D.W. ALLEY & Associates aquatic biology

2018 SUMMARY REPORT− Juvenile Steelhead Densities in the San Lorenzo, Soquel and Aptos Watersheds, Santa Cruz County, CA

Expansive Corner Pool in Mainstem Soquel Creek above Site #10 and the Historic Landslide

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(Sampling for Tidewater Goby under USFWS Endangered Species Recovery Permit TE-793645-4)

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A. EXECUTIVE SUMMARY

WY2018 baseflow was below the median flow statistic, unlike the wet WY2017, making 8 of the last 12 water years below median flow (**Figure 6**). The few stormflows during the wet season provided limited adult steelhead access to upper watershed sites except for November (very early for steelhead), one stormflow in early January, 3 minor stormflows between March and early April, plus one reaching bankfull on 22 March. Despite limited passage opportunities, adults accessed upper watersheds. However, spawning redds laid in March before the bankfull event may have been scoured or smothered by sediment during that stormflow and resulted in low YOY densities at more downstream sites. When 2018 rearing habitat conditions were compared with pre-2017 conditions (2012-2016), they had improved from drought with increased baseflow (more food), increased depth and more escape cover. When 2018 conditions were compared to 2017, they declined due to reduced baseflow (less food) and reduced depth in all watersheds and reduced escape cover in Soquel and Valencia creeks. Increased fine sediment and embeddedness, especially in runs, was the general mainstem San Lorenzo pattern compared to past years. And escape cover increased in mainstem fastwater habitat from 2017 to 2018. No consistent pattern occurred in San Lorenzo tributaries regarding fine sediment and embeddedness. Sediment increased in pools in upper Zayante 13i and Bear 18b (soft underfoot in pools) from 2017, indicating high erosion and sediment sources upstream. But percent fine sediment lessened or was similar in other tributary reaches/sites of the San Lorenzo.

In the San Lorenzo, total and YOY densities were below average at 9 of 10 mainstem sites and 12 of 16 tributary sites, decreasing from 2017 at 5 of 10 mainstem sites (especially lower and middle) and 13 of 15 tributary sites, excepting upper Bean and Zayante sites. Three factors may explain the low YOY densities at the majority of sites. As in 2016 and 2017, the main factor in 2018 may have been low adult returns. A second factor may have been poor egg survival in redds laid just prior to the bankfull stormflow in late March that may have scoured them out or covered them with sediment at all but headwater sites. The third factor was below average baseflow that provided less food and rearing habitat for YOY survival.

Size Class II and III juvenile densities were below average at 9 of 10 mainstem San Lorenzo sites and 10 of 16 tributary sites. Regarding the trend in soon-to-smolt-densities, the 5-site, long term mainstem San Lorenzo average decreased from 9.2 in 2017 to 4.0 fish/ 100 ft in 2018 (**Figure 14**) (18-year average 7.2 fish/ 100 ft). The 8-site, long term San Lorenzo tributary average decreased from 14.5 in 2017 to 10.8 fish/ 100 ft in 2018 (**Figure 15**) (21-year average 11.7 fish/ 100 ft). A positive correlation was evident between average site densities of these larger juveniles and the 5-month baseflow average (**Figure 16**). Causes for more than half the sites to have below average Size Class II and III densities were that YOY densities were low where a high percent typically grow to Size Class II (lower mainstem) and few YOY grew into Size Class II at the 2 lower Zayante sites in 2018 where they sometimes do in other years when flows are higher and/or YOY emergence is earlier. Proliferation of bullfrog tadpoles in Boulder Creek after reservoir draining was alarming.

We may assume that adult spawning and egg survival was patchy from a small adult steelhead population in Soquel Creek in 2018. Total and YOY juvenile steelhead densities in Soquel Creek were near or slightly above average at 4 of 8 sites in 2018 (**Figures 19 and 20**). They increased at 5 of 8 sites from 2017 very low densities. The greatest increase in YOY density occurred at upper Mainstem Site 12 and upper West Branch Site 21 below Girl Scout Falls II. The greatest YOY density decline was at the SDSF Site 16 on the East Branch, though high YOY density was detected upstream above Ashbury Gulch (SDSF historical site). The trend in total densities (consisting of mostly YOY) increased in 2018 but remained the 5th lowest 6-site average in 21 years. The lagoon population estimate was 46, with a 24-year average of 1,422. Size Class II and III juvenile densities were above average at only 1 of 8 sites in 2018 (mainstem Site 10) and much below average at sediment- laden mainstem Site 4 and East Branch 13a below Mill Pond (**Figure 21**). With reduced baseflow and growthrate of YOY in 2018, these soon-to-smolt densities declined from 2017 levels at all 8 sites (**Figure 22**), despite higher YOY densities. The 6-site trend in Size Class II and III densities declined to below the long-term average of 8.1 fish/ 100 ft to 4.9 fish/100 ft compared to the high flow 2017 average (13.5 fish/100 ft) (**Figure 24**). The 6-site trend in average for Size Class II/III density is positively correlated with average 5-month baseflow in some years (**Figure 25**).

Total and YOY steelhead densities were below average at 3 of 4 Aptos watershed sites, excepting upper Valencia Site 3 (**Figures 26 and 27**). Yearling and older densities were slightly above average at the Aptos sites and below average at Valencia sites. Size Class II and III densities were below average at 3 of 4 sites, excepting lower Aptos Site 3 (**Figure 28**). The trend in the 4-site, long term average density of Size Class II/III juveniles declined from 2017 (13.1 fish/100 ft) to 2018 (6.7 fish/100 ft) (below multi-year average of 9.9) (**Figure 29**). The steelhead population estimate for Aptos Estuary was 220. The years 2011−2013 and 2017 had estimates of 32, 140, 423 and 184, respectively, with too few steelhead captured to estimate numbers in 2014. Tidewater goby were present in 2018. The 2018 steelhead increase offered potential for overall population sustainability, though Size Class II and III densities were still below average above the estuary.

B. INTRODUCTION

i. Scope of Work

In fall 2018, 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 2017 and past years in selected reaches of the San Lorenzo, Soquel and Aptos watersheds (**Figures 1−5**). Results from steelhead and habitat monitoring are used to guide watershed management and planning (including implementation of public works projects) and enhancement projects for species recovery. Refer to the Santa Cruz County Environmental Health website for maps that delineate reaches and sampling sites. Hydrographs of all previous sampling years are also available at that 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 are available at the county website.

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, Lompico, Bean, Fall, Newell, Boulder and Bear creeks. Twenty-four 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 2 sites, the 2017 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 2−4**). For the remaining 5 sites, the 2017 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 5**). After habitat typing of the 2 Aptos segments, new sites were chosen. The 2 Valencia Creek sites were replicated at the 2017 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.

Pajaro River Lagoon/ Estuary. The Pajaro River Estuary was sampled in 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.

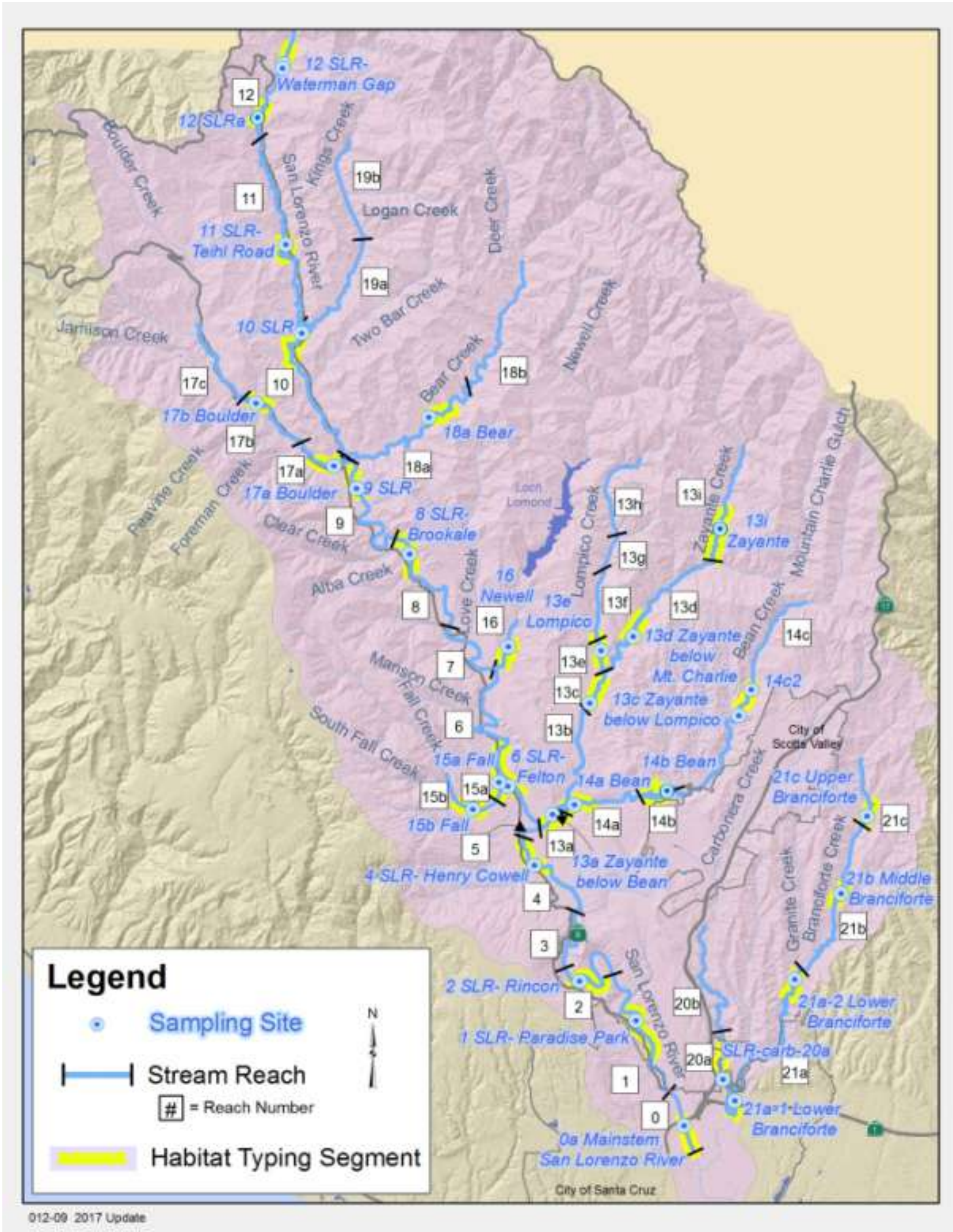

Figure 1. San Lorenzo River Watershed− Sampling Sites and Reaches.

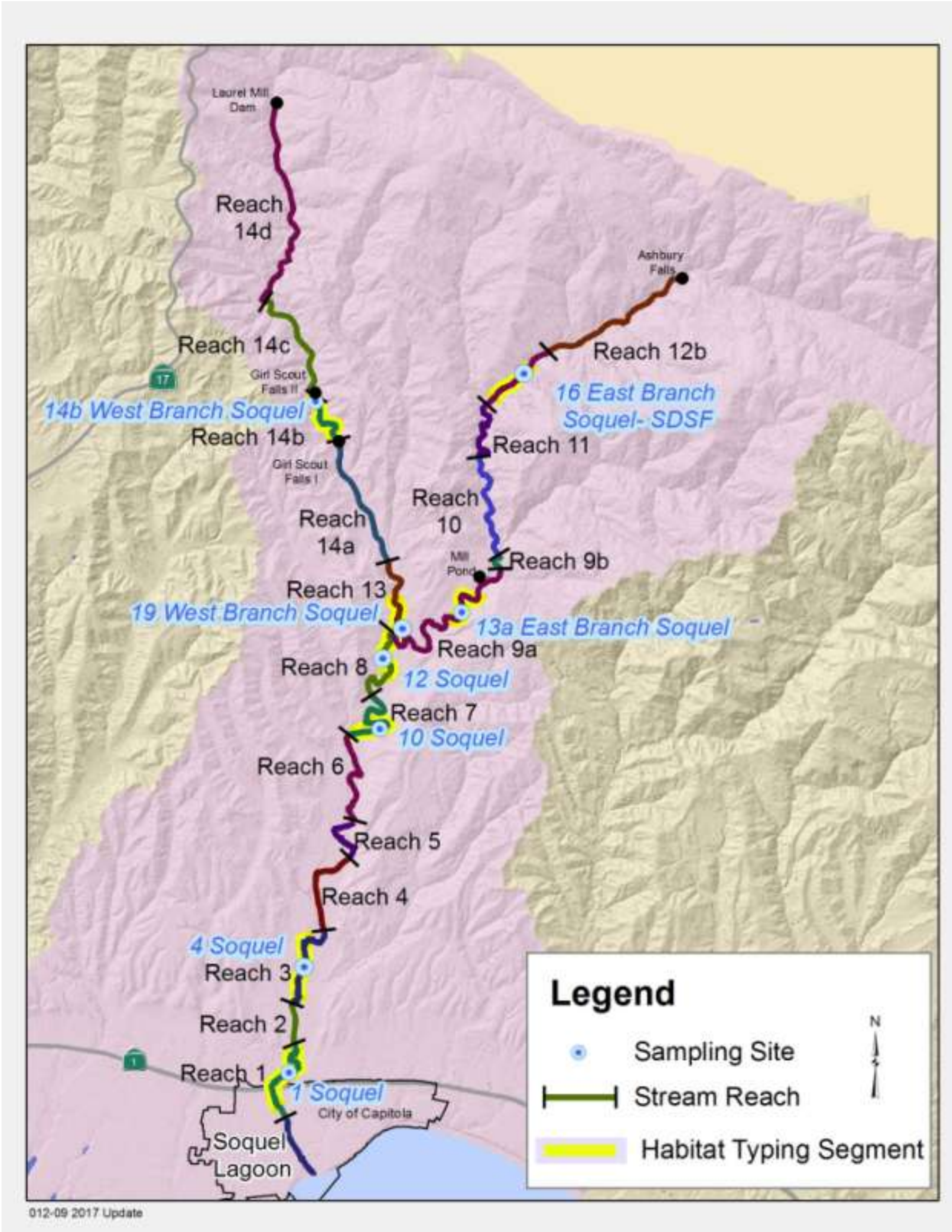

Figure 2. Soquel Creek Watershed.

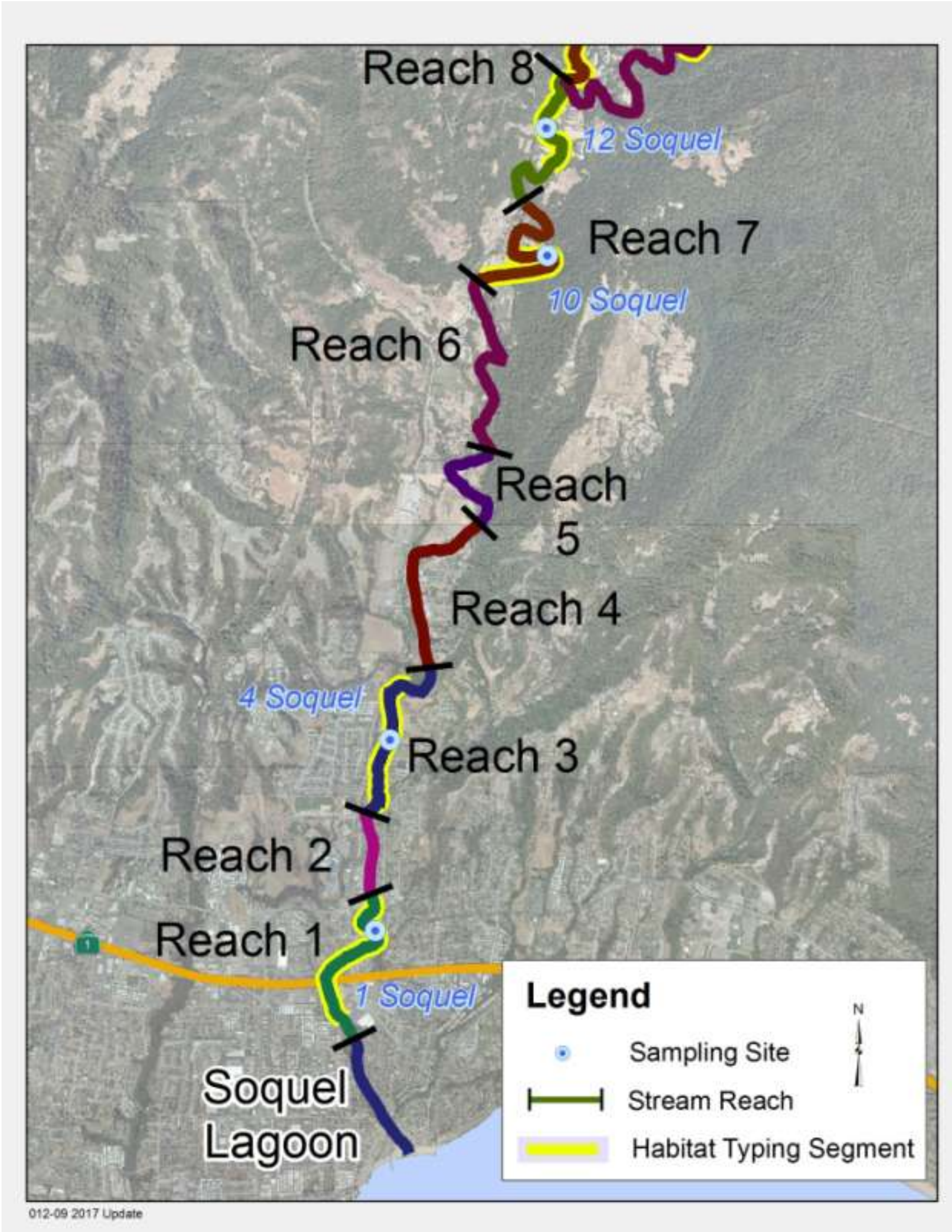

Figure 3. Lower Soquel Creek (Reaches 1–8 on Mainstem).

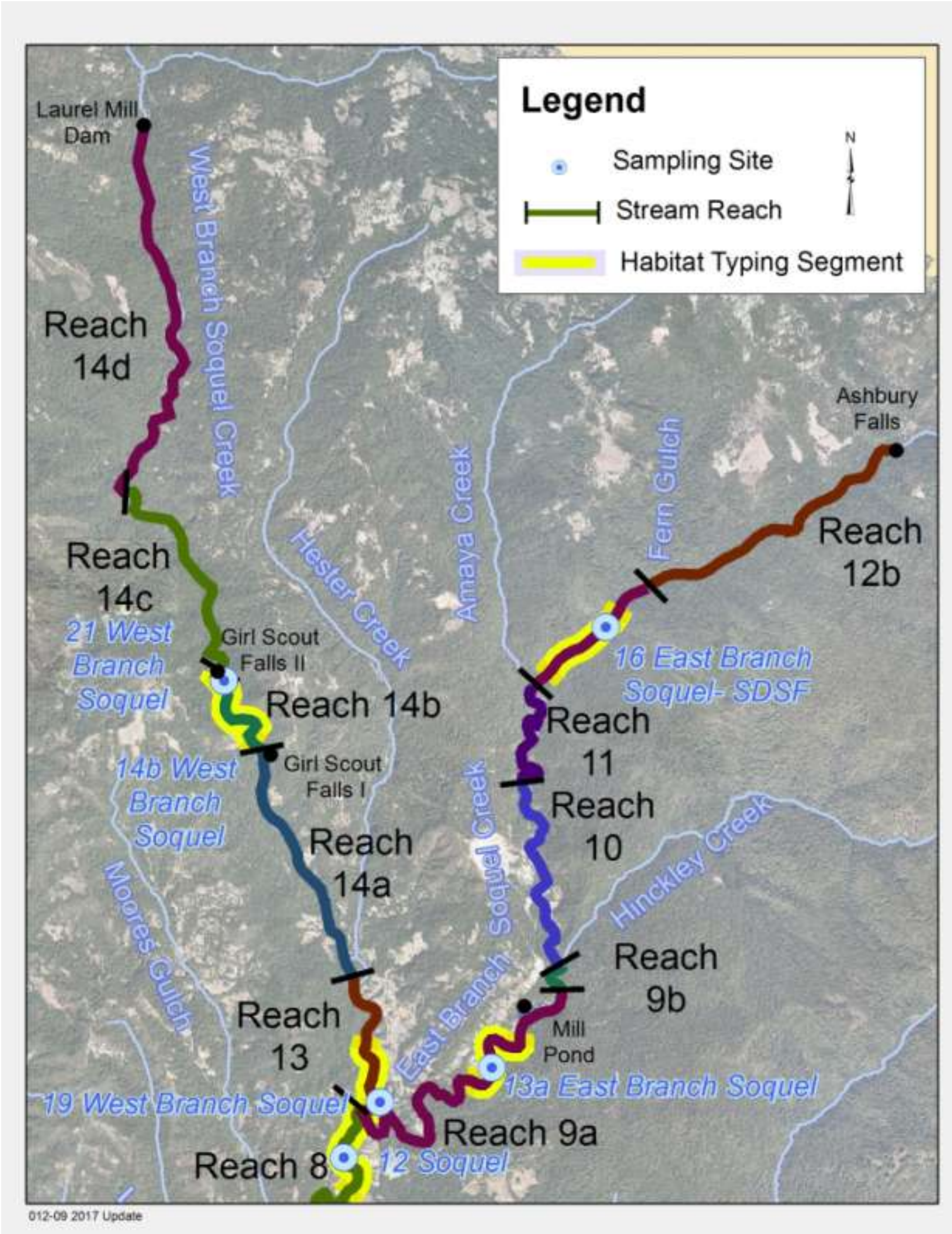

Figure 4. Upper Soquel Creek Watershed (East and West Branches; Reach 9a below habitat-typed segment and Reach 12a were dry in 2014 and 2015).

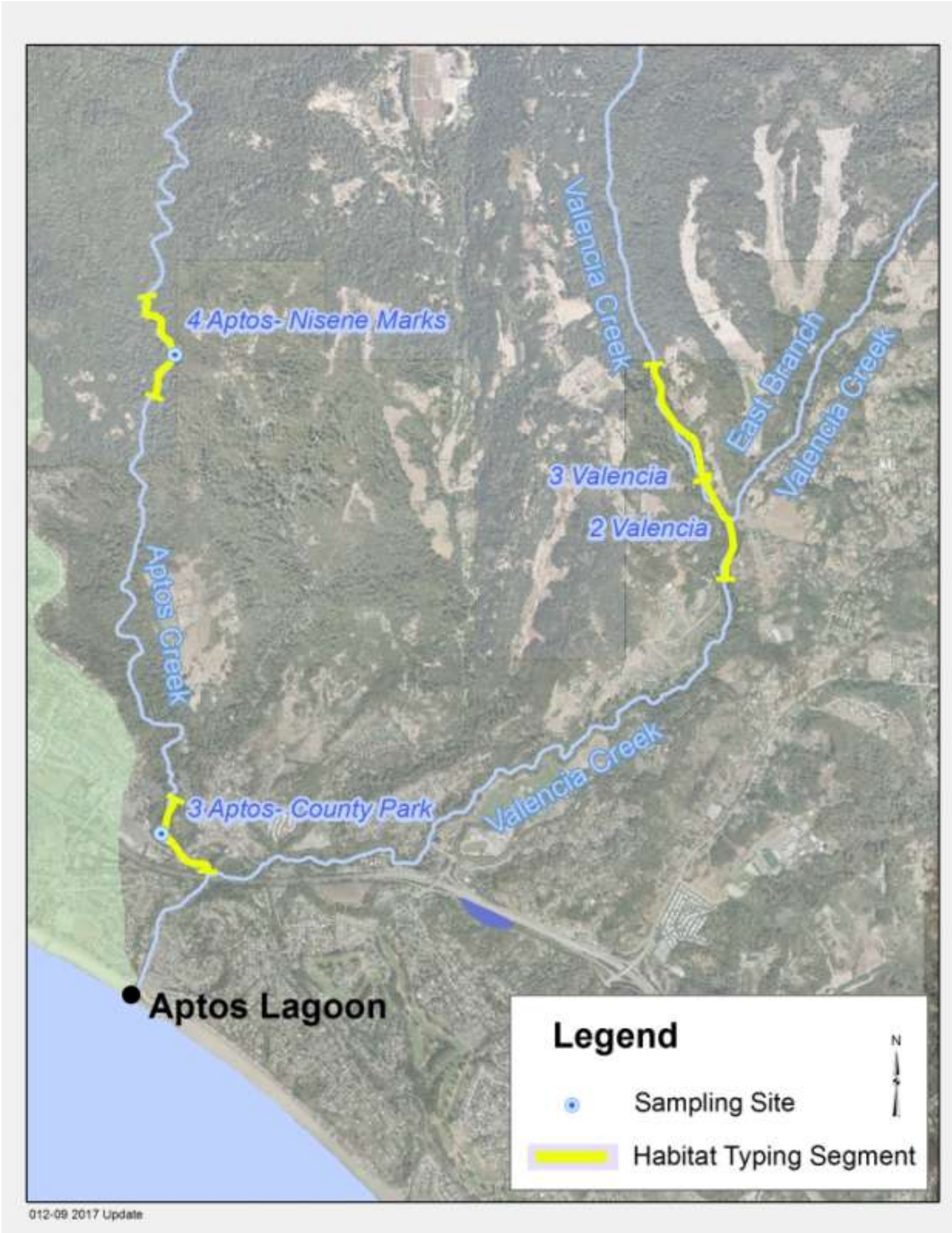

Figure 5. Aptos Creek Watershed (Aptos Lagoon not sampled in 2015 or 2016).

C. RESULTS

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

1. WY2018 streamflows in spring-summer-fall were below the median flow statistic, unlike the wet WY2017, making 8 of the last 12 water years below median flow (**Figure 6**). The few stormflows during the wet season provided limited adult steelhead access to upper watershed sites except for November (very early for steelhead), one stormflow in early January, 3 minor stormflows in March and early April, plus one reaching bankfull at 3,570 cfs at the San Lorenzo mainstem Big Trees Gage No stormflow occurred in December or February. Despite limited passage opportunities, adults accessed the upper watershed. However, spawning redds laid in March before the late bankfull event may have been destroyed or smothered with sediment moved by that stormflow. YOY steelhead were relatively abundant at uppermost Bean Creek 14c-2, upper Zayante 13d and at average density in the mainstem San Lorenzo at Waterman Gap above the Highway 9 culvert. However, relatively lower numbers of YOY at uppermost Zayante 13i above Zayante 13d may indicate passage impedance at the bedrock chute between them. Baseflow well below the 22-year average provided reduced rearing conditions and YOY steelhead growth rate in 2018 compared to the high baseflow 2017 (**Figure 7**). Proliferation of bullfrog tadpoles in Boulder Creek after reservoir draining was alarming. A bullfrog metamorph was at Mainstem Site 8.

2. ***In the mainstem in 2018***, rearing habitat conditions improved in reaches when compared to segment conditions pre- 2017 (2012─2016) with increased depth and cover except for upper mainstem Reach 11 that lost escape cover with more fine sediment (**Tables 2 and 3**). When 2018 conditions in sites or segments were compared to 2017, they declined due to lower baseflow that shallowed habitat and provided less food. More escape cover in mainstem fastwater habitat was the only consistent pattern in escape cover change evident from 2017 to 2018. Increased fine sediment and embeddedness, especially in runs was the general mainstem pattern compared to past years. 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 making the Rincon riffle more challenging to migrating adult steelhead. The middle of the ½-mile habitat typed segment 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. The main channel was habitat typed in braided sections of Reach 2. Sand and gravel bars remained at tails of pools in other mainstem reaches after 2017 formation.

3. As in the mainstem, habitat conditions in ***tributary sites/reaches*** in 2018 improved in reaches when compared to segment conditions pre- 2017 (2011─2016), with increased depth and cover. As in the mainstem, when 2018 site or segment conditions in tributaries were compared to 2017, they declined due to lower baseflow that shallowed habitat and provided less food. No consistent pattern occurred in tributaries regarding fine sediment and embeddedness. Sediment increased in pools in upper Zayante 13i and Bear 18b (soft underfoot in pools) but lessened or was similar in other reaches/sites. Embeddedness remained similar or improved except in runs of Zayante 13a, Boulder 17a and Bear 18b. The large log jam in Newell Creek Reach 16 had been removed.

4. ***Total and YOY juvenile densities in mainstem sites*** were below average at 9 of 10 sites (**Figures 8 and 9**). Few steelhead used lower and middle mainstem pools as the middle mainstem produced much below average steelhead densities. YOY densities declined from 2017 at 5 of 10 mainstem sites (**Figure 10**). With the reduced growth rate of YOY and fewer YOY in 2018, d***ensities of soon-to-smolt juveniles*** were below average at 9 of 10 mainstem sites (**Figure 11**).

5. ***Total and YOY densities in tributary sites*** were below average at 12 of 16 sites (**Figures 8 and 9**). YOY density was especially low at Bean 14b, Newell 16, Boulder 17a and Bear 18a (down since 2012). Exceptions were above average densities at Zayante 13d, Bean 14c-2 and Fall 15a and near average density at Branciforte 21a-2. With higher YOY densities mostly at upper tributary sites, this indicated that a small adult population had poor redd survival at most sites. In comparing 2017 and 2018 YOY densities, they were down at 13 of 15 sites in 2018 except at Zayante 13d and Bean 14c-2, where they more than doubled.

6. Three factors may explain the much below average YOY densities at the majority of sites. As in 2016 and 2017, the main factor in 2018 may have been low adult returns. A second factor may have been poor egg survival in redds laid just prior to the bankfull stormflow in late March that may have scoured them out or covered them with sediment at all but headwater sites. The third factor was the below average baseflow that provided less food and rearing habitat to reduce YOY survival.

7. The 5-site, long term trend in average mainstem site ***total density*** decreased from 2017 to 2018 (**Figure 12**). The 10-site mainstem average decreased from 28 in 2017 to 14 juveniles/100 ft in 2018. But the 8-site, long term trend in average tributary site ***total density*** increased from 2017 to 2018 due to the large YOY production at Zayante 13d and Bean 14c (**Figure 13**). The 16-site total density average for tributary sites decreased from 41 in 2017 to 38 juveniles/100 ft in 2018.

8. ***Yearling densities*** were below average at 15 of 26 sites after low recruitment from below average YOY densities at many 2017 sites and a bankfull event in latter March that may have encouraged out-migration of larger yearlings. The sites with above average yearling density were Waterman Gap mainstem 12b, Zayante 13d, Zayante 13i, Lompico 13e and Bean 14c-2. The 26-site average was 6.6 yearlings/100 ft in 2018 compared to 4.6 yearlings/100 ft in 2017.

9. ***Densities of soon-to-smolt juveniles*** were below average at 9 of 10 mainstem sites and 10 of 16 tributary sites (**Figure 11**), with better than average overwinter survival of yearlings during a mild winter. However, at the 6 sites that had average abundance, size of Size Class II and III juveniles was small (average less than 100 mm SL) (**Table 2**). Eleven of 26 sites were rated "below average" in soon-to-smolt densities.

10. Causes for more than half of the sites to have below average Size Class II and III densities were that YOY densities were low where a high percent typically grow to Size Class II (lower mainstem) and few YOY grew into Size Class II at the 2 lower Zayante sites in 2018 where they sometimes do in other years when flows are higher and/or YOY emergence is earlier.

11. Regarding the ***trend in soon-to-smolt-densities***, the 5-site, long term mainstem San Lorenzo average decreased from 9.2 in 2017 to 4.0 juveniles/ 100 ft in 2018 (**Figure 14**). The 8-site, long term San Lorenzo tributary average decreased from 14.5 in 2017 to 10.8 juveniles/ 100 ft in 2018 (**Figure 15**). A positive correlation was evident between average site densities of these larger juveniles and the 5-month baseflow average (**Figure 16**). 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 17**). When baseflow was relatively high in the April to June growth period in tributaries, more YOY could reach Size Class II. This was evident in lower and middle Zayante Creek and middle Bean Creek in wetter years.

12. The decrease in total, YOY and Size Class II/III densities from 2017 to 2018 in the San Lorenzo system was statistically significant for Size Class II/III steelhead, using the paired t-test for replicated sites (**Table 6** (section iv at the end of the report)).

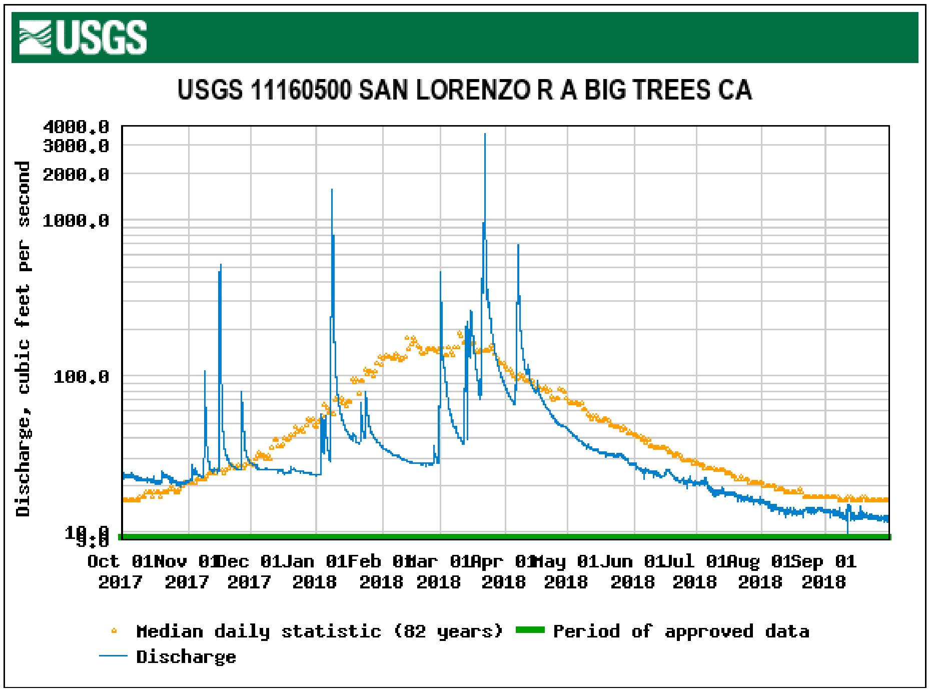

Figure 6. The 2018 Discharge Flow of Record for the USGS Gage on the San Lorenzo River at Big Trees.

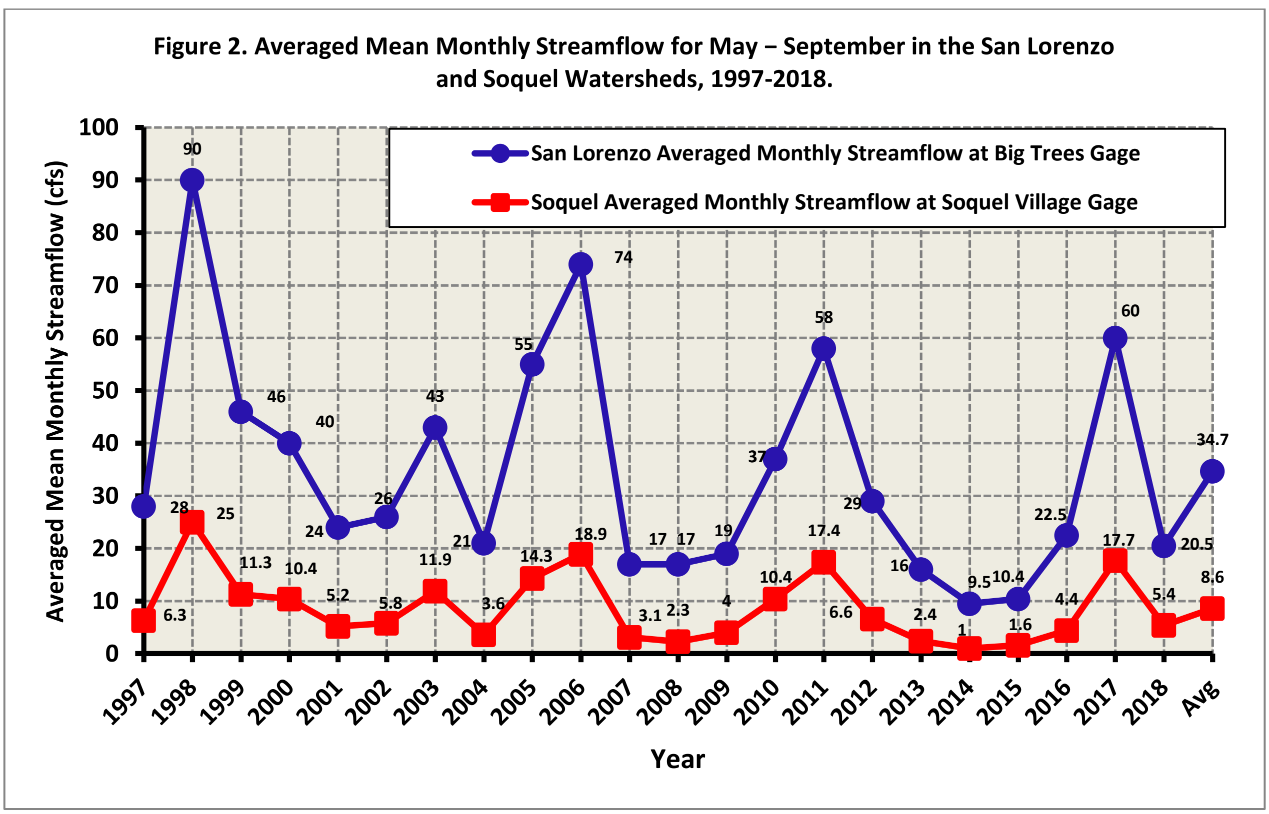

Figure 7. Averaged Mean Monthly Streamflow for May−September in the San Lorenzo and Soquel Watersheds, 1997-2018.

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

Site # / Location	1995	1996	1998	1999	2000	2001	2003	2004	2005	2006	2010	2011	2012	2013	2014	2015	2016	2017	2018
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
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
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
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
12a-b SLR/ Lower Waterman			1.0	0.7										0.33	0.10	0.22		0.85	0.39
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
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
14c-2/Bean abv MacKenzie																			0.02
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 (Balance	1.76	0.94
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
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

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

Table 2. 2018 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.)

Site	Multi-Year Avg. Potential Smolt Density Per 100 ft	2018 Potential Smolt Density (per 100 ft)/ Avg Pot. Smolt Size SL	2018 Symbolic Rating (1 to 7)	2017 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	6.7/ 152 mm	@@@@	7.6/ 160 mm	Site – (Since 2017)
Low. San Lorenzo #1	7.3	6.1/ 104 mm	@@@@	14.0/ 106 mm	Reach + (Since 2014)
Low. San Lorenzo #2	13.1	4.4/ 104 mm	@@@@	20.1/ 101 mm	Reach – (Since 2017)
Low. San Lorenzo #4	12.5	6.4/ 85 mm	@@	13.5/ 92 mm	Reach + (Since 2015)
Mid. San Lorenzo #6	3.6	0.3/ 92 mm	@	3.9/ 82 mm	Site – (Since 2017)
Mid. San Lorenzo #8	5.1	1.6/ 102 mm	@@	3.9/ 90 mm	Reach + (Since 2014)
Mid. San Lorenzo #9	5.8	0.9/ 95 mm	@	3.9/ 88 mm	Site – (Since 2017)
Up. San Lorenzo #10	5.4	2.2/ 117 mm	@@@	13.1/ 92 mm	Reach + (Since 2014)
Up. San Lorenzo #11	6.1	5.4/ 105 mm	@@@@	10.5/ 98 mm	Reach – (Since 2016)
Up. San Loren #12b	14.2	17.5/ 87 mm	@@@@	29.6/ 95 mm	Reach + (Since 2012)
Zayante #13a	8.8	0.9/ 118 mm	@@	11.6/ 89 mm	Reach – (Since 2016)
Zayante #13c	15.9	8.2/ 98 mm	@@@@	34.6/ 90 mm	Reach + (Since 2015)
Zayante #13d	16.5	22.1/ 99 mm	@@@@@	16.9/ 99 mm	Reach – (Since 2017)
Zayante #13i	7.0	10.4/ 98 mm	@@@@	6.7/ 105 mm	Reach + (Since 2015)
Lompico #13e	9.7	17.1/ 89 mm	@@@@	Not sampled.	Site + (Since 2016)
Bean #14a	4.6	1.5/ 90 mm	@	9.5/ 83 mm	Reach + (Since 2015)
Bean #14b	11.6	10.5/ 94 mm	@@@@	11.6/ 90 mm	Reach – (Since 2017)
Bean #14c-2	8.7	13.5/ 96 mm	@@@@	5.4/ 112 mm	Reach + (Since 2016)
Fall #15a	6.4	7.1/ 98 mm	@@@	7.7/ 106 mm	Reach + (Since 2014)
Fall #15b	11.9	10.1/ 98 mm	@@@@	10.9/ 115 mm	Reach + (Since 2014)
Newell #16	12.3	5.5/ 106 mm	@@@@	16.9/ 84 mm	Reach + (Since 2011)
Boulder #17a	10.6	7.0/ 112 mm	@@@@	16.6/ 103 mm	Reach + (Since 2016)
Boulder #17b	10.4	11.8/ 100 mm	@@@@	9.2/ 100 mm	Reach + (Since 2013)
Bear #18a	8.6	2.2/ 114 mm	@@@	6.9/ 100 mm	Reach + (Since 2016)
Bear #18b	12.8	3.7/ 113 mm	@@@	17.3/ 95 mm	Site – (Since 2017)

Site	Multi-Year Avg. Potential Smolt Density Per 100 ft	2018 Potential Smolt Density (per 100 ft)/ Avg Pot. Smolt Size SL	2018 Symbolic Rating (1 to 7)	2017 Potential Smolt Density (per 100 ft)/ Avg Pot. Smolt Size SL	Physical Habitat Change by Reach/Site (Since Previous Measure)
Branciforte #21a-2	9.0	6.7/ 101 mm	@@@	9.4/ 92 mm	Reach + (Since 2014)
Soquel #1	3.4	2.3/ 105 mm	@@@	2.9/ 126 mm	Site – (Since 2017)
Soquel #4	7.5	0.7/ 124 mm	@@	3.7/ 132 mm	Reach – (Since 2017)
Soquel #10	9.3	11.4/ 91 mm	@@@@	32.8/ 109 mm	Site – (Since 2017)
Soquel #12	7.9	7.1/ 85 mm	@@	11.1/ 134 mm	Reach + (Since 2016)
East Branch Soquel #13a	9.7	2.3/ 105 mm	@@@	3.6/ 142 mm	Site – (Since 2017)
East Branch Soquel #16	9.9	3.9/ 111 mm	@@@	27.0/ 90 mm	Reach – (Since 2017)
West Branch Soquel #19	6.1	2.9/ 97 mm	@@	12.3/ 104 mm	Site – (Since 2017)
West Branch Soquel #21	9.9	7.8/ 119 mm	@@@@	19.7/ 93 mm	Site – (Since 2017)
Aptos #3	8.7	8.6/ 110 mm	@@@@@	11.0/ 92 mm	Reach + (Since 2013)
Aptos #4	9.6	6.4/ 115 mm	@@@@	23.4/ 88 mm	Reach + (Since 2014)
Valencia #2	8.6	4.2/ 116 mm	@@@@	4.4/ 102 mm	Site – (Since 2017)
Valencia #3	11.1	6.8/ 106 mm	@@@@	13.6/ 92 mm	Site – (Since 2017)

Steelhead Kelt Over-summering in Lompico Creek.   14 September 2018

Table 3. Habitat Change in the SAN LORENZO MAINSTEM AND TRIBUTARIES from most recent years' reach averages compared to 2018, or site comparisons when reach averages were unavailable.

Reach or (Site Only) Comparison To Previous Years	2018 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 higher baseflow 2017)	−	− / −	− / Similar	+ / +	− / +	− (less embedded streambed)
Mainstem Reach 1 (Since drought baseflow 2014)	+	+ / +	Sim / − riffles	Sim / Sim	+ / +	+ (more food, depth & cover)
Mainstem Reach 2 (Since higher baseflow 2017)	−	− / −	Sim / +	Sim / Sim	+ / +	− (more cover)
Mainstem Reach 4 (Since drought baseflow 2015)	+	+ / +	Sim / − runs	Sim / Sim	+ / −	+ (more food and depth)
(Mainstem Site 6) (Since higher baseflow 2017)	−	/ −	/ +	/ −	/ +	− (less fines and more cover)
Mainstem Reach 8 (Since drought baseflow 2014)	+	+ / +	Sim / − runs	+ / − runs	+ / −	+ (more food & depth, less embeddedness)
(Mainstem Site 9) (Since higher baseflow 2017)	−	/ −	/ − runs	/ − runs	/ +	− (more fastwater cover)
Mainstem Reach 10 (Since drought baseflow 2014)	+	+ / +	Sim / − runs	Sim / − runs	+ / + runs	+ (more food, depth and cover)
Mainstem Reach 11 (Since similar baseflow 2016)	Similar	Sim / − runs	− / Sim	Sim / Sim	− / +	Similar (more cover in fastwater only)
Mainstem Reach 12a (Since drought baseflow 2015)	+	+ / +	− / Sim	Sim / + run	− / +	+ (more food, depth and less embedded runs)
Mainstem Reach 12b (Since higher baseflow 2012)	−	+ / +	− / − run	− / Sim	+ / + run	+ (more depth and cover)
Zayante Reach 13a (Since similar baseflow 2016)	Similar	+ / +	Same / − runs	Similar / − runs	Sim / +	− (more depth and fastwater cover)
Zayante Reach 13c (Since drought baseflow 2015)	+	+ / +	+ / Similar	+ / + run	− / −	+ (more food, depth and better streambed)

Reach or (Site Only) Comparison To Previous Years	2018 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)
Zayante Reach 13d (Since higher baseflow 2017)	−	− / −	Sim / Sim	Sim / Sim	− / −	− (no improvement)
Zayante Reach 13i (Since drought baseflow 2015)	+	+ / +	− / + runs	Sim / Sim	Sim / +	+ (more food, depth and fastwater cover)
(Lompico Site 13e) (Since similar baseflow 2016)	Similar	Sim / +	+ / + runs	Sim / Sim	+ / +	+ (more cover and less fines)
Bean Reach 14a (Since drought baseflow 2015)	+	Sim / +	Sim / Sim	Sim / Same	− / +	+ (more food, more fastwater depth and cover)
Bean Reach 14b (Since higher baseflow 2017)	−	− / −	Same / − runs	+ / +	− / Sim	− (less embedded)
Bean Reach 14c-2 (Since similar baseflow 2016)	Similar	+ / +	+ / +	+ / +	+ / Sim	+ (more depth and cover and better streambed)
Fall Reach 15a (Since drought baseflow 2014)	+	+ / +	Sim / − runs	Same / Sim	+ / +	+ (more food, depth & cover)
Fall Reach 15b (Since drought baseflow 2014)	+	+ / +	Sim / + runs	Sim / Sim	+ / +	+ (more food, depth & cover)
Newell Reach 16 (Since higher baseflow 2011)	−	+ / +	Similar / Similar	+ / +	+ / +	+ (more depth & cover and better streambed)
Boulder Reach 17a (Since similar baseflow 2016)	Similar	+ / Sim	Sim / Sim	Sim / − run	+ / +	+ (more depth and cover)
Boulder Reach 17b (Since lower baseflow 2013)	+	+ / Sim	Sim / Sim	Sim / Sim	+ / −	+ (more food, depth and cover)
Bear Reach 18a (Since similar baseflow 2016)	Similar	Same / Same	Sim / Sim	Sim / Sim	+ / +	+ (more cover)
Bear Reach 18b (Since higher baseflow 2017)	−	− max depth / −	− / Sim	Same / −	+ /	− (more cover)
Branciforte Reach 21a-2 (Since drought baseflow 2014)	+	+ / Sim	Sim / −	+ / + riffles	− / −	+ (more food, depth and less embedded)

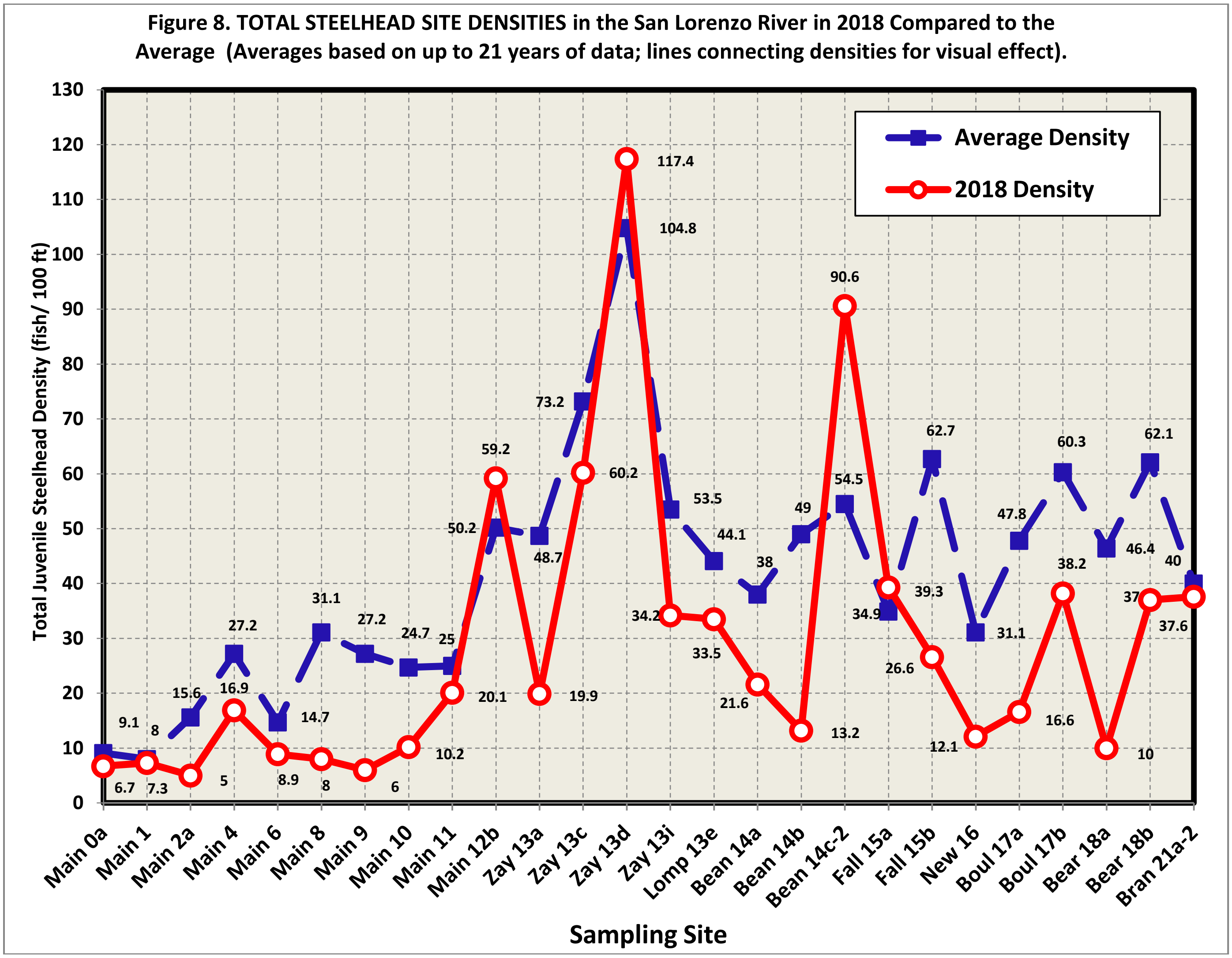

Figure 8. Total Juvenile Steelhead Site Densities in the San Lorenzo River in 2017 Compared to Average Density. (Averages based on up to 21 years of data.)

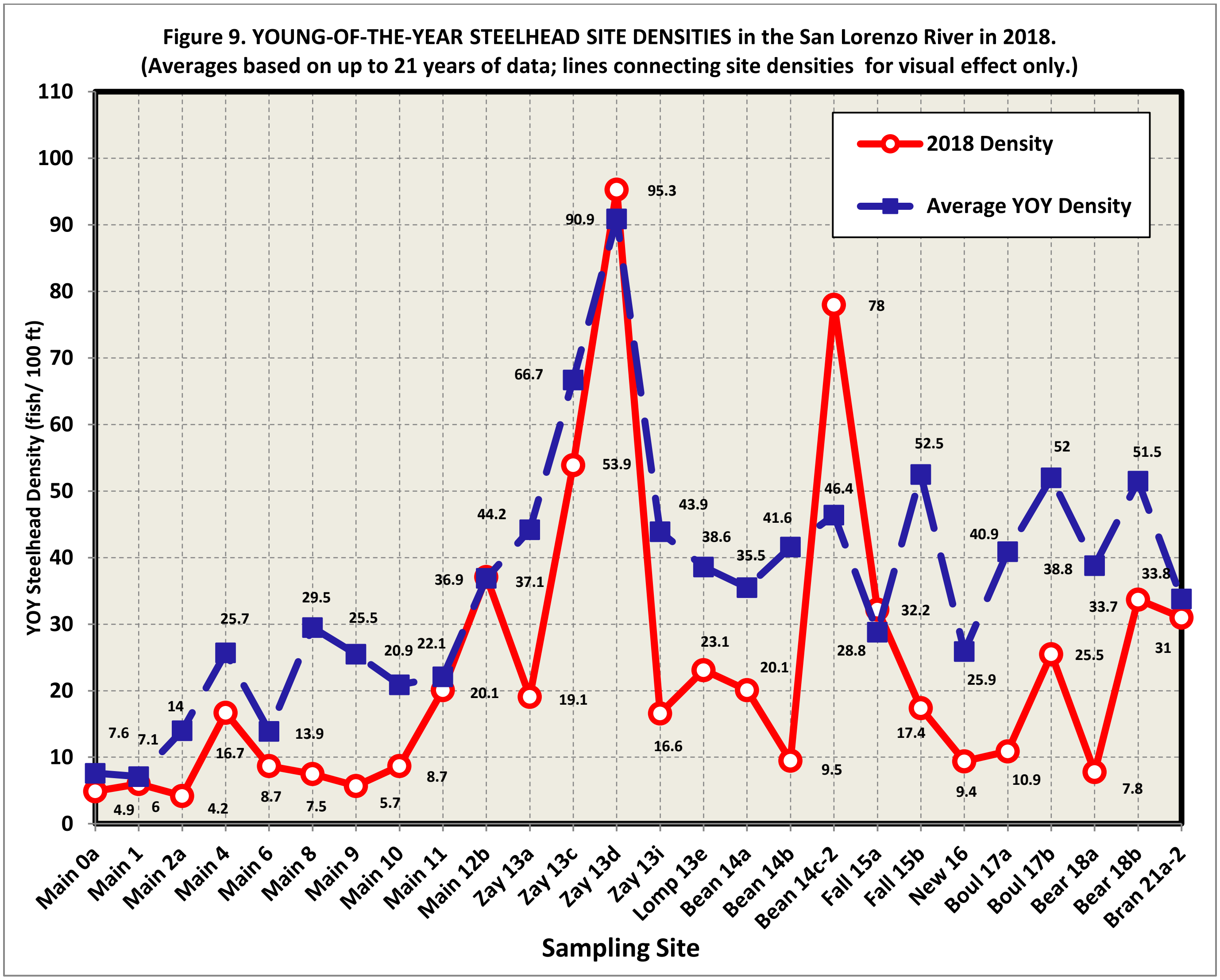

Figure 9. Young-of-the-Year Steelhead Site Densities in the San Lorenzo River in 2018 Compared to Average Density. (Averages based on up to 21 years of data.)

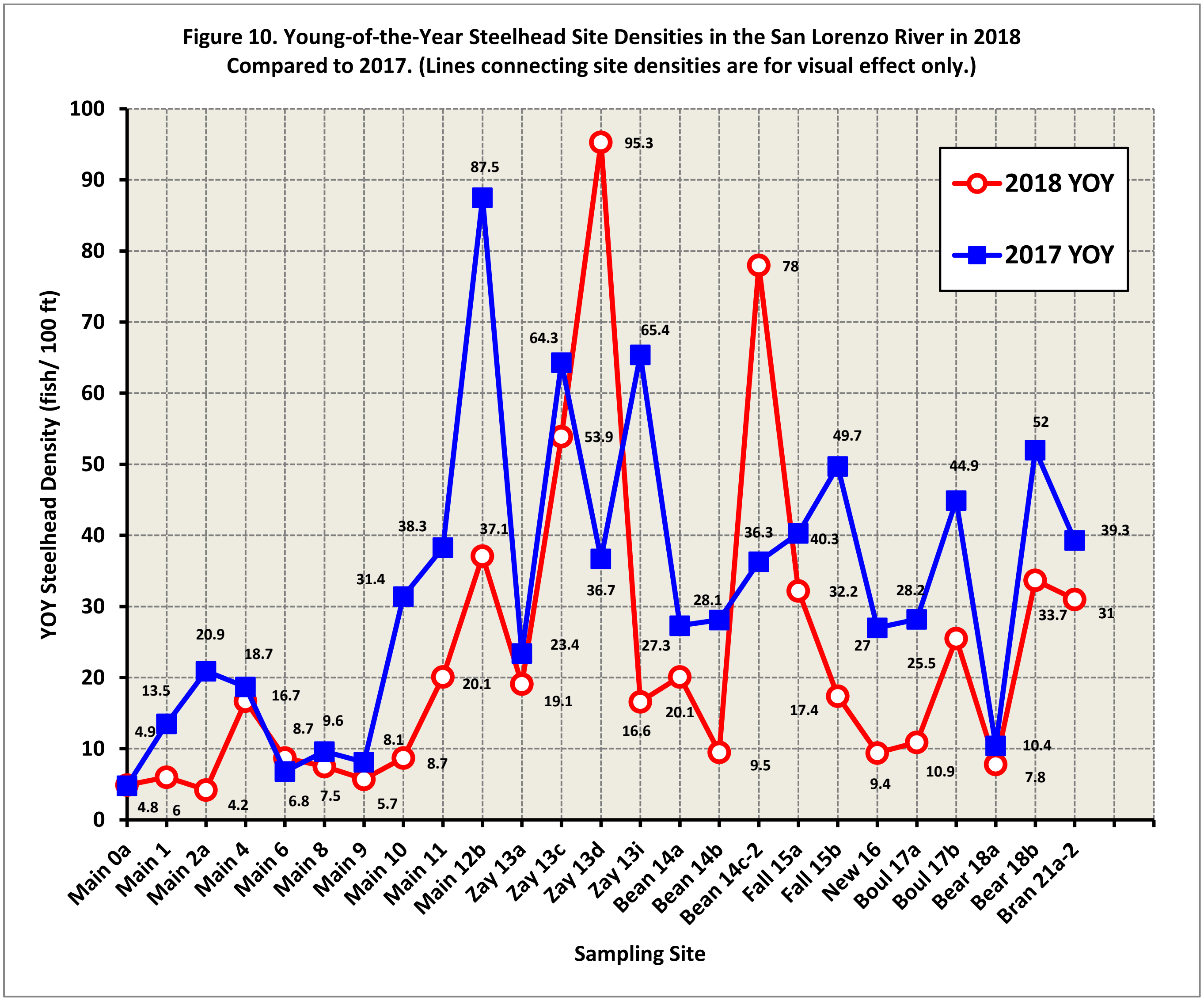

Figure 10. Young-of-the-Year Site Densities in the San Lorenzo Watershed Comparing 2018 to 2017.

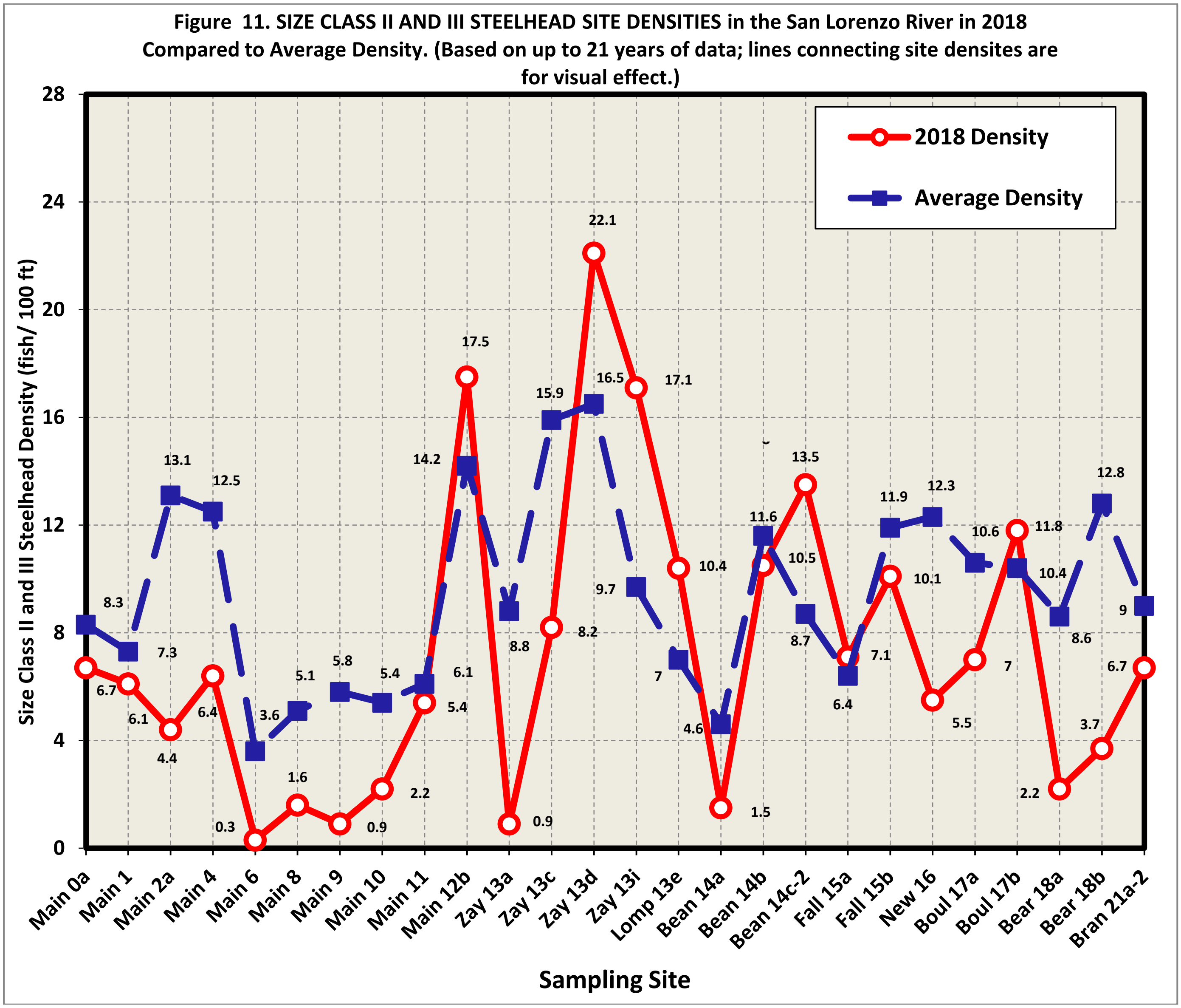

Figure 11. Size Class II and III Steelhead Site Densities in the San Lorenzo River in 2018 Compared to Average Density. (Averages based on up to 21 years of data.)

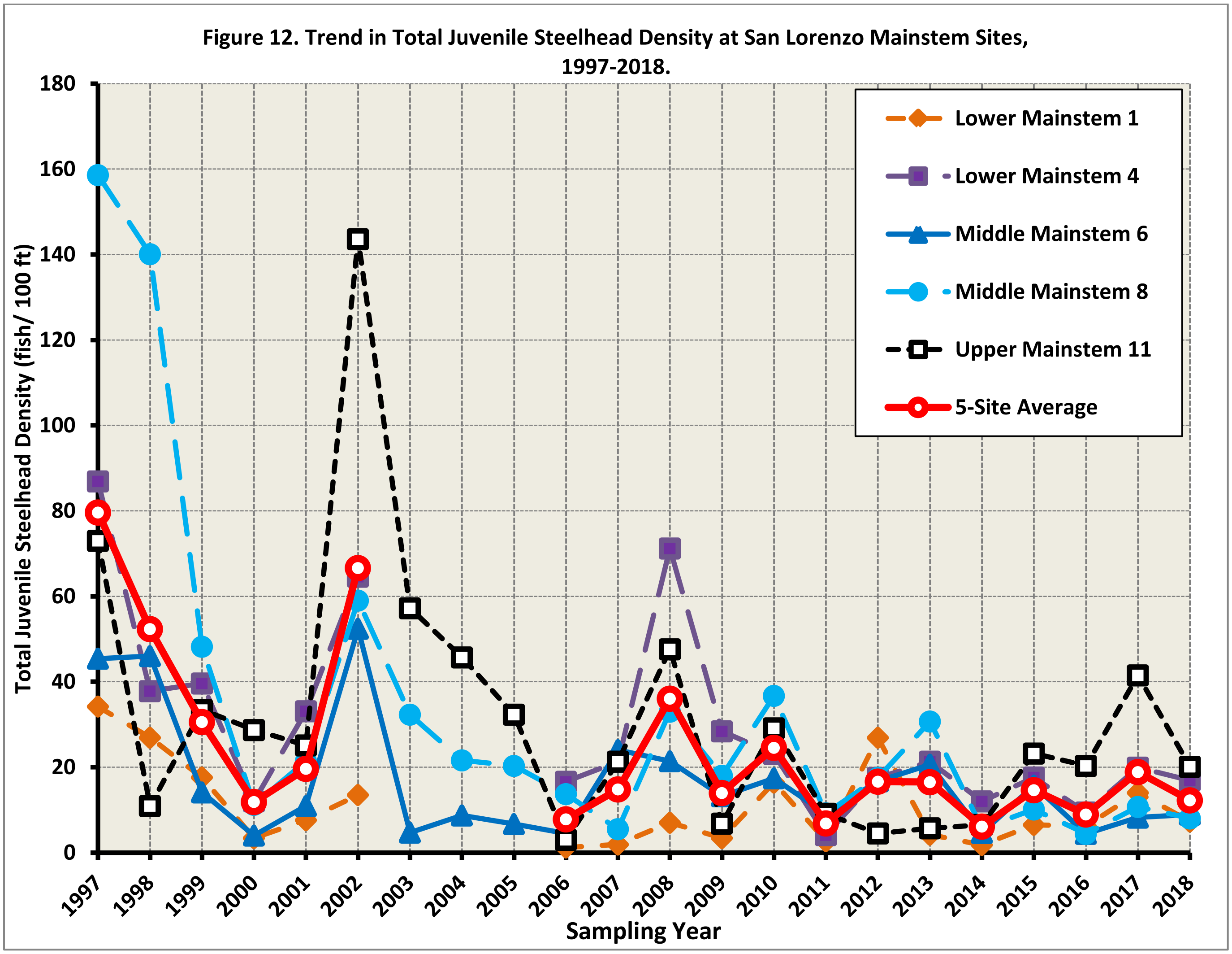

Figure 12. Trend in Total Juvenile Steelhead Density at San Lorenzo Mainstem Sites, 1997-2018.

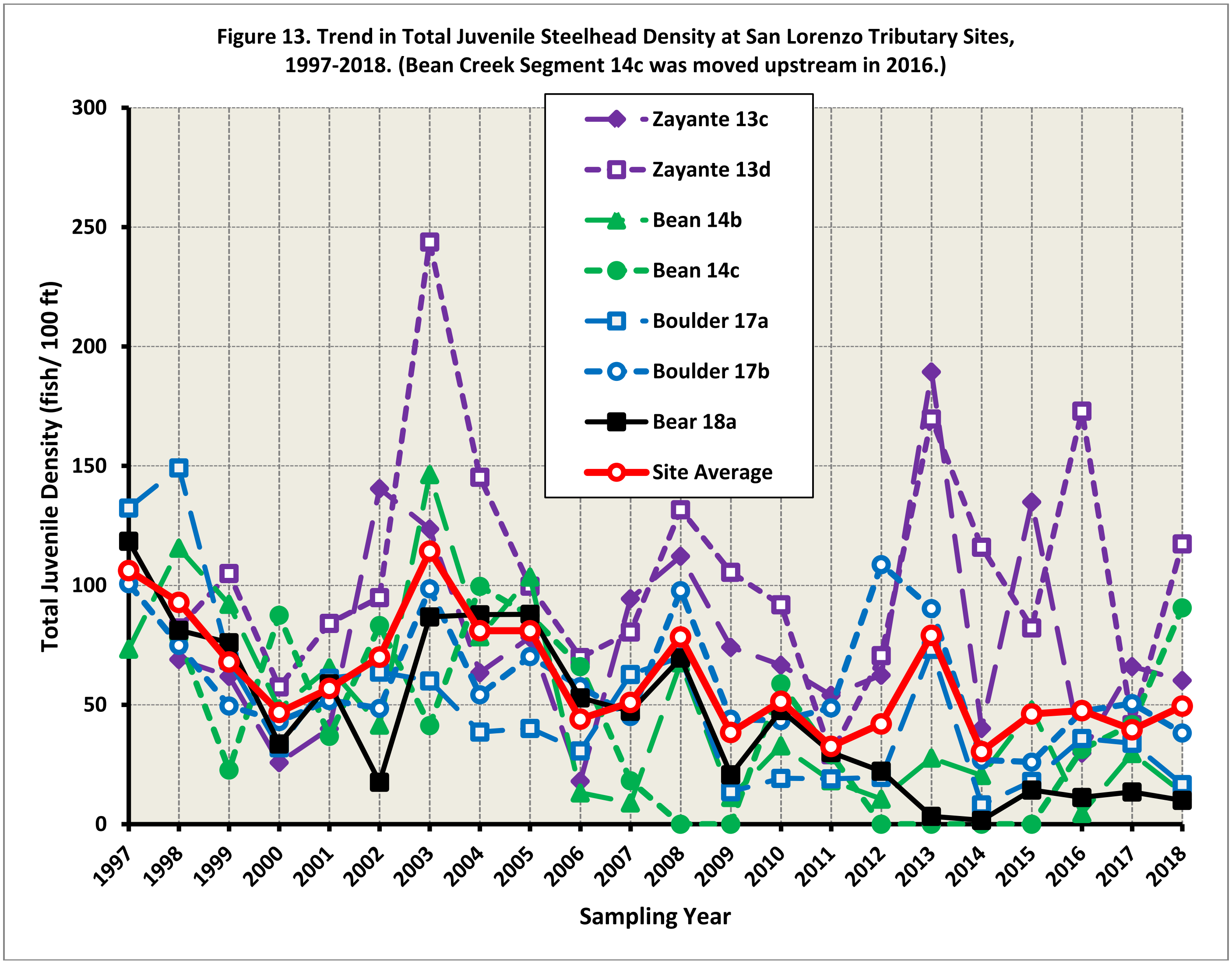

Figure 13. Trend in Total Juvenile Steelhead Density at San Lorenzo Tributary Sites, 1997-2018.

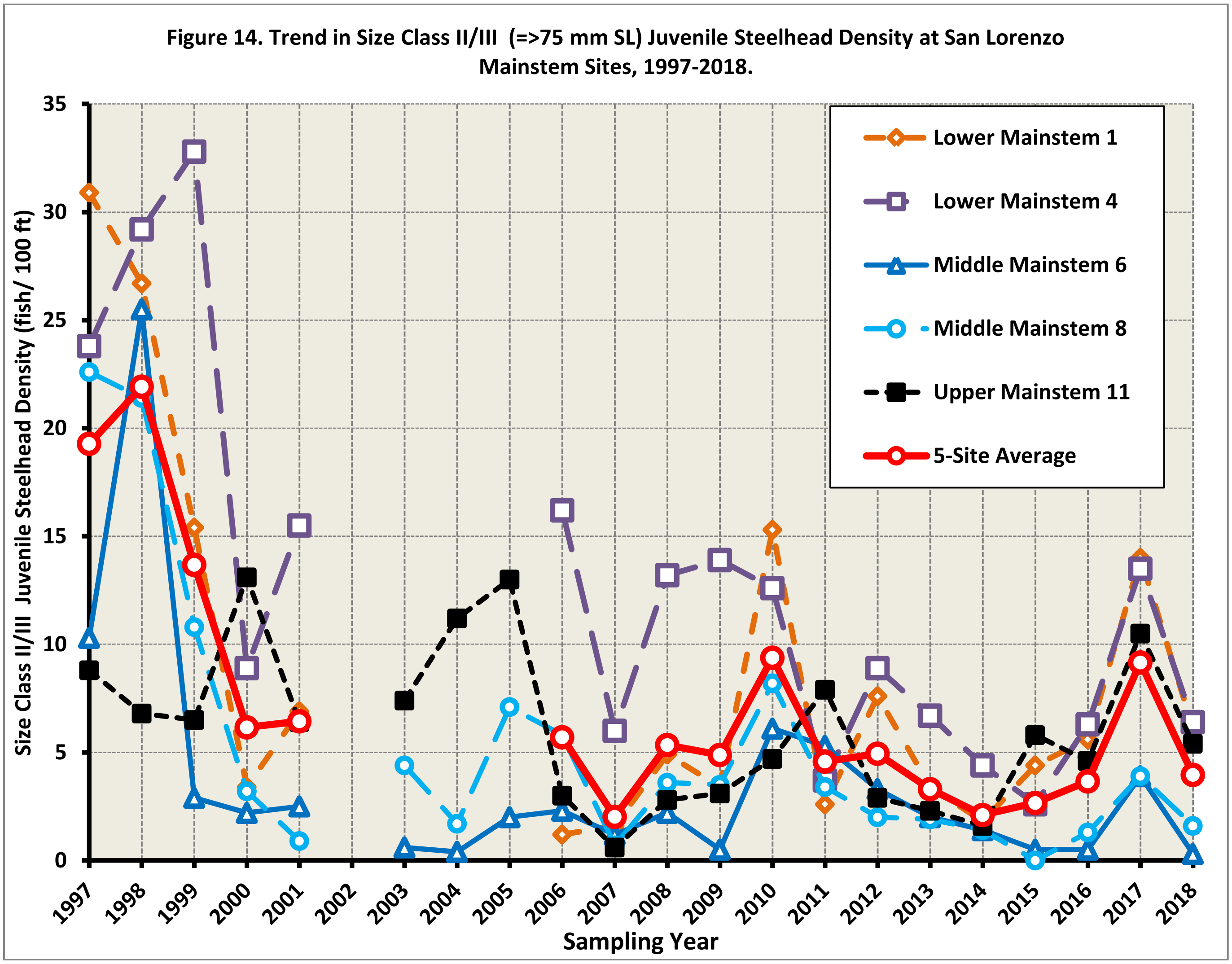

Figure 14. Trend in Size Class II/III Juvenile Steelhead Density at San Lorenzo Mainstem Sites, 1997-2018.

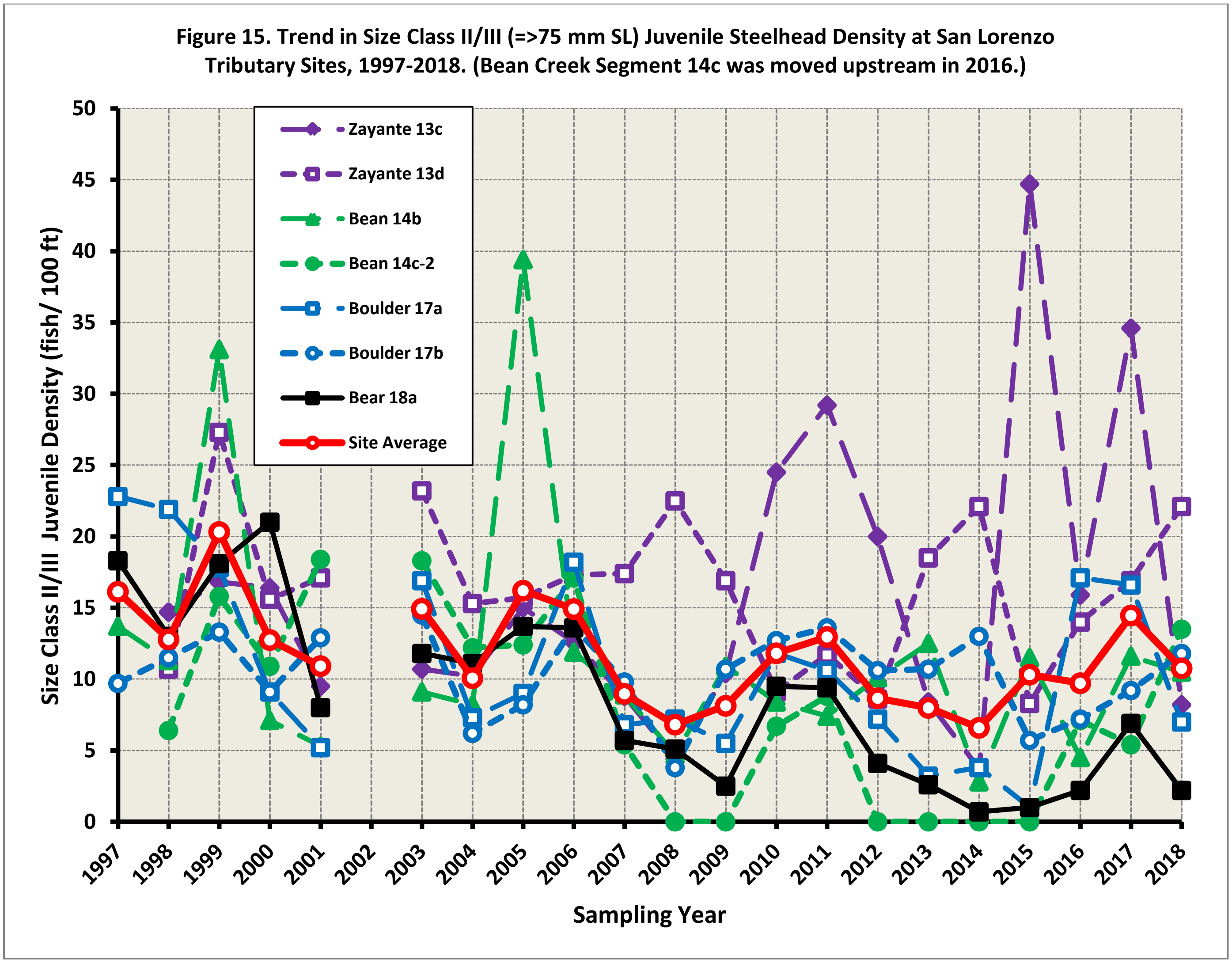

Figure 15. Trend in Size Class II/III Juvenile Steelhead Density at San Lorenzo Tributary Sites, 1997-2018.

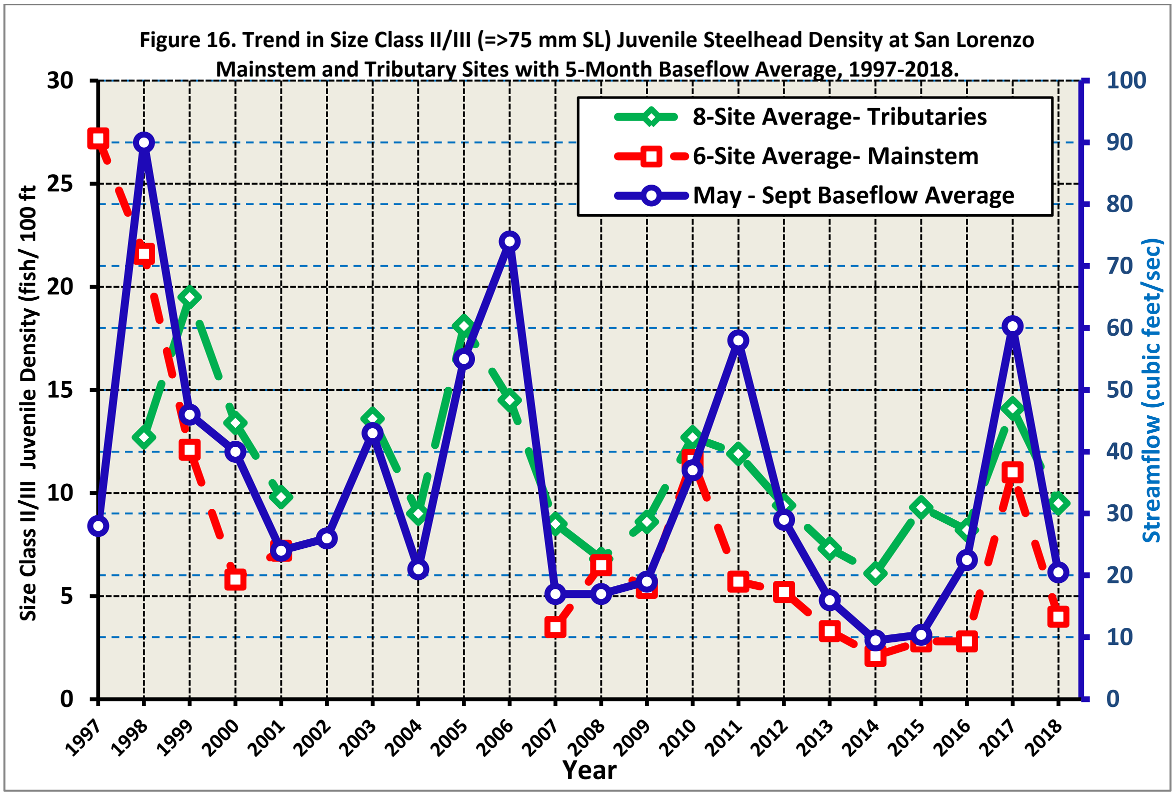

Figure 16. Trend in Size Class II/III (=>75 mm SL) Juvenile Steelhead Density at San Lorenzo Mainstem and Tributary Sites with 5-Month Baseflow Average, 1997-2018.

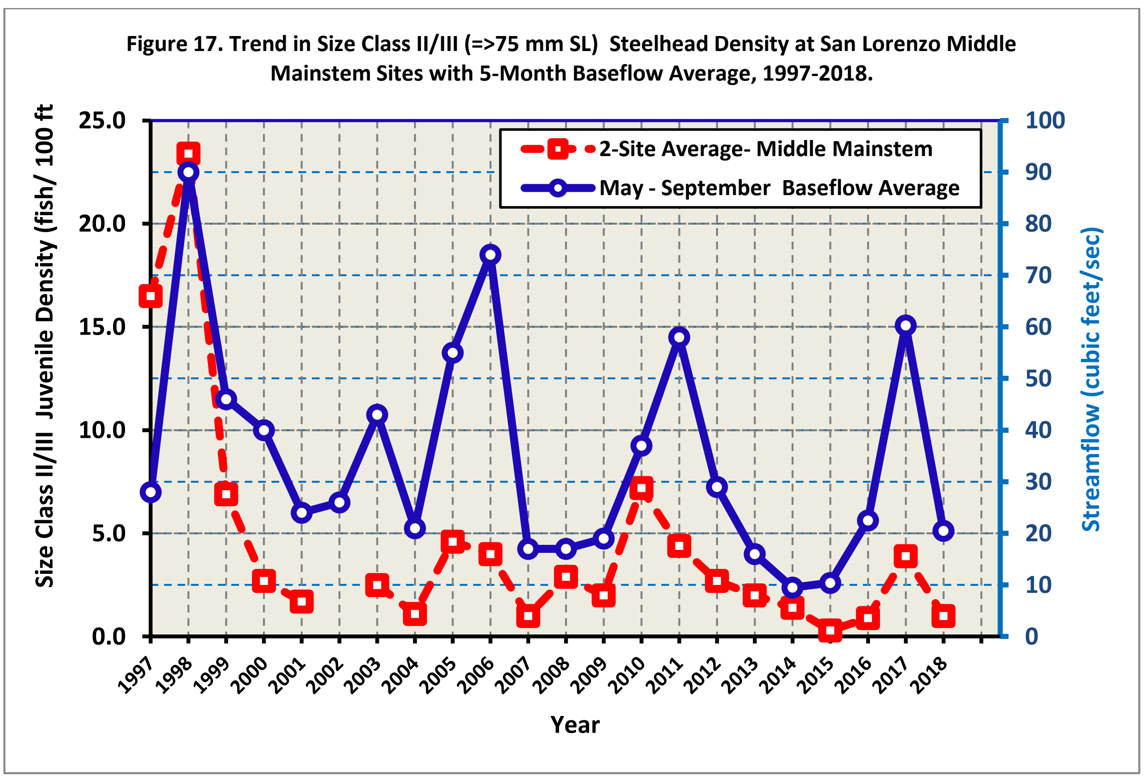

Figure 17. Trend in Average Size Class II/III (=>75 mm SL) Juvenile Steelhead Density at San Lorenzo Middle Mainstem Sites with 5-Month Baseflow Average, 1997-2018.

ii. Steelhead Abundance and Habitat in the Soquel Creek Watershed

1. WY2018 streamflows in spring-summer-fall were below the median flow statistic, unlike the wet WY2017, making 8 of the last 12 water years below median baseflow (**Figure 18**). The few stormflows during the wet season provided limited adult steelhead access to upper watershed sites except for November (very early for steelhead), one stormflow in early January and 3 minor stormflows between March and early April, plus one reaching likely bankfull at 1,460 cfs at the Soquel Village Gage on 22 March. No stormflow occurred in December or February. Despite limited passage opportunities, adults accessed much of the upper watershed to Girl Scout Falls II on the West Branch and above Ashbury Falls on the East Branch (high YOY density found above Ashbury Gulch in a separate project for the Soquel Demonstration State Forest). However, many spawning redds laid in March before the late bankfull event may have been destroyed or smothered with sediment moved by that stormflow. Baseflow steadily declined from mid-April on, down to a minimum of 1.6 cfs in mid-October at the Soquel Village gage.

2. Habitat conditions in upper mainstem Reach 8 improved since 2016 with higher baseflow, increased habitat depth and more escape cover (**Table 5; Figures 2−4**). Habitat conditions declined at the other 7 sites and reaches compared to 2017 primarily due to reduced baseflow (less food), associated reduced pool depth (6 of 7 sites/reaches) and reduced escape cover at 4 of the 7 (similar escape cover between years at 3 sites). Escape cover remained similarly high in 2018 in pools formed by downed trees adjacent the landslide at Site 10 (Reach 7). Percent fine sediment increased in runs of 4 of 8 sites/reaches and in pools of 3 of 8, with less percent fines in pools of the 2 West Branch sites. Percent fines decreased in fastwater habitat at Site 10 adjacent to the 2017 landslide. Embeddedness remained similar in 2018 and 2017 except for increased run embeddedness at 2 mainstem sites and less riffle embeddedness at one West Branch site.

3. ***Total and YOY juvenile steelhead densities*** were near or slightly above average at 4 of 8 sites in 2018 (**Figures 19 and 20**). They increased at 5 of 8 sites from 2017. YOY density increased most at upper Mainstem Site 12 and upper West Branch Site 21 below Girl Scout Falls II. The greatest YOY density decline was at the SDSF Site 16 on the East Branch, though high YOY density was detected above Ashbury Gulch (SDSF historical site). The **trend in total densities** (consisting of mostly YOY) increased in 2018 but remained low (6-site average of 19.5 fish/ 100 ft, the forth lowest average density in 21 years, compared to 13.5 in 2017) (**Figure 23**). We may assume that adult spawning and egg survival was patchy from a small adult steelhead population in 2018.

4. ***Yearling densities*** in 2018 were slightly above average at 4 of 8 sites (2 mainstem and 2 West Branch sites) and notably below average at East Branch Site 16 (3.9 fish/100 ft; avg.= 6.5). Yearling densities were low, in general. They increased from 2017 to 2018 at only 2 of 8 sites, despite the milder winter, and were equal (8.4 fish/100 ft) at West Branch Site 21.

5. ***Size Class II and III juvenile densities*** were above average at 1 of 8 sites in 2018 (Site 10) and much below average at sediment- laden mainstem Site 4, East Branch 13a below Mill Pond and East Branch 16 above Amaya Creek (**Figure 21**). With the reduced baseflow and growthrate of YOY in 2018, these soon-to-smolt densities declined from 2017 levels at all 8 sites (**Table 2; Figure 22**). In high flow 2017, all YOY at mainstem sites and lower East and West Branch Sites reached Size Class II (=>75 mm SL). In 2017, approximately ½ of YOY at East Branch Site 16 and 1/3 at West Branch Site 21 reached Size Class II. In 2018, less than ½ of YOY reached Size Class II at mainstem sites and less than 10% did at Branch sites. Soon-to-smolt densities were “below average” at 6 of 8 sites with average size smaller in 2018 than 2017 at 6 of 8 sites (**Table 2**).

6. The 6-site trend in Size Class II and III densities declined in 2018 (avg=4.6 fish/100 ft) to below the long-term average (8.1 fish/100 ft) and near the 2016 level (avg=5.6 fish/100 ft) after the significant increase in 2017 (avg=13.5 fish/100 ft) (**Figure 24**). The 6-site, long term average for Size Class II/III density is correlated with average 5-month baseflow in some years (**Figure 25**). 1997 and 2002 had relatively high densities despite moderate baseflow, presumably due to high egg and YOY survival and good YOY growth in years without late season bankfull events.

7. The below average densities of YOY in 2018 were likely due to a small returning adult steelhead population with difficult egg survival in most reaches when laid prior to the March 22 bankfull event.

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 1,422 mostly soon-to-smolt sized steelhead (=>75 mm SL) between 1993 and 2013 and 2016–2018 (**Alley 2019**). In 2018, the lagoon population estimate was only 46 with the median size large in the 170-174 mm SL range. It is likely that all steelhead larger than 184 mm SL a d a few smaller were yearlings or older and comprised 30–40% of the 2018 lagoon population. The very small lagoon population indicated limited spawning and/or poor spawning success near the lagoon.

9. Changes in site densities for size classes and age classes from 2017 to 2018 were statistically insignificant at the p=0.05 level at replicated site locations, though decrease in Size Class II and III juveniles had a p=0.054 (**Table 7** (section iv at the end of the report)).

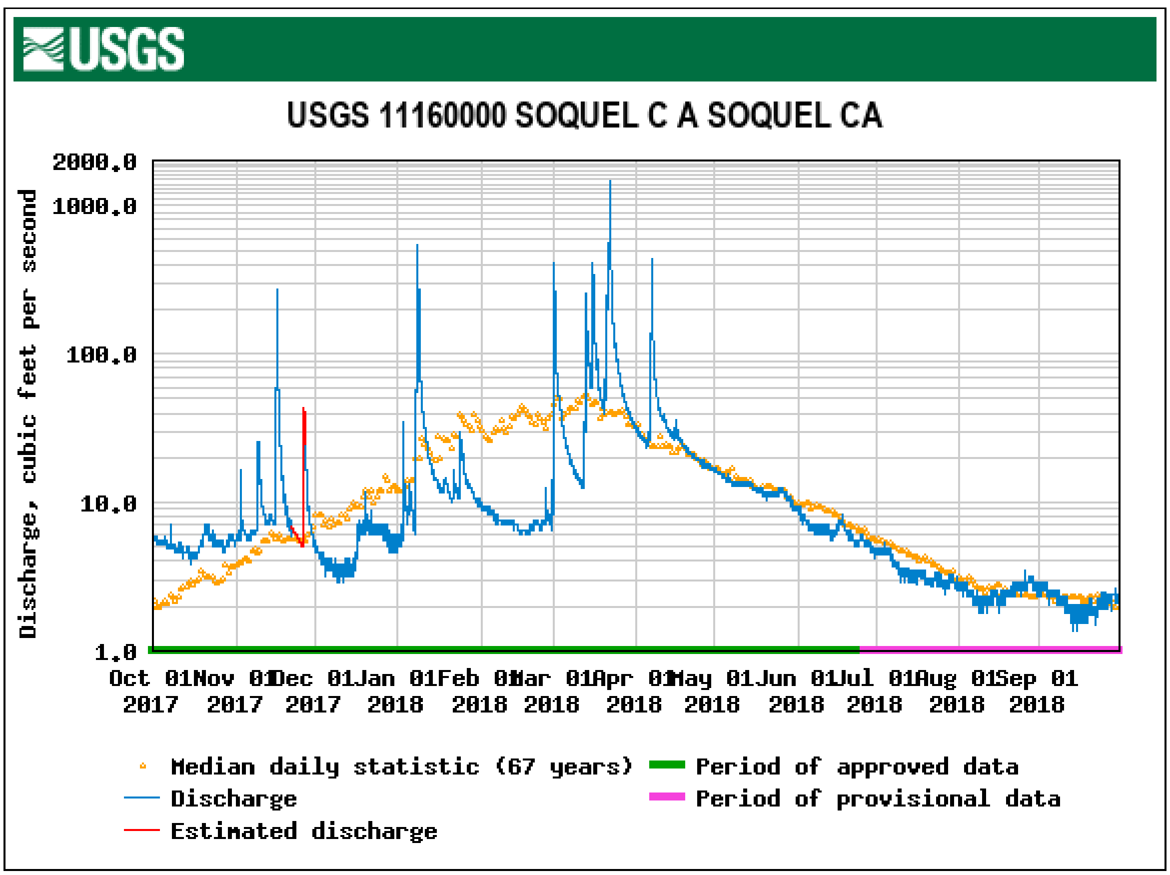

Figure 18. The 2018 Discharge at the USGS Gage on Soquel Creek at Soquel Village.

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

Location	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
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)
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)
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)
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)
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)
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)
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) Comparison To Previous Years	2018 Baseflow Comparison (Most Important Factor May-Sept)	Pool Depth	Fine Sediment Pool / Fastwater	Embeddedness Pool / Fastwater	Pool Escape Cover	Overall Habitat Change and (Any Improvement)
(Site 1); Reach 1 (Since higher baseflow 2017)	−	−	− / − run	Same / − run	−	− (none)
Site 4; Reach 3a (Since higher baseflow 2017)	−	−	Similar/ Similar	Sim / Sim	−	− (none)
(Site 10); Reach 7 (Since higher baseflow 2017)	−	−	− / +	Sim / −	Sim / Sim	− (less fastwater fines)
Site 12; Reach 8 (Since lower baseflow 2016)	+	+	Sim / − runs	Sim / Sim	+	+ (more food, depth and cover)
East Branch (Site 13a); Reach 9a (Since higher baseflow 2017)	−	+	− / − runs	Sim / + runs	Same	− (more pool depth and less embedded runs)
East Branch Site 16; Reach 12a (Since higher baseflow 2017)	−	−	Sim / Sim	Sim / Sim	−	− (none)
West Branch (Site 19); Reach 13 (Since higher baseflow 2017)	−	−	+ / − runs	NA / + riffles	−	− (less embedded riffles with less fines in pools)
West Branch (Site 21); Reach 14b (Since higher baseflow 2017)	−	−	+ / Sim	Sim / sim	Sim	− (less fines in pools, less riffle embeddedness)

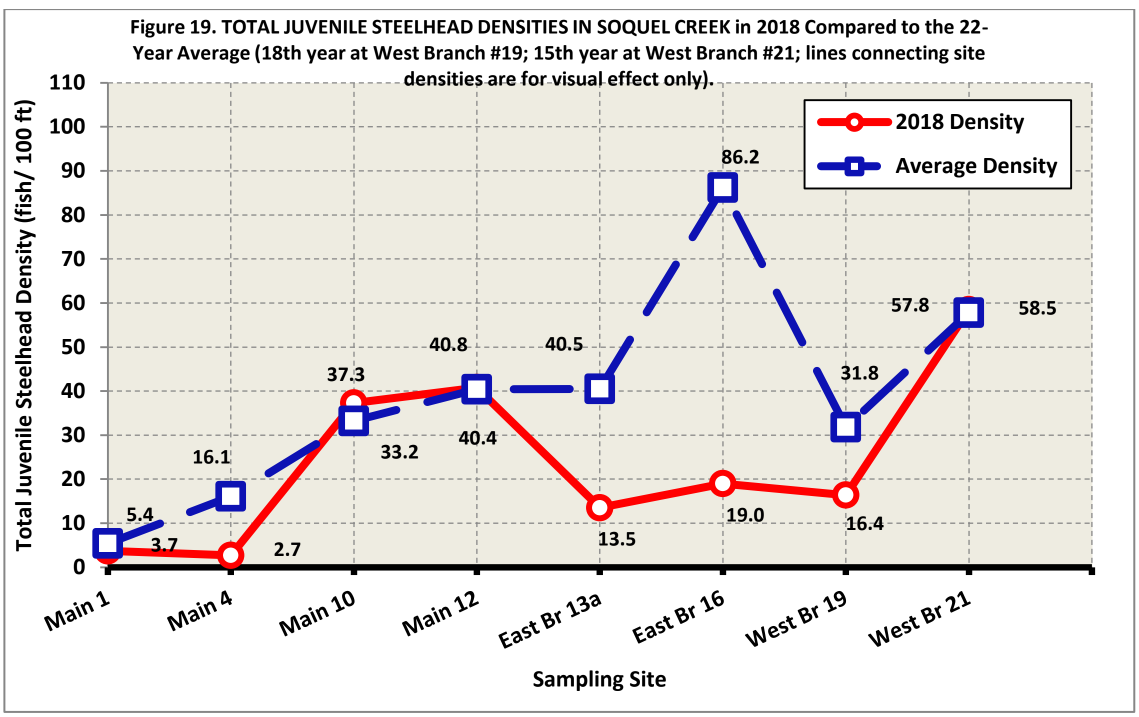

Figure 19. Total Juvenile Steelhead Site Densities in Soquel Creek in 2018 Compared to the 22-Year Average (18th year for West Branch #19.)

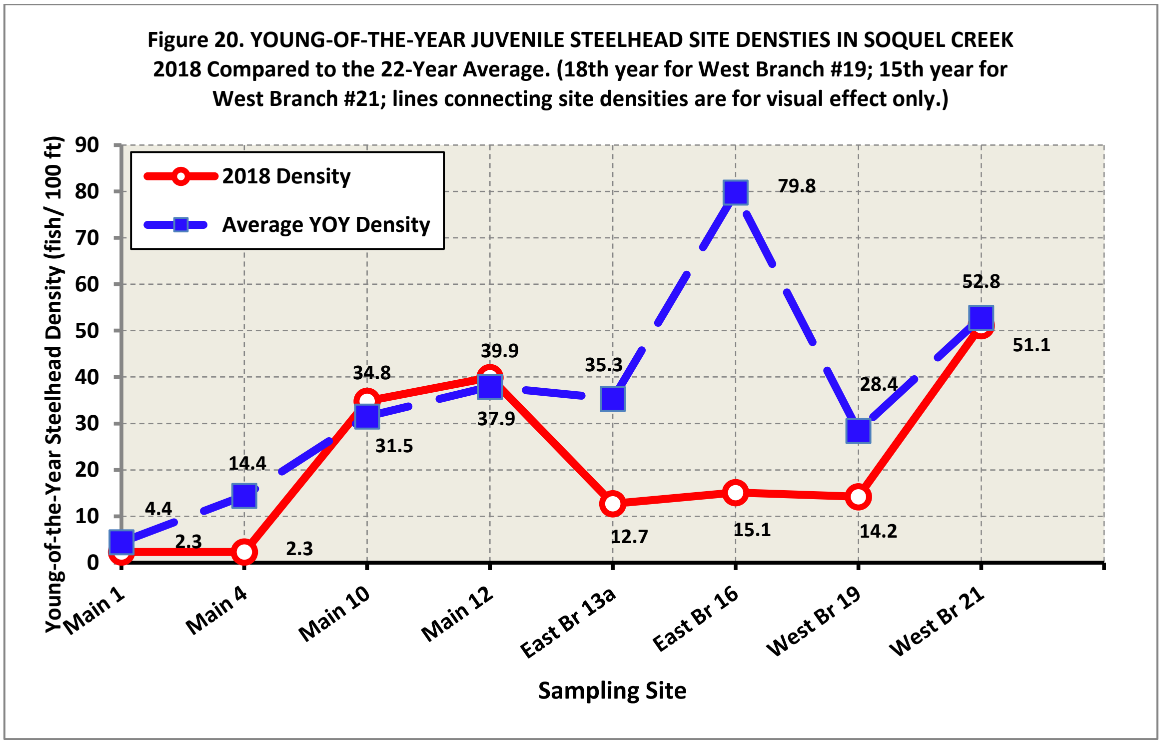

Figure 20. Young-of-the-Year Steelhead Site Densities in Soquel Creek in 2018 Compared to the 22-Year Average (18th year for West Branch #19.)

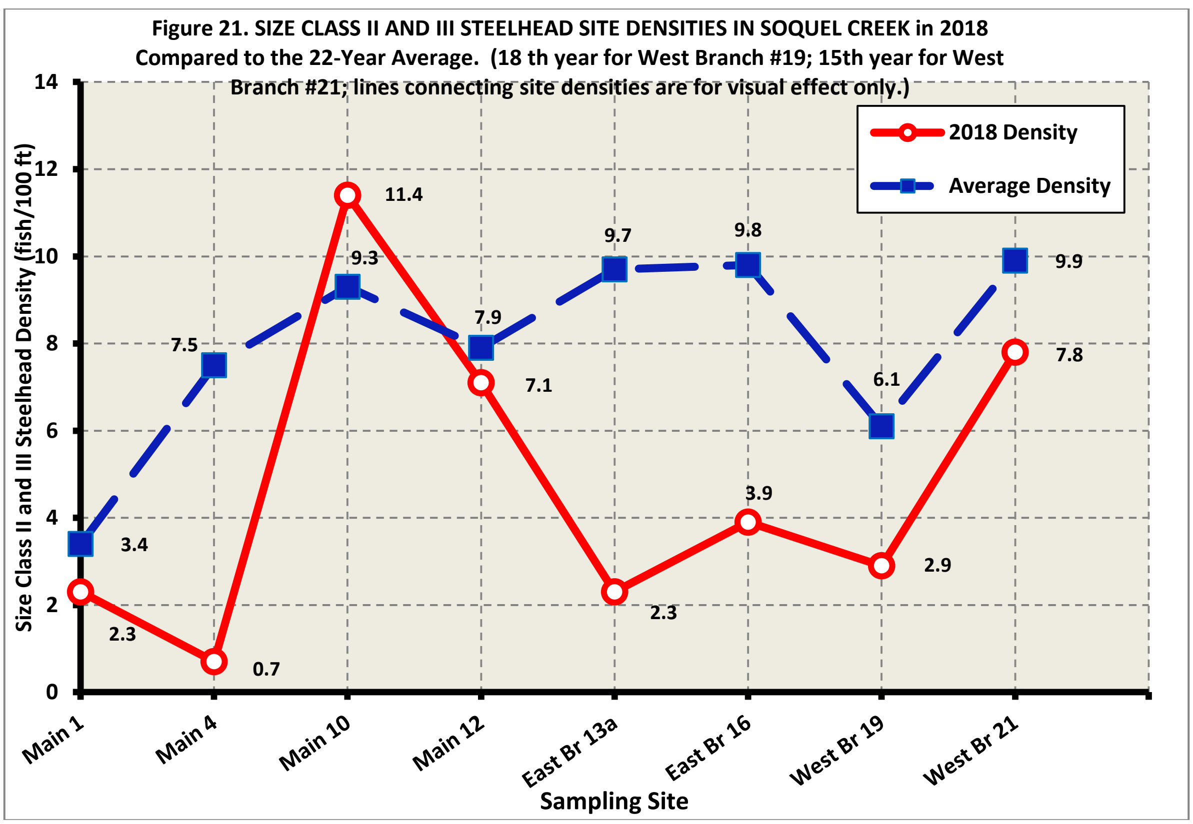

Figure 21. Size Class II and III Steelhead Site Densities in Soquel Creek in 2018 Compared to the 22-Year Average (18th year for West Branch #19.)

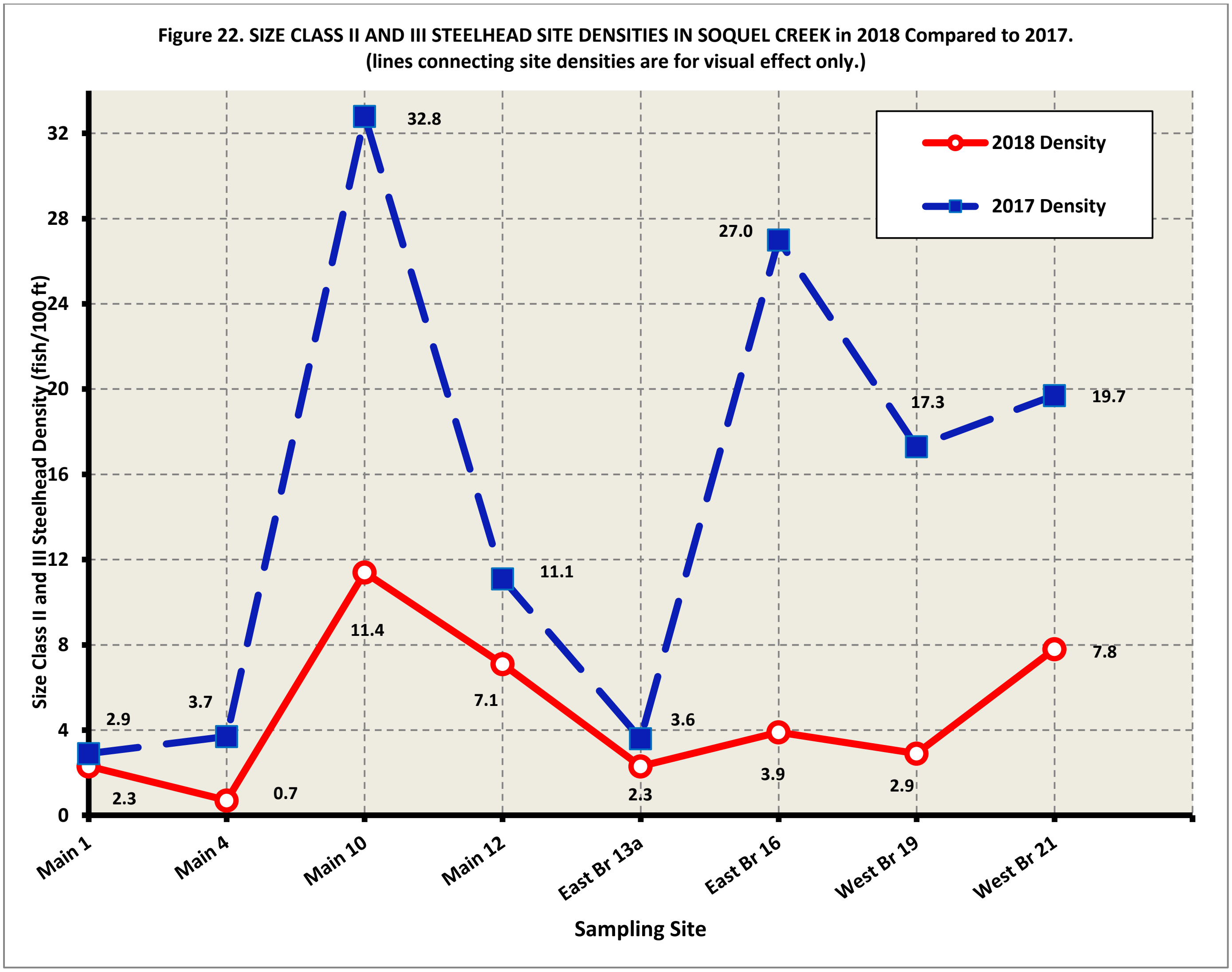

Figure 22. Size Class II and III Steelhead Site Densities in Soquel Creek in 2018 Compared to 2017.

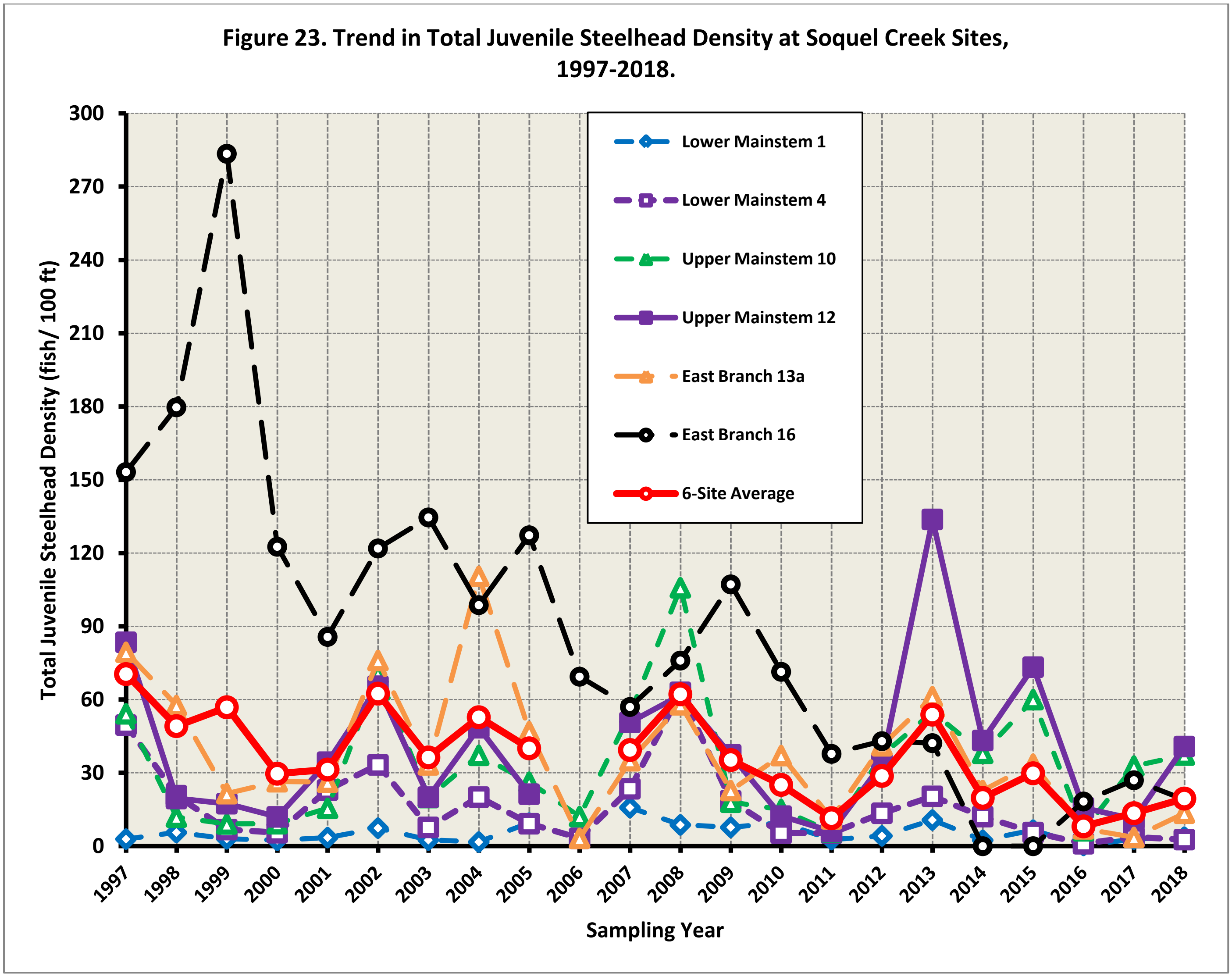

Figure 23. Trend in Total Juvenile Steelhead Density at Soquel Creek Sites, 1997-2018.

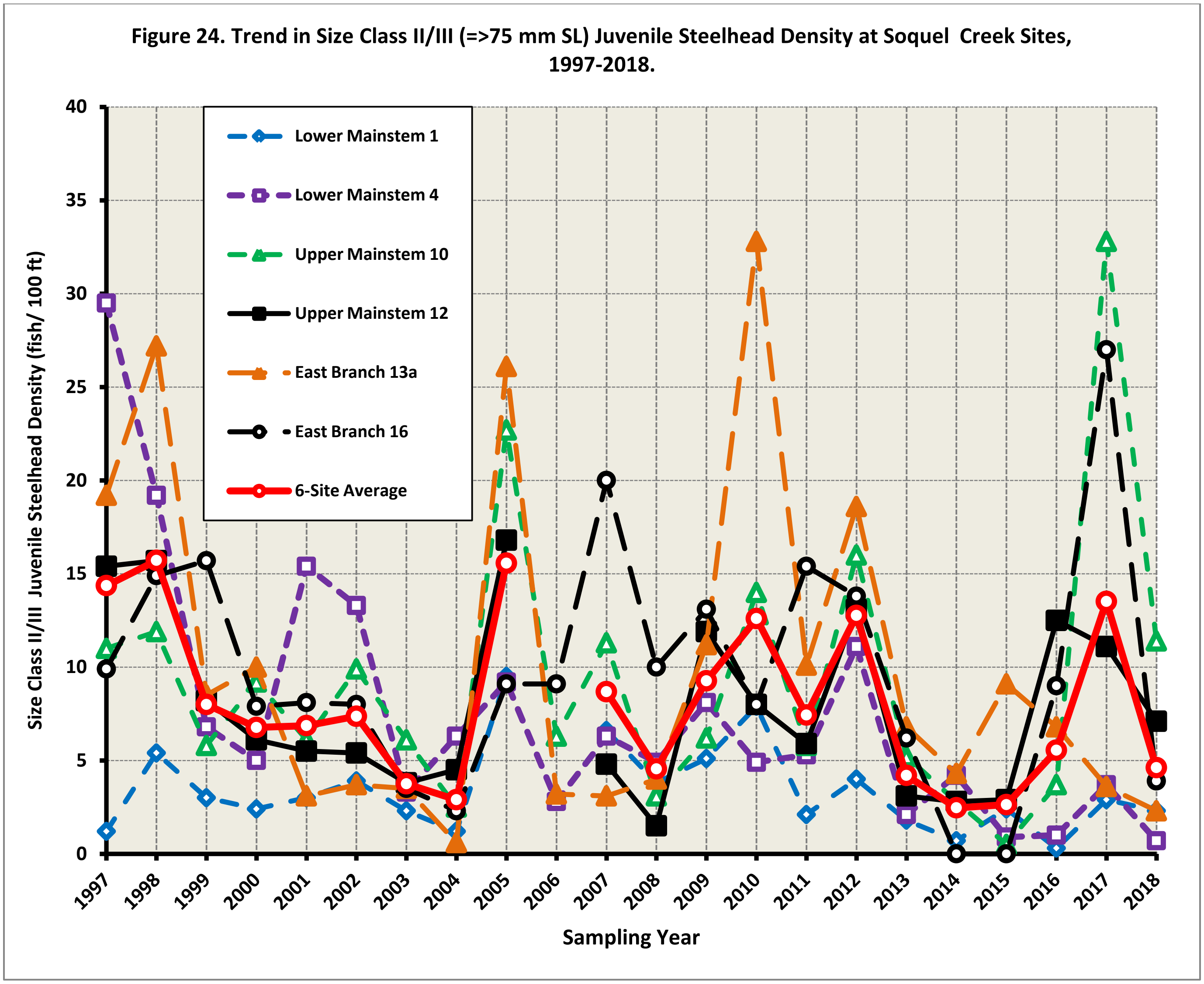

Figure 24. Trend in Size Class II/III Juvenile Steelhead Density at Soquel Creek Sites, 1997-2018.

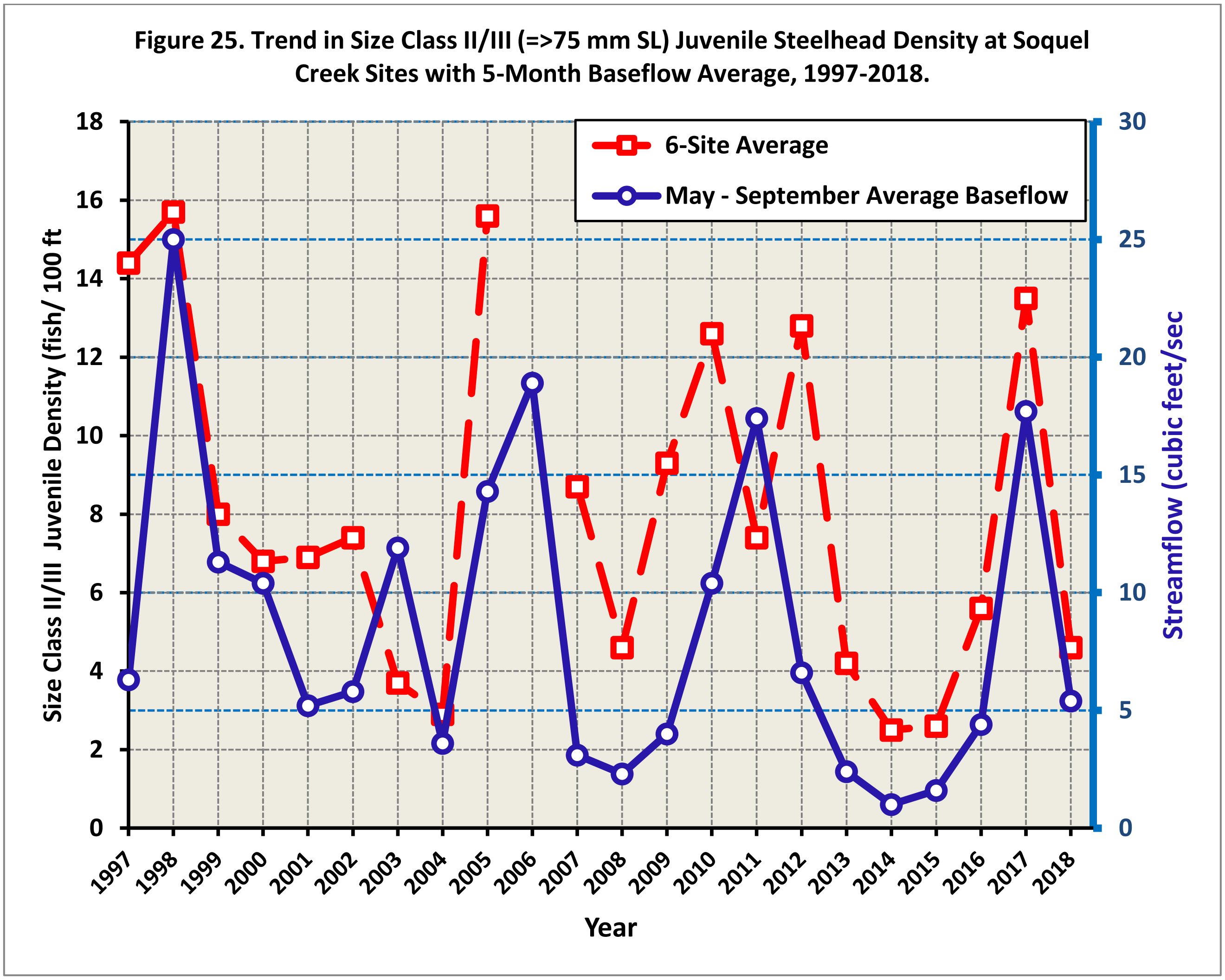

Figure 25. Trend in Size Class II/III (=>75 mm SL) Juvenile Steelhead Density at Soquel Creek Sites with 5-Month Baseflow Average, 1997-2018.

iii. Steelhead Abundance and Habitat in the Aptos Creek Watershed

1. Aptos Creek likely had a WY2018 hydrograph similar to those in the San Lorenzo and Soquel drainages, with stormflows at the same frequency and intensity, resulting in below median baseflow in the dry season (**Figures 6, 7 and 18*).*** The winter/spring streamflow pattern made access to headwater reaches possible for adult steelhead but with limited opportunities until March. The third of the 4 stormflows from March to April 15 was likely a bankfull event that moved significant sediment.

2. ***Habitat conditions*** improved in both Aptos Creek segments compared to pre-2017 drought years (**Table 6**). Compared to those years, 2018 had higher baseflow, pool depth and pool escape cover in both segments, with similar or reduced fine sediment and embeddedness in pools. Sites 2 and 3 in Valencia Creek had poorer habitat conditions than in 2017 with reduced baseflow, pool depth and pool escape cover. Fine sediment and embeddedness were similarly

high or worse compared to 2017 in this sediment laden tributary. Substantial sedimentation and habitat deterioration had occurred in Valencia Creek since 2009, after bankfull stormflows in 2010–2011 and 2016–2018. However, pool habitat was present at the lower Valencia Creek site in 2017 and 2018, when it had been absent in 2016.

3. ***Total and YOY densities*** decreased in 2018 from 2017 at Aptos Creek sites but increased in Valencia Creek sites. ***Yearling and older densities*** increased at Aptos Creek sites and the lower Valencia Creek site after a milder winter. Two-year olds may be more common in Valencia Creek due to slow growth rate, based on previous scale analysis. ***Size Class II and III densities*** declined at all 4 sites in both creeks in 2018 with reduced YOY growth rate. Changes in size and age class densities were found to be statistically insignificant (**Table 8**).

4. ***Total and YOY densities*** were below average at 3 of 4 sites, except for upper Valencia Site 3 (**Figures 26 and 27**). ***Yearling and older densities*** were slightly above average at the Aptos sites but below average at Valencia sites. ***Size Class II and III densities*** were below average at 4 of 4 sites, but near average at lower Aptos Site 3 (**Figure 28**). Lower Aptos Site 3 had near average Size Class II/III densities despite below average total and YOY densities because 68% of YOY grew into Size Class II and yearlings were retained in decent numbers. Only 8% of YOY at upper Aptos Site 4 reached Size Class II, and none did in Valencia Creek sites.

5. The ***trend in the 4-site, long term density of Size Class II/III juveniles*** declined substantially from average site density of 13.1 in 2017 to 6.5 fish/ 100 ft in 2018 (below multi-year average of 9.9) (**Figure 29**). The soon-to-smolt density rating was "fair" for Aptos #4, Valencia #2 and Valencia #3 and "good" for Aptos #3 (**Table 2**). Ratings were boosted one level at each site due to large average sizes (>102 mm SL) of yearlings and older fish that were retained at sites.

6. Aptos Estuary was sampled for steelhead with the large, 3/8-inch mesh bag seine. The steelhead population estimate was 220, based on mark and recapture. This was higher than in 2017. The years 2011−2013 and 2017 had estimates of 32, 140, 423 and 184, respectively. In 2014, only 6 steelhead were captured in 2 days without recaptures to make an estimate. The 2018 size histogram did not indicate a clear bimodal size distribution of age classes (**Figure 30**), as occurred in 2017. Steelhead in the 170-189 mm SL range were likely a mix of YOY and yearlings. Those 190 mm SL and longer were likely yearlings or older. Surprisingly, 33 tidewater gobies (*Eucyclogobius newberryi*) were captured with this large seine on the second day, despite the saline conditions. 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*) and threespine stickleback (*Gasterosteus aculeatus*). The estuary had stratification of water temperature, salinity and oxygen on both sampling days. On 9 October at 0820 hr, the estuary was relatively deep and warm below 0.5 m from the surface. Temperature ranged from 19.5 C at 0.75 m from the surface to 23 C at 1.85 m on the bottom. Salinity ranged from 3.1 to 16.6 ppt at those depths. Oxygen ranged from 16.72 to 0.21 mg/L at those depths. Oxygen within 0.25 m of the bottom was 2.46 mg/L. On 16 October at 0837 hr, the estuary was 0.55 m shallower at the walk bridge and warmer than a week earlier. Steelhead appeared concentrated in the lower estuary, especially along the rip-rapped pilings. Temperature ranged from 22.8 C at 0.75 m from the surface to 25.9 C at 1.0 m and 25.5 C at 1.3 m on the bottom. Salinity ranged from 8.2 to 19.7 ppt. Oxygen ranged from 16.04 to 0.29 mg/L at those depths. Oxygen within 0.25 m of the bottom was 2.76 mg/L.

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

Reach or (Site Only) Comparison To Previous Years	2018 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 lower baseflow 2013)	+	+	Similar	Similar	+	+ (more food, depth and cover)
Aptos Site 4 Aptos Reach 4 (Since drought baseflow 2014)	+	+	+	+	+	+ (more food, depth, cover and better streambed)
(Valencia Site 2) Valencia 2 (Since much higher baseflow 2017)	–	–	Similarly High	NA (lack of cobbles)	–	– (none)
(Valencia Site 3) Valencia 3 (Since much higher baseflow 2017)	–	–	–	Similar	–	– (none)

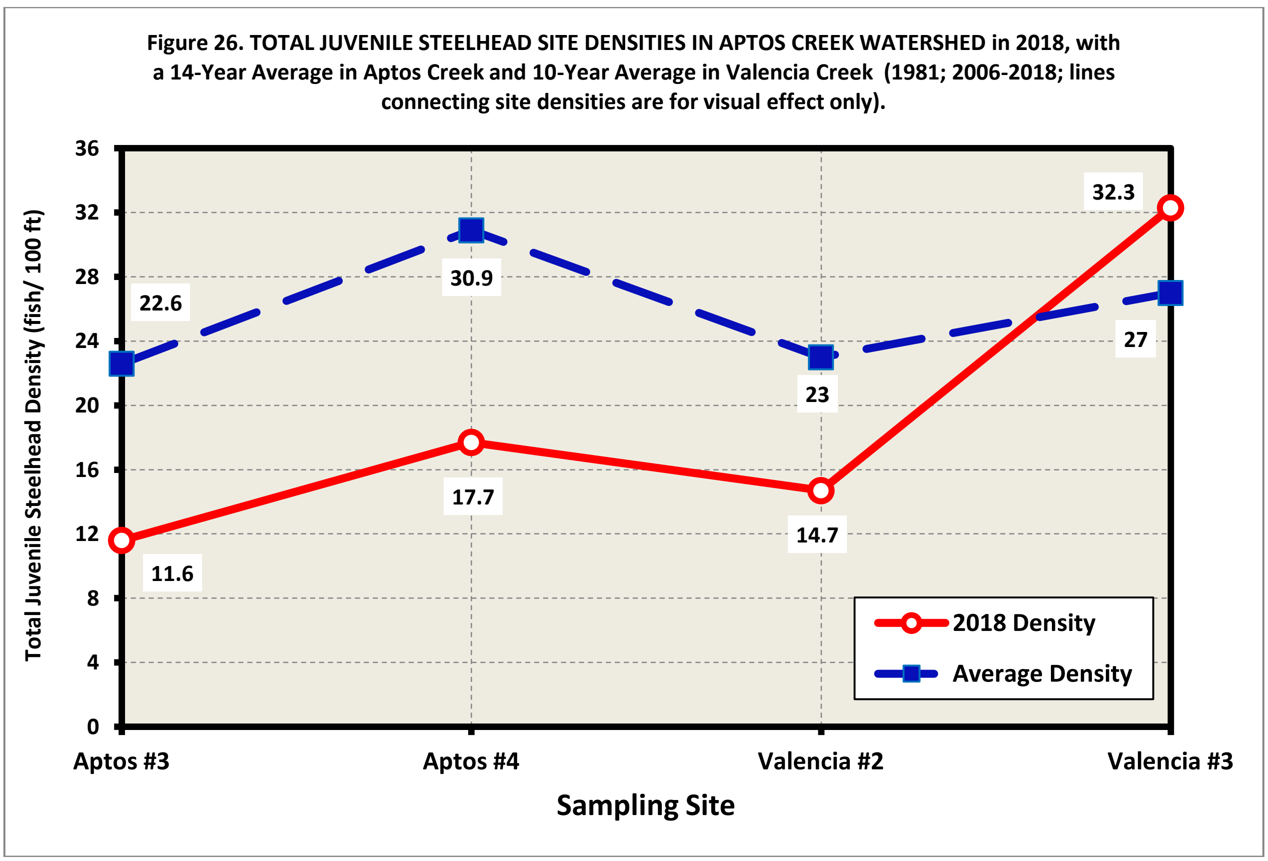

Figure 26. Total Juvenile Steelhead Site Densities in Aptos Watershed in 2018, with a 14-Year Average (1981; 2006-2018).

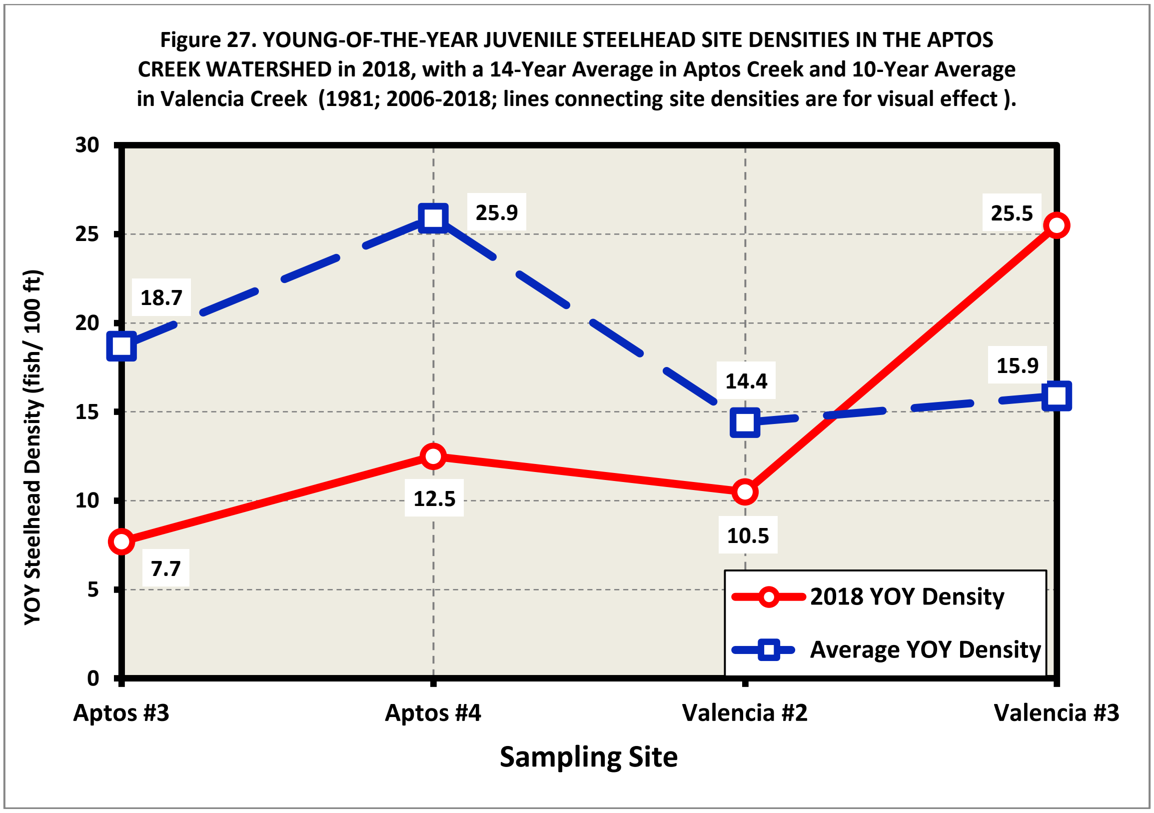

Figure 27. Young-of-the-Year Steelhead Site Densities in Aptos Watershed in 2018, with a 14-Year Average (1981; 2006-2018).

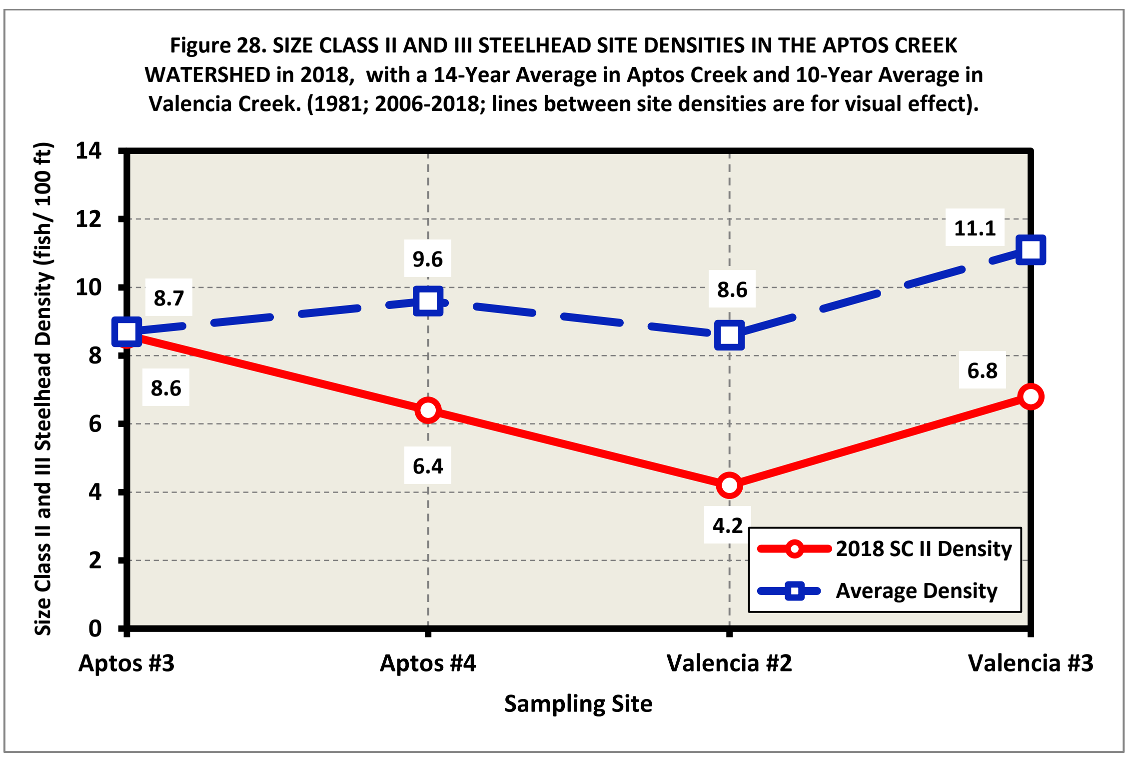

Figure 28. Size Class II and III Steelhead Site Densities in Aptos Watershed in 2018, with a 14-Year Average (1981; 2006-2018).

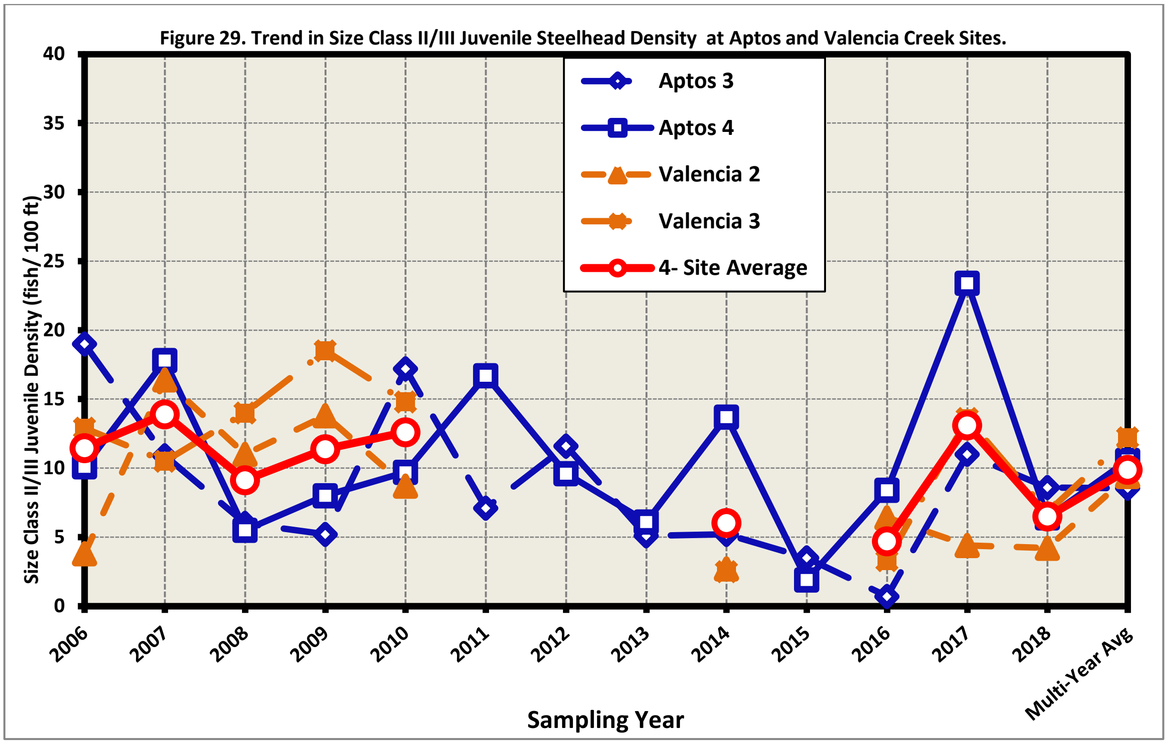

Figure 29. Trend in Size Class II and III Steelhead Site Densities in Aptos Watershed for 2006–2018, with a 14-Year Average (1981; 2006-2018).

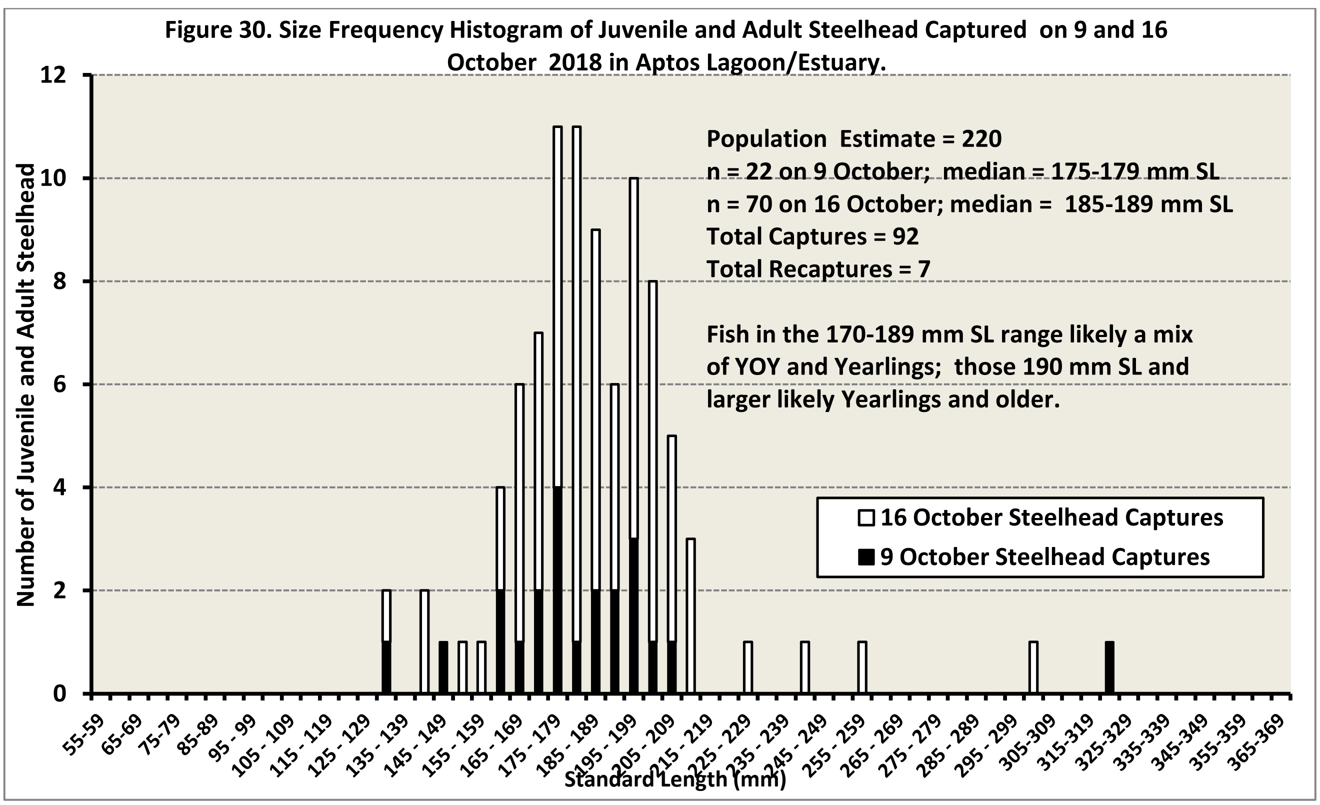

Figure 30. Size Frequency Histogram of Steelhead Captured in Aptos Lagoon, October 2018.

iv. Statistical Analysis of Annual Difference in Juvenile Steelhead Densities

The trend in fish densities between 2017 and 2018 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 2017 and 2018 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 2018 were compared to 2017, such that a positive difference indicated that the densities in 2018 were larger than in 2017 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 that 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 2016 and 2017 densities. The 95% confidence limits are standard and a p-value of < 0.05 was considered significant.

With 15 comparable sites in the San Lorenzo mainstem and tributaries, reduced Size Class II/III site densities were significant at p-value=0.01 (**Table 6**). With 6 comparable sites in the Soquel watershed, no changes in site densities were statistically significant at p-value = 0.05 (**Table 7**). The closest difference to this significance level was reduced Size Class II/III site densities at p-value = 0.054. Densities of Size Class II/III fish were less at 5 of 6 comparable sites in 2018 and similarly low at Site 1 in both years. With only 2 comparable sites between years in Aptos watershed (Valencia sites only), no statistical significance could be found (**Table 8**).

Table 6. 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 (2018 to 2017; n=15).

Statistic	s.c. 2	a.c. 1-YOY	a.c. 2	All Sizes
Mean difference	-6.57	-3.57	0.39	-4.63
Df	14	14	14	14
Std Error	2.10	4.39	0.72	5.03
t Stat	-3.13	-0.81	0.55	-0.92
P-value (2-tail)	0.0074	0.4301	0.5924	0.3728
95% CL (lower)	-11.07	-12.98	-1.15	-15.43
95% CL (upper)	-2.06	5.85	1.93	6.16

Table 7. 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 (2018 to 2017; n=6).

Statistic	s.c. 2	a.c. 1-YOY	a.c. 2	All Sizes
Mean difference	-8.10	12.05	-0.40	10.93
Df	5	5	5	5
Std Error	3.23	5.10	0.66	5.00
t Stat	-2.51	2.36	-0.61	2.09
P-value (2-tail)	0.0538	0.0647	0.5705	0.0806
95% CL (lower)	-16.39	-1.07	-2.09	-1.93
95% CL (upper)	0.19	25.17	1.29	23.80

Table 8. 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 (2018 to 2017; n=2).

Statistic	s.c. 2	a.c. 1-YOY	a.c. 2	All Sizes
Mean difference	-3.50	9.35	0.30	9.50
Df	1	1	1	1
Std Error	3.30	5.25	1.10	4.30
t Stat	-1.06	1.78	0.27	2.21
P-value (2-tail)	0.4813	0.3257	0.8305	0.2706
95% CL (lower)	-45.43	-57.36	-13.68	-45.14
95% CL (upper)	38.43	76.06	14.28	64.14

Girl Scouts' Hidden Falls II on West Branch Soquel Creek above Site #21. September 2018

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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 fish 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