TECHNICAL MEMORANDUM

TO: Chris Berry
City of Santa Cruz Water Department

FROM: Jeff Hagar
Hagar Environmental Science

DATE: June 27, 2023

PROJECT: City of Santa Cruz Habitat Conservation Plan, Lagoon Fish Population Sampling 2022

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 2022 by the City of Santa Cruz Water Department and Hagar Environmental Science (HES). Mark-recapture abundance surveys were conducted in the early summer (June) and again in the late summer (September) 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. The net has a mesh size of 3/8 inch. The net was replaced in July 2021 due to damage. The replacement net of the same dimensions had a somewhat larger mesh (though still sold as 3/8-inch mesh) due to changes in net construction from the supplier. The new net may have a lower capture efficiency for very small young-of-year (YOY) steelhead (less than 80 mm). This does not affect mark-recapture estimates since fish less than 80 mm are also too small to tag and this size class is excluded from population estimates.

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. Additional catch per effort surveys were conducted in the San Lorenzo Lagoon during July and August. Habitat conditions in the San Lorenzo River were altered by construction activities for the lagoon management project (culvert installation).

Laguna Creek

Summary

The winter of 2021-2022 had some early storms including a storm in late October 2021 that produced enough runoff to open the lagoon. Beyond that, a series of wet storms produced high streamflows from mid-December through early January. Rainfall amounts were sufficient to maintain streamflow in Laguna Creek with baseflows gradually receding and inflow to the lagoon from over 8 cubic feet per second (cfs) in mid-January to over 2 cfs by May (City of Santa Cruz stream monitoring data, Laguna Creek anadromous gage). After reclosing for a period in the first two weeks of December, the lagoon was mostly open through late June (City of Santa Cruz lagoon depth record). During this period the lagoon appeared to close briefly, fill or partially fill, and spill again, all during a roughly daily period. These events have a different signature than tidal incursions. The lagoon was closed and filling during the initial survey period in June but opened just as the survey was finishing on the 14th.

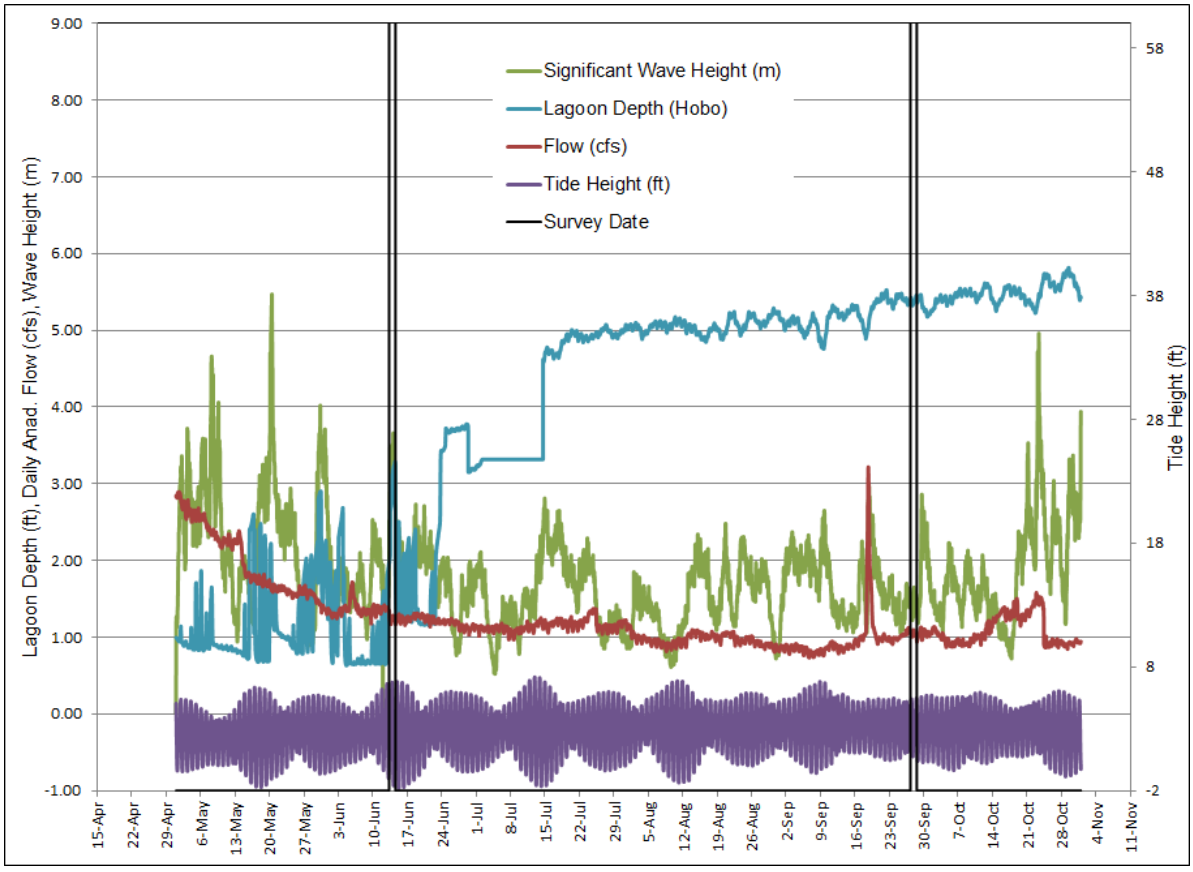

Figure 1. Laguna Creek Lagoon stage, streamflow, wave height, and tides 2022 (Source: lagoon depth from 2ND Nature and City of Santa Cruz, streamflow from City of Santa Cruz, wave and tide data from NOAA)

O. mykiss abundance (CPUE) was low in the lagoon in June for the second year, with relatively low abundance of YOY fish (Table 1). Although the lagoon was open and there were relatively high baseflows during the steelhead migration period, there were no high flow events after early January. Timing of runoff and subsequent stable streamflow conditions would have been ideal for coho.

O. mykiss abundance (CPUE) was in the lowest 20% of all annual spring samples but an apparent influx of YOY and 1+ fish after June resulted in a September abundance that was in the upper 20% of all fall surveys and three times the abundance in June (Table 1). There were no holdovers from 2021 observed in either June or September. Growth observed in 2022 was near the center of the distribution of observations in previous years. No coho were captured in June or September after two consecutive years with coho observed in the lagoon (Table 1).

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, HES 2020, HES 2021, and HES 2022).

	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*	
2019	*17.0*		*2.5*		*0*		*0*	
2020	*56.8*		*11.4*		*1.4*		*0*	
2021	*8.4*		*5.4*		*1.7*		*1.1*	
2022	*4.4*		*14.9*		*0*		*0*	

June Survey (June 13-14)

Early summer Site Conditions

- The mouth was closed but the stage was low and appeared to have recently been open. Stage was only slightly below the sandbar crest with signs of recent wave overwash (Figure 2, Figure 3).
- The water depth was shallow with greatest depths just over 3 feet along the rock bluff and the edge of the marsh upstream to the water quality recorder.
- Algal growth was dense and increased upstream, slowing the sampling effort.
- Inflow from Laguna Creek ranged from 1.4 cfs on the 13th to 1.2 cfs on the 14th (Figure 1).
- The lagoon was fresh at the surface with a pronounced salinity layer at depth, up to 32 ppt near the mouth (Figure 4, center panel).
- Temperature was coolest at the surface and increased in the saline layer. Surface temperature ranged from 11°C to 16°C; no temperature above 19°C was observed (Figure 4, left panel).
- Dissolved oxygen ranged from 7 mg/l to 15 mg/l with values between 10 mg/l and 11 mg/l at the surface (Figure 4, right panel).
- The water column was clear with substrate visible at greatest depth surveyed (1.1 meters or 3.6 feet).

Figure 2. Laguna Creek Lagoon, June 13, 2022

Figure 3. Laguna Creek Lagoon mouth, June 13, 2022

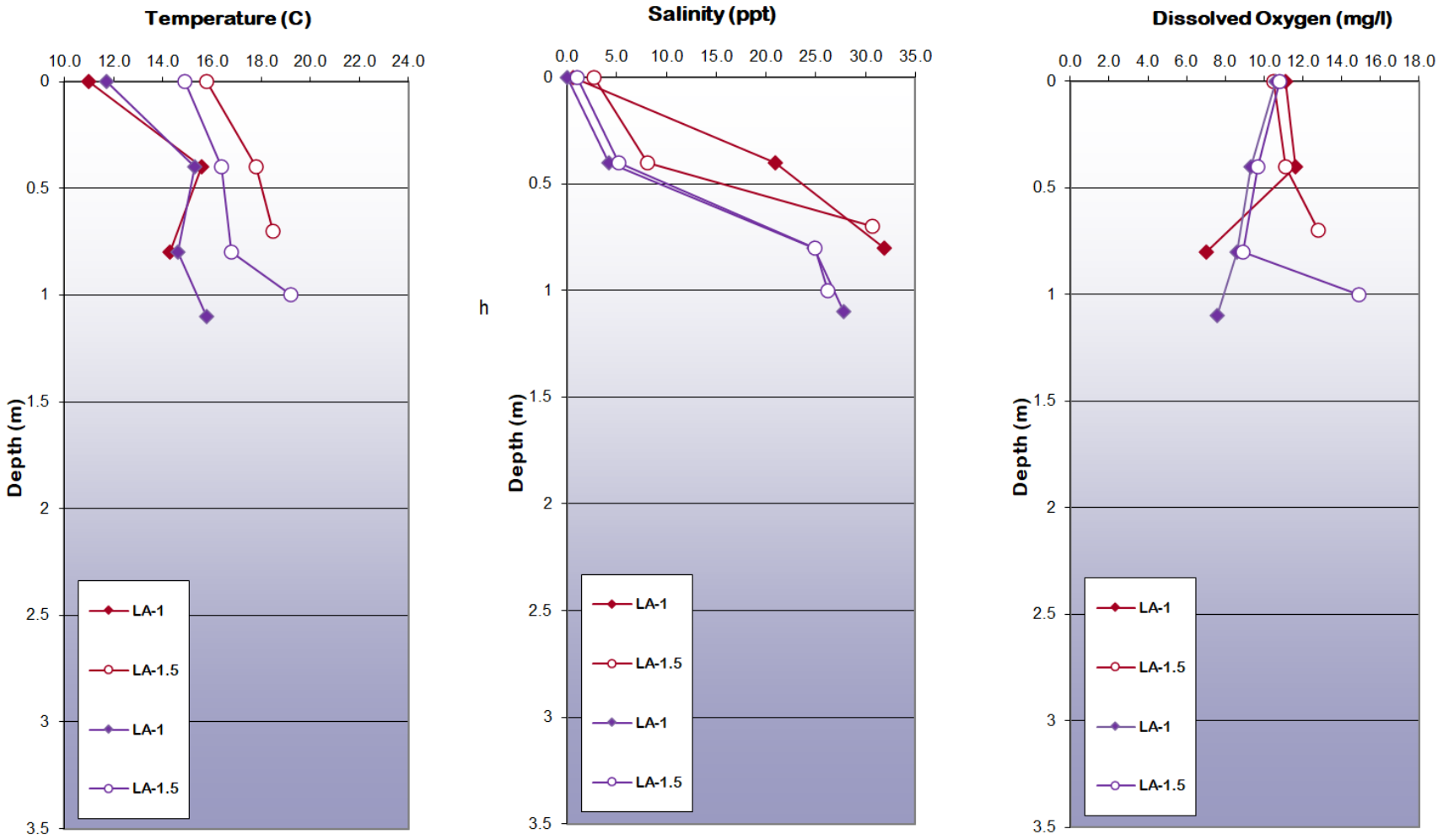

Figure 4. Depth profiles of water quality parameters in Laguna Creek Lagoon during June seining survey. Profiles plotted in red are June 13; profiles in blue are June 14

June Survey Results

- *O. mykiss* were captured and marked on June 13. On June 14 the lagoon was re-sampled and the proportion of re-captured fish was recorded.
- Eight seine hauls were completed on June 13 and eight were completed on June 14 from the beach (LA-1) upstream to the vicinity of the water quality buoy (LA-3).
- *O. mykiss* abundance (CPUE) was in the lowest 20% of all annual spring samples (Table 1).
- In addition to *O. mykiss*, staghorn sculpin were abundant (Table 2) and juvenile starry flounder and threespine stickleback were present. Juvenile starry flounder were present in the lagoon in 2021 but not previously seen since fall 2015. One tidewater goby was captured. The 3/8-inch mesh used for steelhead does not effectively retain tidewater goby.

Table 2. Fish catch in Laguna Creek Lagoon, June 2022

	LA-1	LA-1.5	LA-2	LA-3	Grand Total
# Hauls	*8*	*2*	*4*	*2*	***16***
Species	***Number Caught***				
Steelhead	45	8	16	2	**71**
Threespine stickleback	4	5	5		**14**
Staghorn sculpin	79	141	65	11	**296**
Tidewater goby		1			**1**
Starry flounder	4	3	7	1	**15**
O. mykiss CPUE	*5.6*	*4.0*	*4.0*	*1.0*	***4.4***

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

- Six of the 71 *O. mykiss* captured, about 8% were YOY.
- All *O. mykiss* captured in June were characterized as parr (97%) or advanced parr (3%).
- One *O. mykiss* out of 59 examined had an attached anchor worm (*Lernaea)*. No other external parasites, disease, or abnormalities were noted.
- All *O. mykiss* had an adipose fin present.
- Numbers of steelhead were too low for an accurate length-frequency analysis but there appear to be two or three modes to the length distribution (Figure 5). Fish less than 50 mm FL are likely YOY. Fish in the 20 mm and 30 mm size classes must have emerged fairly recently, indicating possible late spawning (Figure 6). Modes focused on 80-100 mm FL and 120-180 mm FL are likely 1+ and 2+, respectively (Figure 5).

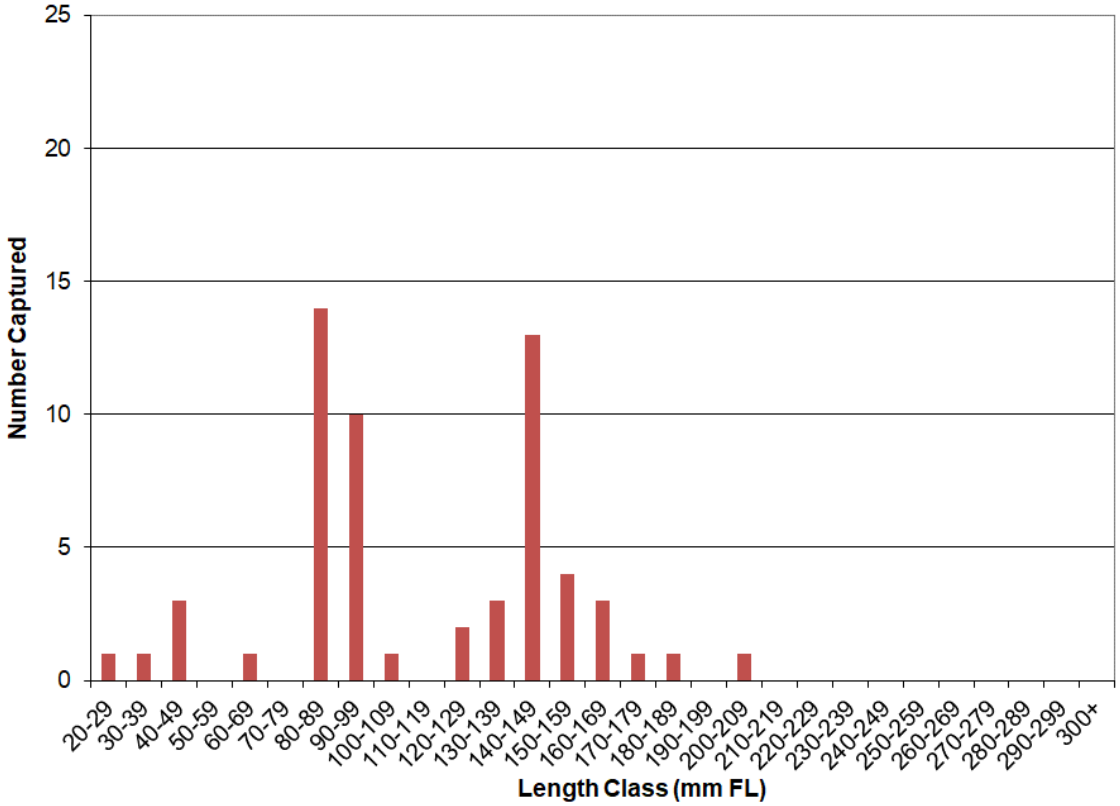

Figure 5. *O. mykiss* length classes in Laguna Creek Lagoon, June 2022

Figure 6. Y- O-Y *O. mykiss* from Laguna Creek Lagoon, June 2022

June *O. mykiss* Population Estimate

- Forty-six *O. mykiss* were captured during the mark period (June 13). Four of these were too small to mark and 8 were recaptures. Therefore, there were 34 individuals 80 mm or larger tagged and returned to the lagoon.
- Twenty-five *O. mykiss* were captured during the recapture period on June 14 but only 23 were 80 mm or larger. Three of the 23 had been tagged during the mark period and one additional fish had an obvious tag scar but no tag was read. This fish was also counted as a recapture from the mark period.
- Based on the Peterson method (Ricker 1975), the population estimate is 168 *O. mykiss* in the lagoon in mid-June. The 95% confidence limits for this estimate are 74 and 331. This estimate was in the lower range for fall surveys in Laguna to date (Figure 7).
- CPUE was higher during the mark period than the recapture period (5.8 vs. 3.1), however, the difference was not statistically different, two sample t-test, equal variance, two-tail, p≈0.45).
- Untagged fish captured during the recapture period were tagged in order to collect over-summer information.

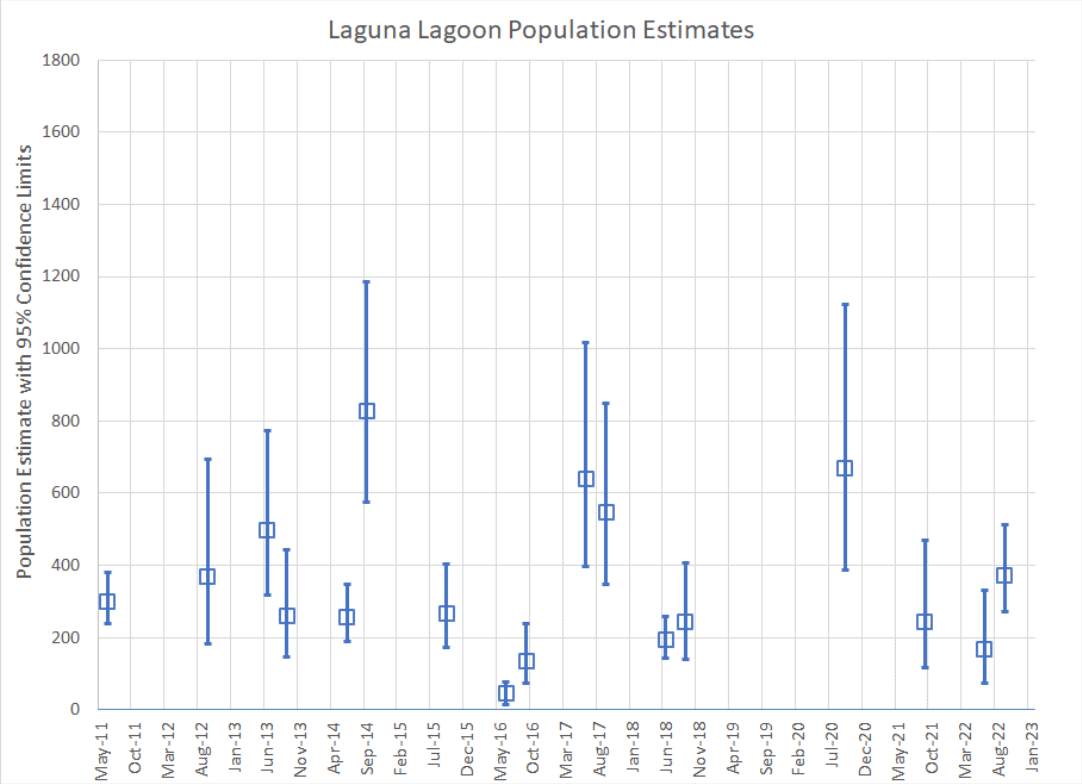

Figure 7. *O. mykiss* population estimates in Laguna Creek Lagoon over time[1]

[1] Population estimates not available in Fall 2011, Spring 2012, Spring 2015, Spring and Fall 2019, Spring 2020, and Spring 2021 due to insufficient catch, low number of recaptures, and/or evidence of transient populations in the lagoon.

September Survey (September 27-28)

Late summer Site Conditions

- The mouth was closed at the time of the survey with lagoon configuration deeper, but otherwise little changed from June. The lagoon had closed in late June and reached 5 feet of depth by mid-July, gradually increasing to 5.5 feet at the time of the September survey (2nd Nature and City of Santa Cruz data) (Figure 1, Figure 8).
- Inflow from Laguna Creek during sampling ranged from 1.1 cfs to 1.0 cfs.
- Maximum depth measured was 1.7 meters (5.6 feet). The deepest water was available along the rock wall and along the interior marsh edge.
- The lagoon temperature ranged between 16.1°C and 18.5°C and was nearly unstratified but slightly cooler at the greatest depths (Figure 9, left panel). Salinity measurements were uniform with depth at 0.4 ppt at both stations reflecting full conversion to freshwater of the closed lagoon (Figure 9, center panel). Dissolved oxygen ranged between 3.9 mg/l and 8.3 mg/l and was nearly unstratified but slightly lower at the greatest depths (Figure 9, right panel), likely due to the accumulation of senescent algae. DO levels in the water column were generally 5.3 mg/l or higher.
- The water column was clear with secchi visibility to the bottom at depths to 1.6 meters to 1.9 meters (5.2 feet to 6.2 feet)

Figure 8. Laguna Creek Lagoon, September 27, 2022

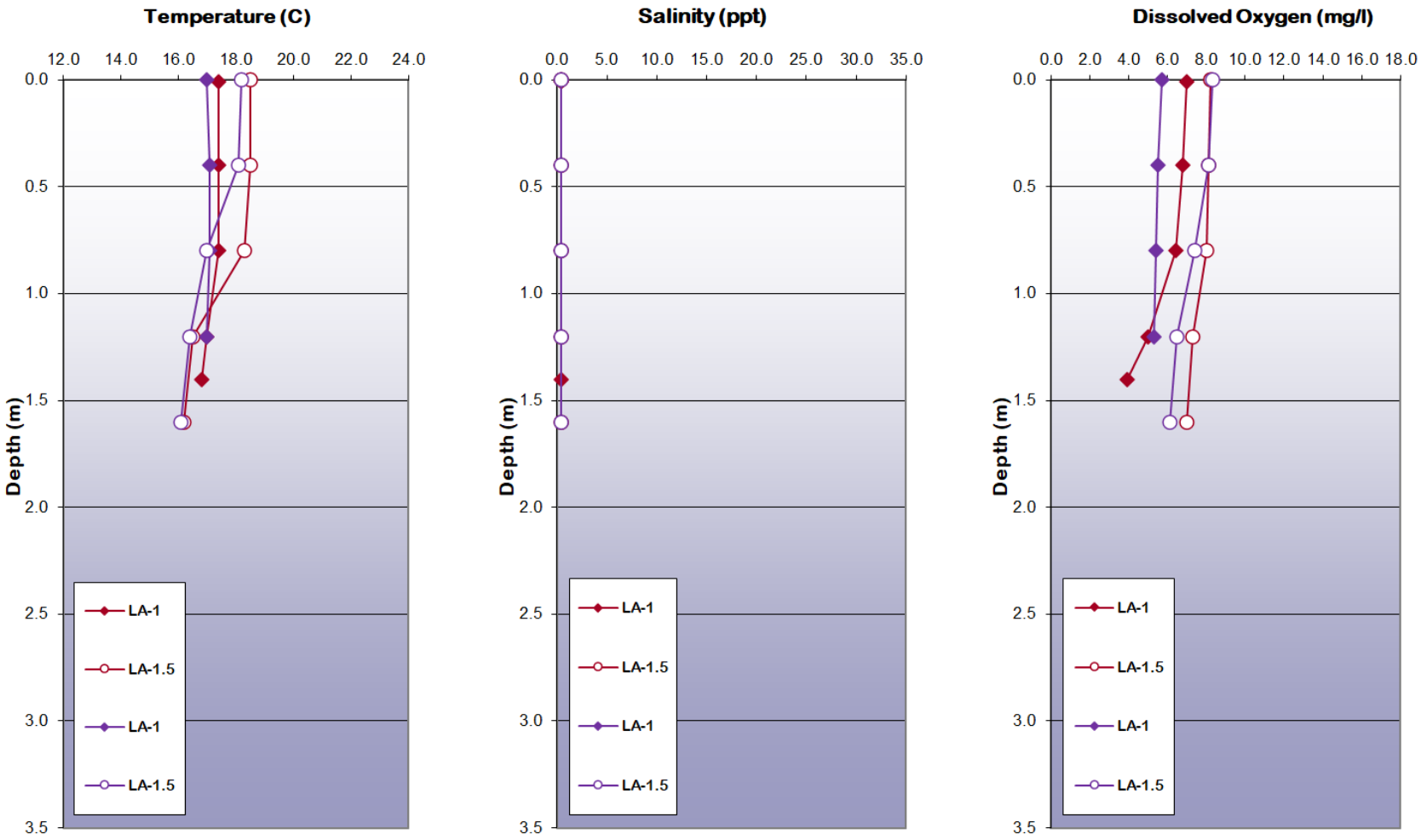

Figure 9. Depth profiles of water quality parameters in Laguna Creek Lagoon during September. Profiles plotted in red are September 27; profiles in blue are September 28

September Survey Results

- *O. mykiss* were captured and marked on September 27. On September 28 the lagoon was re-sampled and the proportion of re-captured fish was recorded.
- Nine seine hauls were completed on each day between the beach (LA-1) upstream to below the water quality buoy (LA-2) (Table 3).
- Species representation was similar to June except staghorn sculpin numbers were greatly reduced and no tidewater goby were captured (Table 3).

Table 3. Fish catch in Laguna Creek Lagoon, September 2022

	LA-1	LA-1.5	LA-2	LA-3	Grand Total
# Hauls	*10*	*4*	*4*		***18***
Species	***Number Caught***				
Steelhead	133	27	108		**268**
Threespine stickleback	2				**2**
Staghorn sculpin	1				**1**
Starry flounder	13	3	1		**17**
O. mykiss CPUE	*13.3*	*6.8*	*27.0*		***14.9***

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

- Overall abundance of *O. mykiss* based on catch per unit effort (CPUE) was in the top 20% for fall surveys to date (Table 1), and over 3 times the abundance in June (significant difference, two sample t-test, unequal variance, two-tail, p≈0.01).
- There were no captures of *O. mykiss* tagged in previous years.
- Six *O. mykiss* tagged in June were recaptured in September. Growth rates ranged from 0.57 to 0.88 mm/day and averaging 0.69 mm/day (Table 4). Growth observed in 2022 was near the middle of the distribution of observations in previous years with the exception of 2018 when exceptionally high growth rates were observed (Figure 10). There were abundant large aquatic invertebrates, preferred by *O. mykiss* as a food source, available in the lagoon in September.

Table 4. *O. mykiss* captured in September 2022 originally tagged in June 2022

Initial Capture Date	Recapture Date	Initial Capture Location	Recapture Location	Initial Length (mm)	Length at Recapture (mm)	Growth Rate (mm/day)
06/14/22	09/27/22	LA-1	LA-2	142	204	0.59
06/13/22	09/27/22	LA-1	LA-2	86	171	0.80
06/13/22	09/27/22	LA-1	LA-1.5	141	205	0.60
06/14/22	09/27/22	LA-1	LA-1	93	185	0.88
06/14/22	09/27/22	LA-2	LA-1	150	210	0.57
06/14/22	09/27/22	LA-3	LA-1	87	173	0.82

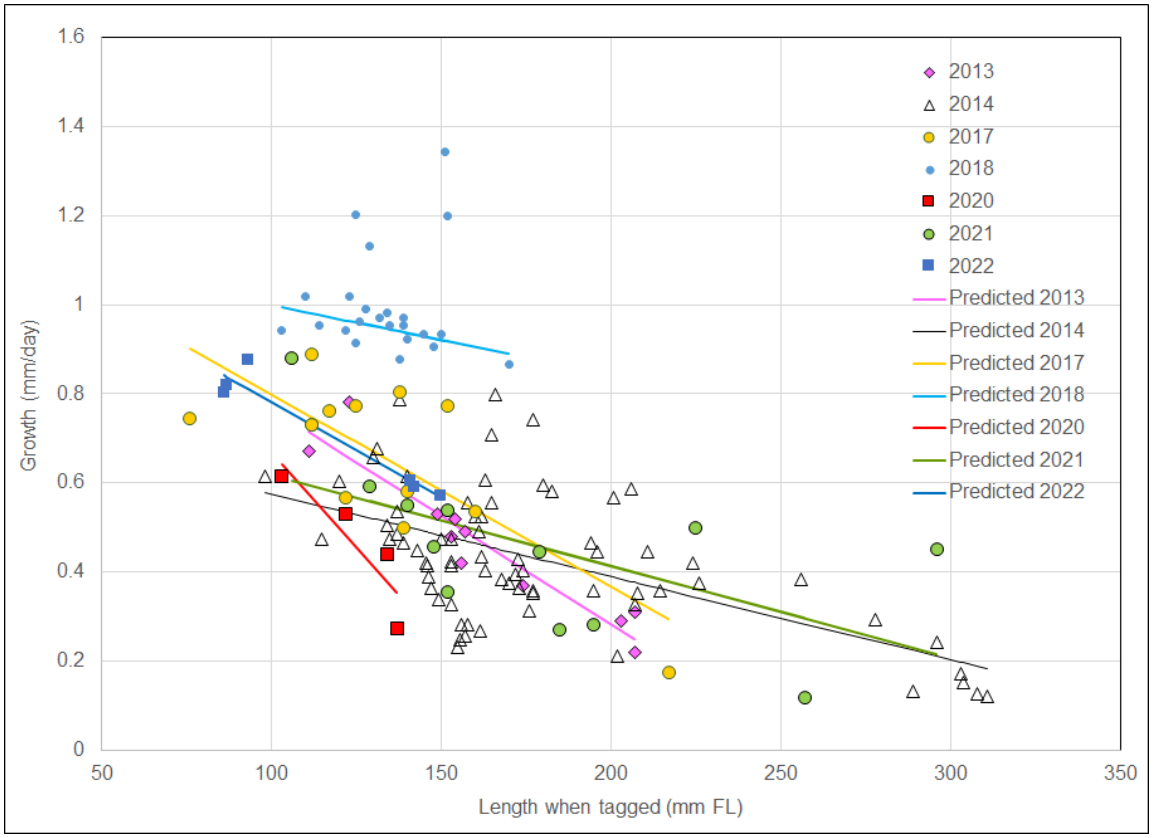

Figure 10. Laguna Creek Lagoon growth rates of *O. mykiss* tagged in June and recaptured in September

- Captured *O. mykiss* ranged in length from 78 mm to 365 mm FL (Figure 11). Based on tag recovery data (Table 4), fish in the 130 mm to 150 mm mode in June grew into the 200 mm to 240 mm mode in September. The group of 80 mm to 100 mm fish present in June grew into the 180 mm to 220 mm size range in September. The large group of *O. mykiss* present in September in the 90 mm to 190 mm size range could have been comprised partially of June YOY and 1+ fish but the large numbers compared to June suggest migration of fish in these size classes into the lagoon after June (Figure 11). Five large *O. mykiss* ranging from 317 mm to 365 mm were captured in September. These fish had the appearance of stream fish, not ocean migrants as seen in other years (Figure 12). The lagoon was open for about nine days following the June survey, potentially allowing movement in or out between the ocean.

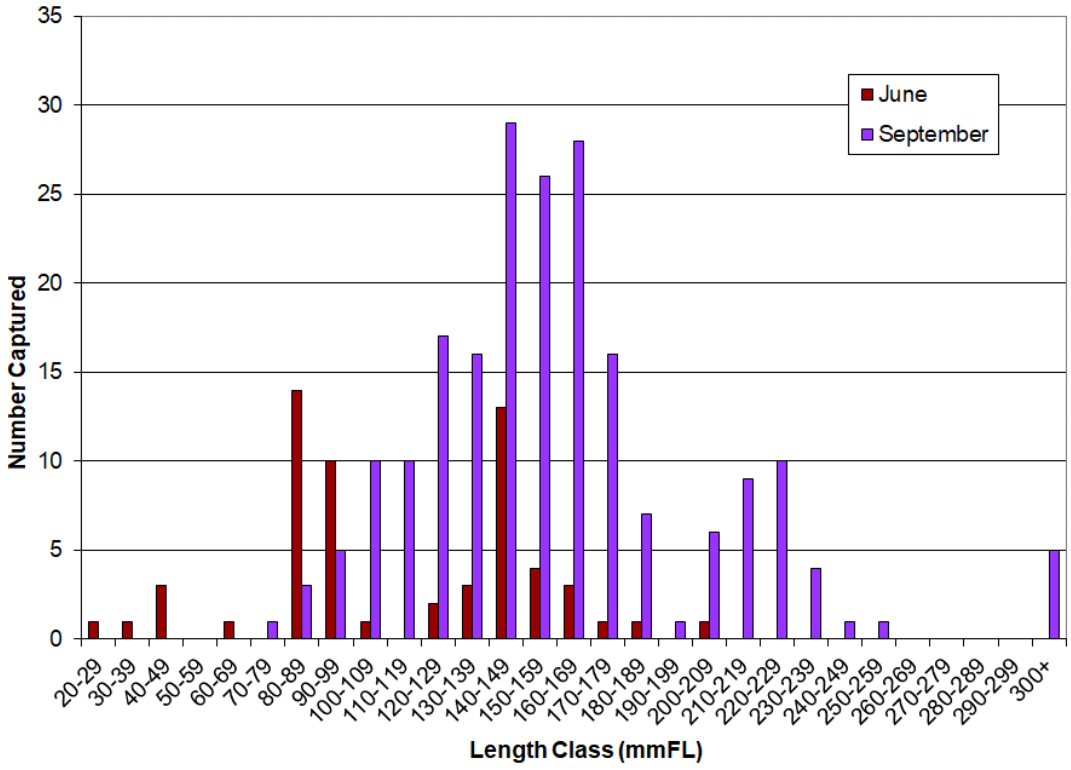

Figure 11. *O. mykiss* length classes in Laguna Creek Lagoon, late summer 2022 compared to spring 2022

Figure 12. *O. mykiss* adult from Laguna Creek Lagoon, June 2022

- Eighty-three percent of the *O. mykiss* catch were characterized as parr or advanced parr and 15% were characterized as silvery parr or advanced silvery parr. Two percent had the appearance of adult stream fish.
- No juvenile coho salmon were captured.
- Two *O. mykiss* out of 204 examined (not including recaptures) were moderately infected with black-spot disease (BSD), no other external parasites, disease, or abnormalities were noted. Incidence of BSD has been low in Laguna Creek lagoon in past surveys.
- All *O. mykiss* had an adipose fin present.

September *O. mykiss* Population Estimate

- One hundred eighty-two *O. mykiss* were captured during the marking period on September 14. Twenty fish were recaptures of fish already tagged during the marking period. The minimum size for tagging was increased to 90 mm to avoid additional tagging mortality. Three *O. mykiss* were less than 90 mm and were not tagged. In addition, there were three *O. mykiss* larger than 320 mm and these were also not tagged. One fish died after tagging. Therefore, there were 155 marked *O. mykiss* released in the lagoon on September 27.
- On September 28, 86 *O. mykiss* were captured with one less than the 90 mm tagging limit. There were 37 recaptures but 2 of these had been tagged during the recapture period. Therefore 35 of the 85 *O. mykiss* within the size limits were fish marked on September 27.
- Based on the Peterson method (Ricker 1975), the population estimate is 373 *O. mykiss* in the lagoon in mid-September. The 95% confidence limits for this estimate are 270 and 513. This estimate was close to the average (366) for fall surveys in Laguna through 2021 (Figure 12).

- CPUE was higher during the mark period than during the recovery periods (20.2 vs. 9.6, not significantly different, two sample t-test, equal variance, two-tail, p≈0.12).
- The relationship between the population estimates and CPUE was updated with the spring and fall 2022 data points (Figure 13). Least squares regression r^2 is 0.55 and was statistically significant with <0.001. Forcing the relationship through the origin improves the r^2 to 0.87. The relationship changed negligibly with the addition of the 2022 data points.

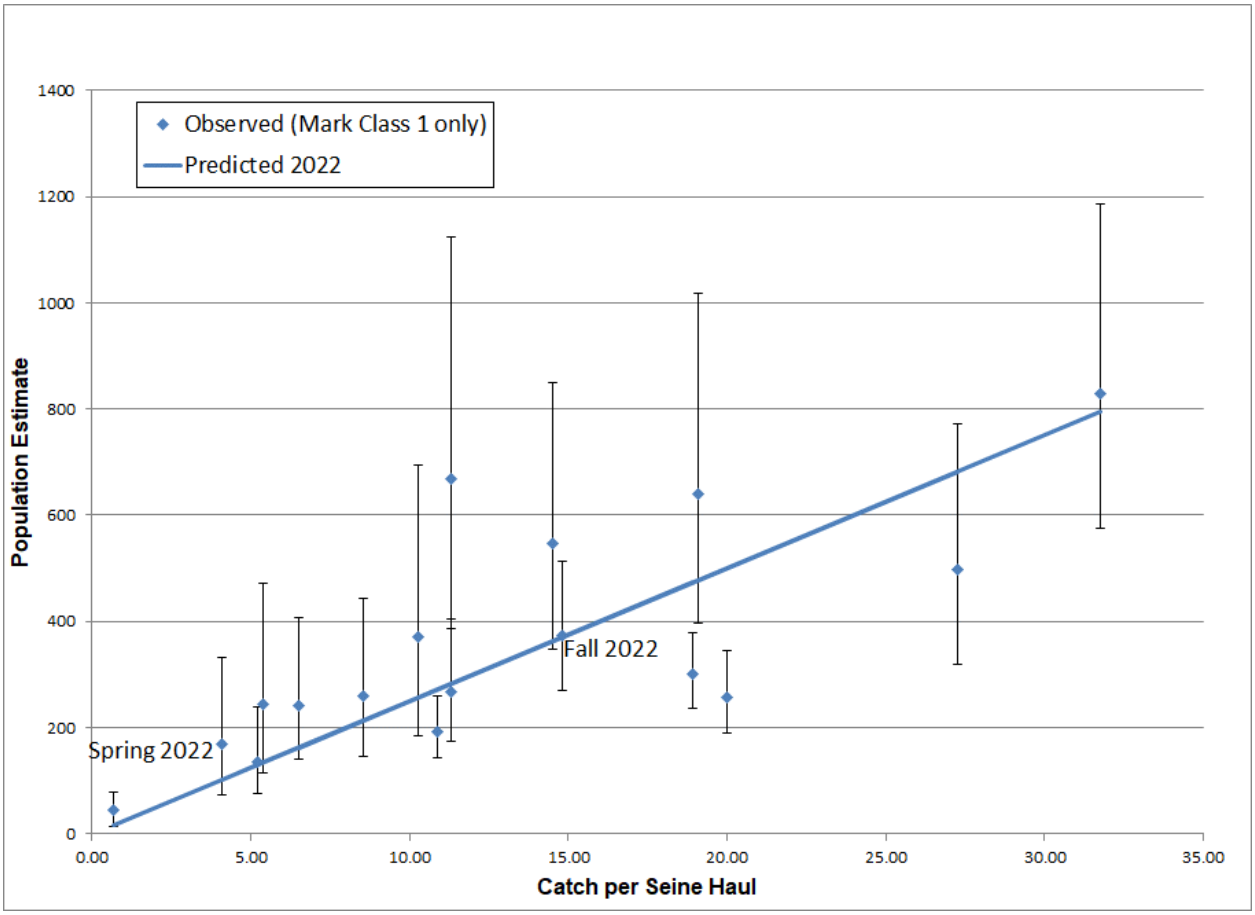

Figure 13. Relationship between *O. mykiss* population estimate and CPUE in Laguna Creek Lagoon[2]

[2] Population estimates not available in Fall 2011, Spring 2012, Spring 2015, Spring and Fall 2019, Spring 2020, and Spring 2021 due to insufficient catch, low number of recaptures, and/or evidence of transient populations in the lagoon.

San Lorenzo River

Summary

Although there was little significant precipitation in 2021-2022 after January 2022, the storms as early as late October and peaking in December were substantial and provided relatively good runoff with good flows (at least 20 to 40 cfs) in the San Lorenzo River at Santa Cruz and into the lagoon through mid-May (USGS online data) (Figure 14). Construction of the culvert for the San Lorenzo River Lagoon Interim Management Plan was initiated between the June and July surveys but disturbance was fairly minimal until after the July survey. Intermittent lagoon closure occurred from late May through mid-August, at which time the construction project closed the lagoon with a large sand plug and pumped flows past the plug to maintain relatively low water level in the lagoon.

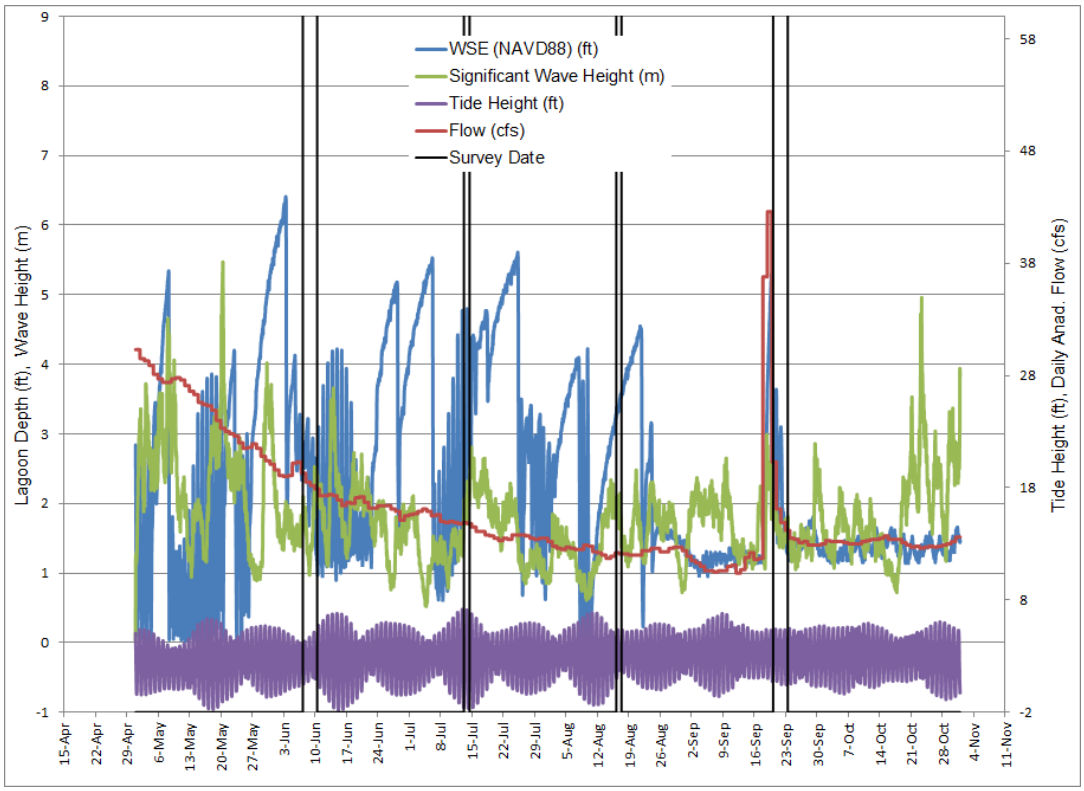

Figure 14. San Lorenzo River Lagoon stage, streamflow, wave height, and tides 2022 (Source: lagoon stage from City of Santa Cruz Public Works, streamflow from USGS, wave and tide data from NOAA)

The 2022 season continued the trend begun in the 2021 season of low abundance of *O. mykiss* in the lagoon in June compared to the 2016-2020 period of higher abundance (Table 5,Table 6). Growth rates were also low for *O. mykiss* through the entire summer period. Water quality conditions were favorable for tagging and handling in June and July but tagging was suspended mid-way through the July survey due to elevated mortality rates, possibly due to osmotic stress. High water temperature precluded tagging, measuring, or close observation in August. Abundance of *O. mykiss* peaked in July with apparent movement of large YOY into the lagoon (Table 5). Abundance was high around the trestle in July and more dispersed in other months (Table 7).

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, HES 2021, and HES 2022)

	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	
2019	92.2	53.4	277.7	228.2	
2020	146.1	120.6		31.0	
2021	4.3	6.3			0.3
2022	2.4	20.5	2.3	8.8	

Table 6. *O. mykiss* mark-recapture population abundance estimates in San Lorenzo River Lagoon for fish >80mm FL and <320mm FL

	O. mykiss Population Estimate	
	Spring	Fall
2011	501	138
2012	60	714[1]
2013	207[2]	No estimate[3]
2014	No estimate[4]	None captured
2015	559[3]	None captured
2016	2,697	1,331
2017	3,636	>3,636[5]
2018	2,378	704
2019	7,637[6]	14,105
2020	26,815	18,720
2021	No estimate	No estimate
2022	53	721

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

[1] May have been fish entering or leaving lagoon

[2] Low number of marks or recaptures, likely biased

[3] Evidence population not closed, violates assumption of the method

[4] No recaptures

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

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

Table 7. *O. mykiss* catch per haul for the San Lorenzo River Lagoon during 2022

		O. mykiss Catch per Haul				
Station	Location	Jun 7-10	Jul 13-14	Aug 17-18	Sep 20-23	Overall
SL-1	South of Trestle	4.0	0.7	3.0	25.0	9.2
SL-2	RR Trestle	2.7	73.0	1.6	8.7	12.5
SL-3	Near YSI Station	NS	NS	NS	NS	NS
SL-5	Riverside Drive	0.5	10.0	4.0	13.8	8.5
SL-6	U/S Bank Restoration	0.8	5.0	0.0	1.4	2
	Overall	***2.4***	***20.5***	***2.3***	***8.8***	***8.1***

NS- Not Sampled

June Survey (June 7-10)

June Site Conditions

- The lagoon was open on the evening of June 6 but closed overnight and was closed when sampling was initiated (Figure 15). Lagoon stage records show very brief periods of closure (from a few hours to about 24 hours) with re-opening and partial draining during the sample period (Figure 16). The river was in the process of cutting through the containment levee created by the City that had maintained the outlet in a more easterly alignment, against the San Lorenzo bluff.
- Flow in the San Lorenzo River at Santa Cruz (USGS gage) ranged from 19.3 cfs on June 7 to 17.9 cfs at the end of the sampling period on June 10. Mean flow for June during the period of record (1953-2022) is 34 cfs (historical discharge, USGS site 11161000 San Lorenzo River at Santa Cruz California). Lagoon water surface elevation ranged from 1.2 to 3.2 feet (NAVD88) (Figure 16).
- Downstream of the trestle, the shoreline was conducive to sampling with sand beach exposed but there was a shelf of shallow water (Figure 15). The net was used as a purse seine with a finish at the edge of the shelf or at the canoe. Upstream of the trestle there was no sand beach with relatively deep (1 to 2 feet) water at the bank. Upstream of Riverside Bridge there was a narrow sand beach in some places but a wide shallow shelf for most of the survey area required a purse-seine finish at the canoe. Some algal growth was present but it was not a significant problem for sampling.
- The lagoon was salinity stratified with a relatively fresh surface layer to 0.4 meters deep having salinities from 0.1 to 4.4 ppt. Below this level salinity increased rapidly to just over 30 ppt near the substrate at 1.5 meters depth (Figure 17, center panel). Salinity was highest upstream of Riverside Bridge at the end of the survey period as the lagoon entered a fully open period.

Figure 15. San Lorenzo River Lagoon mouth June 6, 2022

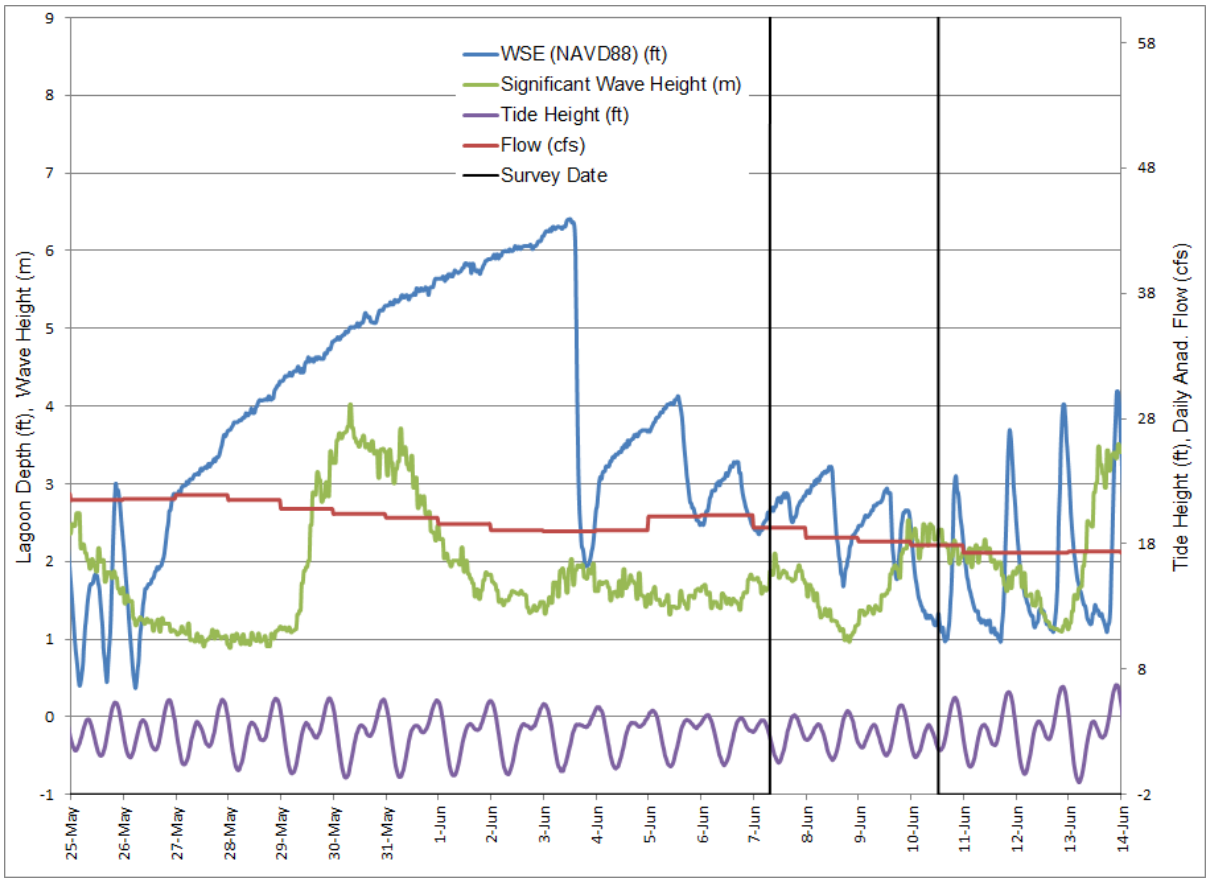

Figure 16. San Lorenzo River Lagoon stage, streamflow, wave height, and tides around June 2022 sample period (Source: lagoon stage from City of Santa Cruz Public Works, streamflow from USGS, wave and tide data from NOAA)

- Temperature was below 22°C in the upper 0.4 meters throughout the study period though surveys were discontinued as afternoon temperatures rose above this level [3]. Temperature peaked in the middle depths (0.8 meters), particularly upstream of Riverside Bridge and later in the survey period (Figure 17, left panel). Temperature conditions were suitable for tagging through the mark period (initial two days).
- Dissolved oxygen was at relatively high levels initially (over 7 mg/l) but deteriorated in deeper waters and upstream of Riverside Bridge by the end of the survey period on June 10 (Figure 17, right panel). Low dissolved oxygen levels precluded sampling on June 10 upstream of Riverside Bridge.
- The water column was relatively clear with secchi disk visible at the substrate in up to 1.7 meters (4.9 feet) of depth.

[3] Permit terms are that sampling will not be conducted if surface water temperature exceeds 21°C. Tagging and measuring will not be conducted unless 50% of the water column is 21°C or less and DO is 5 mg/l or more. Tagging and measuring will not be conducted unless holding water temperature is 20°C or less and DO is 5 mg/l or more.

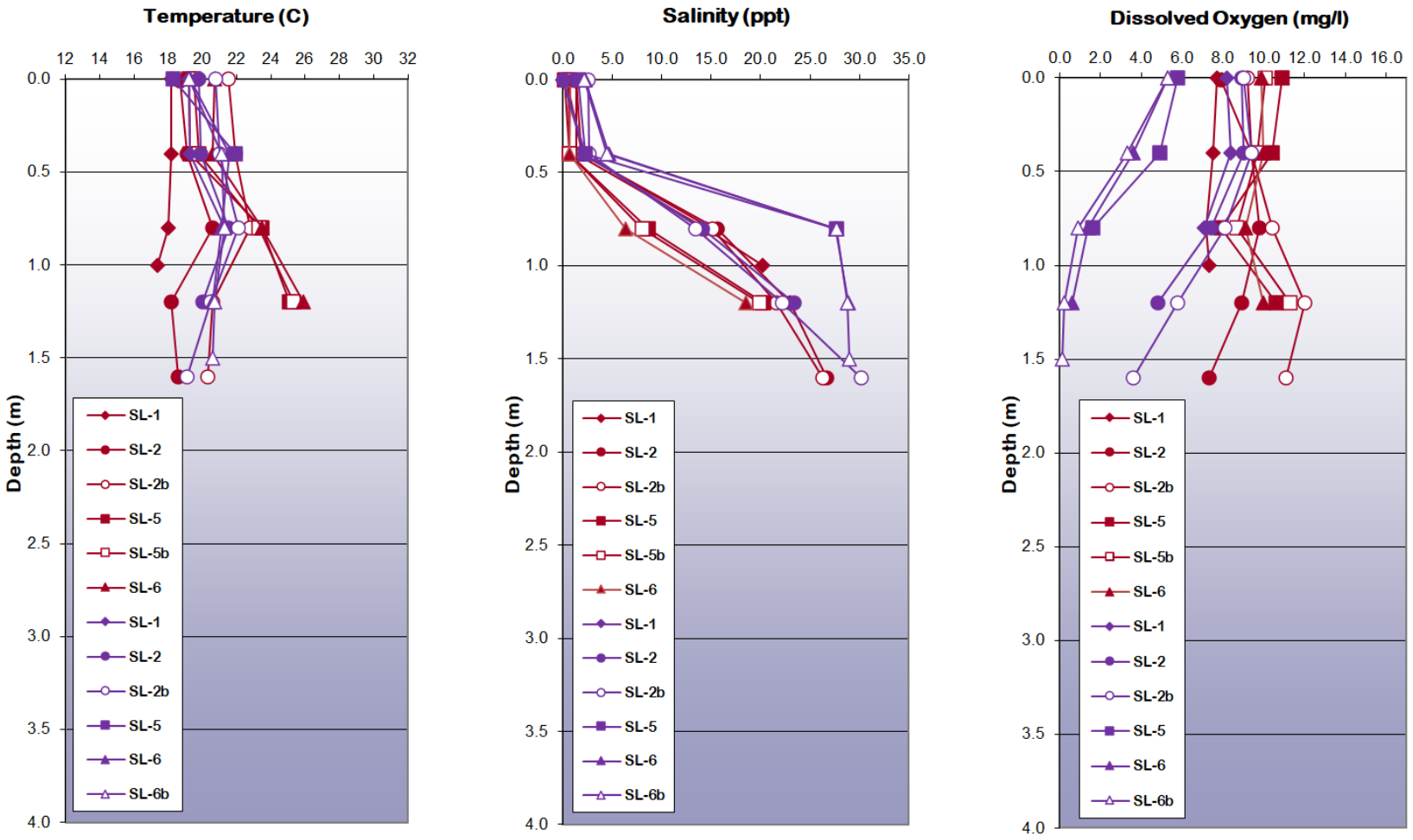

Figure 17. Depth profiles of water quality parameters in the San Lorenzo River Lagoon during June. Profiles plotted in red are June 7-8; profiles in blue are June 9-10

June Survey Results

- The lagoon was sampled between the beach and the bend upstream of Riverside Bridge on June 7th to 8th and again on June 9th. Due to low DO and high temperature upstream of Riverside Bridge on June 10th no survey was completed. All O. mykiss greater than 89 mm in length were tagged.
- Twenty-two seine hauls were completed at regularly sampled stations. The catch was dominated by topsmelt while staghorn sculpin, shiner surfperch, starry flounder, and *O. mykiss* were relatively abundant (Table 8).
- Six chinook salmon, all in the 80 mm to 89 mm size-class were captured. The two largest were characterized as smolt stage, the others as silvery parr or advanced silvery parr (Figure 18). Presence of these fish indicates successful spawning of chinook salmon in the San Lorenzo River. YOY chinook salmon were also captured in the lagoon in June 2014.
- *O. mykiss* abundance (CPUE) was in the lowest third for all surveys to date and the lowest since 2014 (Table 5). Abundance was greatly reduced from the high levels observed in the 2016-2020 period. CPUE was highest downstream of the trestle (Table 8).

Table 8. Fish catch in San Lorenzo River Lagoon, June 2022

	SL-1	SL-2	SL-5	SL-6	Grand Total
# Hauls	*6*	*9*	*2*	*5*	***22***
Species	***Number Caught***				
O. mykiss	24	24	1	4	**53**
Pacific herring		3			**3**
Chinook salmon	3	3			**6**
Topsmelt	1588	4440	1191	2170	**9389**
Threespine stickleback		2	1		**3**
Staghorn sculpin	27	82	4	15	**128**
Striped bass	1				**1**
Barred surfperch		3			**3**
Shiner surfperch	10	67	2		**79**
Starry flounder	18	30	1	4	**53**
O. mykiss CPUE	*4*	*2.7*	*0.5*	*0.8*	***2.4***

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

Figure 18. Chinook salmon silvery parr, San Lorenzo River Lagoon mouth June 9, 2022

- There were two distinct size classes of *O. mykiss* captured in June; one mode with fish in the 80 mm to 89 mm size range and a second mode with fish from 120 mm FL to 190 mm FL (Figure 19). The fish in the 80-89 mm size range were likely large YOY from early spawning. This could have occurred if most steelhead spawning occurred early (December and January), which is highly possible since the majority of storm flows occurred before early January. The larger fish were likely age 1+ and older, consistent with observations in previous years. Two adult *O. mykiss* were captured, or likely the same adult captured twice. Both captures were estimated at 28 inches in length.

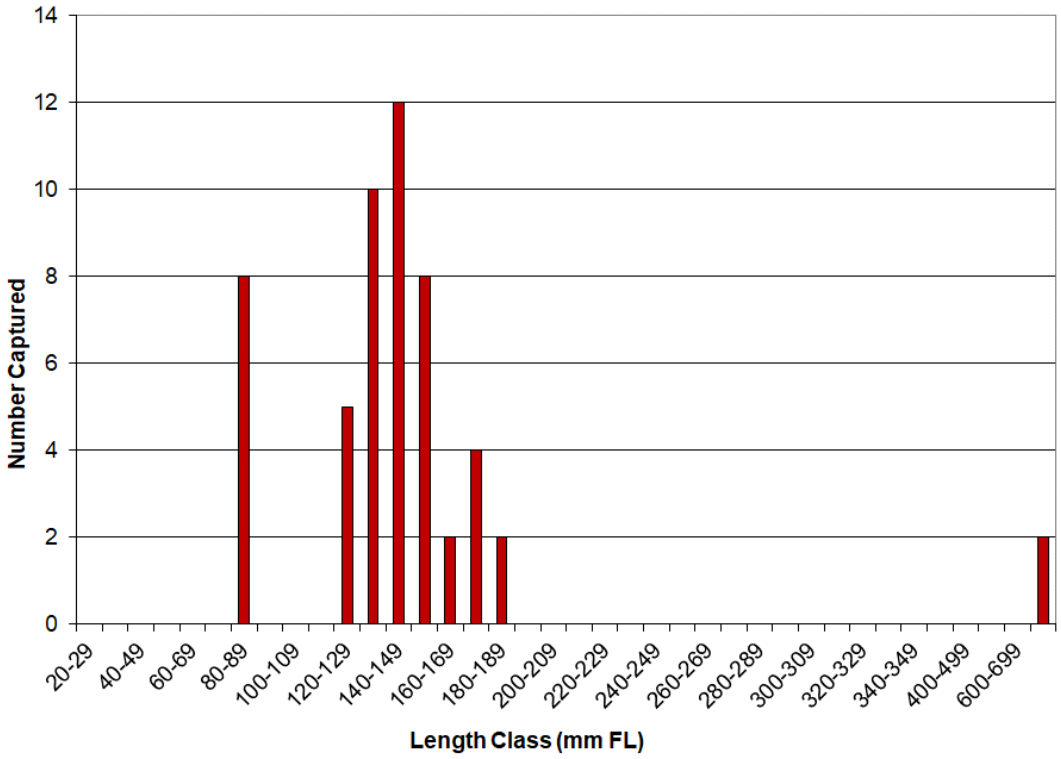

Figure 19. *O. mykiss* length classes in San Lorenzo River Lagoon, June 2022

- All *O. mykiss* were classified as parr or advanced parr except for the adult(s). The adult(s) had olive green coloration on the back, a pinkish blush on the flanks, and red cheeks. It was fairly robust, not skinny. There was an apparent deformity of the upper right mandible partially obscuring the eye and a possible spot of ulceration near the end of the mandible.
- All *O. mykiss* captured had an adipose fin present, indicating they were not of hatchery origin.
- Thirty-three percent of *O. mykiss* examined had black-spot disease (BSD) lesions, most were lightly affected. Incidence of BSD has ranged between 11% and 68% in previous spring surveys since 2010.

June *O. mykiss* Population Estimate

- Twenty-eight *O. mykiss* were captured during the marking period (June 7-8). Three of these were too small to tag (<90 mm) and one was too large (>320 mm). Two others did not recover after processing. Additionally, three were recaptures from the mark period that had already been tagged. Nineteen tagged *O. mykiss* were present in the lagoon following the marking period.
- Twenty-five *O. mykiss* were captured during the recapture period, seven of which were tagged during the marking period. One fish was larger than 320 mm and four were less than 90 mm. These five were not included for the population estimate.

- The Peterson population estimate (Ricker 1975) is 53 *O. mykiss* in the lagoon in June. The 95% confidence limits for this estimate are 27 and 96. This is the lowest estimate in the ten years for which an estimate was possible for fall surveys in the San Lorenzo Lagoon (Table 6).
- Changes in CPUE and size distribution between the mark period and recapture period can indicate movement of fish in and out of the lagoon and violation of the assumption of a closed population. CPUE was similar during the mark and recovery periods (2.0 and 3.1, respectively) though the area upstream of Riverside Bridge, which had very low CPUE during the marking period, was not sampled during the recovery period due to low DO. The difference between mark and recovery periods was not significantly different, two sample t-test, equal variance, two-tail, p>0.30).
- The size distribution was similar for the mark and recapture periods (Figure 20).

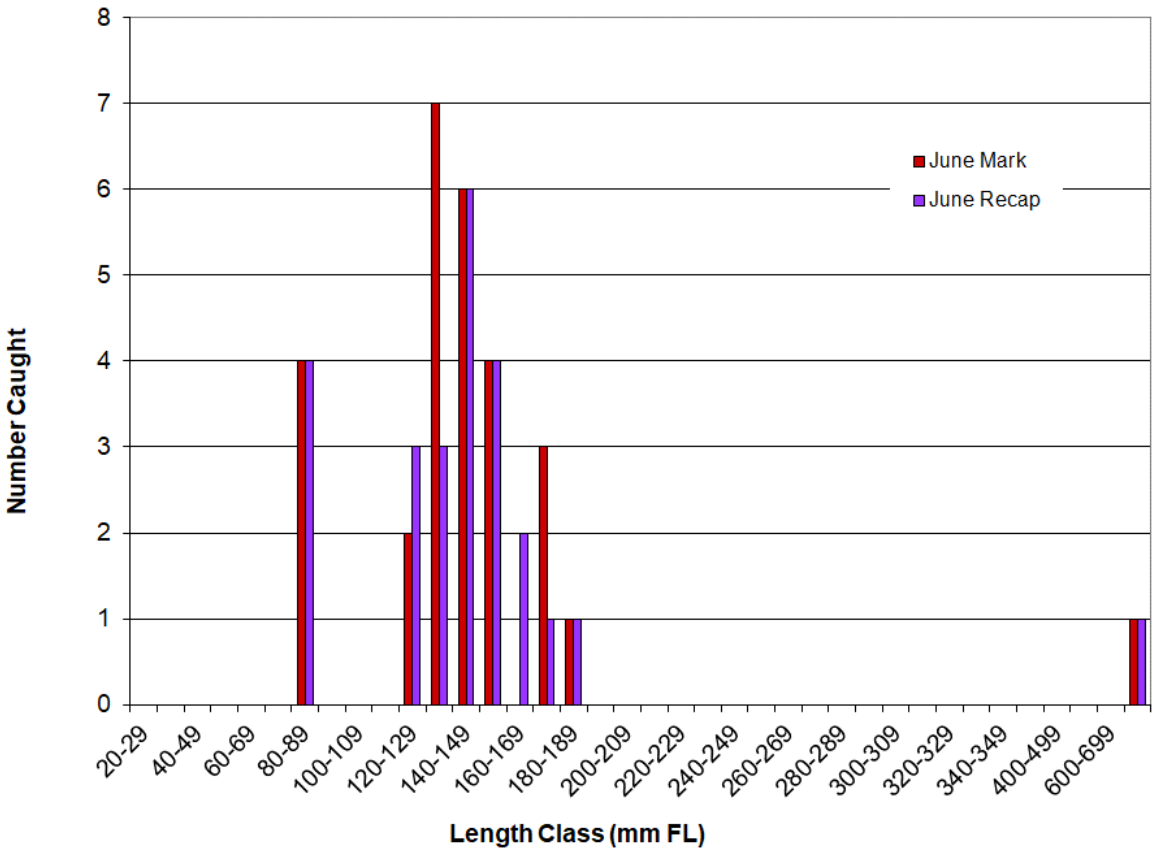

Figure 20. *O. mykiss* size distributions in San Lorenzo River Lagoon, June 2022 during mark and recapture periods

July Survey (July 13-14)

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. Water temperature was sufficiently cool to allow tagging but tagging was suspended on July 14 upstream of Riverside Bridge due to high mortalities in the first haul. Fish may have been suffering osmotic stress as salinity was high (at least 27.5 ppt, close to full seawater) at 0.4 meters (1.3 feet) depth and below. Temperature and DO were at reasonable levels in the lagoon and holding containers.

July Site Conditions

- Work had begun on the culvert project with construction of a floating platform downstream of the trestle (Figure 21).

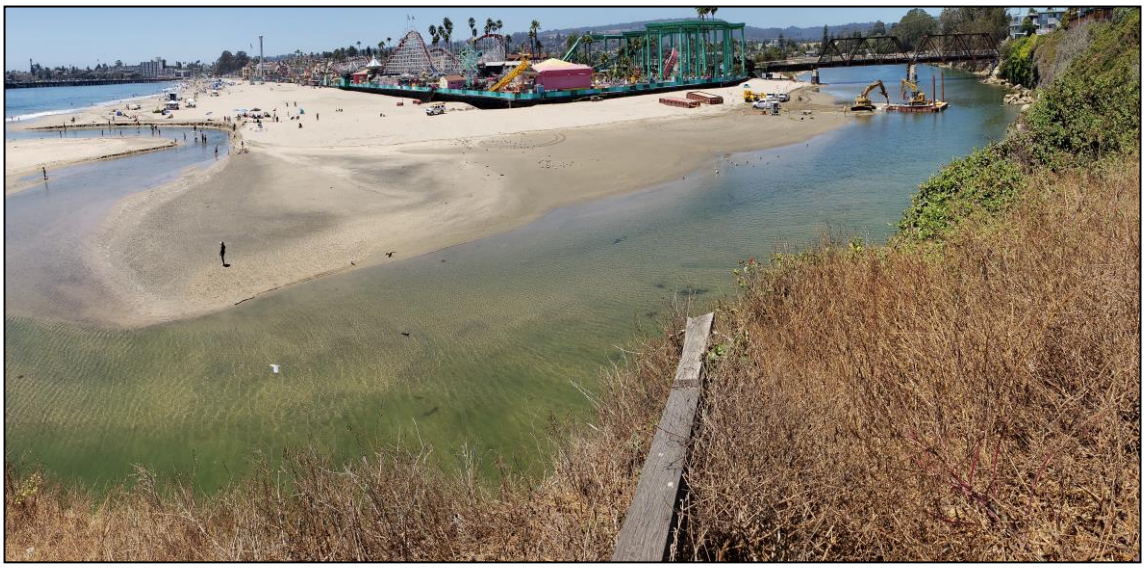

Figure 21. San Lorenzo River Lagoon mouth July 14, 2022

- The lagoon was open and tidal at the time of sampling and had been for the past week. Prior to that, following the June survey, there had been two weeks of mostly closed conditions with one brief breech and fill episode with the lagoon closing and refilling almost immediately (Figure 22). The lagoon outlet had worked its way west since the June survey, cutting through the sand berm constructed by the City.
- Inflow from the San Lorenzo River was 14.9 cfs to 14.8 cfs during the sample period, only about 2.5 cfs less than during the June survey (Figure 14).

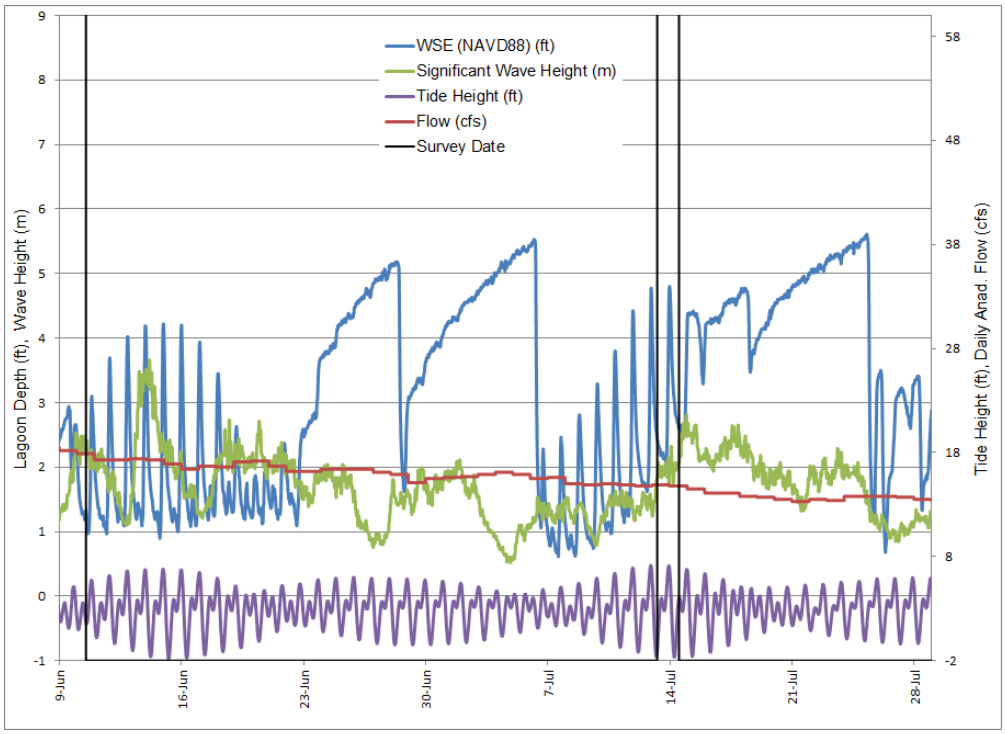

Figure 22. San Lorenzo River Lagoon stage, streamflow, wave height, and tides around July 2022 sample period (Source: lagoon stage from City of Santa Cruz Public Works, streamflow from USGS, wave and tide data from NOAA)

- The lagoon was tidal and stage ranged between 2.1 feet and 4.8 feet during the survey period (City of Santa Cruz data). The high tide was near midnight so maximum stage during the actual sampling did not exceed 2.8 feet. At that relatively low stage there was a sand border for finishing seining in most locations but due to extensive shallow water near shore it was often necessary to finish seine hauls by circling the net to the canoe held just offshore in water.
- The lagoon was quite saline with freshwater found only in a thin layer at the surface (Figure 23, middle panel). Surface salinities ranged from 0.3 ppt to 21.4 ppt at the surface and from 23.1 ppt to 30.8 ppt at a depth of 0.4 m (1.3 feet). Salinity exceeded 33 ppt at all stations at a depth of 0.8 m (2.6 feet) and below.
- Water temperature was relatively cool (for July) at the surface (19.2°C to 21.7°C) and in the deeper part of the water column (16.5°C to 20.3°C). There was an increase in temperature at a depth of 0.4 m (1.3 feet) in the upper part of the saline layer where temperature ranged from 20.5°C to 22.9°C (Figure 23, left panel).
- Dissolved oxygen was well-saturated in surface waters, ranging from 8.4 mg/l to 11.4 mg/l at the surface and 6.0 mg/l to 8.4 mg/l down to 1.2 meters (3.9 feet) (Figure 23, right panel).
- Water clarity was high with secchi disk visibility at the substrate in up to 1.7 meters of water (5.6 feet). Algae was not extensive and not an issue.

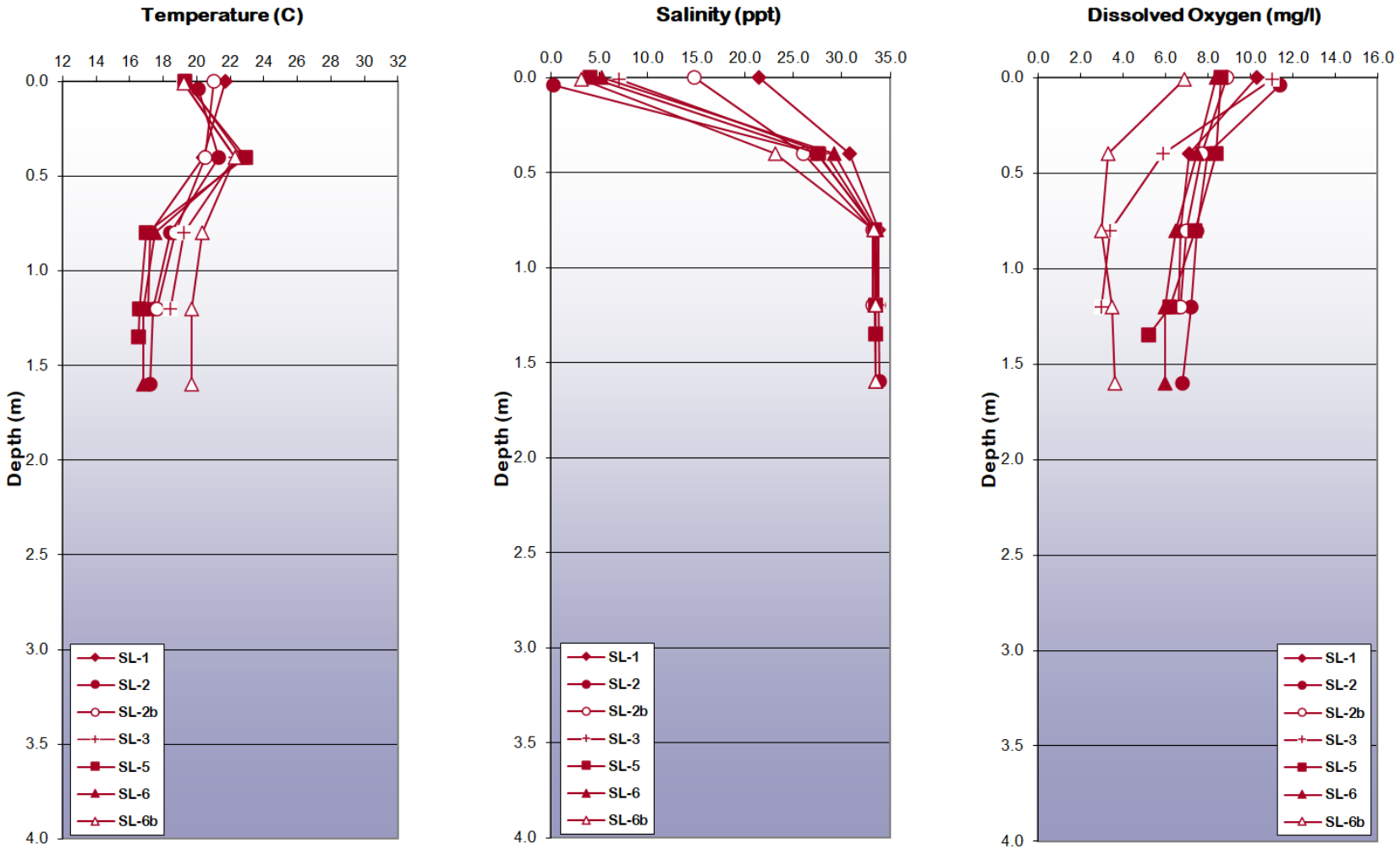

Figure 23. Depth profiles of water quality parameters in the San Lorenzo Lagoon during the July two day relative abundance survey

July Survey Results

- Thirteen seine hauls were completed between the beach and upstream of the trestle (SL-2), and upstream of Riverside Bridge (Table 9).
- CPUE for *O. mykiss* was in the mid-range for July surveys to date and up from June (20.5 vs. 2.4) but the difference was not significant (two sample t-test, unequal variance p>0.10). Topsmelt, staghorn sculpin, and starry flounder numbers were down from June while surfperch numbers were up (Table 8, Table 9).

Table 9. Fish catch in San Lorenzo River Lagoon, July 2022

	SL-1	SL-2	SL-5	SL-6	Grand Total
# Hauls	*3*	*3*	*2*	*5*	***13***
Species	***Number Caught***				
O. mykiss	2	219	20	25	**266**
Topsmelt	26	781	70	1176	**2053**
Threespine stickleback	1			1	**2**
Staghorn sculpin	1		1	1	**3**
Barred surfperch		1			**1**
Shiner surfperch	1	265	1	1	**268**
Walleye surfperch		3			**3**
Starry flounder	3			3	**6**
Crab		2			**2**
Shrimp	1		3	1	**5**
O. mykiss CPUE	*0.7*	*73.0*	*10.0*	*5.0*	***20.5***

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

- Three *O. mykiss* captured in July had been tagged in June (Table 10). The two fish with recorded lengths grew at an average rate of 0.30 mm/day. Although the sample size is small, growth rates of these individuals was among the lowest observed in the San Lorenzo lagoon (Table 11).
- The size distribution for O. mykiss was quite different from June. The same mode of 120 mm to 180 mm fish was still present (and at similar abundance) but a new group of smaller fish in the 80 mm to 109 mm size class was now present at relatively high abundance (Figure 24). These were likely YOY produced by early spawning fish in the high flows of December, the only time high flows occurred during the winter. There was little indication of a shift to larger sizes in the 120 mm to 180 mm mode which is consistent with the low growth rates observed in the limited recaptures from June.
- Fifty-six percent of the catch was evaluated for smolt stage. Eighty-nine percent were characterized as parr or advanced parr and 11% were characterized as silvery parr.

- All *O. mykiss* examined (143) had an adipose fin, indicating they were not of hatchery origin.
- Thirty-nine of the 143 O. mykiss examined (27%) had black spot disease (BSD). Incidence of BSD in the San Lorenzo River Lagoon has ranged between 8% and 72% in annual surveys since 2009.

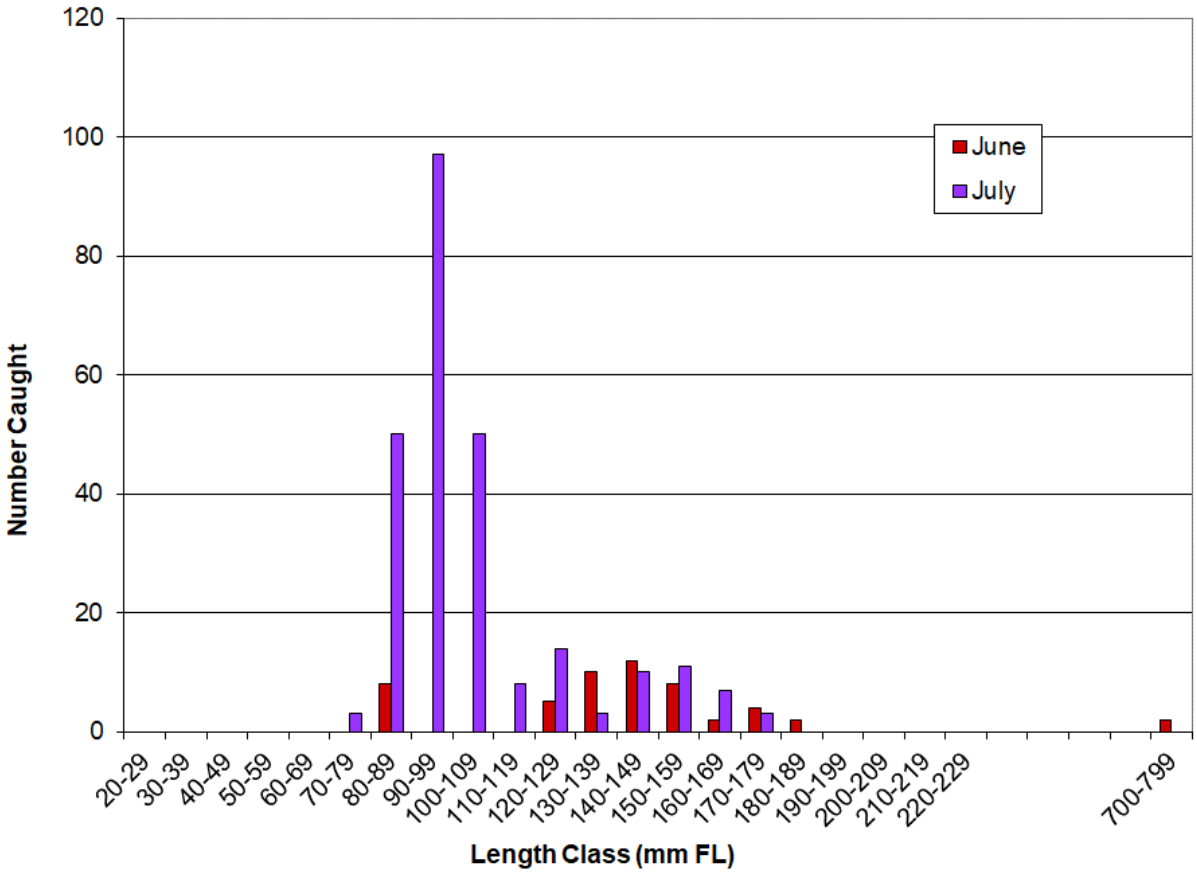

Figure 24. *O. mykiss* length classes in San Lorenzo River Lagoon during June and July 2022

Table 10. *O. mykiss* tagged in June and recaptured in July 2022

Previous Capture Date	Recapture Date	Initial Capture Location	Recapture Location	Initial Length (mm)	Length at Recapture (mm)	Growth Rate (mm/day)
06/09/22	7/13/2022	SL-2	SL-2	134	NA	NA
06/09/22	7/13/2022	SL-1	SL-2	125	132	0.21
06/09/22	7/13/2022	SL-1	SL-2	145	158	0.38

Table 11. *O. mykiss* Growth Rates for Years Available

Year	Period	N	Average Growth (mm/day)	Range (mm/day)	End of Period CPUE
2012	June-Sept	4	0.72	0.58-0.84	14.4
2013	June-Sept	2	0.34	0.27-0.41	4.7
2014		None captured			
2015		None captured			
2016	June-Sept	21	0.90	0.45-1.14	7.8
2017	June-July	35	0.78	0.42-1.16	452
	July-Aug	18	0.62	0.34-1.00	272
	Aug-Sept	15	0.40	0.05-0.73	328
	June-Sept	40	0.46	0.02-0.86	328
2018	June-July	2	0.98	0.88-1.08	2.5
	June-Aug	6	0.55	0.38-0.69	6.4
	June-Sept	10	0.39	0.26-0.49	6.3
2019	June-July	33	0.56	0.14-1.06	53
	July-Aug	57	0.45	0.04-0.89	278
	Aug-Sept	85	0.36	0.00-0.75	228
	June-Sept	88	0.38	0.03-0.85	228
2020	June-July	5	0.51	0.27-0.69	121
	July-Sept	3	0.45	0.25-0.58	31
	June-Sept	5	0.41	0.22-0.62	31
2021	June-July	1	0.26		6.3
2022	June-July	2	0.30	0.21-0.38	20
	July-Aug	1	0.20		2.3
	Jun-Aug	1	0.18		2.3

August Survey (August 16-17)

The August 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. Construction of the culvert project had been active between the July and August sample periods but was temporarily inactive at the time of the August samples. Alterations included a sand dyke across the lagoon, partially submerged at the time of the survey, between the beach and the construction barge at the culvert inlet location (Figure 25); and a high sand dam completely closing the mouth of the lagoon (Figure 26).

Figure 25. Lower San Lorenzo River Lagoon August 17, 2022

Figure 26. San Lorenzo River Lagoon mouth August 17, 2022

The lagoon had been mostly closed since the July survey with one period of mostly open conditions from July 25 to August 1 and again around August 8 and 9 (Figure 27). The lagoon was very warm and high water temperature precluded tagging, measuring, or close observation. Fish were counted and released directly from the net. Length was estimated within 10 mm size classes.

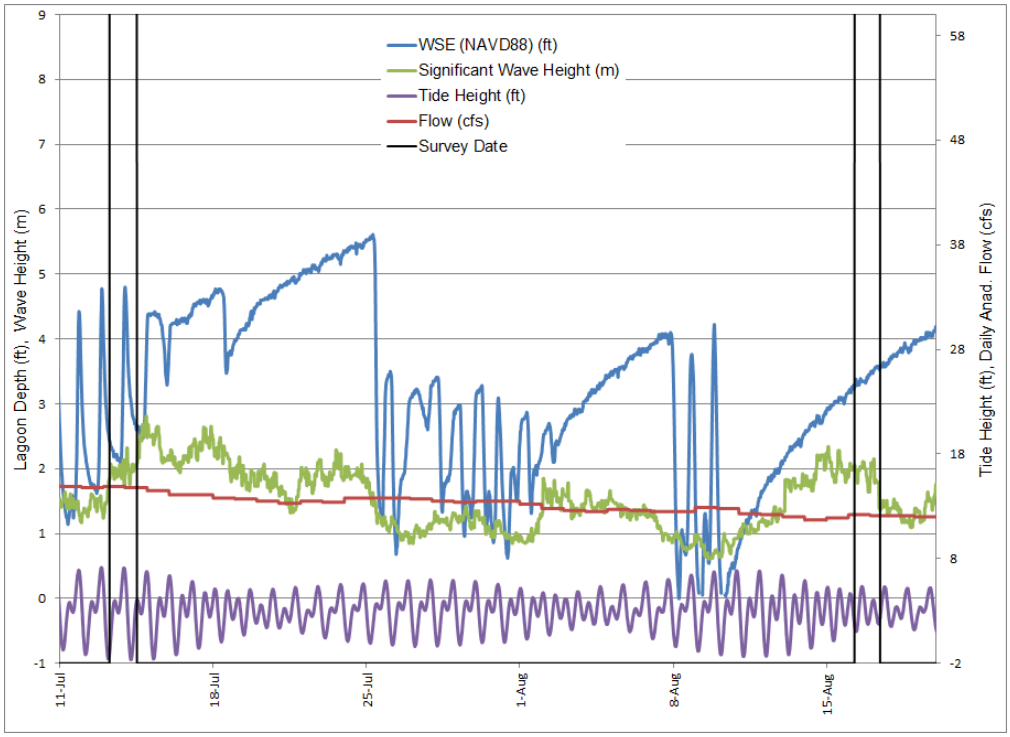

Figure 27. San Lorenzo River Lagoon stage, streamflow, wave height, and tides preceding August 2022 sample period (Source: lagoon stage from City of Santa Cruz Public Works, streamflow from USGS, wave and tide data from NOAA)

August Site Conditions

- The lagoon had been closed for 6 days at the time of sampling and stage was rising (Figure 27). Stage ranged from 3.28 to 3.58 ft (NGVD) during the survey period. Inflow from the San Lorenzo River was at 12 cfs during the sample period.
- Even at the relatively moderate lagoon stage there was extensive shallow water near shore downstream of the trestle and upstream of Riverside Bridge. At most sites the net had to be deployed as a purse seine and finished at the outer edge of the shallow bench. Hauls were processed by counting and scanning fish for tags as they were removed from the net and released to minimize stress from holding.

- Lagoon salinity was less than 4 ppt to a depth of 0.4 meters (1.3 feet) and increased gradually at greater depths. Maximum salinity was at the bottom at Station 6 upstream of Riverside Bridge(25.8 ppt). The lagoon appeared to be freshening over the sample period with the highest salinities recorded on August 15, the day before the survey began. (Figure 28, center panel).
- Water temperature ranged from 20.1°C to 21.8°C in the surface 0.4 meters (1.3 feet)of the water column; increased to 22.4°C to 25.0°C at 0.8 meters (2.6 feet); and reached just over 30°C in the deepest water (1.8 meters (5.9 feet) at station SL-5 upstream of Riverside Bridge (Figure 28, left panel).
- Dissolved oxygen was well-saturated in surface waters with over 8 mg/l down to a depth of 1.2 meters (3.9 feet) but dropping below 6 mg/l at some locations at 1.6 meters (5.2 feet) depth (Figure 28, right panel).
- Secchi disk visibility was 1.5 meters to 1.6 meters (4.3 feet to 5.2 feet) upstream of Riverside Drive. Mats of floating algae were fairly extensive around SL-5 but not at other locations. Algal mats at SL-5 were cleared with a small seine and dip nets before sampling.

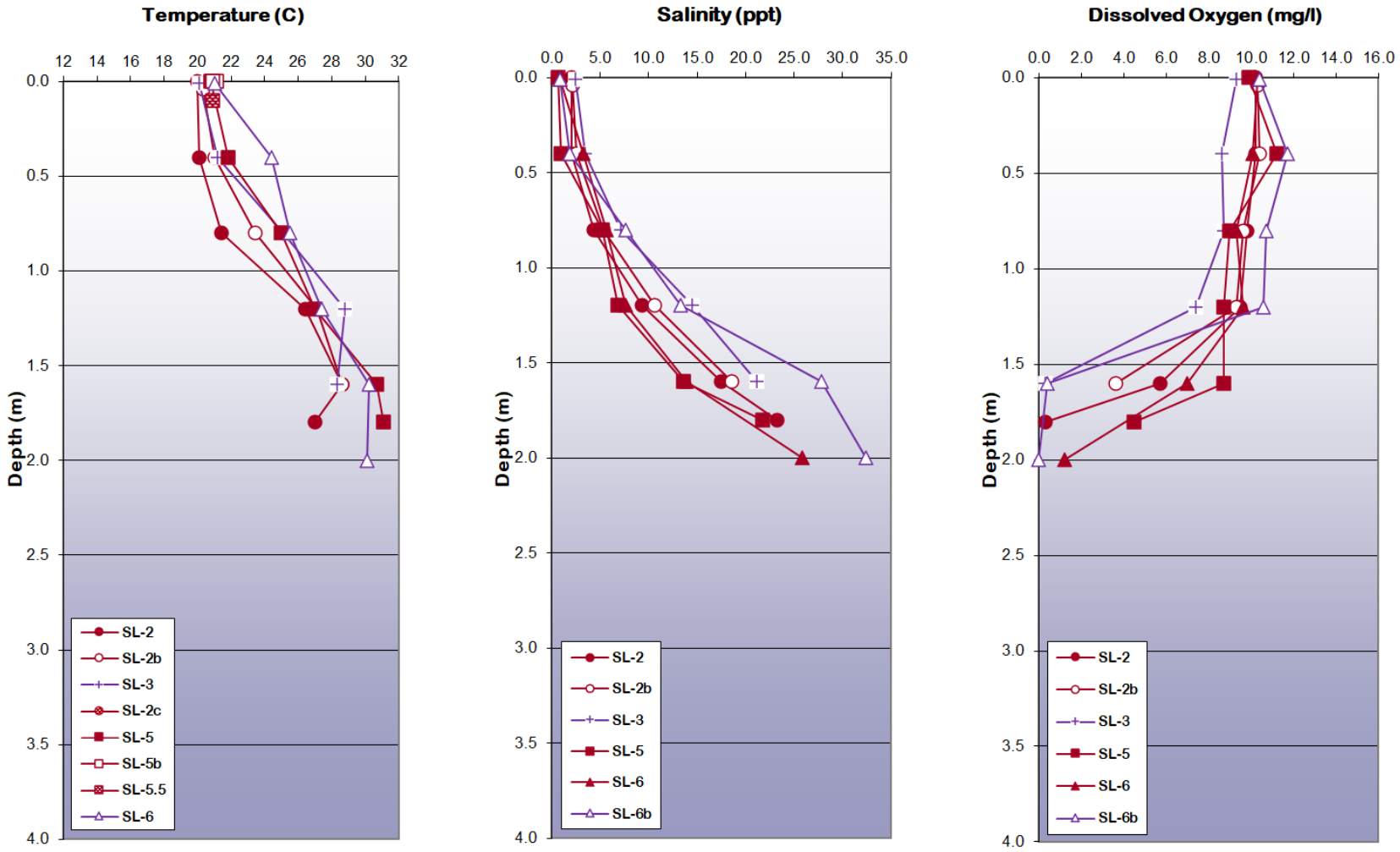

Figure 28. Depth profiles of water quality parameters in the San Lorenzo Lagoon in August. Profiles plotted in red are August 16 and 17 during the two day relative abundance survey; profiles plotted in blue are August 15 and measured by City staff

August Survey Results

- Ten seine hauls were completed at standard sampling stations (Table 12). Fewer hauls were completed at SL-1 than usual due to construction disturbance in the area (sand dike and grading to shallow depth).
- CPUE for *O. mykiss* was down from July but about the same as June (2.3 vs. 20.5 and 2.4) (Table 5). The difference was not statistically significant (two sample t-test, p>0.10).
- Topsmelt numbers were still high and there was an abundance of small crabs present, consistent with the relatively frequent open lagoon conditions (Table 12).

Table 12. Fish catch in San Lorenzo River Lagoon, August 2022

	SL-1	SL-2	SL-5	SL-6	Grand Total
# Hauls	*1*	*5*	*3*	*1*	***10***
Species	***Number Caught***				
O. mykiss	3	8	12	0	**23**
Topsmelt	1127	2796	2749	742	**7414**
Threespine stickleback		3	2		**5**
Staghorn sculpin		7			**7**
Shiner surfperch		34			**34**
Starry flounder	1	4		2	**7**
crab	2	121	9		**132**
O. mykiss CPUE	*3.0*	*1.6*	*4.0*	*0.0*	***2.3***

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

- One *O. mykiss* captured in August had been tagged in June (Table 13). This fish grew at an average rate of 0.18 mm/day which is among the lowest growth rates observed (Table 11). The same fish had been captured in July but length was not recorded. Another *O. mykiss* captured in August had been tagged in July (Table 13). Growth rate for this fish was also relatively low at 0.20 mm/day.
- *O. mykiss* length (FL) was estimated in 10 mm size classes to minimize holding time. Most fish were in the range of 90 mm to 119 mm (Figure 29). This mode was shifted about 10 mm larger from the peak distribution of fish in the 80 mm to 109 mm size range in July. This is consistent with the limited observed growth rates.
- Water quality conditions precluded holding and close observation of fish and only the two recaptures were evaluated for smolt stage. The majority of the catch were not evaluated for smolt stage. The three fish that were examined were at the parr, advanced parr, and silvery parr stage.
- All *O. mykiss* examined (21) had an adipose fin, indicating they were not of hatchery origin.

- Except for the two recaptured individuals, fish were not examined for disease and parasites due to the warm temperatures. Of the two recaptured individuals, one had light black spot disease (BSD) and the other had no indication of external disease or parasites. Incidence of BSD in the San Lorenzo River Lagoon has ranged between 8% and 72% in annual surveys since 2009.

Table 13. *O. mykiss* tagged earlier in the season and recaptured in August 2022

Previous Capture Date	Recapture Date	Initial Capture Location	Recapture Location	Initial Length (mm)	Length at Recapture (mm)	Growth Rate (mm/day)
06/09/22	8/16/22	SL-2	SL-2	134	146	0.18
07/13/22	8/16/22	SL-2	SL-2	NA	146	NA
07/13/22	8/17/22	SL-2	SL-5	94	101	0.20

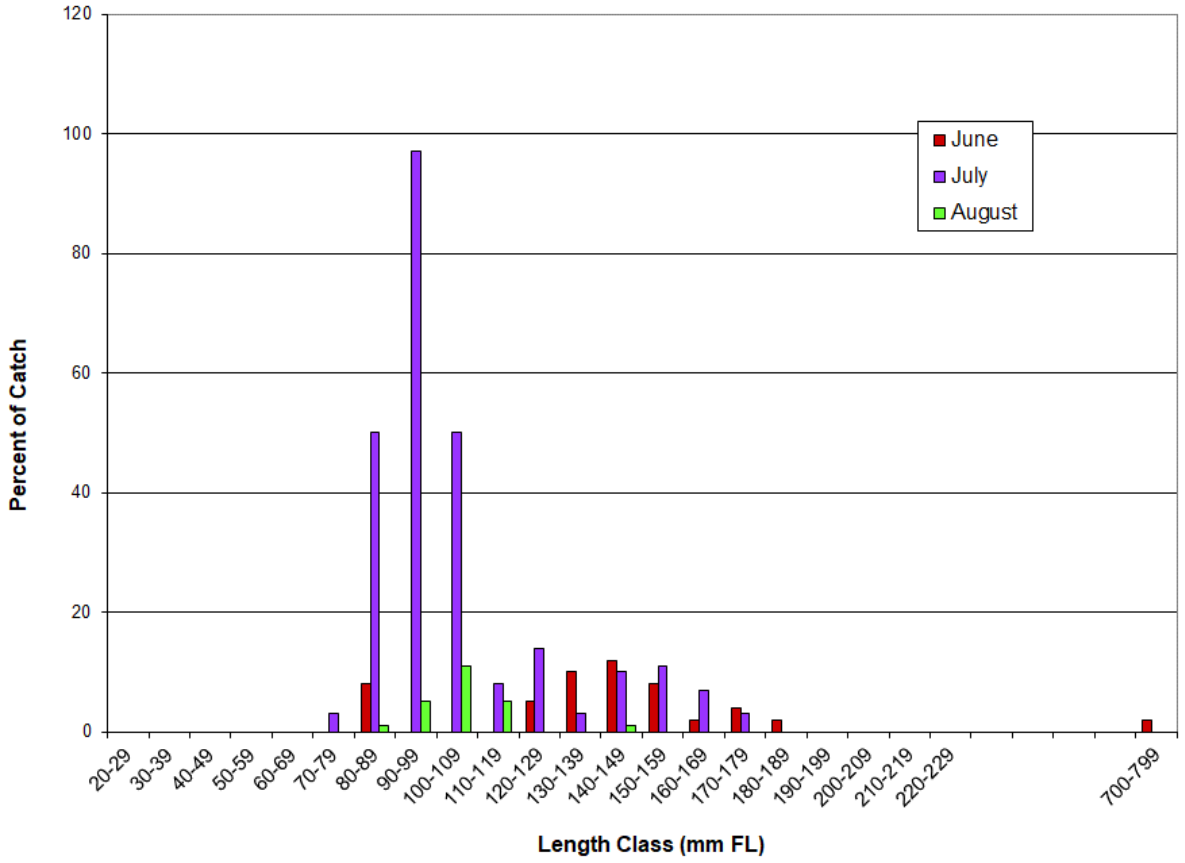

Figure 29. *O. mykiss* length classes in San Lorenzo River Lagoon during June, July, and August 2022

September Survey (September 20-23)

The September survey was a complete survey with mark-recapture population estimate. Sampling was conducted twice 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. *O. mykiss* were captured and tagged on September 20 and 21 with the sites resampled on September 22 and 23 for recaptures. Construction of the culvert project had been active after the August survey and changes in the lagoon habitat may have resulted from manipulation of water levels and opening and closing of the mouth. The mouth remained closed for about four days after the August survey then opened abruptly and drained to low level (approximately 0.23 feet NAVD88) (Figure 30). It closed again almost immediately but opened again about three days later (Aug 24). From August 24 through September 18 lagoon stage remained relatively stable between 1 and 1.5 feet, likely due to closure of the mouth and pumping down the lagoon for construction activities. As a result of a rainfall event on September 18 the stage increased rapidly to just over 5 feet NAVD88, indicating closure, then drained again late at night on the 19th. Sampling was initiated the morning of September 20. The lagoon was open and tidal until closed by construction contractor during ebb tide the morning of September 22. Stage was maintained at less than 2 feet by pumping after closure. Lagoon stage fluctuated between 3.6 feet and 1.4 feet during the 4-day sample period.

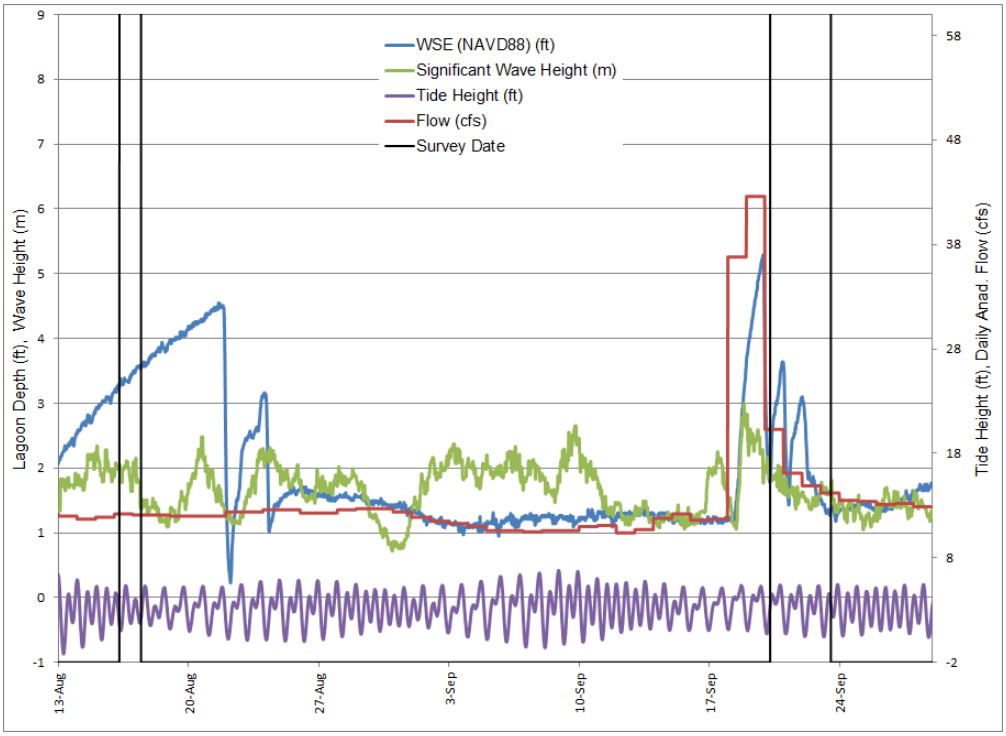

Figure 30. San Lorenzo River Lagoon stage, streamflow, wave height, and tides preceding September 2022 sample period (Source: lagoon stage from City of Santa Cruz Public Works, streamflow from USGS, wave and tide data from NOAA)

Fall Site Conditions

- The lagoon margin was heavily disturbed with tracks of construction equipment evident (Figure). There were numerous dead topsmelt on the substrate in areas dewatered by the recently opened lagoon. Numerous dead and live crabs were present on the substrate at the lagoon margins. Crows were observed scavenging in the area.

Figure 31. San Lorenzo River mouth, September 20, 2022

- The lagoon remained open and tidal during the marking period but was closed during the recapture period with stage maintained below 2 feet by pumping. Water surface elevation ranged from about 3 feet while open on the 20th to about 1.3 feet after closure on the 23rd. Daily average flow at Santa Cruz gage ranged from 20.3 cfs on September 20 to 14.2 cfs on September 23 (historical discharge, USGS site 11161000 San Lorenzo River at Santa Cruz California).
- Salinity was stratified with fresh water (3 ppt or less) at the surface and increasing salinity in deeper water (Figure 33, center panel). Before September 22, profiles reflected open tidal conditions while after September 22 the lagoon was closed and freshening, particularly at the surface.
- Water temperature was not strongly stratified but varied substantially with location in the lagoon (Figure 26, left panel). The coolest temperatures were near the mouth at SL-1 and the warmest were upstream of Riverside Bridge at SL-5. Temperature measurements were all below 21°C except for SL-5 later in the morning of September 23.

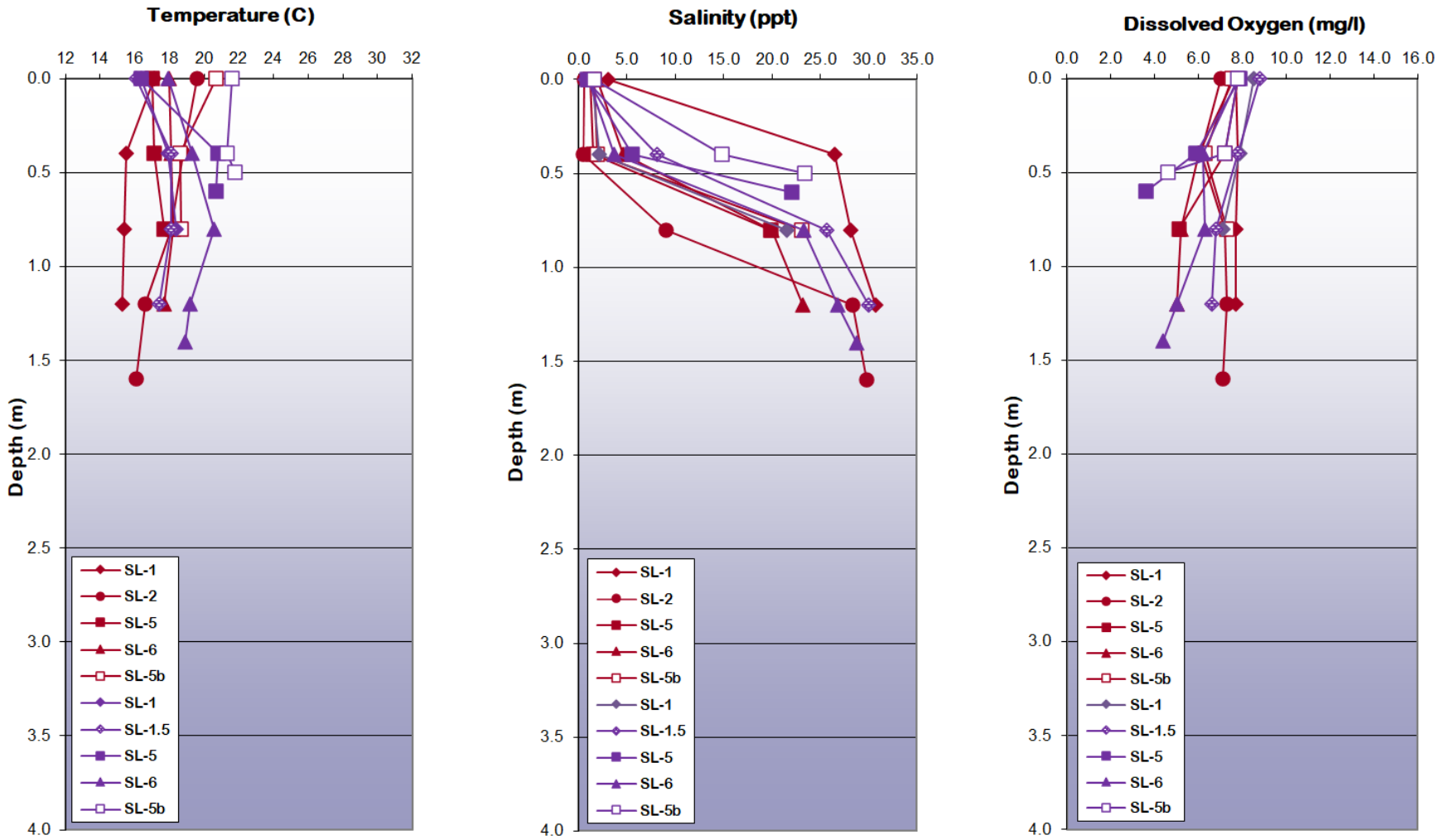

Figure 32. Depth profiles of water quality parameters in the San Lorenzo River Lagoon during September. Profiles plotted in red are September 20-21; profiles in blue are September 22-23

Fall Site Conditions (continued)

- Dissolved oxygen was not strongly stratified for most profiles and generally above 6 mg/l (Figure32, right panel). Declines in oxygen in deeper waters were observed after lagoon closure on the morning of September 22, particularly at SL-5 and SL-6.
- Turbidity was high on September 20 with Secchi depth of 0.5 to 0.7 meters (1.6 to 2.3 feet). Water clarity increased somewhat on the following days ranging from 0.8 to 1.4 meters (2.6 to 4.6 feet).

Fall Survey Results

- Thirty-two seine hauls were completed at regularly sampled Stations (SL-1, SL-2, SL-5, and SL-6). The catch was dominated by topsmelt and *O. mykiss* (Table 14). Sacramento sucker YOY were unusually abundant. Most were from a single haul just upstream of the trestle. Small crabs were also very abundant.
- There were numerous small dead topsmelt mixed with the algae in the net.
- One smolt-stage chinook salmon (116 mm FL) was captured just downstream of the trestle.

Table 14. Fish catch in San Lorenzo River Lagoon, September 2022

	SL-1	SL-2	SL-5	SL-6	Grand Total
# Hauls	*4*	*10*	*5*	*12*	***31***
Species	***Number Caught***				
O. mykiss	100	87	69	17	**273**
Sacramento sucker		67	1	1	**69**
Chinook salmon	1				**1**
Topsmelt	35	294	0	8	**337**
Threespine stickleback		3	6	15	**24**
Staghorn sculpin	1	4	1		**6**
Tidewater goby		1		1	**2**
Starry flounder	1	3	1	4	**9**
crab	5	102	27	93	**227**
O. mykiss CPUE	*25.0*	*8.7*	*13.8*	*1.4*	***8.8***

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

- *O. mykiss* were moderately abundant near the mouth and just upstream of Riverside Bridge. CPUE was in the mid-range for September surveys to date (Table 5). CPUE was up from August but not as high as July (Table 5). None of these differences was statistically significant (ANOVA single factor, Tukey HSD, $p \approx 0.08$).

- There were two distinct size classes of *O. mykiss* captured in September; one broad mode with fish in the 90 mm to 139 mm size range and one narrower, less abundant mode of fish between 160 mm and 189 mm FL (Figure 33). The mode of smaller fish corresponds with the mode in the July size distribution of 80 mm to 109 mm fish with the mean shifted about 20 mm larger and the August distribution of 90 mm to 119 mm fish with mean shifted about 10 mm larger (Figure 34). This would correspond to a growth rate of about 0.33 mm/day or slightly higher than observed growth rates in the lagoon. It is possible that these fish left the lagoon after the July survey and returned sometime before the September survey. The August abundance of this size range was greatly reduced compared to either July or September. The same is true for the mode of larger fish in relation to the group of 140 mm to 169 mm fish in July (Figure 34).

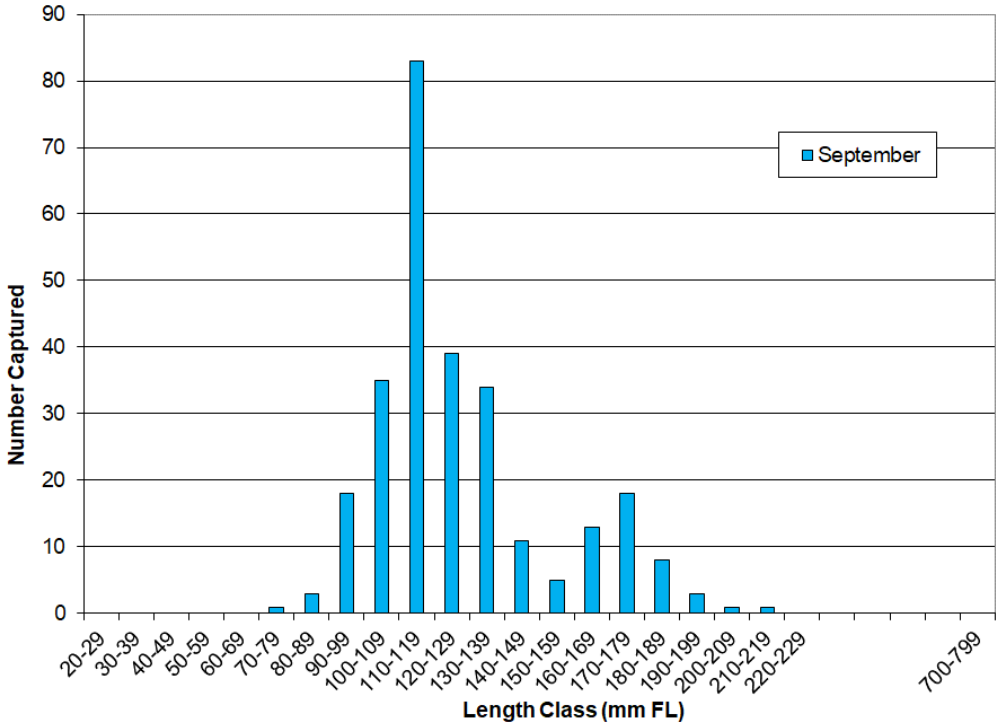

Figure 33. *O. mykiss* length classes in San Lorenzo River Lagoon during September 2022

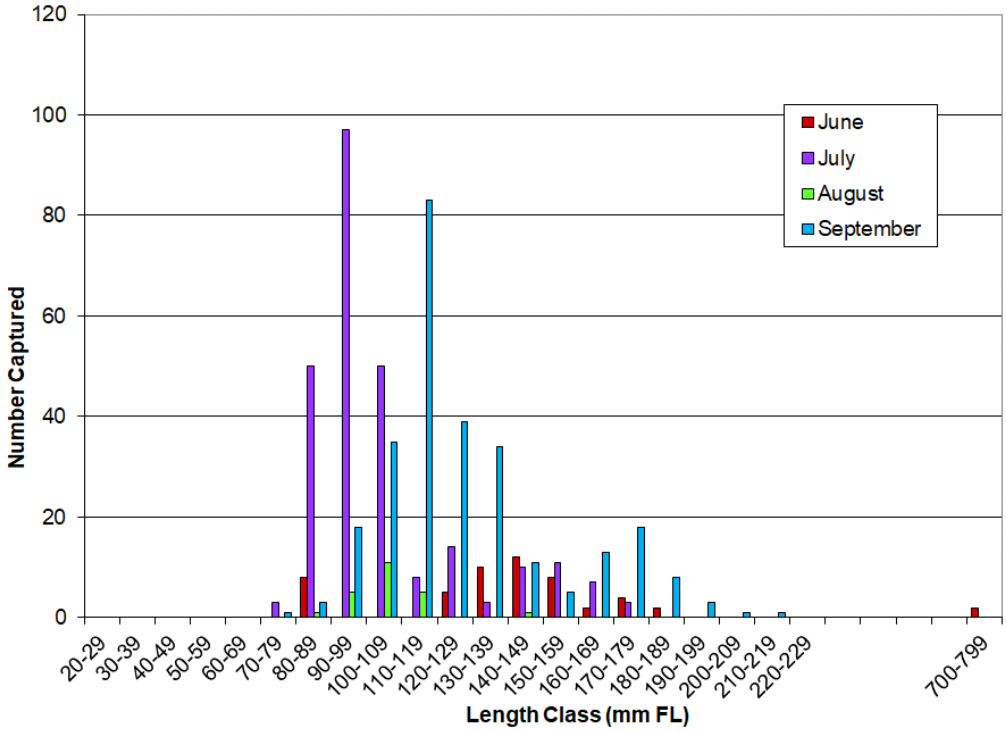

Figure 34. *O. mykiss* length classes in San Lorenzo River Lagoon during June, July, August, and September 2022

- Three of the O. mykiss captured had been tagged earlier in the summer, one in June and two in July (Table 15). The June tagged fish had also been captured in July and August. The fish captured on all survey dates (45937), likely in the lagoon all summer, had the lowest growth rate.

Table 15. *O. mykiss* tagged earlier in the season and recaptured in September 2022

Fish ID	Previous Capture Date	Recapture Date	Initial Capture Location	Recapture Location	Initial Length (mm)	Length at Recapture (mm)	Growth Rate (mm/day)
45937	06/09/22	7/13/22	SL-2	SL-2	134	NA	NA
45937	06/09/22	8/16/22	SL-2	SL-2	134	146	0.18
45937	06/09/22	9/20/22	SL-2	SL-2	134	150	0.16
45489	07/13/22	9/20/22	SL-2	SL-2	109	137	0.41
45471	07/13/22	9/22/22	SL-2	SL-1	125	148	0.32

- Ninety-six percent of *O. mykiss* examined were classified as parr or advanced parr and 4% were classified as silvery parr or advanced silvery parr.

- Two hundred and twenty-six *O. mykiss* captured had an adipose fin present, one did not. Adipose fins are removed from hatchery produced steelhead.
- Fifty-nine percent of *O. mykiss* examined had black-spot disease (BSD) lesions, most were lightly affected. Incidence of BSD has ranged between 4% and 100% and averaged 36% in previous fall surveys since 2009.

September *O. mykiss* Population Estimate

- A total of 67 *O. mykiss* were captured during the marking period (September 20 and 21). Twenty-three of these were not tagged due to warm temperature conditions, two were recaptures, and one was a mortality. That left 41 marked fish in the lagoon at the end of the marking period.
- A total of 206 *O. mykiss* were captured during the recapture period, eleven of which were tagged during the marking period. One fish was less than 90 mm size cutoff limit and was not included for the population estimate.
- The Peterson population estimate (Ricker 1975) is 721 *O. mykiss* in the lagoon in September. The 95% confidence limits for this estimate are 418 and 1213. This is in the midrange for the ten years for which an estimate was possible for fall surveys in the San Lorenzo Lagoon (Table 7, Figure 35).
- Changes in CPUE and size distribution between the mark period and recapture period can indicate movement of fish in and out of the lagoon and violation of the assumption of a closed population. CPUE during the recovery period was higher than during the marking period (14.7 vs. 3.9) but the difference was not statistically significant (two sample t-test, unequal variance, two-tail, $p>0.15$). The size distribution had more *O. mykiss* 160 mm FL and larger during the recapture period than during the mark period (Figure 35).
- The relationship between the population estimates and CPUE was updated with the spring and fall 2022 data points (Figure 36). Excluding the questionable 2020 data points (low recapture rates and questionable validity of the population estimates, see HES 2021), the least squares regression estimate for r^2 is 0.91 and was statistically significant with $p<0.00001$.

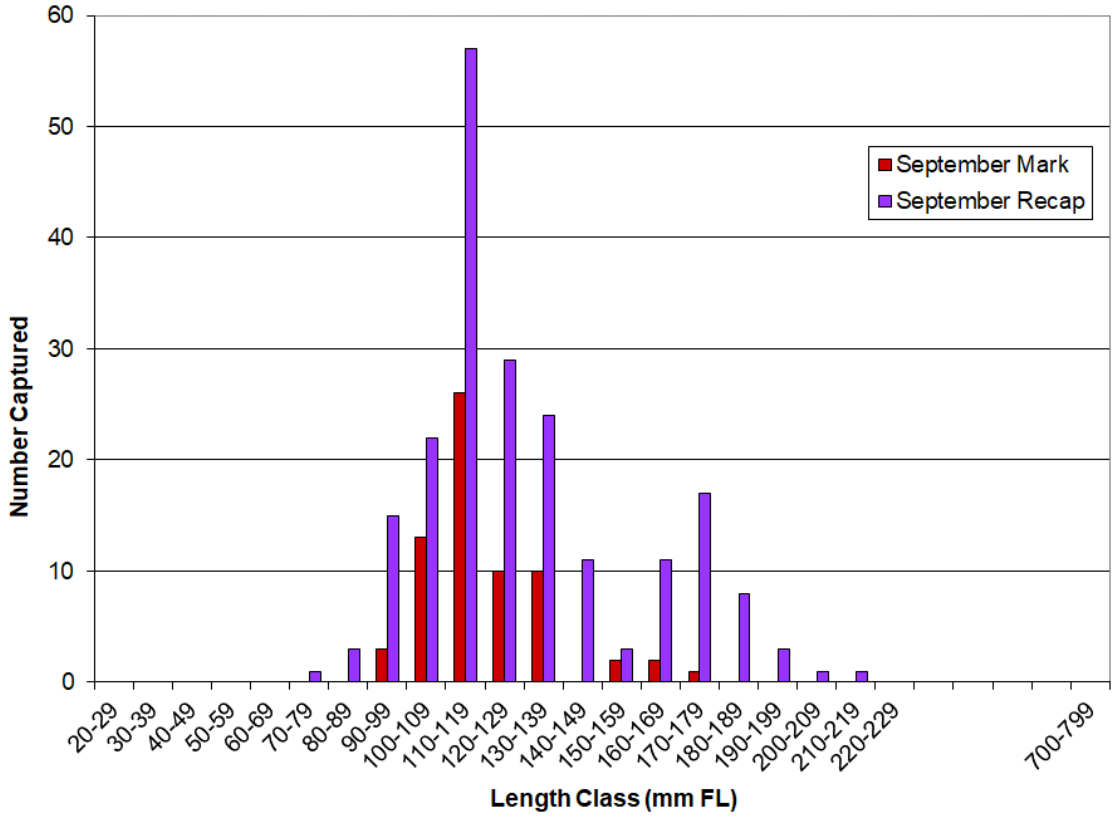

Figure 35. *O. mykiss* size distributions in San Lorenzo River Lagoon, June 2022 during mark and recapture periods

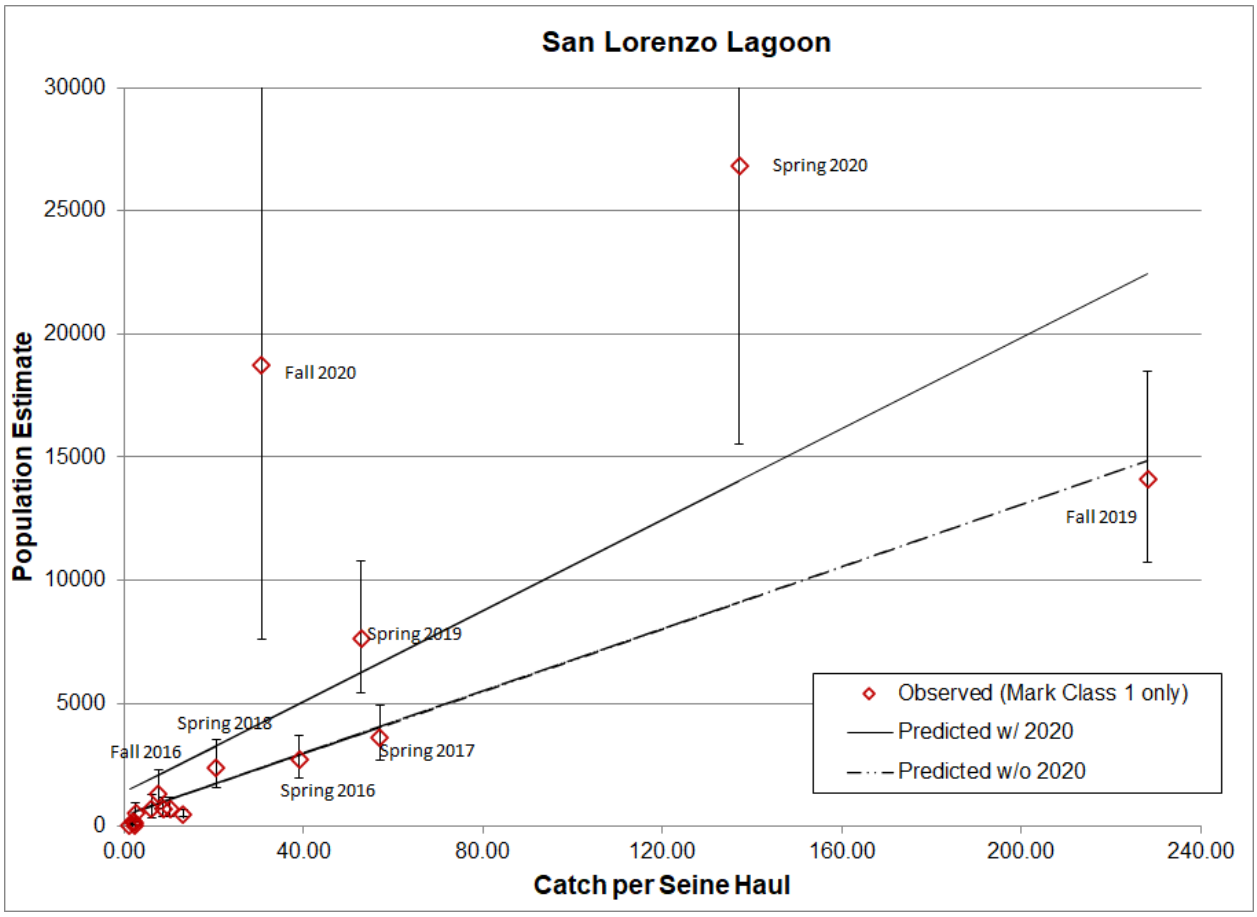

Figure 36. Relationship between *O. mykiss* population estimate and CPUE in the San Lorenzo River Lagoon[4]

[4] 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.

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, HES 2020, HES 2021, and HES 2022)

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	6.0				80.0	
	Overall	***7.7***	***21.5***			***28.25***	
2011		Jun 9-14				Oct 13-18	
SL-2	RR Trestle	11.7				1.7	
SL-3	Near YSI Station	7.8				5.7	
SL-4	Near Marsh Outlet	16.0				1.0	
SL-5	Riverside Drive	48.5				2.2	
SL-6	U/S Bank Restoration	0.5				0.3	
	Overall	***13***				***2.5***	

Table A-1 (continued)

Station	Location	*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[5]	***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***		

[5] Standard sites only (SL1-SL6) used in Overall calculation

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***		
2019		Jun 13-18	Jul 16-17	Aug 13-14	Sep 19-24		
SL-1	South of Trestle	1.0	10.0	49.7	7.2		
SL-2	RR Trestle	55.8	95.7	440.0	509.0		
SL-3	Near YSI Station				35.0		
SL-5	Riverside Drive	274.4	59.0	457.5	462.3		
SL-6	U/S Bank Restoration	40.5	22.0		66.6		
	Overall	***92.2***	***53.4***	***277.7***	***228.2***		
2020		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		
	Overall	***146.1***	***120.6***	NS	***30.7***		
2021		Jun 8-11	Jul 13-14	Aug*	Sep	Oct 12-13	
SL-1	South of Trestle	3.9	1.0	NS	NS	0.0	
SL-2	RR Trestle	4.2	9.7	NS	NS	0.2	
SL-3	Near YSI Station	0.0	NS	NS	NS	0.5	
SL-5	Riverside Drive	7.0	9.5	NS	NS	0.5	
SL-6	U/S Bank Restoration	4.0	6.0	NS	NS	0.3	
	Overall	***4.3***	***6.3***	***NS***	***NS***	***0.3***	
2022		Jun 7-10	Jul 13-14	Aug 16-17	Sep 20-23		
SL-1	South of Trestle	4.0	0.7	3.0	25.0		
SL-2	RR Trestle	2.7	73.0	1.6	8.7		
SL-3	Near YSI Station	NS	NS	NS	NS		
SL-5	Riverside Drive	0.5	10.0	4.0	13.8		
SL-6	U/S Bank Restoration	0.8	5.0	0.0	1.4		
	Overall	2.4	20.5	2.3	8.8		

Figure A-1. Laguna Creek Lagoon sampling stations

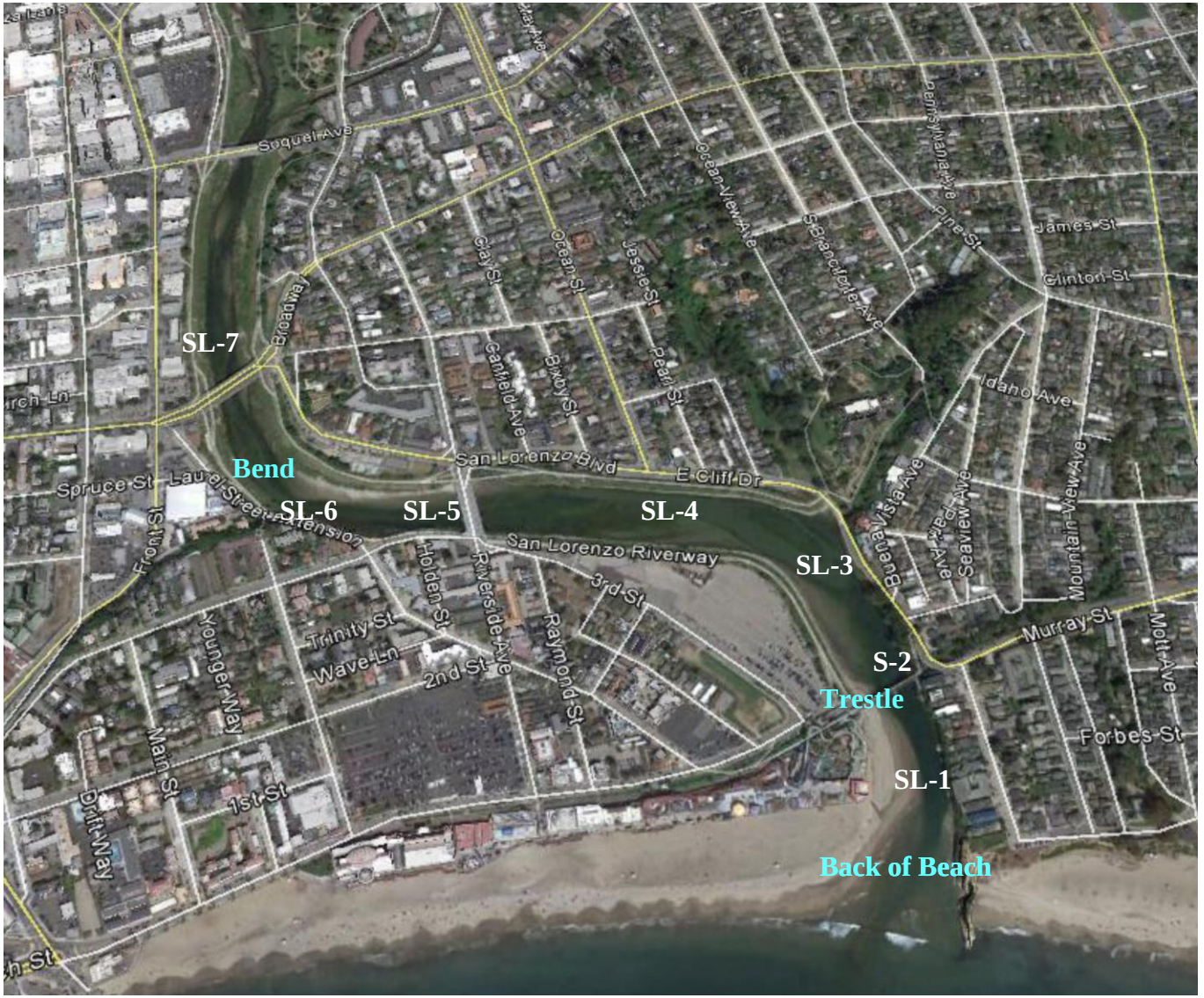

Figure A-2. San Lorenzo River Lagoon sampling stations

Acknowledgements

Field Crew:

Ryan Yarbrough

Noriko Kawamoto

Jake Clouse

Ryan Bassett

Maryna Sedoryk

Randy Holloway

Lissa Giacalone

Chris Berry

Data Management:

Noriko Kawamoto

Project Management:

Chris Berry

Zeke Bean

Principal Investigator

Jeff Hagar

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