TECHNICAL MEMORANDUM

TO: Chris Berry
City of Santa Cruz Water Department

FROM: Jeff Hagar
Hagar Environmental Science

DATE: June 27, 2019

PROJECT: City of Santa Cruz Habitat Conservation Plan, Lagoon Fish Population Sampling 2018

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

Laguna Creek

Summary

The winter of 2017-2018 was relatively dry with spring and early summer flows in Laguna Creek only about one third the levels in 2016-2017. Nevertheless, the mouth remained open with tidal fluctuations, sometimes micro-tidal, until mid-July (Figure 1). Inflow remained steady around 1 cfs after July. The City did not divert from Laguna Creek after June during the summer of 2018.

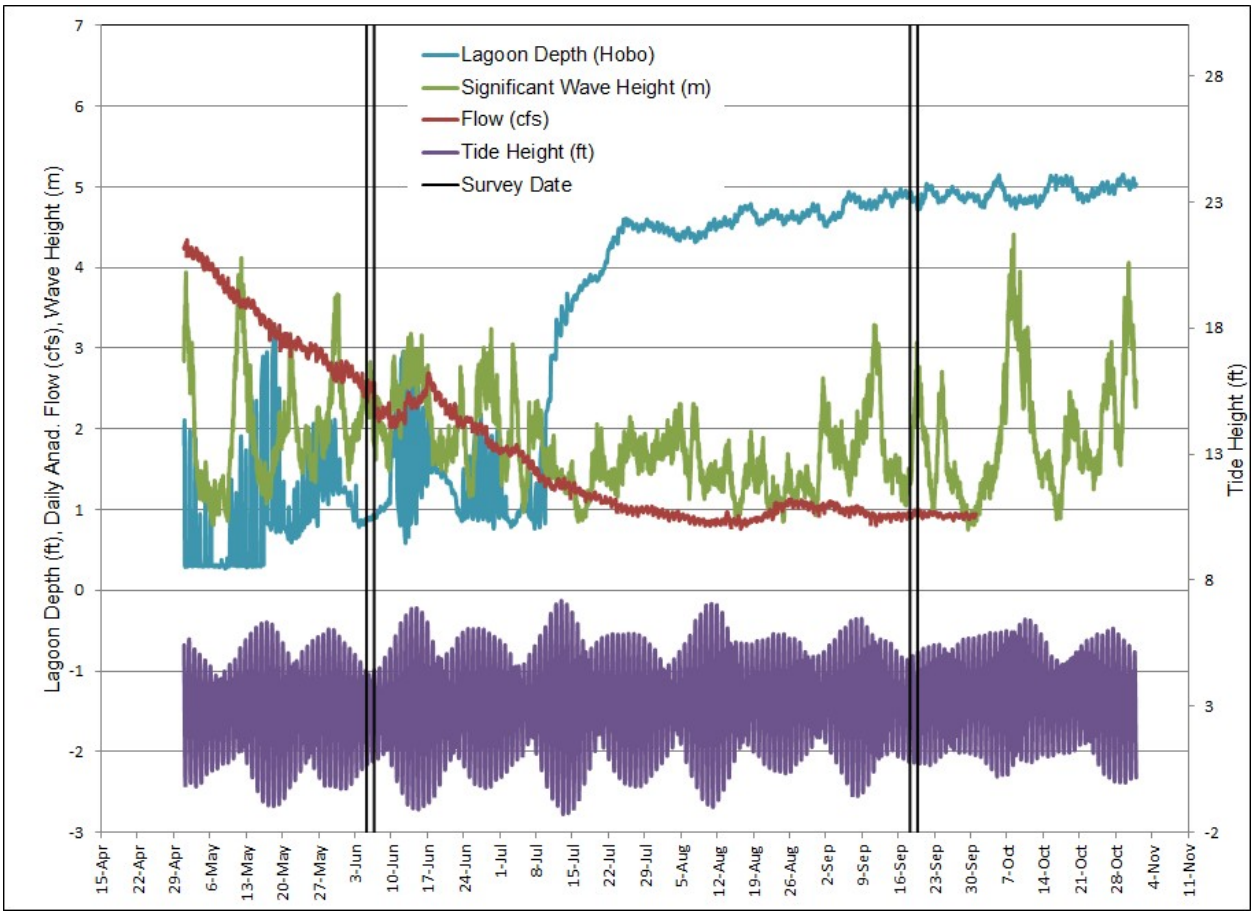

Figure 1. Laguna Creek Lagoon stage, streamflow, wave height, and tides 2018 (Source: lagoon depth from 2ND Nature and City of Santa Cruz, streamflow from Balance Hydrologics, wave and tide data from NOAA)

During the June survey, the mouth was open but the relatively high sandbar and neap tidal cycle resulted in a relatively stable (non-tidal) but low stage lagoon (Figure 2). The greatest lagoon depths were only about 1.2 meters. The lagoon was fresh, cool, and well oxygenated except for a saline layer near the bottom. Catch per unit effort and population estimate in June were in the mid-range for surveys to date. In June the lagoon supported moderately abundant

O. mykiss that appeared to be primarily 1+ and older. Growth rates were excellent over the summer, averaging 0.99 mm/day, but abundance declined between June and September. Smaller *O. mykiss*, likely young-of-year, moved into the lagoon between June and September.

Early summer (June 5-6)

Early summer Site Conditions

- The mouth was open but without much tidal exchange due to perched sandbar elevation and neap tidal cycle. The lagoon elevation was low and any tidal action was muted indicating that the outlet was perched above tidal influence (Figures 1 and 2). Stage ranged from 0.89 to 0.93 feet during the survey. The usual pockets of deeper water were present along the rock bluff, the sand beach at the back of the mouth, and along the edge of the marsh inland but maximum depth was only 1.2 meters (3.9 ft.).

Figure 2. Laguna Creek Lagoon, June 5, 2018

- Inflow from Laguna Creek was around 2.5 cfs during the survey (about 1/3 the levels during the 2017 June survey) (Figure 1).
- The upper two thirds of the water column (0.8 meters) was relatively cool (<18°C), fresh, and well oxygenated (>8 mg/l) with a layer below 0.8 meters with high salinity, high temperature, and low dissolved oxygen (Figure 3). The upper layer provided good conditions for *O. mykiss.*
- The water column was clear with substrate visible at greatest depth surveyed (1.2 meters (4.3 ft.)).

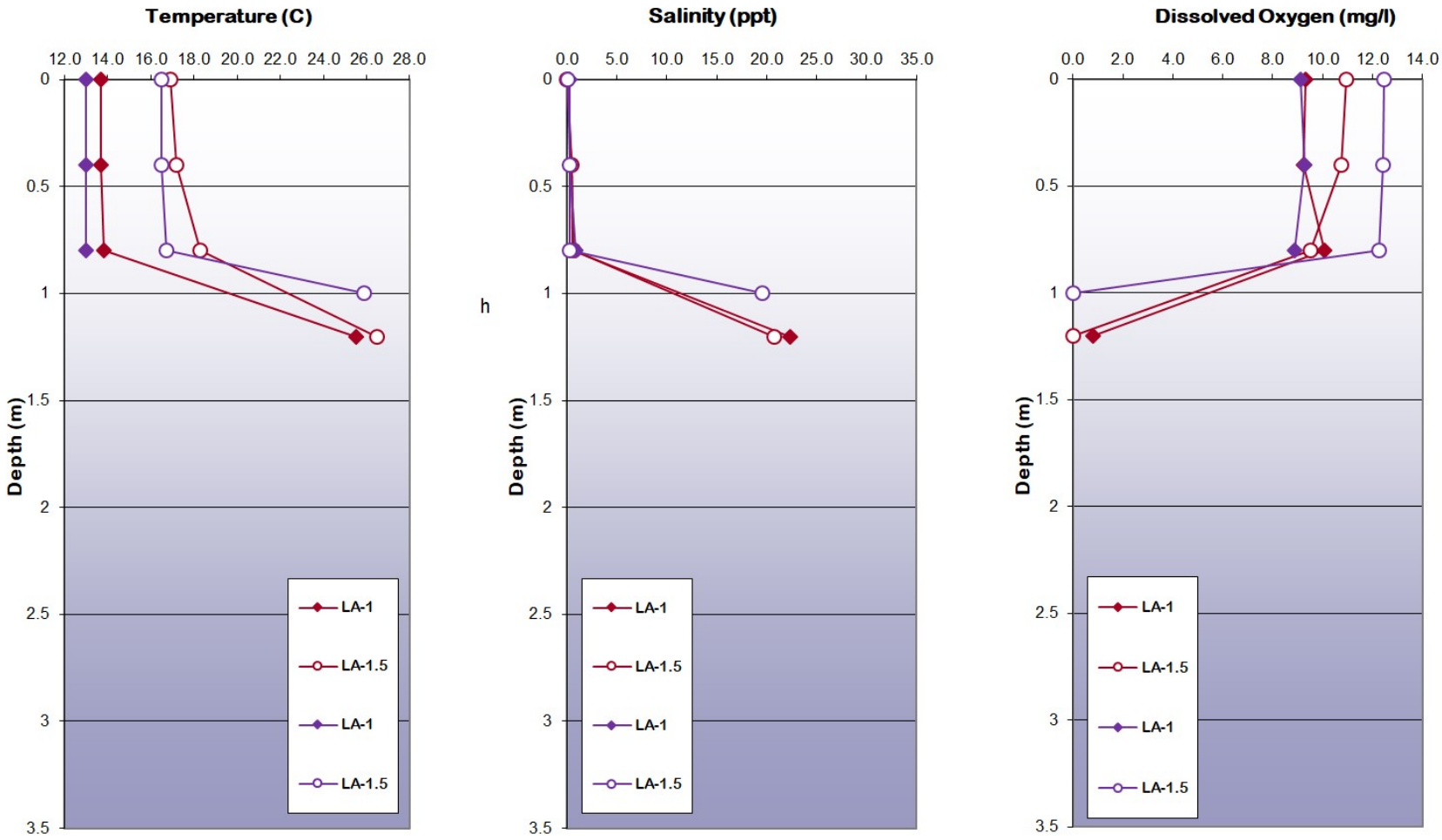

Figure 3. Depth profiles of water quality parameters in Laguna Creek Lagoon during June. Profiles plotted in red are June 5; profiles in blue are June 6

Early summer Survey Results

- *O. mykiss* were moderately abundant in the catch (Table 1). Overall CPUE for *O. mykiss* was in the upper 45% for all early summer surveys, 4 years had higher CPUE and 6 years had lower CPUE (Table 2).

Table 1. Fish catch in Laguna Creek Lagoon, June 2018

	LA-1	LA-1.5	LA-2	LA-3	Grand Total
# Hauls	*6*	*5*	*2*	*0*	***13***
Species	Number Caught				
Steelhead	86	90	10		***186***
Threespine stickleback	756	590	2		***1348***
Prickly sculpin		4	5		***9***
Staghorn sculpin	25	1	4		***30***
O. mykiss CPUE	*14.3*	*18*	*5*		***14.3***

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

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

	O. mykiss Catch per Haul				Coho (*O. kisutch*) 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*	

- All *O. mykiss* captured were larger than 100mm FL, likely age 1+ and older (Figure 4). This is in contrast to June 2017 when the majority of fish (58% of the catch) were less than 80mm FL, probably all young-of-year. Only two were larger than 180mm FL.
- Most of the *O. mykiss* were at parr or advanced parr stage. Only 18% were considered silvery parr and none were characterized as smolts. The two largest individuals (268mm FL and 393mm FL) were characterized as adult in external appearance. The lagoon was still open so any smolts present may have already entered the ocean.
- All *O. mykiss* had adipose fins present.
- Threespine stickleback were very abundant in lower lagoon stations. Tidewater goby were not noted in the catch or otherwise observed.
- The over-wash pond was not sampled.

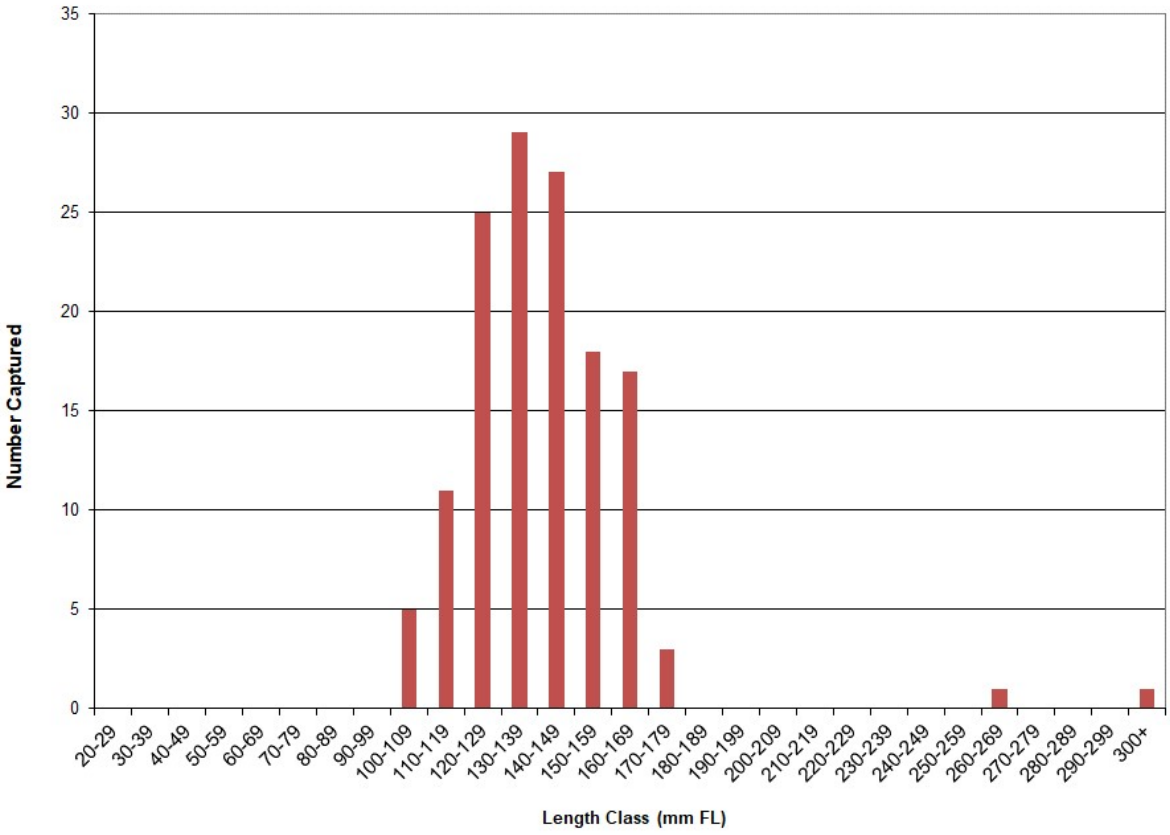

Figure 4. *O. mykiss* length classes in Laguna Creek Lagoon, June 2018

Early summer *O. mykiss* Population Estimate

- Only fish 80mm FL or greater and less than 380 mm FL were included in the population estimate.
- One-hundred and ten *O. mykiss* were captured during the marking period on June 5. One exceeded the upper tagging limit at 393 mm FL and was released untagged. Five were recaptures of fish tagged during the tagging period. Therefore, there was a total of 104 tagged *O. mykiss* in the appropriate size classes released in the lagoon on June 5.
- On June 6, 76 *O. mykiss* were captured. All were within the size limits for tagging. A total of 41 had been tagged on June 5.
- The population estimate using the Petersen method (Ricker 1975) is 193 *O. mykiss* 80mm FL or larger in the lagoon in early-June. The 95% confidence limits for this estimate are 143 and 259.
- Observed CPUE was higher during the mark period and lower during the recapture period (18.3 and 10.9, respectively) indicating possible movement of fish out of the lagoon after the marking period. This difference was not statistically significant at the p=0.05 level (two sample t-test p≈0.5). The size classes had similar distributions in both periods.
- Untagged fish captured during the recapture period were tagged in order to collect over-summer information.

Late summer (September 18-19)

Late summer Site Conditions

- The mouth was closed and had been closed since July 10. Stage was stable during the seining at about 1.4 to 1.5 meters (4.7 to 4.9 ft.) (2nd Nature and City of Santa Cruz data) (Figure 1). Compared to June the stage was higher and the central sandbar present in June had washed away and/or was now inundated (Figure 5).
- Inflow from Laguna Creek at the time of the survey was fluctuating around 0.9 cfs.
- Maximum depth to about 2.2 meters (7.2 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, and along the marsh at LA 1.5 and LA-2.
- The lagoon was de-stratified, fresh, cool, and oxygenated in the entire water column (Figure 6). Temperature profiles were nearly isothermal between 16.0°C and 17.6°C. (Figure 6, left panel). Dissolved oxygen ranged from 6.4 mg/l to 8.9 mg/l (Figure 6, right panel).
- The water column was clear with secchi visibility at the bottom at depths to 2.5 meters (8.2 ft.)

Figure 5. Laguna Creek Lagoon, September 18, 2018

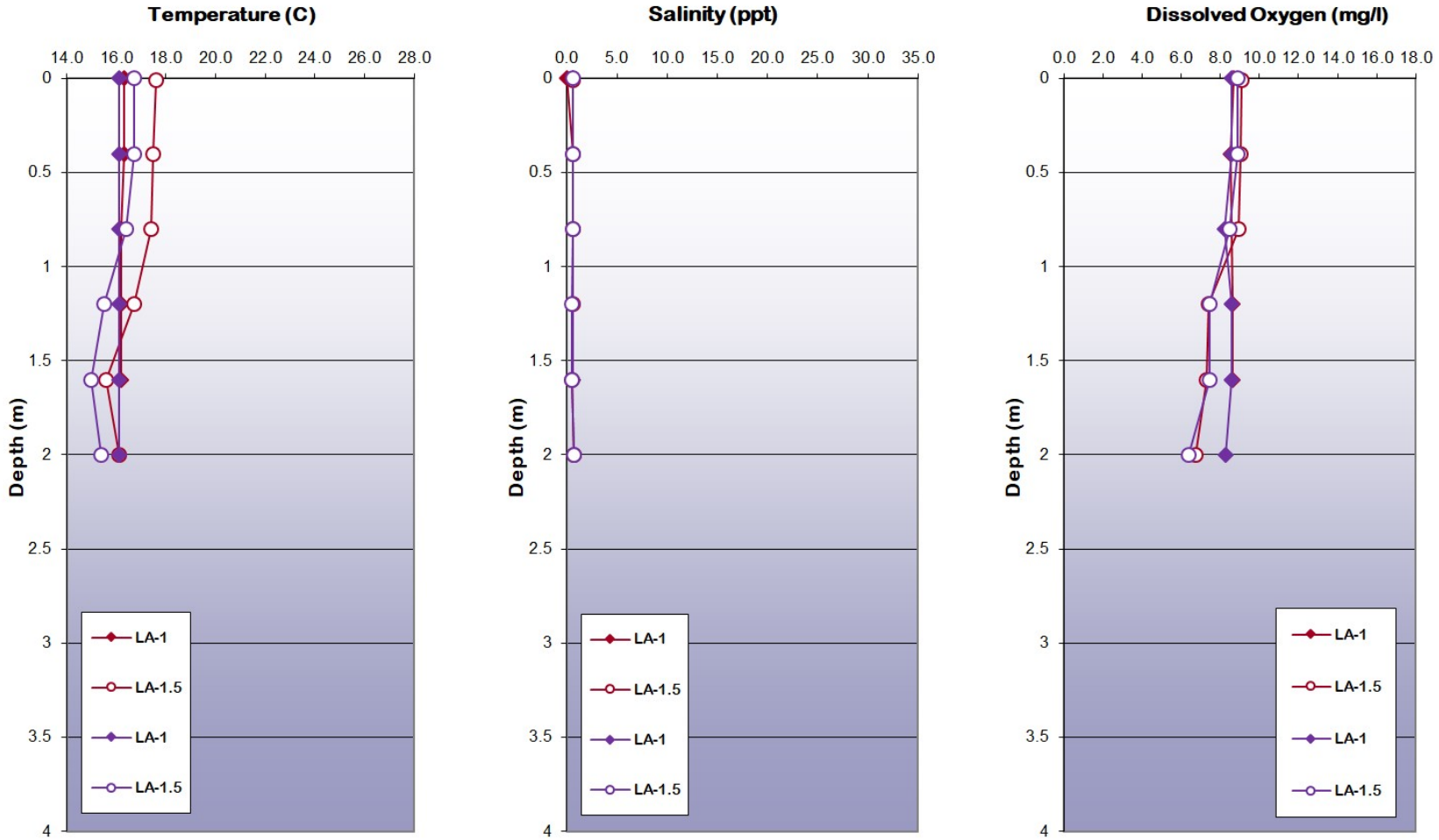

Figure 6. Depth profiles of water quality parameters in Laguna Creek Lagoon during September. Profiles plotted in red are September 18; profiles in blue are September 19

Late summer Survey Results

- *O. mykiss* were captured and marked on September 18. On September 19 the lagoon was re-sampled and the proportion of re-captured fish was recorded.
- Eight seine hauls were completed on September 18 and 9 hauls on September 19 between the beach (LA-1) and just downstream of the water quality monitoring station (Table 3).
- In addition to *O. mykiss*, stickleback and small numbers of sculpin and tidewater goby were captured (Table 3). Large numbers of small stickleback were seen in some areas but were not captured due to the relatively large mesh size of the net. Likewise, small tidewater gobies are not susceptible to capture.
- Overall abundance of *O. mykiss* based on number caught per seine haul (catch per unit effort or CPUE) at 6.5 per haul was at the lower end for Laguna Creek in previous late summer surveys with 5 years having higher CPUE and 3 having lower (Table 2). CPUE was half the level in June (14.3 per haul) although this difference is not statistically significant at the p=0.05 level (two sample t-Test, p≈0.1). Since the lagoon was open for a month after the June survey some fish may have migrated to sea between surveys; although no smolts were observed in June there were some silvery parr present.
- CPUE was higher during the mark period (September 18) at 7.8 per haul but dropped to 5.4 per haul on September19 (not significantly different, two sample t-test, p≈0.3). Fish in the 220 mm FL to 230 mm FL size-class were less abundant on the 19th than the 18th (Figure 7).
- Twenty-three *O. mykiss* tagged in June were recaptured in September. These fish grew at an average rate of 0.99mm per day (range 0.87 to 1.34mm/day), or about 104mm over the period (range 91-141mm FL) (Table 4). This was significantly higher than any previous year (ANOVA single factor, Tukey HSD, $\alpha<0.01$) (Tables 5 and 6).
- There were two modes to the size distribution in September. The smaller group of 90mm FL to 150mm FL apparently moved into the lagoon after the June sampling, likely as young-of-year. The larger group of fish from 190mm FL to 250mm FL were likely holdovers from June. The difference in median size of the larger September fish (~225mm FL) and the June fish (~145mm FL) is consistent with the observed average growth of 0.99mm/day for fish tagged in June and recaptured in September (Figure 8, Table 4).
- Sixty-one percent of the *O. mykiss* catch were characterized as parr (sizes from 80-209mm FL), 16% were characterized as silvery parr (lengths from 170-239mm FL), and 23% had the appearance of advanced silvery parr/adult or ocean migrants (lengths from 200-309mm FL).
- No incidence of *O. mykiss* with black-spot disease or other external parasites, disease, or abnormalities was noted.
- One *O. mykiss* out of 111 examined had no adipose fin. The fish was a 174mm FL silvery parr.
- The over-wash pond was not sampled.

Table 3. Fish catch in Laguna Creek Lagoon, September 2018

	LA-1	LA-1.5	LA-2	LA-3	Grand Total
# Hauls	*8*	*6*	*2*	*1*	***17***
Species	Number Caught				
O. mykiss	23	43	20	25	***111***
Threespine stickleback	54	5	5		***64***
Prickly sculpin	1				***1***
Staghorn sculpin	1				***1***
Tidewater goby	1	1			***2***
O. mykiss CPUE	*2.9*	*7.2*	*10.0*	*25.0*	***6.5***

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

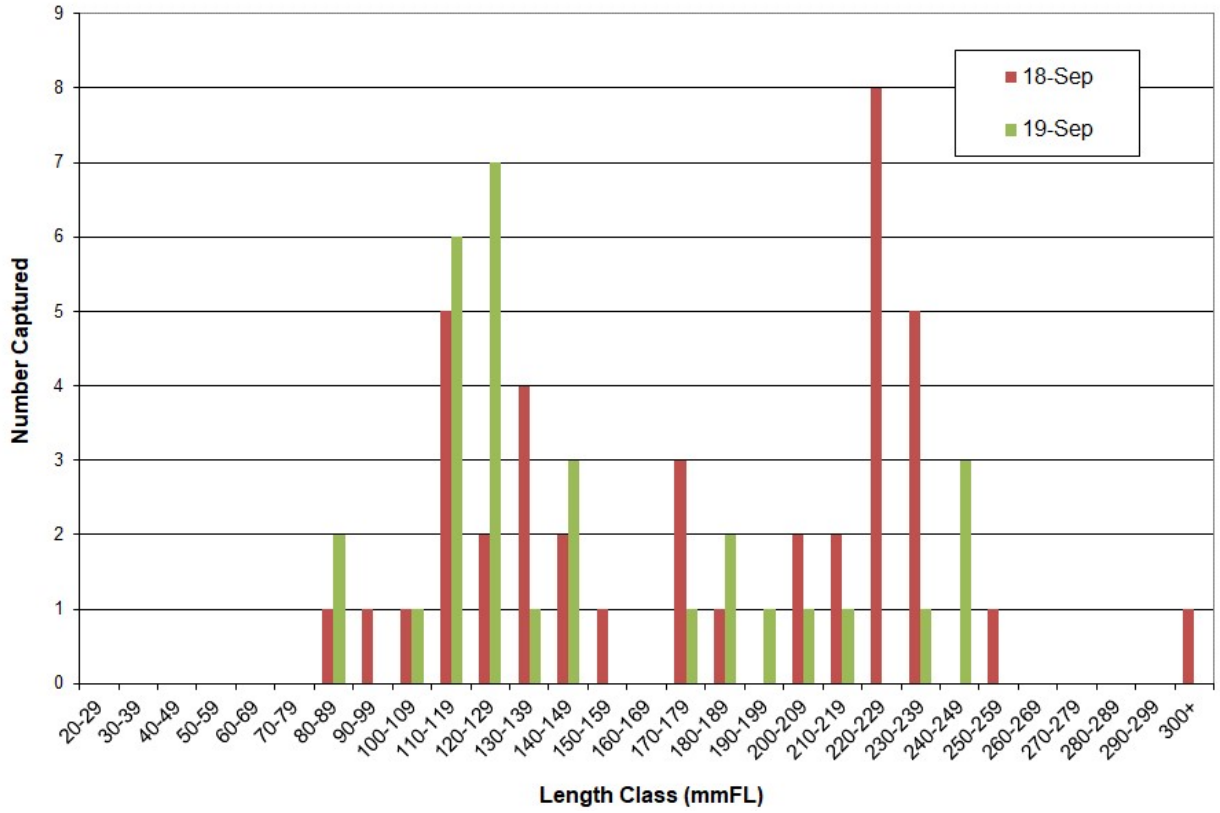

Figure 7. *O. mykiss* length classes in Laguna Creek Lagoon during 2018 mark and recapture periods.

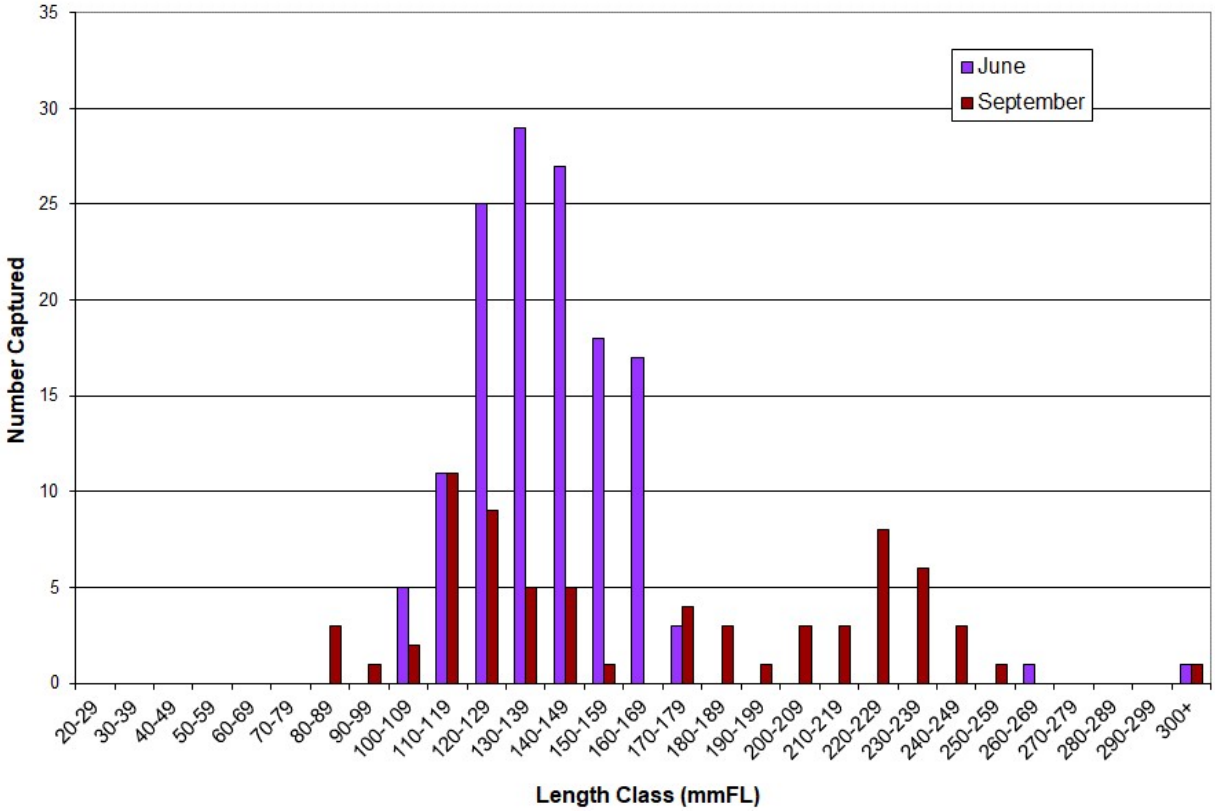

Figure 8. *O. mykiss* length classes in Laguna Creek Lagoon, late summer 2018

Table 4. Laguna Creek Lagoon *O. mykiss* tagged in June and recaptured in September 2018

Previous Capture Date	Recapture Date	Initial Length (mm)	Length at Recapture (mm)	Growth Rate (mm/day)	Growth (mm)
6/5/2018	9/19/2018	103	204	0.94	100
6/5/2018	9/19/2018	110	218	1.02	108
6/6/2018	9/19/2018	114	214	0.95	100
6/5/2018	9/18/2018	122	221	0.94	99
6/6/2018	9/19/2018	123	230	1.02	107
6/5/2018	9/18/2018	125	221	0.91	96
6/6/2018	9/18/2018	125	250	1.20	125
6/5/2018	9/18/2018	126	229	0.96	101
6/5/2018	9/18/2018	128	232	0.99	104
6/5/2018	9/19/2018	129	249	1.13	120
6/5/2018	9/18/2018	132	234	0.97	102
6/5/2018	9/18/2018	134	237	0.98	103
6/5/2018	9/18/2018	135	235	0.95	100
6/6/2018	9/19/2018	138	230	0.88	92
6/5/2018	9/18/2018	139	239	0.95	100
6/5/2018	9/18/2018	139	241	0.97	102
6/5/2018	9/18/2018	140	237	0.92	97
6/5/2018	9/18/2018	145	243	0.93	98
6/5/2018	9/18/2018	148	243	0.90	95
6/5/2018	9/18/2018	150	248	0.93	98
6/5/2018	9/18/2018	151	292	1.34	141
6/5/2018	9/19/2018	152	279	1.20	127
6/5/2018	9/18/2018	170	261	0.87	91
Average				*0.99*	*104*

Table 5. 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

Table 6. Difference in average summer growth rates of *O. mykiss* in Laguna Creek Lagoon

	2014	2017	2018
2013	0.05	-0.18 *	-0.51 **
2014		-0.23 **	-0.56 **
2017			-0.33 **

*significant at α=.05
**significant at α=.01

Late summer *O. mykiss* Population Estimate

- A total of 62 *O. mykiss* was captured on September 18. Five of these were recaptures so 57 were marked on September 18 by insertion of a PIT tag in the abdominal cavity.
- On September 19, 49 *O. mykiss* were captured, of which 11 had been tagged on September 18.
- The population estimate using the Petersen method (Ricker 1975) is 242 *O. mykiss* in the lagoon on September 20. The 95% confidence limits for this estimate are 140 and 407. This estimate is higher than the June estimate (193) by about 25% but the difference is not significant at the p =.05 level.
- Recapture rate of tagged fish on September 19 was 0.193 (11/57). Applying this rate to the 7 fish tagged in June and recovered on the 19th yields an estimate of 36 June tagged fish in the lagoon on September 19. This is only about a third of the 104 fish tagged in June.
- The relationship between population estimate and CPUE was updated with the 2018 data (Figure 9). The least squares regression r^2 is 0.67 and was statistically significant with $p<0.001$. Forcing the relationship through the origin improves the r^2 to 0.91.

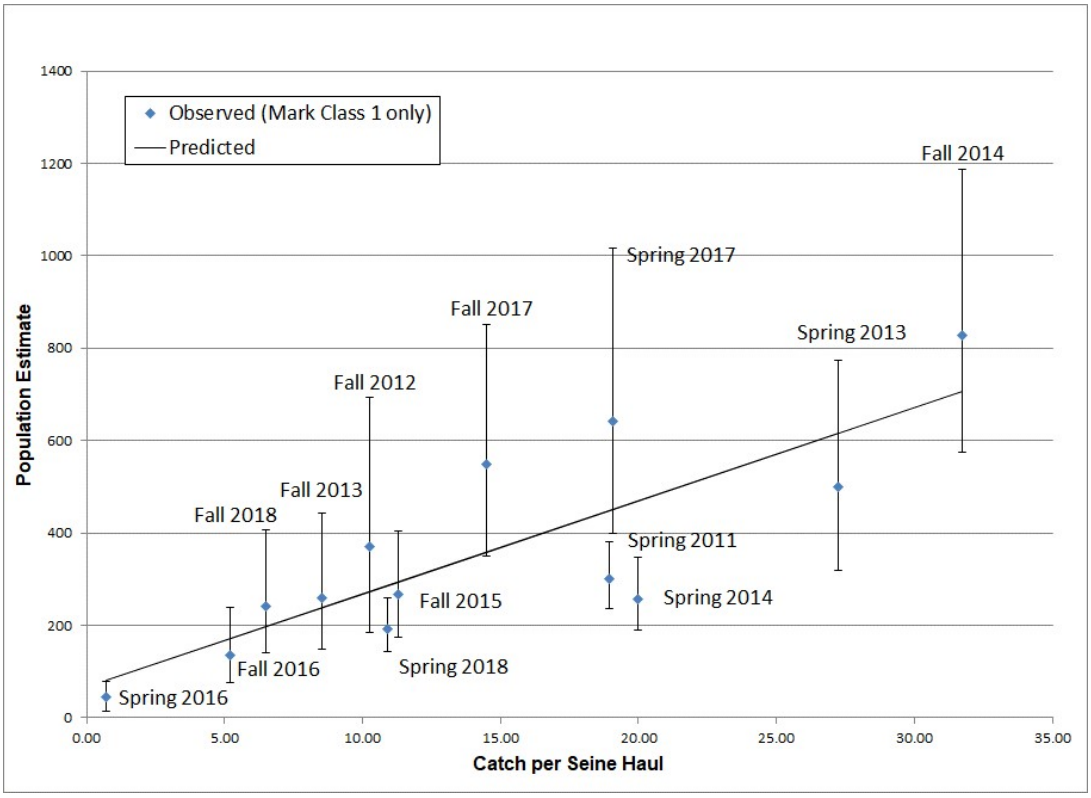

Figure 9. Relationship between *O. mykiss* population estimate and CPUE in Laguna Creek Lagoon[1]

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

San Lorenzo River

Summary

The lagoon remained open until June 30, then was mostly closed through the end of August (Figure 10). During periods of closure the lagoon stage would rise to high levels (over 7 feet NGVD 29) and eventually breach. On two occasions the mouth was artificially opened by the City of Santa Cruz (July 18 and August 27). Previous monitoring has indicated that water quality conditions for rearing steelhead generally deteriorate after breaching with development of a halocline with high salinity, high temperature, and low dissolved oxygen in deeper waters. Presumably this was the case in 2018 as well. As the lagoon fills conditions gradually improve though temperature was relatively high in July, even in the upper water column. Conditions during the August and September survey dates were suitable for steelhead in the upper 1 to 1.5 meters of the water column.

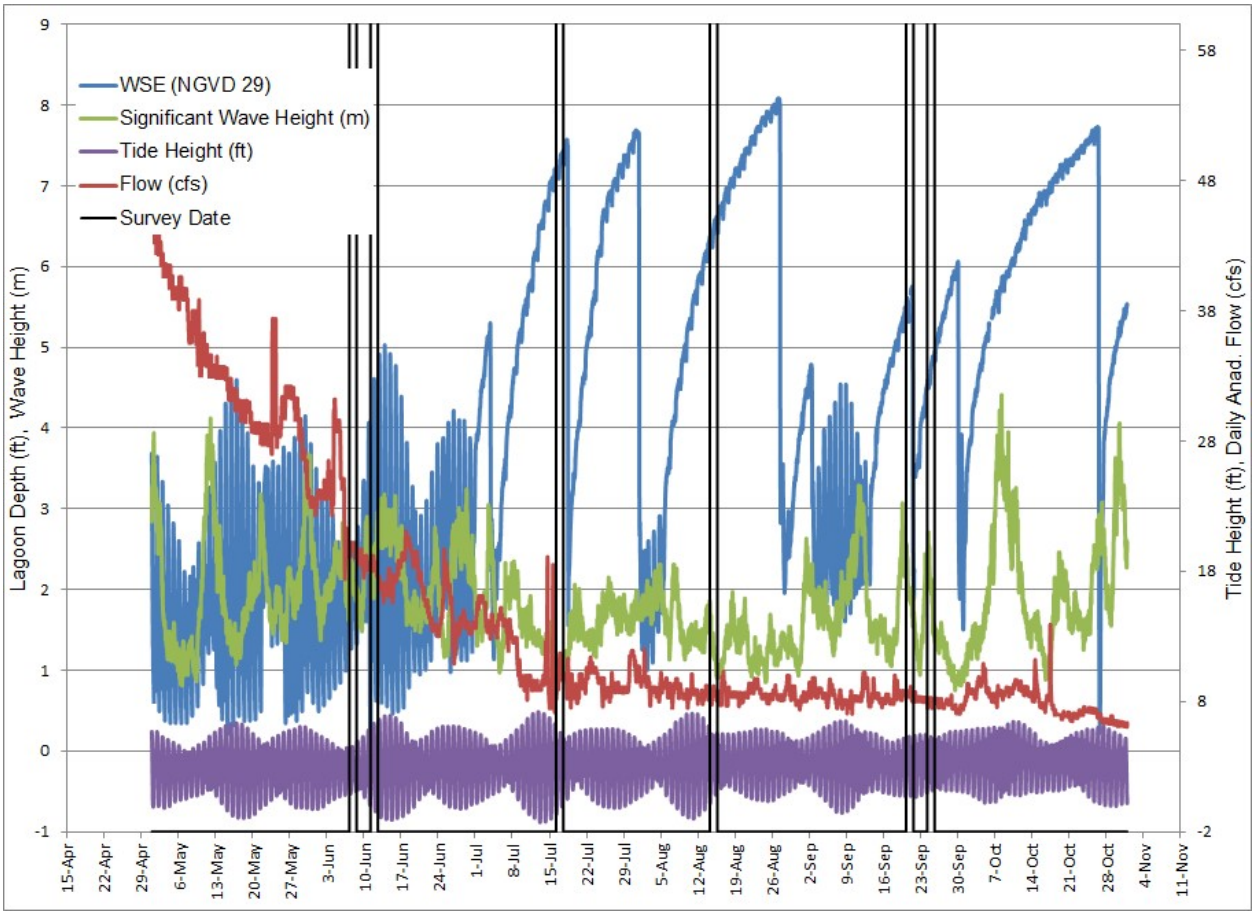

Figure 10. San Lorenzo Lagoon stage, streamflow, wave height, and tides 2018 (Source: lagoon stage from 2ND Nature, streamflow from USGS, wave and tide data from NOAA)

Abundance of *O. mykiss* in the lagoon was relatively high in June (third highest CPUE) but dropped to lower levels later in the summer after lagoon closure, particularly in July when the lagoon was warmest (Tables 7 and 8). Abundance was in sharp contrast to 2017 when flows were high and the lagoon remained open all summer (Table 8). A number of *O. mykiss* moved out of the lagoon and upstream in the San Lorenzo River after mid-June as documented by observations of PIT tagged fish at Felton in July and August.

Table 7. *O. mykiss* catch per haul for the San Lorenzo River Lagoon during 2018

		O. mykiss Catch per Haul				
Station	Location	7-12 Jun	Jul 16-17	Aug 14-15	Sep 20-25	Overall
SL-1	South of Trestle	12.8	5.3	8.5	8.8	9.6
SL-2	RR Trestle	20.5	0.0	1.5	6.0	10.1
SL-3	Near YSI Station	11.0	0.5	0.0	3.0	4.3
SL-5	Riverside Drive	59.8	2.5	14.5	3.0	22.2
SL-6	U/S Bank Restoration	14.8	2.8	5.3	7.3	7.9
	Overall	***23.3***	***2.5***	***6.4***	***6.3***	***11.1***

Table 8. *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, and HES 2018a)

	O. mykiss Catch per Haul				
Year	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	

Growth rates for *O. mykiss* in the lagoon were variable between individuals, with fish tagged in June growing at 0.26 mm/day to 0.49 mm/day and fish tagged in August growing between 0.17 mm/day and 0.76 mm/day. Average growth rates were lower than either 2016 or 2017. Temperature in the lagoon was also warmer than 2016 or 2017.

A group of large (260mm FL to 390mm FL) *O. mykiss* appeared in the catch in September. This size group had not been seen earlier in the summer except for a few individuals in June. These fish all had an external appearance characterized as adult/ocean. Three of these fish had sea lice (possibly *Lepeophtheirus salmonis*).

Early summer (June 7-8, 11-12)

Early summer Site Conditions

- The lagoon was open during the sampling period (Figure 10 and Figure 11). Daily average flow at Santa Cruz gage ranged from 18 cfs to 20 cfs, declining slightly during the sample period (historical discharge, USGS site 11161000 San Lorenzo River at Santa Cruz California).
- Lagoon stage was tidally influenced and ranged from 0.6 to 4.6 ft (NGVD29). The shoreline was conducive to sampling for sufficient area at all regularly surveyed sites. Water quality conditions were highly variable depending on tidal stage (Figure 12).
- The lagoon was salinity stratified with salinity close to seawater at depths of 0.8 meters (2.6 ft.) or more (Figure 12, center panel). Surface salinity ranged from near zero to 26.5 ppt with higher tides near the mouth.
- Temperature was highly variable, depending on tidal influx and air temperature. The highest temperature (21.7°C) was recorded upstream from the trestle bridge during an afternoon low tide. This high was still within the suitable range for juvenile *O. mykiss*.
- Dissolved oxygen levels were generally above 6 mg/L above the halocline but declined to lower levels during morning hours (Figure 12, right panel).
- Water clarity was high with secchi disk visible at or near the substrate at all stations (up to 2.2 meters (7.2 ft.) deep).

Figure 11. San Lorenzo Lagoon mouth June 12, 2018

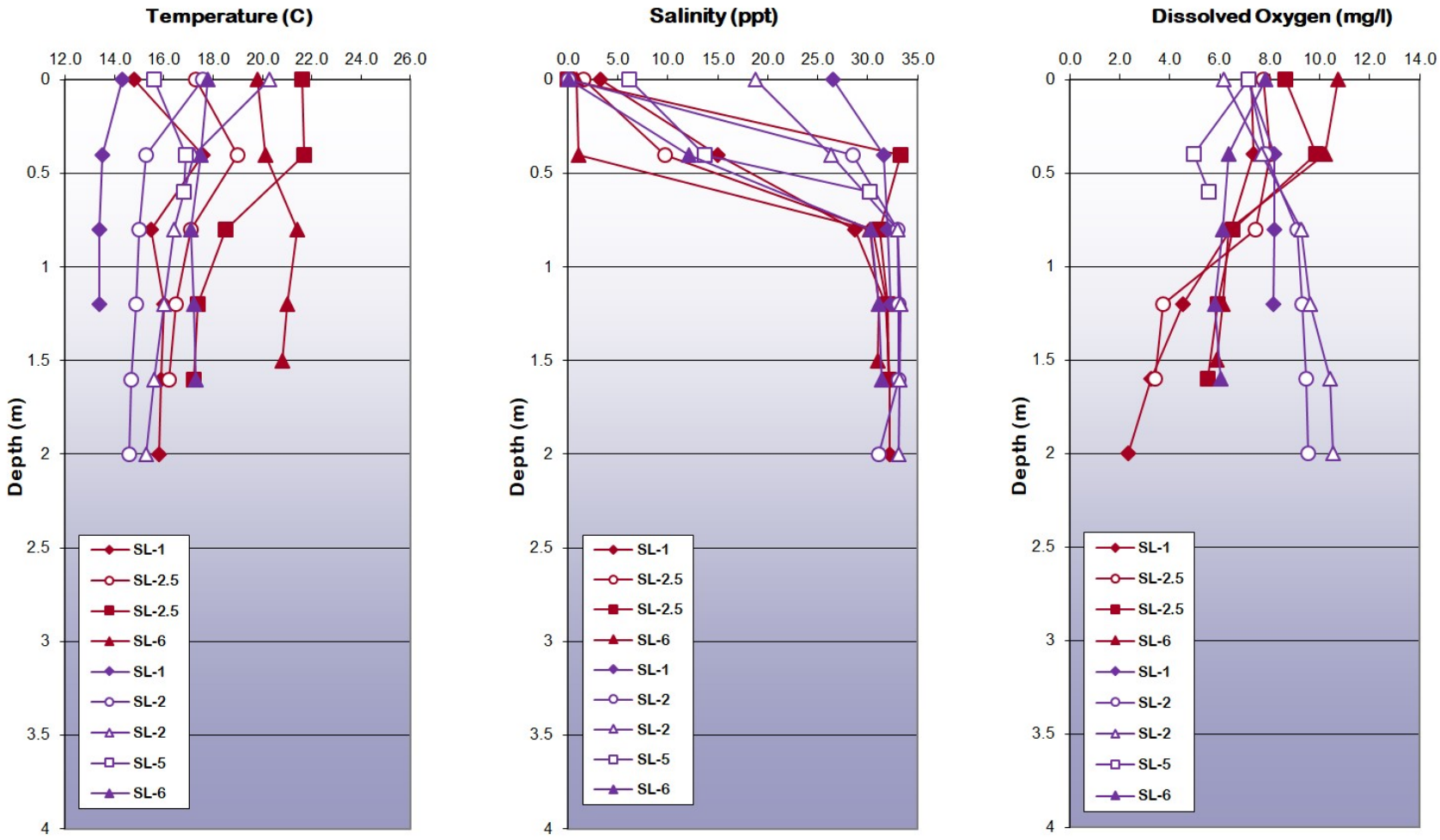

Figure 12. Depth profiles of water quality parameters in the San Lorenzo Lagoon during June. Profiles plotted in red are June 7-8; profiles in blue are June 11-12

Early summer Survey Results

- *O. mykiss* were captured and marked on June 7 and 8 and the lagoon was resampled on June 11 and 12. Untagged *O. mykiss* captured on June 11 and 12 were also tagged for over-summer information.
- Twenty-three seine hauls were completed at regularly sampled stations between the beach and the bend upstream of Riverside Bridge.
- The overall fish catch was dominated by very abundant topsmelt, followed by steelhead and shiner surfperch (Table 9). A total on nine fish species were captured.
- *O. mykiss* abundance (CPUE) was the third highest observed in annual surveys to date (Table 8) and catch was highest at the trestle and just upstream of Riverside Bridge (Table 9). A single large seine haul upstream of Riverside Bridge accounted for 28% of the total June catch.

Table 9. Fish catch in San Lorenzo River Lagoon, June 2018

Species	South of Trestle (1)	Around Trestle (2)	Around Water Quality Station (3)	Upstream of Riverside Bridge (5)	Bend downstream of Laurel Ave. (6)	Grand Total
# Hauls	*6*	*6*	*2*	*4*	*5*	***23***
O. mykiss	77	123	22	239	74	**535**
Northern anchovy	112					**112**
Pacific herring	9	9		2	6	**26**
Topsmelt	1783	3998	542	5446	1915	**13684**
Threespine stickleback	1	3				**4**
Sculpin		1				**1**
Staghorn sculpin	3	15	5	2		**25**
Shiner surfperch	201	113		5	5	**324**
Starry flounder	1	2	1			**4**
Dungeness crab	2					**2**
cancer crab		5	3			**8**
kelp crab	1	1				**2**
O. mykiss CPUE	*12.8*	*20.5*	*11.0*	*59.8*	*14.8*	***23.3***

- The majority of *O. mykiss* captured were between 100mm and 169mm FL (Figure 13). There were also smaller fish, likely young-of-year, in the 40mm to 99mm FL size class, captured primarily upstream of Riverside Bridge. There were a few over 200mm FL including 3 individuals in the 330mm-339mm size class (around 13 inches).

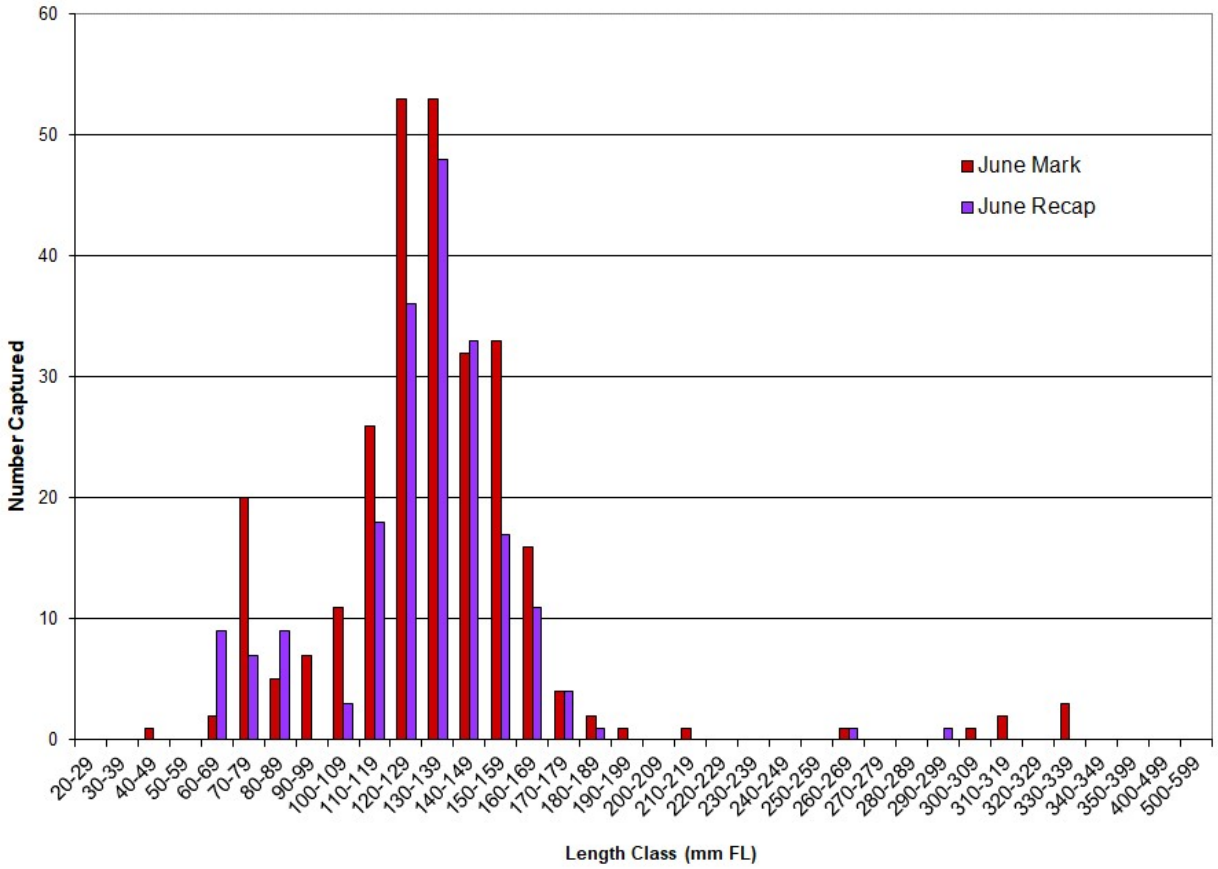

Figure 13. *O. mykiss* length classes in San Lorenzo Lagoon, June 2018

- The majority of the catch (59%) was characterized as parr and an additional 28% were characterized as silvery parr. Advanced silvery parr (8%) and smolts (3%) made up most of the rest with an additional 2% (all 260 mm FL or larger) having an ocean/adult appearance.
- All *O. mykiss* examined (471) had an adipose fin, indicating they were not of hatchery origin.
- Fourteen percent of *O. mykiss* examined had black-spot disease (BSD) lesions. Incidence of BSD has ranged between 5% and 55% in spring surveys since 2010.

Early summer *O. mykiss* Population Estimate

- A total of 291 *O. mykiss* was captured during the marking period (June 7-8). The tag supplier (Biomark) recommends that body cavity tagging should only be done down to a length of 65 mm but due to previous experience with excessive mortality of fish less than 90mm, only fish 90 mm FL or larger were tagged. In addition, permits preclude tagging of adult steelhead. Given the presence of fast-growing juveniles in the lagoon, potential maturity and spawning of lagoon reared fish without ocean entry, and early return of small ocean fish, a length of 320mm FL (12.6 inches) was used to delineate adult fish. Of the 291 *O. mykiss* captured 31 were below the lower tagging limit and 3 were above the limit. In addition, 14 fish were recaptures of previously tagged fish. There were also four mortalities. There were 239 tagged *O. mykiss* released in the lagoon at the end of the mark period.
- A total of 244 *O. mykiss* was captured during the recapture period but only 217 were within the size range for tagging (26 <90mm and 1>320mm). Twenty-one of these had been tagged during the marking period.
- Lagoon population estimate using the Petersen method (Ricker 1975) is 2,378 *O. mykiss* within the taggable size class in June. The 95% confidence limits for this estimate are 1,580 and 3,553. This is the third highest population estimate in spring surveys since 2011, below the record 2017 and nearly equal the 2016 level.
- If capture probability was the same for all size classes (.09) then there would have been an estimated 289 *O. mykiss* less than 90mm and 11 larger than 320mm in the lagoon.
- CPUE was 29 per haul during the mark period and 19 per haul during the recapture period (difference not statistically different, two sample t-test, p≈0.4). This, and the fact that the lagoon was open initially, indicates the potential for an unstable population in the lagoon. The size class proportions in the population were similar during the mark and recapture periods (Figure 13).

<u>July Survey (July 16-17)</u>

The July survey was a two-day relative abundance survey. 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. Due to excessively high water temperatures and in order to minimize potential harmful effects during potentially stressful mid-summer conditions, captured fish were not tagged and no population estimation was conducted.

July Site Conditions

- The lagoon had been closed for 12 days at the time of sampling (Figure 10). Inflow from the San Lorenzo River ranged between 8 and 12 cfs during the sample period (Figure 10).
- The lagoon stage was high, between 7 and 7.5 feet during the survey period (City of Santa Cruz data). Limited areas of beach were present to finish seine hauls at the back side of the beach and around the trestle. Elsewhere, hauls were finished against the levee banks.

- The lagoon was well along in transitioning to freshwater. There was some salinity stratification with salinity increasing gradually to 8 ppt down to 2 meters depth and more steeply increasing below 2 meters (Figure 14 center panel).
- Water temperature was relatively warm with measured temperatures exceeding 23°C below 0.5 meters depth and approaching 25°C at 2 meters depth and exceeding 27° C in deeper water (Figure 14, left panel).
- Dissolved oxygen was generally at 7 mg/l or higher in the upper 2 meters of the water column but decreased to low levels in deeper water (Figure 14, right panel).
- Light transmission in the water column was relatively low with secchi disk visibility of about 0.8 feet near the trestle and up to 1.5 meters (5 feet) upstream of Riverside Bridge. Water depth was up to 3.6 meters (12 feet) at the trestle and 3.2 meters (10.5 feet) at Station 6.

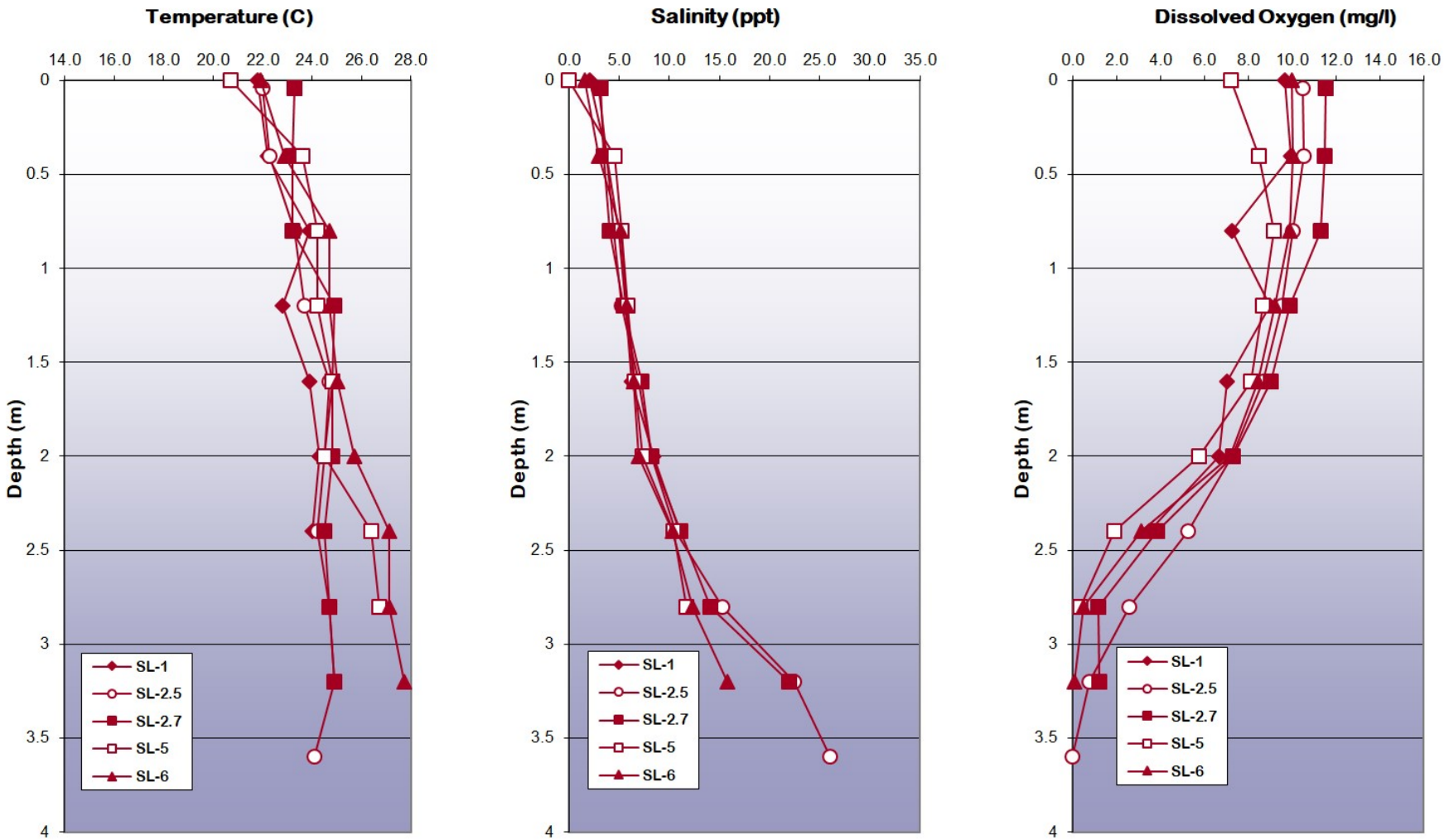

Figure 14. Depth profiles of water quality parameters in the San Lorenzo Lagoon during July Survey (July 16-17)

July Survey Results

- Thirteen seine hauls were completed between the beach and the water quality buoy and upstream of Riverside Bridge (Table 10).
- *O. mykiss* were the second most abundant fish caught (after topsmelt), but CPUE was one-tenth June levels (Table 7) (two sample t-test, $p<0.02$) CPUE for topsmelt was 40% of June levels.
- The size class distribution for *O. mykiss* shifted 20-30mm larger compared to June, consistent with potential growth in the intervening period (Figure 15).
- Two *O. mykiss* captured in July had been tagged in June. These fish grew at an average rate of 0.98 mm/day (Table 11).

Table 10. Fish catch in San Lorenzo River Lagoon, July 2018

Species	South of Trestle (1)	Around Trestle (2)	Around Water Quality Station (3)	Upstream of Riverside Bridge (5)	Bend downstream of Laurel Ave. (6)	Grand Total
# Hauls	*3*	*2*	*2*	*2*	*4*	***13***
O. mykiss	16		1	5	11	**33**
Pacific herring	1					**1**
Sacramento sucker		1	1		15	**17**
Topsmelt	603	500	331	1108	805	**3347**
Bay pipefish			1			**1**
Staghorn sculpin	2		1			**3**
Shiner surfperch	28	1	1			**30**
crab	1	3	3		1	**8**
O. mykiss CPUE	*5.3*	*0.0*	*0.5*	*2.5*	*2.8*	***2.5***

Table 11. *O. mykiss* tagged previously and recaptured in July 2018

Previous Capture Date	Recapture Date	Initial Length (mm)	Length at Recapture (mm)	Growth Rate (mm/day)
7-Jun-18	17-Jul-18	152	187	0.88
8-Jun-18	17-Jul-18	100	142	1.08

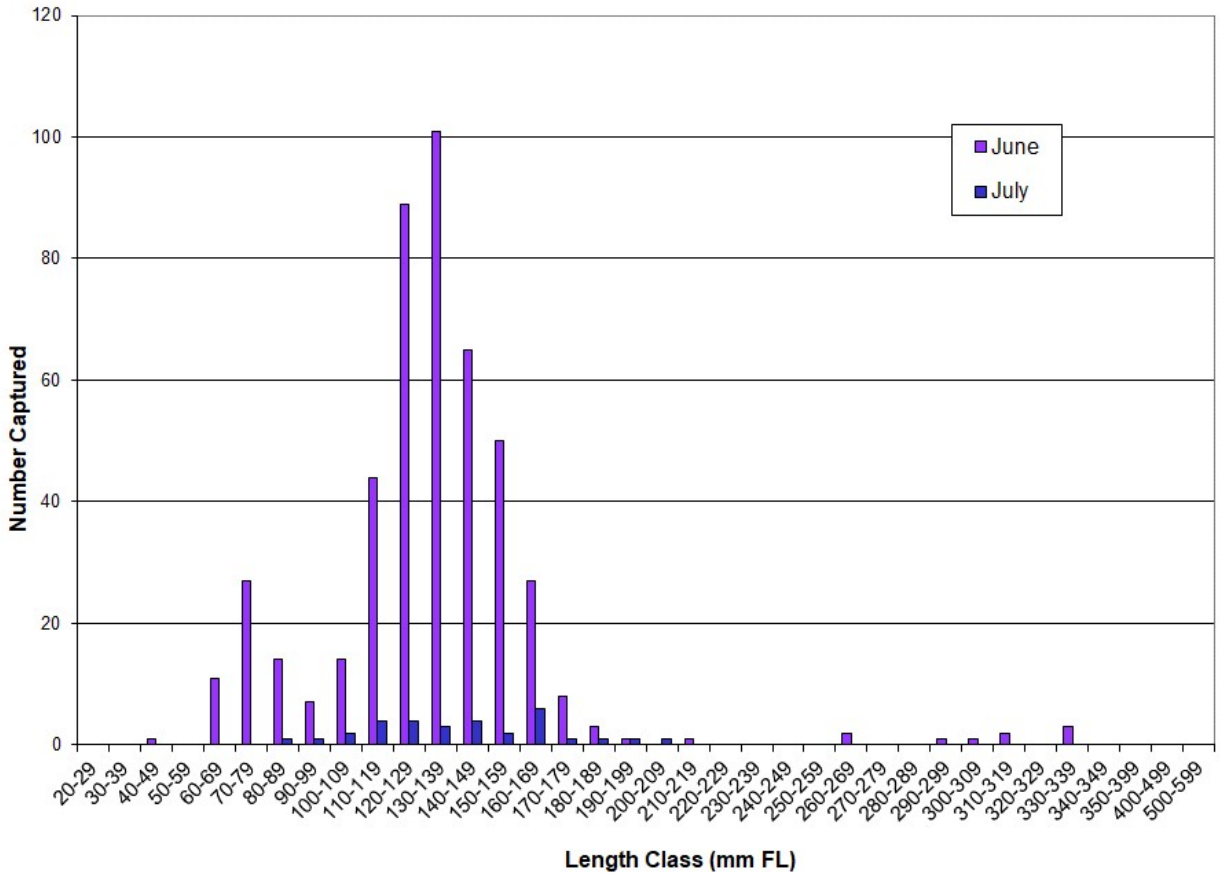

Figure 15. *O. mykiss* length classes in San Lorenzo Lagoon during June and July 2018

August Survey (August 14-15)

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. Temperature conditions had moderated from July so that PIT tags could be placed for later growth assessment though sampling intensity was not sufficient for a population estimate.

August Site Conditions

- The lagoon had been closed since July 4 except for two brief open periods following breaches on July 18 and July 31. The first opening was completed as a Temporary Outlet Channel by the City of Santa Cruz and was closed immediately after draining with little or no tidal exchange (HES 2018b). The second had limited tidal exchange and closed after 5 days. At the time of sampling, the lagoon had been closed for 9 days following the July 31 breach

(Figure 10). Inflow from the San Lorenzo River ranged between 8 and 9 cfs during the sample period (Figure 10).

- The lagoon stage was high, between 6.3 and 6.6 feet during the survey period (City of Santa Cruz data). Limited areas of beach were present to finish seine hauls at the back side of the beach and around the trestle. Elsewhere, hauls were finished against the levee banks.
- The lagoon was well along in transitioning to freshwater. There was some salinity stratification with salinity increasing gradually to 10 ppt down to 1.5 meters depth and 14 ppt at 2 meters with more rapid increase below 2 meters (Figure 15 center panel).
- Water temperature was not as warm as July with surface temperature less than 22°C down to 0.4 meters but reaching 24°C at 0.8 meters and 26°C at 1.6 meters (Figure 16, left panel).
- Dissolved oxygen levels were high down to 1.6 meters (10 mg/l or higher) but dropped as low as 6 mg/l at 2 meters depth and lower levels in deeper water (Figure 16, right panel).
- Light transmission in the water column was moderate with secchi disk visibility of about 1.5 to 1.8 meters (5 to 6 feet) near the trestle and 0.9 to 1.5 meters (3 to 5 feet) upstream of Riverside Bridge. Water depth was up to 3.1 meters (10 feet) at the trestle and 3.2 meters (10.5 feet) at Station 6.

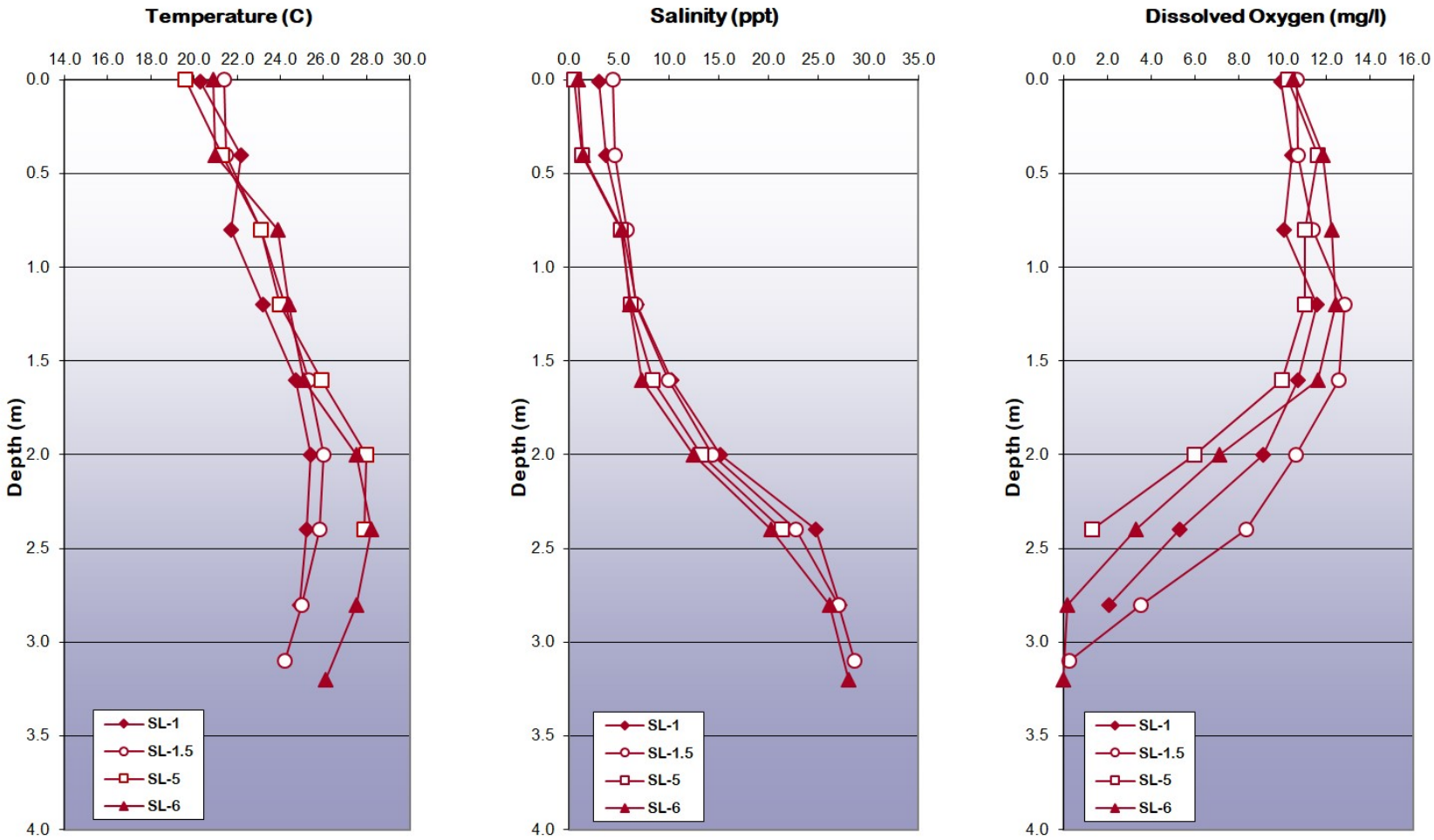

Figure 16. Depth profiles of water quality parameters in the San Lorenzo Lagoon during August Survey

August Survey Results

- Thirteen seine hauls were completed between the beach and the water quality buoy and upstream of Riverside Bridge (Table 12).
- Steelhead CPUE was nearly triple the July value (significant difference, ANOVA single factor, Tukey HSD, $\alpha < 0.05$) but only about a quarter of the June value (significant difference, ANOVA single factor, Tukey HSD, $\alpha < 0.01$).
- Topsmelt dominated the catch and were at similar abundance as in July (Table 12). Young-of-year Sacramento sucker increased in abundance from July.

Table 12. Fish catch in San Lorenzo River Lagoon, August 2018

Species	South of Trestle (1)	Around Trestle (2)	Around Water Quality Station (3)	Upstream of Riverside Bridge (5)	Bend Downstream of Laurel Ave. (6)	Grand Total
# Hauls	*2*	*2*	*1*	*2*	*4*	***11***
O. mykiss	17	3		29	21	**70**
Northern anchovy	8					**8**
Pacific herring	8					**8**
Sacramento sucker		42		9	49	**100**
Topsmelt	1131	1402	216	485	452	**3686**
Threespine stickleback			1	1	1	**3**
Staghorn sculpin		2			6	**8**
crab	1	2				**3**
O. mykiss CPUE	*8.5*	*1.5*	*0.0*	*14.5*	*5.3*	***6.4***

- The *O. mykiss* size class distribution did not appear much different from July (Figure 17).
- Six *O. mykiss* captured in August had been tagged in June. These fish grew at an average rate of 0.55mm/day (Table 13). Average growth rate for fish captured in August was lower than those captured in July (0.98mm/day) (significant difference, ANOVA single factor, Tukey HSD, $\alpha < 0.05$) and not significantly different than those captured in August 2017 (0.61mm/day) (ANOVA single factor, Tukey HSD, $\alpha > 0.05$).

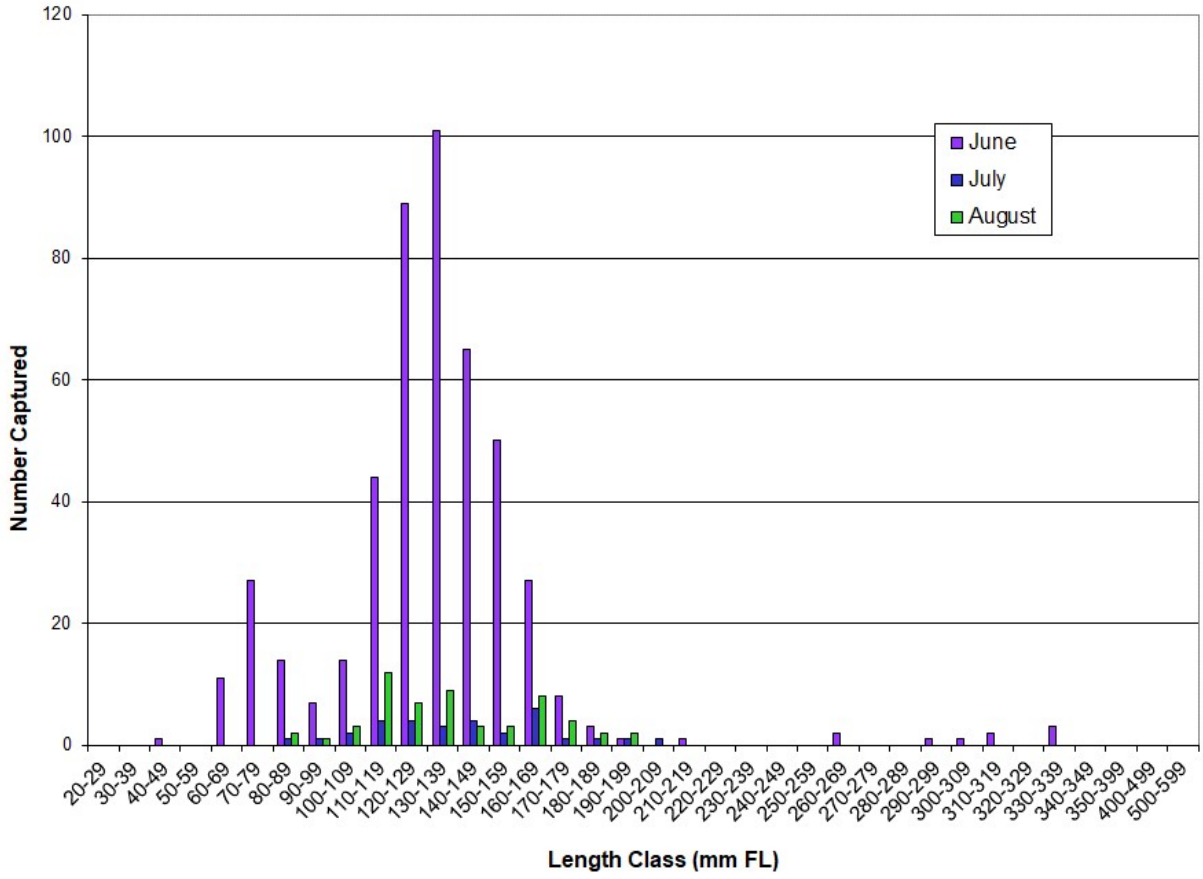

Figure 17. *O. mykiss* length classes in San Lorenzo Lagoon during June, July, and August 2018

Table 13. *O. mykiss* tagged previously and recaptured in August 2018

Previous Capture Date	Recapture Date	Initial Length (mm)	Length at Recapture (mm)	Growth Rate (mm/day)
6/12/2018	8/15/2018	124	148	0.38
6/12/2018	8/15/2018	102	142	0.63
6/8/2018	8/15/2018	104	149	0.66
6/11/2018	8/15/2018	118	163	0.69
6/12/2018	8/15/2018	162	194	0.50
6/8/2018	8/14/2018	107	135	0.42

Late summer (September 20-21, 24-25)

The September survey was a full survey with population estimate. *O. mykiss* were marked on September 20-21 and recaptured on September 24-25. Sampling was conducted at each of the regularly sampled Stations (1, 2, 3, 5, and 6).

Late summer Site Conditions

- The lagoon was very dynamic during the fall sampling and in the period leading up to it (Figure 10). It had been manually opened by the City on August 27. It closed briefly from August 29 through September 2 then opened and was tidal through September 13 (Figure 10). At the beginning of sampling on September 20 the lagoon had been closed 7 days and had reached an elevation of about 5.5 feet, about a foot lower than the August survey. It opened again naturally on September 21 as seining upstream of Riverside Bridge was being completed. It closed almost immediately and was still closed during the recapture seining on September 24 and 25.
- The effect of lagoon opening and closure is evident in water quality profiles taken during seining (Figure 18). On September 20 and 21, before the lagoon opened, there is relatively low salinity down to a depth of 1.2 meters with increasing salinity and very warm temperature below 1.2 meters. On September 24, after breaching and reclosure on the 21st the influx of colder, more saline seawater is evident at the lower stations (SL-1, SL-2, and SL-2.75) in midwater between 0.8 and 1.6 meters deep. Dissolved oxygen levels declined slightly in surface waters but increased at depth with the influx of colder, well-oxygenated seawater (Figure 18).
- Salinity pre-breach was below 10 ppt in water less than 1.2 meters deep, then increased sharply to 25 ppt or higher at 2 meters deep and below. Post-breach, the salinity gradient (halocline) shifted upward about one meter (Figure 18, center panel).
- Water temperature was relatively cool in the upper 0.8 meter of the water column both before and after breaching (Figure 18, left panel). Before the breach, temperature increased to between 23°C and 26°C at 1.2 meters and below. After the breach the water column cooled significantly to between 18°C and 21°C at depths greater than one meter (Figure 18, left panel).
- Dissolved oxygen was 10 mg/l or higher at depths less than 1 meter throughout the sample period (Figure 18, right panel). Before the breach, DO was still relatively high down to 2 meters except at SL-5. After the breach DO declined but remained above 6 mg/l down to 2 meters except at SL-5 and SL-6.
- Temperature and dissolved oxygen conditions were generally in the suitable range for *O. mykiss* in lagoons at depths of 1 to 1.5 meters or less.
- The water column was relatively clear with secchi disk visible near the bottom in 2 meters to 2.5 meters (6.6 feet to 8.2 feet) depth.

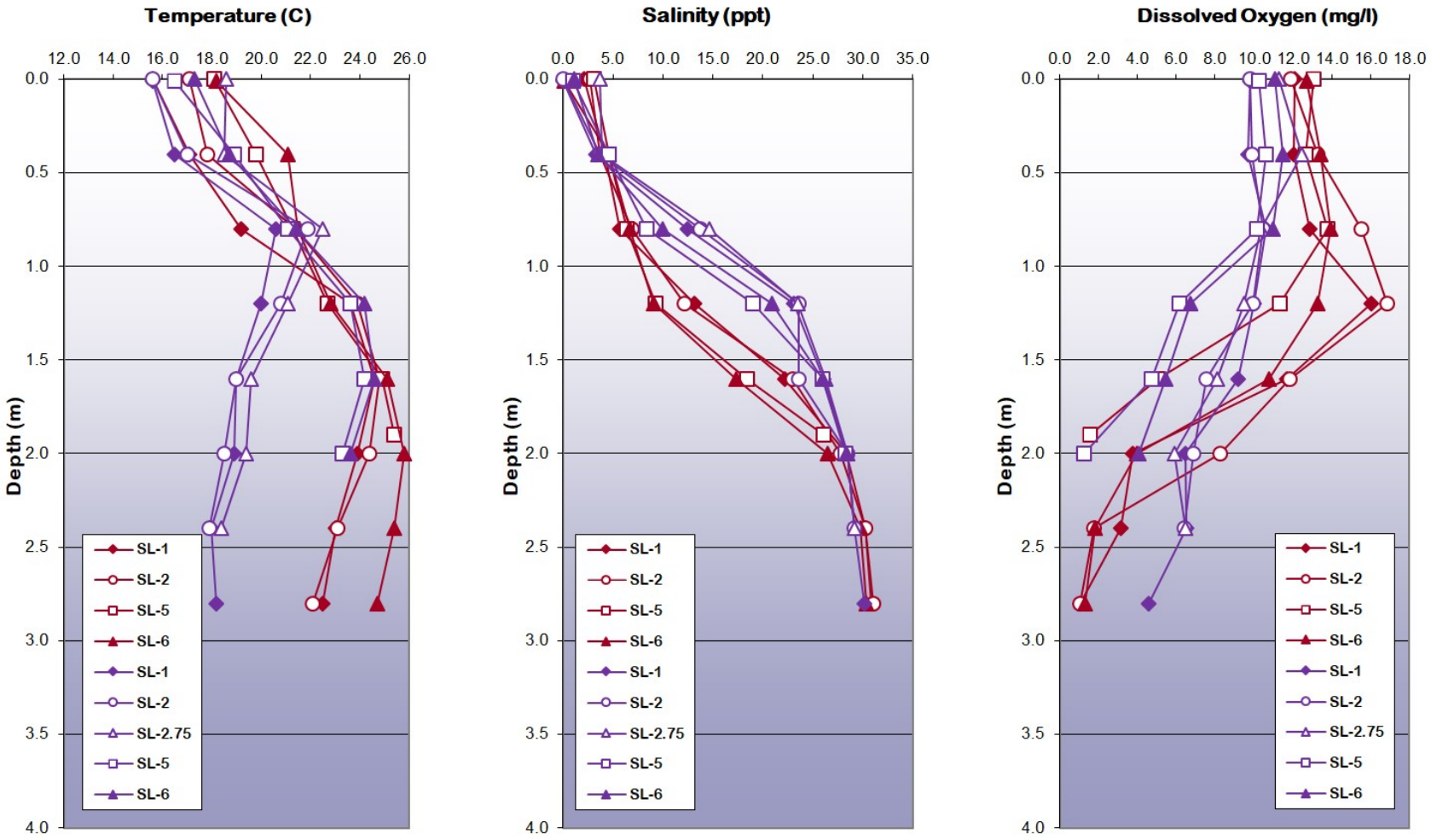

Figure 18. Depth profiles of water quality parameters in the San Lorenzo Lagoon during survey on September 20-25. Profiles plotted in red are September 20-21; profiles in blue are September 24-25

Late summer Survey Results

- Twenty-five seine hauls were completed at regularly sampled Stations (1, 2, 3, 5, and 6).
- CPUE for *O. mykiss* was nearly the same as in August (Table 14). CPUE for topsmelt was approaching levels seen in June. Northern anchovy appeared upstream of Riverside Bridge along with their predator, striped bass, though neither were in great abundance (Table 14).

Table 14. Fish catch in San Lorenzo River Lagoon, September 2018

Species	South of Trestle (1)	Around Trestle (2)	Around Water Quality Station (3)	Upstream of Riverside Bridge (5)	Bend Downstream of Laurel Ave. (6)	Grand Total
# Hauls	*6*	*6*	*1*	*5*	*7*	***25***
O. mykiss	53	36	3	15	51	**158**
Northern anchovy	1	2			301	**304**
Sacramento sucker	1	1		3	5	**10**
Topsmelt	4291	3119	622	1682	1280	**10994**
Threespine stickleback	2	3		11	1	**17**
Staghorn sculpin	1			1	3	**5**
Striped bass					1	**1**
Tidewater goby				1		**1**
Starry flounder		1		1		**2**
crab	5	8			1	**14**
grass shrimp				5		**5**
O. mykiss CPUE	*8.8*	*6.0*	*3.0*	*3.0*	*7.3*	***6.3***

- The peak in the *O. mykiss* size distribution had shifted about 40 mm to 50 mm larger from June, consistent with observed growth rates (Figure 19).

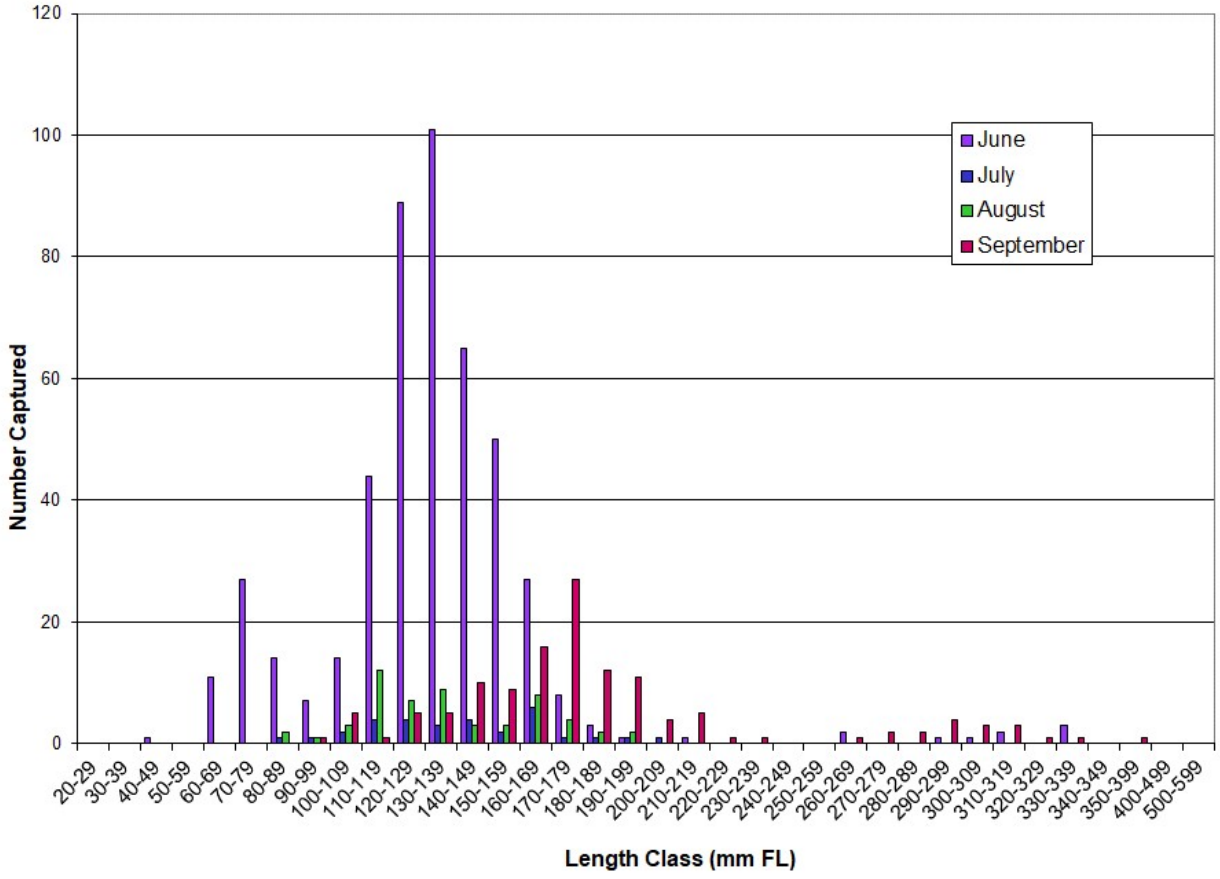

Figure 19. *O. mykiss* length classes in San Lorenzo Lagoon during different sample periods in 2018

- Twelve *O. mykiss* captured in September had been tagged earlier in the summer, 10 in June, and 2 in August. Growth rates were variable between individuals with fish tagged in June growing at 0.26 mm/day to 0.49 mm/day and fish tagged in August growing between 0.17 mm/day and 0.76 mm/day (Table 15). Growth rates were lower than 2012 and 2016 (ANOVA single factor, Tukey HSD, $\alpha<0.01$) but not significantly different from 2013 or 2017 (ANOVA single factor, Tukey HSD, $\alpha>0.05$) (Table 16). Temperature in the lagoon was cooler in both 2016 and 2017 than in 2018. There may have been density dependent growth effects in 2017 due to the unusually large numbers of *O. mykiss* present.

Table 15. *O. mykiss* tagged previously and recaptured in September.

Previous Capture Date	Recapture Date	Initial Length (mm)	Length at Recapture (mm)	Growth Rate (mm/day)
6/7/2018	9/25/2018	133	170	0.34
6/7/2018	9/25/2018	108	155	0.43
6/7/2018	9/24/2018	139	191	0.48
6/7/2018	9/20/2018	135	175	0.38
6/8/2018	9/21/2018	156	183	0.26
6/8/2018	9/20/2018	107	151	0.42
6/11/2018	9/21/2018	124	166	0.41
6/11/2018	9/20/2018	139	180	0.41
6/12/2018	9/21/2018	139	167	0.28
6/12/2018	9/21/2018	102	151	0.49
8/14/2018	9/20/2018	109	137	0.76
8/15/2018	9/20/2018	167	173	0.17

Table 16. *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

- An *O. mykiss* tagged in the lagoon on June 20, 2017 was recaptured in electrofishing surveys in the San Lorenzo Flood Control Channel downstream of the pedestrian bridge. It was 90mm FL at the time it was tagged and was 363mm FL at the time of recapture on September 28, 2018. Average growth rate was 0.59 mm per day between tagging and recapture.
- A group of large (260mm FL to 390mm FL) *O. mykiss* appeared in the catch in September. This size group had not been seen earlier in the summer except for a few individuals in June. These fish all had an external appearance characterized as adult/ocean. Three of these fish had sea lice (possibly *Lepeophtheirus salmonis*) (Figure 20). All were taken on September 20 at the back side of the beach near the mouth.

Figure 20. Sea louse on *O. mykiss* captured September 20 near lagoon mouth

- Twenty-five percent of the catch was characterized as parr, 61% as silvery parr, and 14% as adult/ocean.
- One-hundred and thirty-one of 132 *O. mykiss* examined had an adipose fin, indicating they were not of hatchery origin. One *O. mykiss*, a 195 mm FL advanced silvery parr, appeared to have a clipped adipose fin.
- Sixty out of 132 (45%) *O. mykiss* examined had black-spot disease (BSD) lesions, most with light incidence. Incidence of BSD has ranged between 2% and 100% in fall surveys since 2009.

Fall *O. mykiss* Population Estimate

- Eighty-nine *O. mykiss* were captured during the mark period (September 20 and 21). Six of these were not marked because they were recaptures of fish tagged during the mark period. Therefore, there were a total of 83 marked *O. mykiss* at the end of the marking period.
- Sixty-nine *O. mykiss* were captured during the recapture period. All were above the minimum tagging size of 90 mm FL or greater but 3 were more than 320 mm FL and were not counted. Seven of the 66 eligible captures had been tagged during the marking period.
- The population estimate using the Petersen method (Ricker 1975) is 704 *O. mykiss* in the lagoon at the end of September. The 95% confidence limits for this estimate are 364 and 1,286.
- Overall CPUE was slightly lower during the recapture period (5.3 vs. 7.4 during the marking period). The difference in CPUE was not statistically significant (two sample t-test $p \approx 0.5$). The size distribution of captured *O. mykiss* was similar between the two periods.
- Ten *O. mykiss* captured in September were tagged in June. If recapture rates were the same for these fish as for the September marked fish (7/83 or 0.0843), there would have been 119 June tagged *O. mykiss* in the lagoon in September. There were 239 *O. mykiss* tagged during the mark period in the lagoon in June, and an additional 172 tagged during the recap period for a total of 411 tagged fish in June, so an estimated 29% of the June tagged fish were present in September. Fifteen June tagged fish were recorded at the PIT tag monitoring antenna at Felton in July and August so we know at least some fish left the lagoon for upstream locations in the San Lorenzo River.
- The relationship between population estimate and CPUE was updated with the 2018 data (Figure 21). Least squares regression gives a significant relationship ($P \approx 0.00002$) with an r^2 value = 0.88.

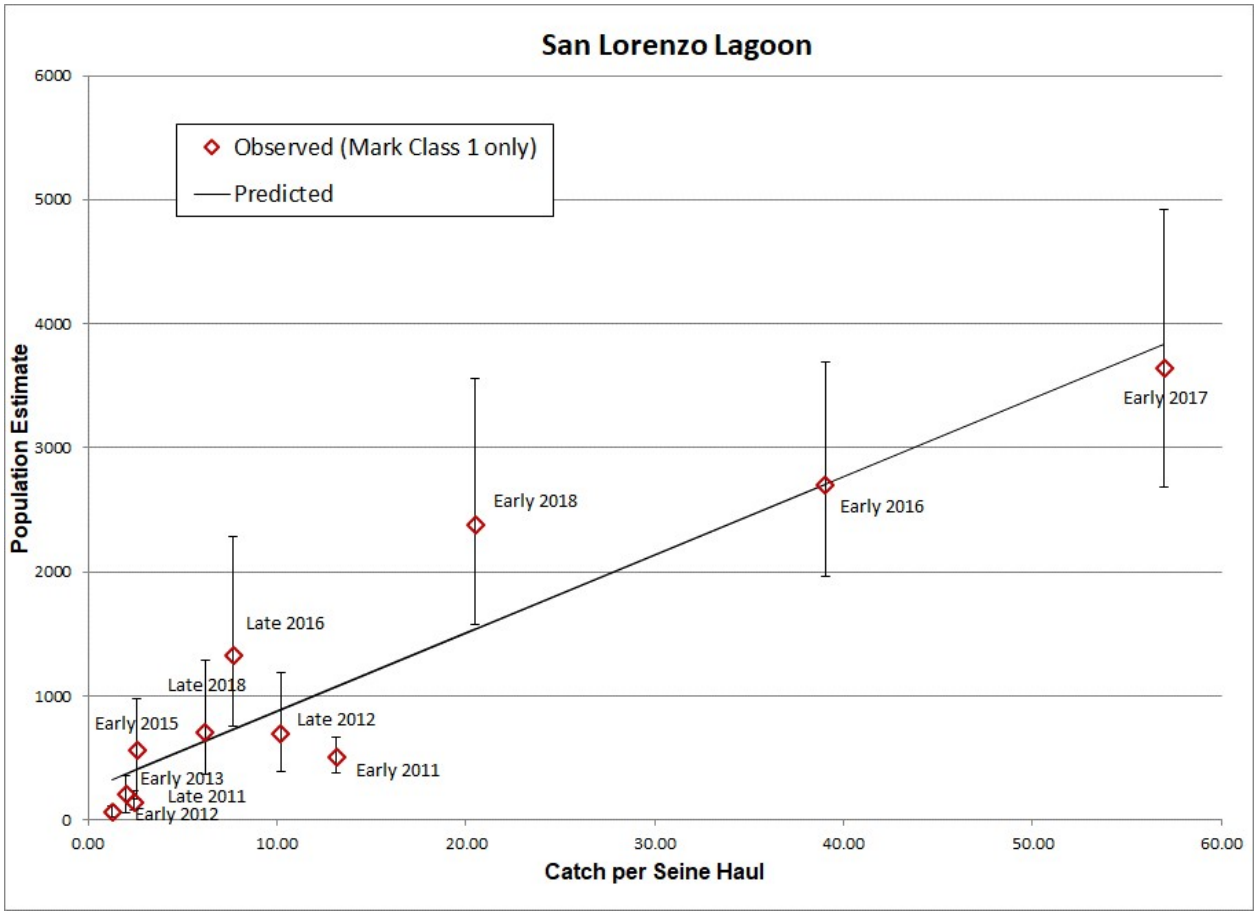

Figure 21. Relationship between *O. mykiss* population estimate and CPUE in the San Lorenzo River Lagoon[2]

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

Felton PIT tag monitoring

- Between May 1, 2018 and May 1, 2019, the NOAA PIT tag antenna at Felton detected 82 *O. mykiss* tagged in the lagoon (J. Kiernen, NOAA Fisheries Santa Cruz, personal communication, May 6, 2019). Thirty-two of those fish had been tagged in previous years (2016 and 2017) (Table 17). Of the 50 tagged in 2018, 27 had been tagged in June, 1 in August, and 22 in September. Almost half the June tagged fish were first observed at Felton in July with one additional fish observed in August and the rest from November through March 2019 (Table 17).

Table 17. *O. mykiss* tagged in the San Lorenzo Lagoon and later observed at Felton

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

Appendix A

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

Station	Location	*O. mykiss* Catch per Haul					
2002						Oct 1	Nov 20
SL-2	RR Trestle						0.0
SL-3	Near YSI Station					5.5	
SL-4	Below Riverside						
SL-5	Riverside Drive						9.0
SL-7	Laurel St.						1.0
SL-8	Soquel Ave.					20.0	0.3
2004			July 6		Sep 21	Sep 29	
SL-1	Near Mouth				0.0	0.0	
SL-2	RR Trestle		24.5			0.5	
SL-3	Near YSI Station		20.0				
SL-4	Below Riverside		0.0				
SL-5	Riverside Drive		62.0		0.0	0.0	
SL-6	U/S Bank Restoration		3.0			0.0	
SL-7	Laurel St.		3.0				
SL-8	Soquel Ave.				0.0	0.0	
2005		Jun 14	Jul 14	Aug 16		Oct 5	
SL-1	Near Mouth	0.0	0.0	1.7		0.0	
SL-2	RR Trestle	28.0	5.3	179.5		0.0	
SL-5	Riverside Drive	0.0	12.3	10.7		62.7	
SL-8	Soquel Ave.	7.7	1.0	0.0		0.0	
2008		Jun 8, 19				Oct 7-8	
SL-1	Near Mouth	0				0	
SL-2	RR Trestle	9				0.25	
SL-3	Near YSI Station	0				0	
SL-5	Riverside Drive	0				0	
SL-6	U/S Bank Restoration	0				0	
SL-8	Soquel Ave.	0				0	
	Overall	***2.6***				***0.1***	
2009		Jun 10-11			Sep 16	Oct 21	
SL-2	RR Trestle	0.75			1.0	0.25	
SL-3	Near YSI Station	0.25					
SL-5	Riverside Drive	0				0	
SL-6	U/S Bank Restoration	0				1.5	
	Overall	***0.3***			***1.0***	***0.5***	
2010		Jun 22-23	Jul 17			Oct 6-7	
SL-1	Near Mouth	0.0				0	
SL-2	RR Trestle	11.7	0.5			31.3	
SL-3	Near YSI Station		42.5			0	
SL-5	Riverside Drive	0.0				9.0	
SL-6	U/S Bank Restoration	9.0				80.0	
	Overall	***8.3***	***21.5***			***28.25***	
2011		Jun 9-14				Oct 13-18	
SL-2	RR Trestle	11.7				1.7	
SL-3	Near YSI Station	7.8				5.7	
SL-4	Near Marsh Outlet	16.0				1.0	
SL-5	Riverside Drive	48.5				2.2	
SL-6	U/S Bank Restoration	0.5				0.3	
	Overall	***13***				***2.5***	

Table A-1 (continued)

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

[3] Standard sites only (SL1-SL6)

Table A-1 (continued)

Station	Location	*O. mykiss* Catch per Haul					
2018		Jun 7-12	Jul 16-17	Aug 14-15	Sep 20-25		
SL-1	South of Trestle	12.8	5.3	8.5	8.8		
SL-2	RR Trestle	20.5	0.0	1.5	6.0		
SL-3	Near YSI Station	11.0	0.5	0.0	3.0		
SL-5	Riverside Drive	59.8	2.5	14.5	3.0		
SL-6	U/S Bank Restoration	14.8	2.8	5.3	7.3		
	Overall	***23.3***	***2.5***	***6.4***	***6.3***		

Figure A-1. Laguna Creek Lagoon sampling stations

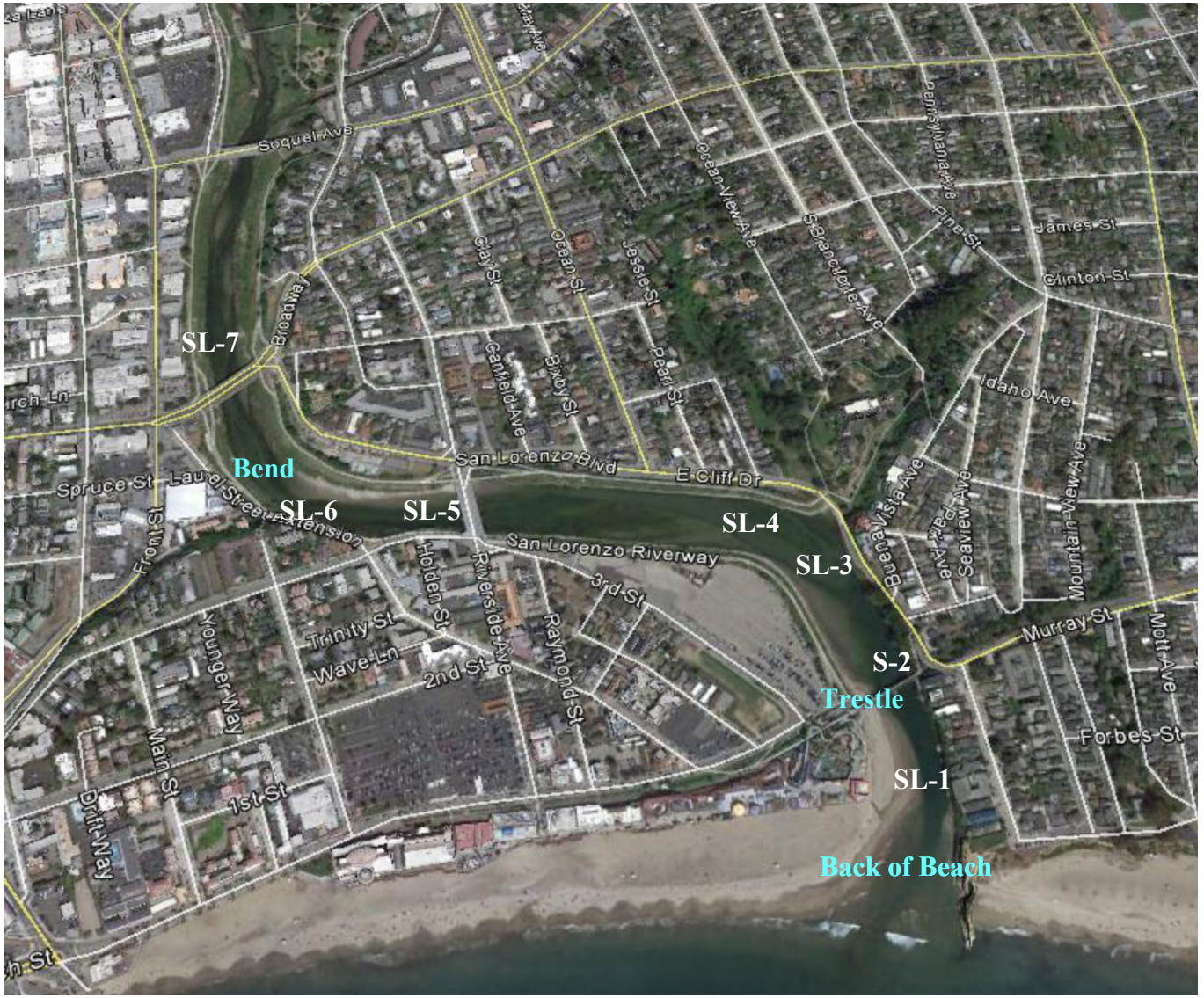

Figure A-2. San Lorenzo River Lagoon sampling stations

Acknowledgements

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