D.W. ALLEY & Associates — aquatic biology

2020 SUMMARY REPORT− Juvenile Steelhead Densities and Indices of Juvenile Production in the San Lorenzo, Soquel and Aptos Watersheds, Santa Cruz County, CA

Fastwater Habitat, San Lorenzo River Downstream of Boulder Creek Confluence. (Photo by D. Alley)

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A. EXECUTIVE SUMMARY

WY2020 baseflow was below the median flow statistic, unlike the previous wetter WY2019, making 9 of the last 14 water years below median flow (**Figures 4 and 21**). Based on NOAA Fisheries' best estimate of only modest adult steelhead returns to Scott Creek over the 2019/2020 winter and spring (**Joseph Kiernan, NOAA Fisheries pers. comm.**), we suspect that numbers of returning adults may have also been similarly low in the San Lorenzo (SLR), Soquel and Aptos watersheds as in other recent years, excepting over the 2018/2019 winter and spring. Juvenile coho salmon were not detected at sampling sites. No juvenile steelhead PIT-tagged in the SLR lagoon/estuary were detected upstream. **Total and young-of-the-year (YOY) densities at most SLR sites** were well below average, and much less than in 2019 (statistically significant). Sampling results indicated lower YOY steelhead densities at many upper tributary sites compared to higher YOY densities at lower mainstem sites and most lower tributary sites except for Boulder and Bear creeks. This indicated that adult steelhead spawners did not take good advantage of early storms in the SLR watershed and may have experienced passage difficulties in reaching some upper sites in March and April when small stormflows occurred. Additionally, few adults likely returned to spawn late, with poor spawning conditions due to low streamflow, contributing to low YOY densities. Nonnative bullfrog tadpoles were abundant in Boulder Creek, and 2 subadults were captured at SLR mainstem below the Boulder Creek confluence. An atypical algal film occurred on pool habitat in Boulder Creek. Unusual filamentous algal blooms occurred at Bear Creek sites, indicating fertilizer pollution.

In the Soquel and Aptos watersheds, total and YOY densities were much below average and much less than in 2019 (statistically significant). Streamflow measured at the Soquel Village gage indicated stormflow patterns similar to the SLR except that the April stormflow reached 1,500 cfs in Soquel Creek instead of the 600 cfs on the SLR, and was likely above bankfull. This late stormflow provided better spawning access in lower gradient watersheds, such as Soquel and Atos, compared to the SLR. Though sampling indicated much below average total and YOY densities throughout, the highest densities occurred at uppermost sites in the Soquel Creek Branches. They were uniformly low at all sites in the Aptos watershed, indicating uniform spawning access but few adult spawners and poor spawning success during a dry winter.

After above average YOY densities in all watersheds in 2019, **2020 densities of yearlings and larger juveniles** (=>75 mm SL) in all watersheds were closer to average than YOY densities and higher than in 2019 at some upper tributary sites where small yearlings still resided. 2020 size Class II/III densities in the SLR were mostly less than in 2019 (statistically significant). Yearling densities were much below average in middle and upper mainstem SLR sites, most lower SLR tributary sites and all sampled Soquel sites except the uppermost Branch sites. The trend in Size Class II/III densities and the trend in index of Size Class II/III numbers tracked positively with averaged 5-month baseflow in SLR and Soquel watersheds but less so in Aptos Creek. At Aptos watershed sites, 2020 densities of larger juveniles were close to average and higher than in 2019, with more small yearlings. Slow juvenile growth rate occurred in 2020 at headwater sites in SLR tributaries and the upper SLR mainstem (Branciforte, Zayante, Bean, Fall (both sites), Boulder and the mainstem at Waterman Gap) and in Soquel Branches (West Branch Site #21 and East Branch–Ashbury site) with more shading and lower baseflows, thus retaining relatively high densities of smaller yearlings. The Aptos Estuary steelhead population estimate was 365 in 2020, the third highest in 7 years. All captured steelhead in the estuary were in the Size Class II/III range.

2020 rearing habitat conditions were compared to 2019. They declined with 1) **reduced baseflow** (less food); 2) with **decreased depth** across all watersheds; 3) with **increased embeddedness** in SLR tributaries including upper Bean and both Fall Creek sites, upper mainstem Soquel and lower West Branch Soquel; 4) with **increased fine sediment** in the 2 uppermost SLR mainstem sites, in SLR tributaries including fastwater habitats in all 3 Bean sites, Fall (both sites), Bear (both sites) and upper

Boulder. Increased fines occurred in upper mainstem Soquel, lower East Branch Soquel, West Branch Soquel (both sites) and Aptos Creek (both sites**); 5)** with **reduced escape cover** in middle SLR mainstem (2 sites), upper SLR mainstem below Kings Creek, Zayante (2 of 4 sites), Fall (both sites), upper Boulder and lower Bear, lowermost and uppermost mainstem Soquel, East Branch Soquel and upper Valencia.

B. INTRODUCTION

i. Scope of Work

In fall 2020, 3 Santa Cruz County watersheds were sampled for juvenile steelhead to primarily compare juvenile abundance at multiple stratified sites in each watershed to assess trends and compare habitat conditions in habitat typed segments and at sampling sites with those in 2019 and past years in selected reaches of the San Lorenzo, Soquel and Aptos watersheds (**Figures 1−3**). Photos of selected sampling sites may be found in **Appendix A**. 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 and more sampling site photos. 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 2019 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 9 sites (5 mainstem and 4 branch sites), Site 6 in Reach 4 added in 2020 after a 15-year break. Four 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 2019 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, sites were chosen with some overlap at Aptos Site 3 and the previous pools at Aptos Site 4 remained average. The 2 Valencia Creek sites were replicated at the 2019 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.

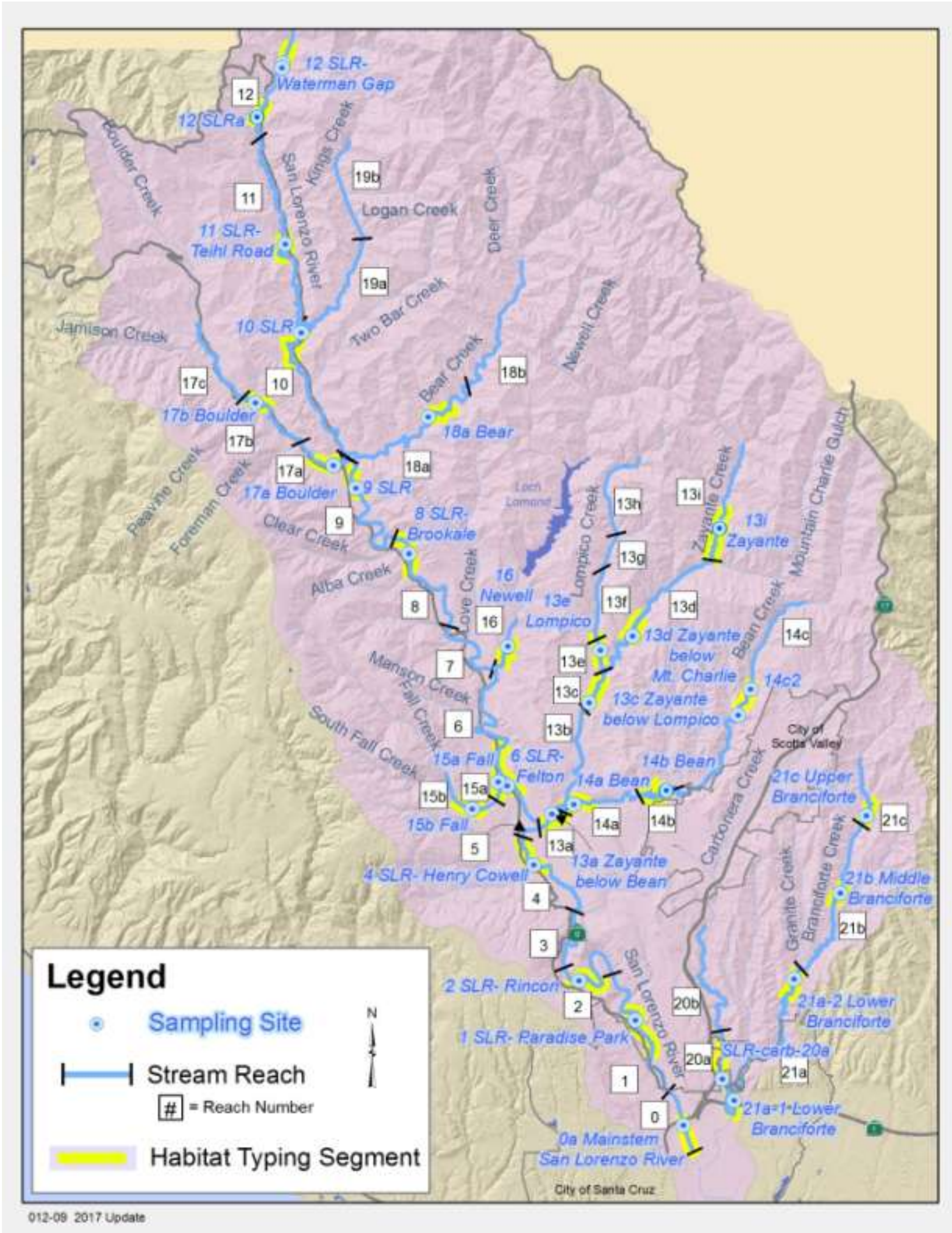


Figure 1. San Lorenzo River Watershed− Sampling Sites and Reaches.

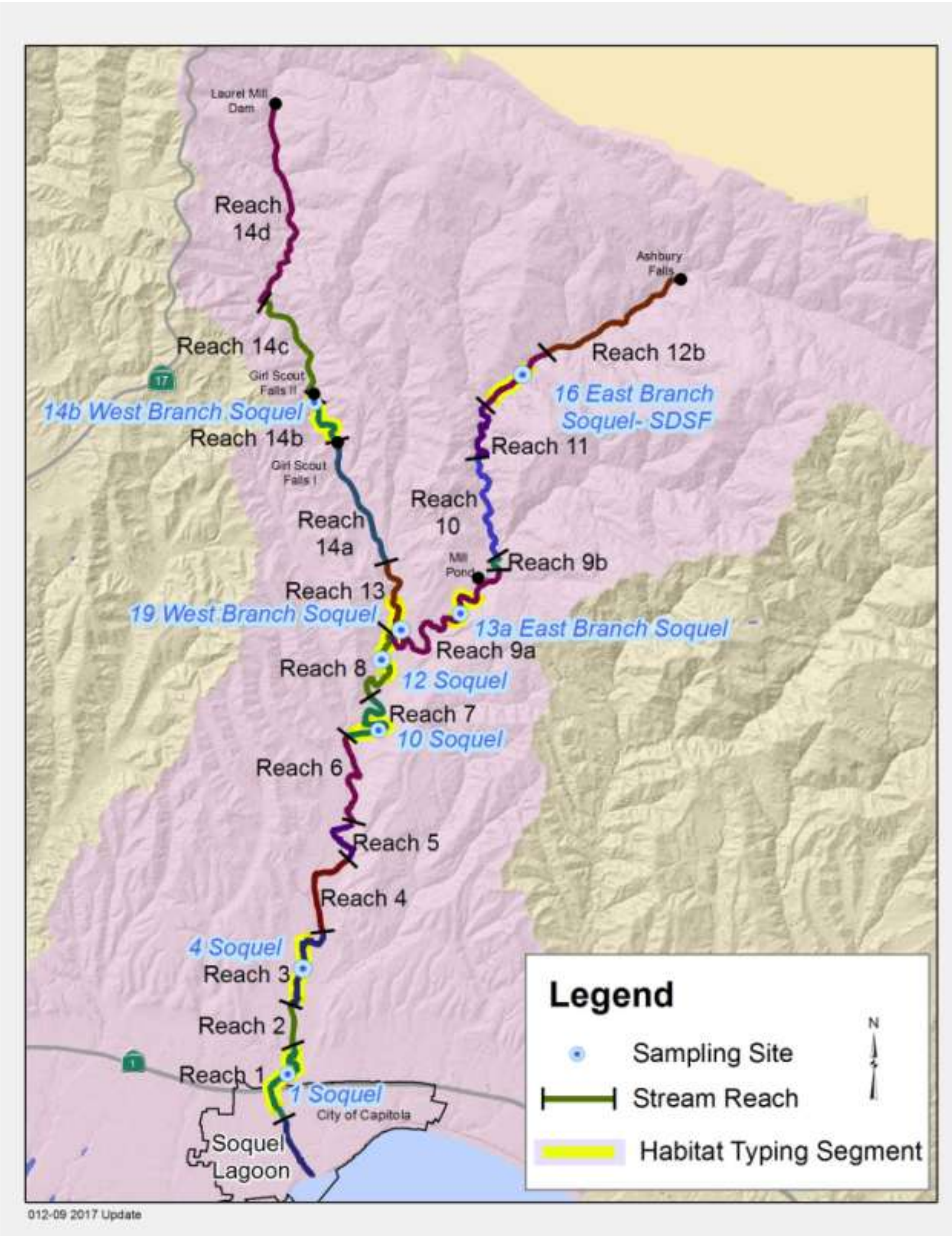


Figure 2. Soquel Creek Watershed.

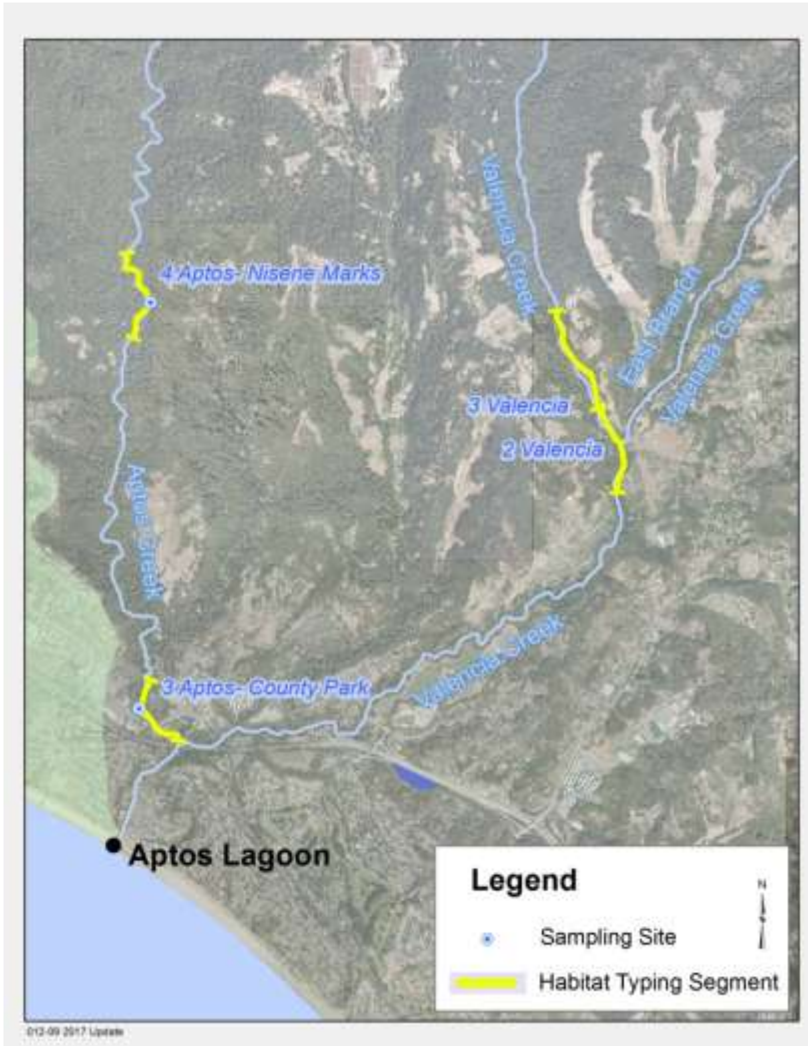


Figure 3. Aptos Creek Watershed.

C. RESULTS

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

1. WY2020 baseflow was low and below the median flow statistic, unlike the previous wetter WY2019, making 9 of the last 14 water years below median flow (**Table 1; Figures 4 and 21**). Based on NOAA Fisheries' best estimate of only modest adult steelhead returns to Scott Creek over the 2019/2020 winter and spring (**Joseph Kiernan, NOAA Fisheries pers. comm.**), we suspect that numbers of returning adults may have been similarly low in the SLR watershed, unlike during the 2018/2019 winter and spring. Locally, during the 2019/2020 winter and spring in the SLR, a series of 7 small, early stormflows between 100 and 2000 cfs (bankfull > 3,000 cfs) occurred from late November 2019 to February 1 2020 (primarily in December) at the Big Trees gage. No rain occurred in February, and two small stormflows between 100 and 600 cfs occurred in March and early April.

2. In the SLR watershed, rearing habitat conditions declined across all sites in 2020 due to **reduced baseflow** (less food) and **decreased depth** (**Table 3**). It declined with **increased embeddedness** in SLR tributaries including upper Bean and both Fall Creek sites and **increased fine sediment** in the 2 uppermost SLR mainstem sites, SLR tributaries including fastwater habitats in all 3 Bean sites, Fall (both sites), Bear (both sites) and upper Boulder creeks. **Escape cover** improved at 7 of 10 mainstem sites and 10 of 16 tributary sites (**Table 3**). It declined in the middle SLR mainstem (2 sites), upper SLR mainstem below Kings Creek, lower Zayante and upper Zayante below Mt. Charlie Gulch, Fall (both sites), upper Boulder and lower Bear creeks. Trends in escape cover and pool depth in the Zayante 13d reach are provided in **Figures 6 and 7**.

3. **SLR total and YOY juvenile densities** were well below average at 8 of 10 SLR mainstem sites (averaging 13 juveniles total/100 ft (35 in 2019), with the exception of 2 lower mainstem sites at above average (**Figures 8 and 9**). Total and YOY juvenile densities were below average at 14 of 16 SLR tributary sites (averaging 35 total juveniles/100 ft (68 in 2019). 2020 YOY densities declined at all 26 SLR sites compared to 2019 (**Figure 10**), as did total densities (statistically significant; **Table 8**). YOY steelhead densities were lowest at many upper tributary sites and higher at most lower tributary sites and lower mainstem sites. The exceptions were higher YOY densities at upper Boulder and Bear creek sites than their lower sites, though they were still below average.

4. The 5-site, long term ***trend in average mainstem site total density*** (consisting of mostly YOY) decreased in 2020 (**Figure 14**). The 10-site mainstem average total density declined more than half from 35 juveniles/100 ft in 2019 to 12 in 2020 (16 in dry 2018). The 10-site mainstem average YOY density decreased by more than two thirds from 33 juveniles/100 ft in 2019 to 10 in 2020 (12 in 2018). The 8-site, long term ***trend in average total density at tributary sites*** (consisting of mostly YOY) also decreased in 2020 (**Figure 15**). The 2020 16-site tributary average total density decreased by more than half from 68 juveniles/100 ft in 2019 to 30 in 2020 (38 in 2018). The 16-site tributary average YOY density was less than half the 63 YOY/100 ft in 2019 with 25 in 2020 (28 in 2018).

5. Four factors may explain the below average YOY densities at most sites in 2020. The main factor may have been low adult returns. Supportively, adult returns to Scott Creek indicated a relatively low adult steelhead run (**Figure 11**). Indications of low adult returns may have resulted from less favorable ocean rearing conditions as other recent years, combined with low adult recruitment from low Size Class II/III juvenile densities produced during the low flow 2018 year and few returning after one year ocean. A second factor may have been poor adult spawning access to the upper SLR watershed with most rains in December, no rain in February and only 2 minor stormflows in March and April. A third factor may have been poor egg survival during a relatively dry winter that provided poor spawning conditions. A fourth factor may have been below median baseflow that provided less food and rearing habitat to reduce YOY survival where YOY densities were moderate in spring/early summer but food competition intensified through the dry season.YOY size was small at most sites except where YOY densities were very low (upper SLR mainstem, Newell, upper tributary sites− Bean, Zayante, Fall and Branciforte) (**Figure 20**).

6. Consistent with low YOY densities in the San Lorenzo, Smith (**2020**) found in Gazos Creek that the average 2020 YOY steelhead density was extremely low (9 YOY/100 ft) for the 3 lowermost sites and the 1 uppermost site of the 9 pre-2020 sampled sites and reduced to about half of the worst previous years. In most low abundance years, access past logjams was a major apparent cause of low density in Gazos Creek. Storms were mild in 2020. So, access may have been a problem. But the spotty abundance included YOY at the uppermost sample site. So, the relative effect of access was unknown. In Waddell Creek with Smith (**2020**) sampling limited to 3 lower mainstem sites in 2020, he found the average YOY density to be low (13.6 YOY/100 feet), as it had been in most of the previous 21 years (since 1999). However, only 3 of the past 14 years exceeded the 2020 density.

7. **Yearling densities** were below average at most SLR sites in 2020 (17 of 26 sites) They were below average at 5 of 10 mainstem sites and 11 of 16 tributary sites (**Figure 12**). They were above average at the 4 lower mainstem sites below Zayante Creek and average at Site 6 below Fall Creek. However, mainstem yearling densities are typically low, on average.

8. **Size Class II/III (=> 75 mm SL) densities** were below average at most SLR sites (19 of 26 sites for these larger juveniles). They were below average at 7 of 10 SLR mainstem sites and above average at 3 of 4 lower mainstem sites (averaging 6.6 fish/100 ft; 9.7 in 2019) (**Figure 13**). They were below average at 12 of 16 tributary sites (averaging 7.8 fish/100 ft; 7.5 in 2019). 2020 size Class II/III densities were mostly less than in 2019 (statistically significant; **Table 8**). The average 5-site mainstem trend in soon-to-smolt-densities decreased for the mainstem SLR (**Figure 16**) (6.4 fish/100 ft; 20-year average of 7.3). The average 7-site tributary trend in the San Lorenzo decreased slightly in 2020 (**Figure 17a**) (7.1 fish/ 100 ft; 23-year average of 11.3). Trends in densities of these larger juveniles follow similar fluctuations through the wet and dry years in the SLR and Soquel watersheds, but less so for the Aptos/Valencia watershed (**Figure 17b**). They increase in wet years and decrease in dry years.

9. Low yearling and Size Class II/III densities in 2020 at non-headwater sites, despite high YOY densities in 2019, may have occurred partially because limited winter and spring stormflows resulted in high water clarity with modest baseflows and sufficient drifting aquatic insects to allow young yearlings to grow and smolt in late spring without spending a second summer in freshwater. This spring growth was noted from our smolts trapped during drought in 1987 and 1988 (**Jerry Smith pers. comm.**). The small, mid-May stormflow also facilitated smolt migration.

10. For soon-to-smolt-sized juveniles, annual average site densities and indices of juvenile numbers positively tracked with the declining 5-month baseflow average in 2020 (**Figures 18a-c and 19**). Although the overall average for mainstem site densities did not decline in 2020, the index of soon-to-smolt numbers in mainstem reaches did decline with lower baseflow. However, the index was still considerably higher than in 2018, likely because late spawning adults focused more heavily on lower mainstem sites than usual due to limited stormflows. And a portion of their YOY grew into Size Class II, as typically occurs in these higher baseflow sites below the Zayante Creek confluence. Decline in these larger juveniles in low baseflow years was partially caused by fewer YOY growing into Size Class II their first summer.

11. Five of 10 mainstem sites were rated “very poor” to “below average” in soon-to-smolt densities, mostly in the middle and upper mainstem above Zayante Creek (**Table 2**). Eight of 16 tributary sites were rated in the same range, including Zayante 13c, which typically has much higher densities.

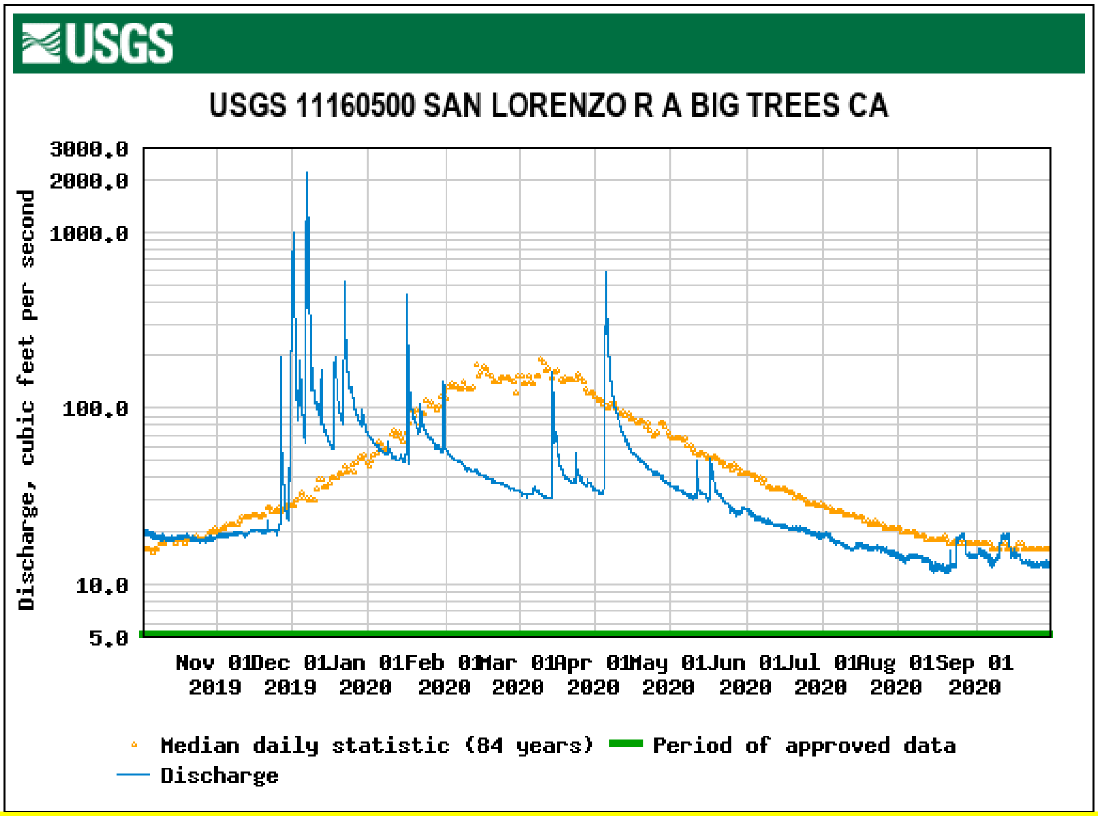


Figure 4. The 2020 Discharge Flow for the USGS Big Trees Gage on the San Lorenzo River at Felton.

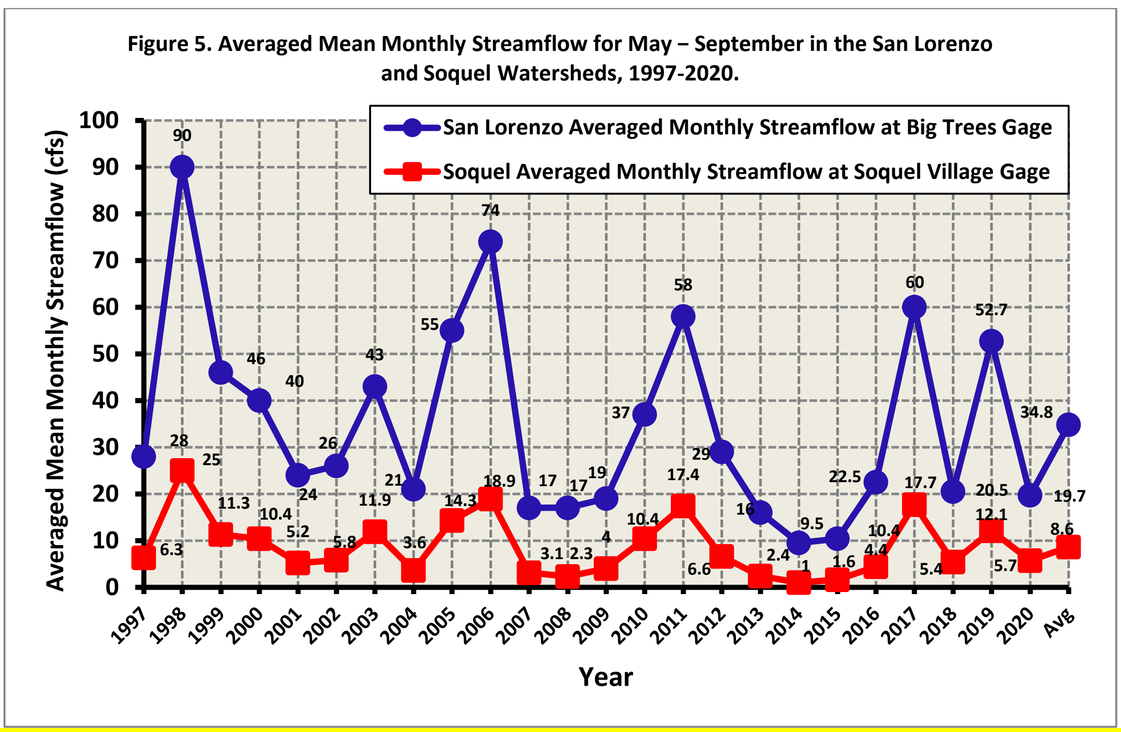


Figure 5. Averaged Mean Monthly Streamflow for May−September in San Lorenzo and Soquel Watersheds, 1997-2020.

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	2020
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	13.1
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/ B. 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	2.41
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	0.24
12a-b SLR/ Lower Waterman		1.0	0.7										0.33	0.10	0.22		0.85	0.39	0.78	0.32
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	4.64
13b/ Zayante above Bean		3.9	2.9	2.8	1.9	2.1	1.7	3.2	2.8											
14b/Bean below 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	Dry
14c-2/Bean abv MacKenzie																		0.02	0.06	0.02
15a–b/ Fall	2.0 Above Div	3.4 Abov Div.	2.2 Abov e Div	1.7 Abov e Div	1.7 Above Div									1.0 belo div. Bal	0.32 Belo div Bal	1.39 Belo div.	2.80 Bel div.	1.00 Bel div.		1.01 Bel div
16/ Newell	1.6			0.51						1.2	0.92	0.78	0.78	0.08	0.04		1.05	0.87		1.07 S.C.
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	1.24
18a/ Bear 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	0.10
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	0.29

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

Table 2. 2020 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	2020 Potential Smolt Density (per 100 ft)/ Avg Pot. Smolt Size SL	2020 Symbolic Rating (1 to 7)	2019 Potential Smolt Density (per 100 ft)/ Avg Pot. Smolt Size SL	Physical Habitat Change by Reach/Site (Since Previous Measure)
Low. San Lorenzo #0a	8.0/ 122 mm	4.1/ 131 mm	@@@@ Fair	8.4/ 124 mm	Site − (Since 2019)
Low. San Lorenzo #1	8.1/ 110 mm	13.3/ 96 mm	@@@@ Fair	15.5/ 95 mm	Site − (Since 2019)
Low. San Lorenzo #2	13.8/ 101	15.7/ 95 mm	@@@@ Fair	24.6/ 92 mm	Reach − (Since 2019)
Low. San Lorenzo #4	12.8/ 89 mm	14.4/ 94 mm	@@@@ Fair	16.2/ 88 mm	Site − (Since 2019)
Mid. San Lorenzo #6	3.6/ 90 mm	1.0/ 132 mm	@@ Poor	6.4/ 129 mm	Site − (Since 2019)
Mid. San Lorenzo #8	4.9/ 90 mm	0.5/ 86 mm	@ Very Poor	4.4/ 86 mm	Site − (Since 2019)
Mid. San Lorenzo #9	5.3/ 91 mm	0.5/ 96 mm	@ Very Poor	3.7/ 93 mm	Reach − (Since 2017)
Up. San Lorenzo #10	5.1/ 100 mm	2.9/ 105 mm	@@@ Below Average	3.7/ 102 mm	Site − (Since 2019)
Up. San Lorenzo #11	5.9/ 103 mm	2.7/ 102 mm	@@@ Below Average	5.7/ 103 mm	Site − (Since 2019)
Up. San Loren #12b	13.6/ 100 mm	11.0/ 97 mm	@@@@ Fair	8.7/ 105 mm	Site − (Since 2019)
Zayante #13a	8.4/ 98 mm	2.4/ 100 mm	@@ Poor	6.9/ 107 mm	Site − (Since 2019)
Zayante #13c	14.9/ 92 mm	2.4/ 84 mm	@ Very Poor	6.0/ 99 mm	Site − (Since 2019)
Zayante #13d	15.8/ 100 mm	8.6/ 98 mm	@@@@ Fair	9.6/ 101 mm	Reach − (Since 2019)
Zayante #13i	10.2/ 103 mm	16.2/ 89 mm	@@@@@ Good	6.1/ 116 mm	Reach − (Since 2019)
Bean #14a	4.3/ 92 mm	1.7/ 101 mm	@ Very Poor	3.6/ 97 mm	Site − (Since 2019)
Bean #14b	11.1/ 103 mm	6.6/ 101 mm	@@@ Below Average	6.6/ 102 mm	Reach − (Since 2019)
Bean #14c-2	9.9/ 104 mm (14c-1 & 14c-2)	12.6/ 101 mm	@@@@ Fair	10.9/ 107 mm	Site + (Since 2019)
Fall #15a	8.0/ 102 mm	11.2/ 103 mm	@@@@@ Good	12.6/ 106 mm	Site − (Since 2019)
Fall #15b	11.8/ 105 mm	10.6/ 97 mm	@@@@ Fair	11.3/ 111 mm	Reach − (Since 2018)
Newell #16	12.1/ 97 mm	9.5/ 123 mm	@@@@@ Good	11.7/ 94 mm	Site + (Since 2019)
Boulder #17a	10.2/ 106 mm	4.9/ 100 mm	@@@ Below Average	5.3/ 95 mm	Site − (Since 2019)
Boulder #17b	10.3/ 97 mm	10.0/ 106 mm	@@@@@ Good	9.0/ 90 mm	Reach + (Since 2018)
Bear #18a	8.2/ 102 mm	4.3/ 91 mm	@@@ Below Average	3.1/ 105 mm	Site − (Since 2019)
Bear #18b	11.0/ 100 mm	4.4/ 91 mm	@@@ Below Average	7.2/ 100 mm	Site − (Since 2019)

Site	Multi-Year Avg. Potential Smolt Density Per 100 ft/ Avg Pot. Smolt Size Since 2006	2020 Potential Smolt Density (per 100 ft)/ Avg Pot. Smolt Size SL	2020 Symbolic Rating (1 to 7)	2019 Potential Smolt Density (per 100 ft)/ Avg Pot. Smolt Size SL	Physical Habitat Change by Reach/Site (Since Previous Measure)
Branciforte #21a-2	8.6/ 102 mm	5.9/ 98 mm	@@@ Below Average	4.7/ 96 mm	Reach − (Since 2018)
Branciforte 21b	11.9/ 100 mm	12.8/ 91 mm	@@@@ Fair	4.7/ 108 mm	Site − (Since 2019)
Soquel #1	3.7/ 103 mm	2.5/ 89 mm	@@ Poor	10.2/ 95 mm	Site - (Since 2019)
Soquel #4	7.2/ 104 mm	4.2/ 102 mm	@@@ Below Average	3.9/ 90 mm	Reach + (Since 2018)
Soquel #6	5.7/ 100 mm	3.3/ 100 mm	@@ Poor	−	
Soquel #10	9.5/ 93 mm	5.4/ 90 mm	@@@ Below Average	18.6/ 86 mm	Site − (Since 2019)
Soquel #12	8.2/ 95 mm	3.5/ 93 mm	@@ Poor	19.1/ 87 mm	Reach − (Since 2018)
East Branch Soquel #13a	9.2/ 100 mm	2.7/ 101 mm	@@ Poor	4.7/ 96 mm	Site − (Since 2019)
East Branch Soquel #16	9.5/ 98 mm	4.2/ 98 mm	@@@ Below Average	8.6/ 88 mm	Reach − (Since 2018)
West Branch Soquel #19	5.8/ 95 mm	2.1/ 94 mm	@@ Poor	4.0/ 88 mm	Site − (Since 2019)
West Branch Soquel #21	1010/ 98 mm	12.1/ 105 mm	@@@@@ Good	7.8/ 119 mm	Site − (Since 2019)
Aptos #3	8.5/ 107 mm	7.1/ 105 mm	@@@@ Fair	8.6/ 110 mm	Reach − (Since 2019)
Aptos #4	9.2/ 103 mm	9.2/ 106 mm	@@@@@ Good	4.0/ 91 mm	Reach − (Since 2019)
Valencia #2	8.1/ 95 mm	6.4/ 87 mm	@@ Poor	5.0/ 91 mm	Site – (Since 2019)
Valencia #3	11.5/ 101 mm	14.9/ 93 mm	@@@@ Fair	12.2/ 111 mm	Site − (Since 2019)

Table 3. Habitat Change in the SAN LORENZO MAINSTEM AND TRIBUTARIES from most recent years' reach averages compared to 2020 reach averages, or site comparisons when reach averages were unavailable.

Reach or (Site Only) Comparison To Previous Years	2020 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 & (Any Improvement)
(Mainstem Site 0a) (Since much higher baseflow 2019)	−	+ avg - max / −	Sim / Sim	+ / Sim	+ / +	− (in pool- more escape cover, less embeddedness, greater avg pool depth)
(Mainstem Site 1) (Since much higher baseflow 2019)	−	/ −	/ Sim riffle + run	/ Sim run − riffle	/ +	− (more cover in sampled fastwater, less run sediment)
Mainstem Rch 2 (Since much higher baseflow 2019)	−	− / −	Sim / Sim	Sim / Sim riffle − run	Sim / Sim	−
(Mainstem Site 4) (Since much higher baseflow 2019)	−	/ − Riffle Same Run	/ + riffle Same run	/ Same riffle − run	/ Very +	− (more cover in fastwater, less riffle sediment)
(Mainstem Site 6) (Since much higher baseflow 2019)	−	/ + (channel narrowed)	/ + riffle Same run	/ +	/ −	− (in fastwater - greater depth, less riffle sediment, reduced embed.)
(Mainstem Site 8) (Since much higher baseflow 2019)	−	/ −	/ − riffle Sim run	/ Sim	/ very +	− (more escape cover in fastwater)
Mainstem Reach 9 (Since much higher baseflow 2017)	−	Same avg + max / −	Sim / Sim riffle Same run	Same / Sim	+ / −	− (greater maximum depth and escape cover in pools)
(Mainstem Site 10) (Since higher baseflow 2019)	−	− / −	+ / − riffle Same run	Sim / very −	+ / Sim	− (less sediment and more cover in sampled pool)
(Mainstem Site 11) (Since higher baseflow 2019)	−	− / −	− / Same run	+ / Sim	− / −	− (less pool embed. in sampled habitat)

Reach or (Site Only) Comparison To Previous Years	2020 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 & (Any Improvement)
(Mainstem Site 12b) (Since higher baseflow 2019)	−	+ avg − max / −	− / Sim riffle Same run	Sim / + run Sim riff	+ / −	− (greater average depth and more cover in pools, less run embed.)
(Zayante Site 13a) (Since higher baseflow 2019)	−	− / −	Sim / −	Same / Same	− /	−
(Zayante Site 13c) (Since higher baseflow 2019)	−	+ / −	Sim / Sim	+ / NA	+ /	− (in sampled pools- greater depth, less sediment and more cover)
Zayante Reach 13d (Since higher baseflow 2019)	−	− / −	− / Sim	Sim / Sim	− / very −	−
Zayante Reach 13i (Since higher baseflow 2019)	−	− / −	Sim / − riffle same Run	Sim / Sim	Sim / Sim	−
(Bean Site 14a) (Since higher baseflow 2019)	−	− / Same riffle − run	Sim / Sim riffle − run	Same/ Sim riffle − run	+ /	− (more cover in sampled pool)
Bean Reach 14b (Since higher baseflow 2019)	−	Sim / Same riffle − run	Sim / Sim riffle − run	Sim / Sim	+ / +	− (more escape cover in pools and fastwater)
(Bean Site 14c-2) (Since similarly low baseflow 2019)	Similarly low	+ avg − max / + riffle − run	Sim / − Riffle Sim Run	− / −	+ /	+ (greater avg pool depth and cover in pools)
(Fall Site 15a) No 2019 streamflow data	No 2019 streamflow data below water diversion	− / −	− / Same runs − riffle	− / −	− /	−
Fall Reach 15b (Since similar baseflow 2018)	Similar	− / + riffle − run	Very − / Very −	− / Sim	− / −	− (greater riffle depth)
(Newell Site 16) (Since similar baseflow 2019)	Similar due to required dam release	+ / −	Similar / +	Sim / − riff + run	Very + /	+ (greater pool depth and cover; less fastwater sediment and embed.)

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 & (Any Improvement)
(Boulder Site 17a) (Since higher baseflow 2019)	− (compared to 2019)	Sim / Sim riffle − run	+ / Sim riffle − run	+ / + riffle − run	+ /	− (more pool cover, reduced sediment and embed. in pools and riffles)
Boulder Reach 17b (Since lower baseflow 2018)	+ (compared to 2018)	− / +	Very − / Sim riffle Very − run	Sim / Sim	− / −	+ (more food and deeper fastwater compared to 2018)
(Bear Site 18a) (Since much higher baseflow 2019)	−	− / −	− / Sim	+ / +	− /	− (reduced embeddedness)
(Bear Site 18b) (Since much higher baseflow 2019)	−	− / −	− / − riff Sim run	Sim / − riffle Same run	+ /	− (more cover in sampled pools)
Branciforte Reach 21a-2 (Since higher baseflow 2018)	−	+ / + riffle − run	Sim / Sim riffle − run	Sim / Sim	+ / +	− (more food and cover in pools)
(Branciforte Site 21b) (Since higher baseflow 2019)	−	+ / + run Sim riffle	Sim / Same	Sim / Same	+ /	− (sampled pools deeper with more cover; deeper runs)

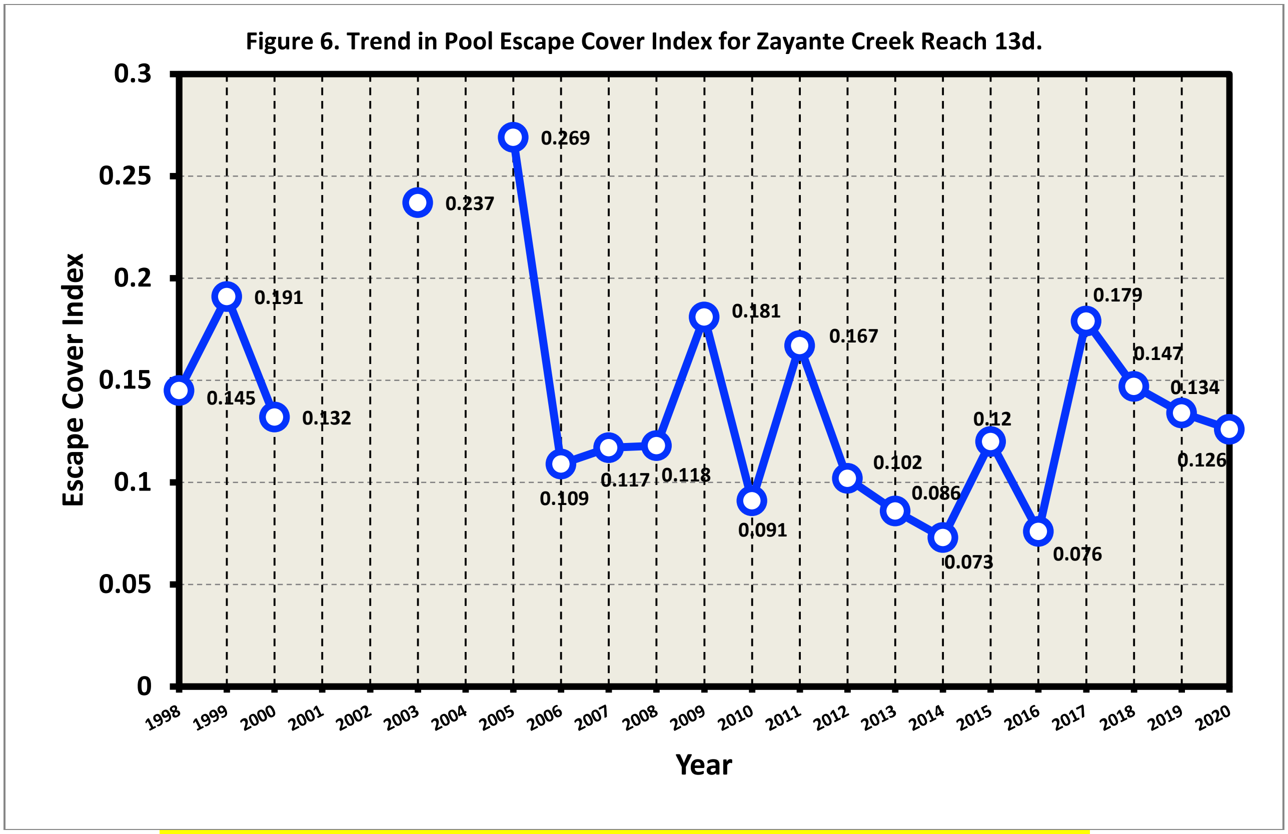


Figure 6. Trend in Pool Escape Cover Index for Zayante Creek, Reach Segment 13d.

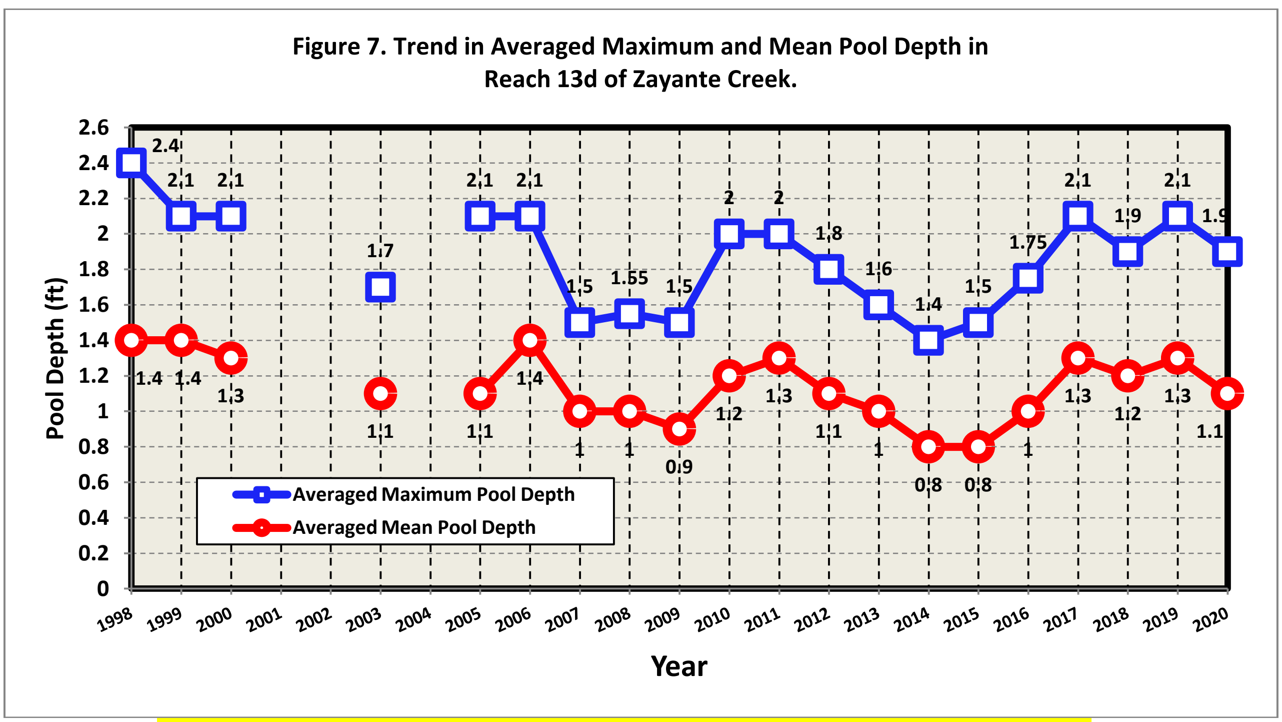


Figure 7. Trend in Averaged Maximum and Mean Pool Depth in Reach Segment 13d of Zayante Creek.

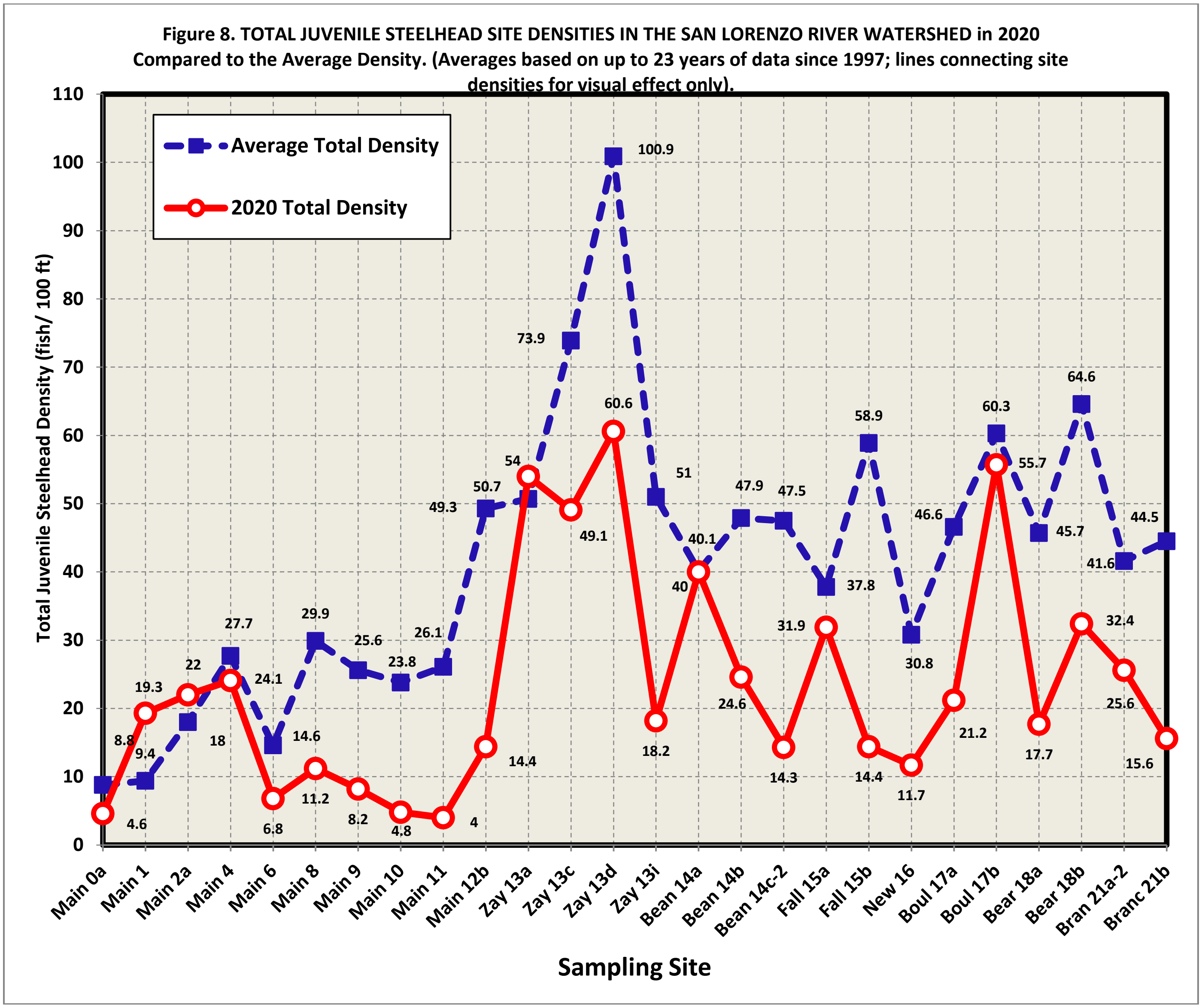


Figure 8. Total Juvenile Steelhead Site Densities in the San Lorenzo River in 2020 Compared to Average Density. (Averages based on up to 23 years of data.)

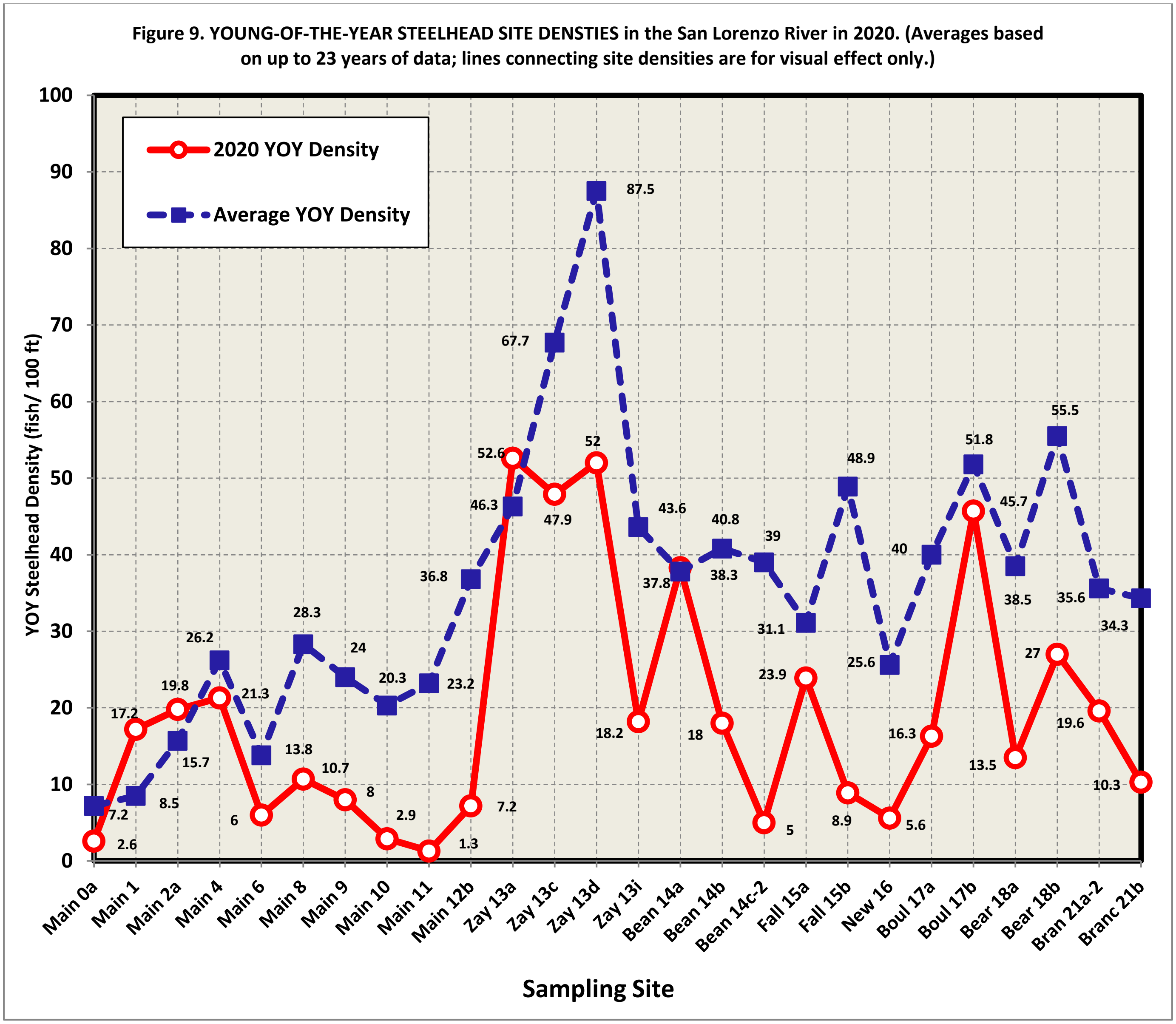


Figure 9. Young-of-the-Year Steelhead Site Densities in the San Lorenzo River in 2020 Compared to Average Density. (Averages based on up to 23 years of data.)

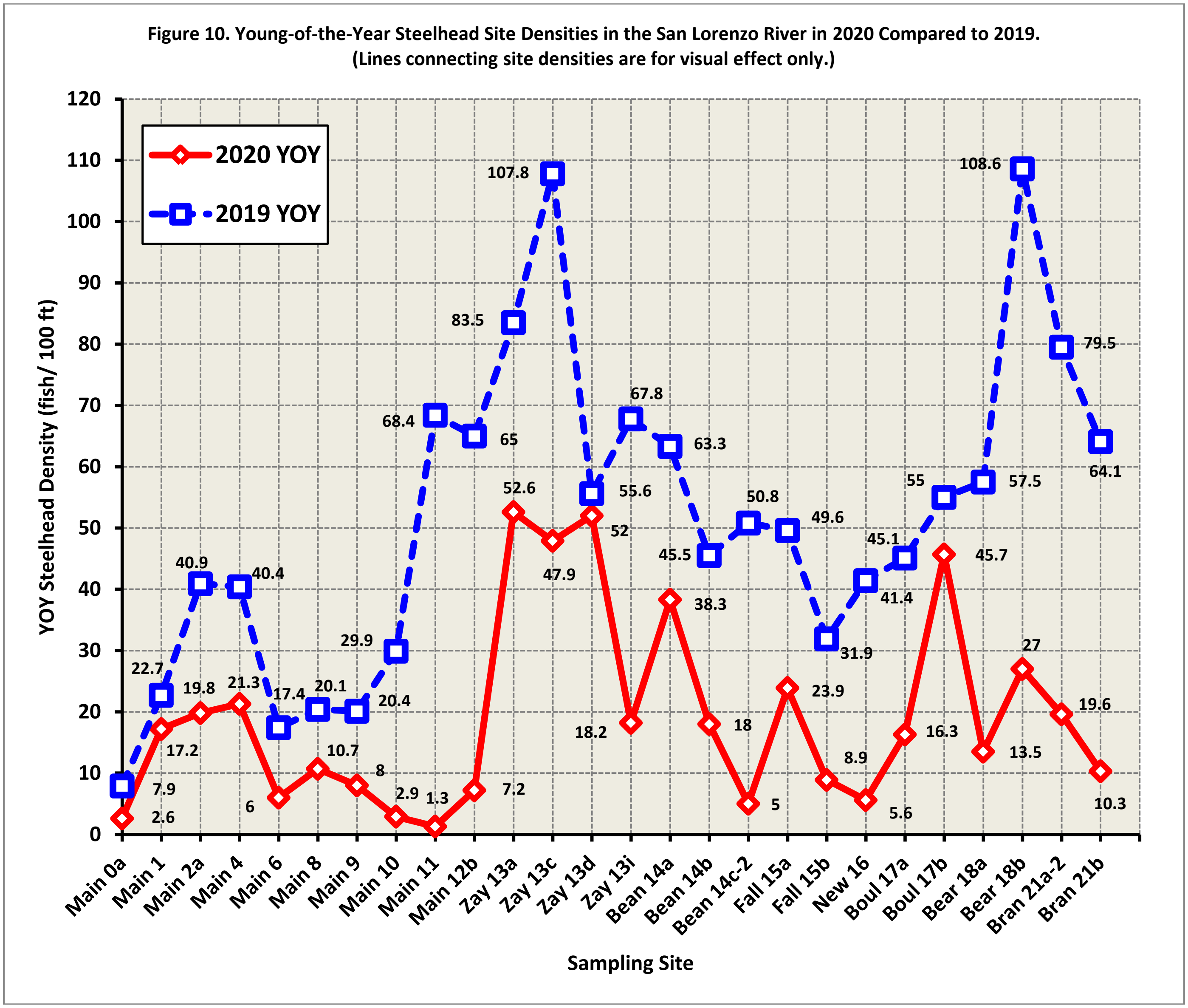


Figure 10. Young-of-the-Year Site Densities in the San Lorenzo Watershed Comparing 2020 to 2019.

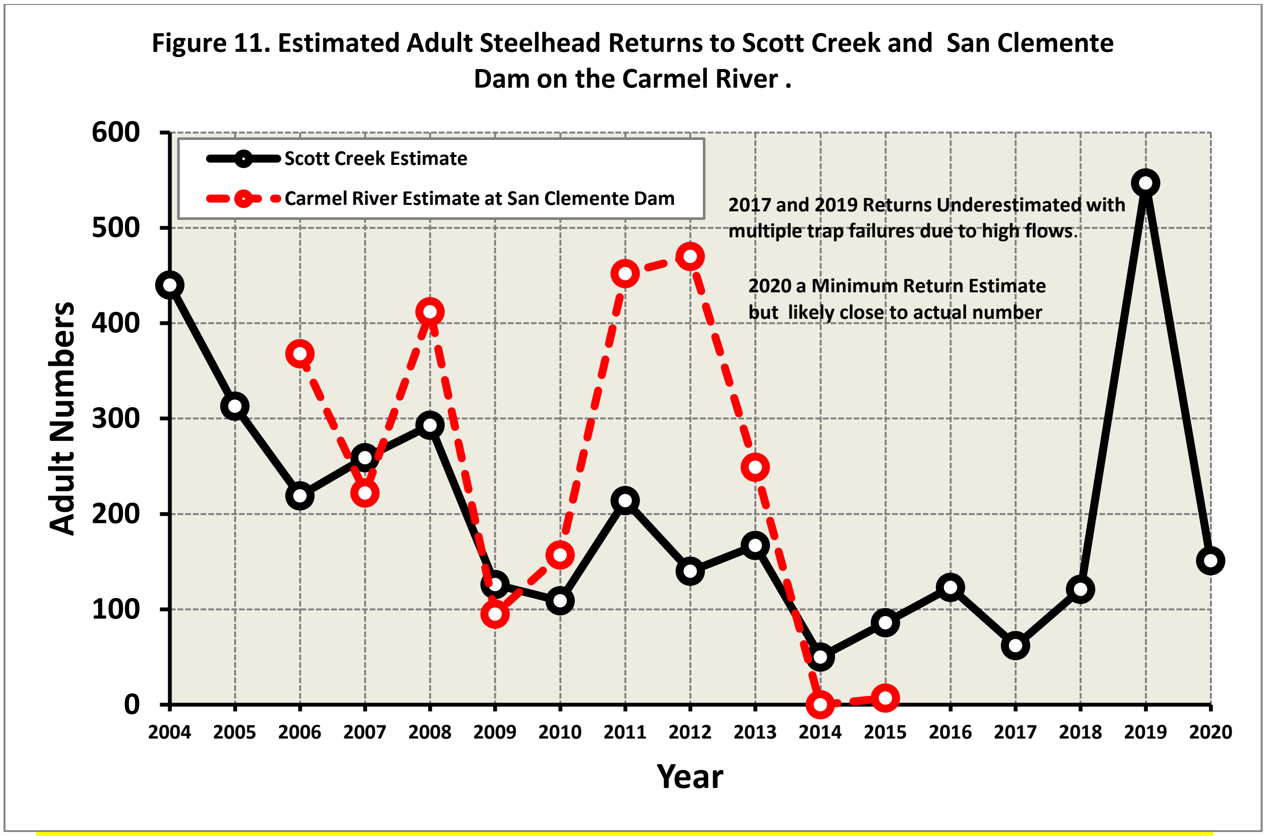


Figure 11. Estimated Adult Steelhead Returns to Scott Creek and San Clemente Dam on the Carmel River.

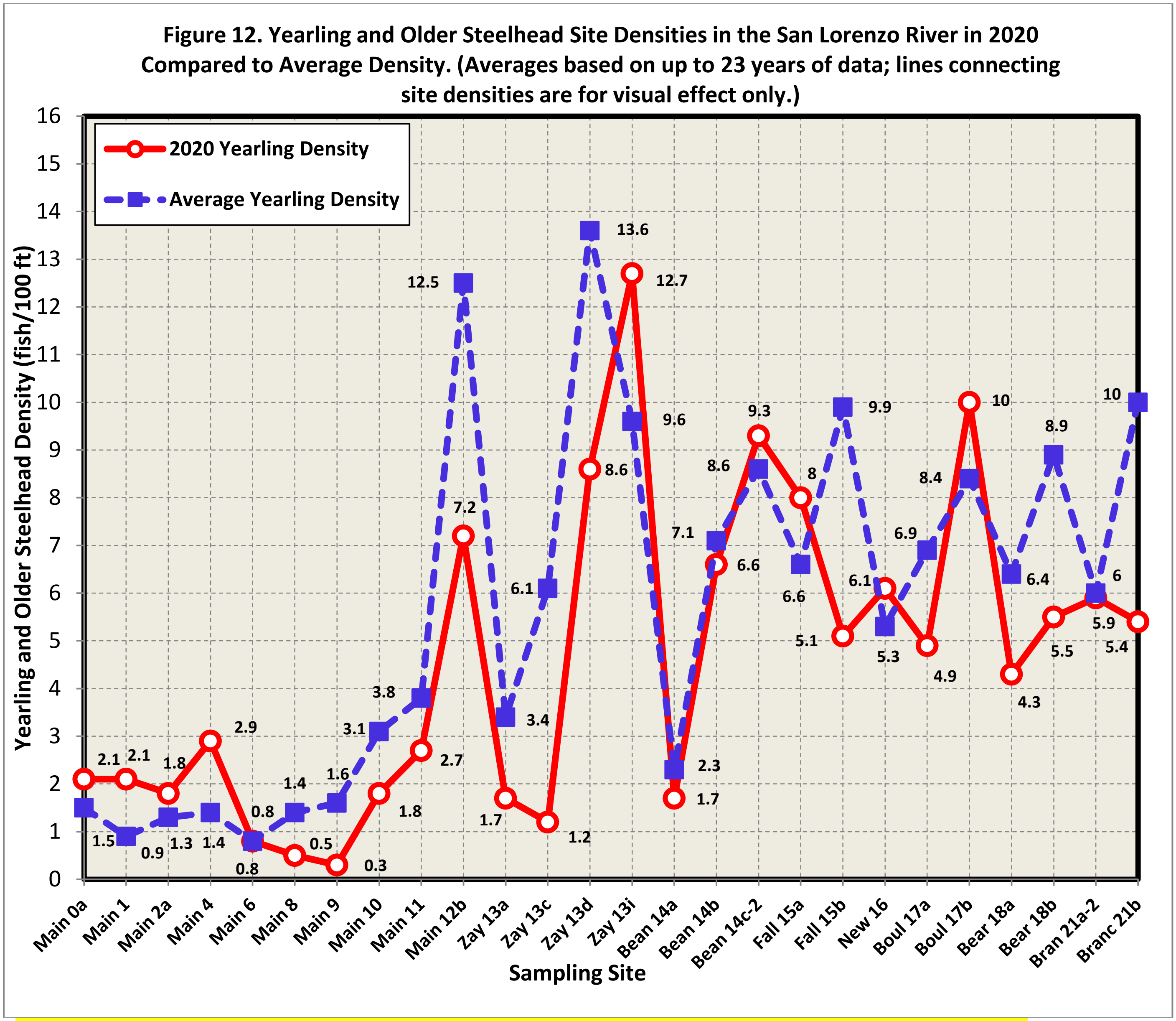


Figure 12. Yearling Steelhead Site Densities in the San Lorenzo River in 2020 Compared to Average Density. (Averages based on up to 23 years of data.)

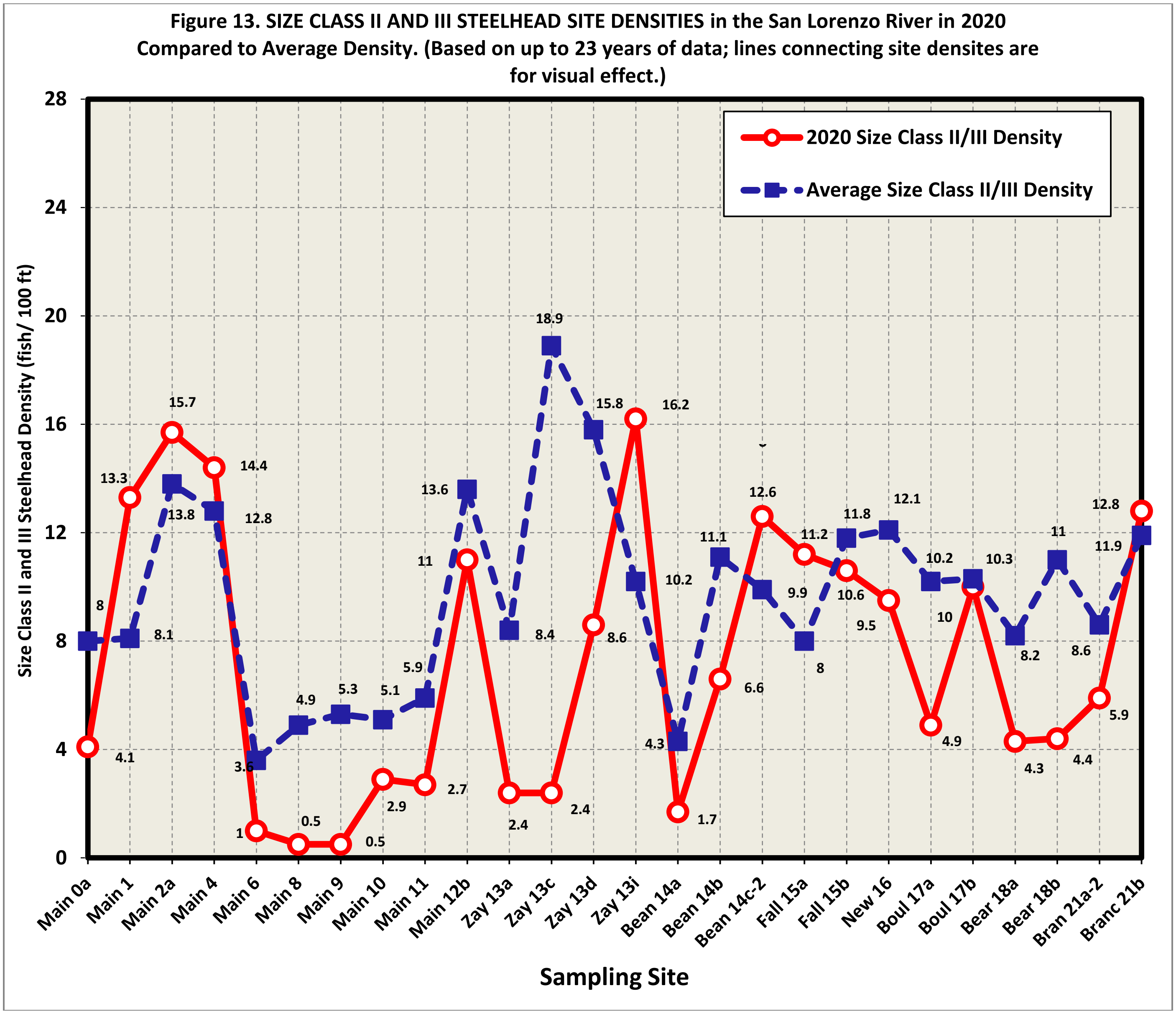


Figure 13. Size Class II and III Steelhead Site Densities in the San Lorenzo River in 2020 Compared to Average Density. (Averages based on up to 23 years of data.)

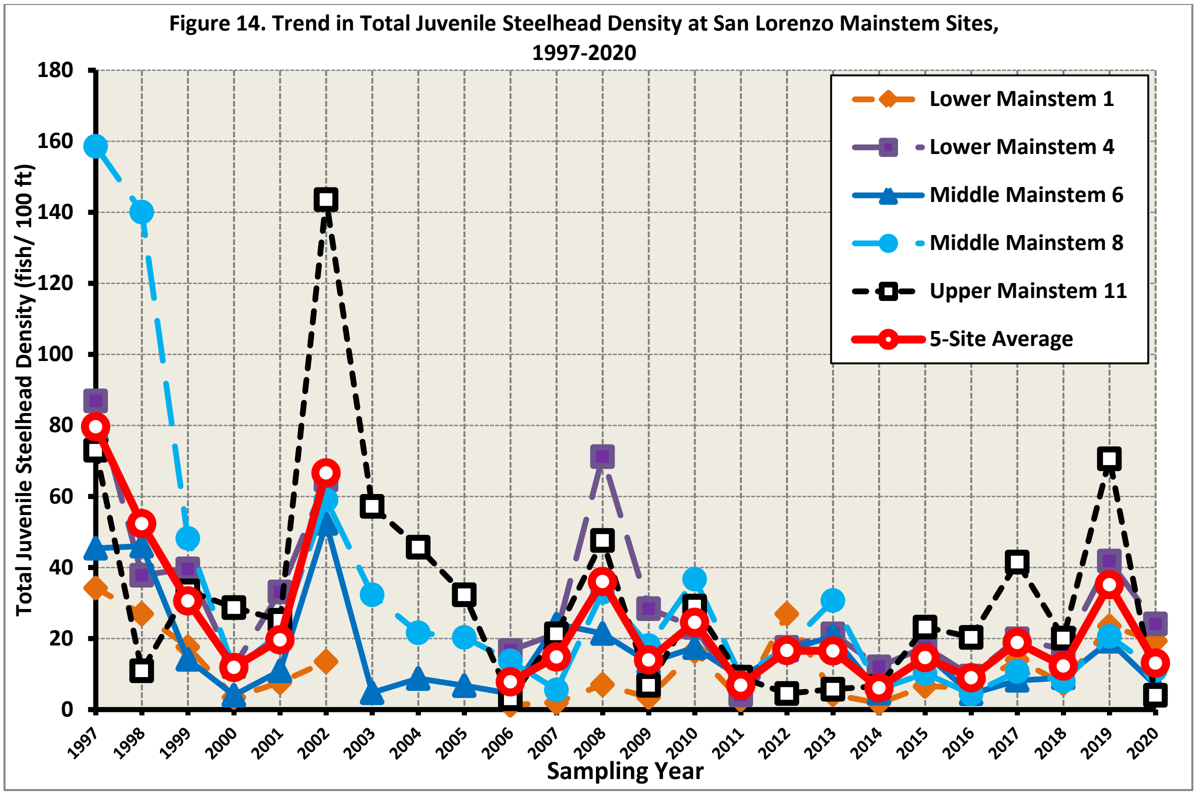


Figure 14. Trend in Total Juvenile Steelhead Density at San Lorenzo Mainstem Sites, 1997-2020.

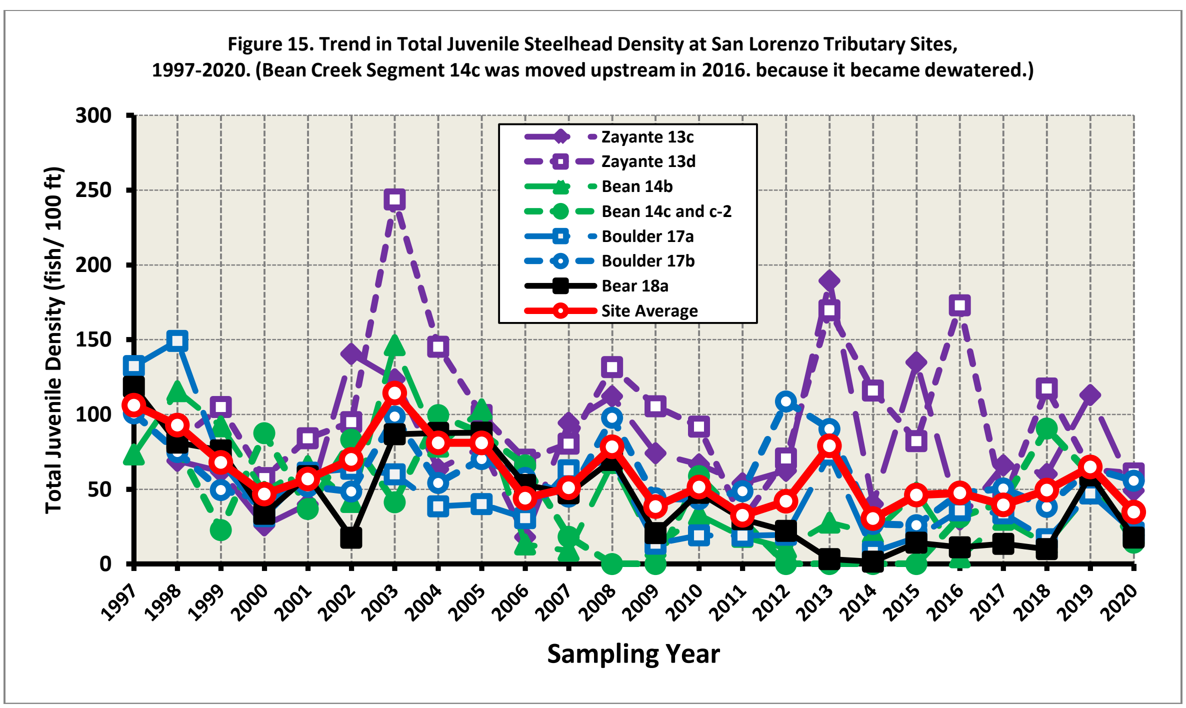


Figure 15. Trend in Total Juvenile Steelhead Density at San Lorenzo Tributary Sites, 1997-2020.

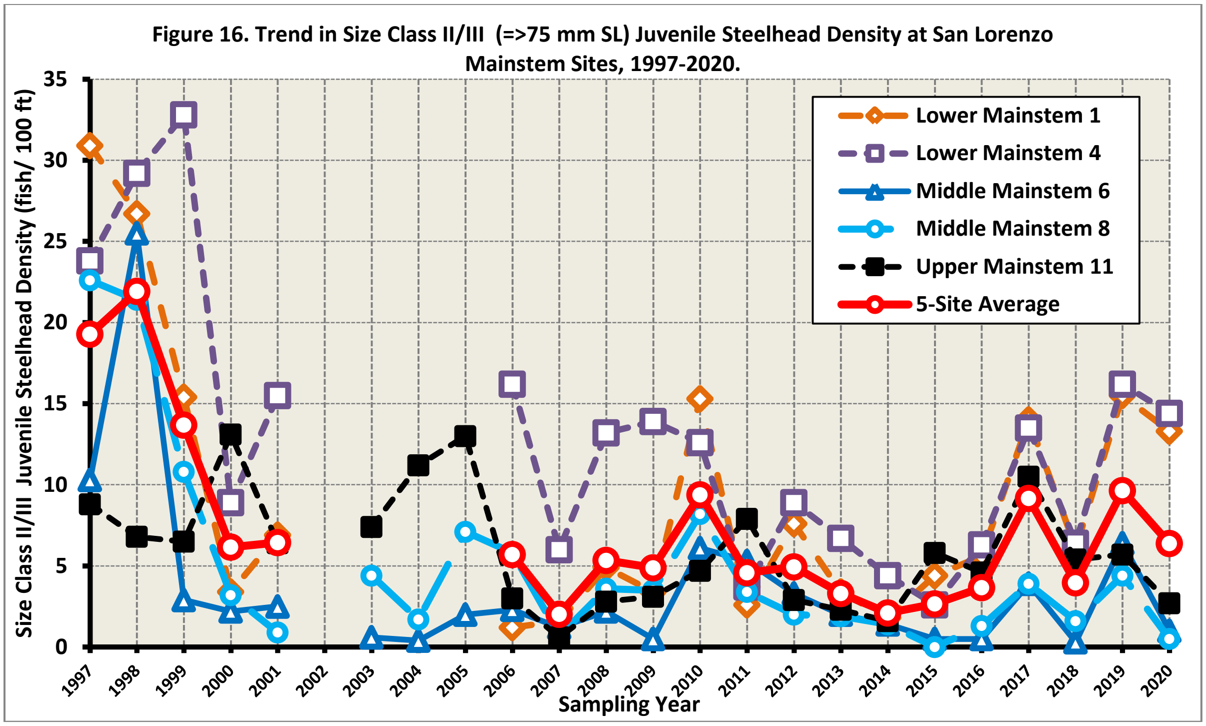


Figure 16. Trend in Size Class II/III Juvenile Steelhead Density at San Lorenzo Mainstem Sites, 1997-2020.

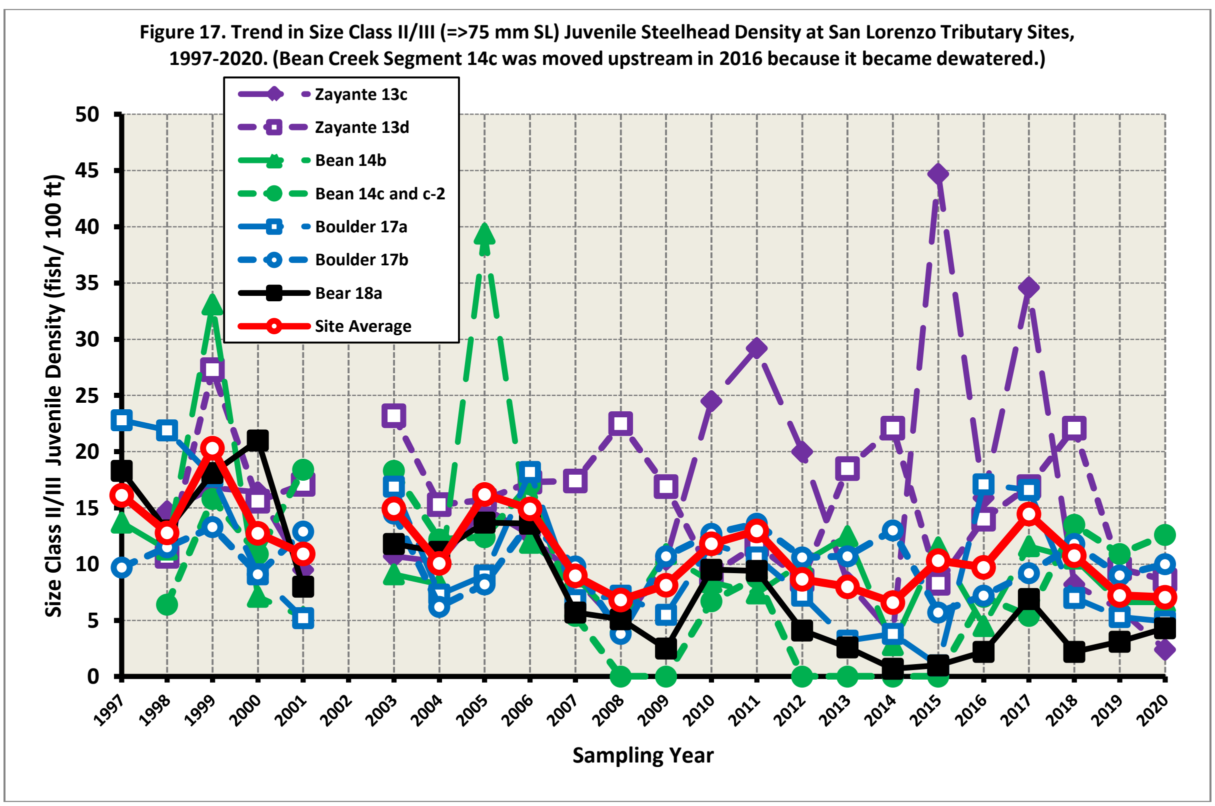


Figure 17a. Trend in Size Class II/III Juvenile Steelhead Density at San Lorenzo Tributary Sites, 1997-2020.

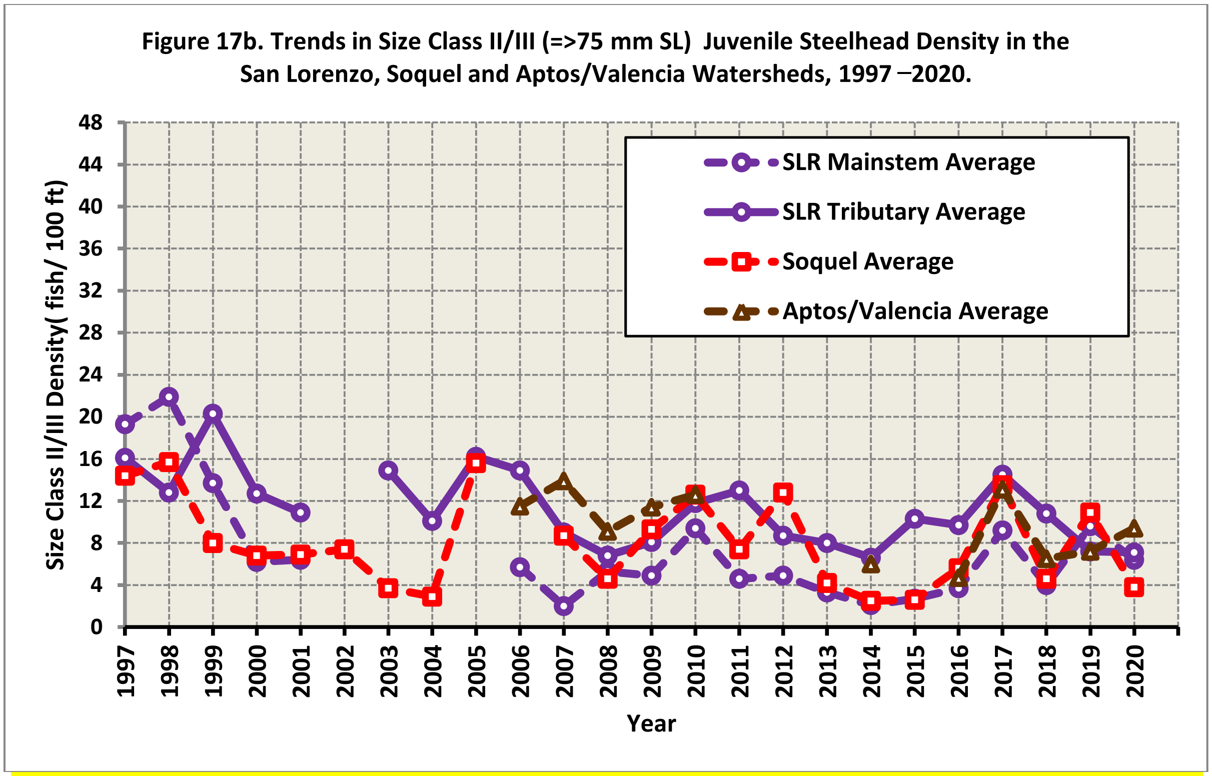


Figure 17b. Trend in Size Class II/III Juvenile Steelhead Density in San Lorenzo, Soquel and Aptos/Valencia Sites, 1997-2020.

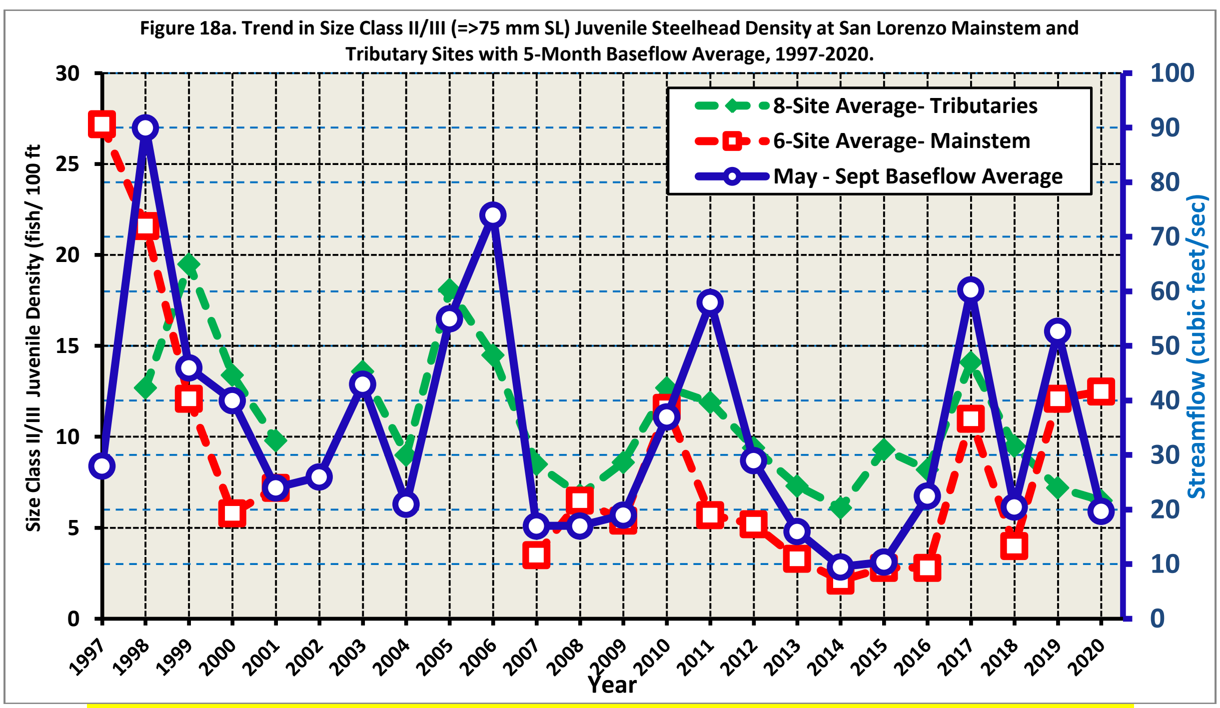


Figure 18a. Trend in Size Class II/III (=>75 mm SL) Juvenile Steelhead Density at San Lorenzo Mainstem and Tributary Sites with 5-Month Baseflow Average, 1997-2020.

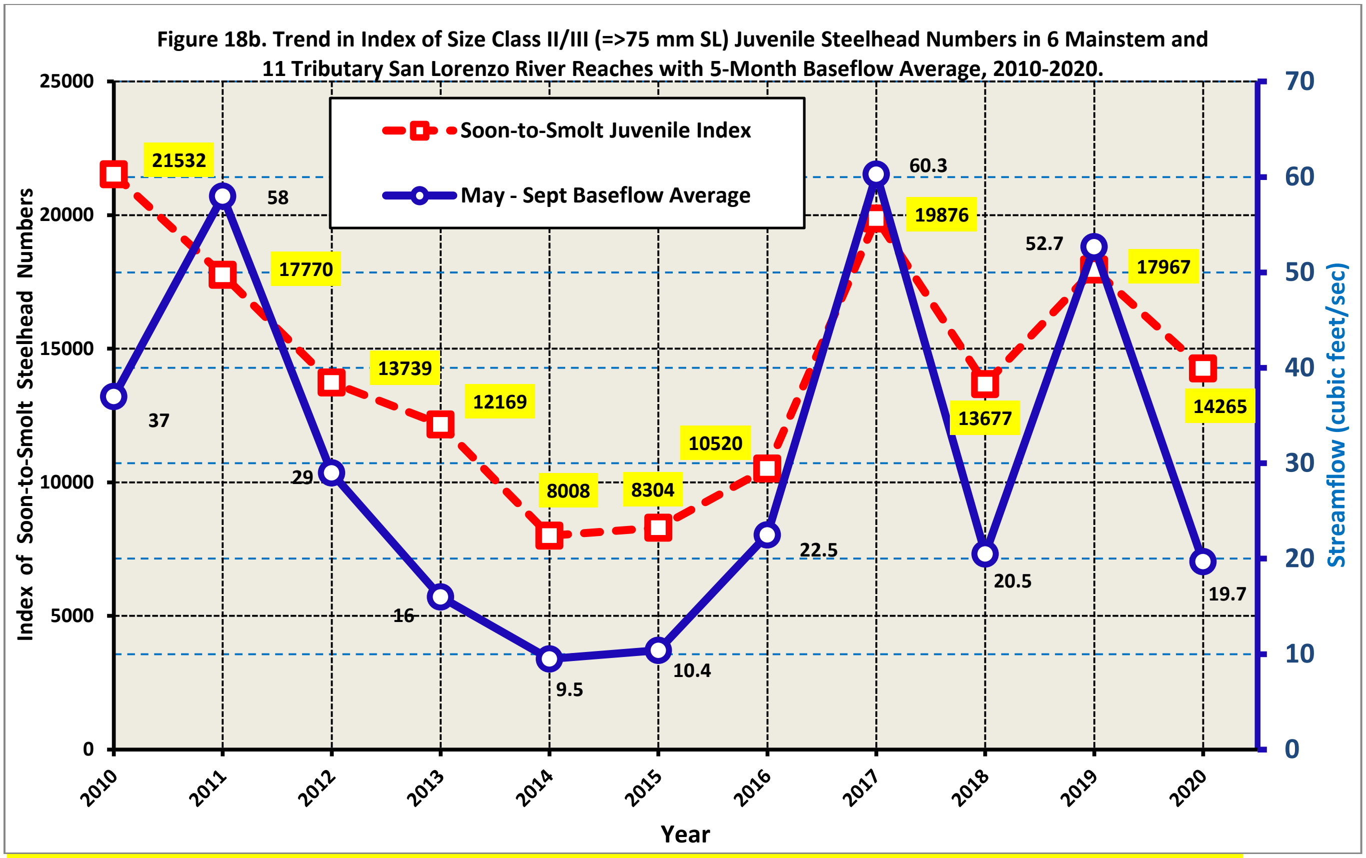


Figure 18b. Trend in Index of Size Class II/III (=>75 mm SL) Juvenile Steelhead Numbers in 6 Mainstem and 11 Tributary San Lorenzo River Reaches with 5-Month Baseflow Average, 2010-2020.

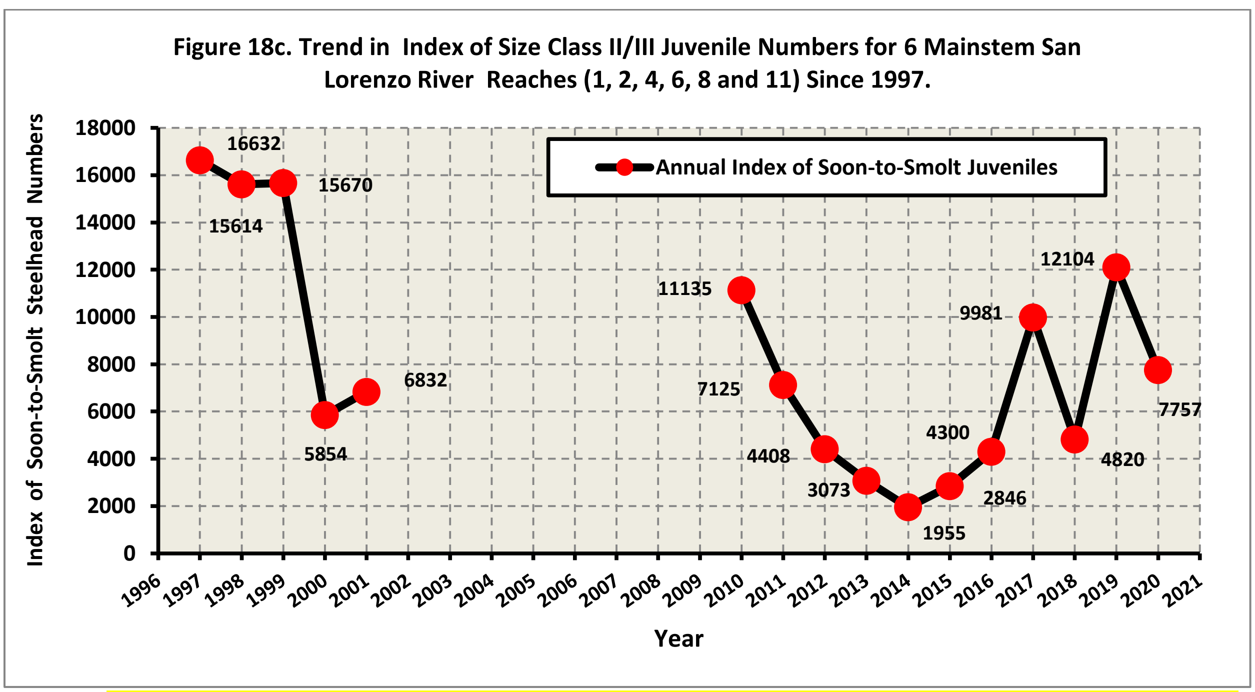


Figure 18c. Trend in Index of Size Class II/III Juvenile Steelhead Numbers in 6 Mainstem San Lorenzo River Reaches Since 1997.

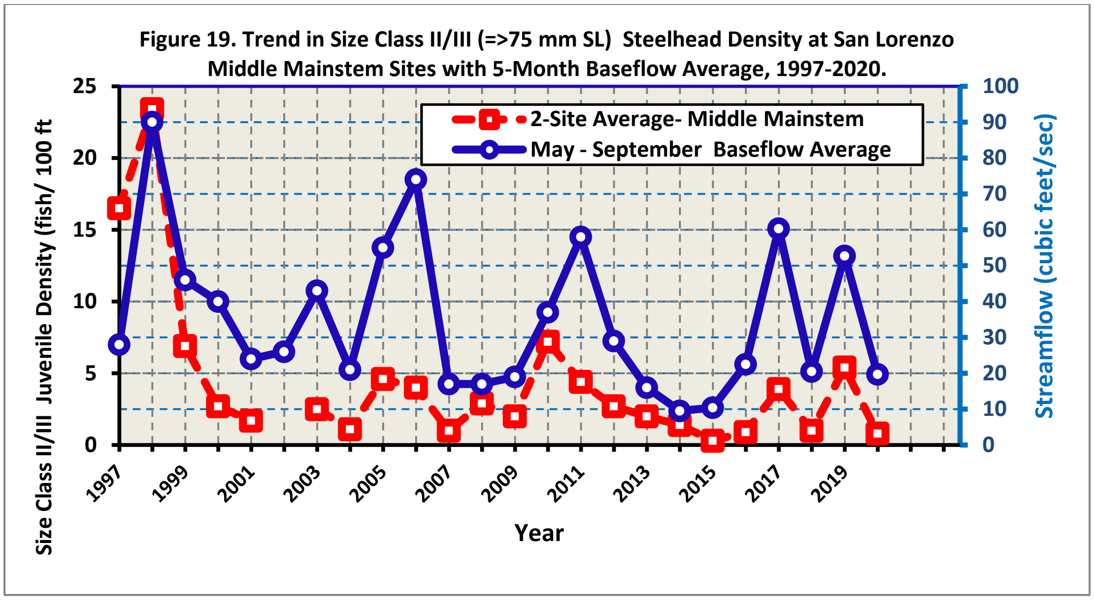


Figure 19. Trend in Average Size Class II/III (=>75 mm SL) Juvenile Steelhead Density at San Lorenzo Middle Mainstem Sites with 5-Month Baseflow Average, 1997-2020.

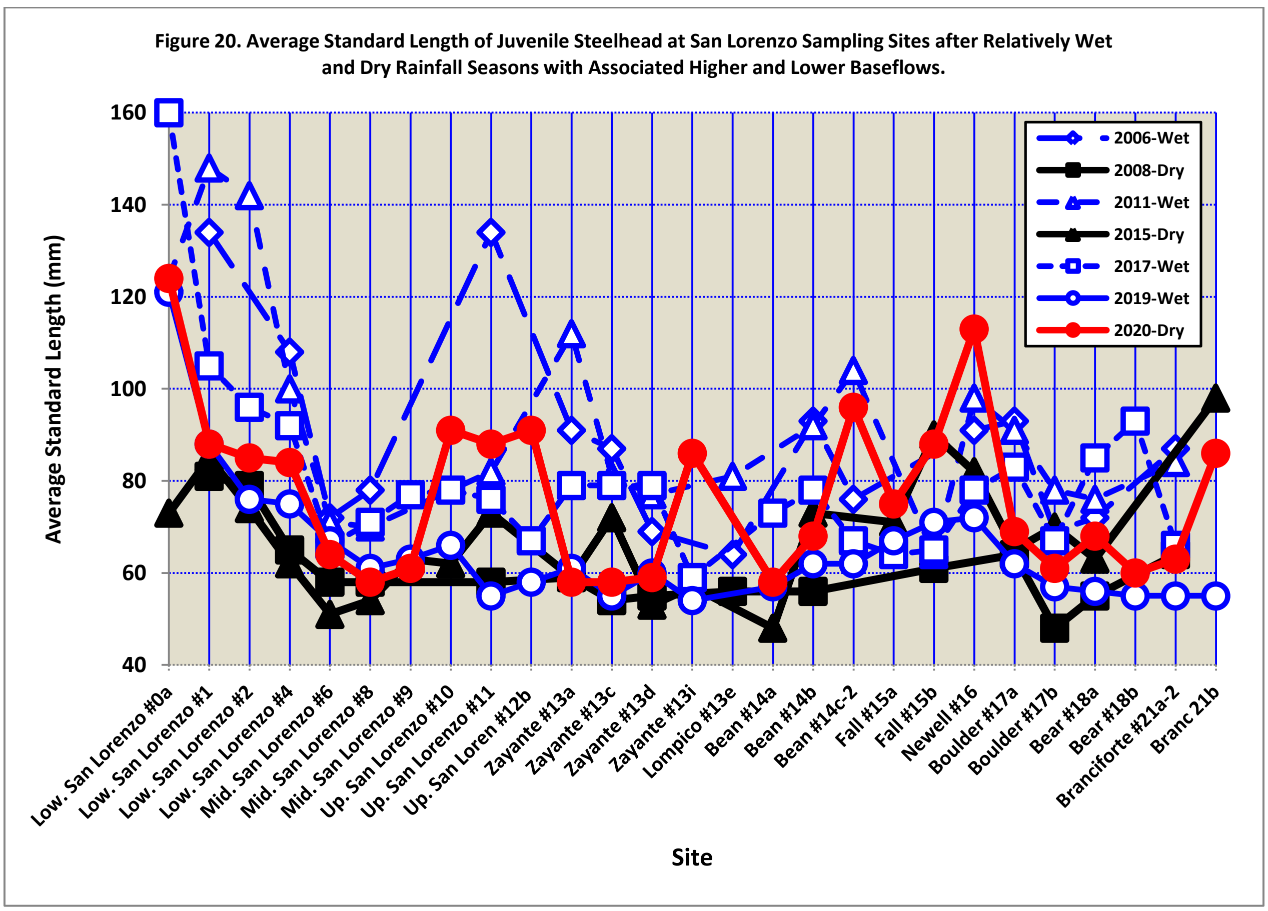


Figure 20. Average Standard Length of Juvenile Steelhead at San Lorenzo Sampling Sites after Relatively Wet and Dry Rainfall Seasons, with Associated Higher and Lower Baseflows.

ii. Steelhead Abundance and Habitat in the Soquel Creek Watershed

1. Streamflow measured at the Soquel Village gage indicated similar dry stormflow patterns as in the SLR for WY2020 except that the April stormflow reached 1,500 cfs at Soquel Village instead of the 600 cfs on the SLR at Felton, and was likely above bankfull (**Figure 21**). This late stormflow provided better spawning access in these lower gradient watersheds compared to the SLR. Another small stormflow of 70 cfs later in May provided additional adult access to lower reaches and also encouraged out-migration of smolts. Baseflow steadily declined from mid-May on at mostly below median baseflow down to 1.8 cfs on 12 October at the Soquel Village stream gage.

2. 2020 habitat conditions declined since 2019 at all sites/reaches with lower baseflow (less drifting food) (**Figure 5**). In the East Branch (**Figure 2**), other habitat parameters, such as habitat depth and escape cover, decreased (**Table 5**). In the West Branch, depth was either similar or less at sites, pools were more sedimented, but pool escape cover increased. In the mainstem where reach conditions were compared to the similar baseflow year of 2018, lower Reach 3 habitat improved with greater depth, less sediment and greater pool escape cover. Upper mainstem Reach 8 habitat declined since 2018 with reduced riffle depth, increased fine sediment in pools and riffles and less pool escape cover. Pool depth did increase in Reach 8, however. In the mainstem where site conditions were compared to 2019, lower Site 1 habitat above Walnut Street Park declined decisively with reduced baseflow, reduced depth, increased fine sediment, greater fastwater embeddedness and reduced pool escape cover. Upper Site 10 habitat mostly declined from 2019 with reduced baseflow, reduced depth, increased pool sediment and embeddedness, but similar pool escape cover.

3. ***Total and YOY juvenile steelhead densities*** were well below average at all 9 sites in 2020 (averaging 38.5 total juveniles/100 ft and 32.9 YOY/100 ft) (**Figures 22 and 23**). Site 6 was added back to mainstem sites in 2020 after 15 years. Total and YOY density decreased at all repeated sites since 2019 (statistically significant) (**Figure 24; Table 9**). YOY densities increased upstream of Site 16 on the East Branch at historical sites funded by CalFire, indicating good access of adult steelhead beyond the Ashbury Gulch confluence and so called Ashbury Falls. The 6-site trend in total site densities (consisting mostly of YOY) decreased greatly in 2020 and was the 3rd lowest average in 23 years at 13.4 fish/100 ft (57.2 in 2019 and 19.5 in 2018) (**Figure 28**). The downward trend in total and YOY juvenile steelhead densities in Soquel Creek over the years, excepting 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. Two of the 4 factors considered to explain low YOY densities in the SLR watershed likely apply to the Soquel watershed except that adult spawning access was likely not a factor in Soquel. Those factors were 1) low adult returns and 2) poor egg survival during a relatively dry winter that provided poor spawning conditions followed by a late bankfull event that may have scoured redds. Similar to our low YOY densities in Soquel Creek, Smith (**2020**) found that average YOY densities in 2020 were very low in Gazos Creek (9 YOY/100 ft) and in lower Waddell Creek (13.6 YOY/100 ft), with possible, though not conclusively, adult spawning impedance from log jams in Gazos Creek. Smith did not sample Scott Creek due to access problems related to the CZU fire.

4. ***Yearling steelhead densities*** were typically low and above average at 5 sites (**Figure 25**). But 2020 densities were near low averages at 7 of 9 sites with all 7 densities 2.1 fish/100 ft or less. As in the SLR watershed, low yearling and Size Class II/III densities in 2020 at non-headwater sites, despite high YOY densities in 2019, may have occurred because lack of winter and spring stormflows resulted in high water clarity with modest baseflows and sufficient drifting aquatic insects to allow many young yearlings to grow and smolt in late spring without spending a second summer in freshwater.

5. ***Size Class II/III steelhead densities*** were below average at all 9 sites in 2020 (**Figure 26**). They decreased at 6 of 8 sites from 2019, especially at upper mainstem sites (**Figure 27**). In 2020, the 6-site

long-term trend in Size Class II/ III densities decreased substantially from 2019 (**Figure 29**). This density trend and trend in index of Size Class II/III numbers positively tracked with averaged 5-month baseflow (**Figure 30a-b**). Decline in these larger juveniles in low baseflow years was partially caused by fewer YOY growing into Size Class II their first summer. Trends in these large juveniles follow similar fluctuations through the wet and dry years in the Soquel and SLR watersheds, but less so for the Aptos/Valencia watershed (**Figure 17b**). The 8-site Size Class II/III density decreased from 10.9 fish/100 ft in 2019 to 3.8 fish/100 ft in 2020. The 2020 Soquel lagoon steelhead population estimate was higher than anticipated at 1,283 (above the median) compared to 3,353 in 2019, and all captured juveniles were in Size Class II/III. This significant lagoon population estimate despite the low YOY densities at stream sites indicates that adult steelhead spawning near the lagoon was relatively successful and seeded the lagoon.

6. Soon-to-smolt densities were rated "poor" at 5 sites (mainstem Sites 1, 6, 12, East Branch 13a and West Branch Site 19), "below average" at 3 sites (Mainstem 4 and 10, East Branch Site 16) and "good" at 1 site (West Branch Site 21 below Girl Scout Falls II) (**Table 2**).

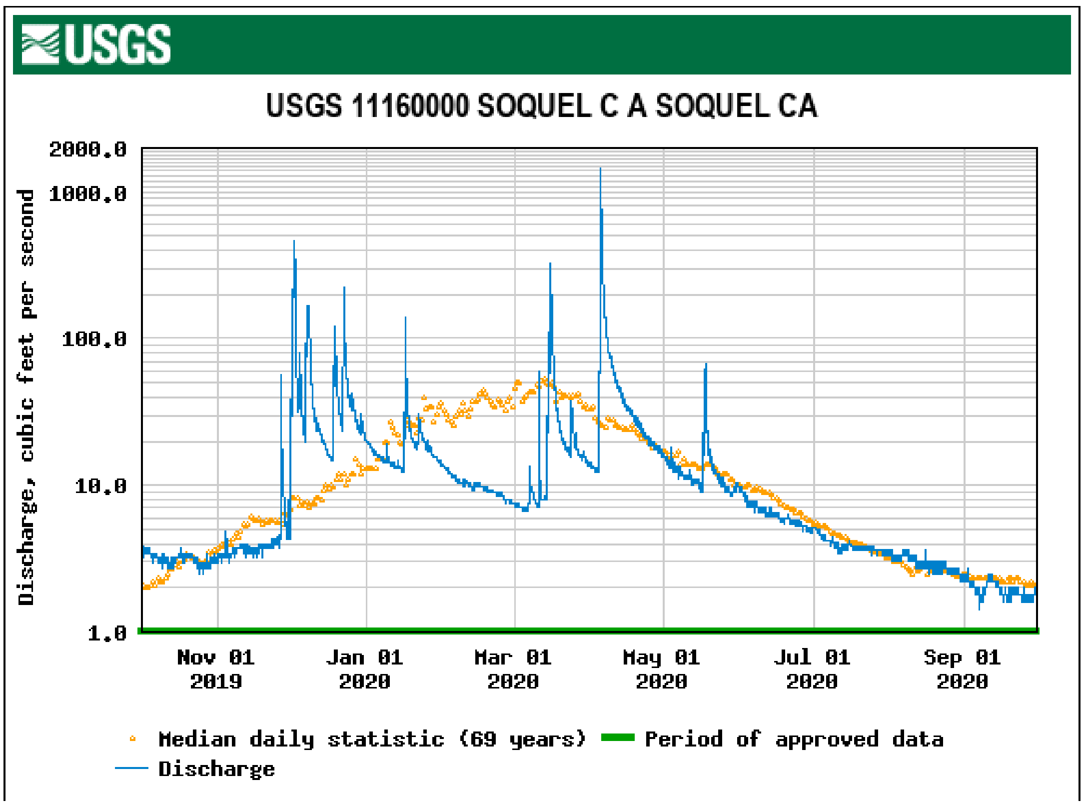


Figure 21. The WY2020 Discharge at the USGS Gage on Soquel Creek at Soquel Village.

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− 2020 (October) at fall baseflow conditions .

Location	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Branciforte @ Isabel Lane			0.3	0.25	0.42 (8/26)		0.57 (8/22)	0.59 (6/20)	0.31 (8/7)						
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)	1.50 (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)		5.0 (12 Oct)	2.18 (12 Oct)	2.93 (12 Oct)	1.79 (12 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)	1.57 (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)	0.93@ Mouth (DWA)
W. Branch Soquel Cr above Hester Creek (SCWD Weir/ Kraeger-prelim.)	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@ Mouth (DWA	0.44@ Mouth (DWA)
E. Branch Soquel Cr above Amaya Ck				Trickle (DWA)	0.44 (DWA)			0.03 (DWA)	Dry (DWA)	Dry (DWA)		0.71 (DWA)	0.15 (DWA)	0.46 (DWA)	0.10 (DWA)
Aptos Cr below Valencia Ck	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)	1.12 (DWA)
Aptos Cr above Valencia C					0.97 (DWA)	1.6 (DWA)			0.63 (DWA)	0.44 (DWA)					
Valencia Cr @ Aptos Cr			0.007	0.34 (May)	0.09 Adj. School (DWA)	0.8 Adj. School (7/27)	0.20 (9/05)	0.105 (9/11)							
Valencia Cr below Valencia R					0.22 (DWA)										

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

Reach or (Site Only) Comparison To Previous Years	2020 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 higher baseflow 2019)	−	Same/ −	− / Sim riff − run	Sim / − riffle Same run	−	−
Site 4 Reach 3a (Since similar low baseflow 2018)	Similar	+ / Same riffle − run	+ / Sim riff − run	Sim / Sim	+	+ (more pool cover, greater pool depth, less pool sediment)
(Site 10) Reach 7 (Since higher baseflow 2019)	−	− / −	− / Sim	− / Sim	Similar	−
Site 12 Reach 8 (Since similar low baseflow 2018)	Similar	+ / − riffle Sim run	− − riffle Sim run	Sim / Sim	−	− (greater pool depth)
East Branch (Site 13a) Reach 9a (Since higher baseflow 2019)	−	− / − riff + run	− / Sim	+ / +	−	− (greater run depth, reduced embeddedness)
East Branch Site 16 Reach 12a (Since similar low baseflow 2018)	Similar	− / + riff − run	Sim / Sim	Sim / Sim	−	− (greater riffle depth)
West Branch (Site 19) Reach 13 (Since higher baseflow 2019)	−	− / − riff Sim run	− / Sim	− / +	+	− (more pool cover, less fastwater embeddedness)
West Branch (Site 21) Reach 14b (Since higher baseflow 2019)	−	Sim / + riffle − run	− / Sim	+ / Same riffle + run	+	− (more pool cover, greater riffle depth, less embeddedness)

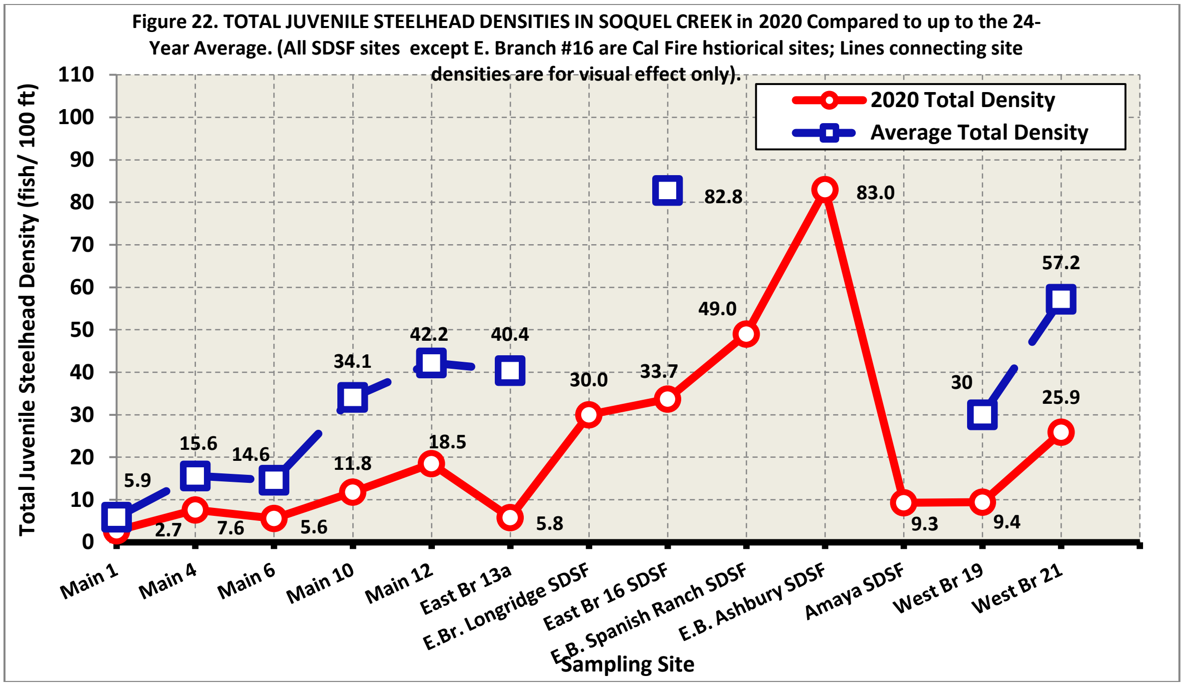


Figure 22. Total Juvenile Steelhead Site Densities in Soquel Creek in 2020 Compared to up to the 24-Year Average (10-year average for Mainstem #6.)

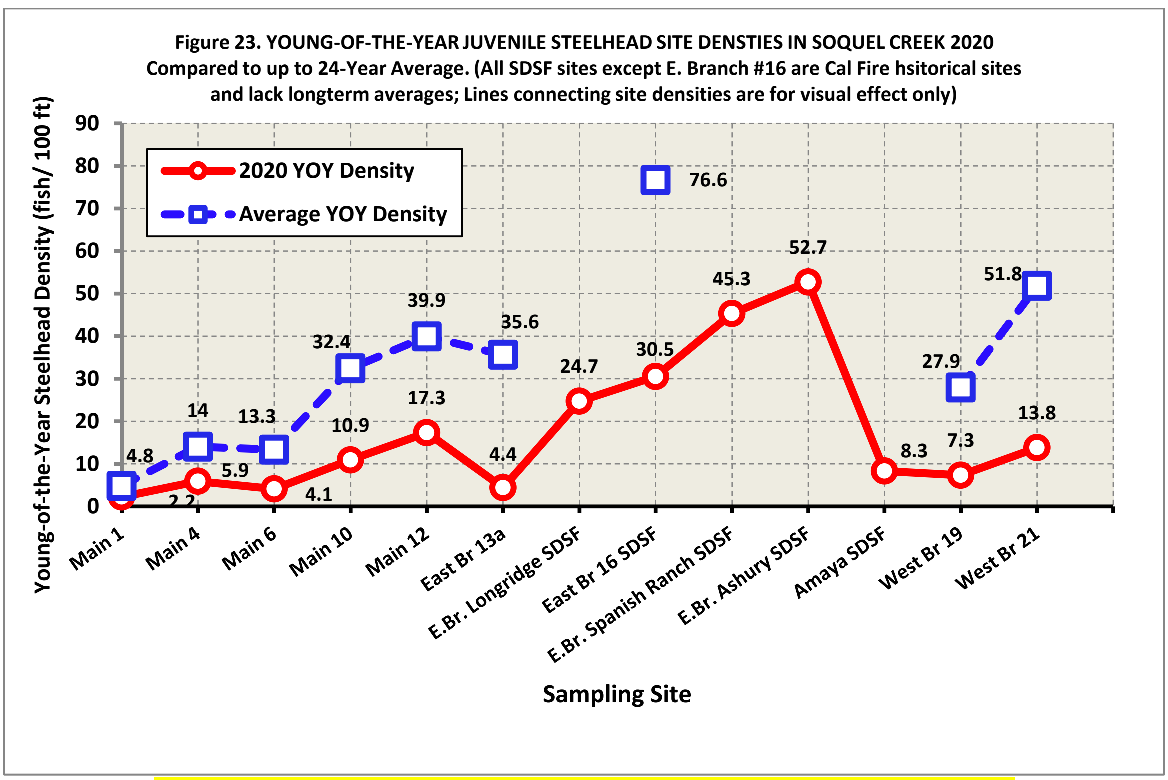


Figure 23. Young-of-the-Year Steelhead Site Densities in Soquel Creek in 2020 Compared to up to the 24-Year Average (10-year average for Mainstem #6.)

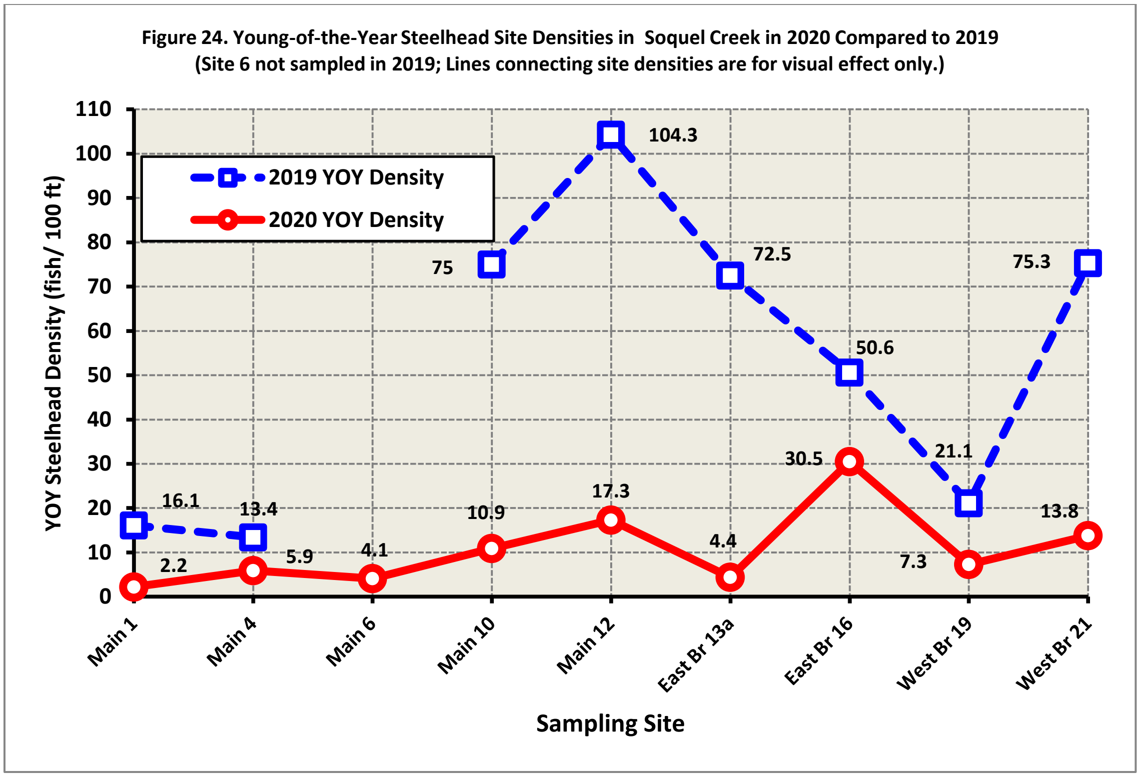


Figure 24. Young-of-the-Year Site Densities in Soquel Creek, Comparing 2020 to 2019.

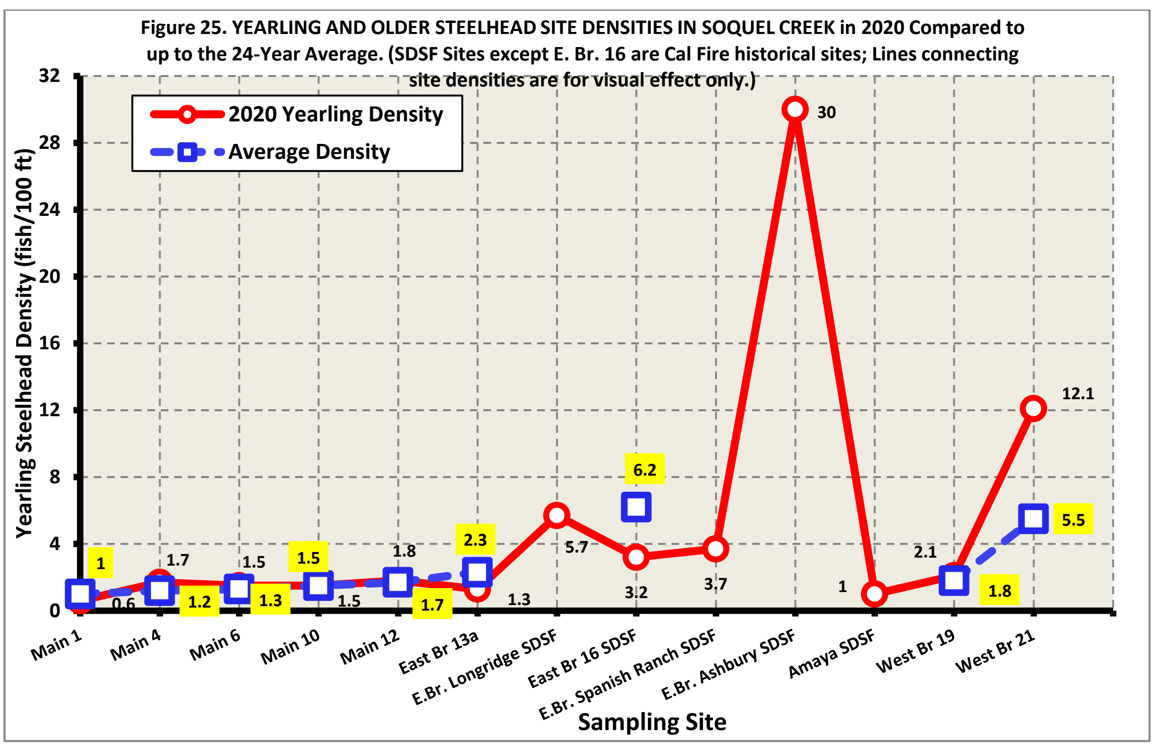


Figure 25. Yearling Steelhead Site Densities in Soquel Creek in 2020 Compared to the 24-year Average (20th year for West Branch #19.)

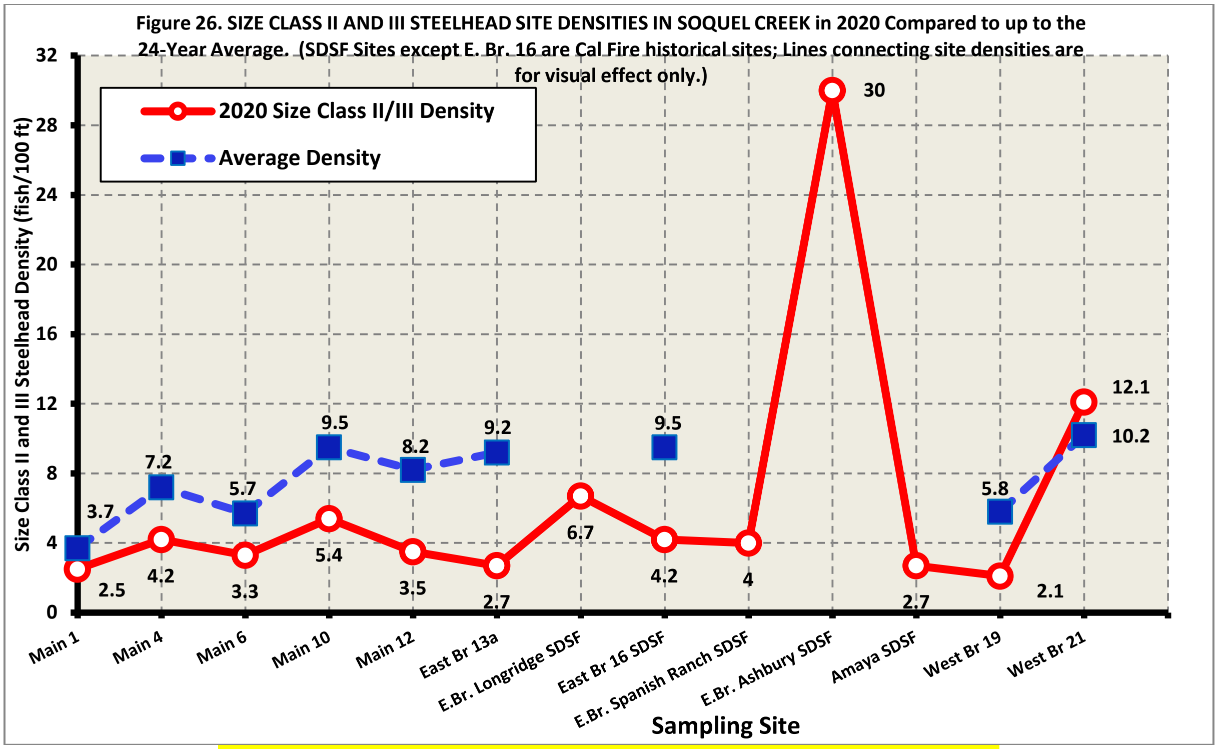


Figure 26. Size Class II and III Steelhead Site Densities in Soquel Creek in 2020 Compared to the 24-Year Average (20th year for West Branch #19.)

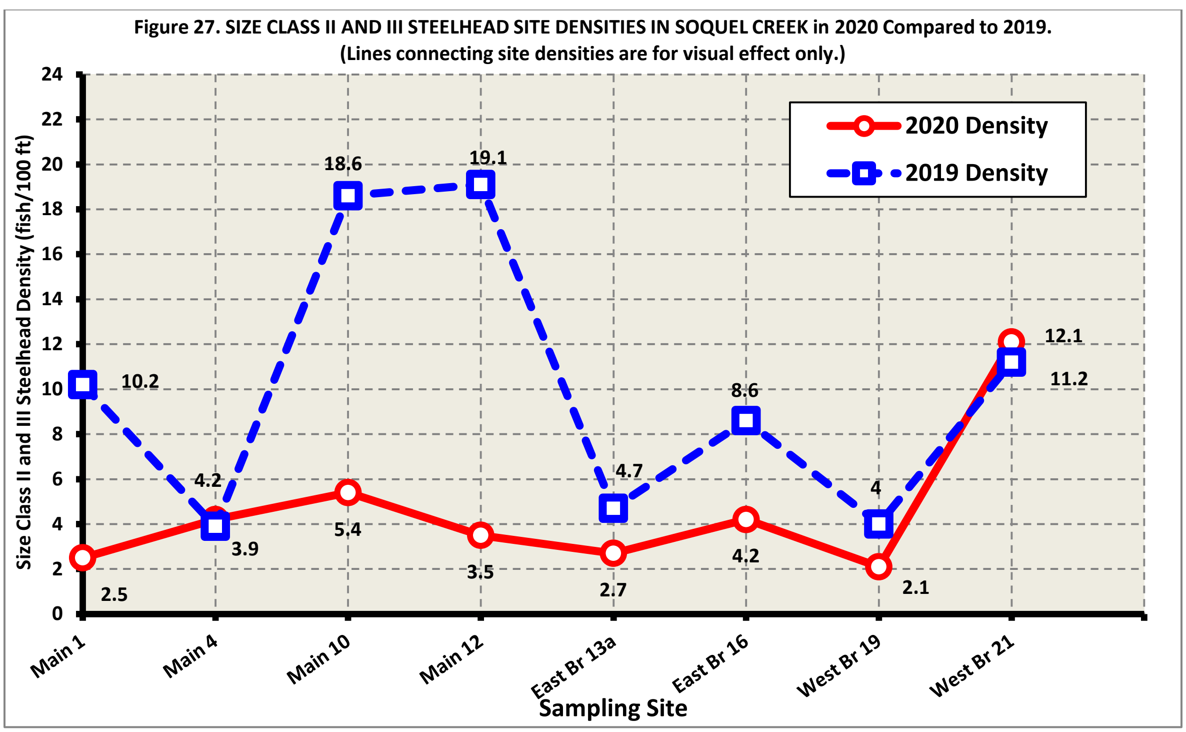


Figure 27. Size Class II and III Steelhead Site Densities in Soquel Creek in 2020 Compared to 2019.

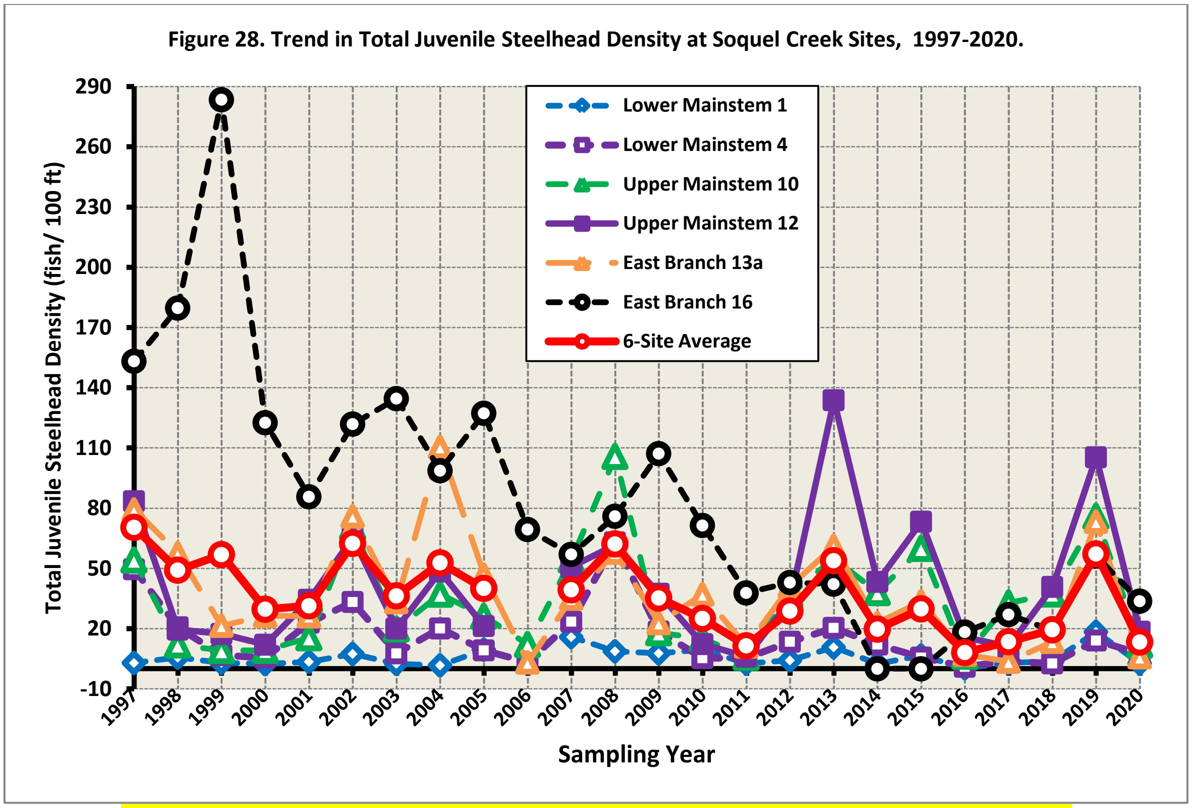


Figure 28. Trend in Total Juvenile Steelhead Density at Soquel Creek Sites, 1997-2020.

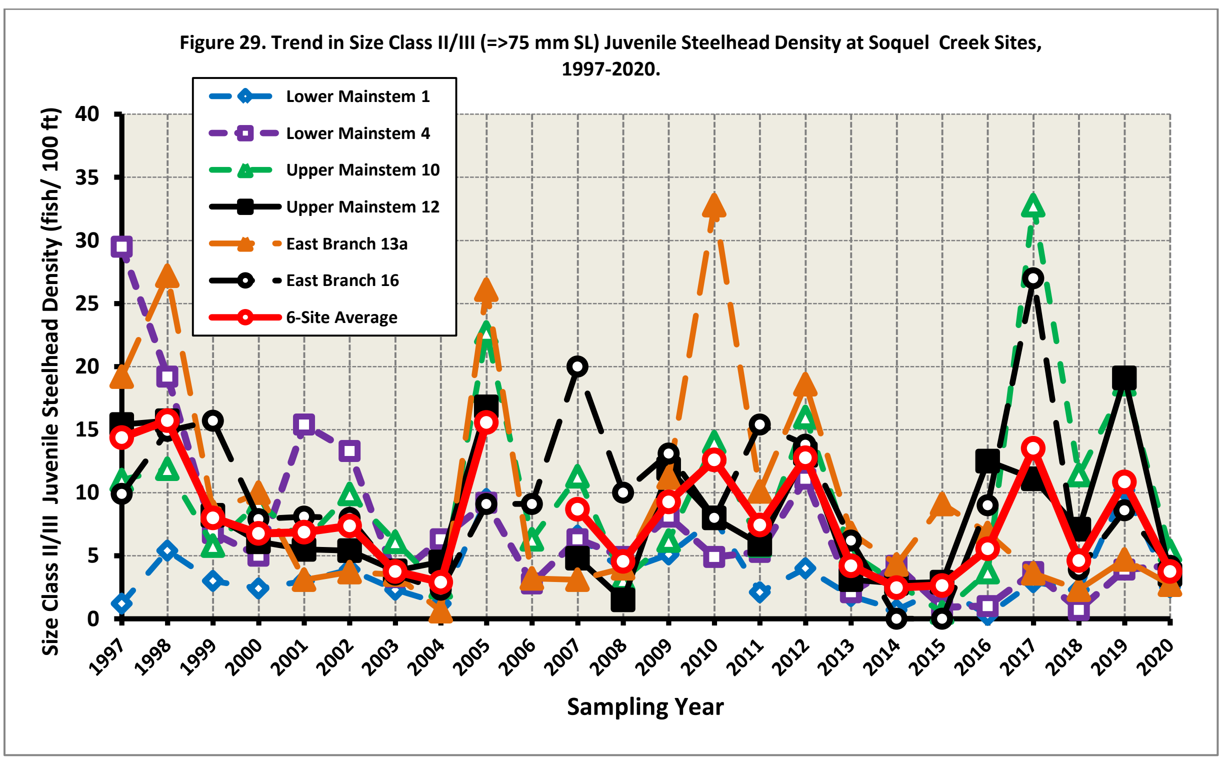


Figure 29. Trend in Size Class II/III Juvenile Steelhead Density at Soquel Creek Sites, 1997-2020.

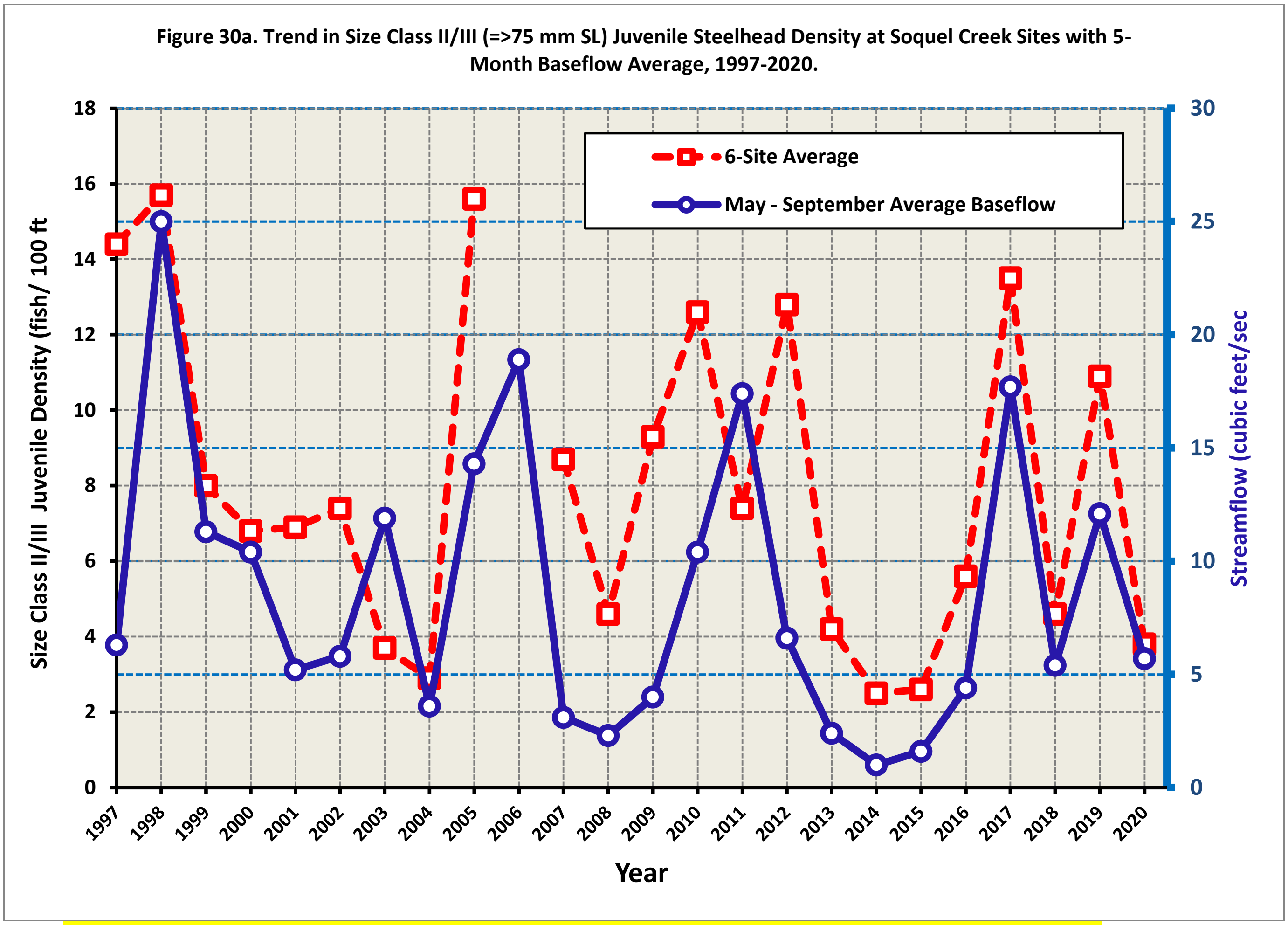


Figure 30a. Trend in Size Class II/III (=>75 mm SL) Juvenile Steelhead Density at Soquel Creek Sites with 5-Month Baseflow Average, 1997-2020.

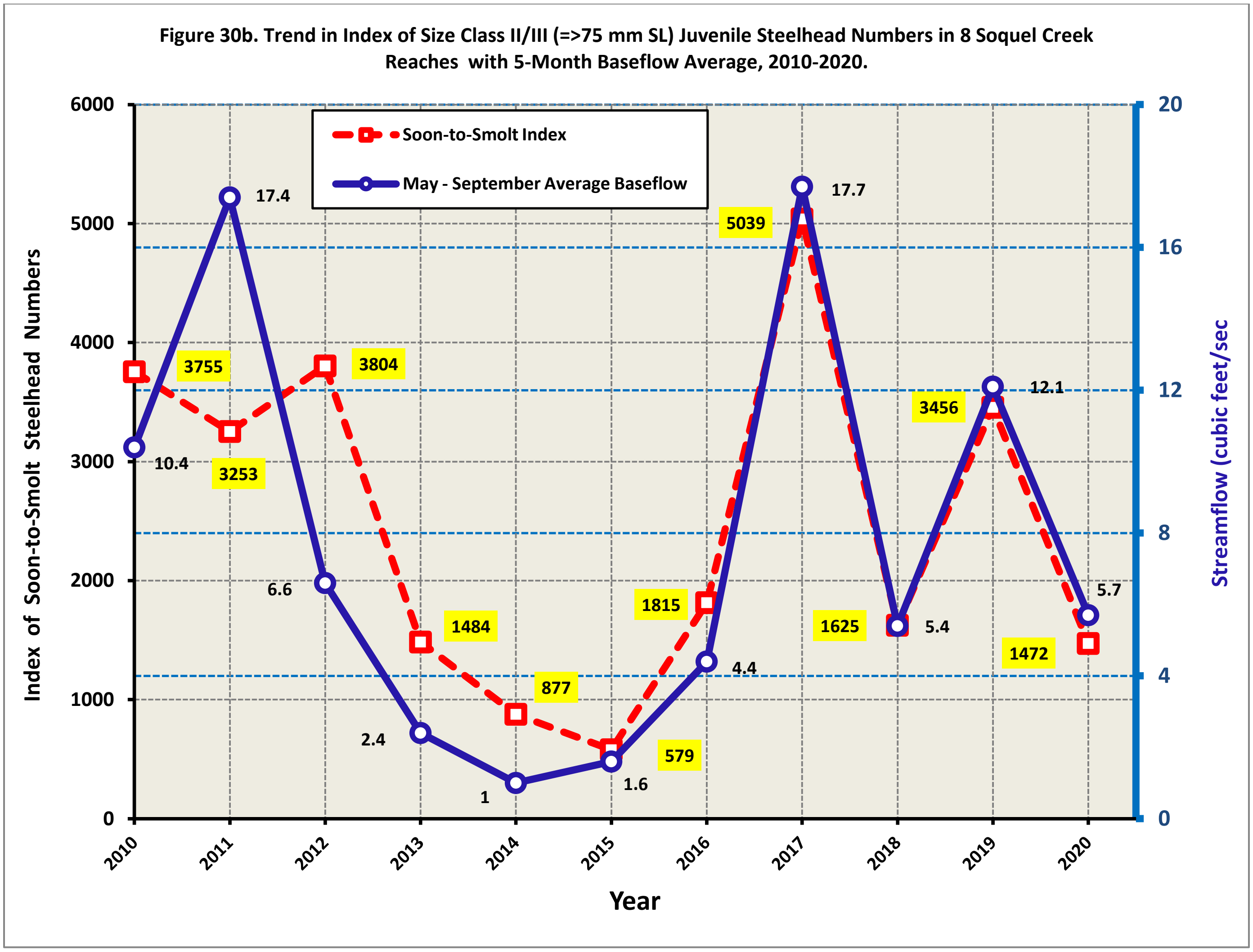


Figure 30b. Trend in Index of Size Class II/III (=>75 mm SL) Juvenile Steelhead Numbers in 8 Soquel Creek Reaches with 5-Month Baseflow Average, 2010 −2020.

iii. Steelhead Abundance and Habitat in the Aptos Creek Watershed

1. Aptos Creek likely had a WY2020 hydrograph similar to those in the San Lorenzo and Soquel drainages, with stormflows at the same frequency and intensity. This resulted in similar dry stormflow patterns as in the SLR for WY2020 except that the April stormflow likely reached above bankfull (**Figure 21**), as it did in the Soquel watershed. This late stormflow provided better spawning access in this lower gradient watershed compared to the SLR. Another small stormflow later in May provided additional adult access to lower reaches and also encouraged out-migration of smolts. Baseflow likely declined steadily from mid-May close to the median baseflow down to 1.1 cfs in early October at a location just downstream of the Valencia Creek confluence (**Table 4**).

2. ***Habitat conditions*** declined in both Aptos segments and Valencia creek sites compared to the 2019 wet year. This was primarily due to less drifting food available with less baseflow, reduced pool depth (except in upper Aptos segment 4) and increased or continued high fine sediment in

pools (**Table 6**). Embeddedness was similar between years, while the escape cover index increased in upper Aptos segment 4 and remained similar in lower Aptos segment 3.

3. ***Total and YOY steelhead densities were below average at all 4 sites*** (averaging 12.1 total juveniles/100 ft and 6.7 YOY/100 ft) (**Figures 31 and 32**), and both decreased statistically significantly from 2019 levels (**Figure 33; Table 10**). The 4-site long-term trend in total density decreased in 2020 (**Figure 37**), consistent with trends in the SLR and Soquel watersheds.

4. ***Yearling and older steelhead densities were below average at 3 sites except Aptos 4***, averaging 5.5 yearlings/100 ft (**Figure 34**). ***Size Class II/III densities were above average at the Valencia 3 site and close to average at the other 3 sites***, averaging 9.4 Size Class II/III juveniles/100 ft **(Figure 35**). They increased at 3 of 4 sites in 2020 compared to 2019 (**Figure 36**). The trend in average site density of Size Class II/III juveniles increased in 2020 from 6.5 in 2018 to 7.1 in 2019 to 9.4 fish/100 ft in 2020 (close to the multi-year average of 9.6) (**Figure 38a**). Trends in the SLR and Soquel watersheds of densities and index numbers of larger juveniles track positively with baseflow through the wet and dry years, but less so for the Aptos/Valencia watershed (**Figures 17b, 18b, 30b and 38b**). This may be because the Aptos adult steelhead population has declined to the point where density dependent competition to reduce juvenile densities does not intensify in dry years having low baseflows. This would occur because the few juveniles produced from a small number of adults do not come close to saturating the rearing habitat in the Aptos branch of the watershed. In the SLR and Soquel watersheds, an increase in these larger juveniles occurs in high baseflow years partially because fewer YOY grow into Size Class II their first summer. But in Aptos Creek, total juvenile density maybe low enough to allow faster YOY growth even in low baseflow years. However, 2019 was an exception during fall sampling, with high YOY densities of small YOY probably produced from late adult spawners with high competition. With few YOY reaching Size Class II and few yearlings, numbers of these larger juveniles did not increase in 2019 in the Aptos watershed.

5. ***The Aptos Estuary steelhead population estimate was 365 in 2020***, the third highest in 7 years (**Figure 39**). The size histogram of captured steelhead indicated no bimodal size distribution of age classes (**Figure 40**). The good-sized Aptos estuary steelhead population of Size Class II and III juveniles in 2020 and their near average density at the 4 stream sites offered potential for overall population sustainability.

6. 36 tidewater gobies (*Eucyclogobius newberryi*) were captured with the large seine (3/8-inch mesh) on 1 October and were present on 8 October, despite the saline conditions in the lower water column. 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 unusual California halibut (*Paralichthys californicus*) (16 captured on October 8).

7. The estuary had stratification of water temperature, salinity and oxygen on both sampling days (**Table 7**). The outlet channel was small and shallow with a well developed beach berm. However, periodically the estuary level was affected by tidal inflow at high tide because the estuary was 0.6 ft shallower on 8 October than on 1 October. The estuary was nearly 0.5 meters shallower under the walk bridge than the previous year. But the gage height was more than 0.6 meters lower, indicating considerable scour from 2019 to 2020. On 1 October at 0835 hr on a clear, smoky morning, the estuary was relatively shallow at the walk bridge, with a gage height of 2.69 and warm, saline water below the near freshwater layer 0.25 meters thick at the surface (>21.0 °C below 0.5 m from the surface). Water temperature was a cool 15.6 °C in the upper 0.25 meters. Temperature ranged from 21.5 °C to 25.2 °C from 0.5 m from the surface down to 1.35 m on the bottom. Salinity was 0.7 ppt

in the upper 0.25 meters. Salinity ranged from 7.1 to 25.9 ppt from 0.5 m down to 1.35 m on the bottom. Oxygen concentration ranged from 10.96 to 10.43 mg/L in the upper 1.0 m. Oxygen then dropped from 4.89 mg/L at 1.25 m down to 0.83 mg/L at 1.35 m. On 8 October at 0835 hr on an overcast day, the estuary shallowed by 0.1 meters from the previous week. Stratification of water temperature went warmer. Stratification of salinity went slightly less. Oxygen was similar.

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

Reach or (Site Only) Comparison To Previous Years	2020 Baseflow Comparison (Most Important Factor May-September)	Pool Depth	Pool Fine Sediment	Pool Embeddedness	Pool Escape Cover	Overall Habitat Change (Any Improvement)
Aptos Site 3 Aptos Reach 3 (Since higher baseflow 2019)	−	−	−	Similar	Similar	−
Aptos Site 4 Aptos Reach 4 (Since higher baseflow 2019)	−	+	−	Similar	+	− (more pool depth and cover)
(Valencia Site 2) Valencia Reach 2 (Since higher baseflow 2019)	−	−	Similarly High	Similar	−	−
(Valencia Site 3) Valencia Reach 3 (Since higher baseflow 2019)	−	−	Similarly High	Same	Similar	−

Table 7. Water quality measurements in the Aptos Estuary during steelhead sampling, 1 and 8 October 2020.

			1-Oct-2020					8-Oct-2020
	Walk-bridge (thalweg) Air temp. 14.2°C Gage Height= 2.69			0835 hr	**Walk-bridge** (thalweg) Air temp. 13.4°C; Gage Height= 2.10			0835 hr
Depth	**Temp**	**Salin**	**Oxygen**	**Cond**	**Temp**	**Salin**	**Oxygen**	**Cond**
(m)	**(C)**	**(ppt)**	**(mg/l)**	**micro-mhos**	**(C)**	**(ppt)**	**(mg/l)**	**micro-mhos**
0 (surface)	15.5	0.7	10.96	1120	15.0	0.7	8.57	1049
0.25	15.6	0.7	11.06	1124	16.1	0.8	10.01	1274
0.5	21.5	7.1	11.10	11800	23.8	9.3	11.87	15583
0.75	25.3	17.7	11.41	28837	27.9	16.5	8.86	28501
1.0	26.5	22.7	10.43	37051	28.3	21.3	4.37	36226
1.25b	25.7	25.2	4.89	40048	27.9	23.4	0.48	39180
1.35b	25.2	25.9	0.83	40679				

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

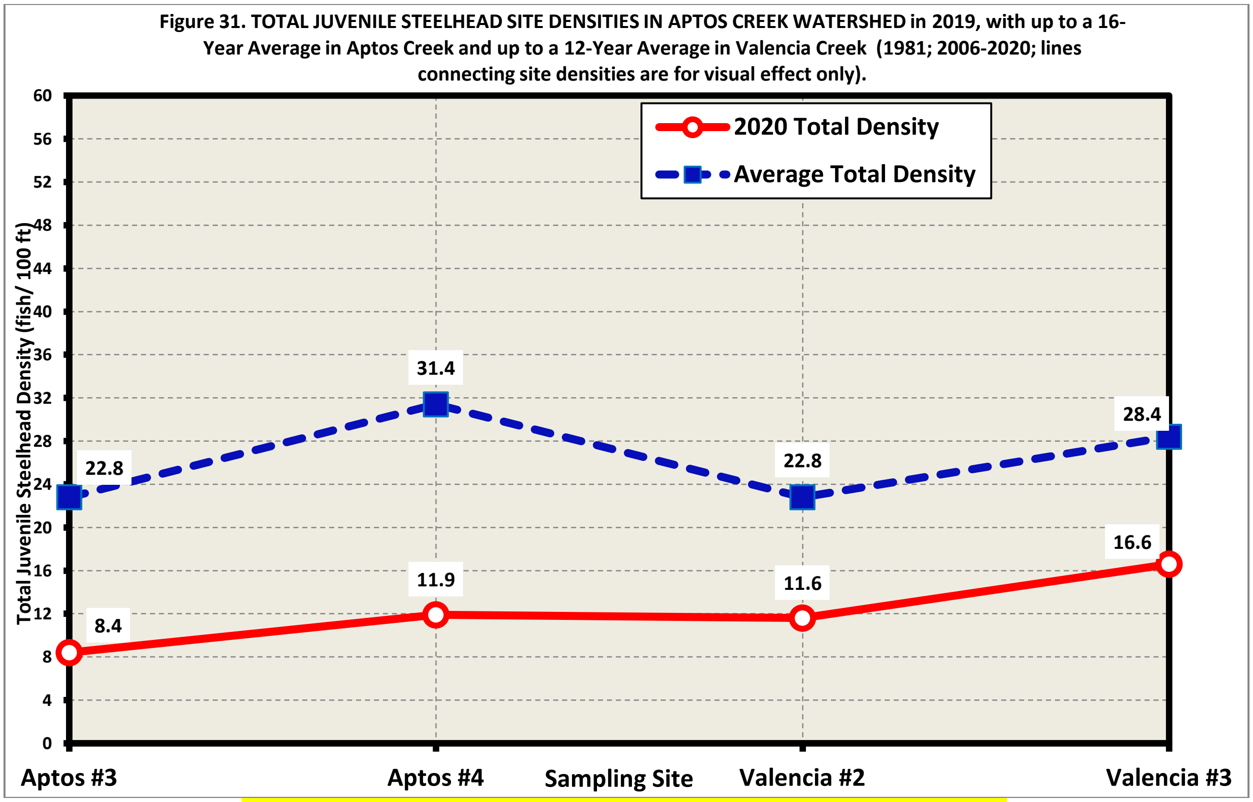


Figure 31. Total Juvenile Steelhead Site Densities in Aptos Watershed in 2020, Compared with a 15-Year Average (1981; 2006-2020).

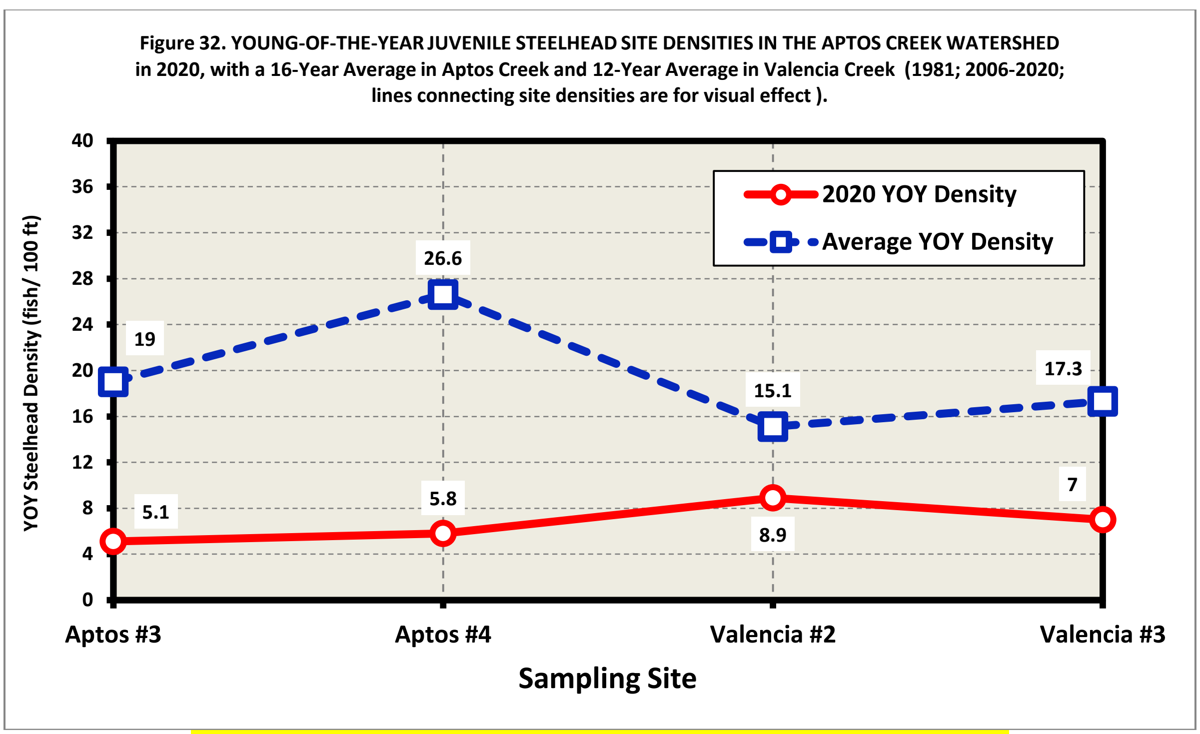


Figure 32. Young-of-the-Year Steelhead Site Densities in Aptos Watershed in 2020, Compared with a 16-Year Average (1981; 2006-2020).

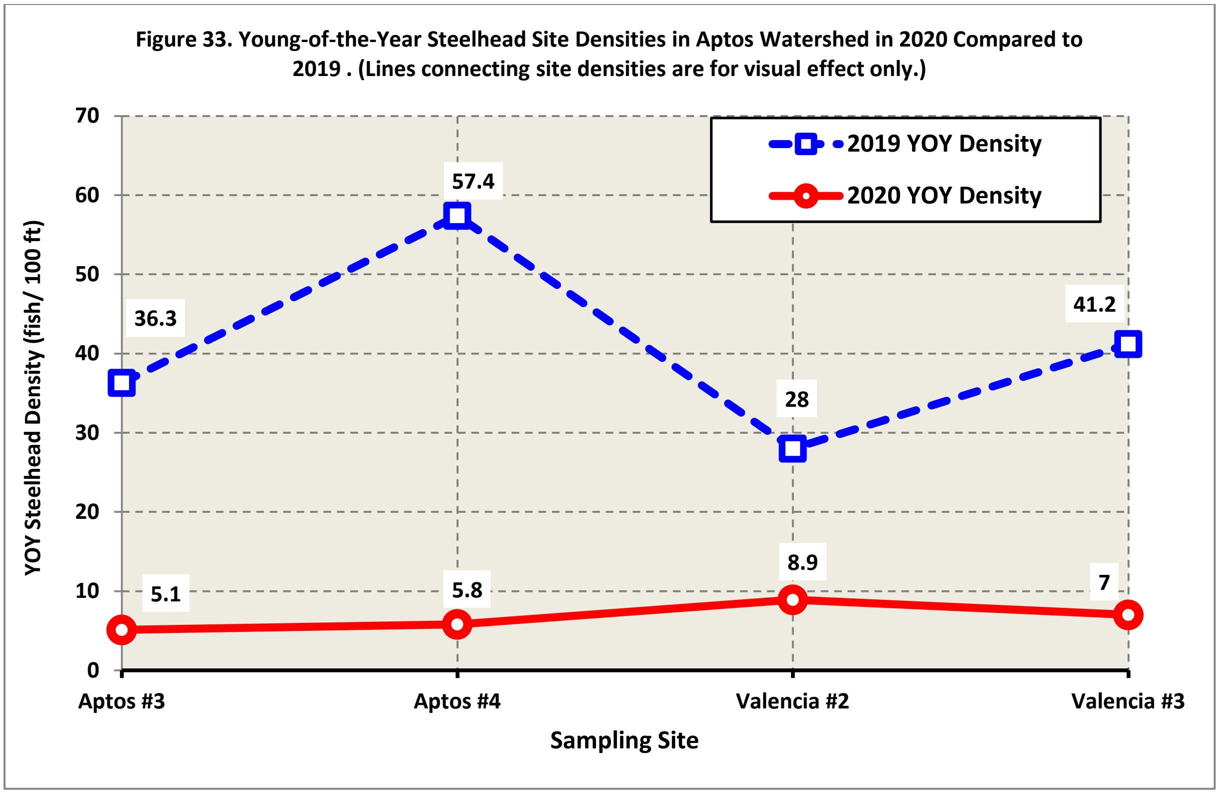


Figure 33. Young-of-the-Year Site Densities in Aptos Creek, Comparing 2020 to 2019.

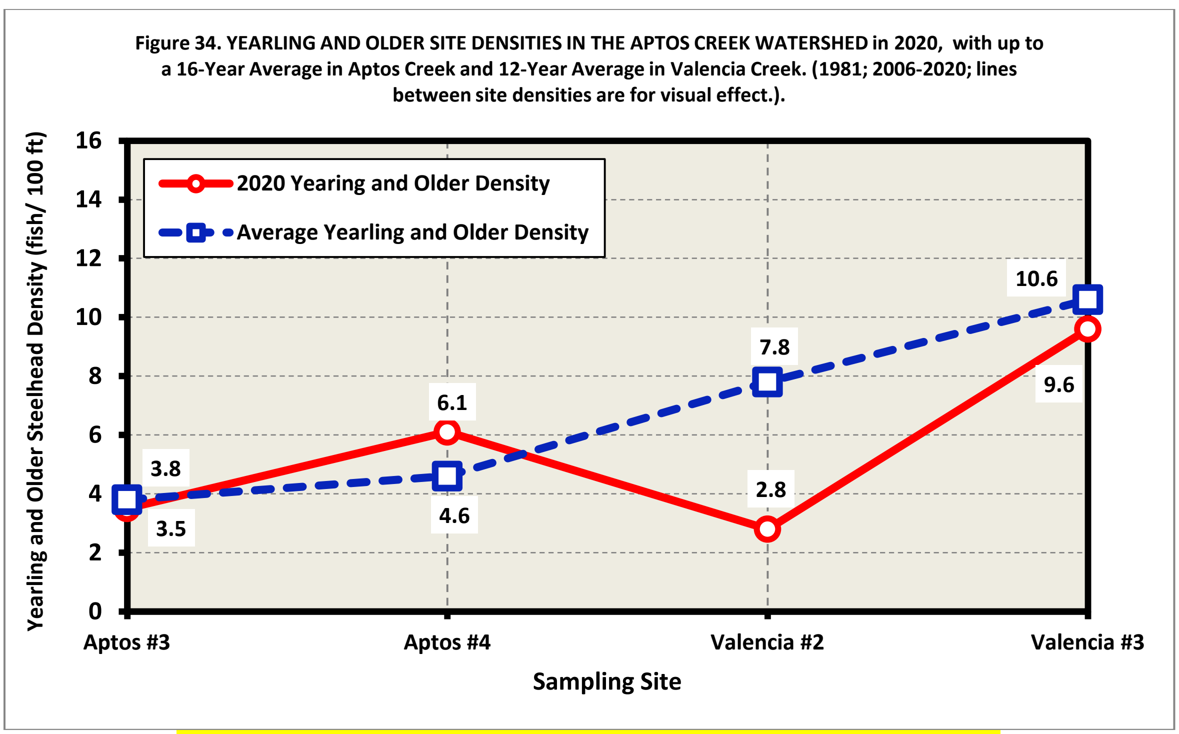


Figure 34. Yearling and Older Steelhead Site Densities in Aptos Watershed in 2020, Compared with a 16-Year Average (1981; 2006-2020).

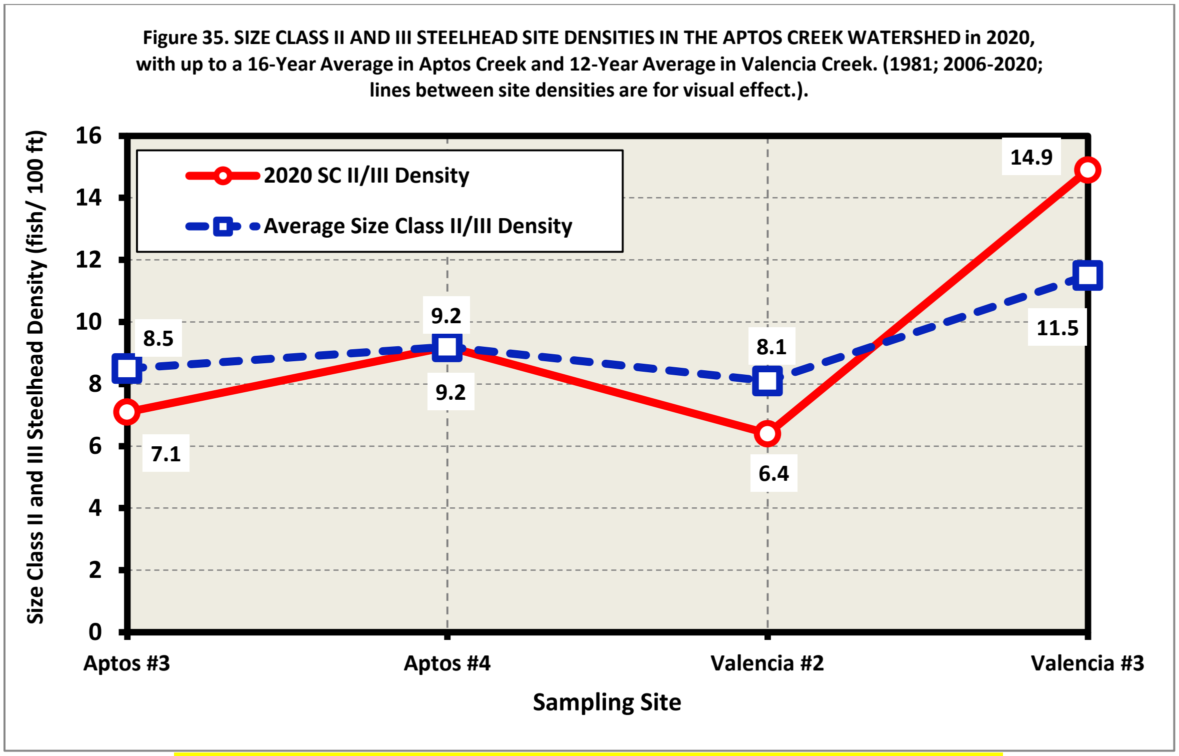


Figure 35. Size Class II and III Steelhead Site Densities in Aptos Watershed in 2020, Compared with a 16-Year Average (1981; 2006-2020).

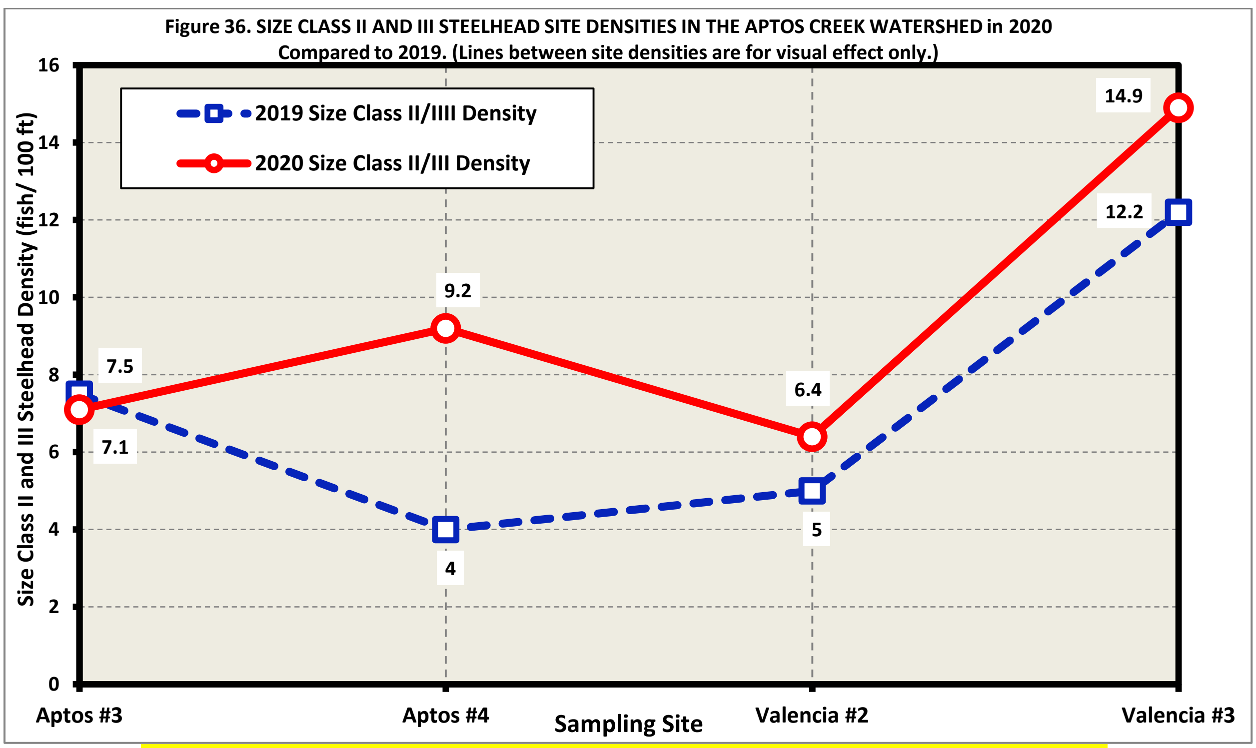


Figure 36. Size Class II and III Steelhead Site Densities in Aptos Creek Comparing 2020 to 2019.

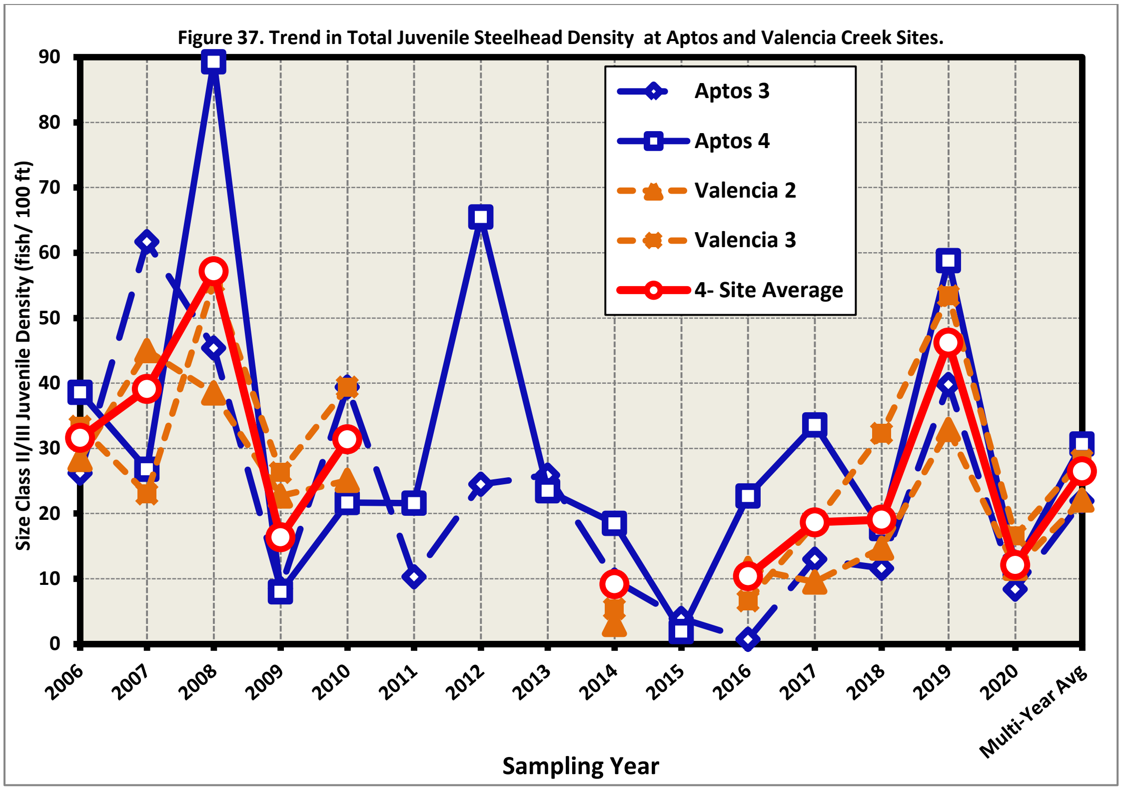


Figure 37. Trend in Total Juvenile Steelhead Site Densities in Aptos Watershed for 2006–2020.

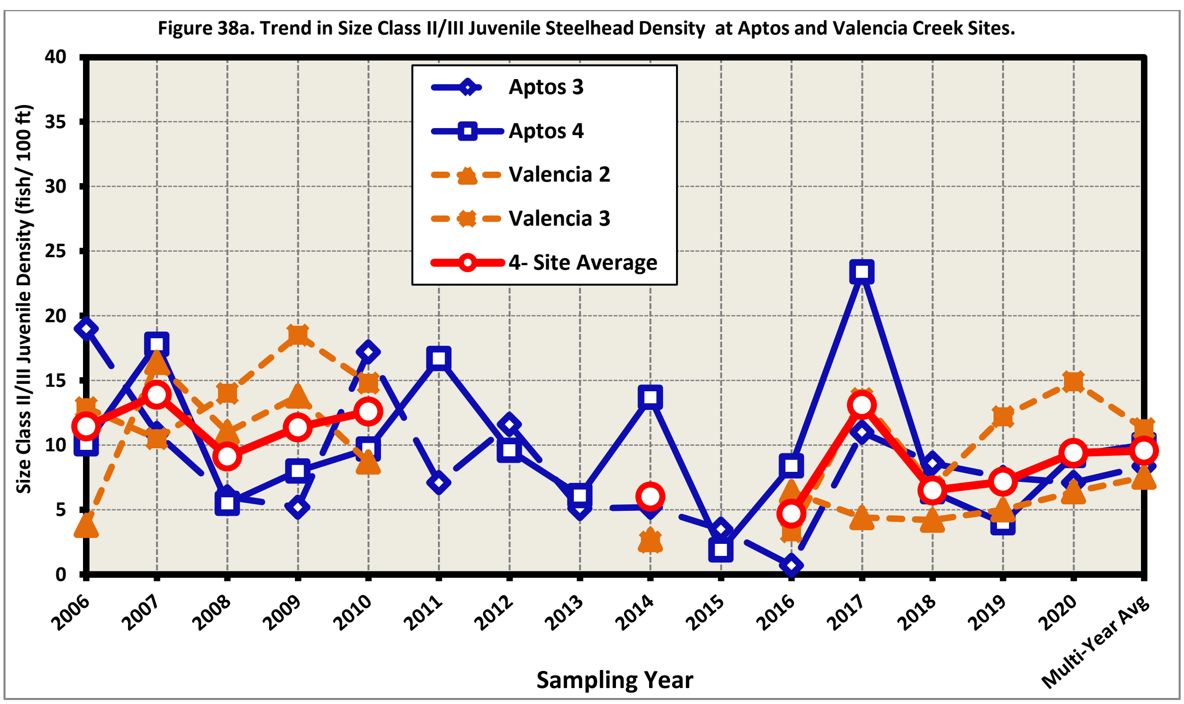


Figure 38a. Trend in Size Class II and III Steelhead Site Densities in Aptos Watershed for 2006–2020.

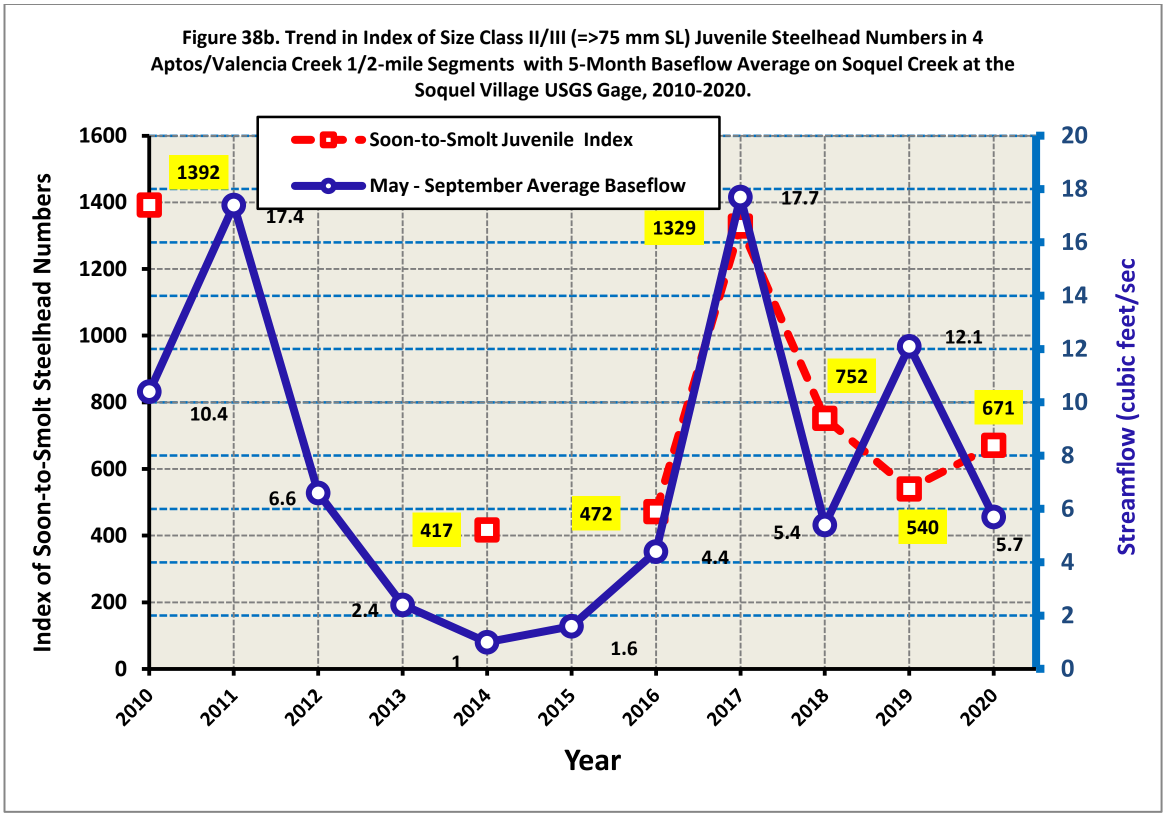
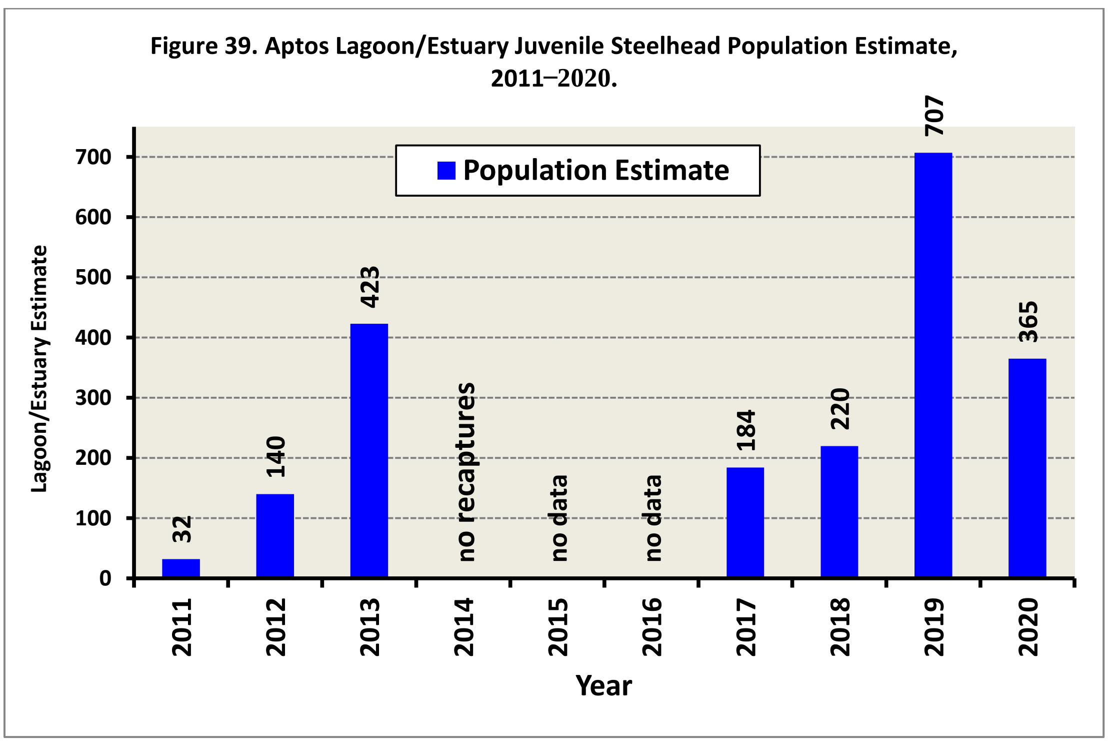


Figure 38b. Trend in Index of Size Class II/III (=>75 mm SL) Juvenile Steelhead Numbers in 4 Aptos/Valencia Creek Segments with 5-Month Baseflow Average in Soquel Creek, 2010 –2020.



39. Aptos Lagoon/Estuary Juvenile Steelhead Population Estimate, 2011–2020.

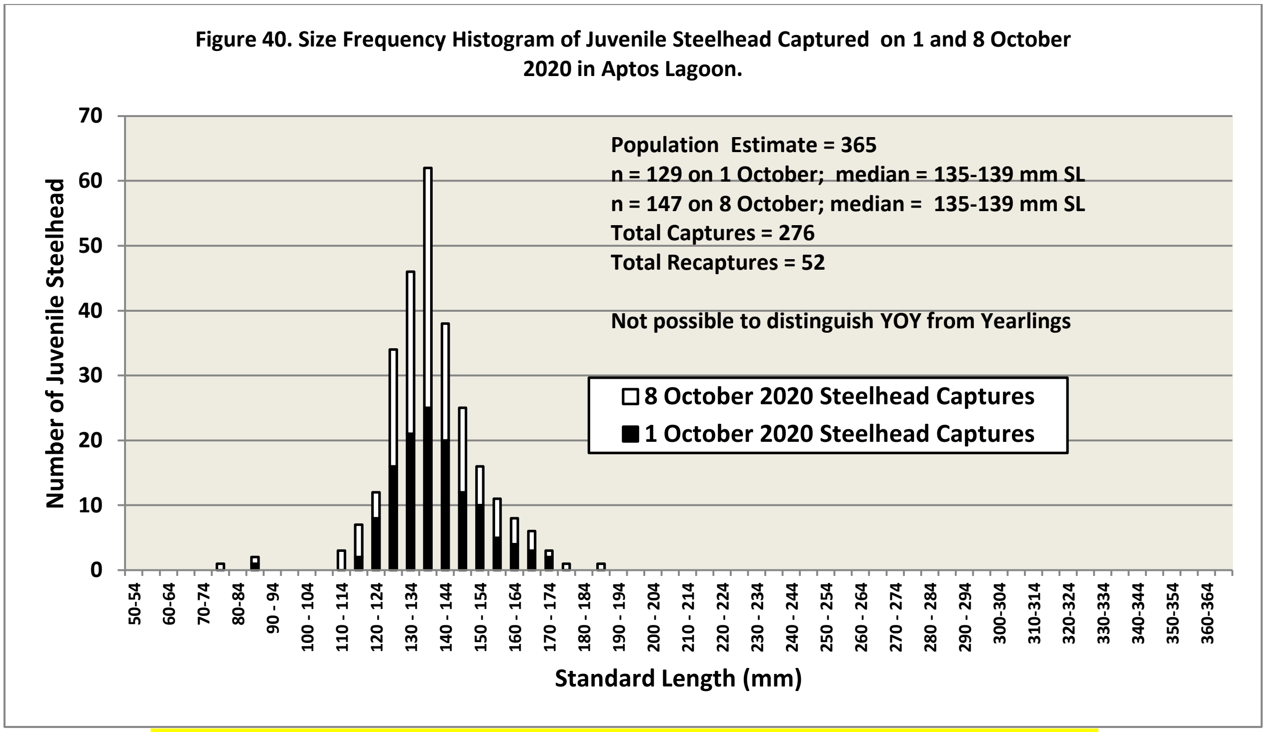


Figure 40. Size Frequency Histogram of Steelhead Captured in Aptos Lagoon, October 2020.

iv. Statistical Analysis of Annual Difference in Juvenile Steelhead Densities

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 (2020 to 2019; n=22).

Statistic	s.c. 2	a.c. 1-YOY	a.c. 2	All Sizes
Mean difference	-1.64	-32.06	0.22	-31.37
Df	21	21	21	21
Std Error	0.72	4.58	0.32	4.62
t Stat	-2.28	-6.99	0.68	-6.78
P-value (2-tail)	0.0335	0.0000	0.5037	0.0000
95% CL (lower)	-3.13	-41.59	-0.45	-40.99
95% CL (upper)	-0.14	-22.52	0.89	-21.75

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 (2020 to 2019; n=6).

Statistic	s.c. 2	a.c. 1-YOY	a.c. 2	All Sizes
Mean difference	-6.58	-51.40	1.28	-50.68
Df	5	5	5	5
Std Error	2.74	12.42	1.28	12.14
t Stat	-2.40	-4.14	1.00	-4.17
P-value (2-tail)	0.0614	0.0090	0.3612	0.0087
95% CL (lower)	-13.63	-83.33	-2.00	-81.89
95% CL (upper)	0.46	-19.47	4.57	-19.47

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 (2020 to 2019; n=4).

Statistic	s.c. 2	a.c. 1-YOY	a.c. 2	All Sizes
Mean difference	2.22	-34.03	0.25	-34.10
Df	3	3	3	3
Std Error	1.18	6.71	1.72	5.34
t Stat	1.89	-5.07	0.15	-6.39
P-value (2-tail)	0.1553	0.0148	0.8935	0.0078
95% CL (lower)	-1.52	-55.37	-5.22	-51.10
95% CL (upper)	5.97	-12.68	5.72	-17.10

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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 little surface turbulence except at the head and that 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. Pools are the primary habitat for coho salmon and larger juvenile steelhead in Santa Cruz Mountain tributaries and mainstem headwater sites.

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.

APPENDIX A. SAMPLING SITE PHOTOS.

SLR Site 2 Productive fastwater run habitat, looking downstream.   25 September 2020

SLR Site 4 Productive fastwater riffle habitat, looking downstream.   24 September 2020

Zayante Creek- Site 13d Step-run and pool habitat among boulders, looking downstream.
14 Sept 2020

Bean Creek- Site 14b Riffle entering productive pool habitat with undercut Bank, looking downstream.
11 September 2020

Fall Creek- Site 15b Productive riffle flowing into good pool habitat with old growth redwood rootwad and instream wood, looking upstream. 5 October 2020

Newell Creek- Productive Pool Habitat with good riprap cover, looking downstream. 22 September 2020

Boulder Creek- Site 17b Step-run flowing into productive pool with algal film, looking downstream. 2 Oct 2020

Bear Creek Site 18b Productive pool habitat, looking upstream. 17 September 2020

Branciforte Creek- Site 21b Productive pool habitat with undercut bank created by old growth redwood, looking upstream. 10 September 2020

Soquel Mainstem Site 12 Productive pool habitat with instream wood, looking upstream. 31 August 2020

East Branch Soquel Creek- Site 13a Productive pool habitat with undercut bank below sycamore rootwad, looking upstream. 31 August 2020

East Branch Soquel Creek, SDSF- Site 16 Run habitat, looking upstream. 3 September 2020

West Branch Soquel Creek- Site 21 Pool with bedrock and large boulders, looking downstream.
4 September 2020

Aptos Creek- Site #3 Productive pool habitat with instream wood, looking downstream.
8 September 2020

Aptos Creek- Site #4 Run and upstream productive pool habitat, looking upstream.
8 September 2020

Valencia Creek- Site 3 Pool habitat on a smoky afternoon, looking upstream. 9 September 2020

Smoky skyline along SLR mainstem in Brookdale, CA. 1723 hr, 9 September 2020.

Lower Aptos Estuary with valuable habitat around pilings, looking downstream. 1 October 2020.