TECHNICAL MEMORANDUM

TO: Chris Berry
City of Santa Cruz Water Department

FROM: Jeff Hagar
Hagar Environmental Science

DATE: June 28, 2016

PROJECT: City of Santa Cruz Habitat Conservation Plan, Lagoon Fish Population Sampling 2015

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 2015 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 fall using a large seine (150 ft. long by 8 ft. deep). Additional catch per effort surveys were conducted in the San Lorenzo Lagoon during July and August. Mark-recapture abundance estimates for *O. mykiss* were completed in both lagoons during both the June and October sampling periods using PIT tags. Fish were tagged one day and recaptured the next day in Laguna Creek Lagoon. In the larger San Lorenzo River Lagoon, fish were captured and tagged on two consecutive days and recaptured during a subsequent two-day period (in the San Lorenzo Lagoon there were two days between the end of the mark period and the beginning of the recapture period). During July and August only catch per unit effort (CPUE) was assessed, no PIT tagging was implemented. A summary of the results of the survey follows.

During the summer of 2015 Laguna Lagoon and the San Lorenzo Lagoon provided very different conditions and were used in very different ways by steelhead. Only a single steelhead was captured in Laguna Lagoon in June, immediately after lagoon closure, but steelhead recruited to the lagoon over the summer, reaching moderate abundance in the fall. Steelhead were present in San Lorenzo Lagoon in June. The closed lagoon became very warm early in the summer and no steelhead were found during sampling in July, August, and September.

Laguna Creek Lagoon

<u>Summary</u>

The winter of 2014-2015 was dry with most of the season's precipitation occurring in December. Flow was between 1 and 2 cfs for most of the winter with only three brief storm pulses, one in early February and two in April. The February storm approached the minimum migration flow estimate for adult steelhead (15.5 cfs) for a couple of hours, but never reached it. The April storms peaked at 4.8 and 4.5 cfs. This was the only time flow reached the smolt migration minimum of 3.8 cfs after mid-February. Flows were well below the optimum spawning level of 9.4 cfs except during December and briefly during the February storm. Summer flows at the anadromous gage dropped below 1 cfs in mid-June. Flows declined abruptly at intervals of a few days at a time after late July, in a pattern that is likely the result of upstream private diversions (Figure 1). Flow was calculated as low as 0.01 cfs at times during August and September. The lagoon closed shortly after the monitoring equipment was installed on May 1 (Figure 1), but opened again from May 14 through May 30. Lagoon depth increased gradually through mid-July then began a gradual decline through late-September (Figure 1).

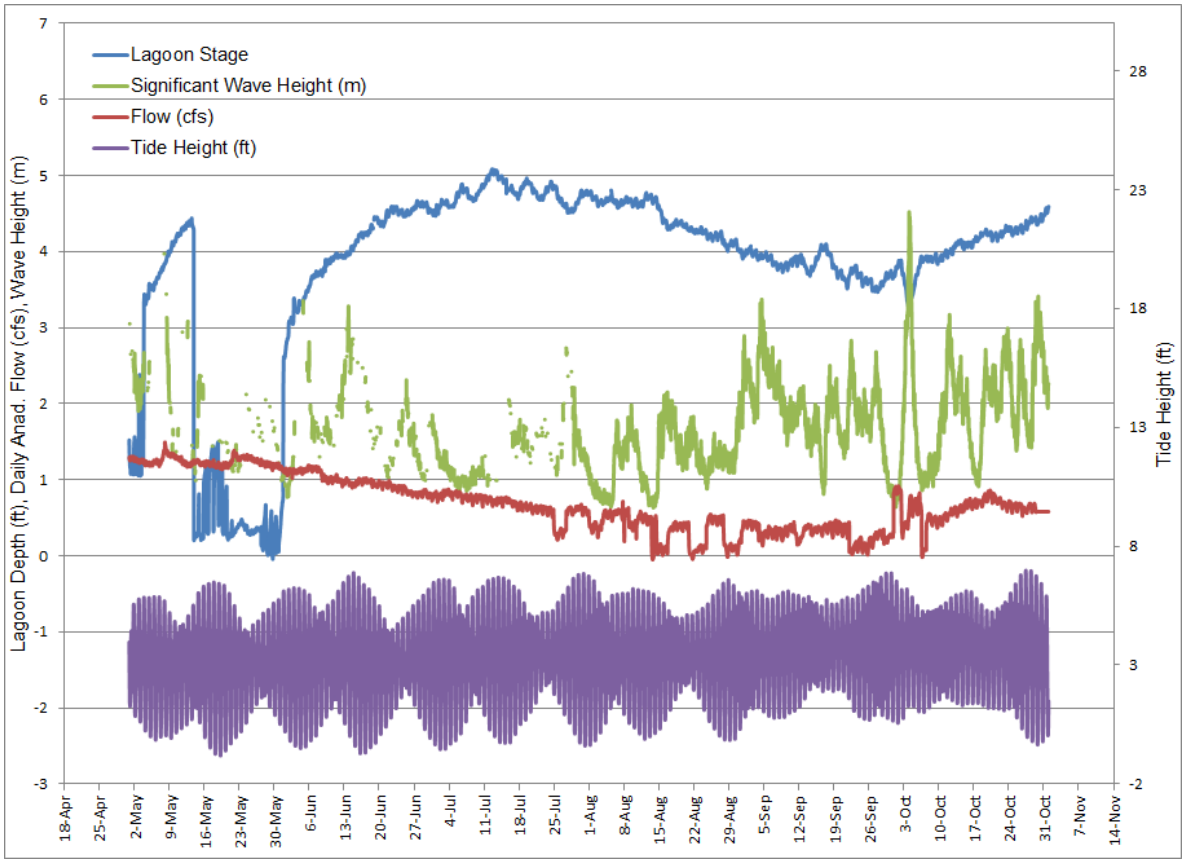

Figure 1. Laguna Creek Lagoon stage, streamflow, wave height, and tides 2015, preliminary data (Source: lagoon stage from 2ND Nature, streamflow from Balance Hydrologics, wave and tide data from NOAA)

On the June 2 initial sample date, the lagoon had recently closed and was still stratified with high salinity and warm temperature (18°C -23.1°C) at 0.8 m depth and below. Only a single *O. mykiss* was captured. By the fall sample date in early October rearing steelhead had moved into the lagoon. The CPUE and population estimate were in the mid-range for surveys to date since 2011. The single *O. mykiss* tagged in June was recaptured in October and showed excellent growth rate (0.99 mm/day).

Spring (June 2)

Spring Site Conditions

- The mouth had closed just 2 days before seining. Stage was ~3.07 ft. at the water quality buoy with greatest depth only about 5 ft. The usual pockets of deep water were present along the rock bluff, the sand beach at the back of the mouth, and along the edge of the marsh inland (Figure 2).
- Inflow from Laguna Creek was about 1.0 cfs.
- Lagoon was stratified with salinity elevated at 0.8 m depth and below (17-27 ppt); temperature ranging from 14°C to 16.6°C at surface and 17.7°C to 23.1°C at the bottom; dissolved oxygen 8.0 mg/L or more (saturation 92% to over 100%).
- The water column was clear with substrate visible at greatest depth surveyed (4.1 feet).

Figure 2. Laguna Creek Lagoon, June 2, 2015

Spring Survey Results

- A single *O. mykiss* was captured and tagged on June 2. Recapture sampling was not conducted on June 3 due to the low catch.
- Eight seine hauls were completed between the beach and the water quality monitoring station (LA-3) (Table 1). An additional haul was completed in the channel upstream of the water quality buoy. The seine was taken upstream to a point where the channel was completely blocked by willows and pulled back to the water quality buoy. The single *O. mykiss* was captured in this haul.
- CPUE for *O. mykiss* was 0.11, the lowest catch seen for June in all survey years (Table 2).
- The single *O. mykiss* was a 95 mm fork length (FL) parr with adipose fin.
- A new species, Pacific mackerel (*Scomber japonicus*) was captured for the first time since this sampling series began (Figure 3). Two individuals were captured near the mouth. Juvenile staghorn sculpin and starry flounder were also present as were threespine stickleback. None of these was abundant. Although tidewater goby were not captured, they were observed at LA-1.5 in emergent vegetation along the bank and escaping through the net.
- The over-wash pond was not sampled.

Table 1. Fish catch in Laguna Creek Lagoon, June 2015

Species	LA-1	LA-1.5	LA-2	LA-3	LA-4/3	Grand Total
	June 2					
# Hauls	4	2	1	1	1	***9***
O. mykiss					1	**1**
Threespine stickleback		1	1			**2**
Staghorn sculpin	1	8	5	5	4	**23**
Pacific mackeral	2					**2**
Starry flounder		2		1	3	**6**
O. mykiss CPUE	*0*	*0*	*0*	*0*	*1.0*	***0.1***

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

Table 2. *O. mykiss* and coho salmon 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, and HES 2015)

	O. mykiss Catch per Haul				Coho 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*

Figure 3. Pacific mackerel, Laguna Creek Lagoon, June 2015

Spring *O. mykiss* Population Estimate

- A single *O. mykiss* was captured and marked on June 2. No population estimate was possible.
- The lagoon population of *O. mykiss* was very low, essentially zero. The single fish recorded was captured at a non-standard sampling station upstream of the water quality buoy.

Fall (October 5-6)

Fall Site Conditions

- Mouth was closed, stage was relatively high fluctuating from 3.6 ft. to 3.9 ft. (2nd Nature data)(Figure 1).
- The lagoon had remained closed since the June survey. Water quality monitoring data indicates a period during July with waves over-washing the sandbar and elevated bottom salinity, warm bottom temperature, and low dissolved oxygen (<5 mg/L) in bottom and surface waters (2nd Nature preliminary data). Surface water temperature varied between 17°C and 22°C over the summer (2nd Nature preliminary data).
- Inflow from Laguna Creek fluctuating between 0.5 to 0.8 cfs.
- Maximum depth to about 5 feet. 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, and along the marsh at LA-1.5 and LA-2 (Figure 4).
- Lagoon was fresh and unstratified. Temperature profiles were isothermal in the morning at 17.2°C to 18.6°C with slight warming at the surface to 19.6°C to 20.9°C later in the day; dissolved oxygen ranged from 6.0 mg/l at the bottom in the morning to 9.4 at the surface in the early afternoon.
- The water column was relatively clear with the secchi disk visible at the bottom in up to 5.0 ft. of depth.
- Large amount of rooted aquatic vegetation was present at LA-1.5 and areas upstream and "leafy" green algae was present near the substrate at LA-1.

Figure 4. Laguna Creek Lagoon, October 5, 2015

Fall Survey Results

- *O. mykiss* were captured and marked on October 5. On October 6 the lagoon was re-sampled and the proportion of re-captured fish was recorded.
- Six seine hauls were completed on October 5 and 7 hauls on October 6 between beach (LA-1) and just downstream of the water quality monitoring station (Table 3).
- 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 mid-range recorded for Laguna Lagoon in previous fall surveys with 2 years having higher CPUE and 5 having lower (Table 2).
- *O. mykiss* were captured at all stations though they were not very abundant at Station 3 (Table 3).
- The length distribution of *O. mykiss* was consistent with the average over past years except for a large group of fish in the 230 mm to 260 mm size classes (Figure 5). The 160 mm to 240 mm size class were likely age 1+ fish that entered the lagoon after the early June survey date. The smaller size groups likely comprised young-of-year fish or fish that had moved into the lagoon after the June survey.
- The single *O. mykiss* captured in June was recaptured in October. This fish grew from 95 mm FL on June 2 to 219 mm FL on October 5 for an average growth rate of 0.99 mm per day. This is one of the fastest growth rates measured in the study to date.
- Thirty-three percent of the catch were characterized as parr, 60% were silvery parr or advanced silvery parr, and 6% had the external coloration and appearance of adult stream fish (no parr marks, not particularly silvery, not thin, no blackened caudal margin, and "rainbow" coloration).
- Three out of 126 *O. mykiss* examined (about 2%) had indication of black-spot disease.
- All *O. mykiss* examined had an adipose fin intact.
- A single chinook salmon (*Oncorhynchus tshawytscha)* was captured October 6. This fish was 167 mm FL and was missing an adipose fin, indicating it was of hatchery origin. It was likely in the system before the lagoon closed just before the June survey.
- A new species, striped mullet (*Mugil cephalus*) was captured for the first time City surveys started (Figure 6). Three individuals were captured though five more jumped out of the seine as it was being retrieved. This species was also captured in the San Lorenzo Lagoon in 2015 for the first time.
- Threespine stickleback, starry flounder, and tidewater goby were the only other species captured. Though only a small number of tidewater goby were captured, numerous small individuals were observed near the beach at LA-1 and in the emergent and floating vegetation at LA-2. A 165 mm *O. mykiss* regurgitated a small tidewater goby when it was being processed.
- The over-wash pond was not sampled.

Table 3. Fish catch in Laguna Creek Lagoon, October 2015

Species	LA-1	LA-1.5	LA-2	LA-3	Grand Total
	October 5 and 6				
# Hauls	*6*	*2*	*4*	*1*	***13***
O. mykiss	42	67	33	6	**148**
Chinook salmon			1		**1**
Striped mullet	2		1		**3**
Threespine stickleback	52		6	1	**59**
Tidewater goby			2		**2**
Starry flounder	26		1	2	**29**
O. mykiss CPUE	*7.0*	*33.5*	*8.3*	*6.0*	***11.4***

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

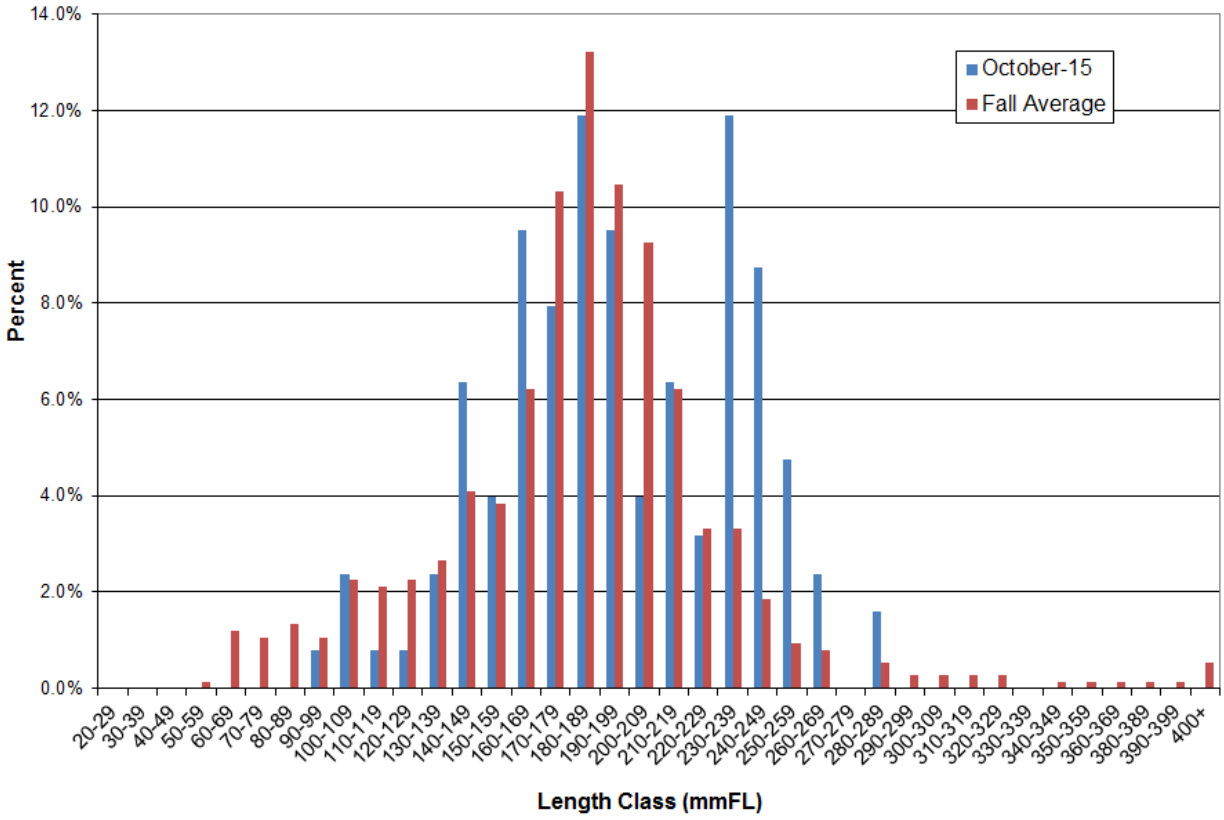

Figure 5. *O. mykiss* length classes in Laguna Creek Lagoon, fall 2015

Figure 6. Striped mullet, Laguna Creek Lagoon, October 2015

Fall *O. mykiss* Population Estimate

- All *O. mykiss* captured on October 5 were larger than 50 mm FL. One *O. mykiss* was over 320 mm and was not included in the population estimate, per the methodology. A total of 64 tagged *O. mykiss* were known to be present in the lagoon at the end of the marking period. This included 63 fish tagged on October 5 and one fish that had been tagged in June and recaptured on October 5.
- On October 6, a total of 81 *O. mykiss* between 50 mm and 320 mm were captured. Of the 81 *O. mykiss* captured, 19 were marked on October 5.
- Population estimate using the Petersen method (Ricker 1975) is 267 *O. mykiss* larger than 50 mm and smaller than 320 mm in the lagoon on October 6. The 95% confidence limits for this estimate are 174 and 405. Since only one *O. mykiss* was captured in the lagoon in June this would indicate that numerous *O. mykiss* entered the lagoon after June. Since the lagoon was closed throughout the period, these fish could only have come from areas upstream of the sample area.
- CPUE was 11.2 on October 5 and 11.6 on October 6, consistent with a stable population during the study period.
- The relationship between population estimate and CPUE was updated with the 2015 data (Figure 7). Least squares regression gives a significant relationship (P=0.028) but with relatively low r^2 = 0.65. Prediction based on only the CPUE during the recapture period (which would be more accurate if the population is changing) is greatly improved with r^2 = 0.94 (P=0.0003). Both relationships are heavily influenced by the fall 2012 data point.

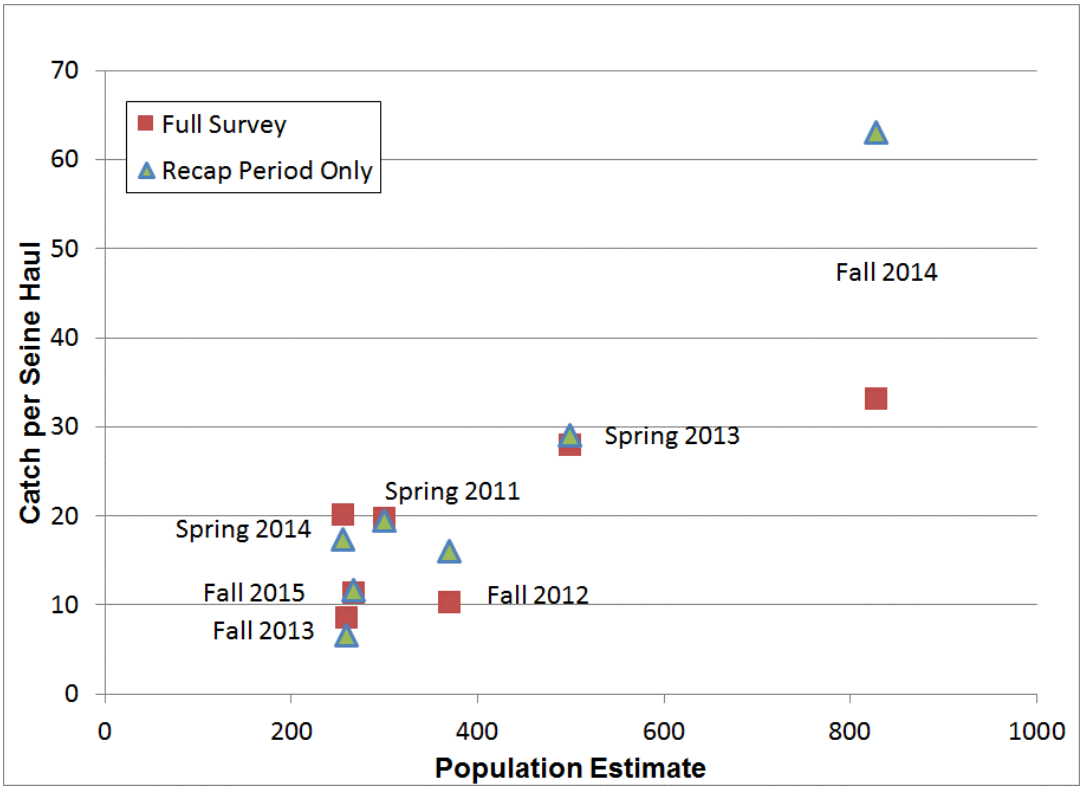

Figure 7. Relationship between *O.mykiss* population estimate and CPUE in Laguna Creek Lagoon[1]

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

San Lorenzo River Lagoon

Summary

The lagoon initially closed on May 3 but re-opened for three brief periods before closing for the season on June 22. Open periods included May 10-11, May 16-28, and June 11-22 (Figure 8). The City of Santa Cruz conducted controlled breaches on August 24 and October 23 in order to reduce lagoon stage. These events consisted of opening the mouth for a few hours with controlled drawdown of up to 2-2.5 feet and subsequent closure. The opening was timed to coincide with low tide so that there was one-way flow out of the lagoon and no inflow from the ocean. The mouth opened naturally on November 3.

After June 22, temperature in the closed lagoon became unusually warm, exceeding 25°C to 26°C for extended periods in both surface and bottom waters (2nd Nature preliminary data). Lagoon stage reached 7 ft. to 7.5 ft. on two occasions but was reduced to 4.5 ft. to 5 ft. by controlled releases. Salinity declined after closure but remained above 5 ppt in both bottom and surface water throughout the summer. Dissolved oxygen levels declined below 5 mg/L at times in both surface and bottom waters, usually for only a few hours during daily cycles at the surface but lasting up to several days in bottom waters. A late summer algae bloom resulted in very high dissolved oxygen in surface waters, particularly at SL-3 (2ndNature preliminary data). The algae bloom was comprised of *Alexandrium*, *Nodularia*, other dinoflagellates, and diatoms (Chris Berry, personal communication, City of Santa Cruz, June 27, 2016). Some strains of these species produce toxins harmful to humans including those leading to paralytic shellfish poisoning.

The San Lorenzo Lagoon was sampled four times during the summer of 2015 (Table 4). The initial seining survey began on June 4, a week after the temporary closure May 28. *O. mykiss* were captured and marked on June 4-5 and sites were resampled for recaptures on June 8-9. Mid-season surveys were completed in July (28-29) and August (18-19), and a final survey was conducted on October 8-9 (since no *O. mykiss* were captured during the marking period, the lagoon was not sampled for recaptures). The two mid-season surveys measured CPUE only, no tagging was completed. The purpose was to get an estimate of steelhead abundance in the lagoon without subjecting fish to the stress of tagging during the period when conditions are likely to be most stressful.

The June CPUE was relatively low but the population estimate was high due to a low number of recaptures. The accuracy of the population estimate is questionable due to a low number of tagged fish, low number of recaptures (only one), and the possibility that fish were moving out of the lagoon between the mark and recapture periods. Lagoon water quality often deteriorates after it closes and *O. mykiss* are known to move upstream out of lagoons at certain times (Hayes et al. 2011). Survival of tagged fish may also have been compromised by warm temperature and small size of many of the fish. Steelhead present in June were mostly large young-of-year and a few smolt-sized fish. No steelhead were found in the lagoon after June.

Table 4. *O.mykiss* catch per haul for the San Lorenzo River Lagoon during 2015

Station	Location	*O. mykiss* Catch per Haul					
2015		4-9 Jun	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					
	Overall	***2.6***	***0***	***0***		***0***	

Spring (June 4-5, 8-9)

Spring Site Conditions

- The lagoon had closed about May 27, a week prior to sampling. It had been open for about 10 days prior to the 27th (Figure 8). Daily average flow at Santa Cruz gage ranged between 8 and 11 cfs during the survey (USGS gage data, San Lorenzo River at Santa Cruz).
- Lagoon stage was relatively high during the survey, increasing from 5.6 ft. (NGVD 29) on the 4th to 6.4 ft. on the 9th (Figures 9 and 10).
- The lagoon had moderate salinity stratification that decreased somewhat over the sample period (Figure 11, center panel). Initially salinity was 4 to 7 ppt in the upper 1.2 meters and as high as 30 ppt at 3 meters depth. During the recapture period (8th and 9th) salinity was 8 ppt or below down to 2.4 meters and bottom salinity was still as high as 30 ppt in the deepest waters (4 meters).
- Temperature was cooler (16-20°C) at the surface and with slight stratification initially and at more downstream locations (Figure 11, left panel), but became warmer (20-22.5°C) and more isothermal during the recapture period (June 8-9).
- Dissolved oxygen was 7 mg/L or higher at depths less than 2 meters, but became depleted at greater depths (Figure 11, right panel).
- Water clarity was relatively high initially with secchi depth from 5.5 ft. near the mouth to 6.9 ft. upstream of Riverside Bridge. Secchi depth was reduced to 3.5-5.4 ft. upstream of Riverside Bridge by the end of the survey period.

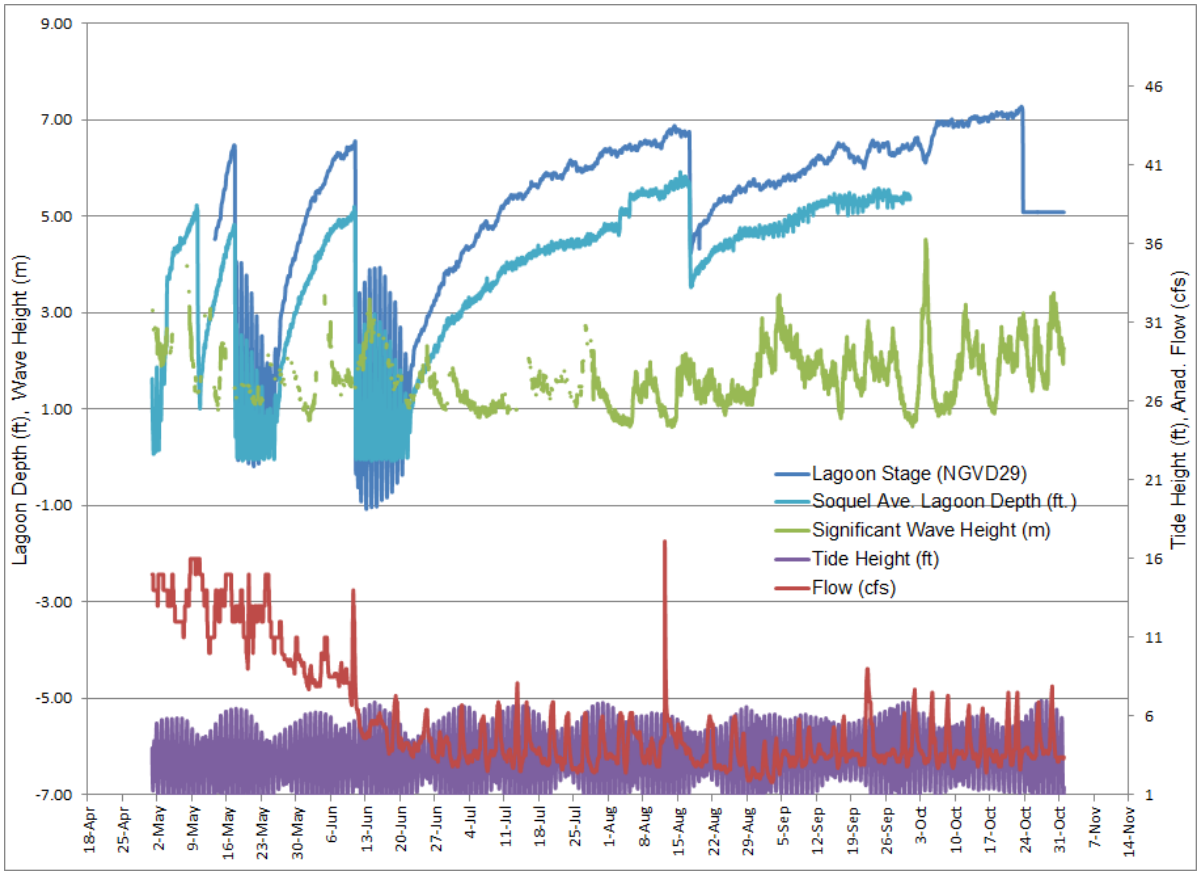

Figure 8. San Lorenzo Lagoon stage, streamflow, wave height, and tides 2015, preliminary data (Source: lagoon stage from 2ND Nature, lagoon depth from City of Santa Cruz, streamflow from USGS, wave and tide data from NOAA)

Figure 9. San Lorenzo Lagoon just upstream of trestle, June 4, 2015

Figure 10. San Lorenzo Lagoon just upstream of Riverside Bridge, June 5, 2015

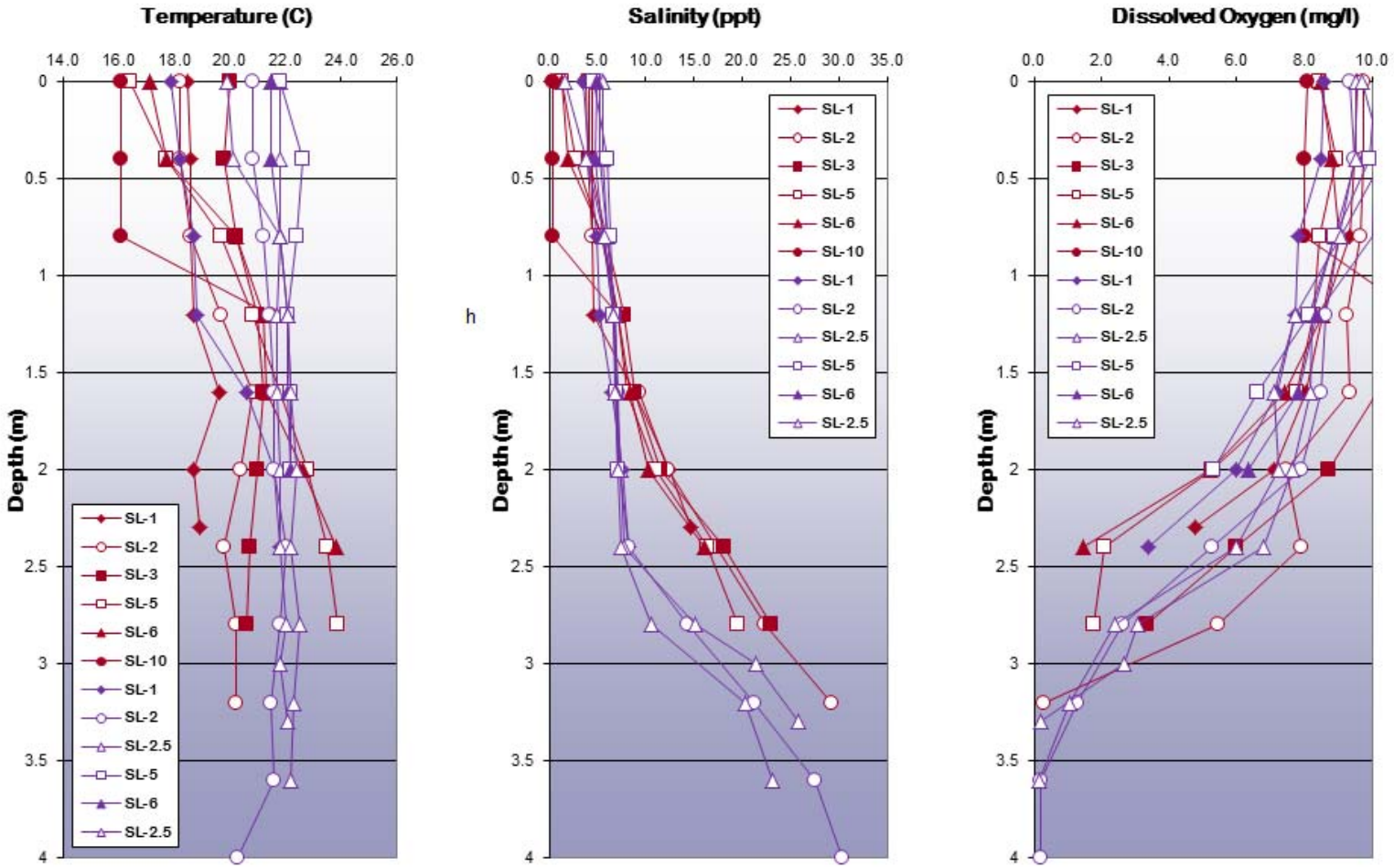

Figure 11. Depth profiles of water quality parameters in the San Lorenzo Lagoon during June. Profiles plotted in red are June 4-5, profiles in blue are June 8-9

Spring Survey Results

- *O. mykiss* were captured and marked on June 4 and 5 and the lagoon was resampled on June 8 and 9. Untagged *O. mykiss* captured on June 8 and 9 were also tagged for over-summer information.
- Completed 28 hauls at regularly sampled stations between the beach and the bend upstream of Riverside Bridge, plus 2 hauls near Water St.
- *O. mykiss* were present at low abundance (2.6 per haul) and were most abundant upstream of Riverside Bridge (Table 5).
- Two size classes of *O. mykiss* were present: presumed young-of-year at 60-90 mm FL, and smolt-size fish at 140-170 mm FL (Figure 12). Sixty percent of *O. mykiss* in the larger size class were characterized as smolts.
- All 65 *O. mykiss* examined had an adipose fin, indicating they were not of hatchery origin.
- The catch was dominated by very abundant topsmelt and Pacific herring. Pacific sardine (*Sardinops sagax*), a new species for the lagoon since the City has conducted surveys, was captured on June 4 upstream of the trestle.

Table 5. Fish catch in San Lorenzo River Lagoon, June 2015

Species	South of Trestle (1)	Around Trestle (2)	Between Trestle and WQ site (3)	Upstream of Riverside Bridge (5)	Bend near Laurel Ave. (6)	Near Water St. (10)	Grand Total
# Hauls	*4*	*9*	*5*	*5*	*5*	*2*	***30***
O. mykiss	3	13	2	44	10		**72**
Pacific herring	46	862	1	16			**925**
Pacific sardine		1					**1**
Topsmelt	1589	7261	1932	410	329		**11521**
Staghorn sculpin	3	1	8	4	27		**43**
Striped bass			36	1			**37**
Shiner surfperch	1	20			1		**22**
Starry flounder		1		9	6		**16**
Crab	2	10	7	4	4		**27**
O. mykiss CPUE	*0.8*	*1.4*	*0.4*	*8.8*	*2.0*	*0.0*	***2.6***[2]

[2] Excluding Water Street which is not regularly sampled.

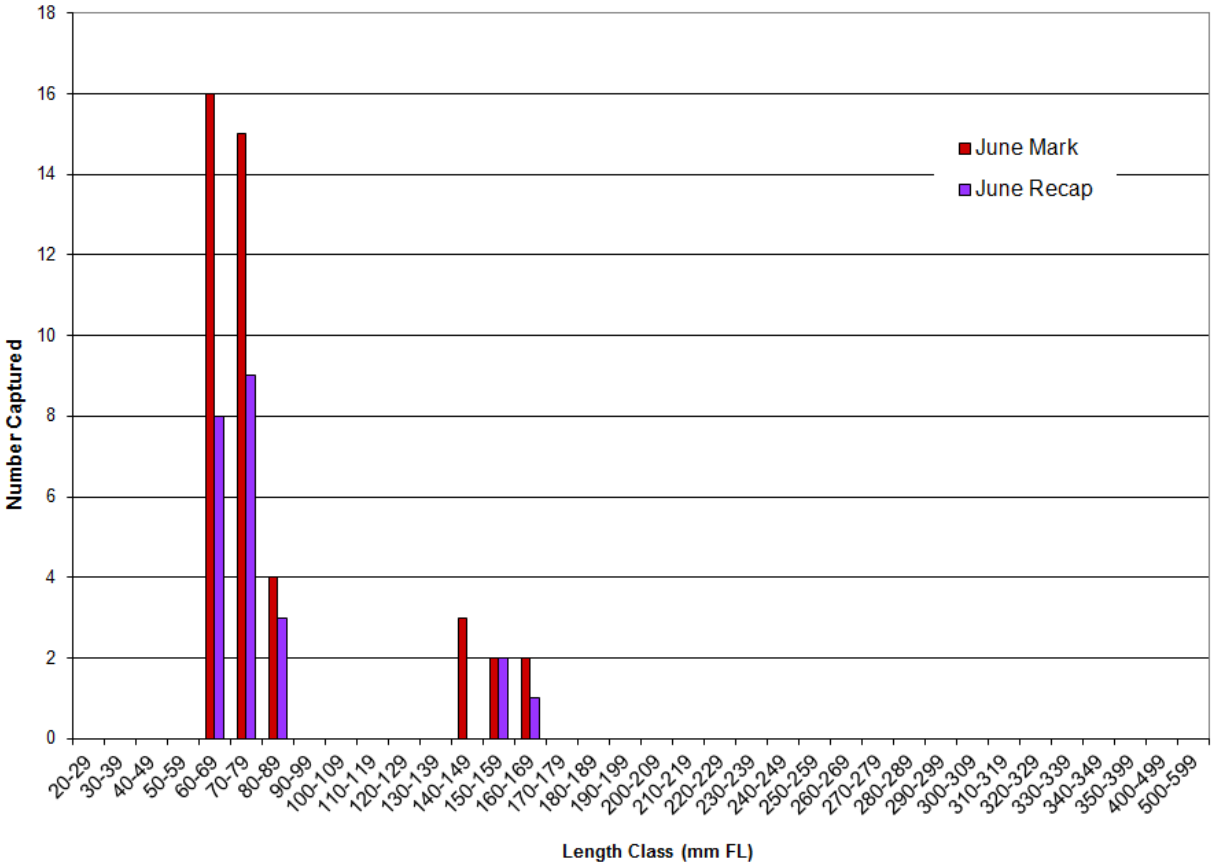

Figure 12. *O. mykiss* length classes in San Lorenzo Lagoon during mark and recapture periods, June 2015

Spring *O. mykiss* Population Estimate

- A total of 47 *O. mykiss* were captured during the marking period. All were larger than 50 mm and smaller than 320 mm. Five fish were captured twice. A total of 42 *O. mykiss* were marked with PIT tags on June 4 and 5.
- Twenty-five *O. mykiss* were captured during the recapture period. Only one of these had been tagged during the marking period.
- Population estimate using the Petersen method (Ricker 1975) is 559 *O. mykiss* in the lagoon in June. The 95% confidence limits for this estimate are 167 and 974. The estimate is likely biased due to the small number of marked fish and small number of recaptures.
- There is also indication that the population may not have been stable, with *O. mykiss* leaving the lagoon. CPUE was 3.1 per haul during the mark period but only 1.9 per haul during the recapture period.
- All untagged fish captured during the recapture period were tagged in order to collect over-summer information. Two of these were recaptured during the recapture period.

Summer (July 28-29)

The July survey was a two-day relative abundance survey. In order to minimize potential harmful effects during potentially stressful mid-summer conditions, captured fish were not tagged and no population estimation was conducted. Sampling was conducted at standard sampling Stations 1, 2, and 3, around the trestle and up to the WQ Station and Stations 5 and 6 upstream of Riverside Bridge.

Summer Site Conditions

- At the time of sampling the lagoon had been open after the June survey but closed for over a month, since June 22. Inflow from the San Lorenzo River was low, about 2.5 to 3 cfs during the sampling period (Figure 8).
- The lagoon stage was at 6.0-6.1 feet NGVD with no beach available for finishing seine hauls except downstream of the trestle.
- There was little to no salinity stratification during the July sample period (Figure 13). Surface salinity ranged from 4.7 ppt near the mouth to 6.4 ppt at SL-3 and bottom salinity from 7.7 ppt at 2.8 meters depth to 8.5 ppt at 3.6 meters depth at SL-3.
- Water temperature was very warm, approaching incipient lethal levels, with surface temperature increasing from 20.7°C in the early morning to 24.4°C in the afternoon (Figure 13). Below the surface, water temperature ranged from 22°C to 24.3°C.
- Dissolved oxygen was at supersaturated levels throughout the water column, ranging from 9.8-15.3 mg/L (Figure 13).
- The water column was moderately clear with secchi depth of 2.9 ft. at SL-1 to 5.3 ft. between SL-5 and SL-6.

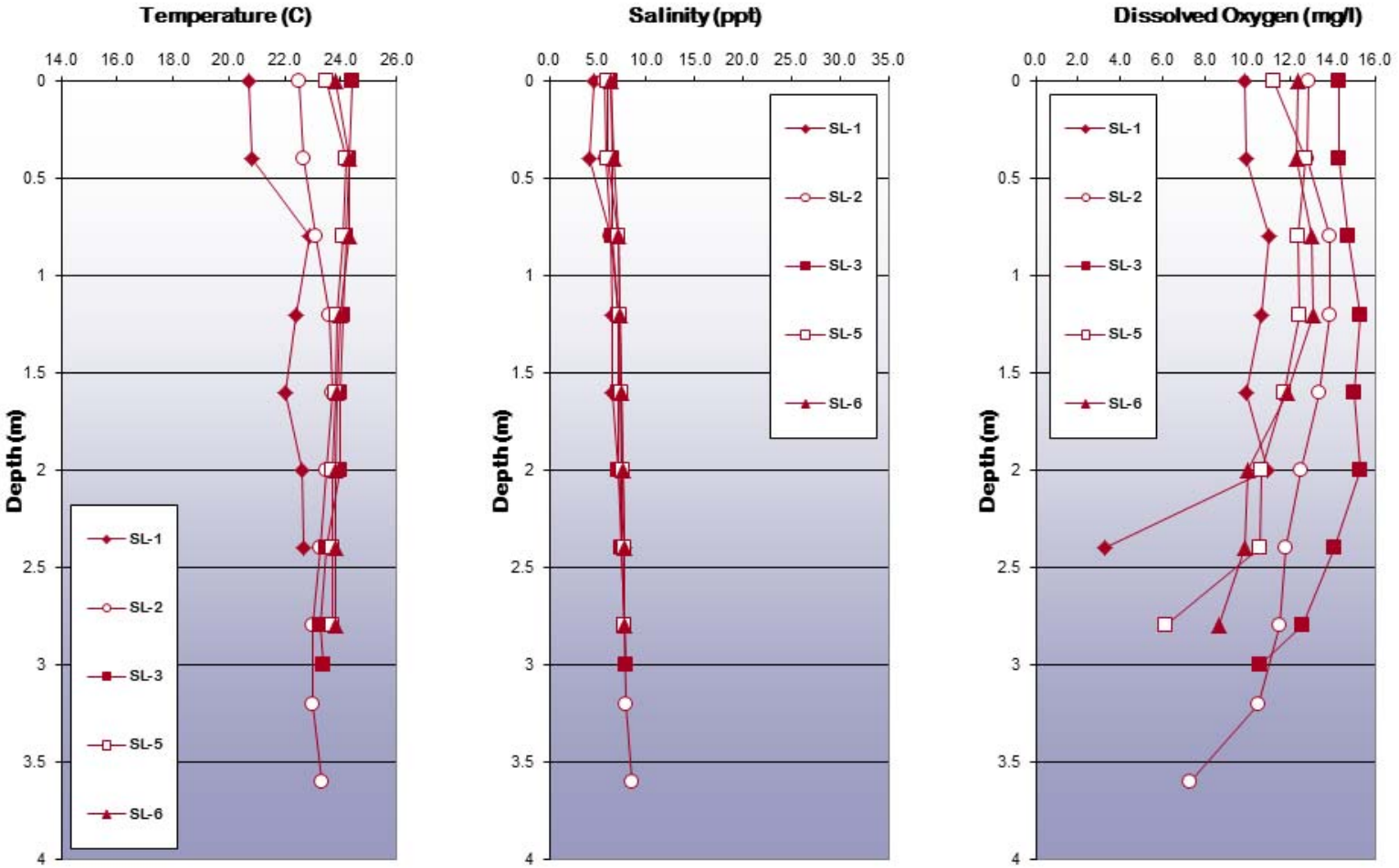

Figure 13. Depth profiles of water quality parameters in the San Lorenzo Lagoon during July Survey (July 28-29)

Summer Survey Results

- Thirteen seine hauls were completed between the beach and the water quality buoy and upstream of Riverside Bridge (Table 6).
- No steelhead were captured in the lagoon in July. Catch consisted of abundant topsmelt along with shiner surfperch, staghorn sculpin and starry flounder (Table 6). Catch rates for these species were significantly lower than in June.

Table 6. Fish catch in San Lorenzo River Lagoon, July 2015

Species	South of Trestle (1)	Around Trestle (2)	Between Trestle and WQ site (3)	Upstream of Riverside Bridge (5)	Bend near Laurel Ave. (6)	Grand Total
# Hauls	*3*	*3*	*2*	*2*	*3*	***13***
Topsmelt	332	89	17	17	33	**488**
Staghorn sculpin	2	3				**5**
Shiner surfperch	8			2		**10**
Starry flounder	4					**4**
Crab	5	5	5	2	4	**21**
O. mykiss CPUE	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	***0.0***

Late-Summer (August 18-19)

The August survey, as in July, was a two-day relative abundance survey. Sampling was conducted at standard sampling stations from downstream of the trestle and up to the WQ Station (Stations 1, 2, and 3) and Stations 5 and 6 upstream of Riverside Bridge.

Late-Summer Site Conditions

- The lagoon was opened by the City of Santa Cruz on August 17 to lower the water surface (Figure 8). Block nets were placed at the outlet but they were washed out in the final stages of the drawdown. Although no fish were observed entering or leaving the lagoon through the outlet channel it is possible that they did. It was closed at the end of the day after the lagoon had been drained from 6.7 ft. NGVD to 4.2 ft. NGVD. During the seining survey lagoon stage gradually increased from 4.5 ft. NGVD on the morning of August 18 to 4.8 ft. NGVD on the afternoon of August 19.
- There was little to no salinity stratification in August, similar to the July sampling period with surface salinity ranging from 4.2 ppt upstream of Riverside Bridge to 6.7 ppt near the mouth and bottom salinity from 7.0 to 7.7 ppt depending on total depth (Figure 14).
- Water temperature was warmer than July, with surface temperature increasing from 23.3°C in the early morning to 26.0°C in the afternoon. Below the surface, water temperature ranged from 24.1°C to 26.1°C (Figure 14).
- As in July, dissolved oxygen was at supersaturated levels throughout the water column except in the deepest waters. DO was 11 mg/L or more in most of the water column (Figure 14).
- The water column was moderately clear with secchi depth of 6.8 ft. at SL-1 to 4.9 ft. at SL-6.

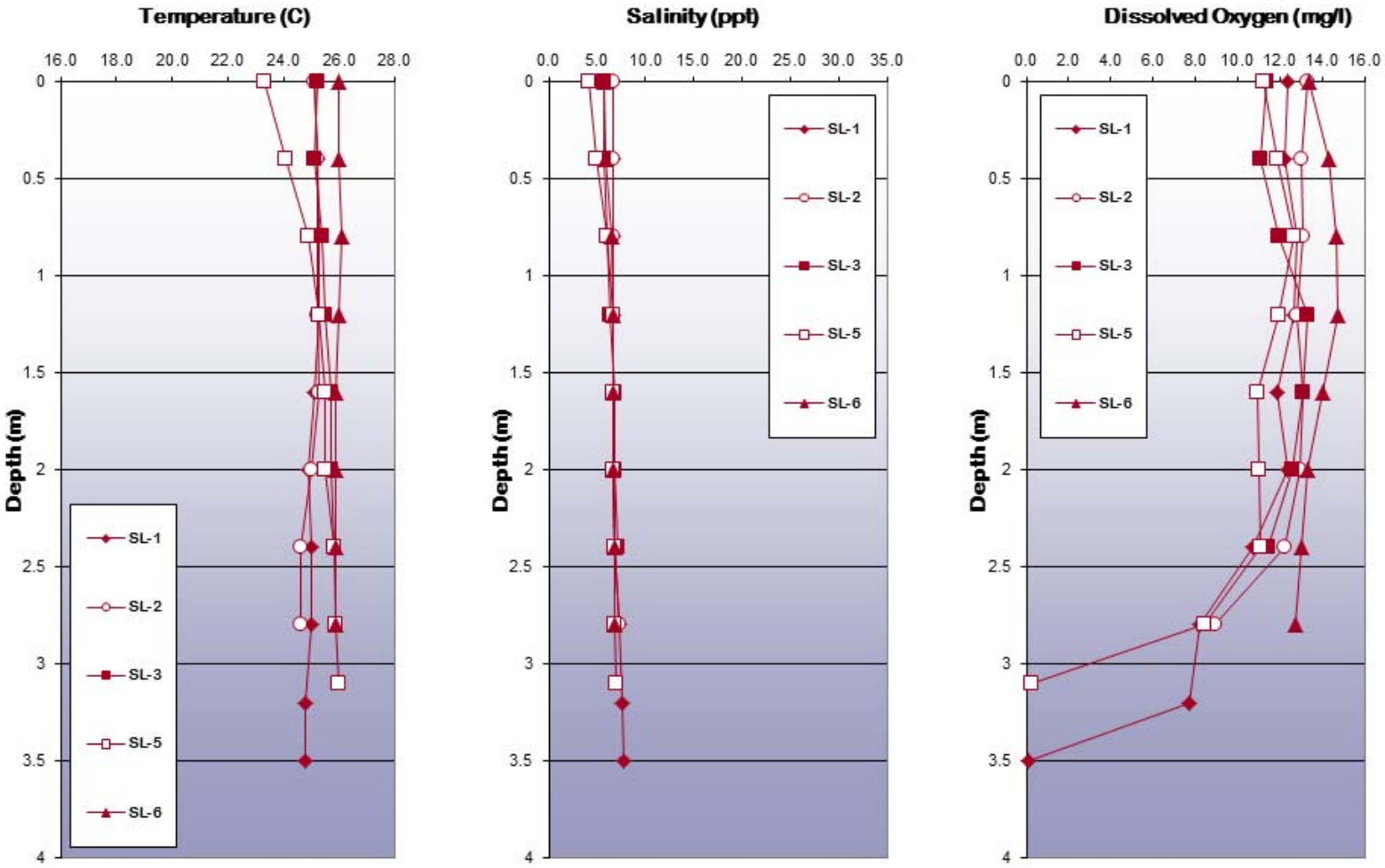

Figure 14. Depth profiles of water quality parameters in the San Lorenzo Lagoon during August Survey (August 18-19)

Late-Summer Survey Results

- Fifteen seine hauls were completed between the beach and the water quality buoy and upstream of Riverside Bridge (Table 7).
- No steelhead were captured in the lagoon in August. Catch was dominated by abundant topsmelt along with shiner surfperch (Table 7). Striped mullet, a new species for the lagoon since the City has conducted surveys, was captured in small numbers, all in a single haul at Station 5.

Table 7. Fish catch in San Lorenzo River Lagoon, August 2015

Species	South of Trestle (1)	Around Trestle (2)	Between Trestle and WQ site (3)	Upstream of Riverside Bridge (5)	Bend near Laurel Ave. (6)	Grand Total
# Hauls	*3*	*4*	*2*	*2*	*4*	***15***
Sacramento sucker			1			**1**
Striped mullet				9		**9**
Topsmelt	372	310	42	102	234	**1060**
Threespine stickleback				1		**1**
Striped bass	2				1	**3**
Shiner surfperch	368	258				**626**
Crab	6	3	8	3	4	**24**
O. mykiss CPUE	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	***0.0***

Fall (October 8-9)

Fall Site Conditions

- Lagoon was closed during the survey period (Figure 8). The stage was high at about 7 feet NGVD29. It had been closed since June 22 except for a one-day managed drawdown event August 17. Water clarity was variable, with secchi disk readings of 0.7 ft. near the mouth to 4.3 ft. at Station 6.
- Salinity at the time of the survey was less than 5 ppt throughout the lagoon and lowest at the surface upstream of Riverside Bridge (Figure 15).
- The highest temperature observed during sampling was 22.4°C. Temperature was uniform with depth at lower lagoon stations while upper stations were relatively cool at the surface and warmer with depth (Figure 15).
- Dissolved oxygen was high through the upper water column at levels ranging from 10-18 mg/ l (Figure 15). Oxygen depletion at levels below 5 mg/L occurred only at depths of 2.5 meters or more.

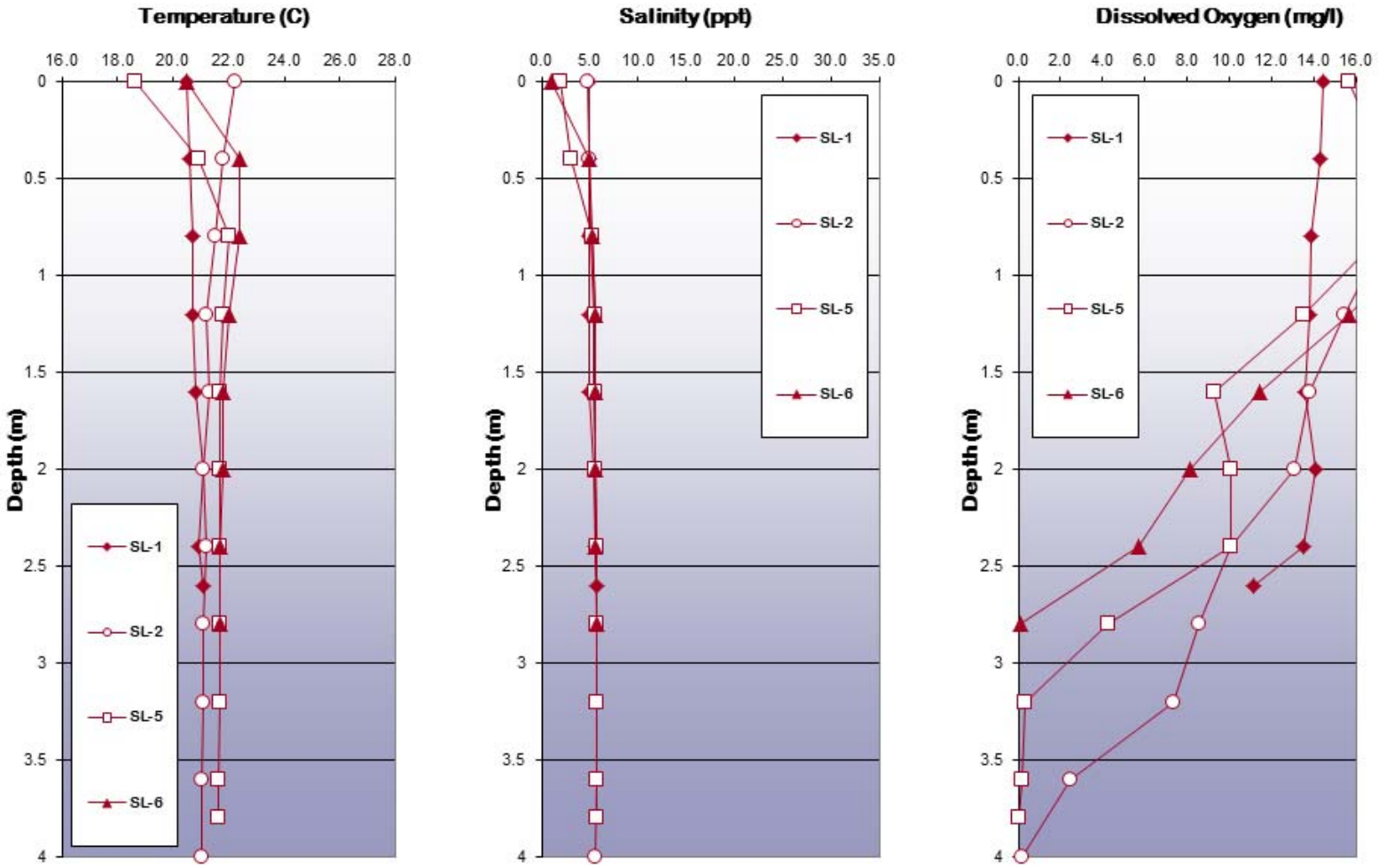

Figure 15. Depth profiles of water quality parameters in the San Lorenzo Lagoon during October Survey (October 8-9)

Fall Survey Results

- Fourteen seine hauls were completed at Stations 1, 2, 3, 5, and 6 on October 8 and 9. No *O. mykiss* were captured. Since no *O. mykiss* were tagged, no recaptures were possible and no additional seining was completed at these sites.
- Topsmelt were relatively abundant and shiner surfperch were also present (Table 8). Starry flounder, striped bass, staghorn sculpin, and Sacramento sucker were present at very low abundance.

Fall *O. mykiss* Population Estimate

- No *O. mykiss* captured during the mark period on October 8 and 9.
- No population estimate is possible though it is likely the population was at or close to zero.
- The relationship between population estimate and CPUE was updated with the 2015 data (Figure 16). Least squares regression gives a not significant relationship (*P*=0.08) with a relatively low $r^2 = 0.57$. The Spring 2015 data point is problematic and may be biased for reasons cited above. Without the 2015 data point, the relationship is significant (*P*=0.007) with an $r^2 = 0.93$.

Table 8. Fish catch in San Lorenzo River Lagoon, October 2015

Species	South of Trestle (1)	Around Trestle (2)	Between Trestle and WQ site (3)	Upstream of Riverside Bridge (5)	Bend near Laurel Ave. (6)	Grand Total
# Hauls	*2*	*5*	*2*	*2*	*3*	***14***
Sacramento sucker					1	**1**
Topsmelt	41	432	26	477	684	**1660**
Staghorn sculpin	1					**1**
Striped bass				1		**1**
Shiner surfperch		41	6			**47**
Starry flounder		2				**2**
Crab		4				**4**
O. mykiss CPUE	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	***0.0***

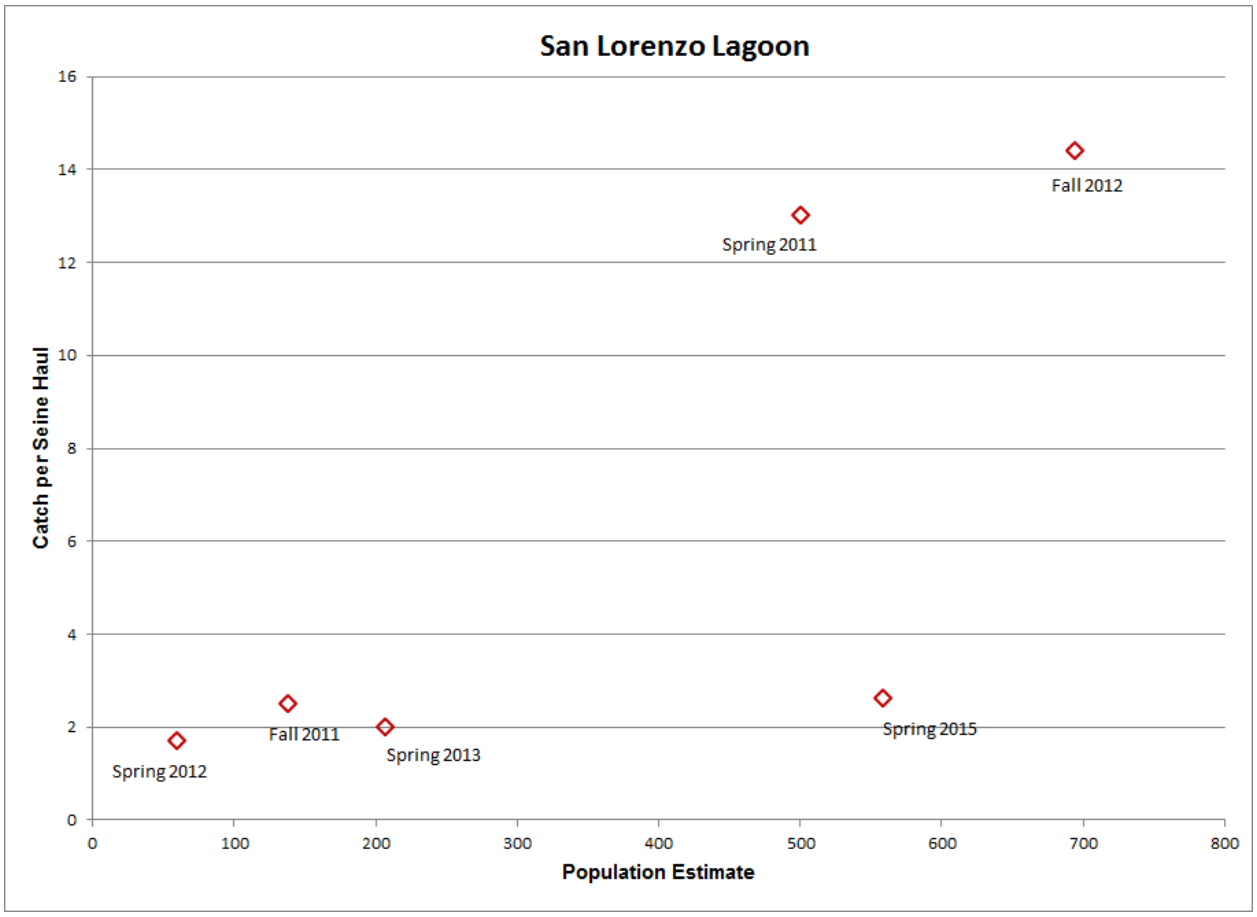

Figure 16. Relationship between *O.mykiss* population estimate and CPUE in the San Lorenzo River Lagoon[3]

[3] The spring 2015 estimate is likely biased due to the small number of marked fish and small number of recaptures.

Table A-1. *O.mykiss* catch per haul for the San Lorenzo River Lagoon during all recent 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, and HES 2015)

Station	Location	*O. mykiss* Catch per Haul					
2002						1 Oct	20 Nov
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			6 July		21 Sep	29 Sep	
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		14 Jun	14 Jul	16 Aug		5 Oct	
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		8, 19 Jun				7-8 Oct	
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		10-11 Jun			16 Sep	21 Oct	
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		22-23 Jun	17 Jul			Oct	
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	9.0				80.0	
	Overall	***8.3***	***21.5***			***28.25***	
2011		9-14 Jun				Oct	
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 9 (continued)

Station	Location	*O. mykiss* Catch per Haul					
2012		7-12 Jun			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		6-11 Jun	17 July		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		5-10 Jun	17 July		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		
	Overall[4]	***1.2***	***1.1***		***0.0***		
2015		4-9 Jun	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					
	Overall[4]	***2.6***	***0***	***0***		***0***	

[4] Standard sites only (SL1-SL6)

Figure A-1. Laguna Creek Lagoon sampling stations

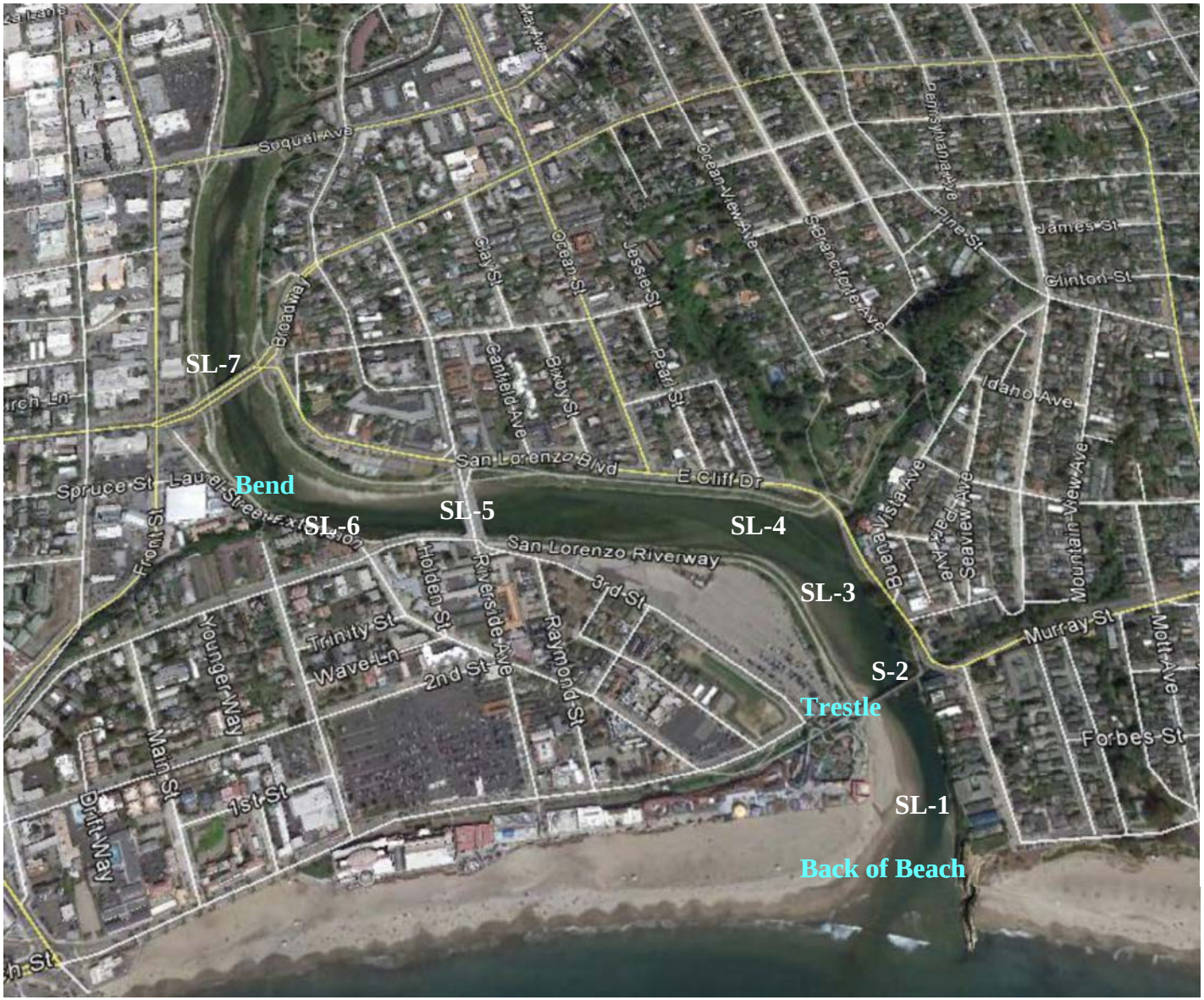

Figure A-2. San Lorenzo River Lagoon sampling stations

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