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## TECHNICAL MEMORANDUM

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**TO:** Chris Berry  
City of Santa Cruz Water Department

**FROM:** Jeff Hagar  
Hagar Environmental Science

**DATE:** June 22, 2021

**PROJECT:** City of Santa Cruz Habitat Conservation Plan, Lagoon Fish Population Sampling 2020

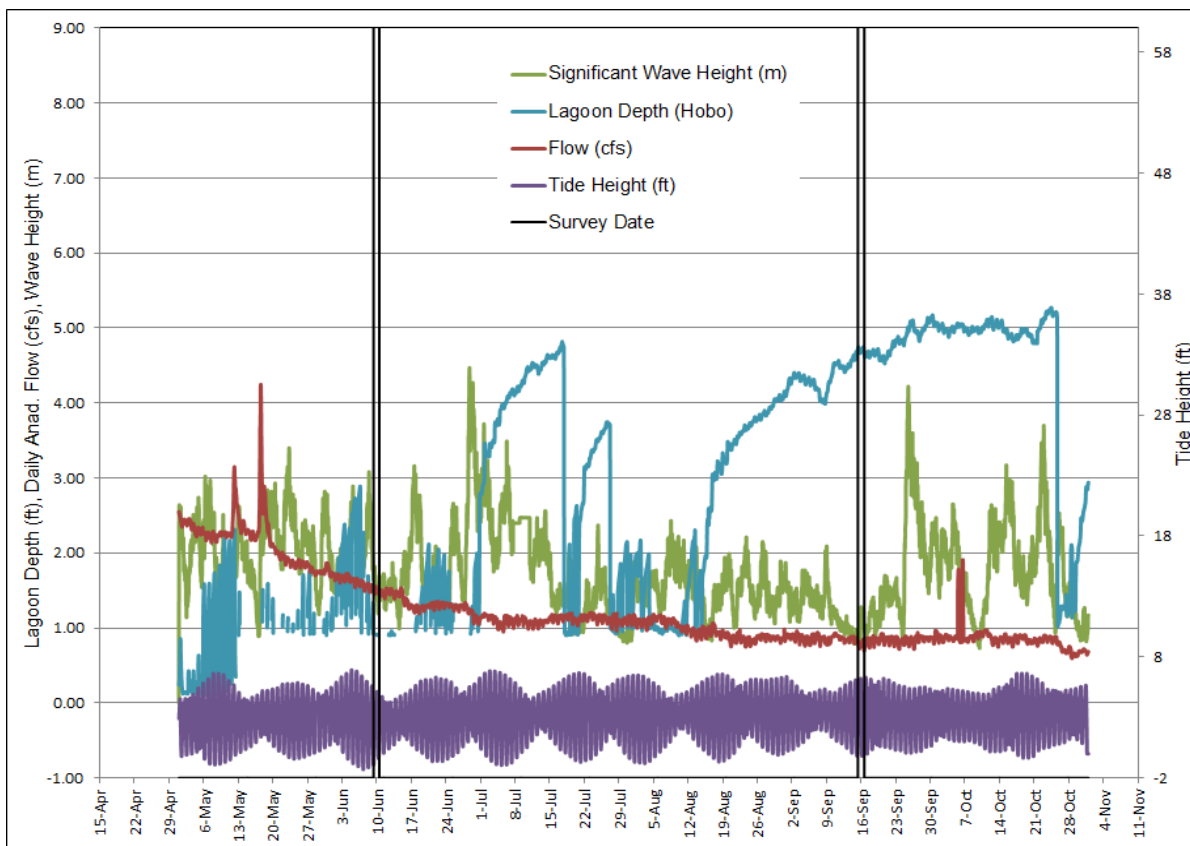
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Steelhead (*O. mykiss*) population abundance and life-history characteristics were assessed in Laguna Creek Lagoon and the San Lorenzo River Lagoon during the summer of 2020 by the City of Santa Cruz Water Department and Hagar Environmental Science (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. Planned surveys for August were not completed due to excessive temperature in the lagoon. PIT tagging was greatly reduced in July due to warm temperatures.

# Laguna Creek

## Summary

Runoff in 2020 was classified as a dry water year (based on USGS San Lorenzo River at Big Trees gage and City of Santa Cruz water year type classification) but total annual flow was only slightly in excess of the critically dry classification (33,302 acre-feet runoff for WY 2020 with the cutoff at 29,000 acre-feet). Flows in Laguna Creek were relatively low in May with a small storm peak occurring after mid-month returning quickly to baseflow conditions (Figure 1). The lagoon had not closed at the time of the survey and remained open with tidal fluctuation until early July. In spite of the open lagoon and very low (though tidally influenced) lagoon levels, juvenile steelhead catch per effort was the highest observed in surveys to date (Table 1). In addition, 13 coho young-of-year were captured, the first capture of coho since 2005. Unlike 2019, the majority of steelhead were under 80mm FL, presumably young-of-year. Abundance of age 1+ and older steelhead was comparable to 2019. Initial closure of the lagoon did not occur until June 30 and it opened again for four days beginning July 17 and for 20 days beginning July 27 (Figure 1). Inflow was relatively stable from about 1.3 cfs in mid-June to about 0.9 cfs in early October.



**Figure 1. Laguna Creek Lagoon stage, streamflow, wave height, and tides 2020 (Source: lagoon depth from 2<sup>ND</sup> Nature and City of Santa Cruz, streamflow from Balance Hydrologics, wave and tide data from NOAA)**

*O. mykiss* were relatively abundant in the fall in spite of late lagoon closure. Relatively few fish tagged in June were recaptured in the lagoon in September. The four June recaptures had relatively low growth rates compared to previous surveys.

**Table 1. *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, HES 2019, and HES 2020).**

	<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		0		0	
2020	56.8		11.4		1.4		0	

Early summer (June 9-10)

Early summer Site Conditions

- The mouth was open and the lagoon elevation was low and subject to tidal influence on both the first and second days of sampling (Figures 2 and 3).
- The water depth was very shallow from the end of the rock bluff upstream past the water quality recorder (Figure 4). Stage was less than 1.0 feet during sampling. There was a pocket of deeper water along the rock bluff but maximum depth was only 0.4 meters (1.3 ft.).
- Inflow from Laguna Creek was around 1.5 cfs during the survey (Figure 1).
- The early morning water temperatures were cooler than later in the day in response to solar heating. Dissolved oxygen levels were greater than 9.0 mg/l on June 9, with one anomalous reading of 24.0 mg/l measured at Station LA-1.5. Dissolved oxygen varied

between 6.9 mg/l and 8.4 mg/l on June 10, with the lower dissolved oxygen measured closer to the mouth on both days. Salinity stratification was observed on both days where salinity below 0.4 meters showed marine influence (Figure 5). Water temperature and dissolved oxygen levels were good for *O. mykiss* through the water column.

- The water column was clear with substrate visible at greatest depth surveyed (0.4 meters (1.3 ft.)).



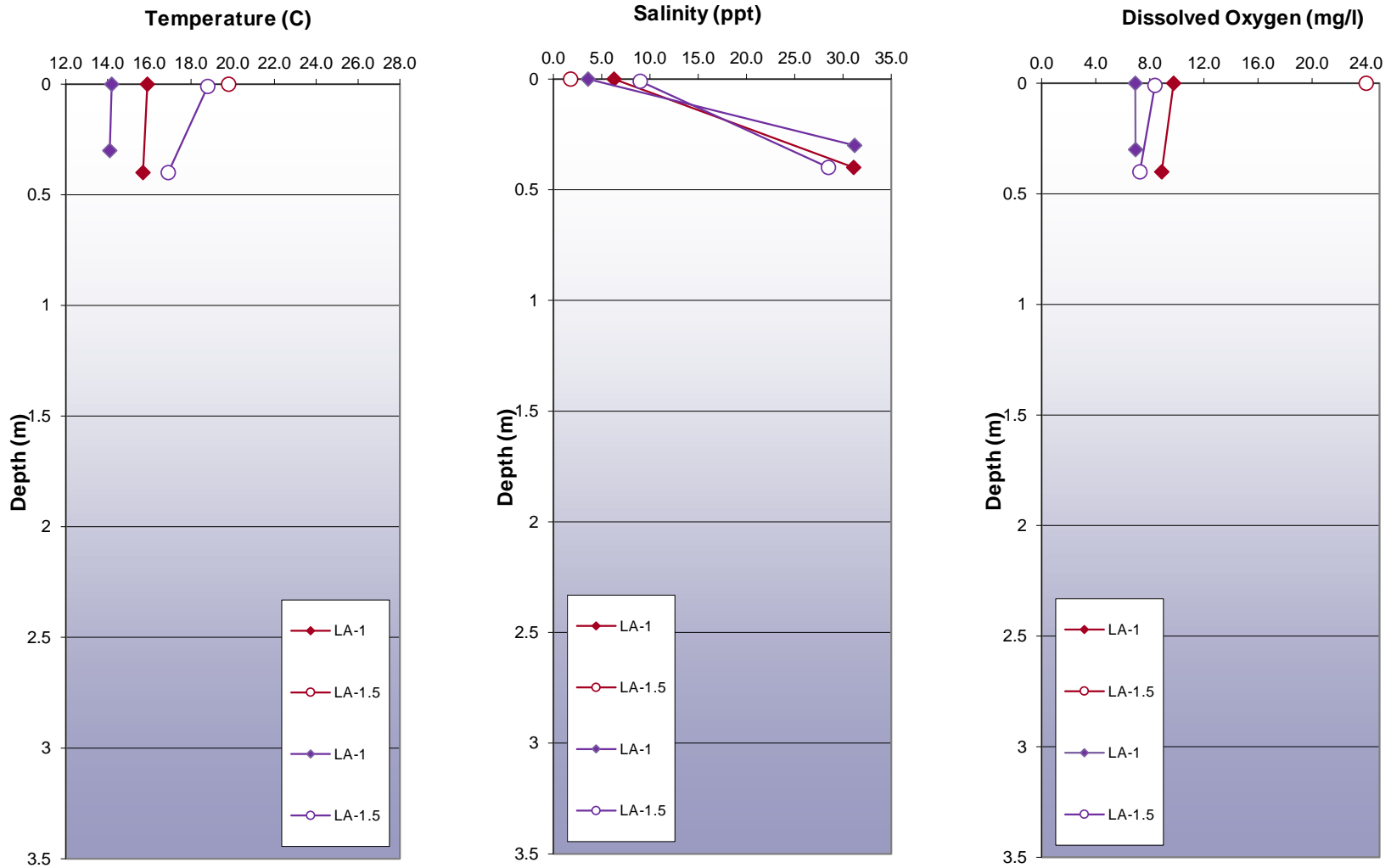
**Figure 2.** Laguna Creek Lagoon, June 9, 2020, ~9:15 am



**Figure 3.** Laguna Creek Lagoon, June 10, 2020, ~9:00 am



**Figure 4.** Laguna Creek Lagoon, June 10, 2020, ~10:50 am



**Figure 5. Depth profiles of water quality parameters in Laguna Creek Lagoon during June. Profiles plotted in red are June 9; profiles in blue are June 10**

## Early summer Survey Results

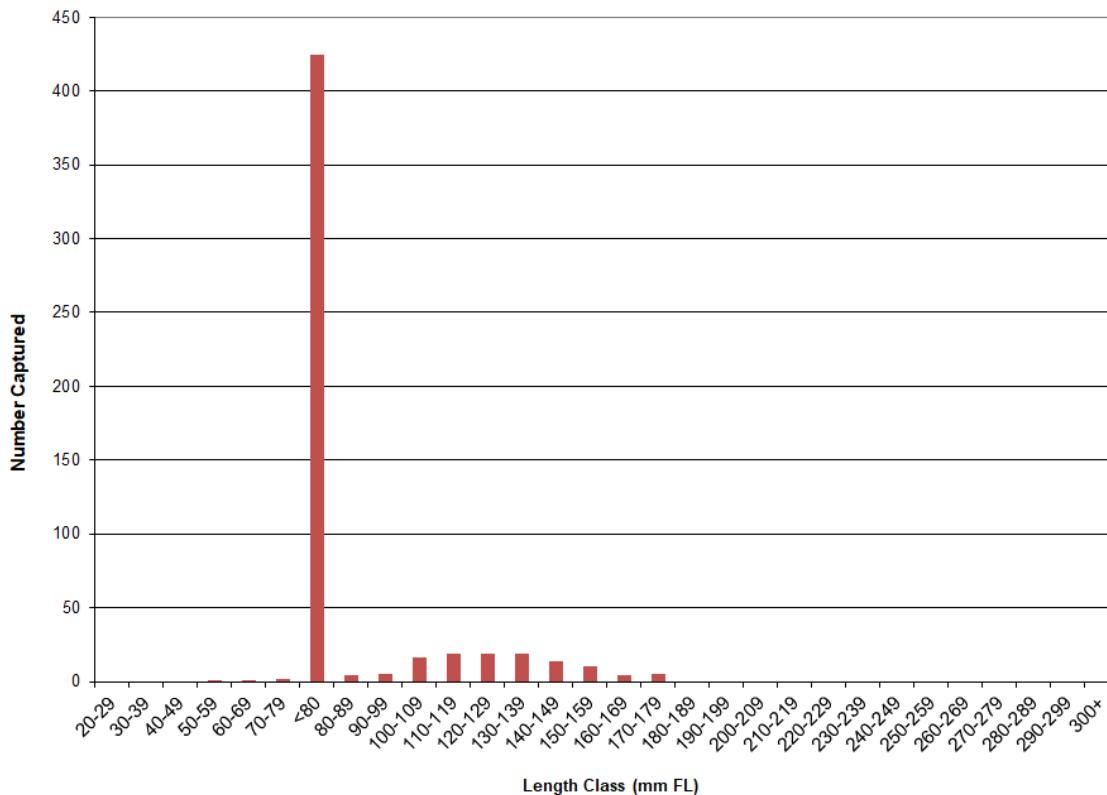
- *O. mykiss* abundance was high due to presence of a large number of young-of-year. Overall CPUE was the highest recorded in 14 years of sampling (Table 1).
- The majority of steelhead captured (79%) were less than 80mm FL, likely young-of-year (Figure 6).
- Thirteen juvenile coho salmon were captured, the first time coho were observed in the lagoon since 2005.
- Coho ranged from 72 mm FL to 95 mm FL with one in the 30-39 mm size class. These were presumed to be all young-of-year since no coho were observed in snorkel surveys in the fall of 2019. The large size difference between the larger fish and the 30-39 mm individual may indicate early and late spawning events.

**Table 2. Fish catch in Laguna Creek Lagoon, June 2020**

	LA-1	LA-1.5	LA-2	LA-3	Grand Total
<i># Hauls</i>	4	4	1	0	9
Species	Number Caught				
Steelhead	221	319	5		<b>545</b>
Topsmelt	2	1			<b>3</b>
Threespine stickleback	1012	611	36		<b>1659</b>
Staghorn sculpin	33	28	1		<b>62</b>
Tidewater goby	3	4	8		<b>15</b>
Coho salmon	3	10			<b>13</b>
<i>O. mykiss CPUE</i>	45.0	80.8	55.0		<b>56.8</b>

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

- Ninety-eight percent of the *O. mykiss* captured were at parr or advanced parr stage. The rest 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* or coho with black-spot disease or other external parasites, disease, or abnormalities was noted.
- All *O. mykiss* and coho had adipose fins present.
- Threespine stickleback were abundant and a few staghorn sculpin and tidewater goby were also captured.
- The over-wash pond was not sampled.



**Figure 6. *O. mykiss* length classes in Laguna Creek Lagoon, June 2020**

Early summer *O. mykiss* Population Estimate

- Only fish 80mm FL or greater and less than 380mm FL were included in the population estimate.
- Four hundred forty *O. mykiss* were captured during the marking period on June 9. Three hundred thirty-seven were too small to tag and one tagged fish died after tagging. A total of 102 tagged *O. mykiss* was released in the lagoon on June 9.
- On June 10, 105 *O. mykiss* were captured but only 12 were in the size range for tagging. Only one *O. mykiss* in the taggable size range 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 in the shallow lagoon. CPUE for all fish dropped from 110 during the mark period on June 9 to 21 on June 10 and for fish in the taggable range CPUE dropped from 25.8 to 2.6. 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.



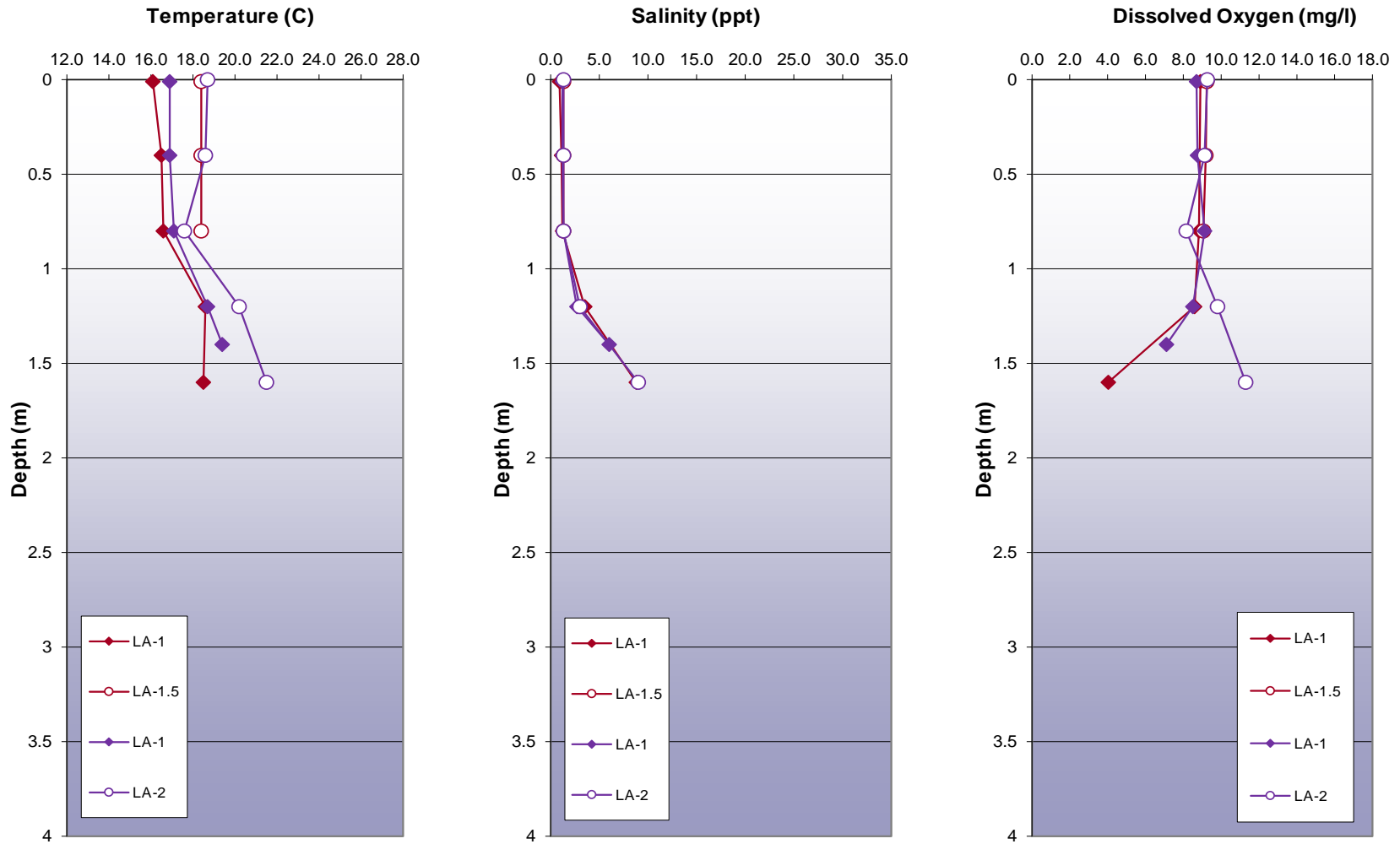
### Late summer (September 15-16)

#### Late summer Site Conditions

- The mouth was closed at the time of the survey. The lagoon had closed on June 30 with two subsequent breaches during July and early August (Figure 1). Stage fluctuated slightly around 1.4 meters (4.7 ft.) during seining. (2nd Nature and City of Santa Cruz data) (Figure 1). Much of the inner beach was inundated as was the back marsh and over-wash pond (Figure 7).
- Inflow from Laguna Creek during sampling fluctuated between 0.77 cfs and 0.89 cfs.
- Maximum depth was 1.6 meters (5.2 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.
- The lagoon temperature ranged between 16.1°C and 18.7°C at the surface, with the higher temperatures later in the day. A thermocline was observed between 0.8 meters and 1.2 meters. Salinity measurements reflected the freshwater nature of a closed lagoon as compared to the June sampling. Salinity increased with depth at each of the stations with the halocline around 1.2 meters and with a maximum of 9 ppt (Figure 8, center panel). Dissolved oxygen was generally well-mixed and ranged from 8.7 mg/l to 11.3 mg/l, with one low reading of 4 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 depths to 1.6 meters (5.2 ft.)



**Figure 7. Laguna Creek Lagoon, September 16, 2020**



**Figure 8. Depth profiles of water quality parameters in Laguna Creek Lagoon during September. Profiles plotted in red are September 15; profiles in blue are September 16**

## Late summer Survey Results

- *O. mykiss* were captured and marked on September 15. On September 16 the lagoon was re-sampled and the proportion of re-captured fish was recorded.
- Nine seine hauls were completed on September 15 and 8 hauls on September 16 between the beach (LA-1) and just downstream of the water quality monitoring station (Table 3).
- In addition to *O. mykiss*, threespine stickleback were abundant and tidewater goby and topsmelt were represented by a single capture each (Table 3).

**Table 3. Fish catch in Laguna Creek Lagoon, September 2020**

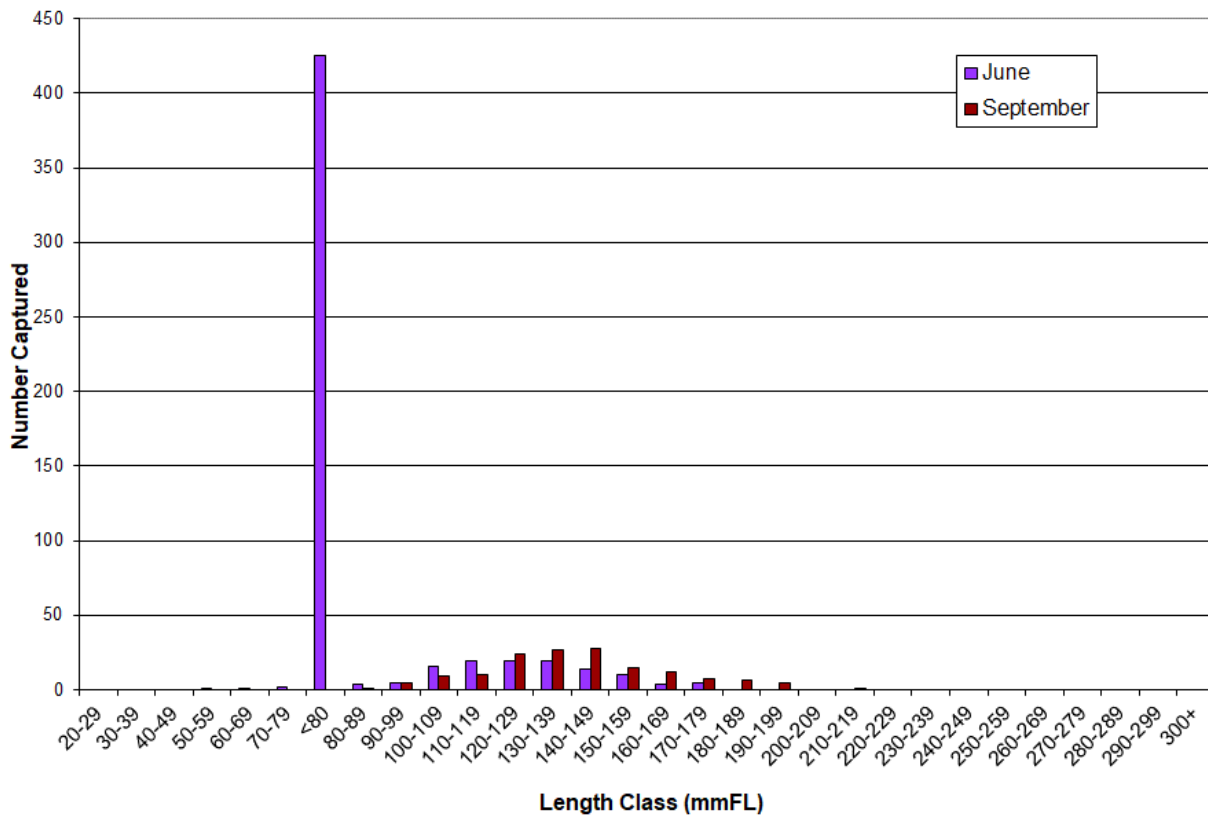
	LA-1	LA-1.5	LA-2	LA-3	Grand Total
# Hauls	11	4	2		17
Species	Number Caught				
<i>O. mykiss</i>	139	4	50		193
Threespine stickleback	166	103	44		313
Topsmelt	1				1
Tidewater goby	1				1
<i>O. mykiss</i> CPUE	12.6	1.0	25.0		11.4

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

- Overall abundance of *O. mykiss* based on number caught per seine haul (catch per unit effort or CPUE) at 11.4 per haul was in the upper end of the range of surveys to date (Table 1). Nine years had lower abundance, three had higher abundance, and one year was the same. CPUE was about one fifth the level in June though they were not significantly different due to high levels of variance (two sample t-Test, unequal variance, two-tail,  $p \approx 0.1$ ). *O. mykiss* may have been transient in the lagoon between the June survey and September due to the open lagoon periods and resulting diminished habitat.
- Four *O. mykiss* tagged in June were recaptured in September. Average growth rate was 0.46 mm/day, among the lowest values recorded in Laguna Lagoon (Table 4).
- Captured *O. mykiss* ranged in length from 80 mm FL to 220 mm FL (Figure 9). Abundance was similar to the 70 mm to 180 mm size range in June but the mode was shifted about 20 mm to larger sizes. The population may have been transient during the summer so it is difficult to relate the size distribution to lagoon conditions. The abundant <80 mm size class from June had diminished greatly, possibly moving back upstream.

**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
2020	4	0.46	46	11.4	56.8

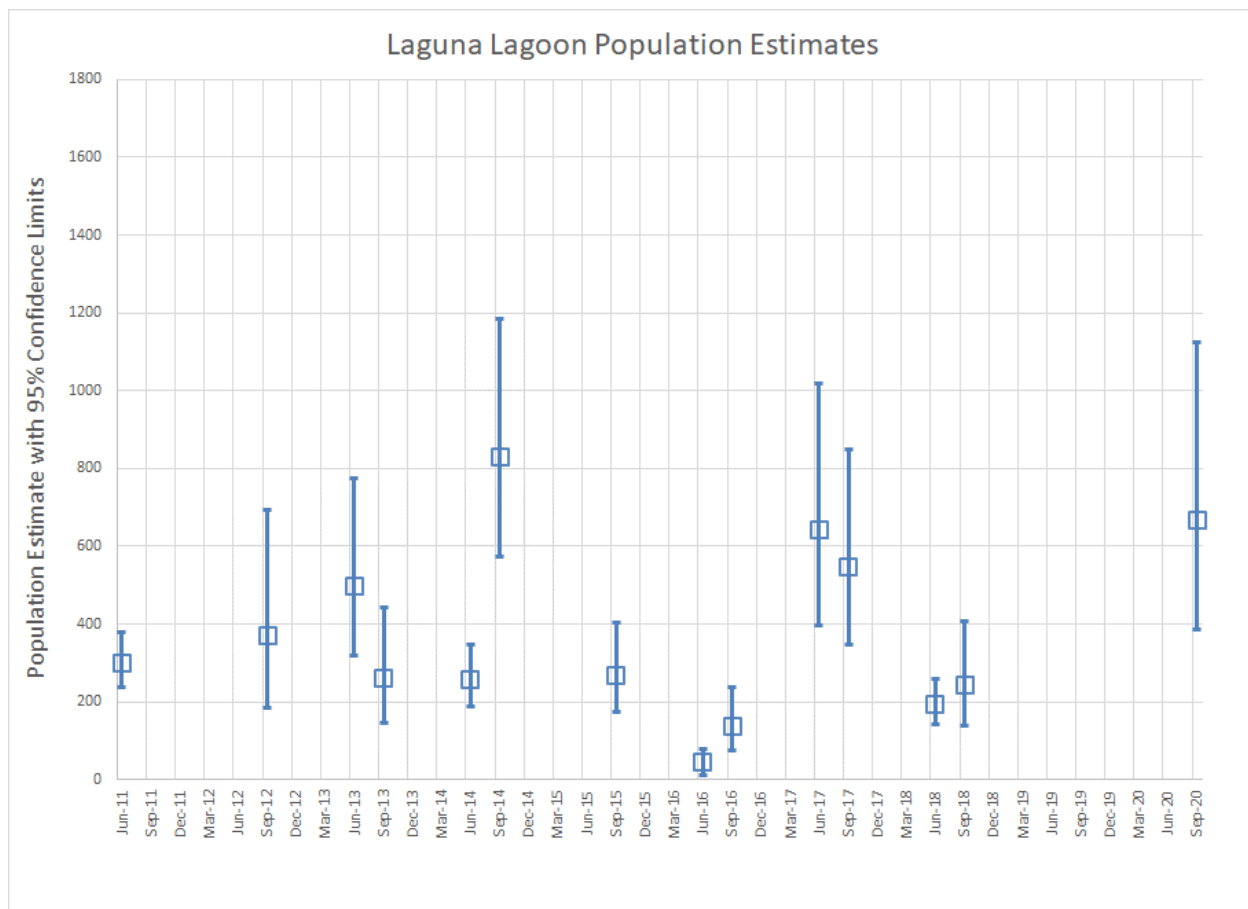


**Figure 9. *O. mykiss* length classes in Laguna Creek Lagoon, late summer 2020 compared to spring 2020**

- Eighty-five percent of the *O. mykiss* catch were characterized as parr or advanced parr (sizes from 80-199 mm FL) and 10% were characterized as silvery parr (lengths from 133-192 mm FL). One *O. mykiss* was characterized as a smolt and 7 of the larger individuals (168 mm to 218 mm) had the appearance of adult resident fish.
- 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.

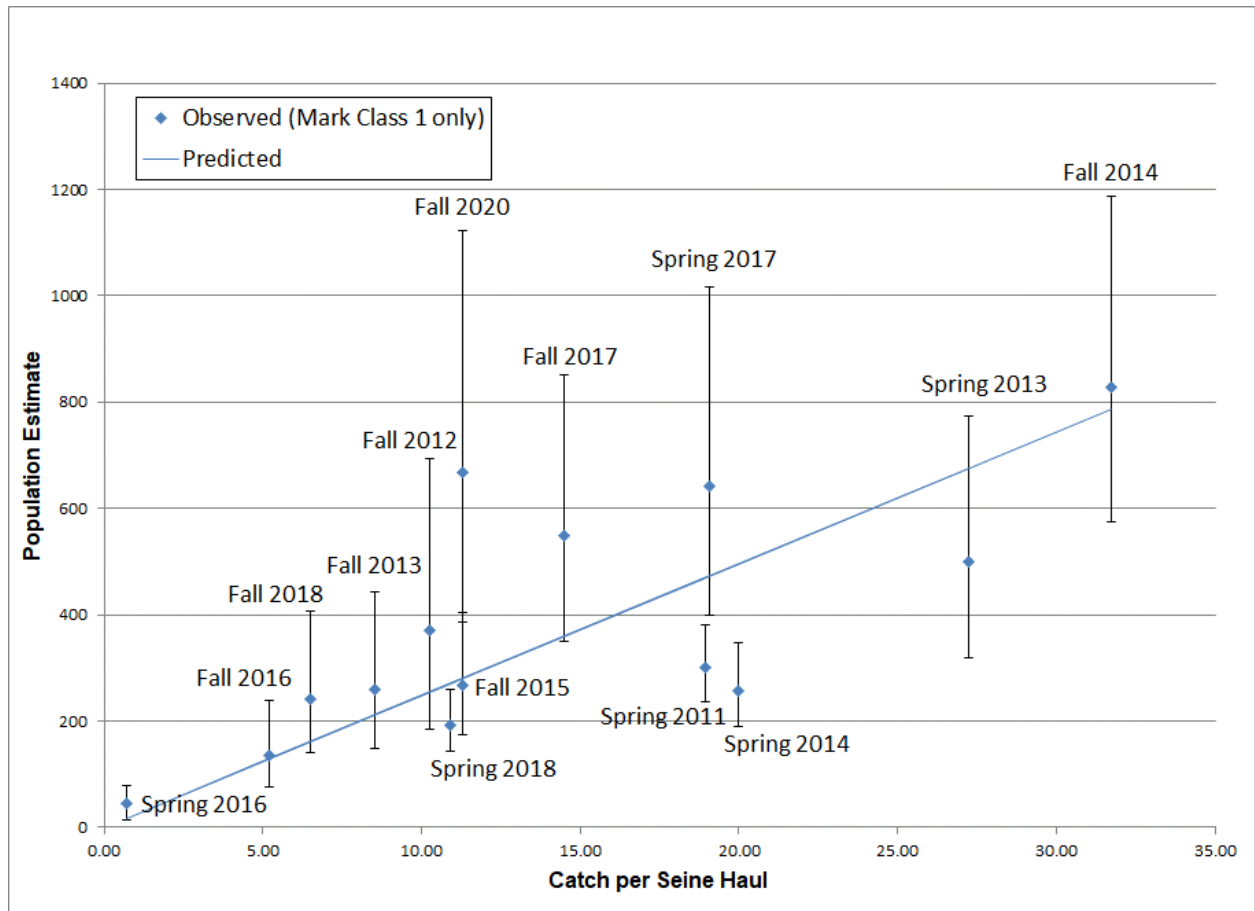
#### Late summer *O. mykiss* Population Estimate

- One hundred five *O. mykiss* were captured during the marking period on September 15. All were over the 80 mm FL and under the 320 mm FL tagging limits. Fifteen of the total were recaptures from the marking period leaving 90 individuals tagged. There was one mortality after tagging so a total of 89 tagged *O. mykiss* were released in the lagoon on September 15.
- On September 16, 88 *O. mykiss* were captured, all within the tagging limits. Nine *O. mykiss* caught during the recapture period had been tagged on September 15. Two additional fish had obvious tag wounds but no tag was read. These were assumed to be fish from the mark period that had lost tags and were included as recaptures bringing the total to 11.
- Based on the Peterson method (Ricker 1975), the population estimate is 668 *O. mykiss* in the lagoon in mid-September. The 95% confidence limits for this estimate are 387 and 1,123. This is the second highest abundance recorded in Laguna Creek Lagoon (Figure 10).
- CPUE was comparable during the mark and recovery periods (11.7 vs. 11.0, not significantly different, two sample t-test, equal variance, two-tail,  $p \approx 0.3$ ).
- The relationship between the population estimates and CPUE was updated with the fall 2020 data point (Figure 11). Least squares regression  $r^2$  is 0.52 and was statistically significant with  $p = 0.004$ . Forcing the relationship through the origin improves the  $r^2$  to 0.86. The relationship deteriorated somewhat in 2020 since the population estimate was quite large for the CPUE observed.



**Figure 10. *O. mykiss* population estimates in Laguna Creek Lagoon over time<sup>1</sup>**

<sup>1</sup> Population estimates not available in Late Summer 2011, Early Summer 2012, and Early Summer 2015, Early and Late Summer 2019, and Early Summer 2020 due to insufficient catch, low number of recaptures, and/or evidence of transient populations in the lagoon.



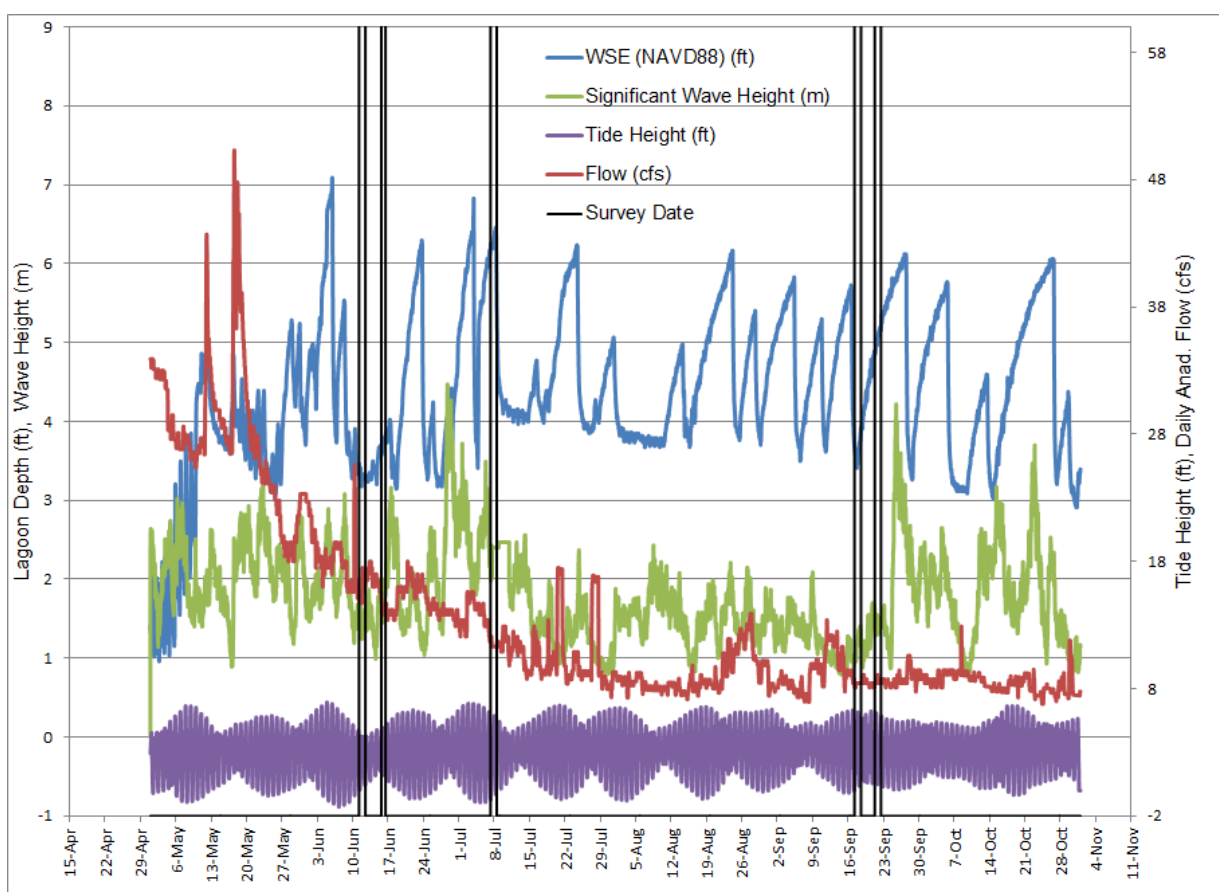
**Figure 11. Relationship between *O. mykiss* population estimate and CPUE in Laguna Creek Lagoon<sup>2</sup>**

<sup>2</sup> Population estimates not available in Late Summer 2011, Early Summer 2012, and Early Summer 2015, Early and Late Summer 2019, and Early Summer 2020 due to insufficient catch, low number of recaptures, and/or evidence of transient populations in the lagoon.

## San Lorenzo River

### Summary

The lagoon outlet was extended to the west and opened closer to the center of the beach. This configuration was fairly stable and over the course of the summer, the lagoon open and closed on multiple occasions. With the mouth closed, the lagoon would fill to about 6 feet before breaching and draining. During the draining part of the cycle the lagoon outlet and stage would stabilize at about 3 to 4 feet elevation and remain open with micro-tidal conditions for up to a few days or close rapidly and begin filling again (Figure 12). Due to high air and water temperatures, no August sampling was conducted.



**Figure 12. San Lorenzo Lagoon stage, streamflow, wave height, and tides 2020 (Source: lagoon stage from City of Santa Cruz Public Works, streamflow from USGS, wave and tide data from NOAA)**

Abundance of *O. mykiss* in the lagoon was high for the fifth year running in spite of warm water temperatures. Inflow from the San Lorenzo River, though low compared to wetter years, remained at no less than 8 cfs due to interim bypass flow requirements related to the City's



Anadromous Species Habitat Conservation Plan. Previous dry year inflows could go to zero during the summer. June CPUE was the highest of any survey to date (Table 5). As in past surveys, abundance was concentrated near the Trestle Bridge and upstream of Riverside Drive Bridge (Table 6). Catch per effort dropped to a lower level in July, and was even lower in September. Population estimates exceeded any that have been previously made in the lagoon but are suspected of being inaccurate. The results are somewhat anomalous in that the September 2020 population estimate exceeded September 2017 and 2019 estimates (Table 7) but CUPE was significantly lower in 2020 than 2019 (ANOVA single factor, Tukey HSD,  $\alpha < .05$ ) and not significantly different than 2017 (ANOVA single factor, Tukey HSD,  $\alpha > .05$ ) (Table 5). The population estimates for 2020 are of questionable validity due to these discrepancies. The most likely cause is that a significant portion of fish tagged during the mark period were no longer susceptible to capture during the recapture period, possibly having left the lagoon. We know that some fish did this since two fish tagged on June 11 and 12 were recorded at Felton, one on June 16, still during the recapture period, and another on June 24. This result could have been compounded by the warm water temperature, making fish more likely to leave after tagging, and the low number of tags implanted due also to the warm temperature conditions.

**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, HES 2020)**

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	
2020	146.1	120.6		31.0	

**Table 6. *O. mykiss* catch per haul for the San Lorenzo River Lagoon during 2020**

Station	Location	<i>O. mykiss</i> Catch per Haul				
		Jun 11-16	Jul 7-8	Aug 19-20*	Sep 17-22	Overall
SL-1	South of Trestle	70.5	29.5	NS	0.1	<b>26.3</b>
SL-2	RR Trestle	75.0	369.0	NS	30.1	<b>96.1</b>
SL-3	Near YSI Station	155.0	NS	NS	NS	<b>155.0</b>
SL-5	Riverside Drive	257.0	70.5	NS	19.0	<b>109.8</b>
SL-6	U/S Bank Restoration	207.3	13.5	NS	83.8	<b>115.9</b>
	<b>Overall</b>	<b>146.1</b>	<b>120.6</b>	NS	<b>30.7</b>	<b>85.4</b>

NS- Not Sampled

\*August survey cancelled due to excessive water temperature in the lagoon

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

	<i>O. mykiss</i> Population Estimate	
	Spring	Fall
2011	501	138
2012	60	714 <sup>1</sup>
2013	207 <sup>2</sup>	No estimate <sup>3</sup>
2014	No estimate <sup>4</sup>	None captured
2015	559 <sup>3</sup>	None captured
2016	2,697	1,331
2017	3,636	>3,636 <sup>5</sup>
2018	2,378	704
2019	7,637 <sup>6</sup>	14,105
2020	26,815	18,720

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

<sup>1</sup> May have been fish entering or leaving lagoon

<sup>2</sup> Low number of marks or recaptures, likely biased

<sup>3</sup> Evidence population not closed, violates assumption of the method

<sup>4</sup> No recaptures

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

<sup>6</sup> 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

The 2020 season continued the trend of higher abundance of *O. mykiss* in the lagoon in June, and through the summer in most years (Table 5). The five consecutive years 2016 through 2020 had the highest June CPUE and population estimates 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.

PIT tag data indicated that at least a few *O. mykiss* may have been in the lagoon all summer (or at least returned to the lagoon by September). Five fish tagged in June were recaptured in July and five were recaptured in September, including one recaptured in both July and September. Also, three *O. mykiss* tagged in July were recaptured in September. These represent a fairly small proportion of all fish tagged however (252 in June and 170 in July). Average growth rates for *O. mykiss* in the lagoon, at 0.41 mm/day, were comparable to other years except for the high growth years of 2012 and 2016. A relatively healthy and abundant *O. mykiss* population persisted in the lagoon in 2020 in spite of very high water temperature and disruptive fill and spill cycles throughout the summer.

## Early summer (June 11-12, 15-16)

### Early summer Site Conditions

- The lagoon was open during the sampling period but was beginning to close over the six days of the survey (Figure 12). The outlet channel flowed northward from the bluff across the beach before emptying to the ocean (Figure 13). Daily average flow at Santa Cruz gage ranged from 14.2 cfs to 17.5 cfs (Figure 12). Mean flow for June between 2004 and 2020 is 34 cfs. (historical discharge, USGS site 11161000 San Lorenzo River at Santa Cruz California).
- The lagoon stage did not vary greatly and gradually increased over the sample period, ranging from 3.2 ft. to 3.8 ft. (City of Santa Cruz Trestle gage data). Downstream of the trestle, the shoreline was conducive to sampling with sand beach exposed (Figure 14). Some areas of very shallow water near shore had to be avoided when pulling in the net. Upstream of Riverside Bridge there was no sand beach with relatively deep (1 to 2 feet) water at the bank (Figure 15). Dense mats of submerged green algae were present beginning around the trestle and were particularly dense upstream of Riverside Bridge.



**Figure 13. San Lorenzo Lagoon outlet to mouth June 16, 2020**

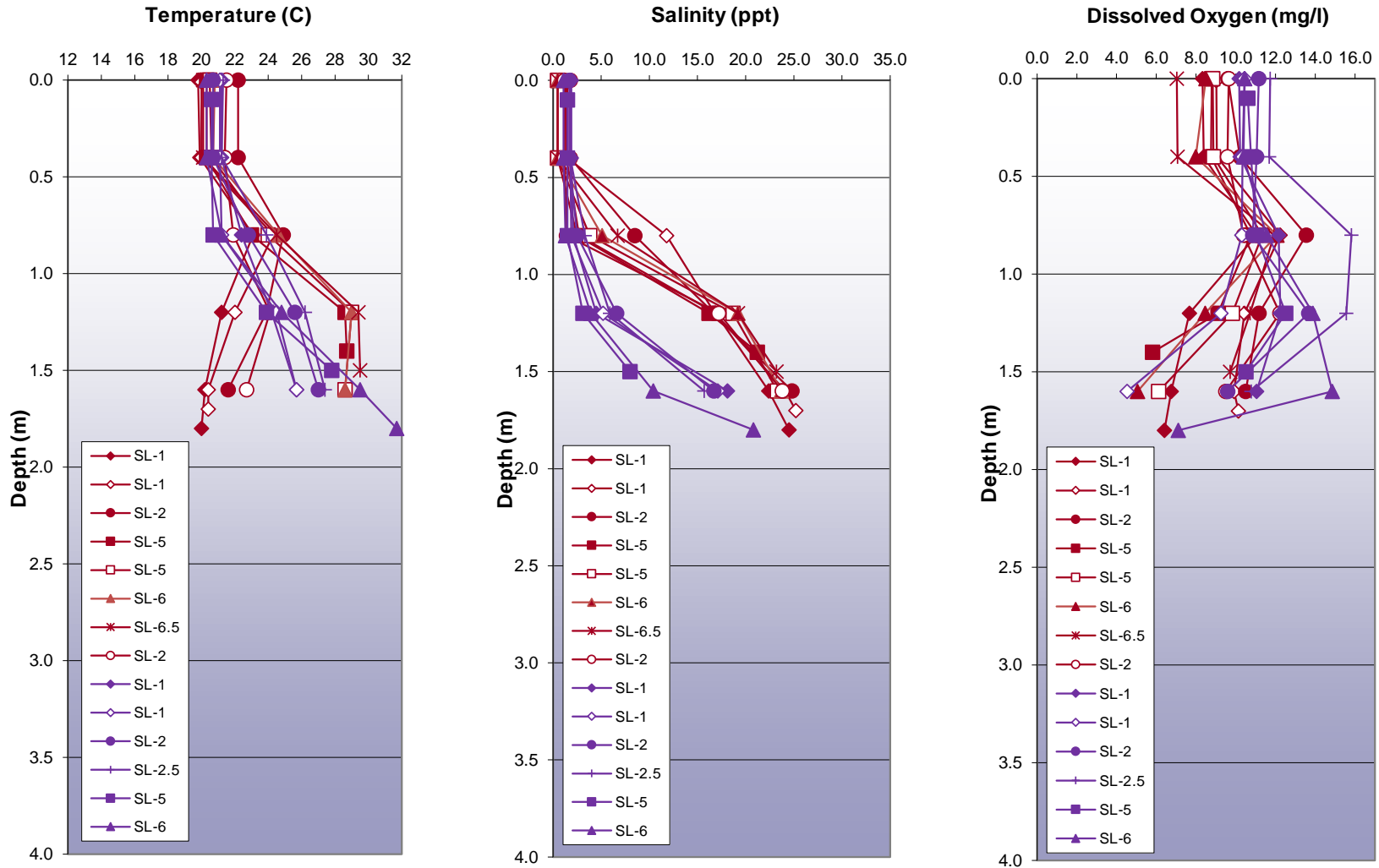


**Figure 14. San Lorenzo Lagoon near trestle June 16, 2020**



**Figure 15. San Lorenzo Lagoon upstream of Riverside Bridge June 12, 2020**

- The lagoon was salinity stratified throughout with surface salinities ranging from 0.5 ppt to 1.9 ppt down to 0.4 meters (1.3 ft.) then increasing at the halocline (0.8 meters or 2.6 ft.) to 25.2 ppt at depth (Figure 16, center panel). Salinity in the deeper water (0.8 meters and deeper) decreased between the mark and recapture periods.
- The lagoon was very warm in June with surface temperatures generally around 20°C and a thermocline at 0.8 meters with increasing temperature below. During the marking period, temperatures below 0.8 meters, though warmer than surface waters, were cooler at the lower stations and warmer upstream of Riverside Bridge. During the recapture period, sub-surface temperature at the lower stations was increasing but temperature upstream of Riverside was moderating (Figure 16, left panel). The highest temperature (31.7°C at 1.8 meters) was recorded near SL-6 (across from the skate park) on the morning of June 16. The Santa Cruz region was experiencing a heatwave and the lagoon was exhibiting minimal nighttime cooling. Where water temperatures were within the suitable range for juvenile *O. mykiss*, such as the first day of sampling near the mouth and the early morning near the Riverside Bridge on the second day, tagging was conducted. However, elevated water temperatures at the upstream stations were of concern and no tagging was carried out.
- Dissolved oxygen levels were generally above 8 mg/L in the surface waters, increased to a peak at the upper thermocline/halocline (0.8 meters), and were variable in deeper waters (Figure 16, right panel). Dissolved oxygen was at levels supportive of *O. mykiss* except at the very deepest levels of the lagoon. Dissolved oxygen levels at the time of the survey were likely influenced by photosynthesis of the abundant algae present.
- Water clarity was high with secchi disk visible at or near the substrate at all stations (up to 1.75 meters (5.75 ft.) deep). However, at the upstream stations the water surface was covered with dense algae that was cleared to the extent possible prior to deploying the nets.



**Figure 16. Depth profiles of water quality parameters in the San Lorenzo Lagoon during June. Profiles plotted in red are June 11-12; profiles in blue are June 15-16**

## Early summer Survey Results

- *O. mykiss* were captured and marked on June 11 and 12 and the lagoon was resampled on June 15 and 16. Tagging was suspended during the marking period after the first haul on June 12 (upstream of Riverside Bridge) due to excessive water temperature. Subsequent captures upstream of Riverside and during the recapture period on June 15 and 16 were scanned and released from the net if untagged. Counts were recorded for fish less than 80 mm FL and greater than 80 mm FL but actual lengths were not measured. Recaptures were held for measurement and then released.
- Sixteen seine hauls were completed at regularly sampled stations between the beach and the bend upstream of Riverside Bridge. Samples at Station SL-3 were limited due to the extended time required to process fish at Stations SL-1 and SL-2 and temperature limitations.
- *O. mykiss* were the most abundant fish species captured, followed by topsmelt. Staghorn sculpin and shiner surfperch were moderately abundant, particularly in the lower lagoon. Other species were relatively rare (Table 8).
- *O. mykiss* abundance (CPUE) was the highest for June in annual surveys to date (Table 5). Catch was highest upstream of Riverside Bridge.
- The majority of *O. mykiss* captured were between 100 mm FL and 160 mm FL (Figure 17). A smaller mode with 60 mm FL to 99 mm FL fish may have represented a separate year class. The size class distribution was similar in the lower lagoon (SL-1 and SL-2) and upstream of Riverside Bridge (SL-4 and SL-5).

**Table 8. Fish catch in San Lorenzo River Lagoon, June 2020**

Species	South of Trestle (SL-1)	Around Trestle (SL-2)	Around Water Quality Station (SL-3)	Upstream of Riverside Bridge (SL-5)	Bend downstream of Laurel Ave. (SL-6)	Grand Total
<i># Hauls</i>	4	4	1	3	4	<b>16</b>
<i>O. mykiss</i>	282	300	155	771	829	<b>2337</b>
Sacramento sucker		4		2	6	<b>12</b>
Topsmelt	384	454	28	51	111	<b>1028</b>
Threespine stickleback			5	3	3	<b>11</b>
Prickly sculpin				3		<b>3</b>
Staghorn sculpin	1	134	177	70	114	<b>496</b>
Striped Bass				4		<b>4</b>
Shiner surfperch	1	111	49	16		<b>177</b>
Rock crab	7	2	1			<b>10</b>
Dungeness crab		1				<b>1</b>
<i>O. mykiss CPUE</i>	70.5	75.0	155.0	257.0	207.3	<b>146.1</b>



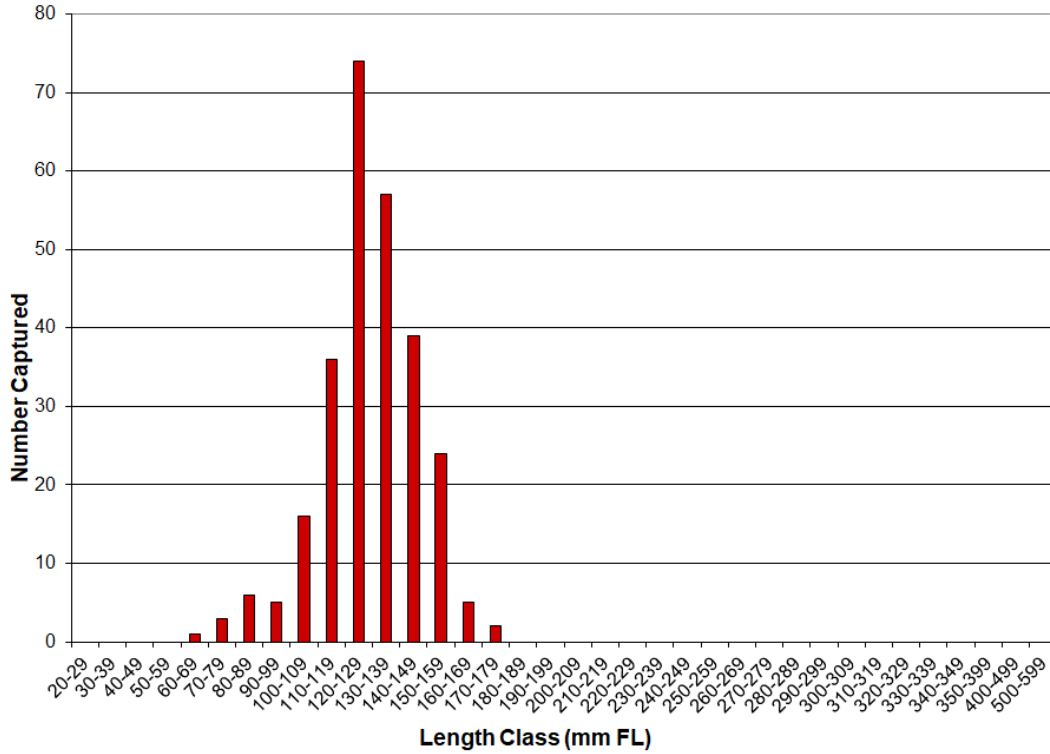


Figure 17. *O. mykiss* length classes in San Lorenzo Lagoon, June 2020

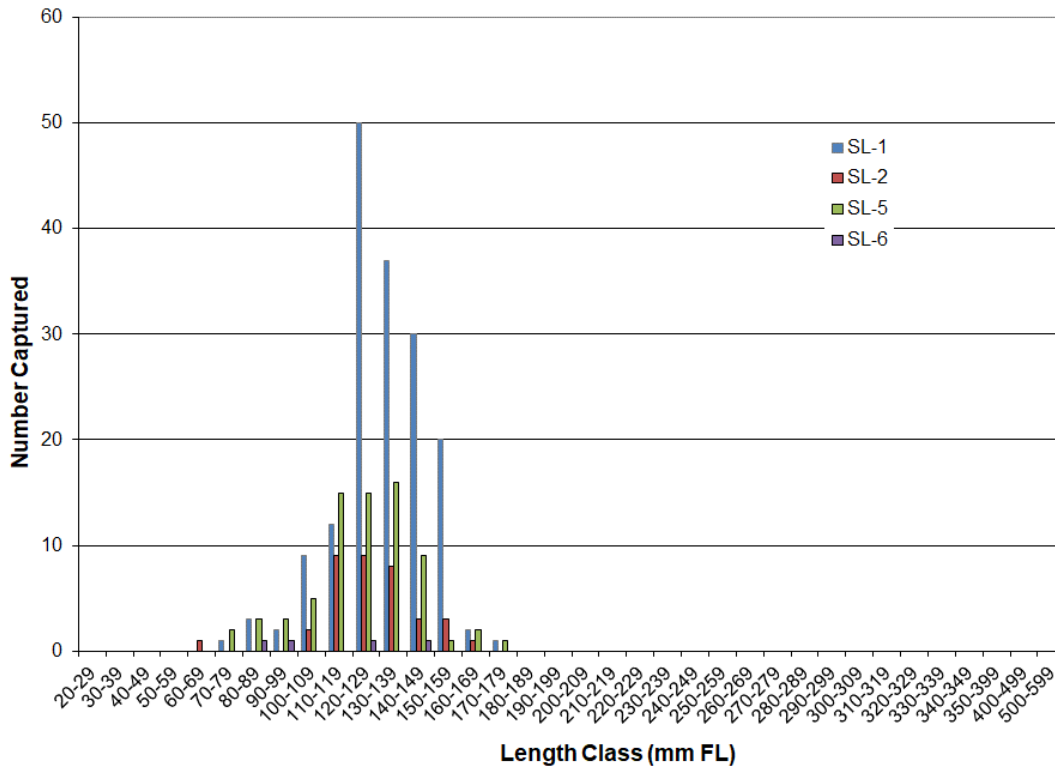


Figure 18. *O. mykiss* length classes in San Lorenzo Lagoon by Station, June 2020

- The majority of the catch (74%) was characterized as parr or advanced parr and 25% were characterized as silvery parr or advanced silvery parr. Only 1% of the catch was characterized as smolt stage. All smolt stage fish (n=3), advanced silvery parr (n=5), and 80% of silvery parr were captured at SL-1, closest to the outlet.
- One *O. mykiss* had been captured previously on July 17, 2019. At the time of tagging the fish was 95 mm FL and was characterized as an advanced parr. At time of recapture on June 15, 2020 it was estimated in the 140-149 mm FL size class and was characterized as an advanced parr. It was captured at SL-5 in 2019 and at SL-3 in 2020.
- Of 296 *O. mykiss* examined, all 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 11% and 68% in spring surveys since 2010. One *O. mykiss* had an attached *Lernaea* parasite (anchor worm).

#### Early summer *O. mykiss* Population Estimate

- The tag supplier (Biomark) recommends that body cavity tagging should only be done down to a length of 65mm but due to previous experience with excessive mortality of fish less than 80mm, only fish 80mm 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.
- A total of 967 *O. mykiss* was captured during the marking period (June 11-12). Seven hundred four were released from the net due to overcrowding and were not processed. Of the 704 released, 55 were also below the minimum size for tagging. An additional 11 were recaptures of previously tagged fish. Two fish were tagged but did not survive for release. Tagging was suspended during the marking period after the first haul on June 12 (upstream of Riverside Bridge) due to excessive water temperature. There was a total of 250 tagged *O. mykiss* released in the lagoon at the end of the mark period.
- A total of 1,370 *O. mykiss* was captured during the recapture period with 1,281 within the size range for tagging. Eleven of these had been tagged during the marking period.
- Lagoon population estimate using the Petersen method (Ricker 1975) is 26,815 *O. mykiss* within the taggable size class in June. The 95% confidence limits for this estimate are 15,538 and 45,128. This is more than three times the previous high population estimate for June made in 2019. This is inconsistent with CPUE data for 2020 which was only 60% higher than June 2019 and only 9% higher than June 2017 (the previous record CPUE). It is likely an overestimate. The number of recaptures may have been underestimated since fish were scanned directly from the net and released. It is possible that the scanners missed fish under these conditions. It is also possible that tagged fish left the lagoon due to the combination of stress from tagging and high water temperature.
- If taggable fish (80mm FL or greater) were 93.8% of the total catch (2,170/2,314), then the total population estimate including fish too small to tag would be  $26,815/0.938$  or 28,587 and the population of fish less than 80mm FL would be 1,772.

- CPUE was 161 per haul during the mark period and 137 per haul during the recapture period (difference not statistically different, two sample t-test,  $p \approx 0.7$ ).
- Lengths were not recorded during part of the mark period and during the recapture period but the proportion of *O. mykiss* less than 80 mm FL was comparable during the mark and recapture periods (5.8% vs. 6.6%).

## July Survey (July 7-8)

The July survey was a two-day relative abundance survey without mark-recapture population estimates. Sampling was conducted at standard sampling Stations SL-1 and SL-2, downstream and around the trestle; and Stations SL-5 and SL-6 upstream of Riverside Bridge. Station SL-3 was not sampled due to the high number of fish captured and extended processing time at Station SL-2. The water temperatures were at a suitable range for juvenile *O. mykiss* and captured fish were tagged on the first day (lower lagoon near the trestle). Fish were not tagged or measured on the second day (upstream of Riverside Bridge) due to high water temperatures in the deeper part of the water column and substantial amounts of algae.

### July Site Conditions

- The lagoon was closed at the time of sampling but had breached 3 days prior on July 4 (Figure 12). There had been two other short periods of closure lasting 3 days each since the June survey.
- Inflow from the San Lorenzo River was a maximum of 12.1 cfs during the sample period and dropped to 11.3 cfs on the second day (Figure 12).
- The lagoon stage ranged between 6.5 feet and 5.6 feet during the survey period (City of Santa Cruz data). The lagoon breached again during or right after the last seine haul (SL-6) on the second day. During the survey, the lagoon was high and wide with extensive very shallow water near shore downstream of the trestle. The net had to be deployed as a purse seine and finished at the edge of the shallow bench at sites downstream of the trestle. Above Riverside Bridge, the net was also deployed as a purse seine and hauls were finished by counting and scanning fish for tags as they were removed from the net and released to minimize stress from processing.
- Lagoon salinity ranged from 0.6 ppt to 2.0 ppt in the surface waters (0 meters to 0.4 meters) at both the lower and upper lagoon locations, with salinity slightly higher in the downstream locations. Salinity began to rise in the halocline at 0.8 meters and was highest at a depth of 2.8 meters near the Trestle Bridge (27.8 ppt) on July 7 (Figure 16, middle panel).
- Water temperatures were adequate for sampling down to 0.4 meters depth but rose to peak levels at the top of the halocline before declining somewhat at greater depths (Figure 16, left panel). From the surface to 0.4 meters, measured temperatures – all taken in the morning – ranged from 18.5°C to 21.3°C. At the thermocline, water temperatures were above 20°C, with the maximum of 24.6°C measured at 1.6 meters at SL-6 across from the skate park on the second day. With the higher temperatures on the second day of sampling upstream of Riverside Bridge, high lagoon levels, and very dense floating algae, fish were processed in-situ to minimize stress.
- Dissolved oxygen was well-saturated in surface waters, varying from 8.7 mg/l to 11.4 mg/l but showed a general decrease with depth, mirroring the increase in salinity (Figure 16, right panel). From 0.8 meters to 3.0 meters, dissolved oxygen levels dropped from a high of 10.7 mg/L to a low of 0.4 mg/l at SL-6 across from the skate park.

- Water clarity was lower than in June with the secchi disk readings to 1.5 meters closer to the mouth and 1.3 meters to 1.4 meters upstream of the Riverside Bridge. Algae was thick and significant at the upper lagoon stations.

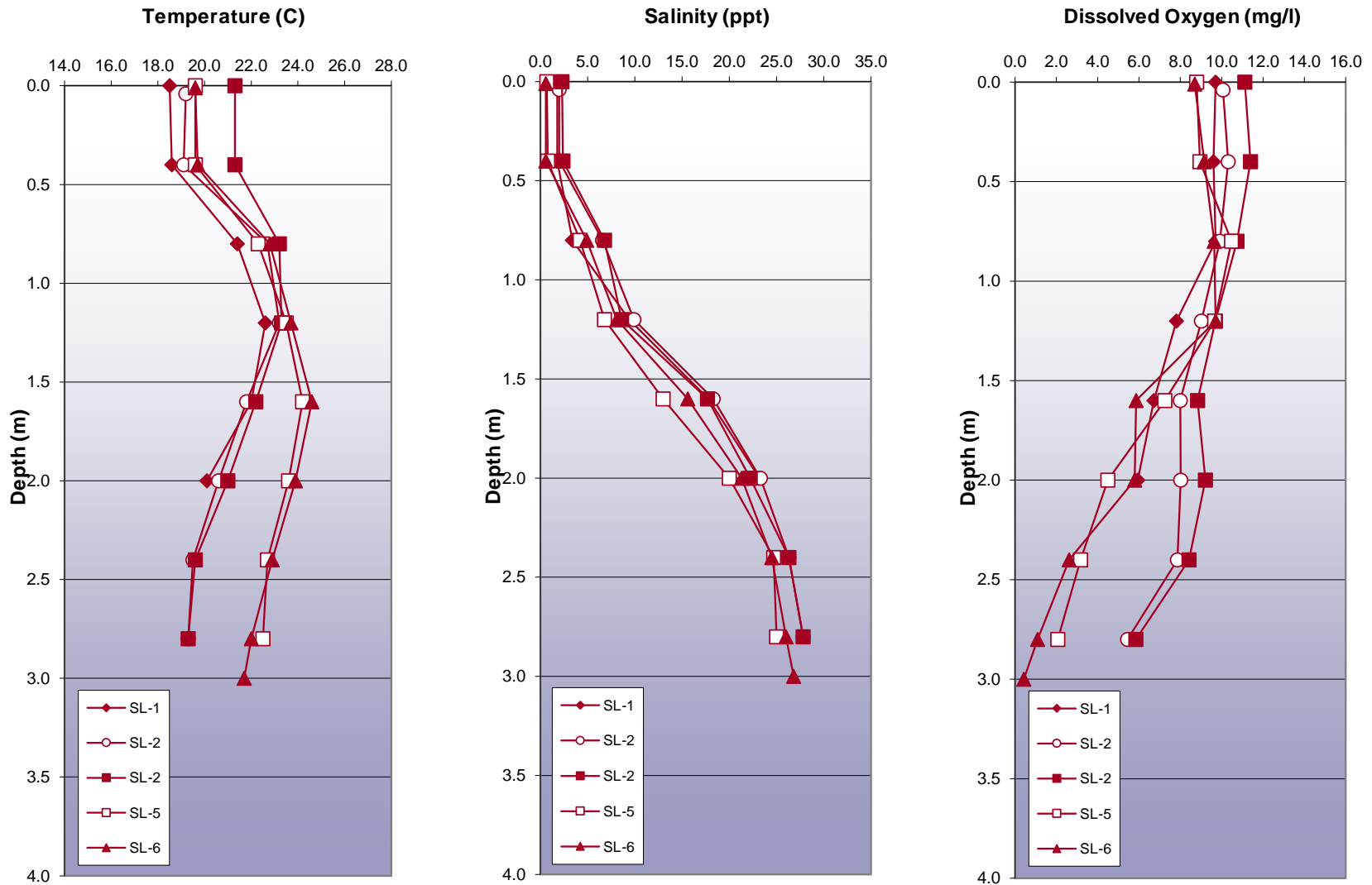


Figure 19. Depth profiles of water quality parameters in the San Lorenzo Lagoon during July Survey (July 7-8)

## July Survey Results

- Eight seine hauls were completed between the beach and the water quality buoy, and upstream of Riverside Bridge (Table 9).
- *O. mykiss* dominated the catch. CPUE was down about 17% from June levels (Table 6) (no significant difference ANOVA single factor, Tukey HSD,  $\alpha >.05$ ) and, at 120.6 was the second highest for July surveys.
- Five *O. mykiss* captured in July had been tagged in June. These fish grew at an average rate of 0.51 mm/day with a range from 0.27 mm/day to 0.69 mm/day (Table 10). All five had been tagged at SL-1 or SL-2 and were recovered at these same two locations.
- The size class distribution for *O. mykiss* shifted 10-20mm larger compared to June (Figure 17), consistent with measured growth rates (Table 10).

**Table 9. Fish catch in San Lorenzo River Lagoon, July 2020**

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>	2	2		2	2	<b>8</b>
<i>O. mykiss</i>	59	738		141	27	<b>965</b>
Sacramento sucker		4		2	3	<b>9</b>
Topsmelt	26	103		5	1	<b>135</b>
Threespine stickleback		4			3	<b>7</b>
Staghorn sculpin				24	22	<b>46</b>
Striped bass					1	<b>1</b>
shrimp					2	<b>2</b>
<i>O. mykiss CPUE</i>	29.5	369.0		70.5	13.5	<b>120.6</b>

- Twenty-seven percent of the catch was characterized as parr or advanced parr and 73% were characterized as silvery parr or advanced silvery parr. None were characterized as smolts.
- All *O. mykiss* examined (189) had an adipose fin, indicating they were not of hatchery origin.
- Fifteen 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.

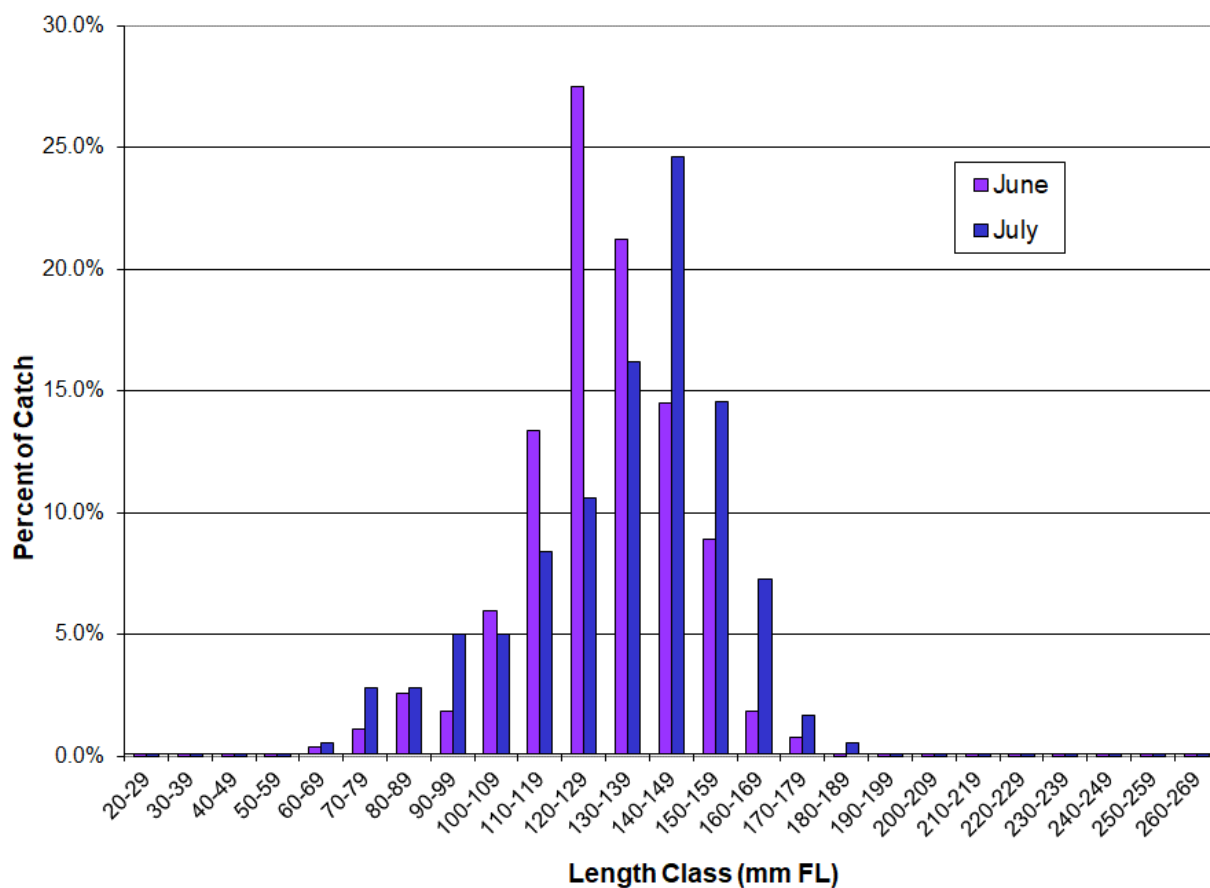


Figure 20. *O. mykiss* length classes in San Lorenzo Lagoon during June and July 2020

Table 10. *O. mykiss* tagged in June and recaptured in July 2020

Previous Capture Date	Recapture Date	Initial Length (mm)	Length at Recapture (mm)	Growth Rate (mm/day)
11-Jun-20	07-Jul-20	117	135	0.69
11-Jun-20	07-Jul-20	117	134	0.65
11-Jun-20	07-Jul-20	120	133	0.50
11-Jun-20	07-Jul-20	132	139	0.27
11-Jun-20	07-Jul-20	173	184	0.42



### August Survey (August 18-19)

The August survey was cancelled due to excessive water temperatures in the lagoon measured on August 12 (Figure 18). Water temperature exceeded 21°C at all depths at Stations SL-1, SL-3, and SL-6 by 10:00 am.

#### August Site Conditions

- The lagoon had breached on July 31 and was micro-tidal at a stage of about 3.6 feet to 3.8 feet through August 10 when it closed again. When water quality was measured on August 12, the lagoon was filling and the stage had increased to about 4.4 feet. Inflow from the San Lorenzo River was relatively stable at 8 cfs to 8.5 cfs (Figure 12).
- The lagoon was fresh with salinity of 2 ppt or less throughout the water column (Figure 21, center panel).
- Water temperature was very warm with minimal stratification (Figure 18, left panel). Temperature exceeded 22°C throughout the water column at Stations SL-1 and SL-3. The surface 0.4 meters was cooler at Station SL-6, likely due to slightly cooler inflows from the San Lorenzo River. The warmest temperatures were at SL-3 with a slight increase in temperature with depth.
- Dissolved oxygen levels were suitable for *O. mykiss* at the time of measurement with the water column above 7 mg/l except for right above the substrate (Figure 21, right panel). Dissolved oxygen levels were elevated at SL-6 relative to the lower lagoon, likely due to the influence of inflow from the San Lorenzo River and/or increased algal productivity where inflows mixed with more lagoon influenced water.
- Water clarity was high with secchi disk visible at the substrate in water up to 2 meters deep at all stations.

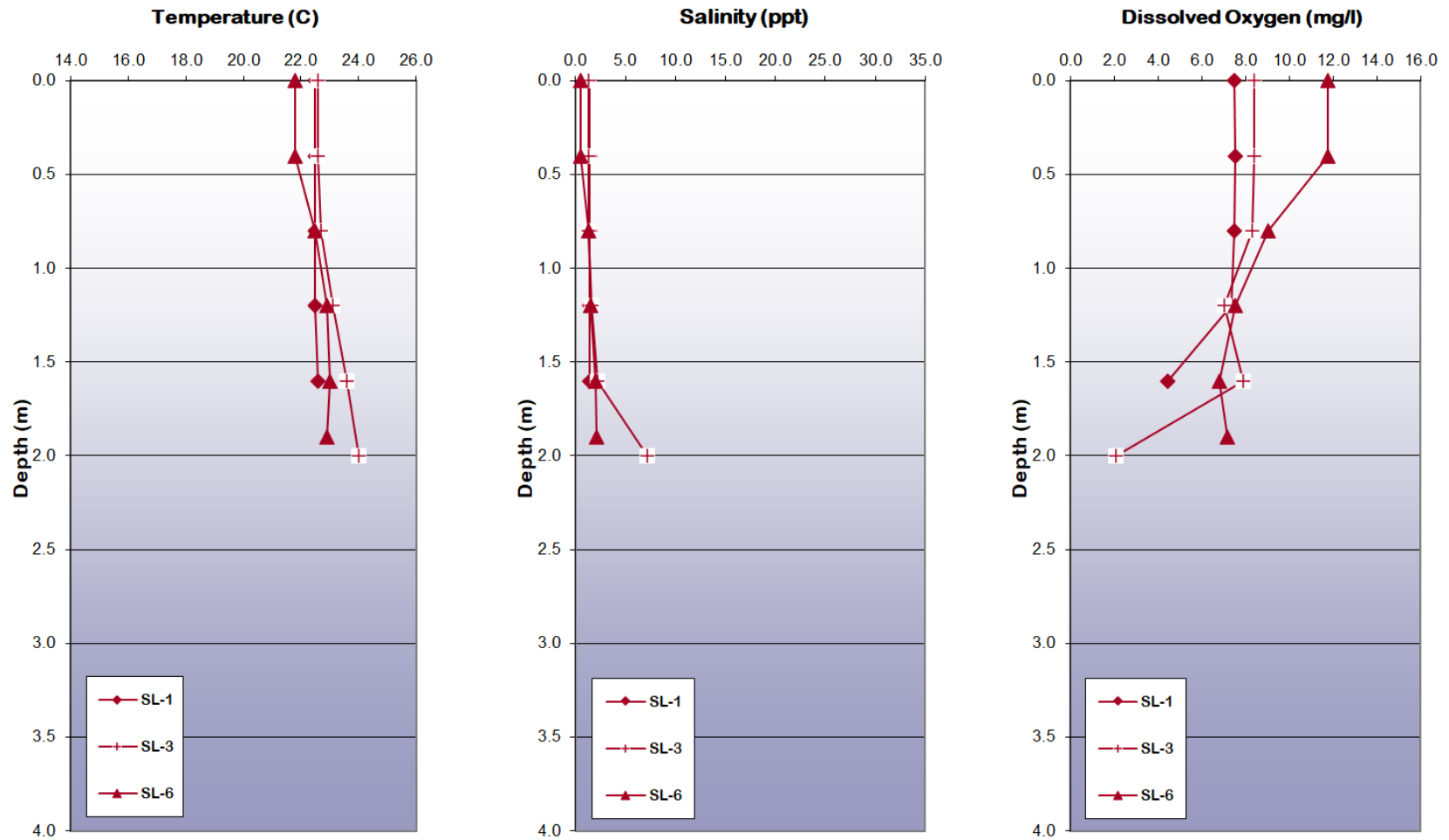


Figure 21. Depth profiles of water quality parameters in the San Lorenzo Lagoon on August 12

### Fall (September 17-18, 21-22)

The September survey was a full survey with population estimate. *O. mykiss* were marked on September 17-18 and recaptured on September 21-22. Sampling was conducted at each of the regularly sampled Stations (SL-1, SL-2, SL-3, SL-5, and SL-6). The lagoon had undergone several fill and spill cycles since the previous sampling in July, with a ten-day period in early August when the lagoon was open with a relatively stable elevation just below 4 feet.

#### Fall Site Conditions

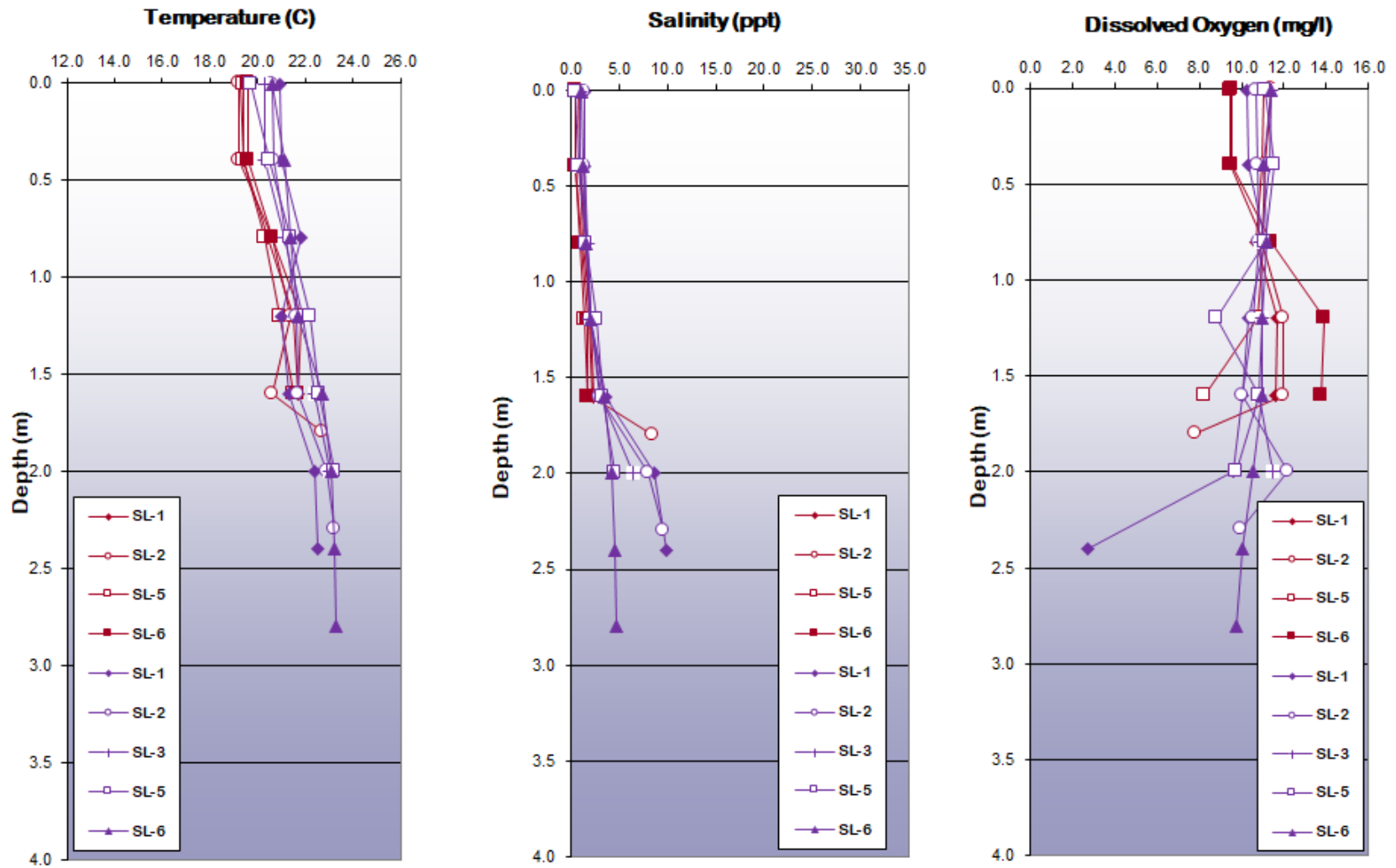
- The lagoon opened on the afternoon of September 16 and dropped about 2 feet over the next 24 hours. It was open when sampling began in the morning on September 17 but closed again late in the day and was filling during the rest of the sampling period (Figure 12, Figure 22). Large amounts of algae drifted down into the lower lagoon overnight on the 16<sup>th</sup>/17<sup>th</sup> (Figure 23). Similar to the early summer site conditions, the outlet channel flowed northward from the bluff across the beach before emptying to the ocean. Daily average flow at Santa Cruz gage ranged from 8.1 cfs to 9.1 cfs. (historical discharge, USGS site 11161000 San Lorenzo River at Santa Cruz California).
- Salinity was low and relatively un-stratified throughout the lagoon during the sampling events. A slight saline lens was observed below 1.5 meters. Salinities ranged from 0.4 ppt to 2.0 ppt in the shallow waters above 1.5 meters and maximum of 9.9 ppt at depth closest to the mouth at SL-1. In general salinities reflected more of a riverine influence than the influx of marine water (Figure 20, center panel).
- Water temperature was warm but in a suitable range for *O. mykiss* in lagoons and was generally well-mixed especially at the stations closer to the mouth (Figure 20, left panel). Temperatures were somewhat higher during the recapture period at all stations. The highest recorded temperature (23.3°C) was upstream of Riverside Bridge at the deepest (2.8 meters) measurement at Station SL-6.
- Dissolved oxygen was well-mixed in the lagoon during the seining (Figure 20, right panel). From the surface to 2.0 meters, dissolved oxygen levels were high, ranging from 7.8 mg/l (just off the bottom at SL-2) to 13.8 mg/l at SL-6 but generally varying between 10 mg/l and 11 mg/l. The lowest reading was 2.7 mg/l on the bottom (2.4 meters) at SL-1, which was measured early in the morning. Floating algae mats were significant through the lagoon and could have contributed to the higher dissolved oxygen levels observed.
- The water column was clear with secchi disk visible near the bottom down to 2.8 meters (9.2 feet) depth. It should be noted that the surface waters at all of the sampling stations were covered with floating mats of algae, particularly in the lower lagoon on September 17 and the upper lagoon on September 22.



**Figure 22. San Lorenzo Lagoon mouth September 16, 4 pm**



**Figure 23. San Lorenzo Lagoon upstream of trestle, September 17 about 7 am**



**Figure 24. Depth profiles of water quality parameters in the San Lorenzo Lagoon during survey on September 17-22**  
**Profiles plotted in red are September 17-18; profiles in blue are September 21-22**

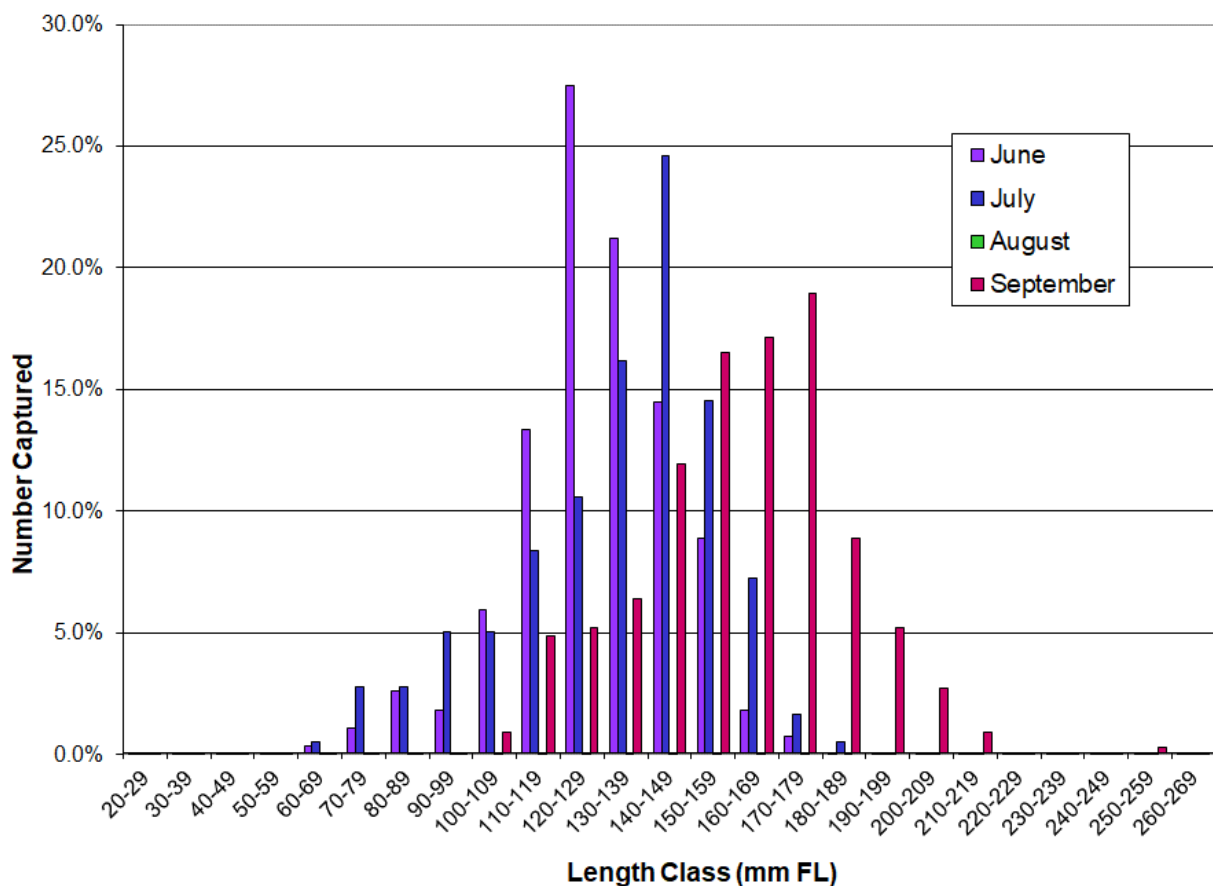
## Fall Survey Results

- Twenty-three seine hauls were completed at regularly sampled Stations (SL-1, SL-2, SL-5, and SL-6).
- Dense algae interfered with sampling upstream of Riverside Bridge where the seine had to be deployed further off the bank than usual due to dense algal mats close to shore. Attempts were made to clear algae from the seine path using a small seine and dipnets for several hauls where algal mats were particularly thick. Sampling at SL-3 was not feasible due to dense algal mats.
- *O. mykiss* had to be scanned for tags at the net and released for two hauls due to large catch and in one case, low dissolved oxygen in holding tanks. These fish were not tagged or measured.
- CPUE for *O. mykiss* was about 25% of the July level and 20% of June level (Table 6). The decline from June was statistically significant (ANOVA single factor, Tukey HSD,  $\alpha < .05$ ) but the decline from July was not (ANOVA single factor, Tukey HSD,  $\alpha > .05$ ).
- Striped mullet were captured. Striped mullet was previously seen in the San Lorenzo Lagoon in August 2015 and September 2016.

**Table 11. Fish catch in San Lorenzo River Lagoon, September 2020**

Species	South of Trestle (SL-1)	Around Trestle (SL-2)	Around Water Quality Station (SL-3)	Upstream of Riverside Bridge (SL-5)	Bend Downstream of Laurel Ave. (SL-6)	Grand Total
<i># Hauls</i>	7	7		4	5	<b>23</b>
<i>O. mykiss</i>	1	211		76	419	<b>707</b>
Striped mullet		1			3	<b>4</b>
Topsmelt	1	55		8	11	<b>75</b>
Threespine stickleback	7	68		21	3	<b>99</b>
Staghorn sculpin		5				<b>5</b>
Tidewater goby		6			1	<b>7</b>
crab	1	9				<b>10</b>
shrimp				2		<b>2</b>
				76	419	
<i>O. mykiss CPUE</i>	0.1	30.1		19.0	83.8	<b>30.7</b>

- The peak in the *O. mykiss* size distribution had shifted about 20 mm to 30 mm larger from July and about 40 mm to 50 mm larger from June, indicating growth over the summer (Figure 25).



**Figure 25. *O. mykiss* length classes in San Lorenzo Lagoon during different sample periods in 2020**

- PIT tag data indicated that at least a few *O. mykiss* may have been in the lagoon all summer (or at least returned to the lagoon by September). Five fish tagged in June were recaptured in July and five were recaptured in September, including one recaptured in both July and September. Also, three *O. mykiss* tagged in July were recaptured in September. These represent a fairly small proportion of all fish tagged however (252 in June and 170 in July).
- Growth rates of recaptured individuals over the period from June to September was less than in 2012 and 2016 (significant difference ANOVA single factor, Tukey HSD,  $\alpha < 0.05$ ) but comparable to the other years (no significant difference, ANOVA single factor, Tukey HSD,  $\alpha > 0.05$ ) (Table 13).

**Table 12. *O. mykiss* tagged previously and recaptured in September 2020**

Tag Date	Recapture Date	Number	Average Growth Rate (mm/day)	Growth Rate Range (mm/day)
June	September	5	0.41	0.22-0.62
July	September	3	0.45	0.25-0.58

**Table 13. *O. mykiss* Growth Rates for Years Available**

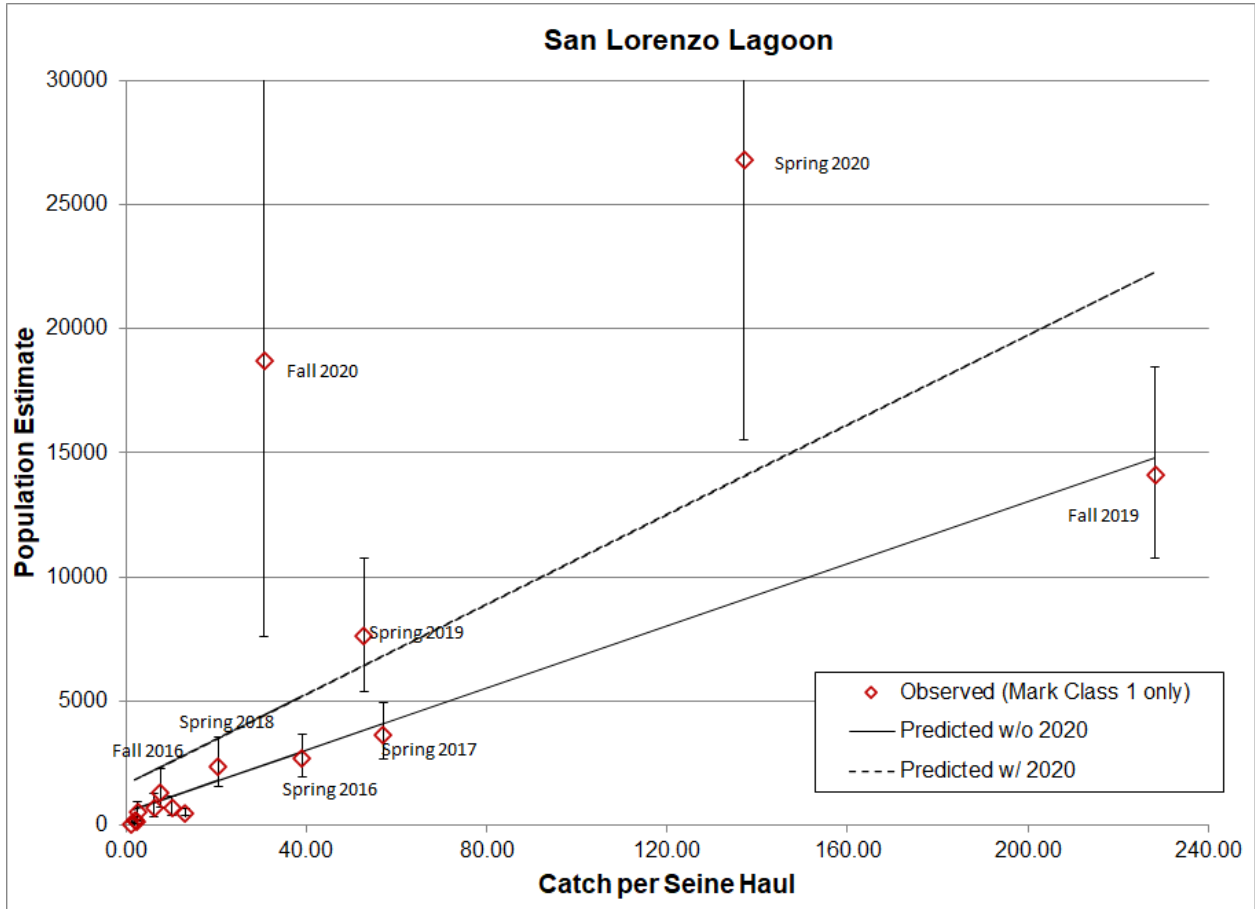
Year	N	Average June-Sept Growth (mm/day)	Range June-Sept Growth (mm/day)	September CPUE
2012	4	0.72	0.58-0.84	14.4
2013	2	0.34	0.27-0.41	4.7
2014	None captured			
2015	None captured			
2016	21	0.90	0.45-1.14	7.8
2017	40	0.46	0.02-0.86	328
2018	10	0.39	0.26-0.49	6.3
2019	88	0.38	0.03-0.85	216
2020	5	0.41	0.22-0.62	31

- Sixty-two percent of the catch was characterized as parr or advanced parr, 38% as silvery parr or advanced silvery parr, and one fish had the appearance characterized as adult/ocean. This was a substantial shift from July when 27% of the catch was characterized as parr or advanced parr and 73% were characterized as silvery parr or advanced silvery parr. The shift may reflect movement of parr into the lagoon over the late-summer period. Nearly 80% of parr and advanced parr were captured upstream of Riverside Bridge. The adult/ocean fish was 258 mm in length and was captured at SL-6.
- All *O. mykiss* examined (330) had an adipose fin, indicating they were not of hatchery origin.
- Sixteen percent of 327 *O. mykiss* examined had black-spot disease (BSD) lesions. The majority (78%) of black spot infestations were characterized as light. Incidence of BSD has ranged between 8% and 72% in annual surveys since 2009.
- Eighty-two *O. mykiss* (25% of those examined) were infected with *Lernaea* (anchor worm). Only one *O. mykiss* was infected with *Lernaea* in June.



## Fall *O. mykiss* Population Estimate

- One hundred thirty-two *O. mykiss* were captured during the mark period (September 17 and 18). All were within the taggable size range (80 mm to 320 mm FL). Two of these were recaptures of fish tagged during the mark period. One fish was tagged but did not recover. A total of 129 tagged *O. mykiss* was released in the lagoon by the end of the mark period including 127 fish first tagged during the mark period and 2 fish previously tagged in June or July.
- Five hundred seventy-five *O. mykiss* were captured during the recapture period. All were within the tagging limits. Three had been tagged during the marking period.
- The population estimate using the Petersen method (Ricker 1975) is 18,720 *O. mykiss* in the lagoon at the end of September. The 95% confidence limits for this estimate are 7,610 and 37,440. This is the largest estimate for the *O. mykiss* population in the lagoon during fall and the second highest estimate after the June 2020 estimate of 26,815 (Table 7). The estimate is 70% of the June level but the difference is not statistically significant based on overlapping confidence intervals. The estimate is likely biased due to the low number of recaptures.
- 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 higher during the recapture period (57.5 vs. 10.2 during the marking period) due largely to a single large haul upstream of Riverside Bridge during the recapture period. The difference was not statistically significant (two sample t-test  $p > 0.05$ ). The size distribution of captured *O. mykiss* was similar between the two periods. The lagoon stage was about 2 feet higher during the recapture period but capture efficiency would more likely be lower at a higher stage. Two *O. mykiss* tagged in June and one captured in July were recorded at Felton shortly after tagging (4, 13, and 11 days, see additional discussion below).
- Recapture rates were unusually low in September (0.02), and in 2020 in general (0.04 in June). Recapture rates in the San Lorenzo Lagoon have previously ranged from 0.07 to 0.50 and averaged 0.17. Recapture rates were between 0.07 and 0.09 for all sample periods in 2019 and 2018.
- The relationship between population estimates and CPUE was updated with the 2020 data (Figure 26). The 2020 data points both lie well outside the previous relationship and have much larger error bars than previous estimates. This is consistent with the low recapture rates and questionable validity of the population estimates. The previous least squares regression (through 2019) gave a significant relationship ( $P < .0000004$ ) with an  $r^2$  value = 0.91. Including the 2020 data points reduces the  $r^2$  value to 0.45. The relationship is still significant with  $P \approx 0.004$ .



**Figure 26. Relationship between *O. mykiss* population estimate and CPUE in the San Lorenzo River Lagoon<sup>3</sup>**

<sup>3</sup> 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 also assumed to be near zero. CPUE values adjusted to reflect portion of population in tagging size range only.

Felton PIT tag monitoring

- Between October 1, 2019 and January 12, 2021, the NOAA PIT tag antenna at Felton detected 144 *O. mykiss* tagged in the lagoon (J. Kiernen, NOAA Fisheries Santa Cruz, personal communication, January 13, 2021). Eight fish, recorded at Felton during the winter of December 2019 through April 2020, were likely returning adult steelhead, tagged in the lagoon during the summers of 2017 and 2018. The majority of fish recorded at Felton were tagged in the lagoon during the summer of 2019. These fish were recorded at Felton as early as October but the majority (85%) arrived in December. One of the fish tagged in the lagoon in June reached Felton within 4 days, and another arrived within 13 days.

**Table 14. *O. mykiss* tagged in the San Lorenzo Lagoon and later observed at Felton**

Date Tagged	Number Observed at Felton by Date									Grand Total
	2019		2020							
	Oct	Dec	Jan	Feb	Mar	Apr	Jun	Jul	Nov	
2017										
Jun						1				1
Jul			2		1					3
2018										
Jun				1	2					3
Sep		1								1
2019										
Jun	2	43	2	1	2	2				52
Jul		32			4					36
Aug		16	1	1	2					20
Sep		22		1	1					24
2020										
Jun							2			2
Jul								1		1
Sep									1	1
Grand Total	2	114	5	4	12	3	2	1	1	144

## 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, HES 2018a, HES 2019, and HES 2020)**

Station	Location	<i>O. mykiss</i> Catch per Haul					
<b>2002</b>						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
<b>2004</b>			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	
<b>2005</b>		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	
<b>2008</b>		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	
	<b>Overall</b>	<b>2.6</b>				<b>0.1</b>	
<b>2009</b>		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	
	<b>Overall</b>	<b>0.3</b>			<b>1.0</b>	<b>0.5</b>	
<b>2010</b>		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	
	<b>Overall</b>	<b>7.7</b>	<b>21.5</b>			<b>28.25</b>	
<b>2011</b>		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	
	<b>Overall</b>	<b>13</b>				<b>2.5</b>	

**Table A-1 (continued)**

Station	Location	<i>O. mykiss</i> Catch per Haul					
		Jun 7-12			Sep 13-18		
<b>2012</b>		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		
	<b>Overall</b>	<b>1.7</b>			<b>14.4</b>		
<b>2013</b>		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		
	<b>Overall</b>	<b>2</b>	<b>8.4</b>		<b>4.7</b>		
<b>2014</b>		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		
	<b>Overall<sup>4</sup></b>	<b>1.2</b>	<b>1.1</b>		<b>0.0</b>		
<b>2015</b>		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					
	<b>Overall<sup>4</sup></b>	<b>2.6</b>	<b>0</b>	<b>0</b>		<b>0</b>	
<b>2016</b>		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		
	<b>Overall</b>	<b>39.7</b>	<b>1.0</b>	<b>2.0</b>	<b>7.8</b>		
<b>2017</b>		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		
	<b>Overall</b>	<b>134.4</b>	<b>452.0</b>	<b>272.0</b>	<b>328.5</b>		

<sup>4</sup> Standard sites only (SL1-SL6) used in Overall calculation

**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		
<b>2018</b>							
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		
	<b>Overall</b>	<b>23.3</b>	<b>2.5</b>	<b>6.4</b>	<b>6.3</b>		
<b>2019</b>		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		
	<b>Overall</b>	<b>92.2</b>	<b>53.4</b>	<b>277.7</b>	<b>228.2</b>		
<b>2020</b>		11-16 Jun	Jul 7-8	Aug 19-20*	Sep 17-22		
SL-1	South of Trestle	70.5	29.5	NS	0.1		
SL-2	RR Trestle	75.0	369.0	NS	30.1		
SL-3	Near YSI Station	155.0	NS	NS	NS		
SL-5	Riverside Drive	257.0	70.5	NS	19.0		
SL-6	U/S Bank Restoration	207.3	13.5	NS	83.8		
	<b>Overall</b>	<b>146.1</b>	<b>120.6</b>	NS	<b>30.7</b>		



Figure A-1. Laguna Creek Lagoon sampling stations





**Figure A-2. San Lorenzo River Lagoon sampling stations**

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