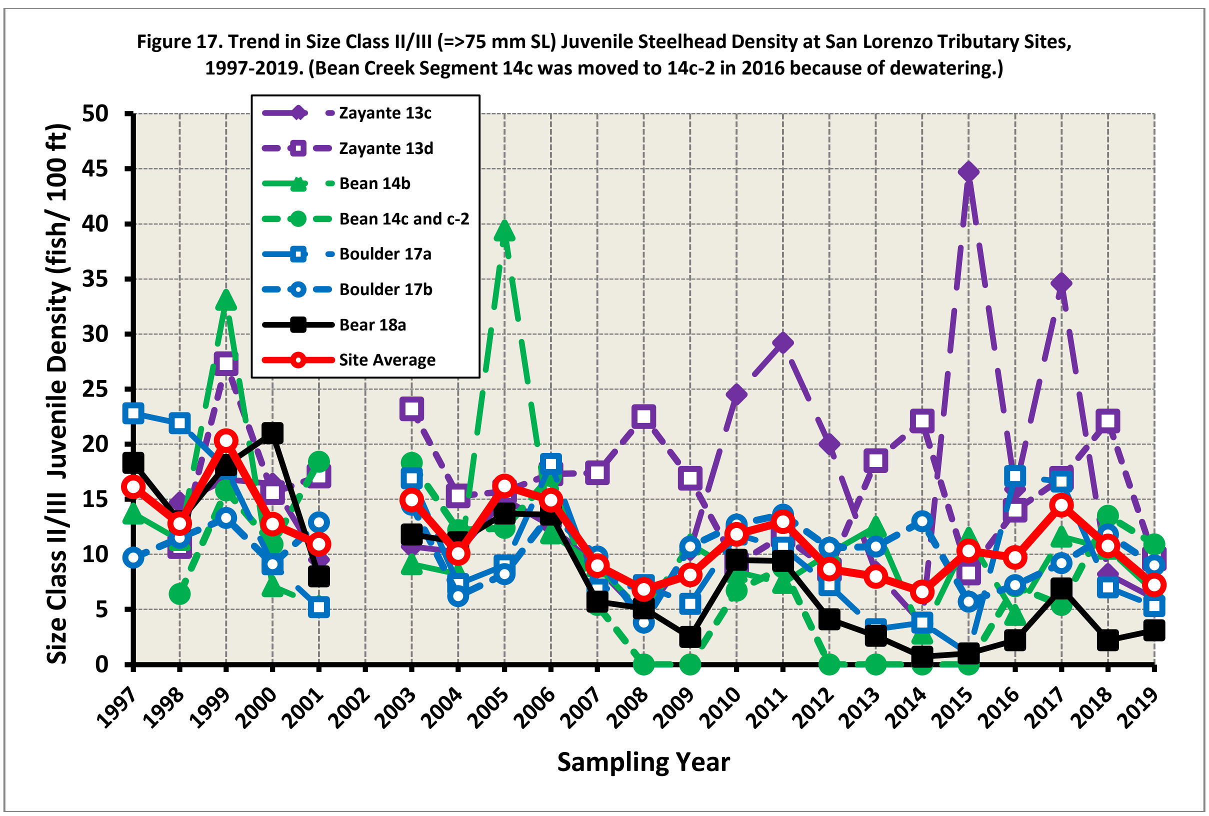



**Figure 17. Trend in Size Class II/III Juvenile Steelhead Density at San Lorenzo Tributary Sites, 1997-2019.**

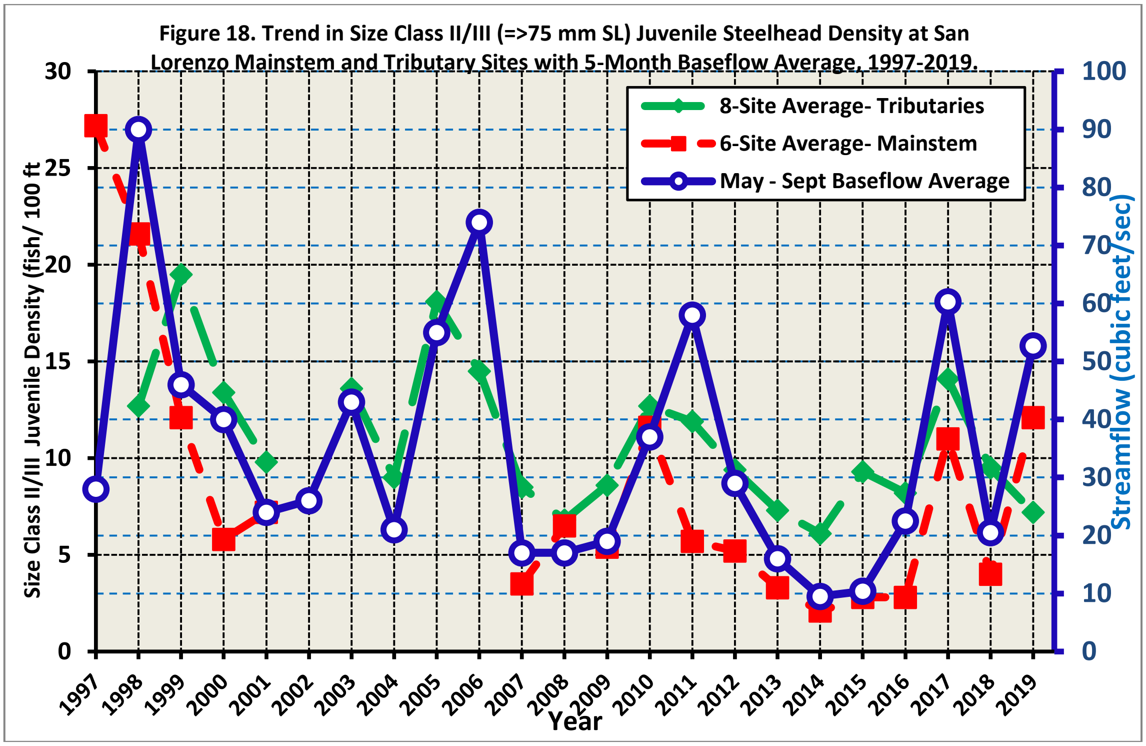



**Figure 18. Trend in Size Class II/III (=>75 mm SL) Juvenile Steelhead Density at San Lorenzo Mainstem and Tributary Sites with 5-Month Baseflow Average, 1997-2019.**

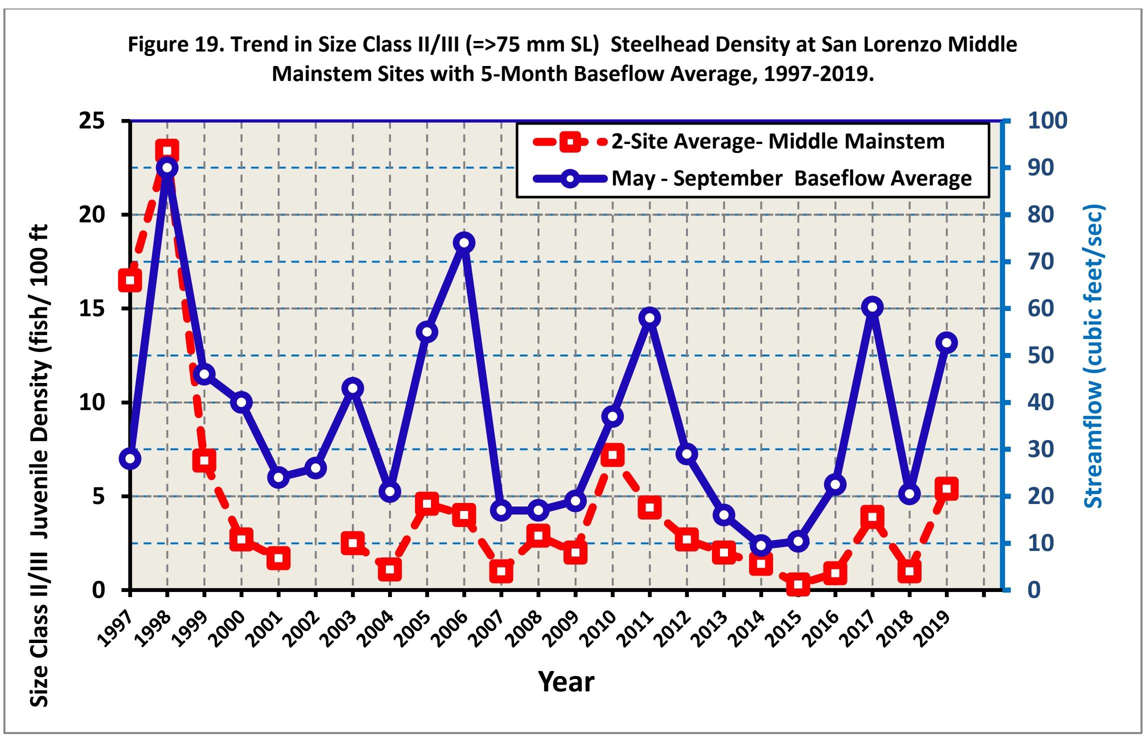



**Figure 19. Trend in Average Size Class II/III (=>75 mm SL) Juvenile Steelhead Density at San Lorenzo Middle Mainstem Sites with 5-Month Baseflow Average, 1997-2019.**

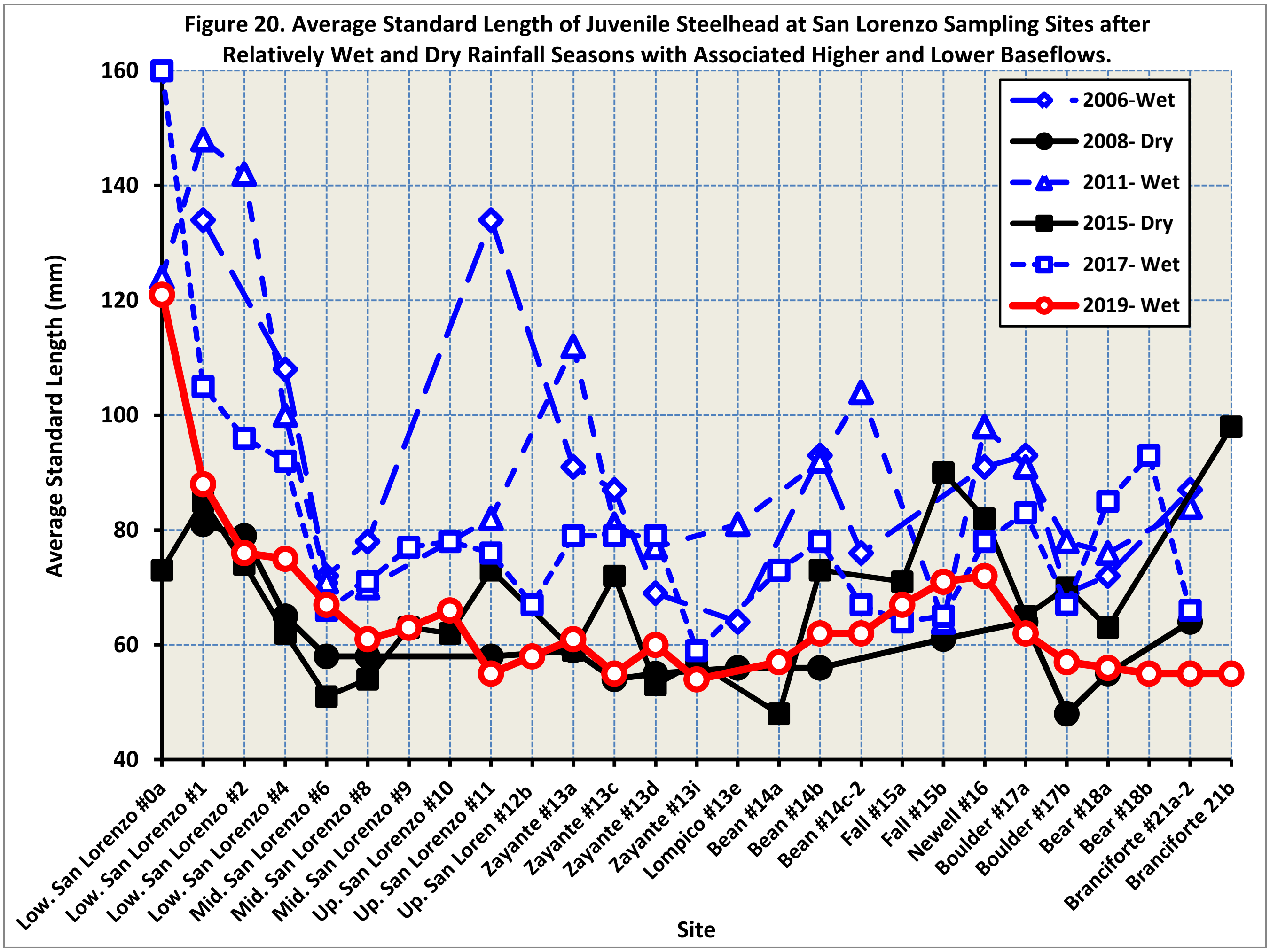



**Figure 20. Average Standard Length of Juvenile Steelhead at San Lorenzo Sampling Sites after Relatively Wet and Dry Rainfall Seasons, with Associated Higher and Lower Baseflows..**

## *ii. Steelhead Abundance and Habitat in the Soquel Creek Watershed*

1. WY2019 streamflows in spring-summer-fall were above the median flow statistic, unlike the below median WY2018, making 8 of the last 13 water years below median flow (**Figure 21**). Good adult steelhead spawning access to the upper watershed was provided by 5 stormflows greater than bankfull (1,500+ cfs) from January to late February and 3 more stormflows above 700 cfs by 15 March, with 2 prior stormflows in November and December and one as late as May. However, some spawning redds laid prior to March 15 before the bankfull events may have been destroyed by scour or smothered with sediment moved by those stormflows. Even so, YOY steelhead were relatively abundant. Baseflow steadily declined from mid-May on at well above median flow down to 3.5 cfs on 1 October at the Soquel Village stream gage.

2. Habitat conditions improved since 2018 with higher baseflow (more drifting food), increased habitat depth at all Reaches/sites and increased escape cover at 4 of 8 Reaches/sites (Reaches 1 and 9a; Sites 4 and 21) (**Tables 4 and 5; Figures 2−4**). In Reach 1 above the lagoon, average pool depth increased 0.6 feet and maximum pool depth increased 0.9 feet since 2016. In Reach 7 above Moores Gulch Reach, average pool depth increased 0.6 feet and maximum pool depth increased 0.8 feet since 2015. At Site 4 above Bargettos' Winery, average pool depth increased 1.1 feet and maximum depth increased 1.7 feet since 2018. At Site 12 below the East Branch

and West Branch confluence, average pool depth increased 0.3 feet and maximum pool depth increased 0.5 feet. In Reach 9 on the lower East Branch, average pool depth increased 0.85 feet and maximum pool depth increased 1 foot since 2016. At the lower West Branch Site 19, average pool depth increased 0.75 feet and maximum pool depth increased 1 foot since 2018. These are substantial deepenings and improvement in pool habitat in the mainstem and Branches, indicating significant sediment transport downstream over winter. After sediment moved through the system in winter, percent fine sediment on the streambed in fastwater habitat remained similar (2 sites/reaches) or increased (6 sites/reaches) in 2019, and increased in pools of mainstem Reach 7 and East Branch Site 16, with less percent fines in pools of Reach 1 and upper West Branch Site 21. Pool embeddedness remained similar in 2019 (less than a 10% change) in 6 of 7 comparable sites/reaches and decreased in mainstem Reach 7. Embeddedness increased only in fastwater habitat; in riffles in 3 of 8 sites/reaches, those being at mainstem Site 12, East Branch Site 16 and West Branch Site 19.

3. ***Total and YOY juvenile steelhead densities*** were above average at 5 of 8 sites in 2019 (averaging 55.8 total juveniles/100 ft and 53.5 YOY/100 ft), especially at upper mainstem Sites 10 and 12 and East Branch 13a (**Figures 22 and 23**). Site 16 in the SDSF was still just two-thirds of the long-term average density for that site; 50.6 YOY/100 ft in 2019 compare to the long-term average of 78.6 YOY/100 ft. Total and YOY densities increased at all 8 sites from 2018 to 2019 (statistically significant) (**Table 8; Figure 24**), especially at upper mainstem Sites 10 and 12 and East Branch Sites 13a and 16. **The long-term trend in total densities** (consisting of mostly YOY) increased substantially in 2019 (6-site average of 57.2 fish/ 100 ft, the fourth highest average density in 22 years, compared to 19.5 in 2018) (**Figure 27**). The 8-site YOY density more than doubled from 21.6 YOY/100 ft in 2018 to 53.5 YOY/100 ft in 2019. We may assume that spawning and egg survival were widely distributed from an adult steelhead population larger than usual, with relatively good egg and YOY survival after the larger stormflows that occurred prior to 15 March. The downward trend in total juvenile steelhead densities in Soquel Creek over the years until 2019 was likely due to a steady decline in returning adults that made spawning patchy and egg survival low during a preponderance of dry winters. Smith (**2019**) found that average YOY densities in 2019 were 1) similarly low to the 2018 average in Gazos Creek (27/100 ft), with likely adult spawning access problems from log jams; 2) were substantially greater than the 2018 average for Waddell Creek but low (21/100 ft); and 3) were substantially greater than the 2018 average for Scott Creek and second highest in the last 15 years (54/100 ft).

4. ***Yearling densities*** in 2019 were slightly above average at 3 of 8 sites (2 mainstem and 1 West Branch sites) and below average at East Branch Site 16. 2019 yearling densities were low, in general, with an 8-site average of 1.8/100 ft compared to 2.3/100 ft in 2018. They increased only slightly from 2018 to 2019 at 3 of 8 sites (mainstem Sites 4 and 12 and East Branch 13a), and were equally low at mainstem Site 1 (1.4 fish/100 ft) and West Branch Site 19 (2.2 fish/100 ft).

5. ***Size Class II and III juvenile densities*** were above average at 4 of 8 sites in 2019 (averaging 10 fish/100 ft), especially at mainstem Sites 1, 10 and 12 (**Figure 25**). Three of 4 mainstem sites were above average, and 3 of 4 Branch sites were below average. Upper West Branch Site 21 was just above average. With above median baseflow and associated faster growthrate of YOY in the mainstem, Size Class II densities were mostly above average there. Egg survival of late spawning steelhead was likely better than for earlier spawning adults prior to 15 March, thus limiting the growth period for YOY before baseflows declined later in summer. Thus, a reduced proportion of YOY reached Size Class II in the Branches than was expected for a higher baseflow year, and yearling densities were low, leading to below average densities of soon-to-smolt juveniles in the Branches in 2019. Size Class II/III densities were still higher in 2019 than in the drier 2018 at all 8 sites (averaging 10 fish/100 ft in 2019 and 4.8 fish/100 ft in 2018) (**Figure 26**). Soon-to-smolt densities were rated “fair” at 4 of 8 sites (mainstem Sites 1, 10, 12 and West Branch Site 21), “below average” at 2 sites (East Branch Sites 13a and 16) and “poor” at 2 sites (mainstem Site 4 and West Branch Site 19) (**Table 2**). Since this size class consists as yearlings at the uppermost Branch Sites 16 and 21 in all but the wettest years or when YOY densities are very low, the density of Size Class II/III is determined by recruitment of YOY from the previous year. Site densities of Size Class II/III at Site 16 in 2013 were low due to low recruitment from low YOY densities in 2012, combined with reduced rearing habitat during drought conditions in 2013. Site densities at Site 16 were zero in

severe drought years of 2014 and 2015 because the stream went dry, leading to low density of Size Class II/III steelhead in 2016. They did rebound well in wet 2017, declined in the dry 2018, but did not rebound in the wet 2019, presumably because overwinter survival of YOY to yearlings was low, and predominantly late spawned YOY in spring 2019 had insufficient growing time to reach Size Class II in fall 2019.

6. The 6-site trend in Size Class II and III densities increased in 2019 (avg=10.9 fish/100 ft) after the plunge in 2018 typical of dry years (avg=4.6 fish/100 ft) to above the long-term average (8.2 fish/100 ft) (**Figure 28**). By comparison, the 2019 average was still below the 2017 average (avg=13.5 fish/100 ft). The 6-site, long term average for Size Class II/III density is correlated with average 5-month baseflow in some years (**Figure 29**). 1997 and 2002 had relatively high Size Class II/III densities despite moderate baseflow, presumably due to high egg and YOY survival and good YOY growth in years without late season bankfull events but adequate baseflow. Increases in total, YOY and Size Class II/III site densities from 2018 to 2019 were statistically significant at better than the p=0.05 level at replicated site locations (**Table 9**; section iv at the end of the report).

7. The above average densities of YOY in 2019 were likely due to a larger than usual returning adult steelhead population that included relatively higher numbers of late spawners that laid their eggs after 15 March and after the prior bankfull events that would have made redd scour or burying with sediment more likely and egg survival more difficult. Data on adult returns in Scott Creek support the possibility of improved ocean survival and higher adult returns than recent years (**Figure 11**).

8. Soquel Lagoon is typically habitat for a sizeable juvenile steelhead population, as indicated by our long-term population censusing for the City of Capitola. It indicated a long-term average population size of 1,498 (median=875) of mostly soon-to-smolt sized steelhead (=>75 mm SL) between 1993 and 2013 and 2016−2019 (**Alley 2020**). In 2019, the lagoon population estimate was 3,322 (4th largest in 27 years) with a relatively small median size range of 90-95 mm SL. This high lagoon population estimate with smaller than usual YOY indicate that the adult steelhead population had been larger than usual and that spawning late in the season near the lagoon was relatively successful.

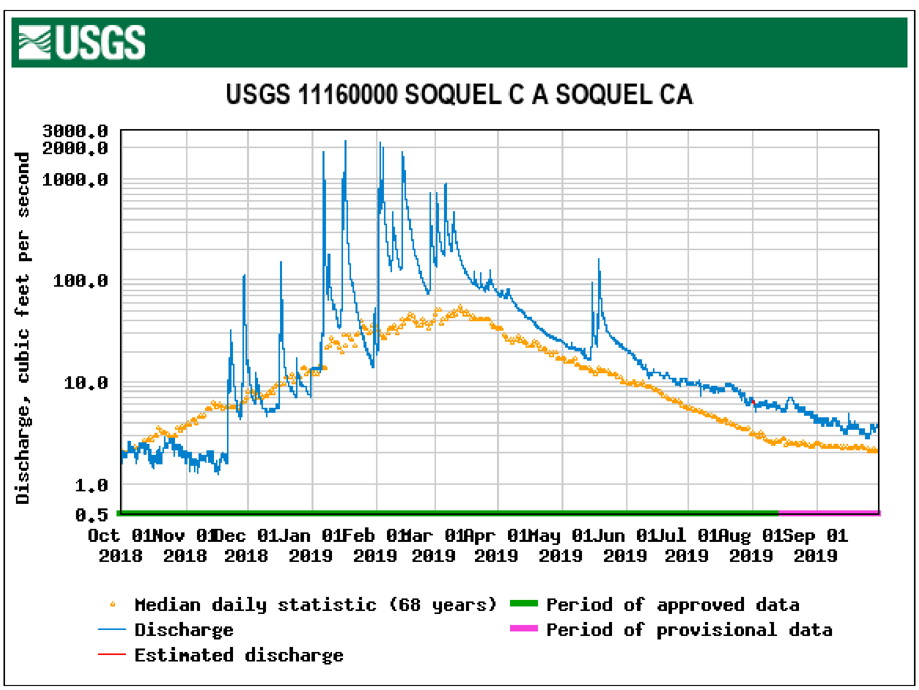



**Figure 21. The 2019 Discharge at the USGS Gage on Soquel Creek at Soquel Village.**

**Table 4. Fall/Late Summer STREAMFLOW (cubic feet/ sec) Measured by Santa Cruz County Staff in 2006−2017 (Date specified)and from Stream Gages; Measurements by D.W. ALLEY & Associates; 2010 (September), 2011−2015, 2018− 2019 (October) at fall baseflow conditions .**

| Location | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Soquel Cr above Lagoon** | | | | | 2.3(DWA) | 4.9 (DWA) | 1.8 (DWA) | 0.33 (DWA) | 0.19 (DWA) (Walnut St.) | 0.18 (DWA) (Walnut St.) | | 3.98 (DWA) (Walnut St) | 1.59 (DWA) (Walnut St) | 2.84 (DWA) (Walnut St) |
| **Soquel Cr @ USGS Gage** | 6.6** | 1.4** | 0.65** | 1.2** | 3.4** | 5.8** | 1.8** | 0.36** | 0.35** | 0.36** 0.10 (9/9) | 1.4** 0.7(1 Oct) | 5.0 (12 Oct) | 1.6 (15 Oct) | |
| **Soquel Cr @ Bates Cr** | 5.73 | - | 1.08 | | 4.2 (9/1) | 7.3 (8/31) | 2.0 (9/19) | 0.95 (9/11) | 0.22 (9/17) | 0.35 (9/9) | 1.16 (10/4) | | | |
| **Soquel Cr above Moores Gulch** | | | | | 2.16 (DWA) | 4.3 (DWA) | 2.0 (DWA) | 1.26 (DWA) | 0.72 (7/16) 0.80 (DWA) | 0.54 (7/28) 0.56 (DWA) | | 4.46 (DWA) | 1.51 (DWA) | 3.30 (DWA) |
| **W. Branch Soquel Cr @ Old S.J. Road Olive Springs Bridge** | 2.2 | 1.75 After | – | – | 1.2 @ Mouth (DWA) | 2.2 @ Mouth (DWA); 3.0 (8/31) | 1.1 @ Mouth (DWA); 1.21 (9/05) | 0.91 @ Mouth (DWA) 1.73 (5/14) | 0.80 (9/16) 0.74 @ Mouth (DWA) | 0.58 (9/14) 0.59 @ Mouth (DWA) | | 1.85 @ Mouth (DWA) | 1.16 Mouth (DWA) | 1.59 @ Mouth (DWA) |
| **W. Branch Soquel Cr abv Hester Cr (Weir)** | 1.5 (15 Sep) | 1.0 (15 Sep) | – | – | – | – | – | – | | | | | | |
| **E. Branch Soquel Cr @ 152 Olive Springs Rd.** | - | 1.0 After | – | – | 0.77 @ Mouth (DWA) | 2.1 Mouth (DWA); 2.7 (8/31) | 0.54 Mouth (DWA); 0.43 (9/05) | 0.16 @ Mouth (DWA) 2.0 (5/14) | 0.0 (7/16) Trickle @ Mouth; Dry above (DWA) | Dry (DWA) | 0.67 (7/21) | 1.44 Mouth (DWA) | 0.45 Mouth (DWA) | 1.06 (DWA) |
| **E. Branch Soquel Cr below Amaya ; abv Olive Spgs Quarry(Weir)** | 1.5 (15 Sep) | 0.43 (15 Sep) | – | – | – | – | | | | | | | | |
| **E. Branch Soquel Cr abv Amaya C** | | | | Trickle (DWA) | 0.44 (DWA) | | | 0.03 (DWA) | Dry (DWA) | Dry (DWA) | | 0.71 (DWA) | 0.15 (DWA) | 0.46 (DWA) |
| **Aptos Cr below Valencia Cr** | 2.5 | 1.2 After | 0.77 | 0.53 | 0.85 (9/1) | | 0.87 (DWA); 1.10 (9/05) | 0.75 (DWA) 0.84 (9/11) (Valencia Cr. dry) | 0.47 (9/16) | | 0.46 (9/22) | 2.52 (DWA) | 1.08 (DWA) | 1.65 (DWA) |
| **Aptos Cr above Valencia Cr** | | | | | 0.97 (DWA) | 1.6 (DWA) | | | 0.63 (DWA) | 0.44 (DWA) | | | | |
| **Valencia Cr @ Aptos Cr** | | | 0.007 | 0.34 (May) | 0.09 School (DWA) | 0.8 School (7/27) | 0.20 (9/05) | 0.105 (9/11) | | | | | | |

**** Estimated from USGS Hydrographs for September 1.**

**Table 5. Habitat change in SOQUEL CREEK WATERSHED Reaches and Sites from Previous Years.**

| Reach or (Site Only if in parenthesize) Comparison To Previous Years | 2019 Baseflow Comparison (Most Important Factor May-September) | Depth - Pool / Fast-water | Fine Sediment - Pool / Fastwater | Embeddedness - Pool / Fastwater | Pool Escape Cover | Overall Habitat Change and (Any Improvement) |
|---|---|---|---|---|---|---|
| Site 1 Reach 1 (Since 2016) | + | + / + | + / − riff; Sim run | Sim / Sim | + | + (more food and cover, greater depth but more riffle fines) |
| (Site 4) Reach 3a (Since 2018) | + | + / + | + / Same | Sim / Sim riff; Same run | + | + (more food and cover, greater depth) |
| Site 10 Reach 7 (Since 2015) | + | + / + | − / Sim riff; − run | + / Sim | − | + (more food, greater depth but less cover and more fines) |
| (Site 12) Reach 8 (Since 2018) | + | + / Same | Sim / − | Sim / Sim run; − riff | − | + (more food and pool depth but less pool cover and more fastwater fines and embeddedness) |
| East Branch Site 13a Reach 9a (Since 2016) | + | + / + | Same / Sim | Sim / + runs; Sim riff | + | + (more food and cover and greater depth) |
| East Branch (Site 16) Reach 12a (Since 2018) | + | + / + | − / − | Sim / − riff; Same step-run | − | + (more food and depth but more fines and fastwater embeddedness, less pool cover) |
| West Branch (Site 19) Reach 13 (Since 2018) | + | + / + riff − max run | + / − | NA / − | − | + (more food and depth but more fastwater fines and embeddedness and less pool cover) |
| West Branch (Site 21) Reach 14b (Since 2018) | + | + / + | Sim / − riff; Same run | Sim / + riff; Same run | + | + (more food, depth and cover but more fastwater fines) |

**Juvenile Coho Salmon (*Oncorhynchus kisutch*) reared in East Branch Soquel Creek, 2008. (Photo by Chad Steiner)**

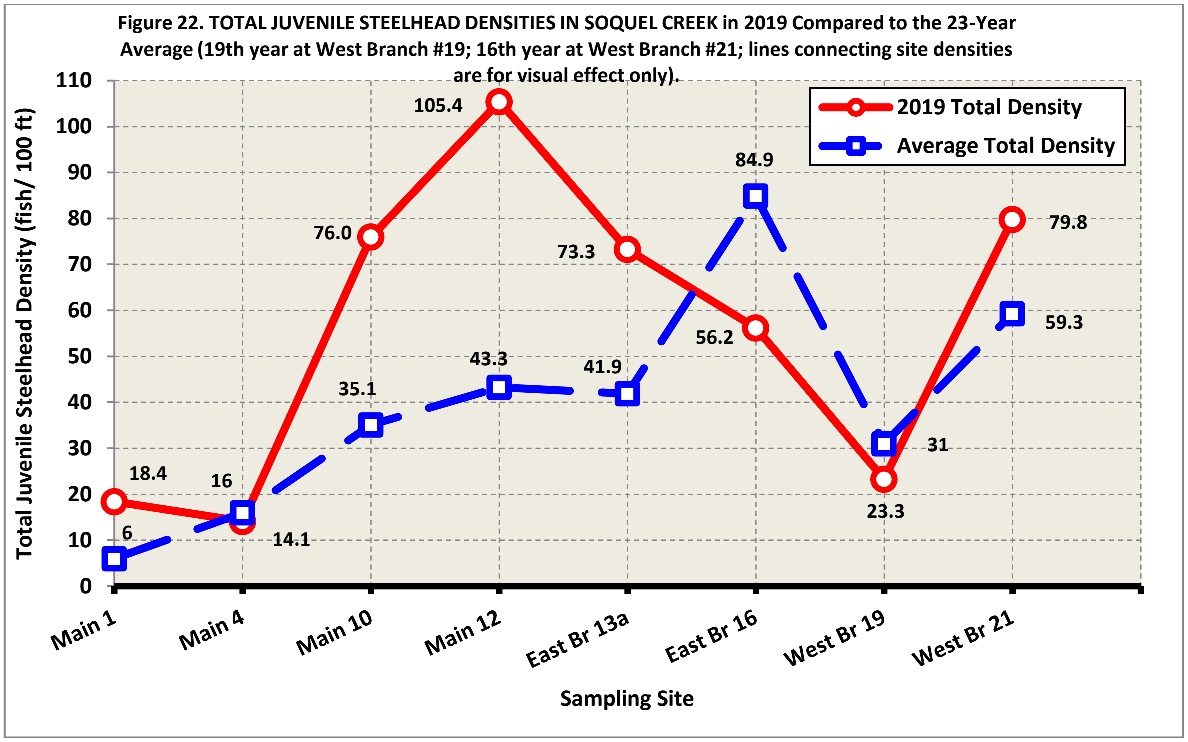



**Figure 22. Total Juvenile Steelhead Site Densities in Soquel Creek in 2019 Compared to the 23-Year Average (19th year for West Branch #19.)**

**Prickly Sculpin (*Cottus asper*) reared in mainstem Soquel Creek. (Photo by Don Alley)**

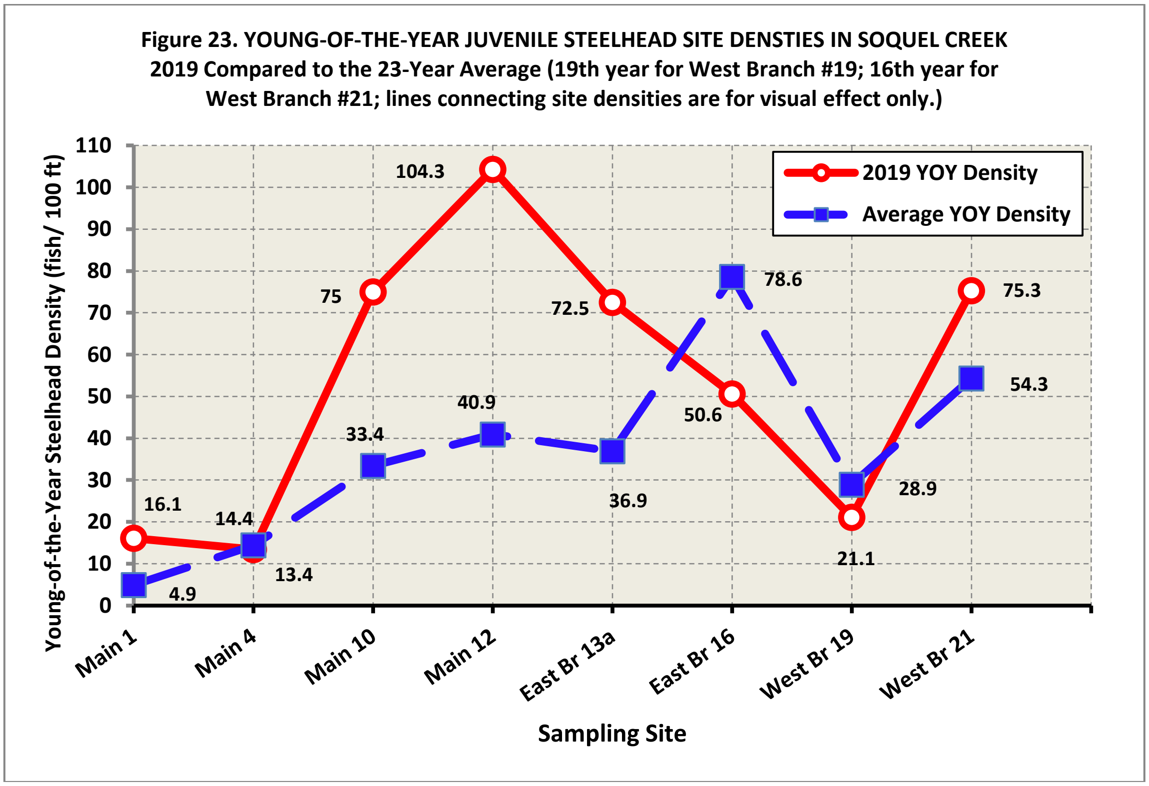



**Figure 23. Young-of-the-Year Steelhead Site Densities in Soquel Creek in 2019 Compared to the 23-Year Average (19th year for West Branch #19.)**

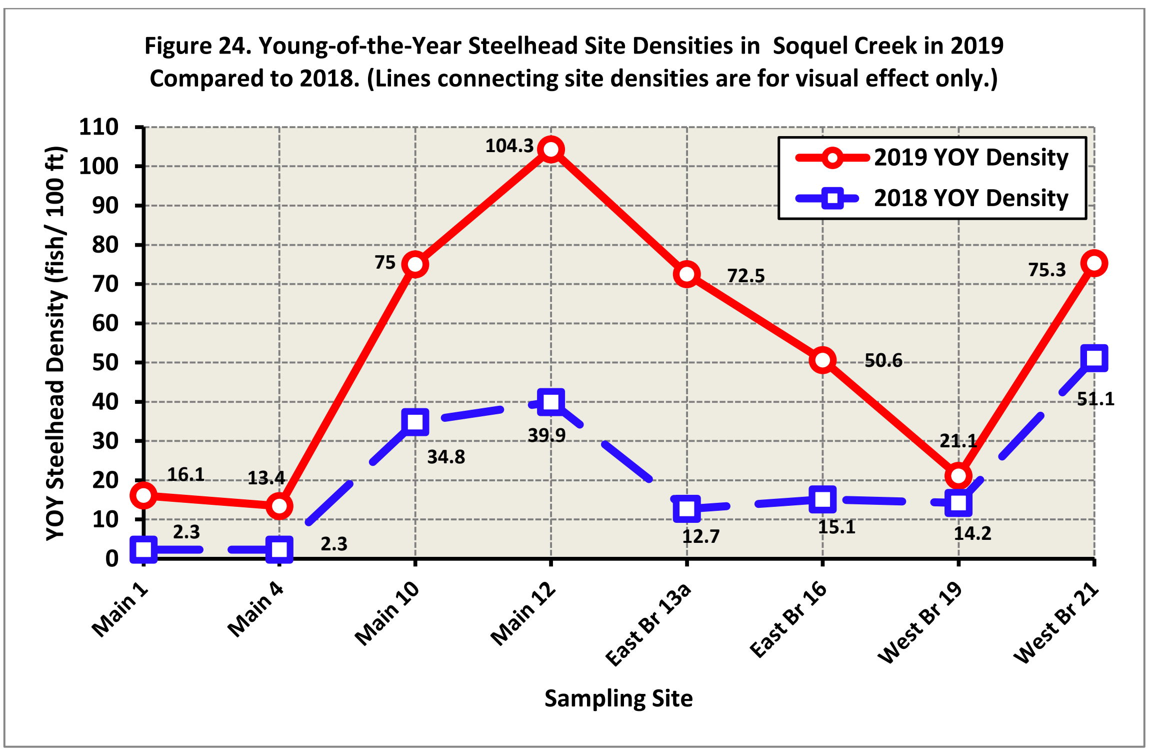



**Figure 24. Young-of-the-Year Site Densities in Soquel Creek, Comparing 2019 to 2018.**

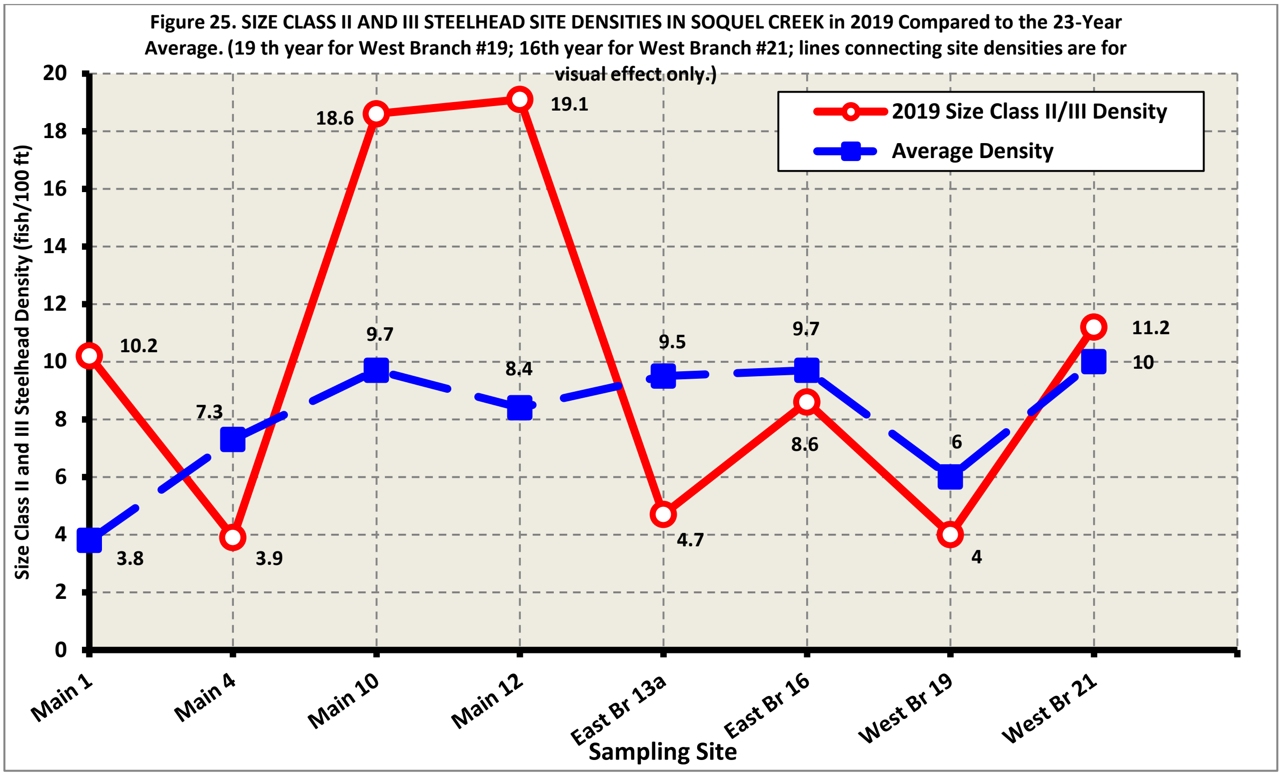



Figure 25. Size Class II and III Steelhead Site Densities in Soquel Creek in 2019 Compared to the 23-Year Average (19th year for West Branch #19.)

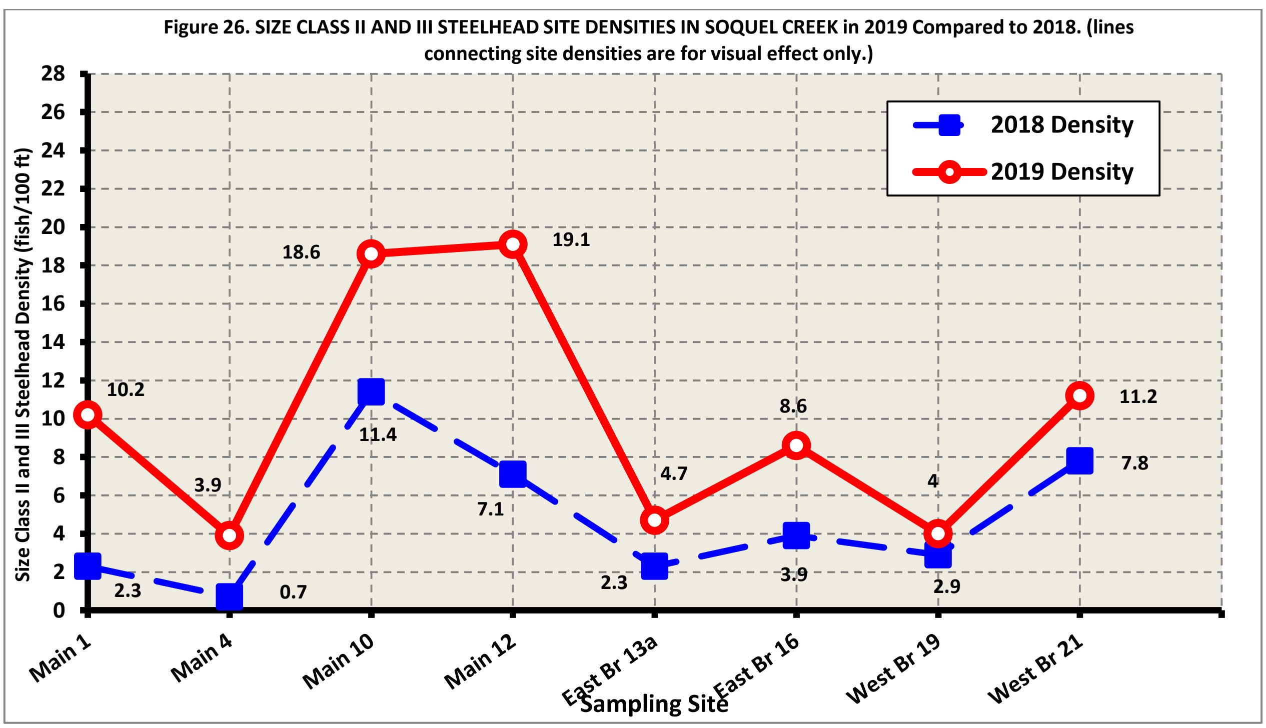



Figure 26. Size Class II and III Steelhead Site Densities in Soquel Creek in 2019 Compared to 2018.

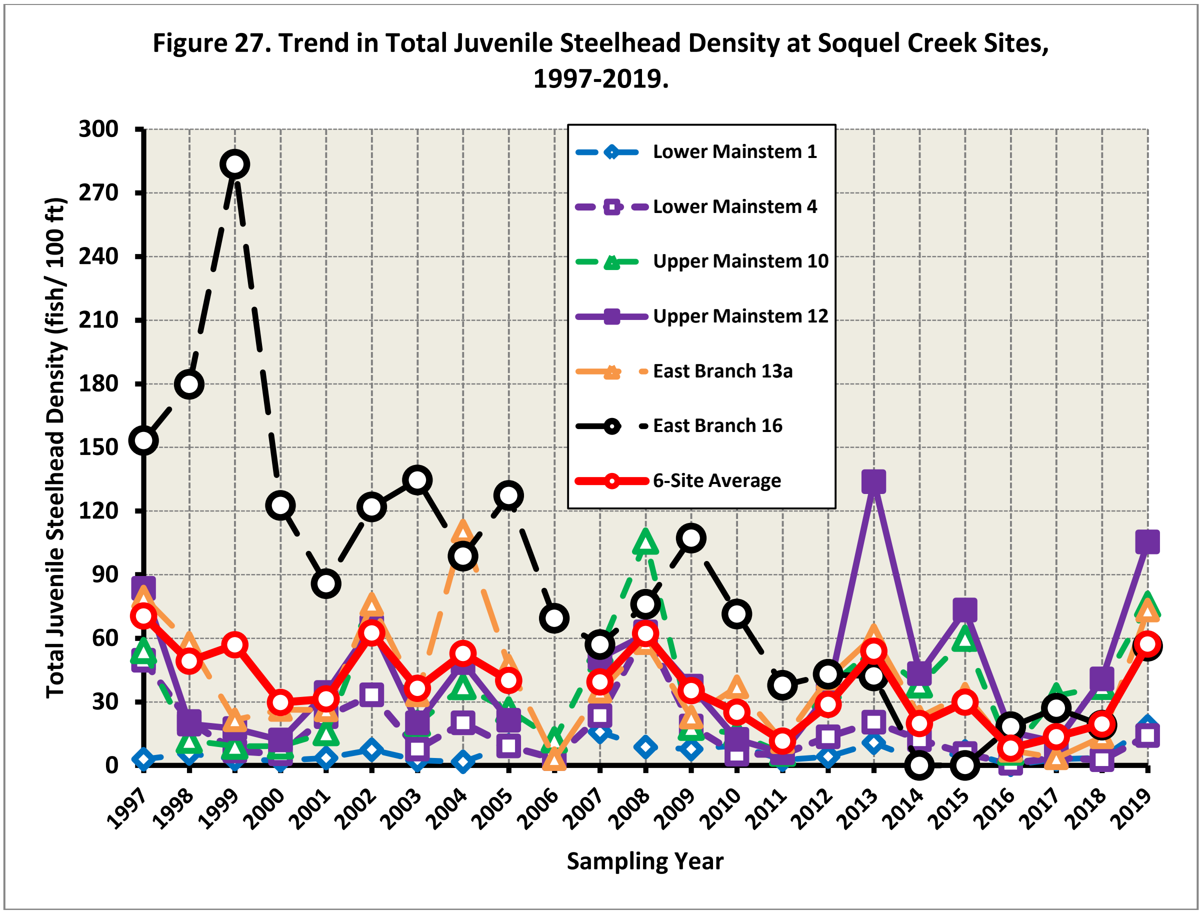



**Figure 27. Trend in Total Juvenile Steelhead Density at Soquel Creek Sites, 1997-2019.**

**Jessica Wheeler and Josie Moss Recording 2019 Data- San Lorenzo River, Rincon Reach in Henry Cowell State Park**

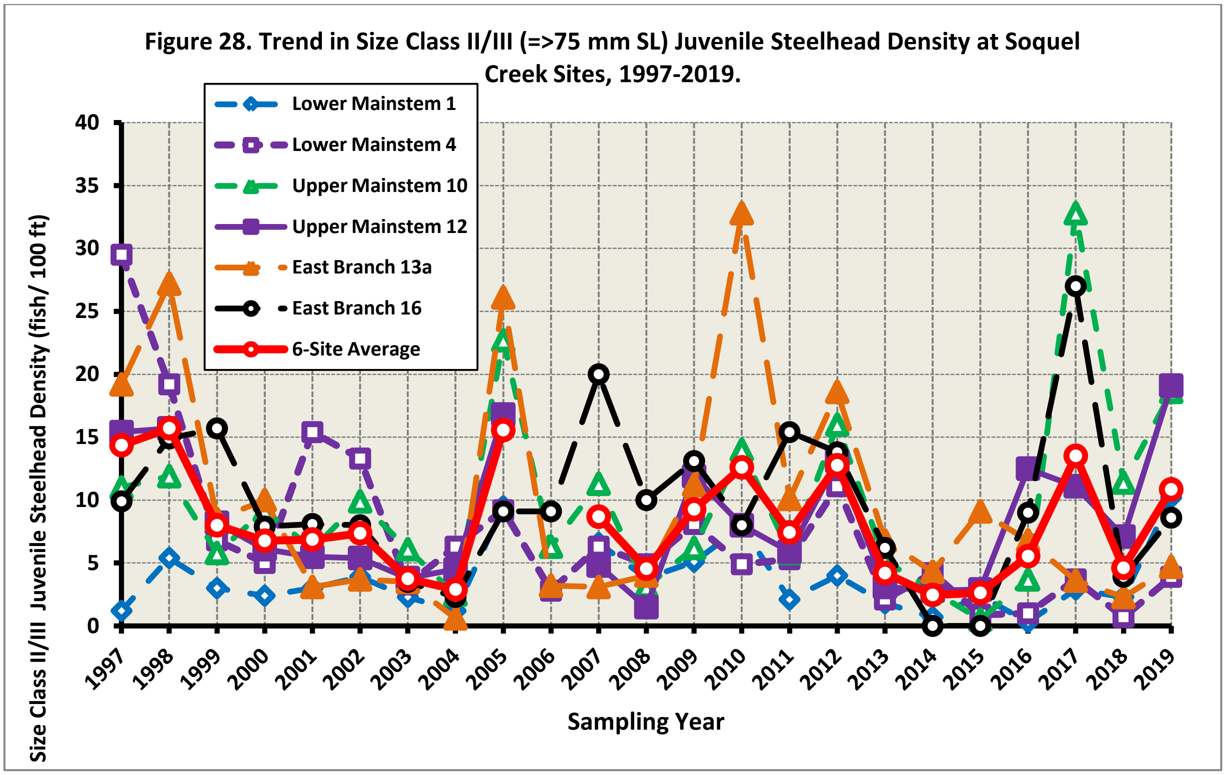



**Figure 28. Trend in Size Class II/III Juvenile Steelhead Density at Soquel Creek Sites, 1997-2019.**

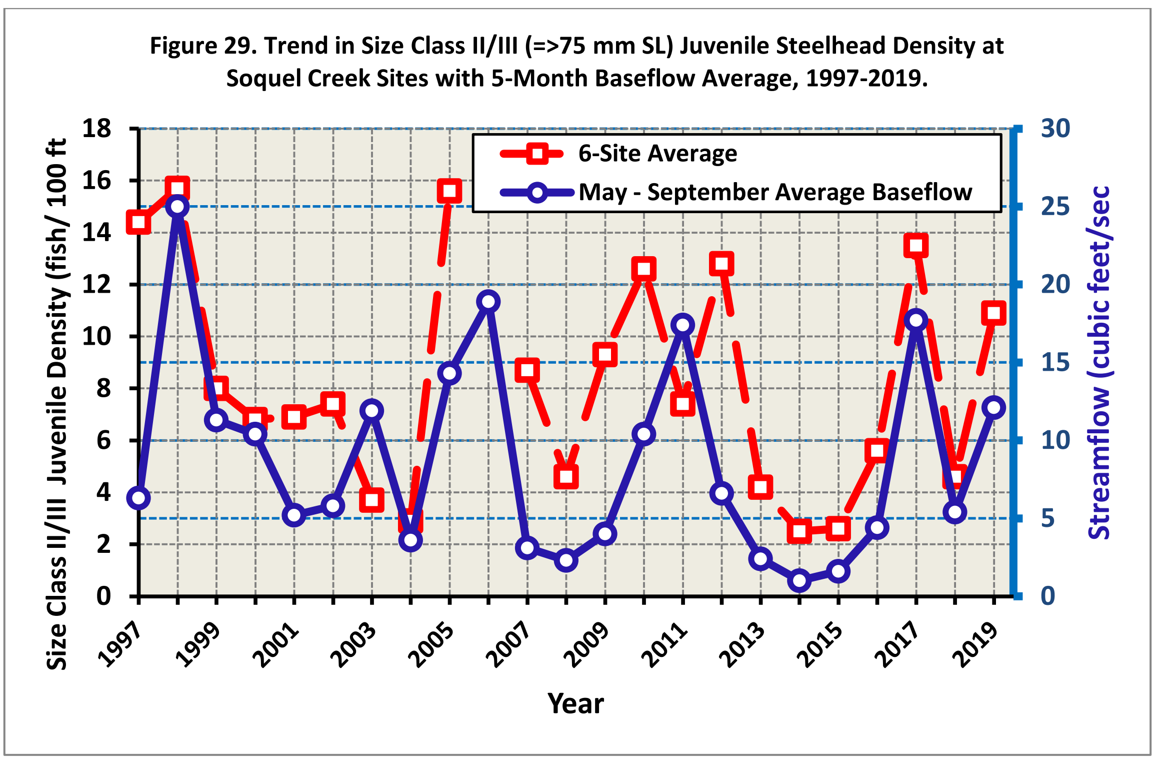



**Figure 29. Trend in Size Class II/III (=>75 mm SL) Juvenile Steelhead Density at Soquel Creek Sites with 5-Month Baseflow Average, 1997-2019.**

## ***iii. Steelhead Abundance and Habitat in the Aptos Creek Watershed***

1. Aptos Creek likely had a WY2019 hydrograph similar to those in the San Lorenzo and Soquel drainages, with stormflows at the same frequency and intensity, resulting in several bankfull stormflows before 15 March and above median baseflow in the dry season (**Table 4; Figures 4, 5 and 21*).*** The winter/spring streamflow pattern made good adult steelhead access to headwater reaches. The 5 bankfull events occurring between January and 15 March likely moved significant sediment and made redd and egg survival more difficult until after 15 March. Baseflow below the Valencia Creek confluence declined to 1.65 cfs in early October 2019 compared to 1.08 cfs in 2018 and 2.52 cfs in 2017 (**Table 4**).

2. ***Habitat conditions*** improved in both Aptos Creek segments and upper Valencia Site 3 compared to the 2018 dry year, primarily due to increased drifting food created by increased baseflow and more escape cover at upper sites/segments in 2019 (**Table 6**). Lower Valencia Site 2 declined in habitat quality because pool water depth and escape cover declined with no improvement in very sedimented conditions that offered little aquatic insect habitat and likely no improvement in drifting insect food for steelhead despite increased baseflow. Unlike in the San Lorenzo and Soquel watersheds, water depth did not increase across the board as it did there, but instead decreased in lower Aptos Segment 3 and lower Valencia Site 2. This indicated sedimentation in the lower portions of these channels in 2019. Pool water depth increased at Valencia Site 3 and remained the same in habitat typed upper Aptos Segment 4 compared to 2018. Escape cover increased in upper Aptos Segment 4 and at Valencia Site 3. Escape cover remained similar to 2018 in lower habitat typed Aptos Segment 3 and declined at Valencia Site 2. Percent fine sediment and embeddedness in pools remained similar to 2018 in 3 of 4 sites/segments, with less fine sediment in upper Aptos Segment 3.

3. ***Total and YOY densities*** were above average at all 4 sites in 2019 (averaging 46.2 total juveniles/100 ft and 40.7 YOY/100 ft), consistent with most sites in the San Lorenzo and Soquel watersheds (**Figures 30 and 31**).They also trended up in 2019 (**Figure 35**).  Smith (**2019**) found that 2019 average YOY densities were similarly low to the 2018 average in Gazos Creek (27/100 ft) with difficult adult spawning access; were much greater than the 2018 average for Waddell Creek but low (21/100 ft); and were much greater than the 2018 average for Scott Creek and second highest in 15 years (54/100 ft).

4. ***Yearling and older densities*** and ***Size Class II/ III densities*** were above average at the Valencia 3 site and below average at the other 3 sites (**Figure 33**). Lower Aptos Site 3 had near average Size Class II/III densities because 15% of the YOY captured reached Size Class II, and yearlings were retained in decent numbers. Only 4.5% of the even more abundant YOY captured at upper Aptos Site 4 reached Size Class II, and none did at Valencia Creek sites.

5. ***YOY densities*** increased in 2019 from 2018 at all sites (**Figure 32**). ***Yearling and older densities*** and ***Size Class II/III densities*** increased at Valencia Creek sites and decreased at Aptos Creek sites in 2019 (**Figure 34**). The soon-to-smolt density rating was "fair" for Aptos  Site 4 and Valencia Site 2 and "good" at Aptos Site 3 and Valencia Site 3 because ratings were boosted one level due to average length greater than 102 mm SL at the latter 2 sites (**Table 2**). Two-year olds may be more common in Valencia Creek due to slow growth rate, based on previous scale analysis. Increased total and YOY densities from 2018 to 2019 were statistically significant at the p=0.05 level (**Table 10**).

6. The ***trend in the 4-site, long term density of Size Class II/III juveniles*** increased slightly in 2019 from average site density of 6.5/ 100 ft in 2018 to 7.2/ 100 ft in 2019 (below multi-year average of 9.6) (**Figure 36**). The 2019 ***4-site yearling density*** was 5.3/100 ft and similar to 2018 (5.1/100 ft). Smith (**2019**) found 2019 yearling densities to be higher than most years in Gazos Creek (8/100 ft) but less than in 2018; to be similar to 2017 and 2018 in Scott Creek (7/100 ft). Yearlings are the primary source of Size Class II/III steelhead in these small, shaded streams.

7. Aptos Estuary was sampled for steelhead with the large, 3/8-inch mesh bag seine. The steelhead population estimate was 707, based on mark and recapture. This was the highest estimate in 7 years of censusing and consistent with the high population estimate in Soquel Lagoon in 2019. The years 2011−2013 and 2017-2019 had estimates of 32, 140, 423, 184, 220 and 707, respectively (**Figure 37**). In 2014, only 6 steelhead were captured in 2 days without recaptures to make an estimate. The 2019 size histogram indicated a bimodal size distribution of age classes (**Figure 38**). Steelhead in the 115--134 mm SL range were likely a mix of YOY and yearlings; those 135 mm SL and larger were likely yearlings and older. Juveniles were much smaller than in previous years, as was the case in Soquel Lagoon, supporting the indication that late spawning near the estuary was successful.

8. Surprisingly, 2 tidewater gobies (*Eucyclogobius newberryi*) were captured with this large seine (3/8-inch mesh), despite the saline conditions in the lower water column in deep water. Tidewater goby sampling was unbudgeted and not done with the finer, 1/8-inch meshed goby seine. Besides steelhead and tidewater goby, other species captured were smelt (*Atherinopsis spp.)*, staghorn sculpin (*Leptocottus armatus*), threespine stickleback (*Gasterosteus aculeatus*) and prickly sculpin (*Cottus asper*).

9. The estuary had stratification of water temperature, salinity and oxygen on both sampling days. The outlet channel was small and shallow with a well developed beach berm, indicating little tidal inflow at high tide and stable water depth. On 8 October at 0831 hr on a clear morning, the estuary was relatively deep at the walk bridge, with a gage height of 4.95 and warm, saline water below the near freshwater layer at the surface (>21.0 °C below 0.75 m from the surface) (**Table 7**). Water temperature was a cool 14.4 °C in the upper 0.75 meters. Temperature ranged from 21.0 °C to 24.8 °C from 1.0 m from the surface down to 1.75 m on the bottom. Salinity was 0.6 ppt in the upper 0.75 meters. Salinity ranged from 8.0 to 16.6 ppt from 1.0 m down to 1.75 m on the bottom. Oxygen concentration ranged from 10.54 to 11.77 mg/L in the upper 1.0 m. Oxygen ranged from 26.12 down to 13.53 mg/L from 1.25 m down to 1.75 m. On 15 October at 0820 hr on an overcast, foggy day, the estuary remained deep at gage height 4.90, only 0.05 m shallower than the previous week. Stratification of water temperature, salinity and oxygen was similar to the previous week, with water temperature 0.5 °C cooler in the nearly freshwater 0.75 m upper layer and 2.7 °C warmer at the bottom and approaching lethal levels at 27.5 °C. Salinity was very similar through the water column compared to the previous week. Oxygen levels were somewhat higher through the water column compared to the previous week.

**Table 6. Habitat Change in Reaches and Sites in the APTOS WATERSHED from previous years.**

| Segment or (Site Only) (when in parenthesize) Comparison To Previous Years | 2019 Baseflow Comparison (Most Important Factor May-September) | Pool Depth | Pool Fine Sediment | Pool Embeddedness | Pool Escape Cover | Overall Habitat Change |
|---|---|---|---|---|---|---|
| Aptos Site 3<br>Aptos Segment 3<br>(Since 2018) | + | − | Similar | Similar | Similar | +<br>(more food but shallower) |
| Aptos Site 4<br>Aptos Segment 4<br>(Since 2018) | + | Same | + | Similar | + | +<br>(more food, and pool cover with less fines) |
| (Valencia Site 2)<br>Valencia 2<br>(Since 2018) | + | − | Similarly High | NA<br>(lack of cobbles in 2018) | − | –<br>(less pool depth and cover with likely little food improvement; highly sedimented) |
| (Valencia Site 3)<br>Valencia 3<br>(Since 2018) | + | + | Similarly High | Similar | + | +<br>(more food, depth and cover) |

**Table 7. Water quality measurements in the Aptos Estuary during steelhead sampling, 8 and 15 October 2019.**

| | | | 8-Oct-19 | | | | | 15-Oct-19 |
|---|---|---|---|---|---|---|---|---|
| | **Walk-bridge** (thalweg) Gage Height= 4.95 | | | 831 hr | **Walk-bridge** (thalweg) Air temp. 8.8°C; Gage Height= 4.90 | | | 0820 hr |
| **Depth (m)** | **Temp ( C)** | **Salin (ppt)** | **Oxygen (mg/l)** | **Cond micro-mhos** | **Temp ( C)** | **Salin (ppt)** | **Oxygen (mg/l)** | **Cond micro-mhos** |
| **0 (surface)** | 14.4 | 0.6 | 10.71 | 952 | 23.9 | 0.6 | 12.28 | 870 |
| **0.25** | 14.4 | 0.6 | 10.56 | 945 | 13.9 | 0.5 | 12.34 | 867 |
| **0.5** | 14.4 | 0.6 | 10.54 | 961 | 13.9 | 0.5 | 12.37 | 857 |
| **0.75** | 14.4 | 0.6 | 11.77 | 962 | 14.9 | 0.7 | 14.97 | 1106 |
| **1.0** | 21.7 | 8.0 | 26.12 | 13030 | 20.6 | 4.5 | 32.52 | 7411 |
| **1.25** | 23.9 | 11.8 | 22.19 | 19369 | 24.3 | 10.2 | 31.17 | 17182 |
| **1.5** | 24.7 | 14.1 | 21.74 | 23151 | 26.8 | 13.4 | 27.66 | 23077 |
| **1.75bot*** | 24.8 | 16.6 | 13.53 | 27729 | 27.5 | 16.0 | 14.58 | 27455 |

*** "bot" indicates the estuary bottom where measurements were taken through the water column.**

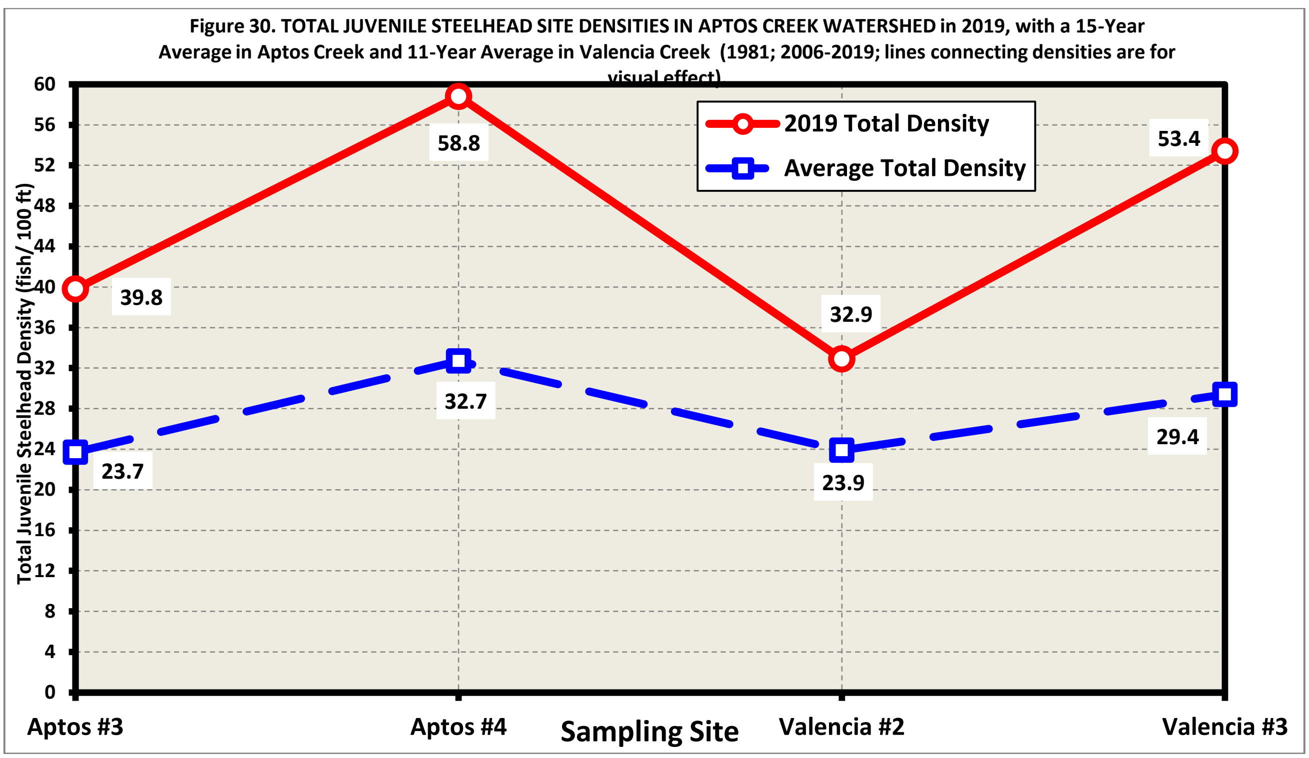



**Figure 30. Total Juvenile Steelhead Site Densities in Aptos Watershed in 2019, Compared with a 15-Year Average (1981; 2006-2019).**

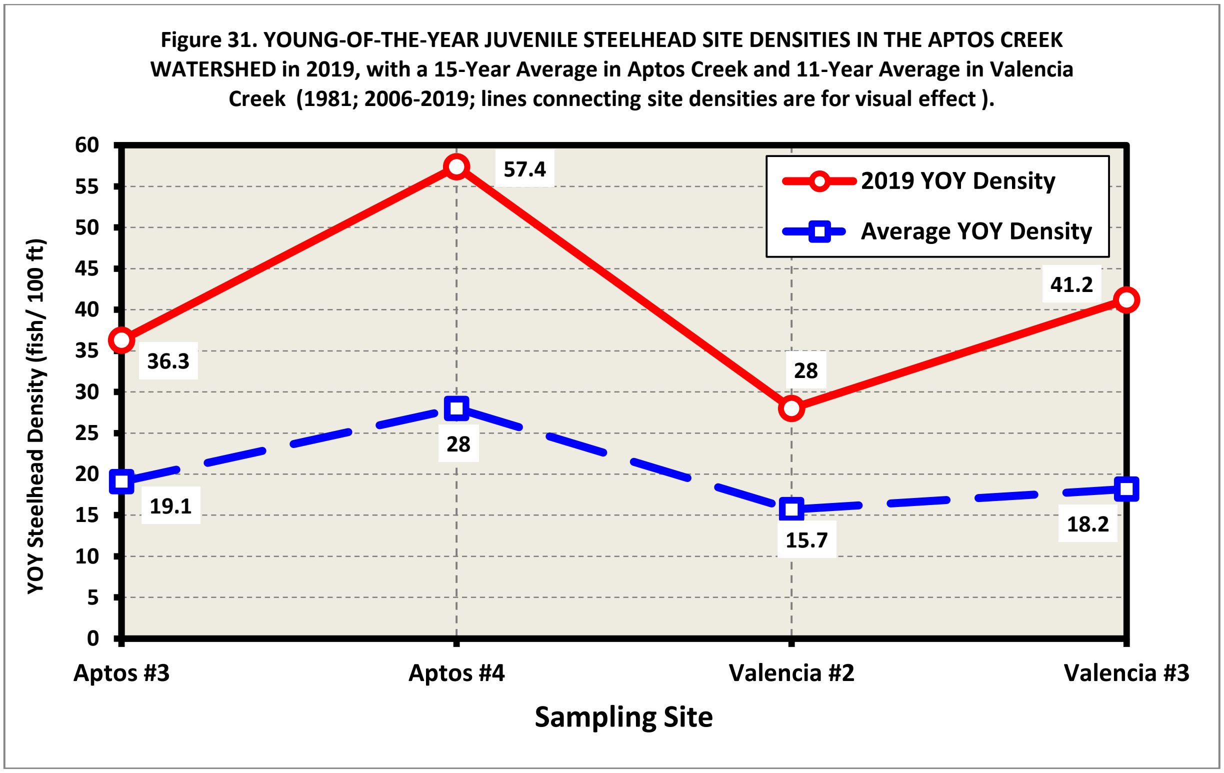



**Figure 31. Young-of-the-Year Steelhead Site Densities in Aptos Watershed in 2019, Compared with a 15-Year Average (1981; 2006-2019).**

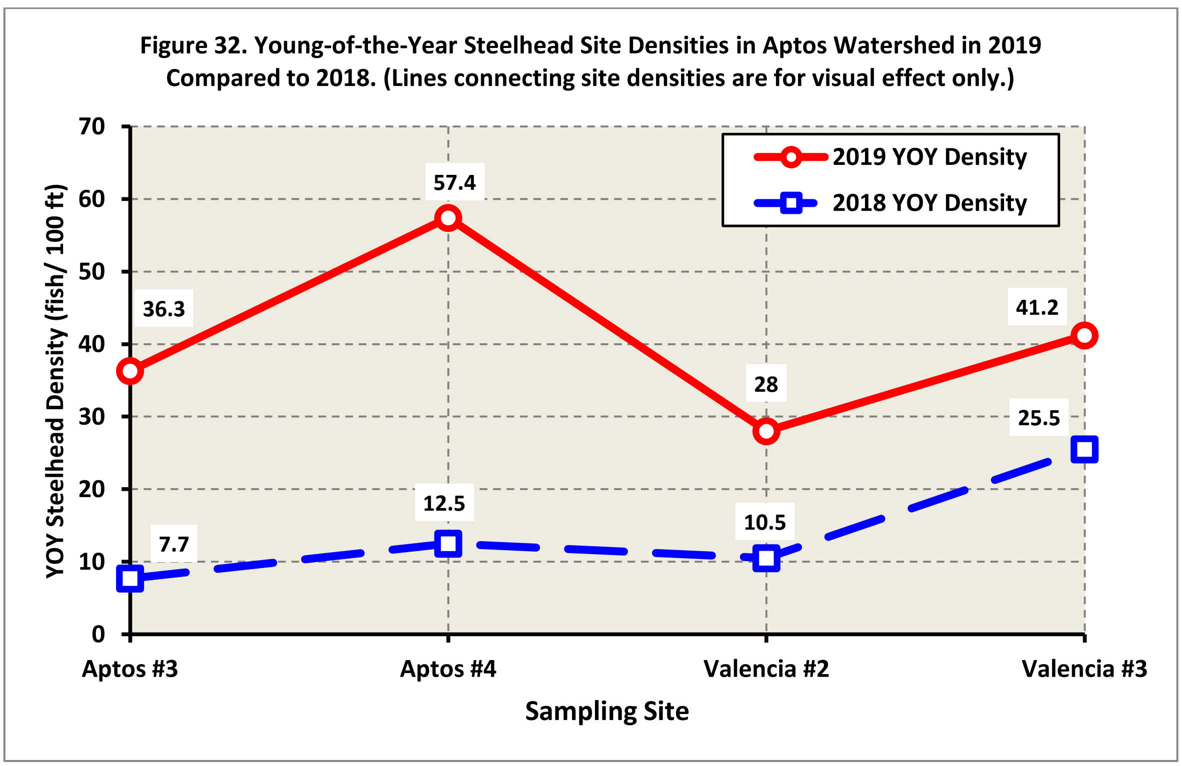



**Figure 32. Young-of-the-Year Site Densities in Aptos Creek, Comparing 2019 to 2018.**

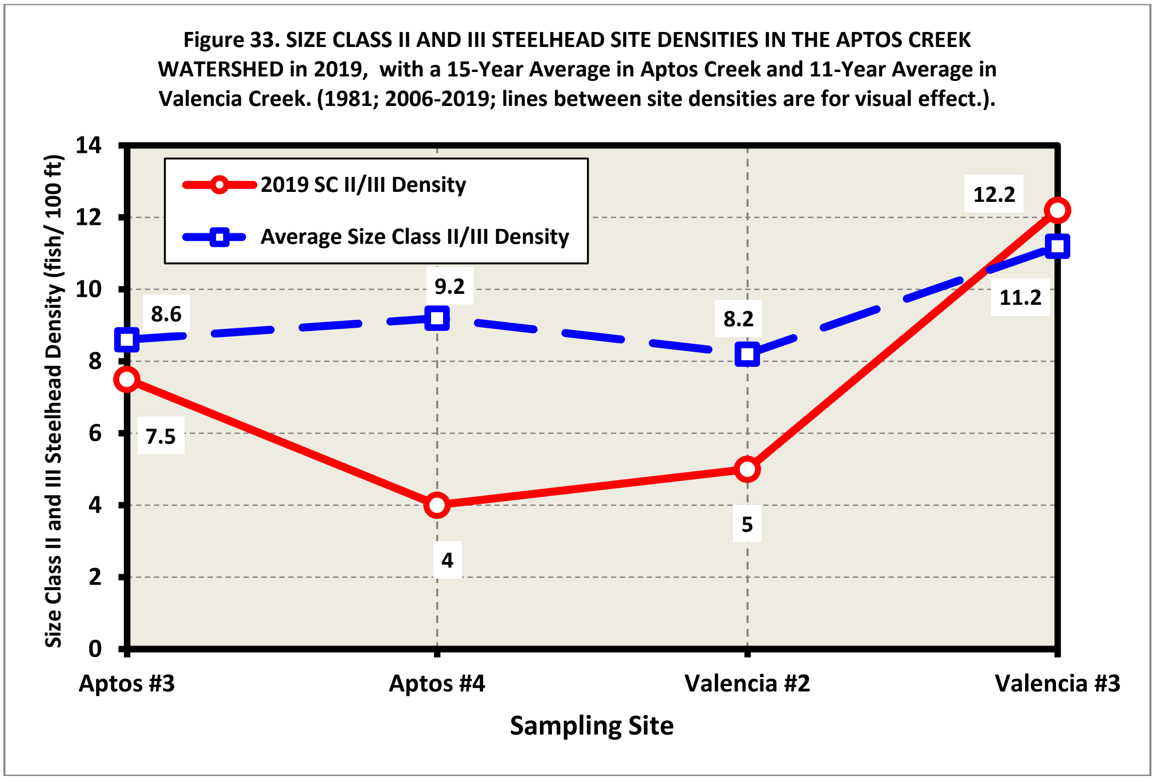



**Figure 33. Size Class II and III Steelhead Site Densities in Aptos Watershed in 2019, Compared with a 15-Year Average (1981; 2006-2019).**

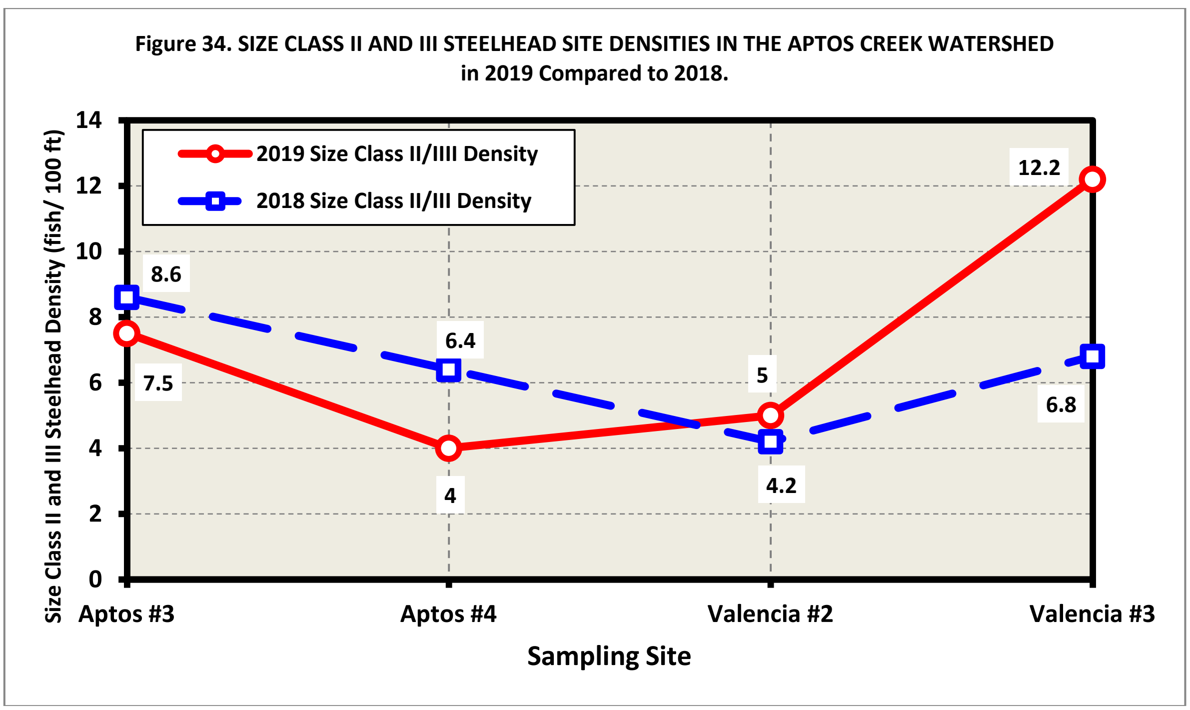



**Figure 34. Size Class II and III Steelhead Site Densities in Aptos Creek in 2019 Compared to 2018.**

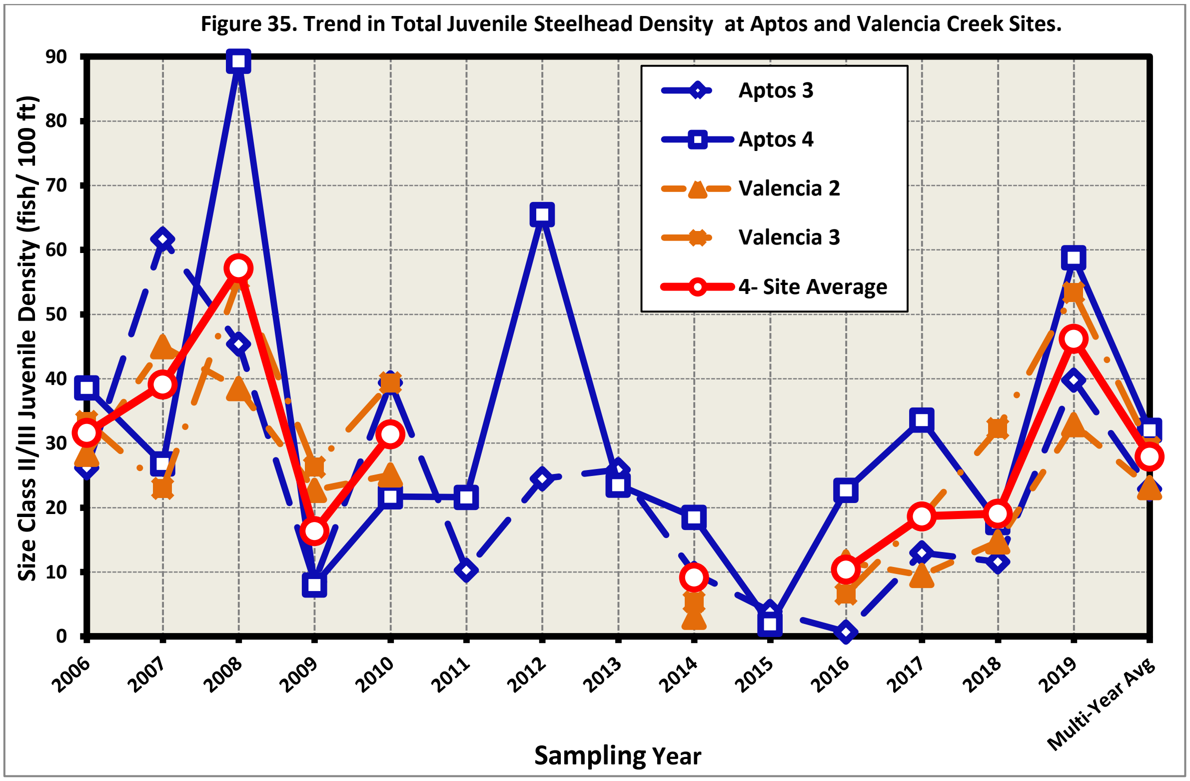



**Figure 35. Trend in Total Juvenile Steelhead Site Densities in Aptos Watershed for 2006–2019.**

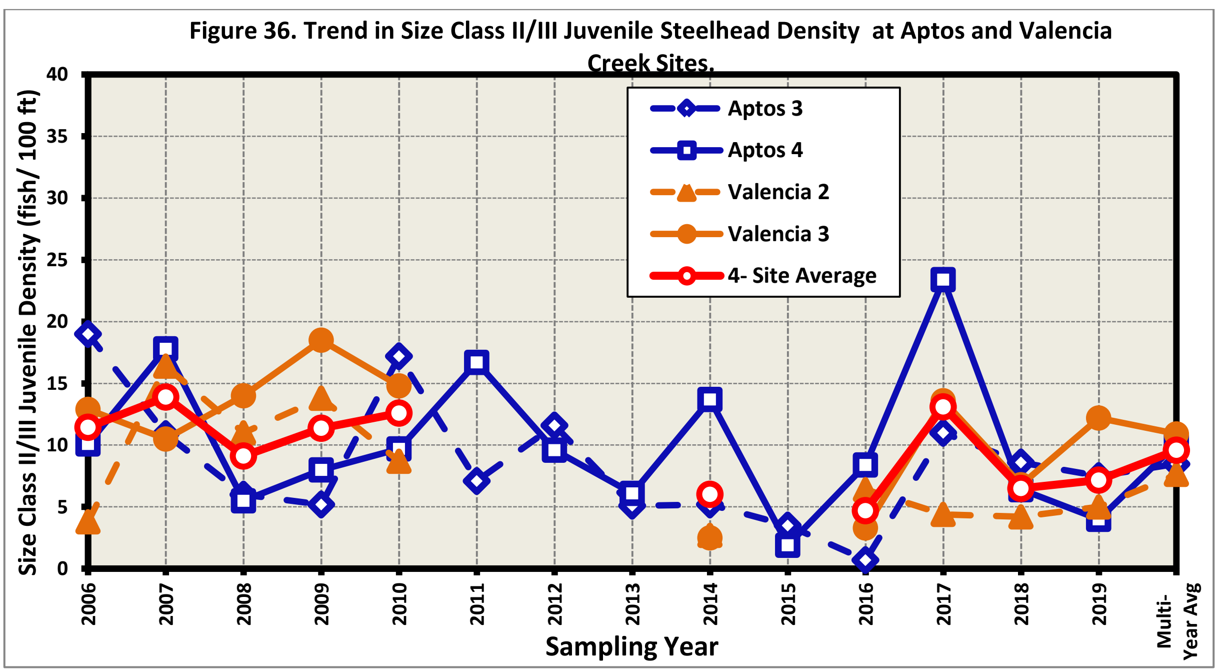
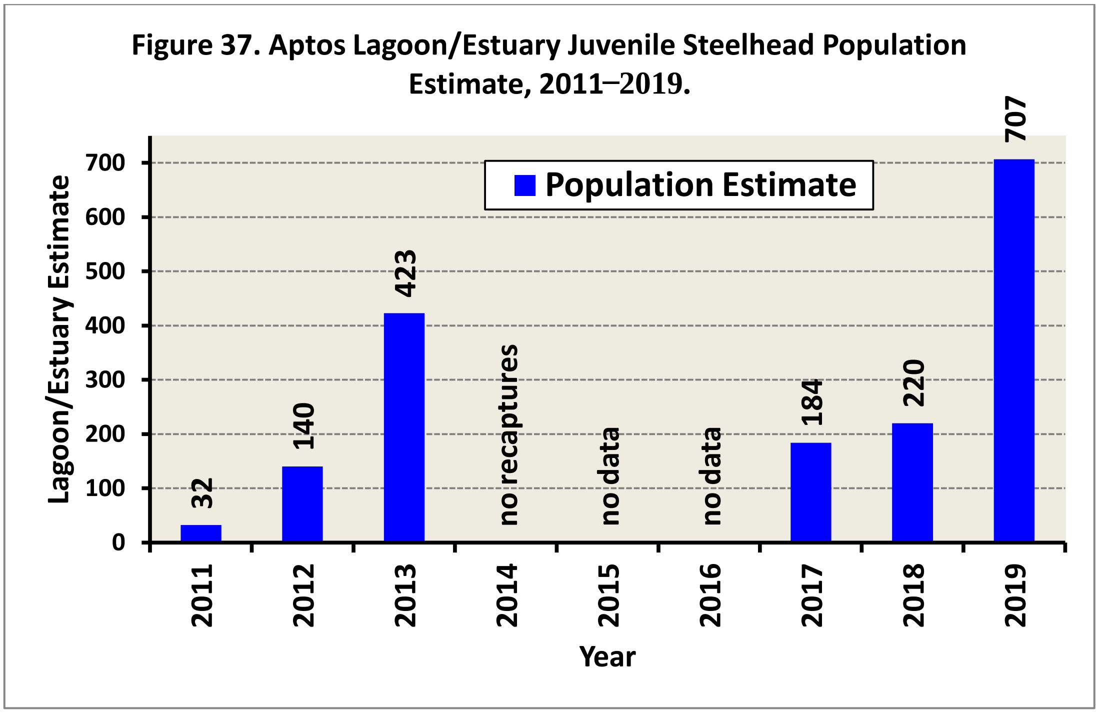



**Figure 36. Trend in Size Class II and III Steelhead Site Densities in Aptos Watershed for 2006–2019.**




**37. Aptos Lagoon/Estuary Juvenile Steelhead Population Estimate, 2011–2019.**

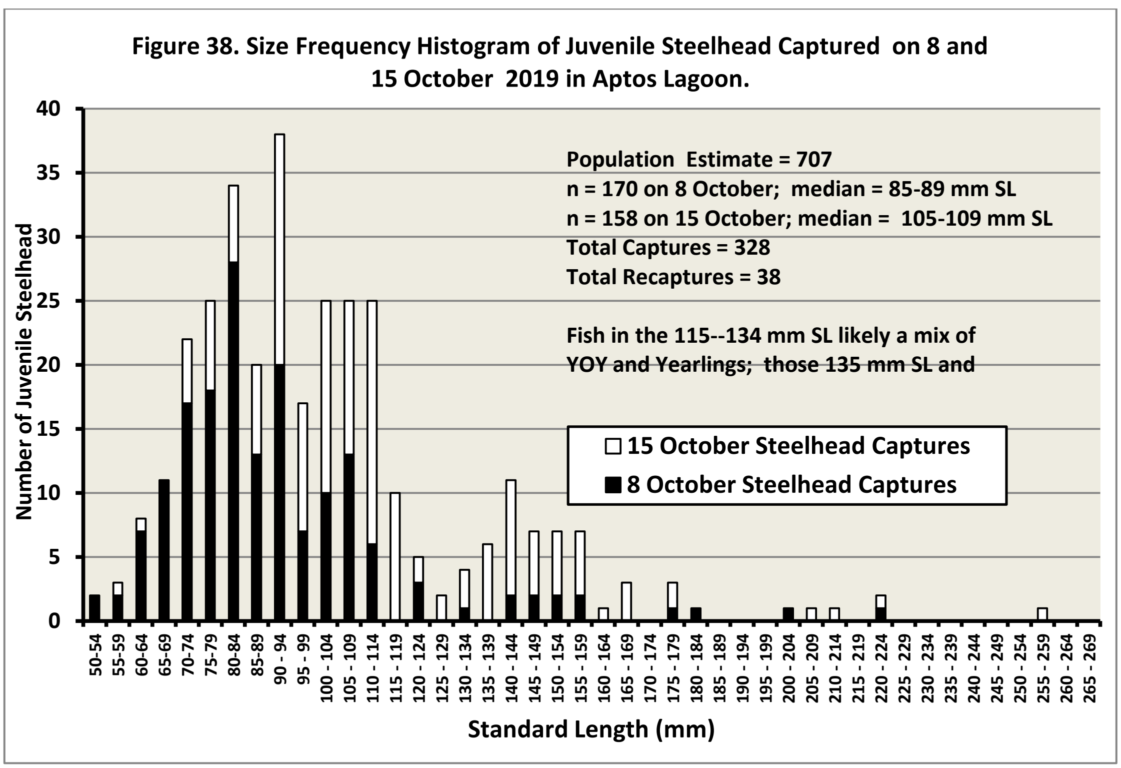



**Figure 38. Size Frequency Histogram of Steelhead Captured in Aptos Lagoon, October 2019.**

## *iv. Statistical Analysis of Annual Difference in Juvenile Steelhead Densities*

The trend in fish densities between 2018 and 2019 was analyzed by using a paired t-test (**Snedecor and Cochran 1967; Sokal and Rohlf 1995; Elzinga et al. 2001**). Comparisons were made for total density, age class densities and size class densities (Total, AC1, AC2, SC2). The paired t-test is among the most powerful of statistical tests, where the difference in mean density (labeled "mean difference" in the analysis) is tested. This test was possible because the compared data were taken at the same sites between years with consistent average habitat conditions between years, as opposed to re-randomizing each year. The null hypothesis for the test was that among all compared sites, the site-by-site difference between years 2018 and 2019 was zero. The non-random nature of the initial choice of sites was necessary for practical reasons and does not violate the statistical assumptions of the test; the change in density is a randomly applied effect (i.e. non-predictable based on knowledge of the initial sites) that does not likely correlate with the initial choice of sites. So, the mean difference is a non-biased sample.

The null hypothesis was that the difference in mean density was zero. Sampling results from 2019 were compared to 2018, such that a positive difference indicated that the densities in 2019 were larger than in 2018 on average. A p-value of 0.05 meant that there was only a 5% probability that the difference between densities was zero and a 95% probability that it was not zero. A 2-tailed test was used, meaning that an increase or a decrease was tested for. The confidence limits tell us the limits of where the true mean difference was. The 95% confidence interval indicated t there was a 95% probability that the true mean difference was between these limits. If these limits included zero, then it could not be ruled out that there was no difference between 2018 and 2019 densities. The 95% confidence limits are standard and a p-value of < 0.05 was considered significant.

With 20 comparable sites in the San Lorenzo mainstem and tributaries, increased total densities and YOY densities in 2019 were significant at the p-value=0.01 level (**Table 8**). Increased Size Class II/III densities in 2019 was nearly significant at the p-value=0.05 level. With 6 comparable sites in the Soquel watershed, increases in total densities and densities of YOY and Size Class II were statistically significant at p-value = 0.05 (**Table 9**). With 3 comparable sites between years in the Aptos watershed, increases in total densities and YOY densities were statistical significant at the p-value=0.05 level (**Table 10**).

**Table 8. Paired T-test for the Trend in Steelhead Site Densities by Size Class and Age Class at All Replicated Sampling Sites in the SAN LORENZO Watershed (2019 to 2018; n=20).**

| Statistic | s.c. 2 | a.c. 1-YOY | a.c. 2 | All Sizes |
|---|---|---|---|---|
| Mean difference | 2.8 | 29.85 | -0.94 | 28.94 |
| Df | 19 | 19 | 19 | 19 |
| Std Error | 1.35 | 5.28 | 0.74 | 5.43 |
| t Stat | 2.09 | 5.65 | -1.26 | 5.33 |
| P-value (2-tail) | 0.0507 | 0.0000 | 0.2227 | 0.0000 |
| 95% CL (lower) | -0.01 | 18.80 | -2.50 | 17.57 |
| 95% CL (upper) | 5.62 | 40.89 | 0.62 | 40.30 |

**Table 9. Paired T-test for the Trend in Steelhead Site Densities by Size Class and Age Class at All Replicated Sampling Sites in the SOQUEL Watershed (2019 to 2018; n=6).**

| Statistic | s.c. 2 | a.c. 1-YOY | a.c. 2 | All Sizes |
|---|---|---|---|---|
| Mean difference | 5.38 | 25.98 | -0.63 | 26.02 |
| Df | 5 | 5 | 5 | 5 |
| Std Error | 1.61 | 8.76 | 0.77 | 9.84 |
| t Stat | 3.35 | 2.97 | -0.82 | 2.94 |
| P-value (2-tail) | 0.0204 | 0.0313 | 0.4485 | 0.0321 |
| 95% CL (lower) | 1.25 | 3.46 | -2.61 | 3.30 |
| 95% CL (upper) | 9.52 | 48.51 | 1.35 | 48.74 |

**Table 10. Paired T-test for the Trend in Steelhead Site Densities by Size Class and Age Class at All Repeated Sampling Sites in the APTOS Watershed (2019 to 2018; n=3).**

| Statistic | s.c. 2 | a.c. 1-YOY | a.c. 2 | All Sizes |
|---|---|---|---|---|
| Mean difference | 1.70 | 21.27 | 1.60 | 22.50 |
| Df | 2 | 2 | 2 | 2 |
| Std Error | 1.93 | 3.67 | 2.00 | 2.97 |
| t Stat | 0.88 | 5.80 | 0.80 | 7.57 |
| P-value (2-tail) | 0.4712 | 0.0285 | 0.5083 | 0.0170 |
| 95% CL (lower) | -6.60 | 5.49 | -7.02 | 9.72 |
| 95% CL (upper) | 10.00 | 37.05 | 10.22 | 35.28 |

**Don Alley, Josie Moss and Chad Steiner measuring steelhead; Fall Creek. (Photo by Nina Moore)**

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# D. GLOSSARY

**Bankfull stage/ discharge:** Corresponds to the discharge (streamflow) at which channel maintenance is most effective. It is the discharge at which moving sediment, forming or removing bars, forming or changing bends and meanders, and generally doing work that results in the average morphologic characteristics of stream channels. The bankfull discharge or greater discharges are channel-forming streamflows. The bankfull discharge has a recurrence interval of approximately 1.5 years.

**Baseflow:** Streamflow that is derived from natural storage i.e., groundwater outflow outside the net rainfall that creates surface runoff. It is the discharge (streamflow) sustained in the stream channel, not as a result of direct runoff and without the effects of regulation, diversion or other human activities. Also called groundwater flow.

**Escape cover:** Where a fish hides from predators, including beneath surface turbulence and overhanging riparian vegetation and under unembedded boulders, within undercut banks and under instream wood.

**Fish Density:** Number of fish per 100 feet of stream channel in this report.

**Fish Habitat:** Where a fish lives that provides food and shelter necessary to survive. It is the aquatic environment and the immediate terrestrial environment that combine to provide biological and physical support systems required by fish species during various life stages.

**Fork Length (FL):** Fish length from snout to mid point in the tail's edge.

**Hydraulic control point:** The top of an obstruction in the stream channel in which streamflow must rise before passing over, or a point in the stream where the flow is constricted. The hydraulic control point determines the water surface elevation upstream to the next riffle or run. It is typically at the tail of a pool. Riffles and runs have no hydraulic controls except for very short distances at most.

**Hydrograph:** A graph showing the discharge (streamflow) or stage (water surface elevation) at a specific location with respect for time.

**Instream Wood cluster:** Logjam that extends into the summer low flow channel.

**Large woody debris:** A large piece of relatively stable instream wood having a diameter greater than 1 foot and length greater than 6 feet that extends into the stream channel, either at baseflow or during winter stormflows. We prefer to call it **large instream wood**.

**Low flow:** The lowest streamflow recorded over a specified period of time. Also called **minimum flow**.

**Mainstem:** The principal or dominating stream channel in a drainage (watershed) system. Tributary streams flow into the mainstem.

**Overwintering cover:** Where fish find refuge and resting places from fast water during stormflows. It may be along undercut banks or behind large boulders and/or large instream wood.

**Percent Embeddedness:** The percent buried in fine sediment or sand of large streambed particles (cobbles and boulders large enough for Size Class II salmonids to hide under for escape cover).

**Percent fines:** The percent of the streambed area covered with silt and sand in a habitat type.

**Pool:** A deeper stream habitat with no surface turbulence except at the head and has places where downstream water velocity is near zero or where water is backwatered with upstream eddies. Pools are formed by scour objects, such as large instream wood, large boulders, streambank tree roots or bedrock faces.

**Reach segment:** A specified length of stream within a stream reach. In this study, stream segments are ½ mile in length and are considered representative of habitat in the reach. Habitat characteristics and fish are sampled within historically designated reach segments to assess annual trends in habitat conditions and fish densities within reaches.

**Representative reach fish sampling:** For all stream reaches except the mainstem San Lorenzo River up to the Boulder Creek confluence, fish sampling sites are chosen within representative stream segments of stream reaches based on the pools within the sampling site having near-average pool depth and escape cover for the segment. Representative pools and adjacent fastwater habitats are sampled by electrofishing at the site. For the mainstem San Lorenzo River, representative fastwater riffles and runs regarding near-average stream depth are electrofished, and nearby historical pools are snorkel censused.

**Riffle:** Relatively shallow, fastwater habitat with surface turbulence and often exposed cobbles and boulders. It is where most of the aquatic insect larvae are produced and where insect drift rate is the highest.

**Riparian vegetation:** Vegetation growing on or near streambanks or other water bodies on soils that exhibit near or completely water saturated conditions during some portion of the growing season. Common native riparian tree species in the Santa Cruz Mountains include redwood, Douglas fir, California bay, tanoak, willow, alder, bigleaf maple, cottonwood, dogwood, sycamore and box elder. Acacia, a non-native riparian tree species, is becoming more common.

**Run:** Deeper than riffle, fastwater habitat without surface turbulence, but is moving.
**Scour:** The localized removal of material from the streambed by flowing water. It causes the stream channel to deepen and is the opposite of fill.

**Shade:** The percent canopy closure over the stream as estimated by a spherical densiometer.

**Size Class I steelhead/ coho salmon:** Juvenile steelhead or coho salmon captured in the fall that are less than 75 mm Standard Length.

**Size Class II steelhead/ coho salmon:** Juvenile steelhead or coho salmon captured in the fall that are between 75 and 150 mm Standard Length. Steelhead in this size class include fast-growing young-of-the-year and yearling juveniles.

**Size Class III steelhead:** Juvenile steelhead captured in the fall that are at least 150 mm Standard Length.

**Soon-to-smolt-steelhead:** Juvenile steelhead captured in the fall that are 75 mm Standard Length or larger and will likely smolt the following spring.

**Spawning Gravel:** Streambed particle size between one quarter and 3 and a half inches in diameter. Usually found within **spawning glides** at the tails of pools or runs just upstream of steep, focused riffles.

**Standard Fish Length (SL):** Fish length from snout to end of spinal column in caudal peduncle before the tail.

**Steelhead/ coho salmon adult migration:** Adult steelhead are sexually mature and typically migrate upstream from the ocean through an open sandbar after several prolonged storms; the migration seldom begins earlier than December and may extend into May if late spring storms develop. Many of the earliest migrants tend to be smaller than those entering later in the season. Adult fish may be blocked by barriers such as bedrock falls, wide and shallow riffles and occasionally logjams. Man-made objects, such as culverts, bridge abutments, dams and remnant dam abutments are often significant barriers. Some barriers may completely block upstream migration, but many barriers in coastal streams are passable at higher streamflows. If the barrier is not absolute, some adult steelhead are usually able to pass in most years, since they can time their upstream movements to match optimal stormflow conditions. However, in drought years and years when storms are delayed, some obstructions can be serious barriers to steelhead and especially coho salmon spawning migration. Sexually mature adult coho salmon often have more severe migrational challenges because much of their migration period, November through early February, may be prior to stormflows needed to pass bridge abutments, shallow riffles, boulder falls and partial logjam barriers. Access is also a greater problem for coho salmon because they die at maturity and cannot wait in the ocean an extra year if access is poor due to failure of sandbar breaching during drought or delayed stormflow.

**Steelhead/ coho salmon smolt migration:** Fish undergo physiological changes to their gills and kidneys to adapt to saltwater to prevent dehydration. Juveniles passively migrate with the current at night, downstream to the ocean, mostly in February through May. They may spend time in the estuary and become silvery with black-tipped fins before exiting the stream.

**Step-run:** A habitat that is turbulent like a riffle but has many hydraulic controls formed by larger cobbles and boulders to create slower, deeper pocket water as the stream's water surface stair-steps over the multiple hydraulic controls. Step-runs often have considerable escape cover in the form of surface turbulence and spaces under unembedded boulders.

**Streambank:** The portion of the stream channel cross section that restricts lateral movement of water at below bankfull flows. The streambank often has a gradient steeper than 45 degrees and exhibits a distinct break in slope from the stream bottom.

**Stream Gradient:** The slope or rate of change in vertical elevation of the water surface of a flowing stream per unit of horizontal distance.

**Stream Reach:** A relatively homogeneous section of a stream having a repetitious sequence of physical characteristics and habitat types, and it differs from adjacent reaches. Reach boundaries may be determined by changes in stream gradient that determine dominant particle size and habitat length, changes in streamflow and water temperature with the confluence of tributaries, changes in substrate composition associated with stream gradient and tributary sediment input, and changes in tree canopy (shade). As stream gradient lessens, pool length increases and pool to riffle ratios increase.

**Thalweg:** The line connecting the deepest points along a streambed (where the water depth is greatest). Most of the water volume with the fastest water velocity flows through the thalweg. Salmonids spawn in the thalweg of spawning glides.

**Tributary:** A smaller stream feeding, joining, confluencing with or flowing into a larger stream.

**Turbidity:** It is related to water clarity. It is a measure of the extent to which light passing through water is reduced due to suspended materials- can be suspended sediment or phytoplankton. Juvenile salmonids are visual feeders and require conditions of low turbidity to see their drifting prey.

**Undercut streambank:** A streambank with its base cut away by water scour action along man-made and natural overhangs in streams, such as those formed by rootmasses of riparian trees.

**Water Depth:** The vertical distance from the water surface to the streambed.

**Yearling steelhead:** Juvenile steelhead captured in the fall and hatched 2 springs previously.

**Young-of-the-year steelhead and coho salmon (YOY):** Juvenile steelhead and coho captured in the fall and hatched earlier in the spring