
TECHNICAL MEMORANDUM

TO: Chris Berry
City of Santa Cruz Water Department

FROM: Jeff Hagar
Hagar Environmental Science

DATE: July 2, 2020

PROJECT: City of Santa Cruz Habitat Conservation Plan, Lagoon Fish Population Sampling 2019

Steelhead (*O. mykiss*) population abundance and life-history characteristics were assessed in Laguna Creek Lagoon and the San Lorenzo River Lagoon during the summer of 2018 by the City of Santa Cruz Water Department and Hagar Environmental Science (HES). Mark-recapture abundance surveys were conducted in the early summer and again in the late summer using a large seine (46 meter (150 foot) long by 2.4 meter (8 foot) deep) to capture fish and PIT tag technology to identify recaptures. Fish were tagged one day and recaptured the next day in Laguna Creek. In the larger San Lorenzo River Lagoon, fish were captured and tagged on two consecutive days and recaptured during a subsequent two-day period (there are two days between the end of the mark period and the beginning of the recapture period). Additional catch per effort surveys were conducted in the San Lorenzo Lagoon during July and August. Although no population estimates were made during these intermediate surveys, PIT tags were implanted in captured individuals for additional information including growth rates and movement patterns.

Laguna Creek

Summary

Runoff in 2019 was classified as a normal water year (based on USGS San Lorenzo River at Big Trees gage and City of Santa Cruz water year type classification) but mean flow was above average (213 cfs vs. 131 cfs). Flows in Laguna Creek were high in May with a storm peak occurring mid-month and receding through the beginning of the seining survey (Figure 1). The 2019 season was highly unusual in that, except for a few limited closures up to about 10 days in length, the mouth remained open the entire summer (Figure 1). Inflow remained steady between 2 and 3 cfs after early June.

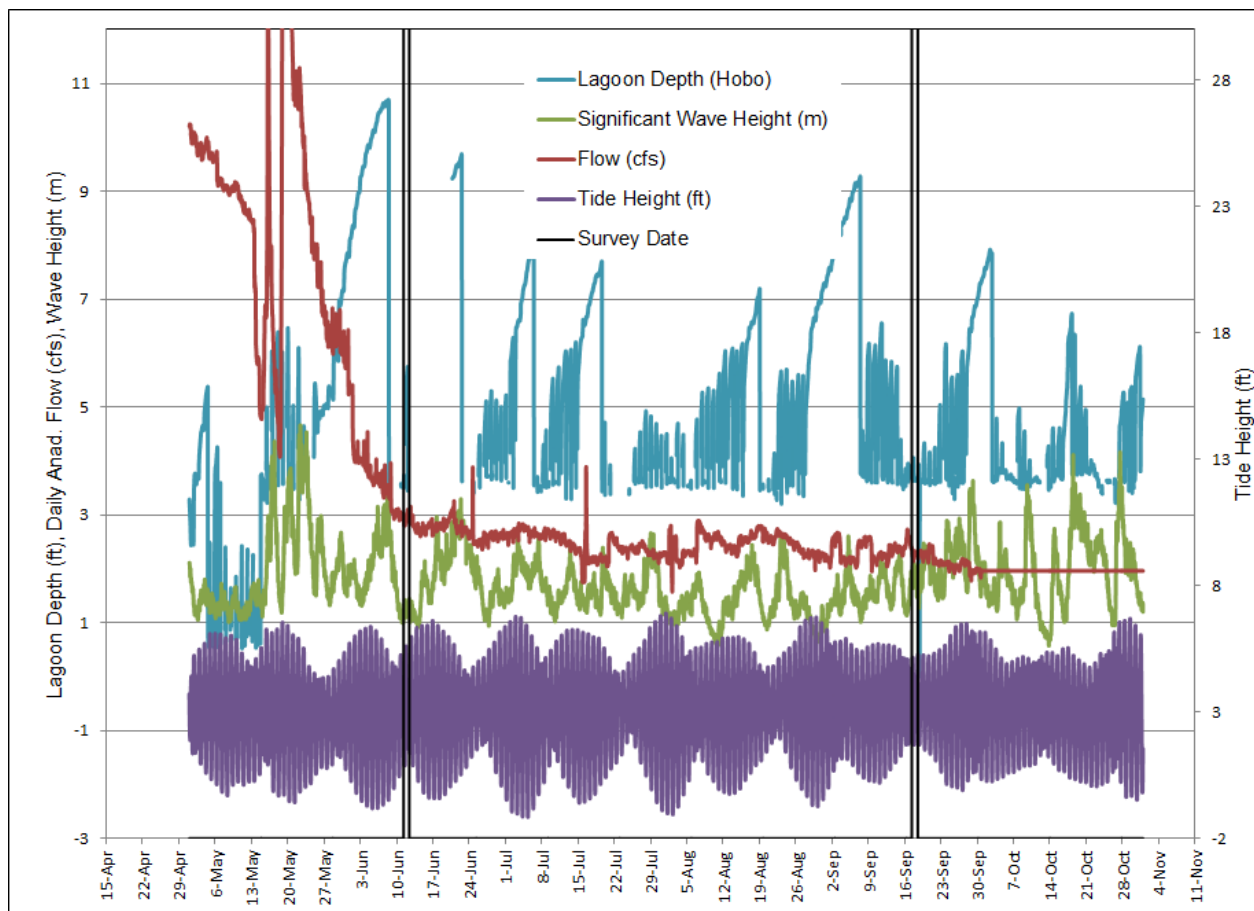


Figure 1. Laguna Creek Lagoon stage, streamflow, wave height, and tides 2019 (Source: lagoon depth from 2ND Nature and City of Santa Cruz, streamflow from Balance Hydrologics, wave and tide data from NOAA)

In spite of the open lagoon condition and low stage, catch per unit effort and population estimate in June were in the mid-range for surveys to date. The unexpectedly large number of *O. mykiss* appeared to be primarily 1+ and older. Very few *O. mykiss* were captured in the fall

and none of them were recaptures from June. The frequent open condition of the lagoon and limited habitat available for *O. mykiss* under open conditions appeared to preclude much use of the lagoon by juvenile steelhead during the summer of 2019. This is in contrast to the San Lorenzo River lagoon which supported abundant *O. mykiss* use during 2019 with mostly open lagoon conditions.

Early summer (June 11-12)

Early summer Site Conditions

- On June 11, the first day of sampling, the mouth had been mostly open since a breach from high level on June 7. The mouth appeared to have closed briefly late in the evening of the 10th and again the morning of the 11th but was just starting to open as sampling began (Figure 2) and it mostly drained by noon (Figure 3). The lagoon closed again the evening of the 11th but opened at about 3 am on the 12th (City of Santa Cruz lagoon water quality monitoring data). During sampling on the 12th the lagoon elevation was low and subject to tidal influence. Water depth was very shallow from the end of the rock bluff upstream past the water quality recorder (Figure 4). Stage was not recorded during either sampling event since the recorder was dewatered. There was a pocket of deeper water along the rock bluff but maximum depth was only 1.3 meters (4.3 ft.).
- Inflow from Laguna Creek was around 2.9 cfs during the survey (Figure 1).
- The water column (1.2 meters) was consistently cool to the bottom (<18°C) and well oxygenated (>8 mg/l) on June 11, with higher salinity below 0.4 meters (Figure 5). On June 12, there was a warmer surface layer (19.3°C) and dissolved oxygen levels slightly below those measured on June 11. Salinity stratification was also observed on June 12 (Figure 5). The upper layer provided good conditions for *O. mykiss*.
- The water column was clear with substrate visible at greatest depth surveyed (1.3 meters (4.3 ft.))



Figure 2. Laguna Creek Lagoon, June 11, 2019, ~9:30 am.



Figure 3. Laguna Creek Lagoon, June 11, 2019, ~12:00 pm



Figure 4. Laguna Creek Lagoon, June 11, 2019

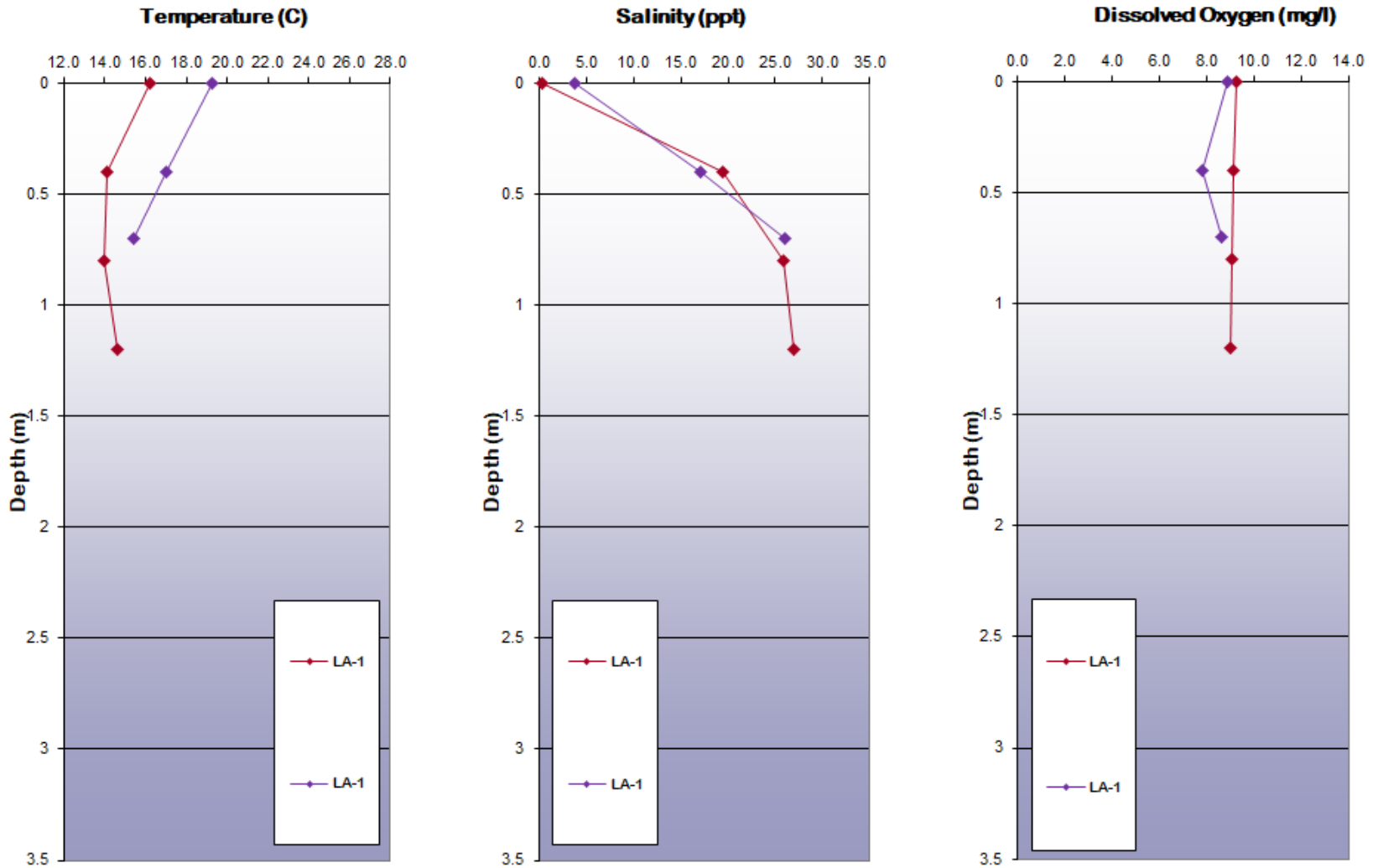


Figure 5. Depth profiles of water quality parameters in Laguna Creek Lagoon during June. Profiles plotted in red are June 11; profiles in blue are June 12

Early summer Survey Results

- Only site LA-1 was sampled on June 11 since the rest of the lagoon was mostly dewatered. Lagoon stage was slightly higher on June 12 and Sites LA-1 and LA-1.5 were sampled.
- A visual survey was conducted upstream of LA-1 on June 11 and a large school of *O. mykiss* (size class 1+ or 2+) was seen in a pool in the willow section between LA-4 and LA-5.
- *O. mykiss* were moderately abundant at LA-1 (Table 1). Overall CPUE for *O. mykiss* was in the upper third for all early summer surveys, 4 years had higher CPUE and 7 years had lower CPUE (Table 2).

Table 1. Fish catch in Laguna Creek Lagoon, June 2019

	LA-1	LA-1.5	LA-2	LA-3	Grand Total
# Hauls	5	0	0	0	5
Species	Number Caught				
Steelhead	85				85
Topsmelt	1				1
Threespine stickleback	26				26
Staghorn sculpin	4				4
<i>O. mykiss</i> CPUE	17.0				17.0

Note: See Figures at end of document for sample station locations.

Table 2. *O. mykiss* and coho salmon (*O. kisutch*) catch per seine haul in Laguna Creek Lagoon at consistently sampled stations (data from HES 2005, HES 2009, HES 2010, HES 2011, HES 2012, HES 2013, HES 2014, HES 2015, HES 2016, HES 2017, HES 2018, and HES 2019)

	<i>O. mykiss</i> Catch per Haul				Coho (<i>O. kisutch</i>) Catch per Haul			
	Jun	Jul	Sep	Oct	Jun	Jul	Sep	Oct
2004		2.4	0			0	0	
2008	11		6		0		0	
2009	7		19		0		0	
2010	13			1.7	0			0
2011	19.8			0.1	0			0
2012	11.3		10.3		0		0	
2013	28		8.6		0		0	
2014	20		33		0			
2015	0.1			11.4	0			0
2016	1.1		5.2		0		0	
2017	42.8		14.5		0		0	
2018	14.3		6.5		0		0	
2019	17.0		2.5					

- The majority of *O. mykiss* captured were between 100mm FL and 169 mm FL, likely age 1+ or older (Figure 6). A smaller group ranged from 50 mm FL to 100 mm FL. These were likely young-of-year or small age 1+.
- Most of the *O. mykiss* (76%) were at parr or advanced parr stage. The remaining 24% were characterized as silvery parr or advanced silvery parr. None were characterized as smolts. With the extensive open lagoon conditions through much of May and early June, smolts would have had abundant opportunity to enter the ocean.
- No incidence of *O. mykiss* with black-spot disease or other external parasites, disease, or abnormalities was noted.
- All *O. mykiss* had adipose fins present.
- Threespine stickleback were present but not abundant and a few staghorn sculpin were captured. Tidewater goby were not noted in the catch or otherwise observed.
- The over-wash pond was not sampled.

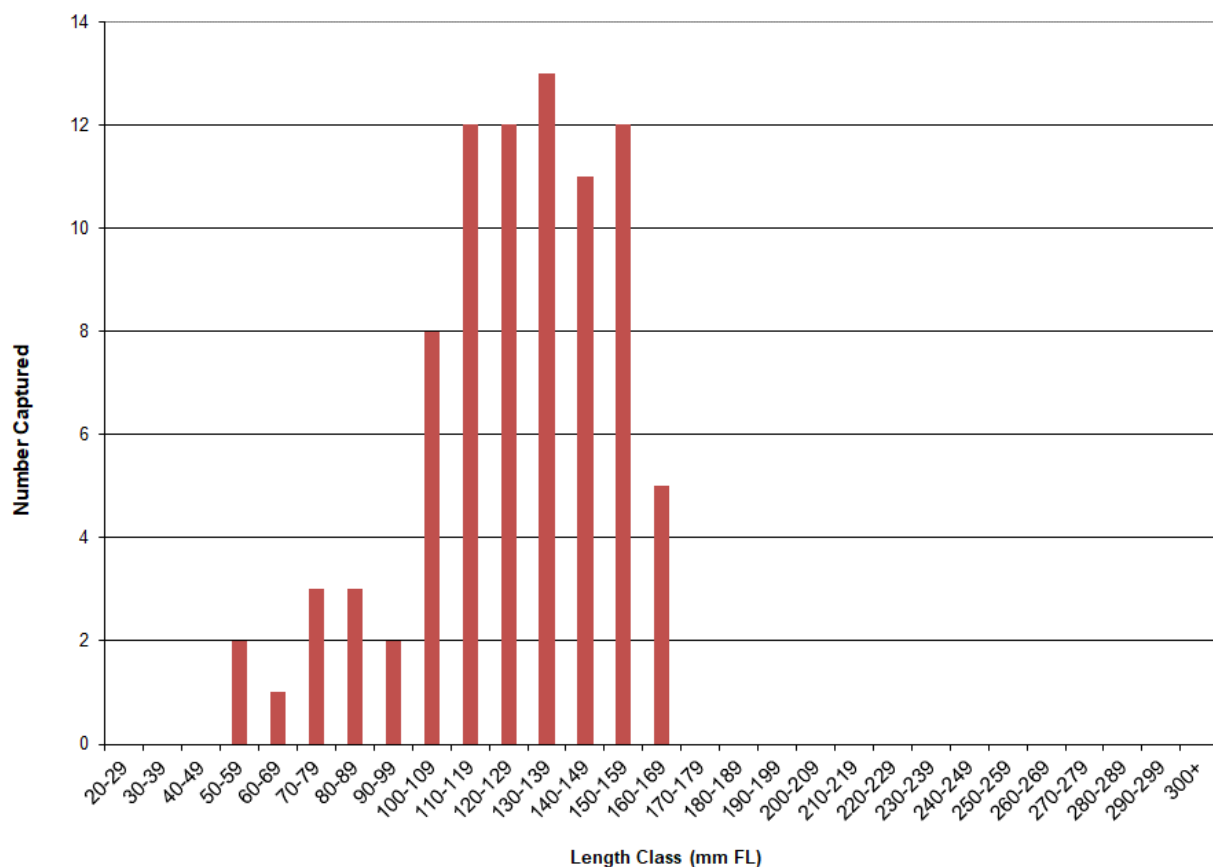


Figure 6. *O. mykiss* length classes in Laguna Creek Lagoon, June 2019

Early summer *O. mykiss* Population Estimate

- Only fish 80mm FL or greater and less than 380 mm FL were included in the population estimate.
- Sixty-three *O. mykiss* were captured during the marking period on June 11. Two were too small to tag. A total of 61 tagged *O. mykiss* were released in the lagoon on June 11.
- On June 12, 22 *O. mykiss* were captured. Four were below the 80 mm FL tagging limit. Only one *O. mykiss* caught during the recapture period had been tagged.
- Population estimation based on a single recapture would likely be biased. In addition, it is very likely that the population could not be considered closed since the lagoon was open, habitat was very limited, and fish were likely disturbed by the sampling activity. CPUE dropped from 31.5 during the mark period on June 11 to 7.3 on June 12. Sampling efficiency would have been quite high due to the confinement of fish in a relatively small area.
- Untagged fish captured during the recapture period were tagged in order to collect over-summer information.

Late summer (September 17-18)

Late summer Site Conditions

- The mouth was open at the time of the survey and had been open since September 7. Except for a few limited closures up to about 10 days in length, the mouth remained open the entire summer (Figure 1). Stage was stable during the seining at about 1.1 to 1.2 meters (3.7 to 3.8 ft.) (2nd Nature and City of Santa Cruz data) (Figure 1). Compared to June the stage was slightly higher but still very low (Figure 7).
- Inflow from Laguna Creek at the time of the survey was fluctuating between 2.2 and 2.4 cfs.
- Maximum depth was 0.5 meters (1.6 ft.). The deepest water was available in a narrow band along the rock wall and in the corner of the marsh and rock wall at LA-1.
- There was a large amount of algae throughout the deeper water at LA-1.
- Due to the shallow depth, only surface and bottom water quality readings were taken. The lagoon was tidally influenced with temperature between 13.8°C and 16.4°C at the surface. Salinity increased with depth at LA-1.5 which was sampled later in the morning under a rising tide (Figure 8, center panel). Dissolved oxygen ranged from 7.0 mg/l to 8.8 mg/l, with one low reading of 3.8 mg/l on the bottom at LA-1 (Figure 8, right panel), likely due to the accumulation of algae.
- The water column was clear with secchi visibility at the bottom at depths to 0.5 meters (1.6 ft.)



Figure 7. Laguna Creek Lagoon, September 18, 2018

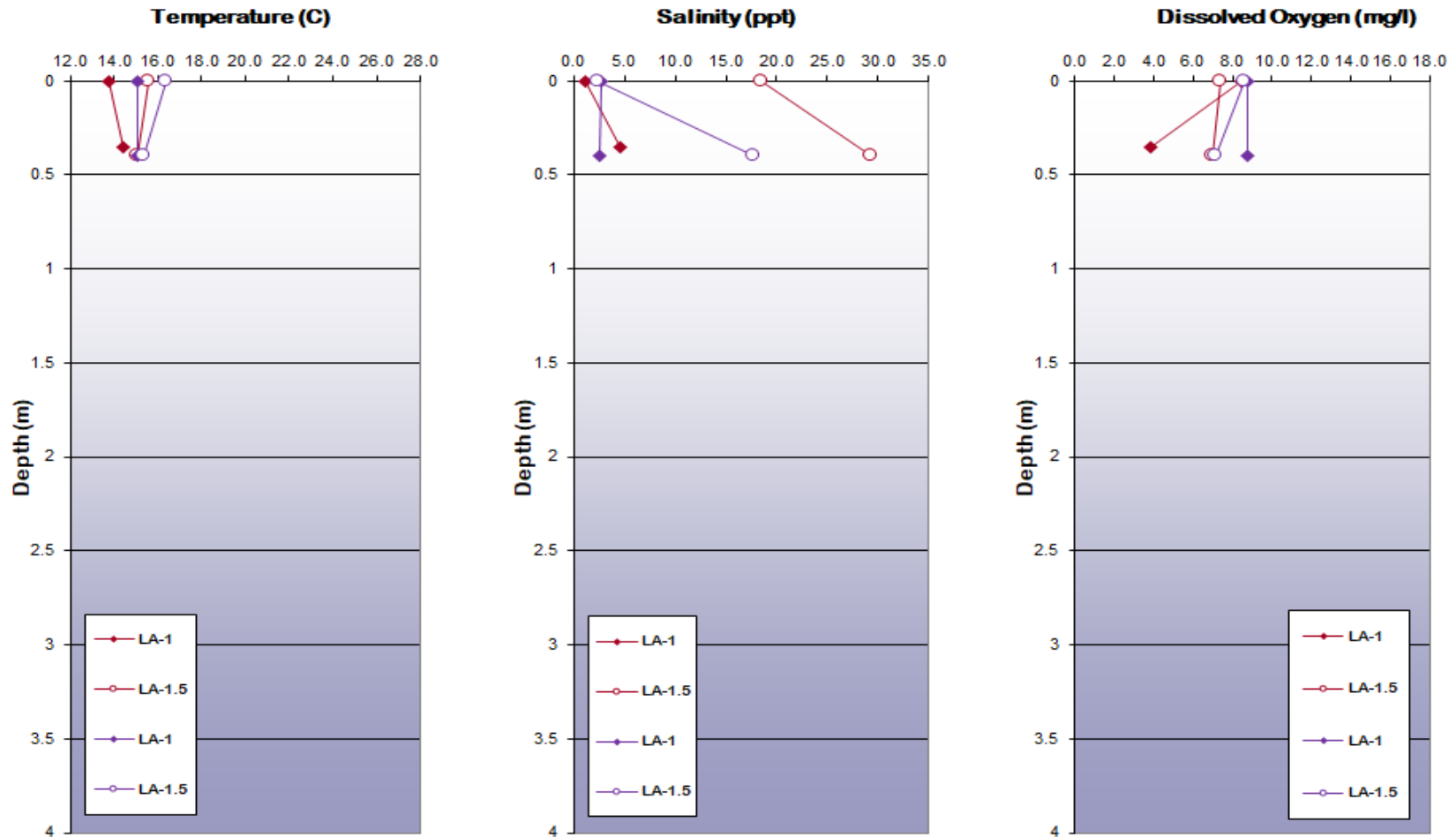


Figure 8. Depth profiles of water quality parameters in Laguna Creek Lagoon during September. Profiles plotted in red are September 17; profiles in blue are September 18

Late summer Survey Results

- *O. mykiss* were captured and marked on September 17. On September 18 the lagoon was re-sampled and the proportion of re-captured fish was recorded.
- Sampling was limited to LA-1 and LA-1.5 due the shallow depths in more upstream areas. LA-1.5 was very shallow and clear.
- Three seine hauls were completed on September 17 and 3 hauls on September 18 between the beach (LA-1) and just downstream of the water quality monitoring station (Table 3).
- In addition to *O. mykiss*, stickleback were very abundant and staghorn sculpin were seen in low numbers. No tidewater goby were captured or observed (Table 3).
- Overall abundance of *O. mykiss* based on number caught per seine haul (catch per unit effort or CPUE) at 2.5 per haul was one of the lowest seen since 2004 (Table 2). CPUE was 1/7 the level in June (17.2 per haul) although this difference is not statistically significant at the $p=0.05$ level (two sample t-Test, $p\approx 0.2$). *O. mykiss* were likely transient in the lagoon during the summer of 2019 due to the frequent open condition and resulting diminished habitat.
- CPUE was 4 times higher during the mark period (September 17) than on September 18 (not significantly different, two sample t-test, $p\approx 0.3$).
- No *O. mykiss* tagged in June were recaptured in September. Growth rates could not be determined (Table 4).
- Captured *O. mykiss* ranged in length from 70 mm FL to 169 mm FL (Figure 9). The catch was too small to draw firm conclusions regarding size distribution in September. The population may have also been transient so it is difficult to relate the size distribution to lagoon conditions.
- Sixty-nine percent of the *O. mykiss* catch were characterized as parr (sizes from 70-129 mm FL) and 31% were characterized as silvery parr (lengths from 110-169 mm FL).
- No incidence of *O. mykiss* with black-spot disease or other external parasites, disease, or abnormalities was noted.
- All *O. mykiss* had adipose fins present.
- The over-wash pond was not sampled.

Table 3. Fish catch in Laguna Creek Lagoon, September 2019

	LA-1	LA-1.5	LA-2	LA-3	Grand Total
<i># Hauls</i>	4	2			6
Species	Number Caught				
<i>O. mykiss</i>	11	4			15
Threespine stickleback	thousands	thousands			thousands
Staghorn sculpin	2				2
<i>O. mykiss</i> CPUE	2.8	2.0			2.5

Note: See Figures at end of document for sample station locations.

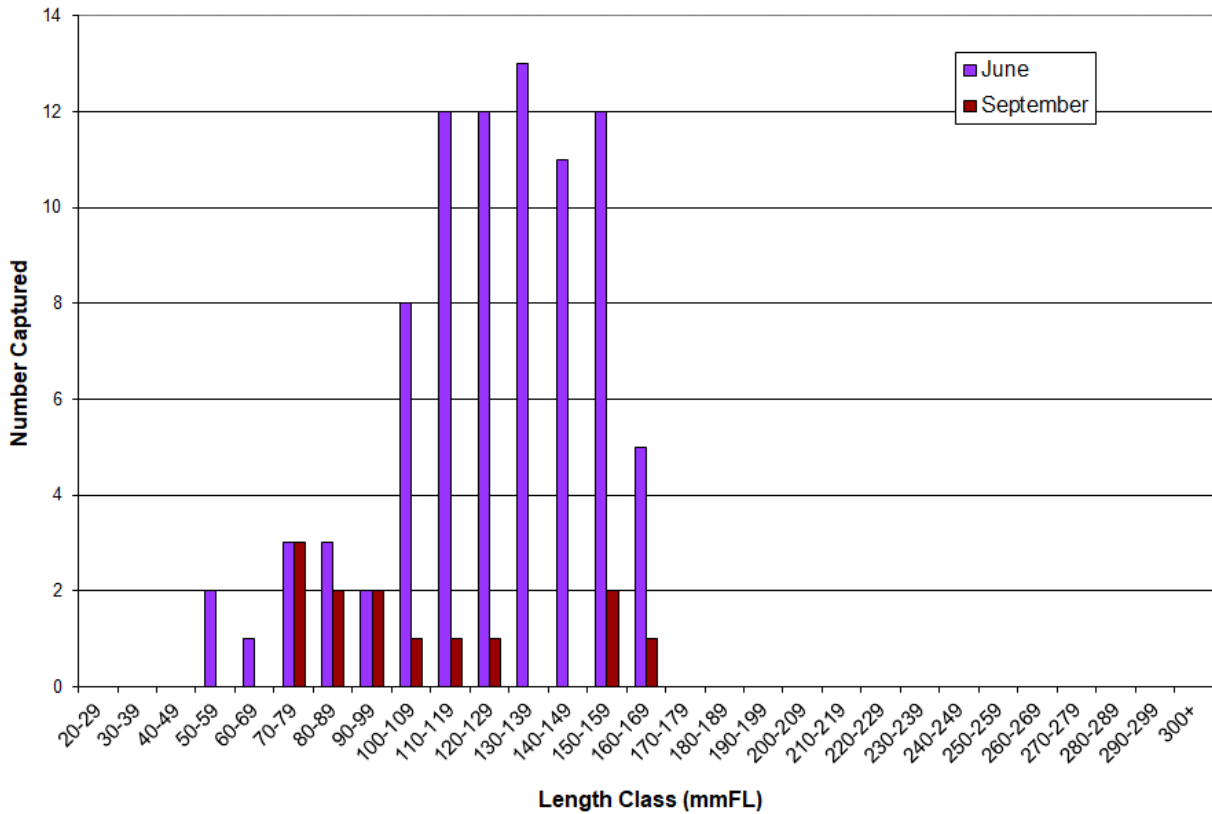


Figure 9. *O. mykiss* length classes in Laguna Creek Lagoon, late summer 2019 compared to spring 2019.

Table 4. Laguna Creek Lagoon *O. mykiss* tagged in June and recaptured in September, annual averages

	Number Recaptured	Average Growth Rate (mm/day)	Average Growth (mm)	Fall CPUE	June CPUE
2012	1	0.86	83	10.3	11.3
2013	10	0.48	47	8.6	28
2014	72	0.43	42	33	20
2015	1	0.99	124	11.4	0.1
2016	0	NA	NA	5.2	1.1
2017	13	0.66	64	14.5	42.8
2018	23	0.99	104	6.5	14.3
2019	0	NA	NA	2.5	17.0

Late summer *O. mykiss* Population Estimate

- Twelve *O. mykiss* were captured during the marking period on September 17. Three were too small to tag and one was captured twice. A total of 8 tagged *O. mykiss* were released in the lagoon on September 17.
- On September 18, only 3 *O. mykiss* were captured. All were larger than the 80 mm FL tagging limit. One *O. mykiss* caught during the recapture period had been tagged on September 17.
- Population estimation based on the small number of tagged fish, small number caught during the recapture period, and a single recapture would likely be biased. In addition, it is very likely that the assumption of a closed population was violated since the lagoon was open, habitat was very limited, and fish were likely disturbed by the sampling activity and moved out of the areas that could be sampled. CPUE was 4.0 during the mark period on September 17 and only 1.0 on September 18. Sampling efficiency would have been quite high due to the confinement of fish in a relatively small area.
- The relationship between population estimate and CPUE was not updated since population estimates were not possible in either the spring or fall surveys. The relationship for prior year surveys is depicted in Figure 10. least squares regression r^2 is 0.67 and was statistically significant with $p < 0.001$. Forcing the relationship through the origin improves the r^2 to 0.91.

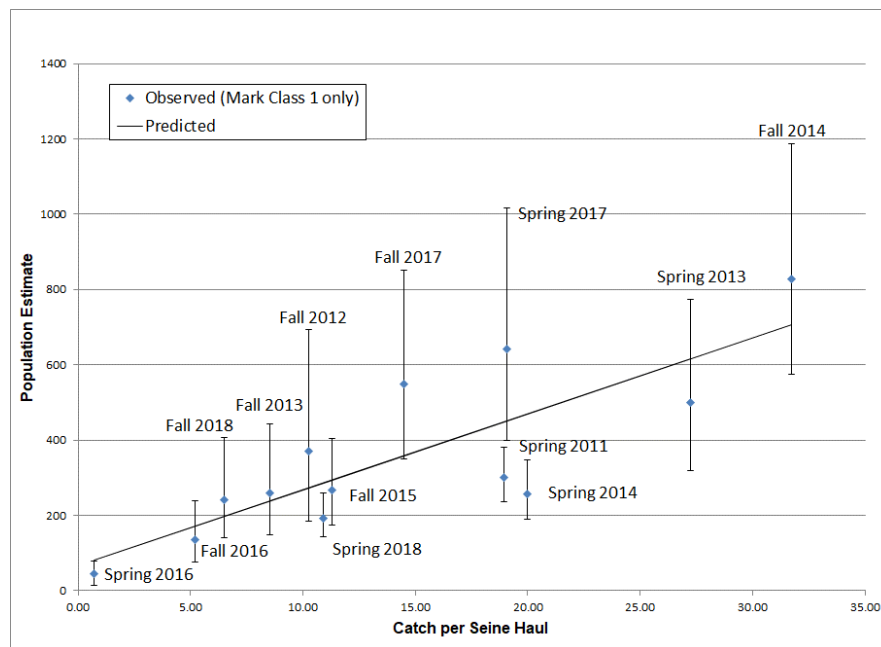


Figure 10. Relationship between *O. mykiss* population estimate and CPUE in Laguna Creek Lagoon¹

¹ Population estimates not available in Late Summer 2011, Early Summer 2012, and Early Summer 2015 due to insufficient catch. In two cases (Late Summer 2011 and Early Summer 2012) the lagoon was open and in one case (2015) it had only recently closed.

San Lorenzo River

Summary

With the exception of two brief closures (1 to 2 days) on August 7 and August 22, the lagoon was open and tidally influenced until September 8. During the September closure, the lagoon stage rose to a high level (close to 8 feet NGVD 29) and eventually breached on September 17, two days prior to the first fall survey date (Figure 11). There were intermittent brief closures through late September and October.

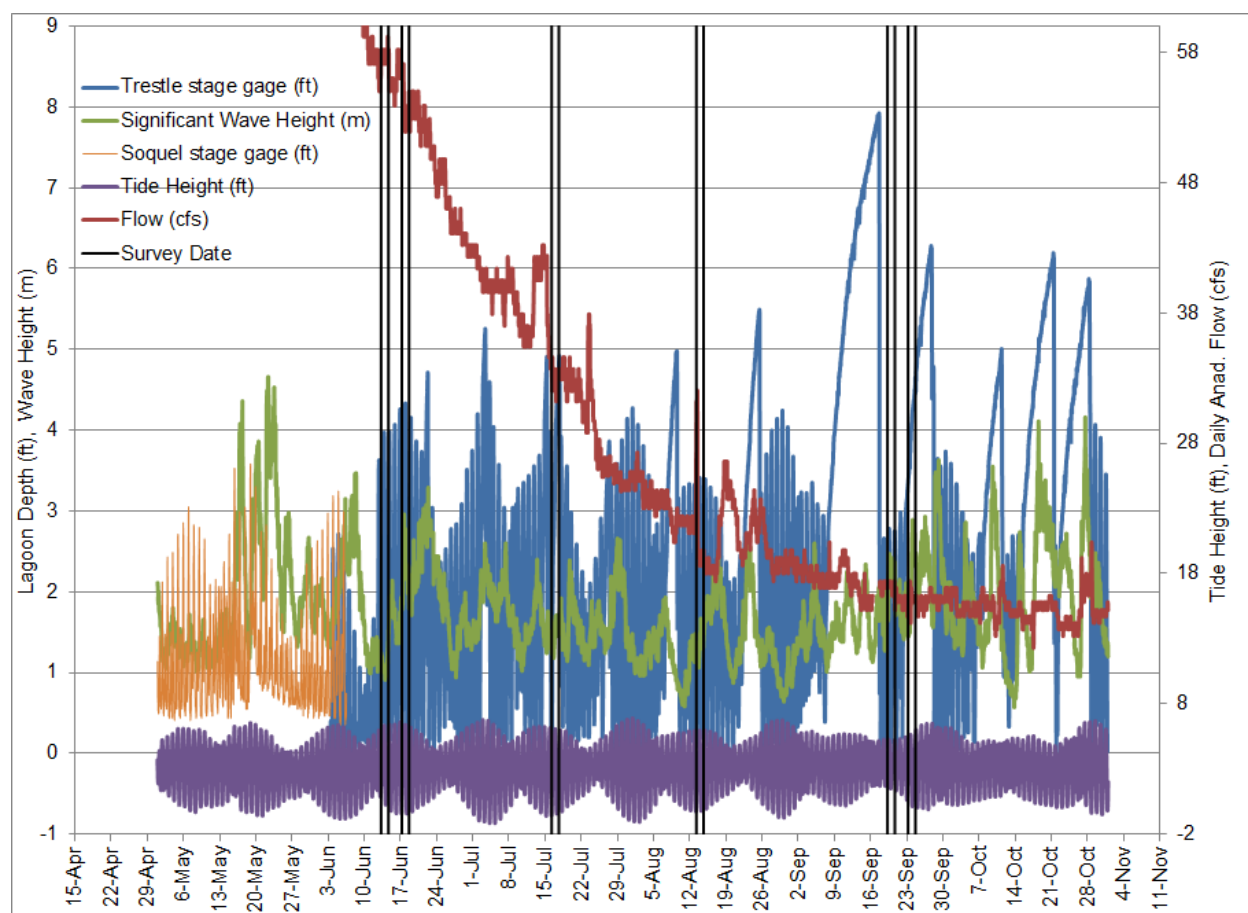


Figure 11. San Lorenzo Lagoon stage, streamflow, wave height, and tides 2019 (Source: lagoon stage from 2ND Nature, streamflow from USGS, wave and tide data from NOAA)

Abundance of *O. mykiss* in the lagoon was at record high levels in 2019, comparable or exceeding the bumper year of 2017 (Table 5). As in past surveys, abundance was concentrated near the Trestle Bridge and Riverside Drive Bridge (Table 6). Catch per effort was high in June, dropped to a lower level in July, then peaked in August and to a lesser degree September. Abundance estimates in June were almost double the 2017 estimate and the fall estimate was almost double the June estimate (Table 7). The 2019 season continued the trend of higher

abundance of *O. mykiss* in the lagoon in June and through the summer. The four consecutive years 2016 through 2019 had the highest abundance by far of all previous survey years back to 2008. The relatively wet 2017 and 2019 seasons carried a high abundance through the summer into the fall, larger by an order of magnitude than any previous year.

Table 5. *O. mykiss* catch per haul for the San Lorenzo River Lagoon by month and year (data from HES 2009, HES 2010, HES 2011, HES 2012, HES 2013, HES 2014, HES 2015, HES 2016, HES 2017, HES 2018a, HES 2019)

Year	<i>O. mykiss</i> Catch per Haul				
	June	July	August	September	October
2008	2.6				0.1
2009	0.3			1.0	0.5
2010	8.3	21.5			28.25
2011	13				2.5
2012	1.7			14.4	
2013	2	8.4		4.7	
2014	1.2	1.1		0.0	
2015	2.6	0	0		0
2016	39.7	1.0	2.0	7.8	
2017	134.4	452.0	272.0	328.5	
2018	23.3	2.5	6.4	6.3	
2019	92.2	53.4	277.7	228.2	

Table 6. *O. mykiss* catch per haul for the San Lorenzo River Lagoon during 2019

Station	Location	<i>O. mykiss</i> Catch per Haul				Overall
		7-12 Jun	Jul 16-17	Aug 14-15	Sep 20-25	
SL-1	South of Trestle	1.0	10.0	49.7	7.2	16.5
SL-2	RR Trestle	55.8	95.7	440.0	509.0	221.8
SL-3	Near YSI Station	NS	NS	NS	35.0	35.0
SL-5	Riverside Drive	274.4	59.0	457.5	383.3	316.0
SL-6	U/S Bank Restoration	40.5	22.0	NS	66.6	45.9
	Overall	92.2	53.4	277.7	228.2	153.1

NS- Not Sampled

Table 7. *O. mykiss* mark-recapture population abundance estimates in San Lorenzo River lagoon for fish >80 mm FL and <320 mm FL.

	<i>O. mykiss</i> Population Estimate	
	Spring	Fall
2011	501	138
2012	60	714 ¹
2013	207 ²	No estimate ³
2014	No estimate ⁴	None captured
2015	559 ³	None captured
2016	2,697	1,331
2017	3,636	>3,636 ⁵
2018	2,378	704
2019	7,637 ⁶	14,105

Source: data from HES 2012, HES 2013, HES 2014a, HES 2015, and HES 2016

¹ May have been fish entering or leaving lagoon

² Low number of marks or recaptures, likely biased

³ Evidence population not closed, violates assumption of the method

⁴ No recaptures

⁵ Estimate based on CPUE, mark-recapture estimate not possible, recapture period precluded due to incidental take limitations

⁶ Based on proportion of fish in the catch greater and less than 80 mm FL there would have been an estimated 4,504 *O. mykiss* less than 80 mm FL for a total population of 12,141

Average growth rates for *O. mykiss* in the lagoon, at 0.38 mm/day, were among the lowest observed in all surveys to date although some individuals grew at relatively high rates up to 0.85 mm/day. High numbers of previously tagged fish captured in July, August, and September together with the very high and increasing abundance of *O. mykiss* through the summer suggests high affinity for rearing in the lagoon during 2019. Water quality monitoring suggests that parameters were in a suitable range for rearing juveniles with occasional transient and isolated occurrence of low dissolved oxygen. It is possible that the relatively low average growth rates observed are a result of density dependent factors given the high abundances observed.

A small group of large (260mm FL to 390mm FL) *O. mykiss* appeared in the catch in September during the mark period. These fish all had an external appearance characterized as ocean/adult and three of them had sea lice (possibly *Lepeophtheirus salmonis*). Their presence was coincidental with the capture of two pink salmon, also with sea lice.

Recoveries of tagged *O. mykiss* at the NOAA PIT tag antenna array at Felton were not available since NOAA personnel have not been able to conduct downloads due to restrictions on movement during the COVID-19 Pandemic.

Early summer (June 13-14, 17-18)

Early summer Site Conditions

- The lagoon was open during the sampling period (Figure 11 and Figure 12). Daily average flow at Santa Cruz gage ranged from 51.9 cfs to 58.2 cfs, declining slightly during the sample period (historical discharge, USGS site 11161000 San Lorenzo River at Santa Cruz California).
- The lagoon stage was tidally influenced and ranged from 0.2 to 4.3 ft (City of Santa Cruz Trestle gage data). The shoreline was conducive to sampling with sufficient area at all regularly surveyed sites. Water quality conditions were highly variable depending on proximity to the mouth and tidal stage (Figure 12).
- Near the mouth, the lagoon was salinity stratified with salinity close to seawater at depths of 0.4 meters (1.3 feet) to 0.8 meters (2.6 ft.) and deeper (Figure 13, center panel). Surface salinity ranged from 4.3 ppt under the trestle to over 33 ppt with higher tides near the mouth. Further upstream lagoon salinity was generally below 2.0 ppt but exhibited seawater influence with a morning high tide (over 27 ppt at 0.8 meters and deeper).
- Temperature was variable, depending on tidal influx and air temperature. The highest temperature (20.7°C) was recorded upstream across the skate park during an afternoon when the air temperature was 26.1°C. This elevated water temperature was still within the suitable range for juvenile *O. mykiss*.
- Dissolved oxygen levels were generally above 6 mg/L and tended to be lower in the morning hours, increasing during the day. Levels were mixed through the water column. On one occasion dissolved oxygen levels were below 6.5 mg/L near the mouth during a low tide
- Water clarity was high with secchi disk visible at or near the substrate at all stations (up to 1.8 meters (5.9 ft.) deep).



Figure 12. San Lorenzo Lagoon mouth June 13, 2019

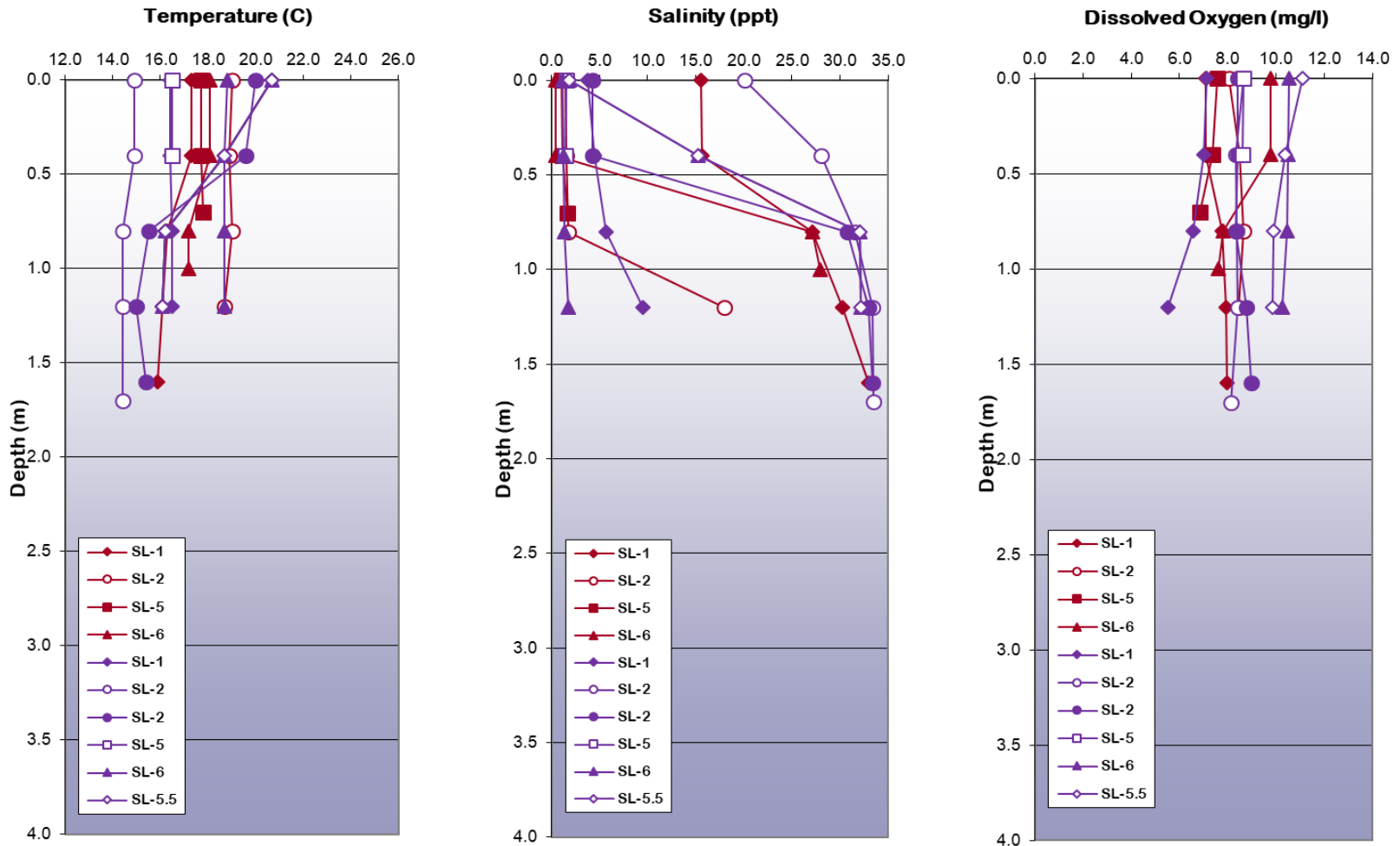


Figure 13. Depth profiles of water quality parameters in the San Lorenzo Lagoon during June. Profiles plotted in red are June 13-14; profiles in blue are June 17-18

Early summer Survey Results

- *O. mykiss* were captured and marked on June 7 and 8 and the lagoon was resampled on June 11 and 12. Untagged *O. mykiss* captured on June 11 and 12 were also tagged for over-summer information.
- Twenty-three seine hauls were completed at regularly sampled stations between the beach and the bend upstream of Riverside Bridge. Station 3 was not sampled due to the extended time required to process fish at Station 2.
- The overall fish catch was dominated by very abundant topsmelt, followed by steelhead. Shiner surfperch were moderately abundant in the lower lagoon, and a few staghorn sculpin were captured but other species were rare (Table 8).
- *O. mykiss* abundance (CPUE) was the second highest for June in annual surveys to date and was 70% of the record 2017 level (Table 5). Catch was highest upstream of Riverside Bridge where large numbers of younger fish were present (60-110 mm FL). Catch of *O. mykiss* was also high around the Trestle bridge where larger fish (110-180 mm FL) were more common.

Table 8. Fish catch in San Lorenzo River Lagoon, June 2019

Species	South of Trestle (1)	Around Trestle (2)	Around Water Quality Station (3)	Upstream of Riverside Bridge (5)	Bend downstream of Laurel Ave. (6)	Grand Total
# Hauls	3	9	0	5	6	23
<i>O. mykiss</i>	3	502		1372	243	2120
Sacramento sucker				1	1	2
Topsmelt	1066	8663		956	37	10722
Threespine stickleback				2		2
Staghorn sculpin	1	15		1	2	19
Striped Bass	1					1
Shiner surfperch		91		1		92
<i>O. mykiss</i> CPUE	1.0	55.8		274.4	40.5	92.2

- There were two somewhat overlapping length modes in the size distribution (Figure 14), with *O. mykiss* less than about 110 mm FL more abundant upstream of Riverside Drive (Stations 5 and 6) and those greater than 110 mm FL more abundant in the lower lagoon (Stations 1-3) (Figure 15).
- The majority of the catch (75%) was characterized as parr or advanced parr and 23% were characterized as silvery parr or advanced silvery parr. Only 2% of the catch was characterized as smolt stage and one fish had an ocean/adult appearance.
- All *O. mykiss* examined (993) had an adipose fin, indicating they were not of hatchery origin.
- Twenty percent of *O. mykiss* examined had black-spot disease (BSD) lesions. Incidence of BSD has ranged between 11% and 68% in spring surveys since 2010.

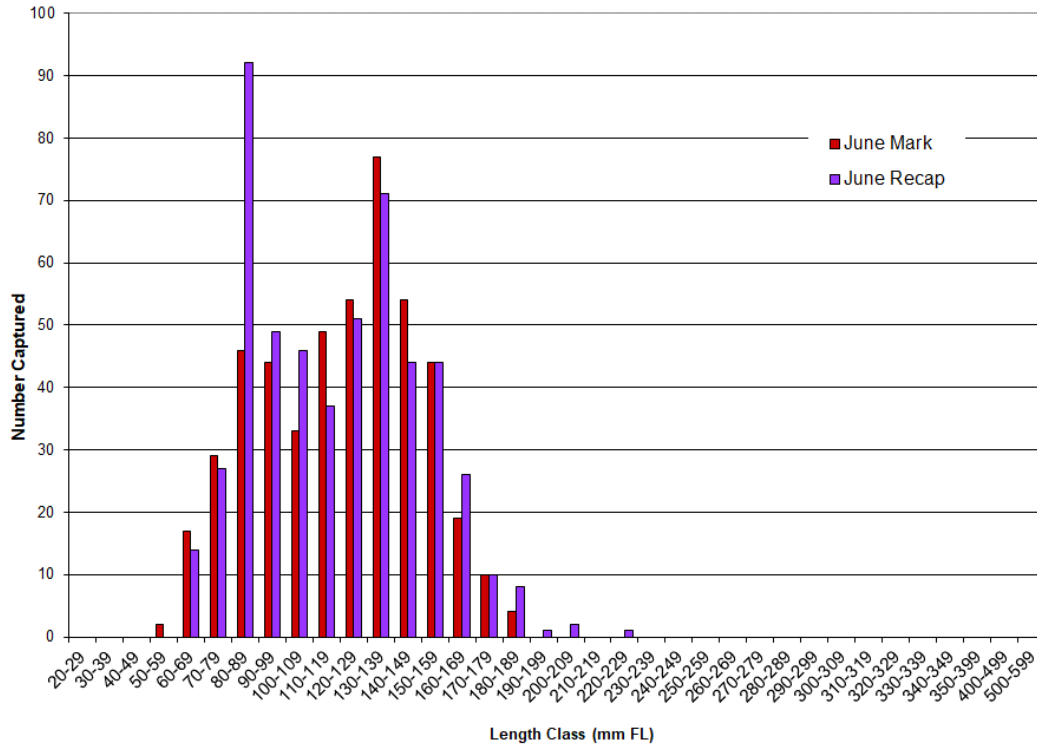


Figure 14. *O. mykiss* length classes in San Lorenzo Lagoon, June 2019

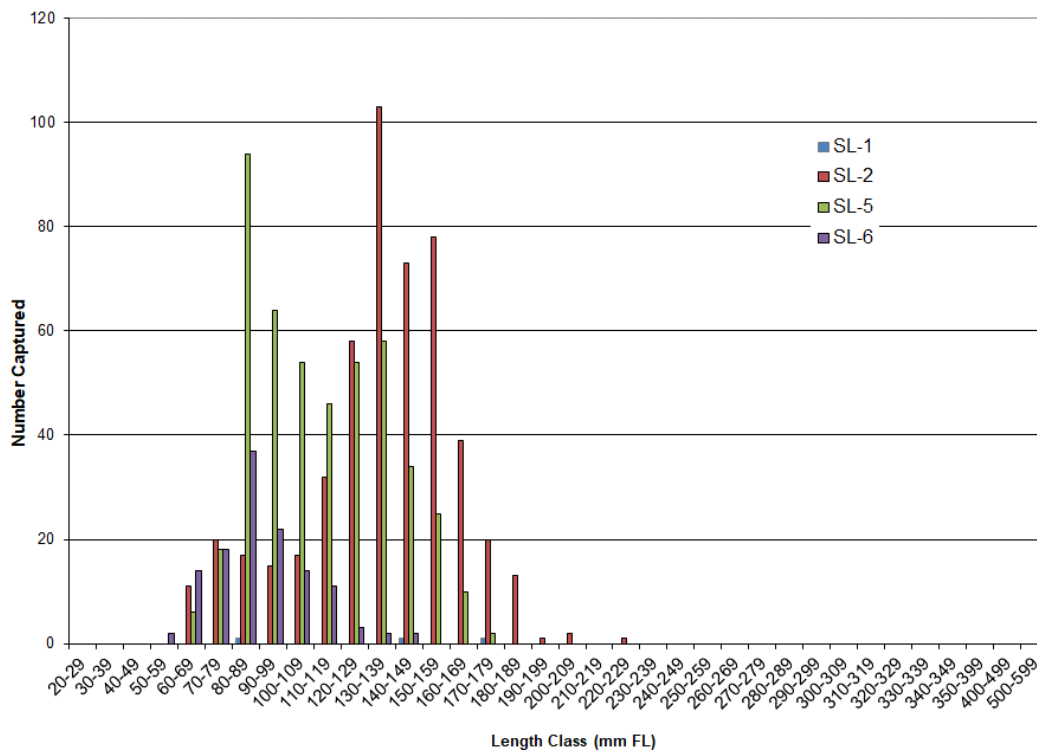


Figure 15. *O. mykiss* length classes in San Lorenzo Lagoon by Station, June 2019

Early summer *O. mykiss* Population Estimate

- The tag supplier (Biomark) recommends that body cavity tagging should only be done down to a length of 65 mm but due to previous experience with excessive mortality of fish less than 80mm, only fish 80 mm FL or larger were tagged. In addition, permits preclude tagging of adult steelhead. Given the presence of fast-growing juveniles in the lagoon, potential maturity and spawning of lagoon reared fish without ocean entry, and early return of small ocean fish, a length of 320mm FL (12.6 inches) was used to delineate adult fish.
- *O. mykiss* were so numerous in some hauls that individuals were removed from the net, counted, and released. During recapture periods, *O. mykiss* were scanned in place for tags before releasing.
- A total of 1250 *O. mykiss* was captured during the marking period (June 13-14). Of these 739 were released from the net due to overcrowding and were not processed. An additional 29 were recaptures of previously tagged fish. Of the 484 unmarked fish that were processed, 48 were smaller than the 80mm length for tagging. There were also 3 mortalities. There were 431 tagged *O. mykiss* released in the lagoon at the end of the mark period.
- A total of 870 *O. mykiss* was captured during the recapture period but only 547 were within the size range for tagging. Thirty of these had been tagged during the marking period.
- Lagoon population estimate using the Petersen method (Ricker 1975) is 7,637 *O. mykiss* within the taggable size class in June. The 95% confidence limits for this estimate are 5,401 and 10,757. This is more than double the previous high population estimate for June made in 2017.
- If taggable fish (80 mm FL or greater) were 62.9% of the total catch (547/870), then the total population estimate including fish too small to tag would be $7,637/0.629$ or 12,141 and the population of fish less than 80 mm FL would be 4,504.
- CPUE was 104 per haul during the mark period and 79 per haul during the recapture period (difference not statistically different, two sample t-test, $p \approx 0.7$).
- The size class proportions in the population were similar during the mark and recapture periods with the exception of a larger number in the 80-89 mm FL class during the recapture period (Figure 14).

July Survey (July 16-17)

The July survey was a two-day relative abundance survey without mark-recapture population estimate. Sampling was conducted at standard sampling Stations 1 and 2, downstream and around the trestle; and Stations 5 and 6 upstream of Riverside Bridge. Station 3 was not sampled due to the high number of fish captured and extended processing time at Station 2. The water temperatures were at a suitable range for juvenile *O. mykiss* and captured fish were tagged.

July Site Conditions

- The lagoon was open at the time of sampling and had not yet been closed during 2019 (Figure 11). Inflow from the San Lorenzo River remained around 33.7 cfs during the sample period, dropping briefly to 31.2 cfs between sampling days (Figure 11).
- The lagoon stage was tidally influenced and ranged between -0.2 and 4.7 feet during the survey period (City of Santa Cruz data). The seine hauls were finished on the beach by the mouth and trestle. However above Riverside Bridge the hauls were finished against the levee banks as the lagoon was beginning to fill.
- Lagoon salinity was tidally influenced near the mouth as shown by high salinity throughout the water column at high tide (Figure 16, center panel). However, river flow was sufficient to form a fresher layer at the surface at upstream locations and when tide was not high. There was an observable halocline at 0.4 meters with salinity increasing gradually to 32 ppt at 1.6 to 1.8 meters depth.
- Water temperature was cool and generally well mixed (Figure 16, left panel). The coolest temperatures were near the mouth during morning just before high tide, reflecting the influx of cold seawater. The highest temperatures were also near the mouth, but during ebb tide in the afternoon and were likely influenced by riverine inflows with diurnal warming. The maximum temperature recorded was 22.4°C at the surface which is still within a suitable range for juvenile *O. mykiss* if abundant food is available. Temperature generally ranged from 16° C to 20° C, with the most fluctuations between 0.4 and 0.8 meters.
- Dissolved oxygen was generally at 7 mg/L or higher throughout the water column but levels were below 5 mg/L and dropped to 1.5 mg/L in deeper water near the mouth just after low tide in the early morning. This may have been influenced by nocturnal dissolved oxygen depletion in the mixing zone (Figure 16, right panel).
- Water clarity was high with secchi disk visible at or near the substrate at all stations (up to 1.9 meters deep).

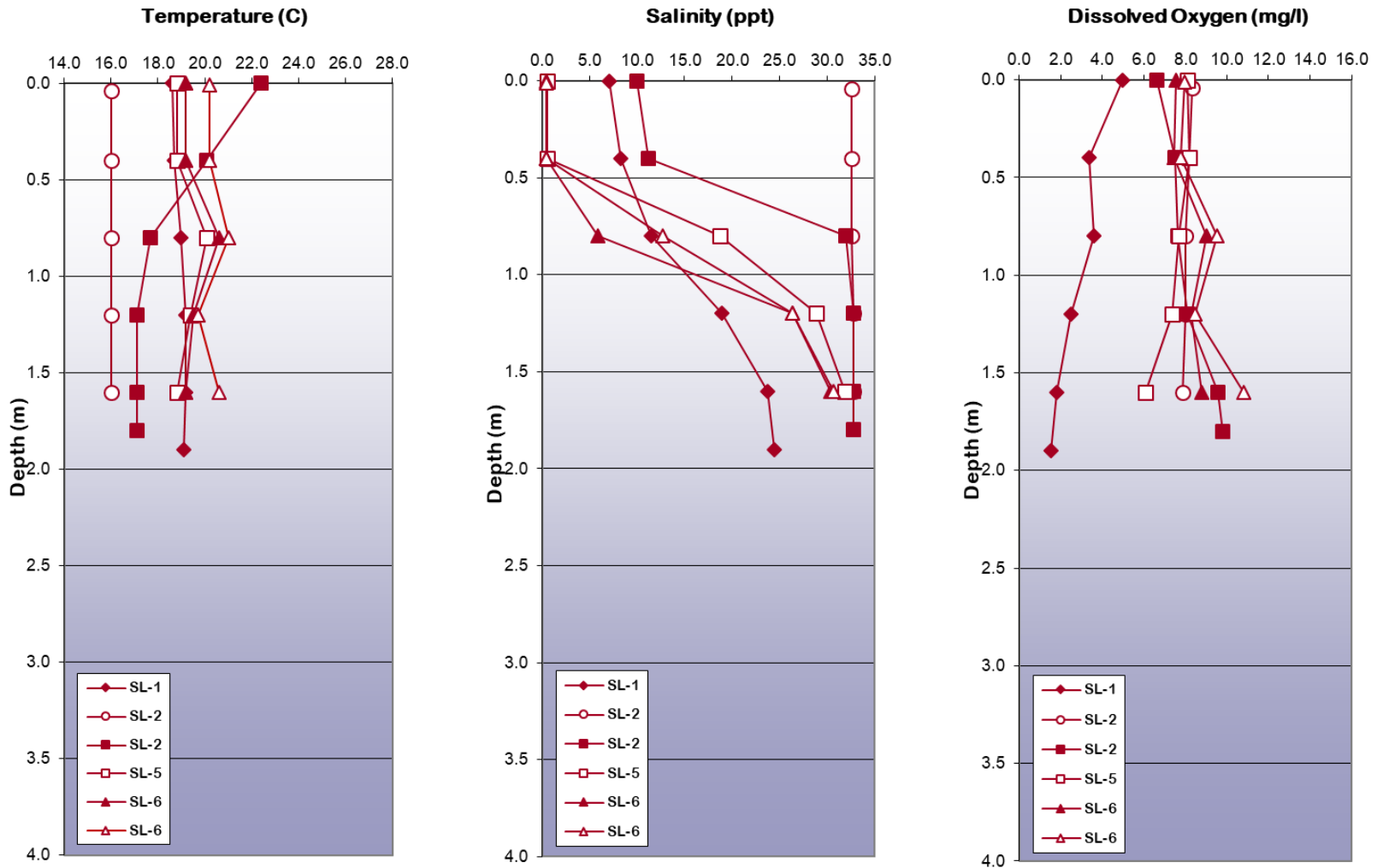


Figure 16. Depth profiles of water quality parameters in the San Lorenzo Lagoon during July Survey (July 16-17)

July Survey Results

- Nine seine hauls were completed between the beach and the water quality buoy and upstream of Riverside Bridge (Table 9).
- *O. mykiss* were the second most abundant fish caught (after topsmelt). CPUE was down about 40% from June levels (Table 6) (significant difference, ANOVA single factor, Tukey HSD, $\alpha < 0.01$).
- The size class distribution for *O. mykiss* shifted 20-30mm larger compared to June for the smaller mode of the distribution and 10-20mm larger for the larger mode (Figure 17), consistent with measured growth rates (Table 10).
- Thirty-three *O. mykiss* captured in July had been tagged in June. These fish grew at an average rate of 0.56 mm/day with a range from 0.14 mm/day to 1.06 mm/day (Table 10).

Table 9. Fish catch in San Lorenzo River Lagoon, July 2019

Species	South of Trestle (1)	Around Trestle (2)	Around Water Quality Station (3)	Upstream of Riverside Bridge (5)	Bend downstream of Laurel Ave. (6)	Grand Total
# Hauls	1	3		2	3	9
<i>O. mykiss</i>	10	287		118	66	481
Pacific herring	28	10				38
Sacramento sucker					1	1
Topsmelt	121	1634		272	108	2135
Prickly sculpin		1				1
Shiner surfperch		1		1		2
<i>O. mykiss</i> CPUE	10.0	95.7		59.0	22.0	53.4

- The majority of the catch (52%) was characterized as parr or advanced parr and 47% were characterized as silvery parr or advanced silvery parr. One fish out of 434 examined was characterized as a smolt and 2 had the external appearance of adults. One adult was 635 mm FL (25 inches) and the other was 432 mm (17 inches). Both were thin.
- All *O. mykiss* examined (434) had an adipose fin, indicating they were not of hatchery origin.
- Thirteen percent of *O. mykiss* examined had black-spot disease (BSD) lesions. Incidence of BSD has ranged between 8% and 72% in annual surveys since 2009.

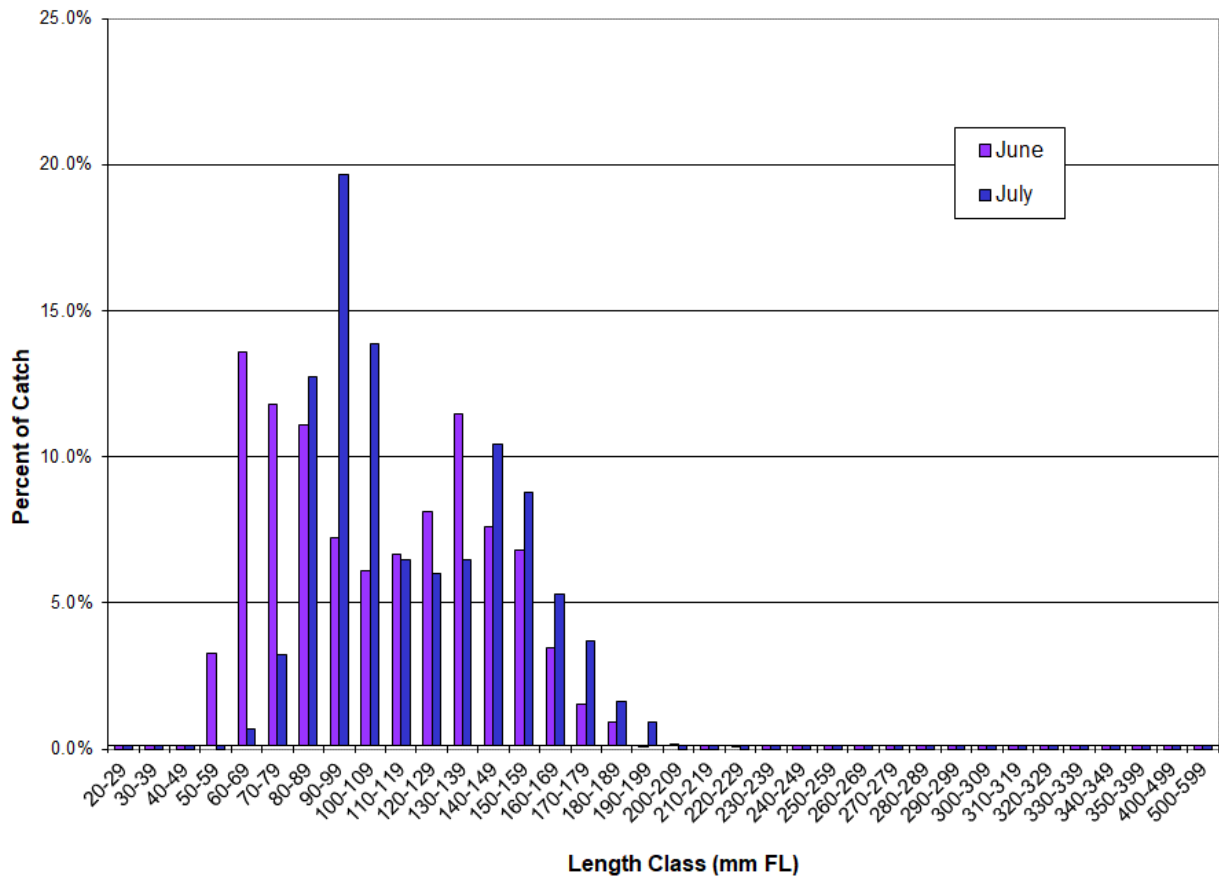


Figure 17. *O. mykiss* length classes in San Lorenzo Lagoon during June and July 2019

Table 10. *O. mykiss* tagged in June and recaptured in July 2019

Previous Capture Date	Recapture Date	Initial Length (mm)	Length at Recapture (mm)	Growth Rate (mm/day)
18-Jun-19	16-Jul-19	88	109	0.75
13-Jun-19	16-Jul-19	93	112	0.58
14-Jun-19	16-Jul-19	102	129	0.84
18-Jun-19	17-Jul-19	104	128	0.83
18-Jun-19	17-Jul-19	109	128	0.66
18-Jun-19	16-Jul-19	113	127	0.50
14-Jun-19	17-Jul-19	117	152	1.06
14-Jun-19	17-Jul-19	120	140	0.61
13-Jun-19	16-Jul-19	120	139	0.58
17-Jun-19	16-Jul-19	120	136	0.55
14-Jun-19	16-Jul-19	122	140	0.56
14-Jun-19	16-Jul-19	124	151	0.84
14-Jun-19	17-Jul-19	125	151	0.79
17-Jun-19	16-Jul-19	128	145	0.59
17-Jun-19	16-Jul-19	128	143	0.52
17-Jun-19	16-Jul-19	131	142	0.38
17-Jun-19	16-Jul-19	132	146	0.48
14-Jun-19	17-Jul-19	137	154	0.52
17-Jun-19	17-Jul-19	138	158	0.67
14-Jun-19	17-Jul-19	139	161	0.67
17-Jun-19	16-Jul-19	139	152	0.45
13-Jun-19	16-Jul-19	141	155	0.42
17-Jun-19	16-Jul-19	142	157	0.52
17-Jun-19	16-Jul-19	143	151	0.28
17-Jun-19	16-Jul-19	145	154	0.31
14-Jun-19	16-Jul-19	145	171	0.81
17-Jun-19	16-Jul-19	146	157	0.38
17-Jun-19	16-Jul-19	150	164	0.48
17-Jun-19	16-Jul-19	154	163	0.31
14-Jun-19	16-Jul-19	156	175	0.59
14-Jun-19	16-Jul-19	157	164	0.22
17-Jun-19	16-Jul-19	173	177	0.14
13-Jun-19	16-Jul-19	180	201	0.64

August Survey (August 13-14)

The August survey, as in July, was a two-day relative abundance survey without mark-recapture population estimation. Sampling was conducted at standard sampling stations from downstream of the trestle and up to the WQ Station (Stations 1 and 2) and Station 5 upstream of Riverside Bridge. Station 3 and Station 6 were not sampled due to a large number of captures and extended processing time at Stations 2 and 5. Temperature conditions were moderate and allowed for PIT tagging for later growth assessment.

August Site Conditions

- The lagoon was open and had closed only briefly (on August 7-9) since fall of 2018. Stage was low, between 0.1 and 1.8 feet during the survey period (City of Santa Cruz data). Inflow from the San Lorenzo River dropped from 32 cfs during the first day of sampling down to 18.6 cfs during the second day (Figure 11). The seine hauls were finished on the beach by the mouth and trestle. Above Riverside Bridge the lagoon was very shallow and hauls were finished on the sandy areas immediately adjacent to the water.
- Lagoon salinity was tidally influenced near the mouth as shown by high salinity throughout the water column on a flood tide and a halocline at 0.4 meters. Directly upstream of the Riverside Bridge, the lagoon was very shallow (0.4 meters) and was almost fresh at low tide. At deeper locations, there was an observable halocline at 0.4 meters with salinity increasing gradually to 24 ppt at 1.7 meters depth. (Figure 18, center panel).
- Water temperature was cool and well mixed near the mouth during the cooler morning hours with incoming tide but temperature stratification was observed as air temperatures increased and the tide began to ebb later in the day (Figure 18, left panel). Surface temperature increased to 20.3°C with the bottom temperature remaining cool at 16.7°C just after noon on the 13th. Upstream of Riverside Bridge, water temperature ranged from 17.9°C to 19.8°C, with the maximum temperature at the halocline. Water temperatures were still within the suitable range for juvenile *O. mykiss*.
- Dissolved oxygen levels were low in the morning at both SL-1 and SL-5 when tide levels were low and nocturnal dissolved oxygen depletion had not fully recovered (Figure 18, right panel). Levels ranged as low as 2.76 mg/L at 1.6 meters depth at SL-1 and 5.92 at SL-5. Increasing dissolved oxygen levels appeared to coincide with a flooding tide and increasing photosynthesis through the morning.
- Water clarity was high with secchi disk visible at or near the substrate at all stations (up to 1.7 meters deep at Station SL-6).

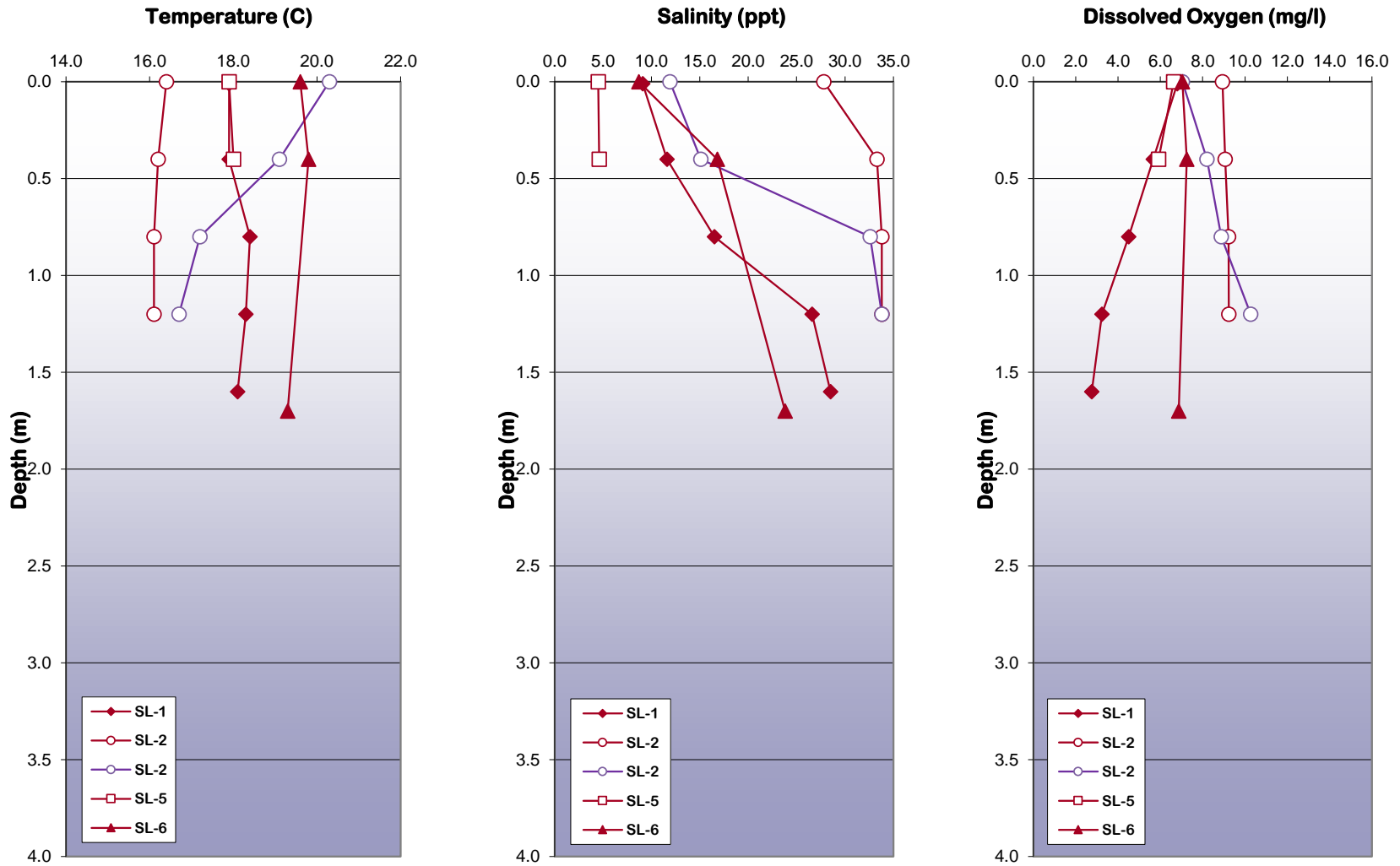


Figure 18. Depth profiles of water quality parameters in the San Lorenzo Lagoon during August Survey

August Survey Results

- Seven seine hauls were completed between the beach and the water quality buoy and upstream of Riverside Bridge (Table 11). Station 3 and Station 6 were not sampled due to large catches and extended processing times at Stations 2 and 5.
- Steelhead CPUE was five times July levels (significant difference, ANOVA single factor, Tukey HSD, $\alpha < 0.01$) and triple June levels (significant difference, ANOVA single factor, Tukey HSD, $\alpha < 0.01$) (Table 6).
- Topsmelt dominated the catch and were at similar abundance as in July (Table 11, Table 9). Young-of-year Sacramento sucker were the third most abundant species but were only found upstream of Riverside Bridge.

Table 11. Fish catch in San Lorenzo River Lagoon, August 2019

Species	South of Trestle (1)	Around Trestle (2)	Around Water Quality Station (3)	Upstream of Riverside Bridge (5)	Bend Downstream of Laurel Ave. (6)	Grand Total
# Hauls	3	2		2		7
<i>O. mykiss</i>	149	880		915		1944
Sacramento sucker				309		309
Topsmelt	762	1505		418		2685
Threespine stickleback				68		68
Staghorn sculpin		1		2		3
<i>O. mykiss</i> CPUE	49.7	440.0		457.5		277.7

- The mode of smaller size *O. mykiss* shifted to larger sizes from July, the mode of larger individuals became less distinct (Figure 19).
- Fifty-nine *O. mykiss* captured in August had been tagged in June. Eight of these had also been captured in July. The 59 fish grew at an average rate of 0.47mm/day between June and August (Table 12). An additional 57 *O. mykiss* captured in August had been tagged in July. These grew at an average rate of 0.45 mm/day. Growth rate for tagged fish between July and August was lower than growth rates between June and July (0.56 mm/day) (significant difference, ANOVA single factor, Tukey HSD, $\alpha < 0.05$).
- The majority of the catch (62%) was characterized as silvery parr or advanced silvery parr and 38% were characterized as parr or advanced parr. Two larger individuals (207 mm FL and 296 mm FL) were characterized as ocean/adult.
- All *O. mykiss* examined (488) had an adipose fin, indicating they were not of hatchery origin.
- Twenty-nine percent of *O. mykiss* examined had black-spot disease (BSD) lesions. Incidence of BSD has ranged between 8% and 72% in annual surveys since 2009.

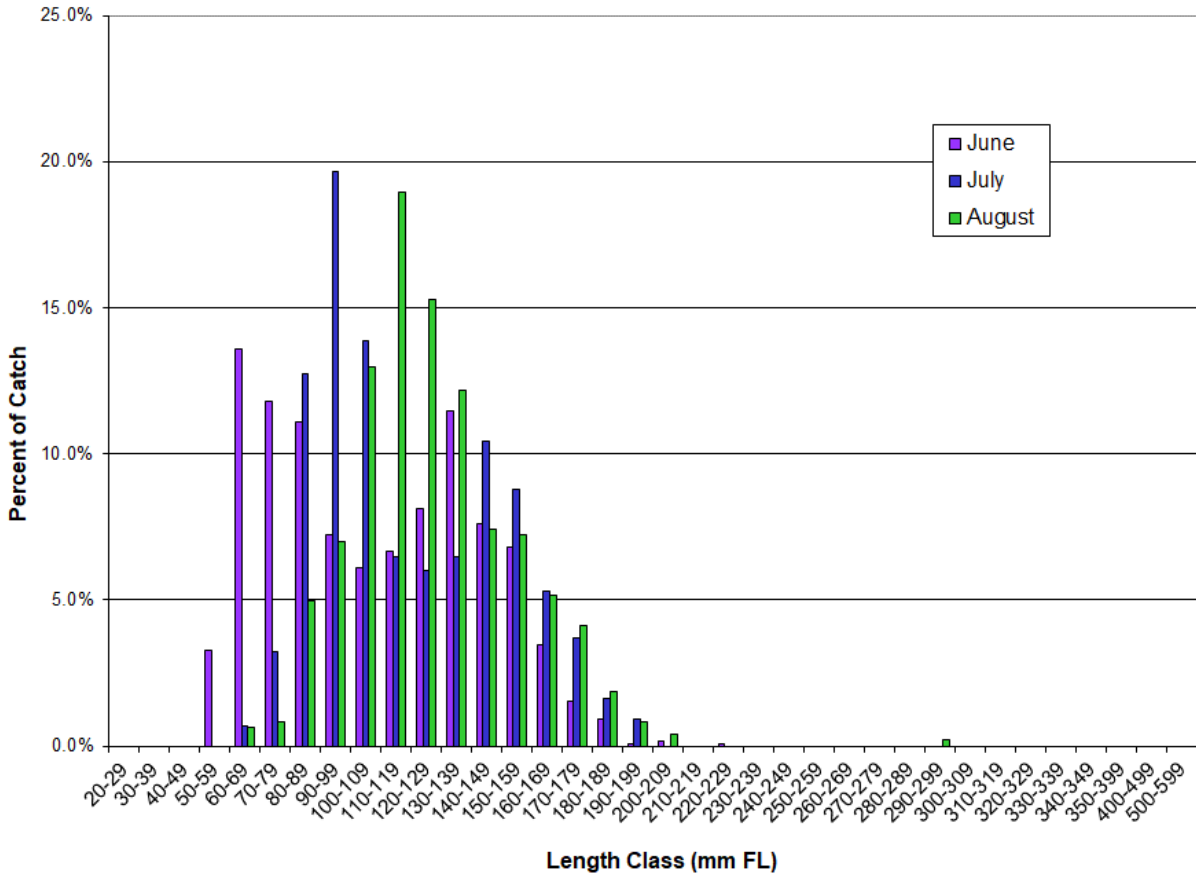


Figure 19. *O. mykiss* length classes in San Lorenzo Lagoon during June, July, and August 2019

Table 12. *O. mykiss* tagged previously and recaptured in August 2019

Tag Date	Previous Capture Date	Recapture Date	Number	Average Growth Rate (mm/day)	Growth Rate Range (mm/day)
June	June	July	33	0.56	0.14-1.06
June	June	August	51	0.47	0.04-1.05
June	July	August	8	0.43	0.07-0.68
July	July	August	57	0.45	0.04-0.89

Late summer (September 19-20, 23-24)

The September survey was a full survey with population estimate. *O. mykiss* were marked on September 19-20 and recaptured on September 23-24. Sampling was conducted at each of the regularly sampled Stations (1, 2, 3, 5, and 6).

Late summer Site Conditions

- The lagoon was breached two days prior to the fall sampling. (Figure 11). Closure had occurred on September 8. It was manually opened by the City on September 17 with an emergency breach action. The lagoon closed again at the beginning of the recapture period on September 23 (Figure 11). Lagoon stage was relatively low during the marking period (0.6 to 2.7 feet at the trestle gage) but increased during the recapture period (3.4 to 4.5 feet at the trestle gage).
- Salinity was stratified throughout the lagoon during the sampling events, with a halocline between 0.4 and 0.8 meters and salinities up to 29.1 ppt at depth (1.6 meters). Higher salinities occurred near the mouth and earlier in the survey period. Salinity increased from 25 ppt to close to seawater at depths of 0.8 meters (2.6 feet) near the mouth and depth of 1.2 to 1.6 meters upstream above Riverside Bridge (Figure 20, center panel).
- Temperature was variable, depending on tidal influx and air temperature and did not exhibit great differences between surface and depth (Figure 20, left panel). The highest temperature (20.8°C) was recorded upstream across the skate park during an afternoon when the air temperature was 23°C. This elevated water temperature was still within the suitable range for juvenile *O. mykiss*.
- Dissolved oxygen profiles taken during seining show the influence of tides and possibly the effect of the lagoon opening (Figure 20, right panel). On the first day of sampling on the morning of September 19 dissolved oxygen levels were low, ranging from 5.35 mg/L to 6.07 mg/L near the mouth on a low tide, yet increasing to 12.45 mg/L later in the afternoon as the tide approached high. On the second sampling day, six days after the breach, dissolved oxygen levels near the mouth improved, ranging from 7.0 mg/L to over 11 mg/L at 2.4 meters and below. At the stations upstream of the Riverside Bridge dissolved oxygen levels were adequate at the surface but below 0.4 meters were generally below 5.0 mg/L during the marking period, but improved during the recapture period.
- Temperature was in a suitable range for *O. mykiss* in lagoons. Dissolved oxygen was below suitable levels at a depth of 0.4 meters or greater during the marking period except at SL-2 (at the trestle bridge).
- The water column was clear with secchi disk visible near the bottom down to 2.8 meters (9.2 feet) depth.

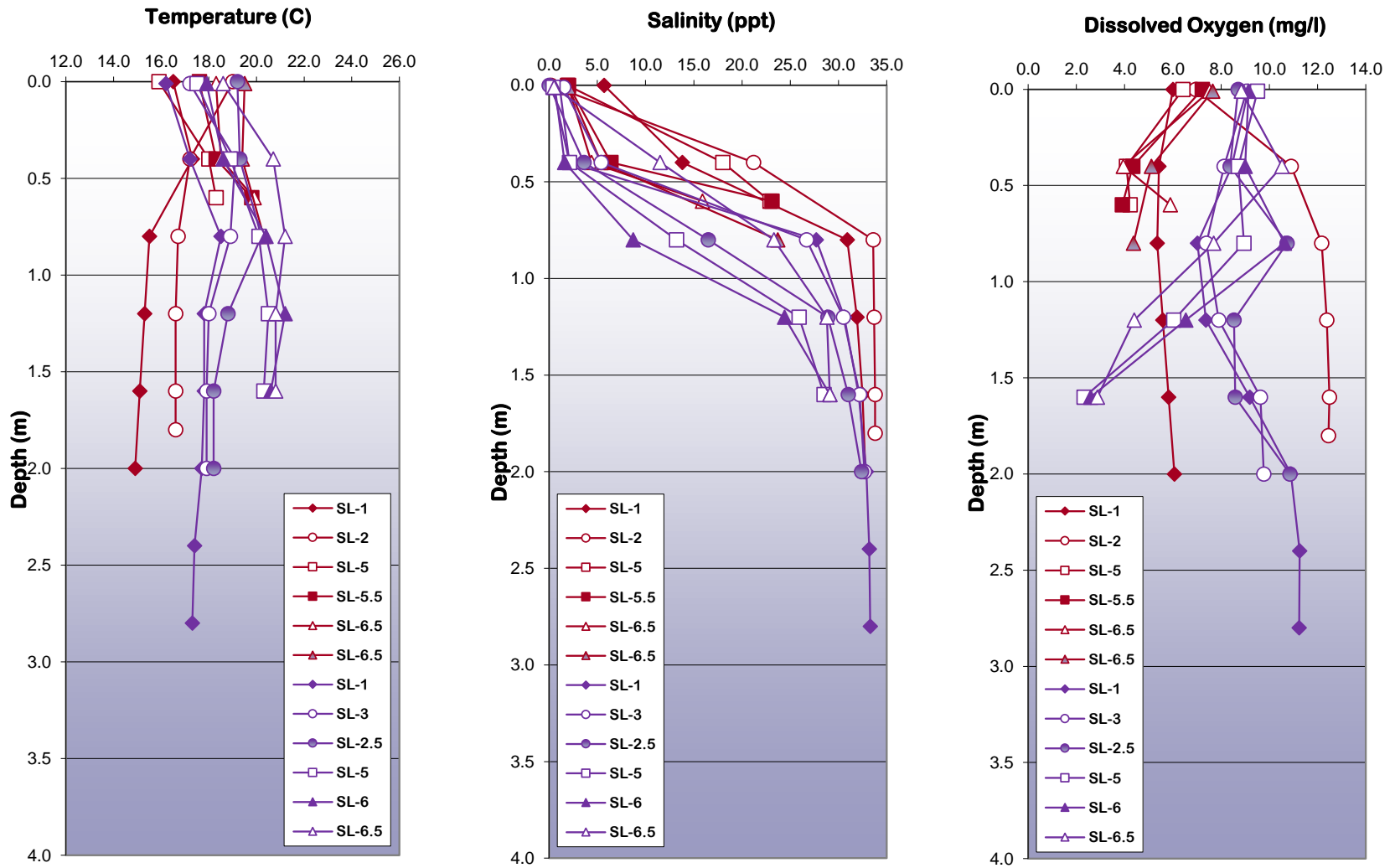


Figure 20. Depth profiles of water quality parameters in the San Lorenzo Lagoon during survey on September 19-24
Profiles plotted in red are September 19-20; profiles in blue are September 23-24

Late summer Survey Results

- Nineteen seine hauls were completed at regularly sampled Stations (1, 2, 3, 5, and 6).
- *O. mykiss* were so numerous in some hauls that individuals were removed from the net, counted, and released. Fish were scanned in place for tags before releasing.
- CPUE for *O. mykiss* was nearly the same as in August, more than twice the June levels and four times the July levels (Table 6). CPUE for topsmelt was comparable to *O. mykiss* (Table 13). Pink salmon were observed for the first time (Figure 21).

Table 13. Fish catch in San Lorenzo River Lagoon, September 2019

Species	South of Trestle (1)	Around Trestle (2)	Around Water Quality Station (3)	Upstream of Riverside Bridge (5)	Bend Downstream of Laurel Ave. (6)	Grand Total
<i># Hauls</i>	5	5	1	3	5	19
<i>O. mykiss</i>	36	2545	35	1387	333	4336
Pink salmon	2					2
Topsmelt	520	2926	85	662	272	4465
Threespine stickleback		12	1		53	66
Staghorn sculpin	1					1
Shiner surfperch		1				1
<i>O. mykiss CPUE</i>	7.2	509.0	35.0	462.3	66.6	228.2



Figure 21. Pink salmon (*O. gorbuscha*) captured in San Lorenzo Lagoon in September 2019 (note sea lice above anal fin).

- The peak in the *O. mykiss* size distribution had shifted about 20 mm larger from August, (Figure 22).

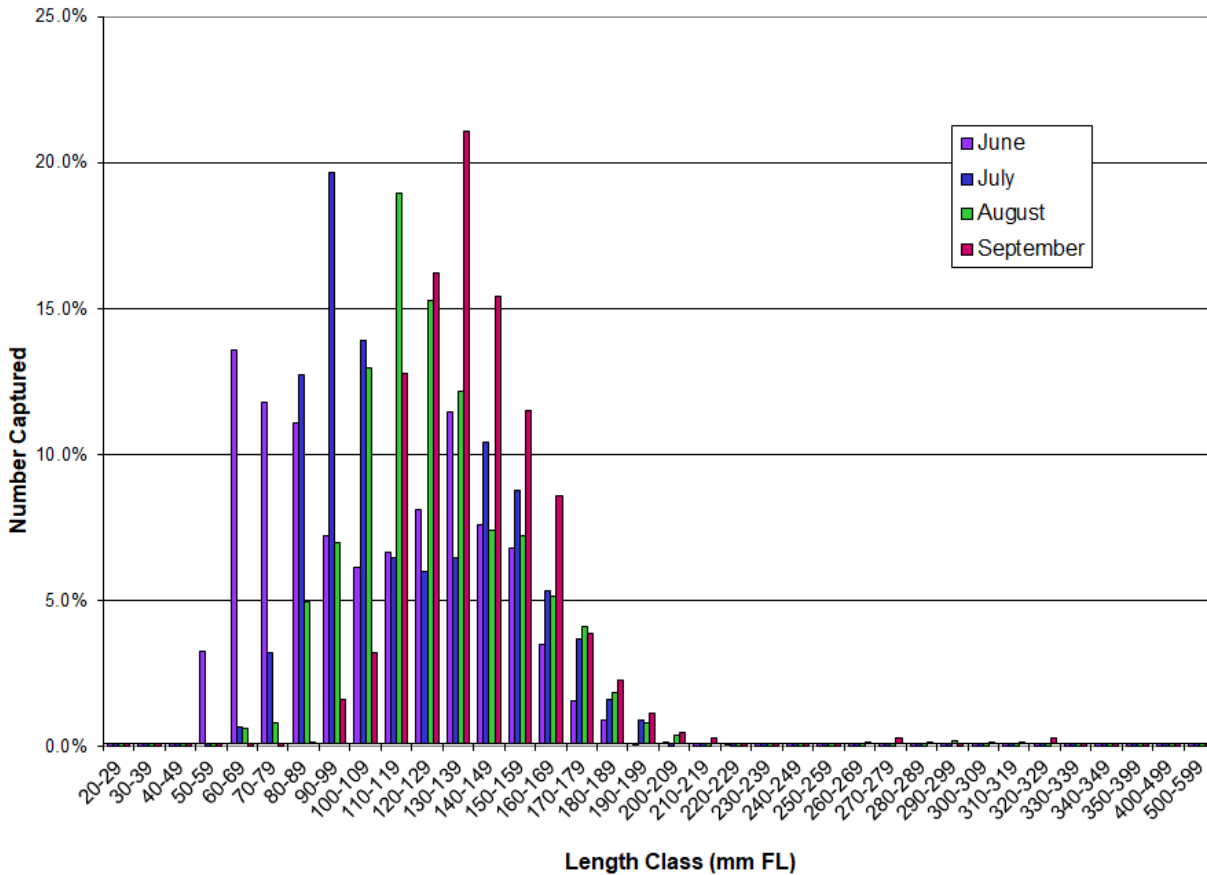


Figure 22. *O. mykiss* length classes in San Lorenzo Lagoon during different sample periods in 2019

- A large number of *O. mykiss* captured in September had been tagged earlier in the summer, 88 in June, 69 in July, and 85 in August. Growth rates were variable between individuals but the average was consistent at 0.36 to 0.38 mm/day (Table 14). Growth rate was similar to 2017 when lagoon conditions were also similar (high runoff year with mostly open lagoon) (Table 15). Growth rates were lower than 2012 and 2016 (ANOVA single factor, Tukey HSD, $\alpha < 0.01$), and also lower than 2017 (ANOVA single factor, Tukey HSD, $\alpha < 0.05$) (Table 15). Growth rates were not significantly different from 2013 or 2018 (ANOVA single factor, Tukey HSD, $\alpha > 0.05$). As in 2017, there may have been density dependent growth effects in 2019 due to the unusually large numbers of *O. mykiss* present.

Table 14. *O. mykiss* tagged previously and recaptured in September 2019

Tag Date	Recapture Date	Number	Average Growth Rate (mm/day)	Growth Rate Range (mm/day)
June	July	33	0.56	0.14-1.06
July	August	57	0.45	0.04-0.89
June	September	88	0.38	0.03-0.85
July	September	69	0.38	0.04-0.80
August	September	85	0.36	0.00-0.75

Table 15. *O. mykiss* Growth Rates for Years Available

Year	N	Average June-Sept Growth (mm/day)	Range June-Sept Growth (mm/day)	September CPUE
2012	4	0.72	0.58-0.84	14.4
2013	2	0.34	0.27-0.41	4.7
2014	None captured			
2015	None captured			
2016	21	0.90	0.45-1.14	7.8
2017	40	0.46	0.02-0.86	328
2018	10	0.39	0.26-0.49	6.3
2019	88	0.38	0.03-0.85	216

- Forty-two percent of the catch was characterized as parr, 57% as silvery parr, and 1% as adult/ocean. All of the 8 fish 250 mm FL or larger were characterized as ocean/adult.
- Six-hundred and eighteen of 619 *O. mykiss* examined had an adipose fin, indicating they were not of hatchery origin. One *O. mykiss*, a 166 mm FL silvery parr, appeared to have a clipped adipose fin.
- Seventeen percent of 618 *O. mykiss* examined had black-spot disease (BSD) lesions. The majority (92%) of black spot infestations were characterized as light. Incidence of BSD has ranged between 8% and 72% in annual surveys since 2009.
- Three fish had sea lice (Figure 23). All were over 300 mm FL and were characterized as ocean/adult in appearance.



Figure 23. Sea lice on 327 mm FL ocean/adult *O. mykiss* captured in San Lorenzo Lagoon in September 2019.

Fall *O. mykiss* Population Estimate

- Three-thousand one-hundred and seventy-three *O. mykiss* were captured during the mark period (September 19 and 20). Of these 2,519 were released from the net due to overcrowding and were not processed. An additional 37 were recaptures of fish tagged during the mark period. That left a total of 617 tagged *O. mykiss* released in the lagoon by the end of the mark period including 449 fish first tagged during the mark period and 168 fish previously tagged in June, July, or August.
- One-thousand one-hundred and sixty-three *O. mykiss* were captured during the recapture period. All were above the minimum tagging size of 90 mm FL or greater and none were more than the upper tagging threshold of 320 mm FL. Fifty of the 1163 eligible captures had been tagged during the marking period.
- The population estimate using the Petersen method (Ricker 1975) is 14,105 *O. mykiss* in the lagoon at the end of September. The 95% confidence limits for this estimate are 10,750 and 18,482. This is the largest estimate for the *O. mykiss* population in the lagoon. The previous highest fall population estimate was >3,636 in 2017. The fall estimate was nearly double the June estimate of 7,637.
- There are indications that the population was not closed during the sample period, in violation of a key assumption of the Petersen method. Overall CPUE was markedly lower during the recapture period (97 vs. 453 during the marking period) a statistically significant difference (two sample t-test $p \approx 0.04$). The size distribution of captured *O. mykiss* was similar between the two periods although the few fish larger than 250 mm FL were not seen

during the recapture period. Water quality conditions improved slightly from the mark period to the recapture period but the mouth was also closing again and the lagoon stage was about 2 feet higher during the recapture period. Capture efficiency could have been lower with the higher stage or some fish may have been left the lagoon.

- Eighty-two *O. mykiss* captured in September were tagged in June. If recapture rates were the same for these fish as for the September marked fish (50/617 or 0.081), there would have been 1012 June tagged *O. mykiss* in the lagoon in September. However, there were only 818 *O. mykiss* tagged in June. This suggests that a high proportion of rearing *O. mykiss* remained in the lagoon all summer. Similarly, 55 fish captured in September had been tagged in July and an abundance estimate of 679 July tagged fish present exceeds the 392 tagged in July. And for the 72 August tagged fish captured in September the estimate would be 889 but the number tagged was only 405. The indication is that capture rates are higher for the previously tagged fish than the 0.081 value for fish tagged during the September marking period. Capture rates in the San Lorenzo Lagoon have ranged from 0.07 to 0.50 and average 0.17. Capture rates were 0.07, 0.08, and 0.09 in the spring of 2019, fall of 2018, and spring of 2018, respectively. Even using the average value of 0.17 suggests that a high number of *O. mykiss* remained in the lagoon in 2019 after they entered it.
- The relationship between population estimate and CPUE was updated with the 2019 data (Figure 24). Least squares regression gives a significant relationship ($P < .0000004$) with an r^2 value = 0.91.

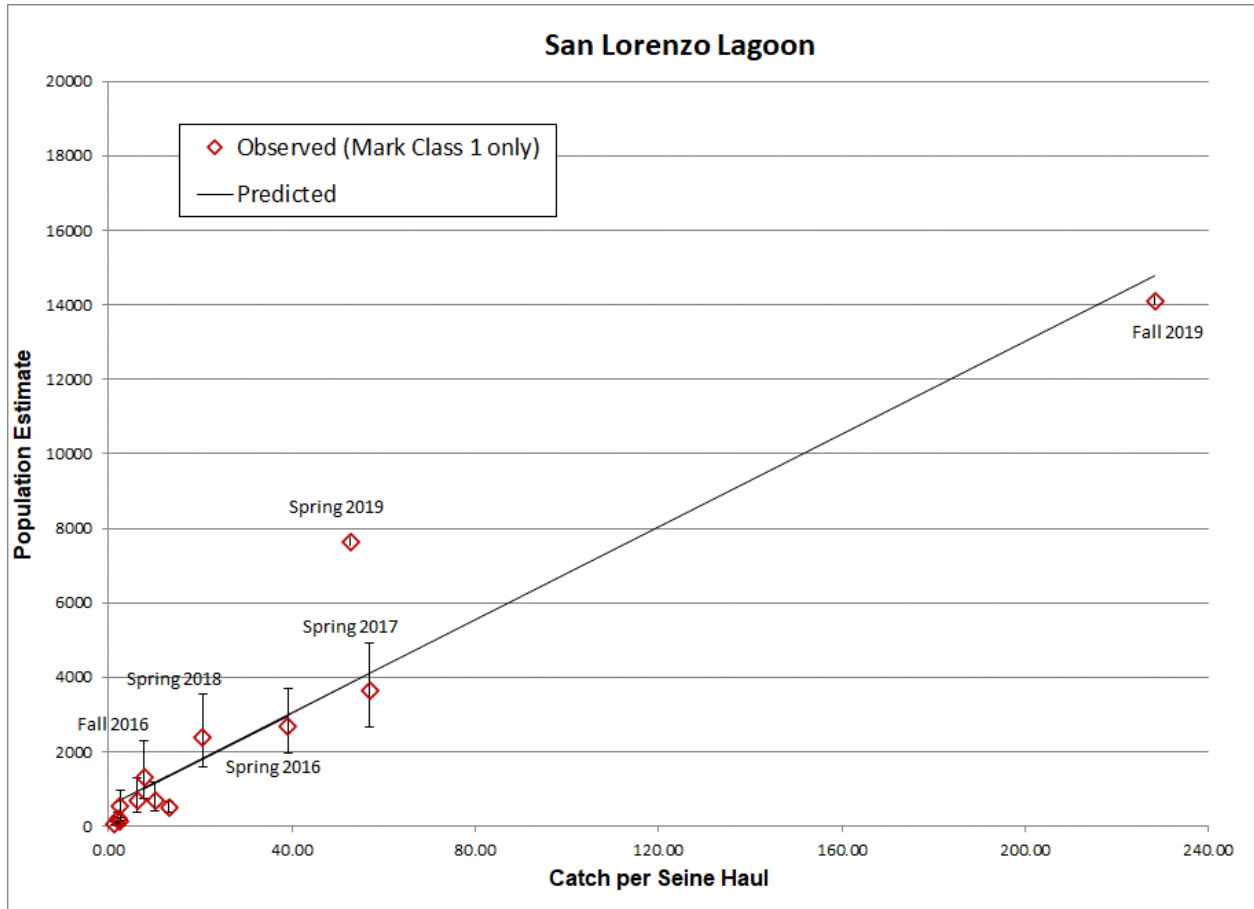


Figure 24. Relationship between *O. mykiss* population estimate and CPUE in the San Lorenzo River Lagoon²

² The Early Summer 2013 and Early Summer 2015 estimates are likely biased due to the small number of marked fish and small number of recaptures. Population estimates are not available for Late Summer 2013 and Early Summer 2014 due to low recapture rates and indications that the assumption of closed population was violated (2013) or lack of recaptures (2014). No *O. mykiss* were captured in Late Summer 2014 and Late Summer 2015 so CPUE was zero and populations were assumed to be near zero also. CPUE values adjusted to reflect portion of population in tagging size range only.

Felton PIT tag monitoring

- Recoveries of tagged *O. mykiss* at the NOAA PIT tag antenna array at Felton were not available for 2019 since NOAA personnel have not been able to conduct downloads due to restrictions on movement during the COVID-19 Pandemic.
- Between May 1, 2018 and May 1, 2019, the NOAA PIT tag antenna at Felton detected 82 *O. mykiss* tagged in the lagoon (J. Kiernen, NOAA Fisheries Santa Cruz, personal communication, May 6, 2019). Thirty-two of those fish had been tagged in previous years (2016 and 2017) (Table 16). Of the 50 tagged in 2018, 27 had been tagged in June, 1 in August, and 22 in September. Almost half the June tagged fish were first observed at Felton in July with one additional fish observed in August and the rest from November through March 2019 (Table 16).

Table 16. *O. mykiss* tagged in the San Lorenzo Lagoon and later observed at Felton

Date Tagged	Number Observed at Felton by Date									
	May 2018	July 2018	Aug 2018	Nov 2018	Dec 2018	Jan 2019	Feb 2019	Mar 2019	Apr 2019	Grand Total
June 2016	1				1	3	1	1		7
Sept 2016	1					3	1		1	6
June 2017	2			1	1		5	2	2	13
July 2017							1	2		3
Aug 2017								1		1
Sept 2017								1	1	2
June 2018		12	3	4	4	1	1	2		27
Aug 2018				1						1
Sept 2018				8	9	2	1	1	1	22

Appendix A

Table A-1. *O. mykiss* catch per haul for the San Lorenzo River Lagoon during sampling events (data from H.T. Harvey and Associates 2003, 2NDNATURE 2006, Ellen Freund (NOAA Fisheries), HES 2005, HES 2009, HES 2010, HES 2011, HES 2012, HES 2013, HES 2014, HES 2015, HES 2016, HES 2017, and HES 2018a)

Station	Location	<i>O. mykiss</i> Catch per Haul					
2002						Oct 1	Nov 20
SL-2	RR Trestle						0.0
SL-3	Near YSI Station					5.5	
SL-4	Below Riverside						
SL-5	Riverside Drive						9.0
SL-7	Laurel St.						1.0
SL-8	Soquel Ave.					20.0	0.3
2004			July 6		Sep 21	Sep 29	
SL-1	Near Mouth				0.0	0.0	
SL-2	RR Trestle		24.5			0.5	
SL-3	Near YSI Station		20.0				
SL-4	Below Riverside		0.0				
SL-5	Riverside Drive		62.0		0.0	0.0	
SL-6	U/S Bank Restoration		3.0			0.0	
SL-7	Laurel St.		3.0				
SL-8	Soquel Ave.				0.0	0.0	
2005		Jun 14	Jul 14	Aug 16		Oct 5	
SL-1	Near Mouth	0.0	0.0	1.7		0.0	
SL-2	RR Trestle	28.0	5.3	179.5		0.0	
SL-5	Riverside Drive	0.0	12.3	10.7		62.7	
SL-8	Soquel Ave.	7.7	1.0	0.0		0.0	
2008		Jun 8, 19				Oct 7-8	
SL-1	Near Mouth	0				0	
SL-2	RR Trestle	9				0.25	
SL-3	Near YSI Station	0				0	
SL-5	Riverside Drive	0				0	
SL-6	U/S Bank Restoration	0				0	
SL-8	Soquel Ave.	0				0	
	Overall	2.6				0.1	
2009		Jun 10-11			Sep 16	Oct 21	
SL-2	RR Trestle	0.75			1.0	0.25	
SL-3	Near YSI Station	0.25					
SL-5	Riverside Drive	0				0	
SL-6	U/S Bank Restoration	0				1.5	
	Overall	0.3			1.0	0.5	
2010		Jun 22-23	Jul 17			Oct 6-7	
SL-1	Near Mouth	0.0				0	
SL-2	RR Trestle	11.7	0.5			31.3	
SL-3	Near YSI Station		42.5			0	
SL-5	Riverside Drive	0.0				9.0	
SL-6	U/S Bank Restoration	6.0				80.0	
	Overall	7.7	21.5			28.25	
2011		Jun 9-14				Oct 13-18	
SL-2	RR Trestle	11.7				1.7	
SL-3	Near YSI Station	7.8				5.7	
SL-4	Near Marsh Outlet	16.0				1.0	
SL-5	Riverside Drive	48.5				2.2	
SL-6	U/S Bank Restoration	0.5				0.3	
	Overall	13				2.5	

Table A-1 (continued)

Station	Location	<i>O. mykiss</i> Catch per Haul					
2012		Jun 7-12			Sep 13-18		
SL-2	RR Trestle	5.2			21.3		
SL-3	Near YSI Station	0.8			17.5		
SL-4	Near Marsh Outlet	0					
SL-5	Riverside Drive	0			3.5		
SL-6	U/S Bank Restoration	0.1			5.0		
	Overall	1.7			14.4		
2013		Jun 6-11	July 17		Sep 12-17		
SL-1	South of Trestle	0.6			13		
SL-2	RR Trestle	0.8	2.2		1.6		
SL-3	Near YSI Station	6	24		1		
SL-4	Near Marsh Outlet	3			2		
SL-5	Riverside Drive	3			5.8		
SL-6	U/S Bank Restoration	0.3			6		
	Overall	2	8.4		4.7		
2014		Jun 5-10	July 17		Sep 11-15		
SL-1	South of Trestle	3.2	0		0		
SL-2	RR Trestle	0.9	3.5		0		
SL-3	Near YSI Station	1.0	0.5		0		
SL-5	Riverside Drive	0.5	0		0		
SL-6	U/S Bank Restoration	0.8	1		0		
SL-8	Water Street				1.1		
	Overall³	1.2	1.1		0.0		
2015		Jun 4-9	July 28-29	Aug 18-19		Oct 8-9	
SL-1	South of Trestle	0.8	0	0		0	
SL-2	RR Trestle	1.4	0	0		0	
SL-3	Near YSI Station	0.4	0	0		0	
SL-5	Riverside Drive	8.8	0	0		0	
SL-6	U/S Bank Restoration	2	0	0		0	
SL-10	Water Street	0					
	Overall³	2.6	0	0		0	
2016		Jun 9-14	July 13-14	Aug 16-17	Sept 22-27		
SL-1	South of Trestle	38.0	2.8	1.8	13.1		
SL-2	RR Trestle	138.5	0.5	2.8	4.4		
SL-3	Near YSI Station	2.0	1.0	0.3	17.0		
SL-4	Near Marsh Outlet		0.0				
SL-5	Riverside Drive	0.7	0.0	2.5	3.3		
SL-6	U/S Bank Restoration	22.0	0.0	2.4	8.0		
	Overall	39.7	1.0	2.0	7.8		
2017		Jun 15-20	July 11	Aug 15	Sept 21		
SL-1	South of Trestle	5.5	466.0	265.0	643.0		
SL-2	RR Trestle	100.9	424.0	279.0			
SL-5	Riverside Drive	566.7			13.0		
SL-6	U/S Bank Restoration	76.6			15.0		
	Overall	134.4	452.0	272.0	328.5		

³ Standard sites only (SL1-SL6)

Table A-1 (continued)

Station	Location	<i>O. mykiss</i> Catch per Haul					
		Jun 7-12	Jul 16-17	Aug 14-15	Sep 20-25		
2018							
SL-1	South of Trestle	12.8	5.3	8.5	8.8		
SL-2	RR Trestle	20.5	0.0	1.5	6.0		
SL-3	Near YSI Station	11.0	0.5	0.0	3.0		
SL-5	Riverside Drive	59.8	2.5	14.5	3.0		
SL-6	U/S Bank Restoration	14.8	2.8	5.3	7.3		
	Overall	23.3	2.5	6.4	6.3		
2019		Jun 13-18	Jul 16-17	Aug 13-14	Sep 19-24		
SL-1	South of Trestle	1.0	10.0	49.7	7.2		
SL-2	RR Trestle	55.8	95.7	440.0	509.0		
SL-3	Near YSI Station				35.0		
SL-5	Riverside Drive	274.4	59.0	457.5	462.3		
SL-6	U/S Bank Restoration	40.5	22.0		66.6		
	Overall	92.2	53.4	277.7	228.2		



Figure A-1. Laguna Creek Lagoon sampling stations

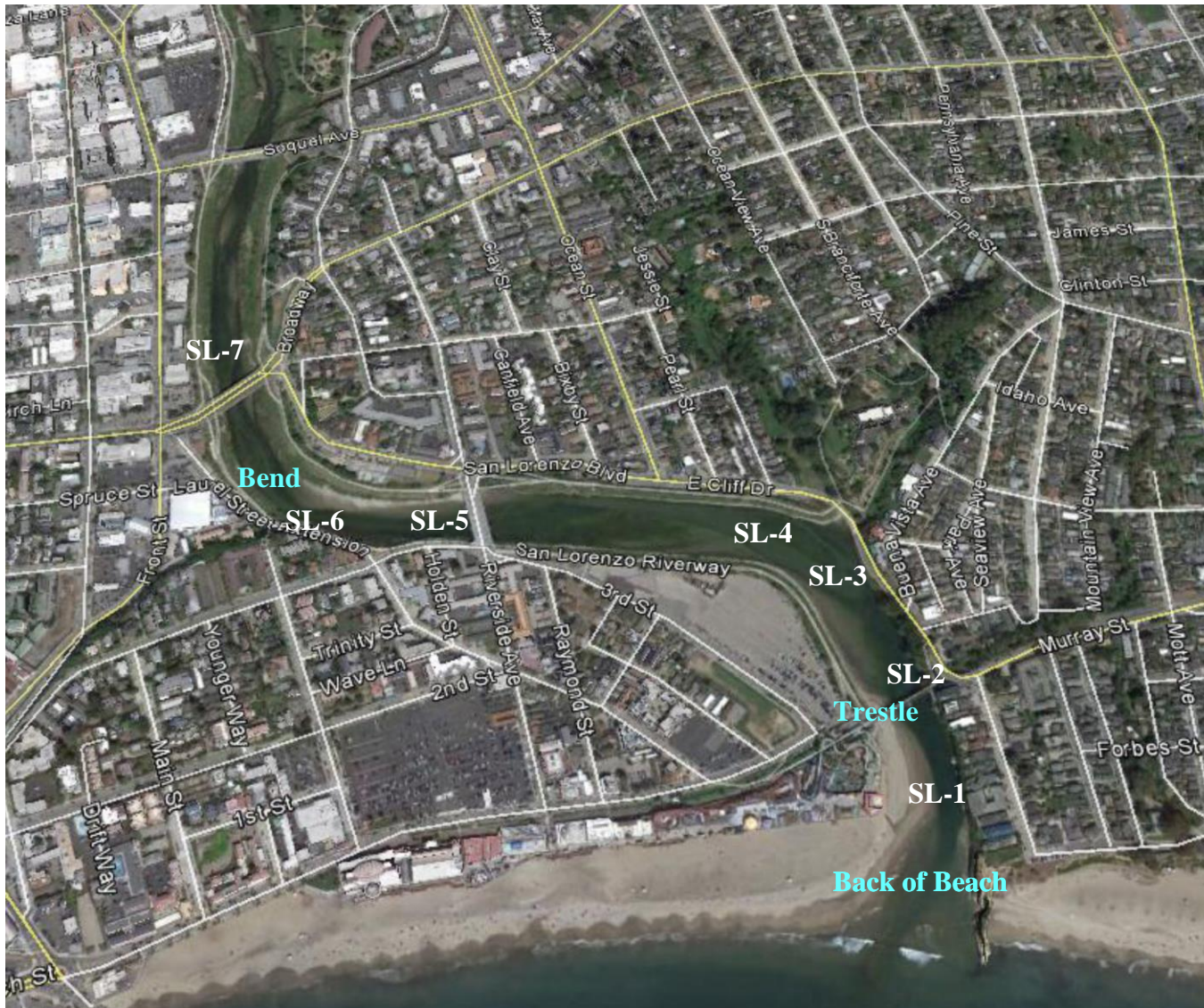


Figure A-2. San Lorenzo River Lagoon sampling stations

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