



Confluence

City of Santa Cruz Habitat Conservation Plan Lagoon Fish Population Sampling 2025

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Introduction

Coastal lagoon systems along central California provide important seasonal rearing habitat for anadromous salmonids, including *Oncorhynchus mykiss* (steelhead). These dynamic environments are characterized by periodic opening and closure of sandbar barriers, resulting in fluctuating hydrologic, physicochemical, and ecological conditions. Understanding how these changes influence fish abundance, growth, and distribution is critical for effective management and conservation of steelhead populations.

This report summarizes lagoon monitoring surveys conducted in 2025 at the San Lorenzo River Lagoon and Laguna Creek Lagoon in Santa Cruz County, California. Monitoring efforts focused on estimating relative abundance, population size, growth rates, and life stage composition of *O. mykiss* using standardized beach seine and mark-recapture methods. In addition, water quality parameters—including temperature, salinity, dissolved oxygen, and water clarity—were measured to characterize habitat conditions during each survey period.

Field surveys were conducted seasonally, with primary sampling events occurring in June, July, and October at the San Lorenzo River Lagoon, and in June and September at Laguna Creek Lagoon. Sampling design and implementation were influenced by environmental conditions, including lagoon connectivity (open versus closed), streamflow, and temperature constraints associated with permit requirements.

The 2025 monitoring season was marked by moderate winter hydrology, frequent lagoon closures and breaches, and elevated summer water temperatures that limited sampling during August and September. These conditions influenced both fish distribution and the ability to conduct consistent sampling across periods.

The objectives of this report are to:

1. Quantify *O. mykiss* abundance and population estimates across survey periods;
2. Evaluate growth rates and life stage composition;
3. Describe lagoon hydrology and water quality conditions; and
4. Assess how environmental variability influenced sampling outcomes and data interpretation.

Results from this monitoring effort provide insight into interannual variability in lagoon habitat function and contribute to ongoing long-term datasets used to inform management and restoration strategies for coastal lagoon systems in the region.

San Lorenzo River Lagoon

Summary

In contrast to the high-flow winters of 2022-2023 and 2023-2024, winter of 2024-2025 was more moderate, with fewer high flow events. A single high flow pulse of 3,800 cfs (USGS data for Station 11160500) occurred in early February 2025, after which flows gradually declined through the spring.

The lagoon remained open through the first seining event in June. It then experienced two closures between mid-June and mid-July. Between July and the fall sampling period in October, the lagoon closed and breached seven times, with an eighth closure and major breach occurring during the fall recapture survey (Figure 1). An additional closure occurred near the end of October.

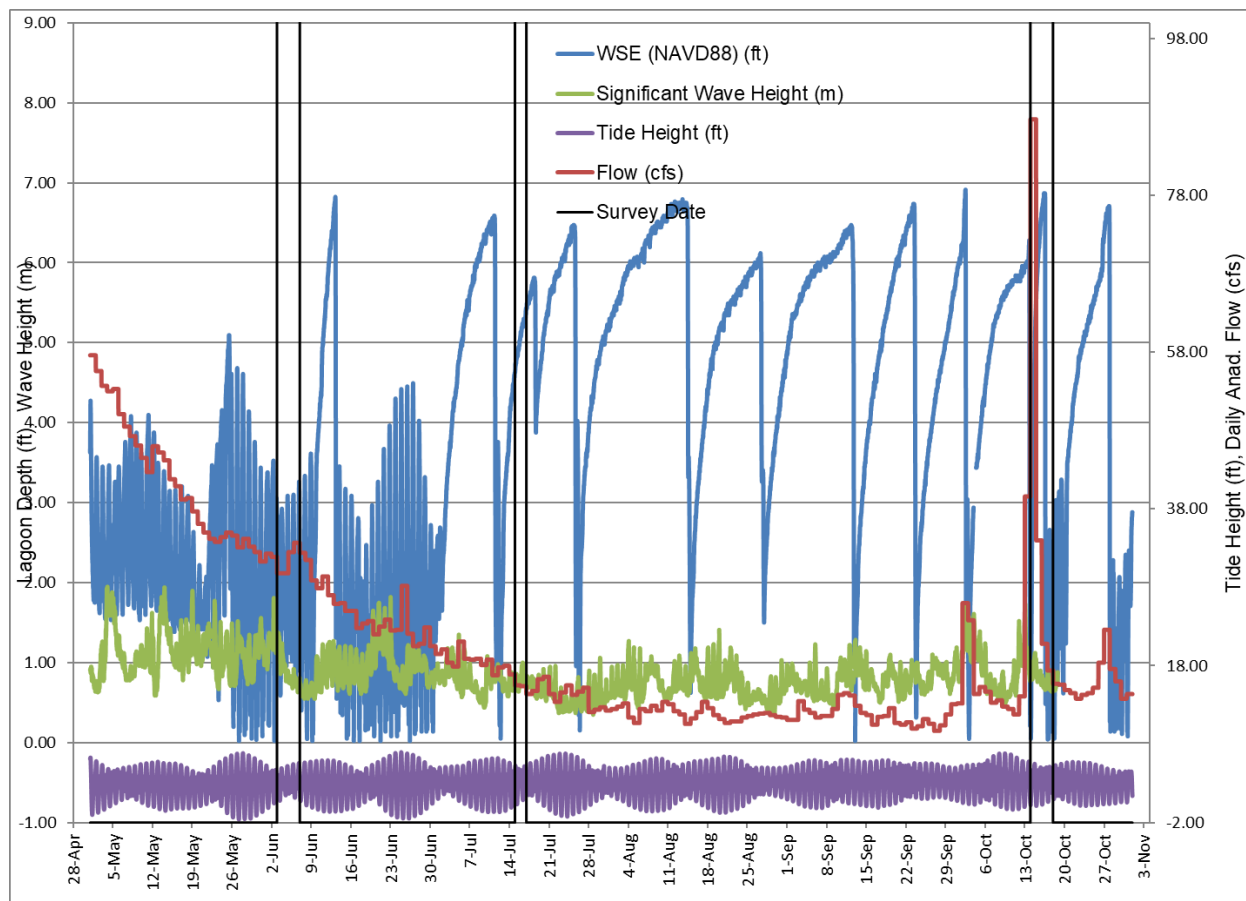


Figure 1. San Lorenzo River Lagoon stage, streamflow, wave height, and tides 2025 (Source: lagoon stage from City of Santa Cruz Public Works, streamflow from USGS, wave and tide data from NOAA)

Abundance of *O. mykiss* in June 2025 was low and comparable to levels observed in 2023 (Tables 1 and 2). Overall catch rates across all 2025 survey periods were lower than 2023 and 2024 (Table 3). In 2025, catch rates were highest near the Trestle Bridge in June and July, consistent with patterns observed in previous surveys (Table 3). Catch rates in October should be interpreted with caution due to the lagoon breach that occurred during the recapture effort, which interrupted sampling. As a result, confidence in October capture estimates is low.

Tagging efforts in July were suspended on the second day of sampling due to water temperatures exceeding permit thresholds. No sampling was conducted in August or September for the same reason.

One *O. mykiss* captured in June 2025 had been previously tagged in September 2024. At that time, it measured 203 mm and was classified as a silvery parr. Upon recapture in June 2025, it measured 261 mm and was identified as a resident adult. Growth rates for *O. mykiss* tagged in June and recaptured in July or October were generally consistent; however, growth rates declined in October.

Overall, the 2025 season was characterized by lower fish abundance, frequent lagoon closures and breaches, and temperature constraints that limited sampling effort.

Table 1. *O. mykiss* catch per unit effort for the San Lorenzo River Lagoon by month and year (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, HES 2022, HES 2023, 2024, Confluence 2025)

	<i>O. mykiss</i> Catch per Unit Effort - San Lorenzo River Lagoon				
Year	June	July	August	September	October
2008	2.6	NS	NS	NS	0.1
2009	0.3	NS	NS	1.0	0.5
2010	8.3	21.5	NS	NS	28.3
2011	13.0	NS	NS	NS	2.5
2012	1.7	NS	NS	14.4	NS
2013	2.0	8.4	NS	4.7	NS
2014	1.2	1.1	NS	0.0	NS
2015	2.6	0.0	0.0	NS	0.0
2016	39.7	1.0	2.0	7.8	NS
2017	134.4	452.0	272.0	328.5	NS
2018	23.3	2.5	6.4	6.3	NS
2019	92.2	53.4	277.7	228.2	NS
2020	146.1	120.6	NS	31.0	NS
2021	4.3	6.3	NS	NS	0.3
2022	2.4	20.5	2.3	8.8	NS
2023	5.8	30.8	46.0	24.1	NS
2024	33.1	NS	106.8	15.3	NS
2025	5.9	4.7	NS	NS	9.9
Average	28.8	55.6	89.2	55.8	5.9
Median	5.9	8.4	26.2	11.6	0.5

NS=Not Sampled

Table 2. *O. mykiss* mark-recapture population estimates in San Lorenzo River Lagoon for fish >80 mm FL and <320 mm FL

	<i>O. mykiss</i> Population Estimate	
Year	Spring	Fall
2011	501	138
2012	60	714 ¹
2013	207 ²	No estimate ³
2014	No estimate ⁴	None captured
2015	5,593	None captured
2016	2,697	1,331
2017	3,636	>3,636 ⁵
2018	2,378	704
2019	7,637	14,105
2020	26,815	18,720
2021	No estimate	No estimate
2022	53	721
2023	444	2,046
2024	2,142	832
2025	1,068	288 ⁶

Source: data from HES 2012, HES 2013, HES 2014a, HES 2015, HES 2016, HES 2017, HES 2018, HES 2019, HES 2020, HES 2021, HES 2022, HES 2023, and HES 2024

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 Low number of recaptures because lagoon breached during the recapture survey, likely biased. This data is anecdotal and reports individuals existing and a descriptive index of presence

Table 3. *O. mykiss* catch per haul for the San Lorenzo River Lagoon over multiple years

<i>O. mykiss</i> catch per haul for the San Lorenzo River Lagoon during 2025					
Station	Location	June 3-6	July 15-16	Oct 14-17	Overall
SL-1	South of Trestle	2.5	3.0	2.5	2.4
SL-2	RR Trestle	13.5	14.0	5.8	11.2
SL-3	Near YSI Station	0.0	NS	NS	0.0
SL-5	Riverside Drive	11.2	1.3	27.3	15.7
SL-6	U/S Bank Restoration	1.1	3.5	9.5	4.6
	Overall	5.9	4.7	9.9	7.1

NS=Not Sampled

<i>O. mykiss</i> catch per haul for the San Lorenzo River Lagoon during 2024					
Station	Location	June 4-7	Aug 13-14	Sep 17-20	Overall
SL-1	South of Trestle	16.6	8.0	3.5	9.1
SL-2	RR Trestle	91.8	471.0	19.9	104.9
SL-3	Near YSI Station	NS	NS	NS	NS
SL-5	Riverside Drive	40.8	59.7	25.8	36.5
SL-6	U/S Bank Restoration	14.1	11.0	14.6	13.9
	Overall	33.1	106.8	15.3	37.1

NS=Not Sampled

<i>O. mykiss</i> catch per haul for the San Lorenzo River Lagoon during 2023						
Station	Location	June 6-9	July 18-19	Aug 15-16	Sep 19-22	Overall
SL-1	South of Trestle	0.2	24.3	1.3	1.8	5.4
SL-2	RR Trestle	7.4	44.7	146.0	46.4	41.2
SL-3	Near YSI Station	NS	NS	NS	NS	NS
SL-5	Riverside Drive	13.5	23.3	30.5	18.3	18.9
SL-6	U/S Bank Restoration	1.8	NS	1.0	17.1	7.8
	Overall	5.8	30.8	46	24.1	20.7

NS=Not Sampled

San Lorenzo Lagoon Site Conditions and Water Quality - 2025

June 2025 Survey (June 3-6)

One week prior to the June surveys, the lagoon outlet was mechanically reconfigured. Before this modification, the lagoon flowed several hundred yards northward before discharging into the ocean. The outlet was relocated to a position adjacent to the southern bluff and remained there for the duration of the 2025 sampling season. The potential effects of this modification on fish movement into and out of the lagoon are unknown.

The lagoon was open and tidally influenced throughout the June survey period (Figures 2-5). Outflow was noticeable at multiple sampling stations, along with wave wash at the lower lagoon sites. Lagoon stage fluctuated with the tidal cycles, with recorded water levels ranging from 0.65 feet to 3.26 feet. Streamflow in the San Lorenzo River at Santa Cruz (USGS station 11161000) ranged from 28.9 cfs on June 3 to 33.7 cfs on June 6 (Figure 2). For reference, the long-term mean June flow (1953-2025) is approximately 35 cfs.

The open lagoon provided improved access to the sampling sites during both the mark and recapture efforts. At lower lagoon stations, hauls were conducted through deeper water along the bluff and finished either at the canoe or as a beach landing, depending on conditions. At the stations upstream of the Riverside Bridge, wide sand beaches extended from the levee toe into the lagoon, forming a shallow shelf along the channel margin. Sampling at these sites required purse seine finish into the canoe at the edge of the shelf.

June Site Conditions

- The lagoon was strongly stratified by salinity, with a relatively fresh surface layer and a pronounced halocline between 0.5 meters and 0.8 meters (1.6-2.6 feet). Surface salinity ranged from 0.1 ppt to 5.7 ppt while salinity below the halocline ranged from 24.5 ppt to 30.6 ppt (Figure 6), consistent with tidal marine influence.
- No thermocline was observed. Surface water temperatures ranged from 16.3°C to 18.4°C and temperatures at depth ranged from 14.7°C to 18.4°C, indicating largely isothermal condition suitable for tagging.
- Surface dissolved oxygen (DO) concentrations ranged from 7.8 mg/L to 9.0 mg/L during the mark period and increased slightly to 8.1 mg/L to 9.4 mg/L during the recapture surveys. DO decreased with depth, with more pronounced gradients below the halocline. The minimum DO recorded was 3.8 mg/L at 1.8 meters (5.9 feet) near the Trestle Bridge.
- On June 3, anomalously high DO concentrations of 11.5 mg/L and 16.7 mg/L were recorded near the Trestle Bridge at depths of 0.8 meters and 1.2 meters. These values likely reflect instrument error (YSI meter) rather than in-situ conditions.
- Water clarity, measured as Secchi depth, extended to the bottom at all but one station, where Secchi depth reached 1.75 meters in a maximum depth of 1.8 meters. Total water depth across stations ranged from 1.3 to 1.75 meters (4.3-5.7 feet). Algal abundance was minimal and did not interfere with sampling operations or visibility.

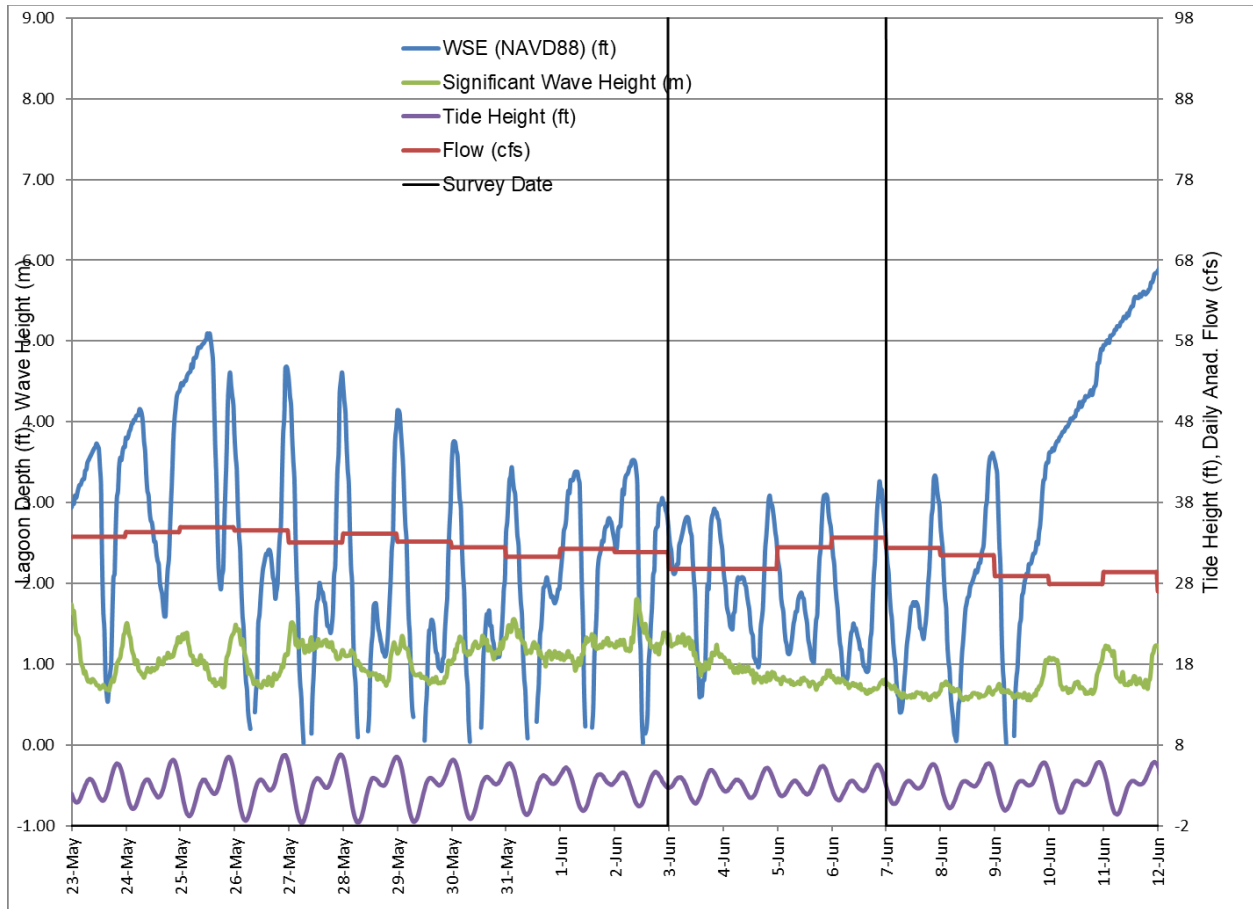


Figure 2. San Lorenzo River Lagoon stage, streamflow, wave height, and tides around June 2025 sample period (Source: lagoon stage from City of Santa Cruz Public Works, streamflow from USGS, wave and tide data from NOAA)



Figure 3. San Lorenzo River Lagoon mouth June 3, 2025



Figure 4. San Lorenzo River Lagoon facing upstream June 3, 2025. Note remnants of former outflow channel to the north after reconfiguration



Figure 5. San Lorenzo River Lagoon mouth June 3, 2025. Note outflow from open lagoon

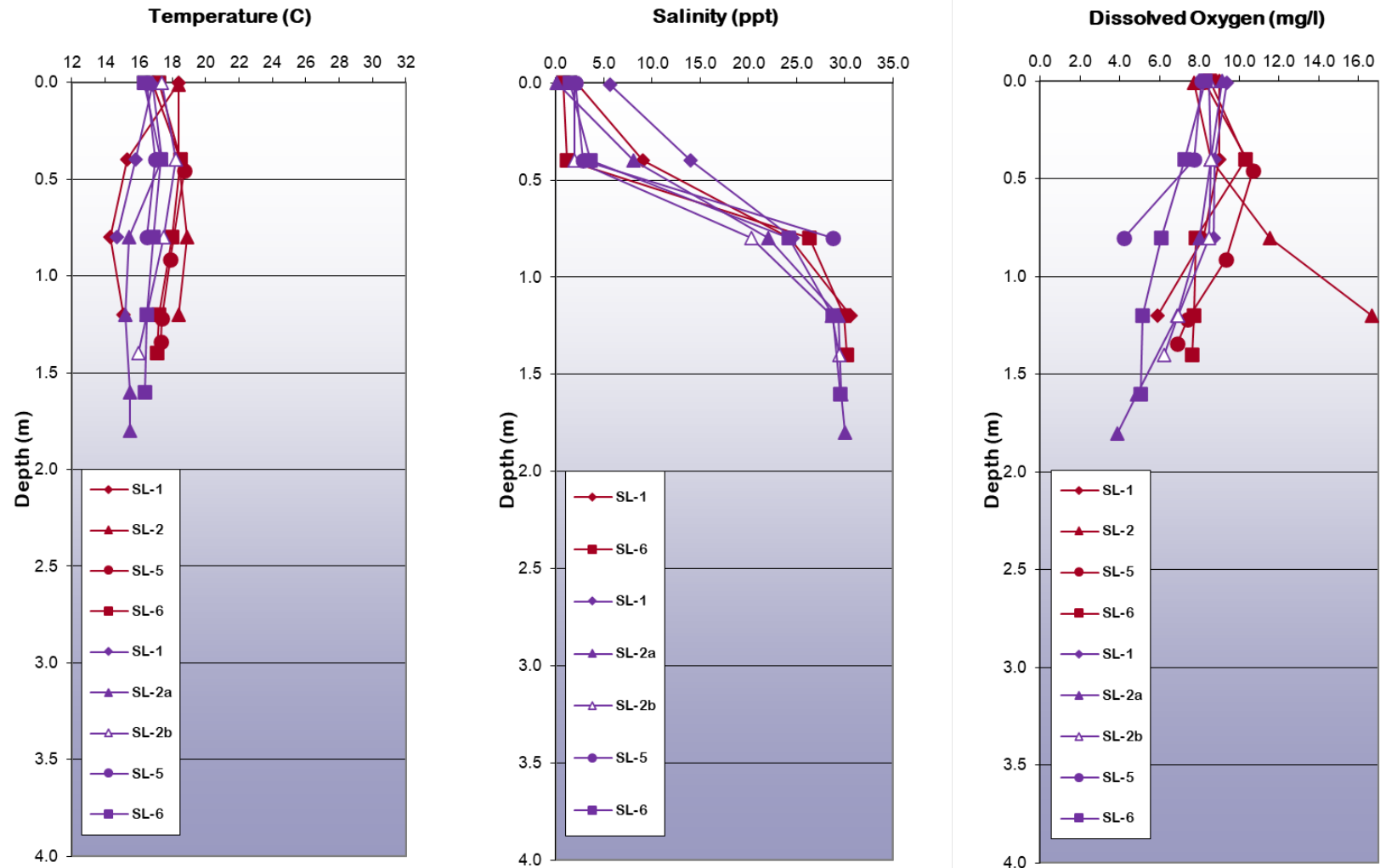


Figure 6. Depth profiles of water quality parameters in the San Lorenzo River Lagoon during June 2025. Profiles plotted in red are June 3-4; profiles in purple are June 5-6

San Lorenzo Lagoon June 2025 Survey Results

A total of 36 seine hauls were completed between June 3 to June 6, spanning sites from the lagoon mouth to locations upstream of the Trestle Bridge and Riverside bridge (Table 4). The lagoon remained open and at very low stage during this period, with observable wave wash and outflow at both lower and upper lagoon stations.

Catch composition was dominated by topsmelt, followed by *O. mykiss* and staghorn sculpin (Table 4). All *O. mykiss* captured and tagged were greater than 90 mm in length.

Table 4. Fish catch in the San Lorenzo River Lagoon, June 2025

	SL-1	SL-2	SL-3	SL-5	SL-6	Grand Total
# Hauls	11	8	1	6	10	36
Species	Number caught					
<i>O. mykiss</i>	27	108	0	67	11	213
Pacific sardine		42				42
Topsmelt	554	3,573	223	6,029	720	11,099
Threespine stickleback				4	1	5
Bay pipefish	1	1				2
Staghorn sculpin	13	2		27	8	50
Shiner surfperch	1	4	1	10	1	17
Tidewater goby				2	3	5
Starry flounder	18	7		2	2	29
Rock crab	4	4				8
Shrimp	1					1
<i>O. mykiss</i> CPUE	2.5	13.5	0.0	11.2	1.1	5.9

O. mykiss abundance, expressed as catch per unit effort (CPUE), was 5.9 per haul. This value is near the long-term median but substantially lower than the June 2024 CPUE of 33.1 (Table 1). Abundance in 2025 was more comparable to 2023 levels. CPUE was highest near the Trestle Bridge (SL-2) and immediately upstream of Riverside Bridge (SL-5).

Most *O. mykiss* captured in June fell within the 130-160 mm fork length range (Figure 7).

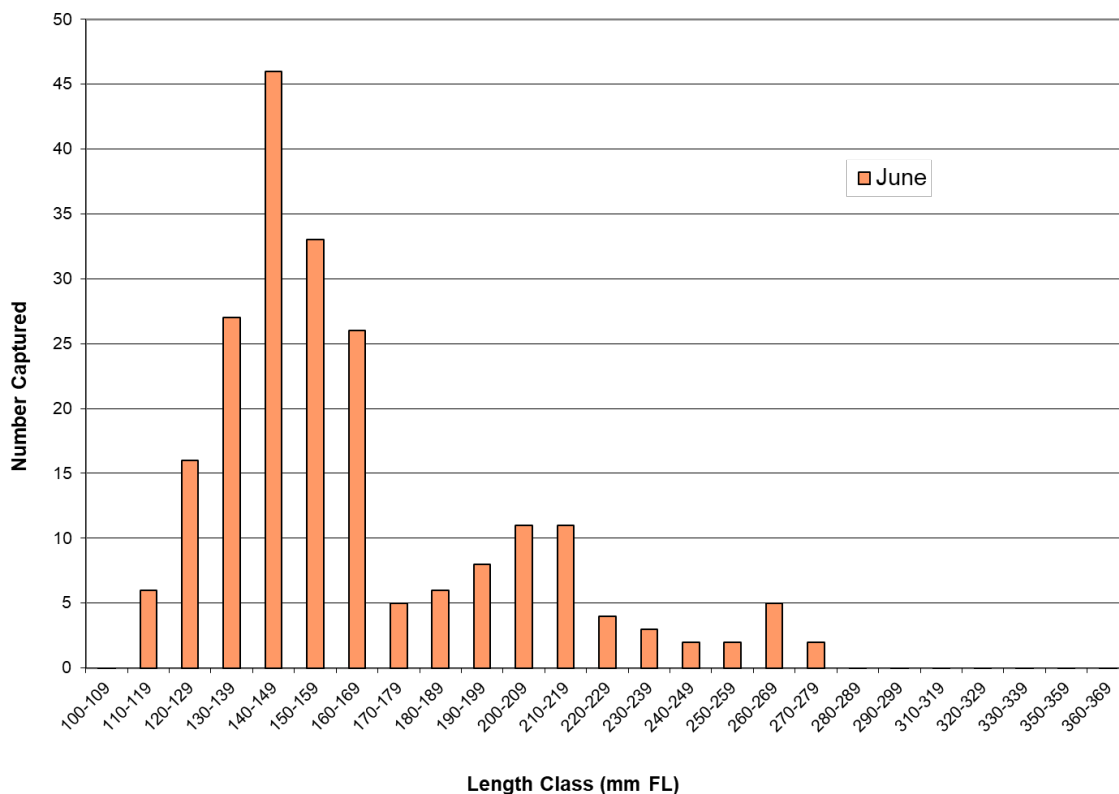


Figure 7. *O. mykiss* length classes in the San Lorenzo River Lagoon, June 2025

Life stage composition data indicated that 44% of individuals were advanced parr or advanced silvery parr, 37% parr or advanced parr, 6% smolts (darkened dorsal and caudal margins), and 13% as resident adults. The resident adults exhibited no morphological changes associated with smoltification and were larger than the typical smolt size class.

All *O. mykiss* captured and examined retained an adipose fin present, indicating that they were natural (non-hatchery) origin.

Black spot disease (BSD) was observed on 22% of the *O. mykiss* captured, with infections generally classified as light. This prevalence falls within the historical range of 11%-68% observed in June surveys since 2010.

June 2025 *O. mykiss* Population Estimate

During the mark period (June 3-4) 142 *O. mykiss* were captured. Of these, 14 were recaptures from earlier in the mark period, one was a recapture from 2024, and one individual escaped prior to processing. A total of 126 tagged *O. mykiss* were released back into the lagoon following the mark period.

The individual recaptured from 2024 was originally tagged September 19, 2024, just downstream of Trestle Bridge. At that time, it measured 203 mm and was classified as a silvery parr. Upon recapture on June 3, 2025, just upstream of Trestle Bridge, it measured 261 mm and was classified as a resident adult.

During the recapture period (June 5-6), 71 *O. mykiss* were captured. Fourteen individuals had tags from the mark period, and one individual was recaptured after being tagged earlier in the recapture period. A total of 56 newly tagged *O. mykiss* were released back into the lagoon following the recapture sampling.

Assuming a closed population, the Peterson population estimate (Ricker 1975) was calculated at 1,068 *O. mykiss*, with 95% confidence limits ranging from 673 to 1,676 individuals.

Size distributions were comparable between mark and recapture periods (Figure 8).

CPUE declined between the mark and recapture period (7.9 vs. 3.9). However, because the lagoon remained open during sampling, fish movement into and out of the system likely occurred, violating the closed-population assumption required for the Peterson method. Therefore, this population estimate should be interpreted with that in mind.

Overall, June 2025 results indicate relatively low abundance and moderate growth, with open lagoon conditions likely influencing both fish distribution and population estimates.

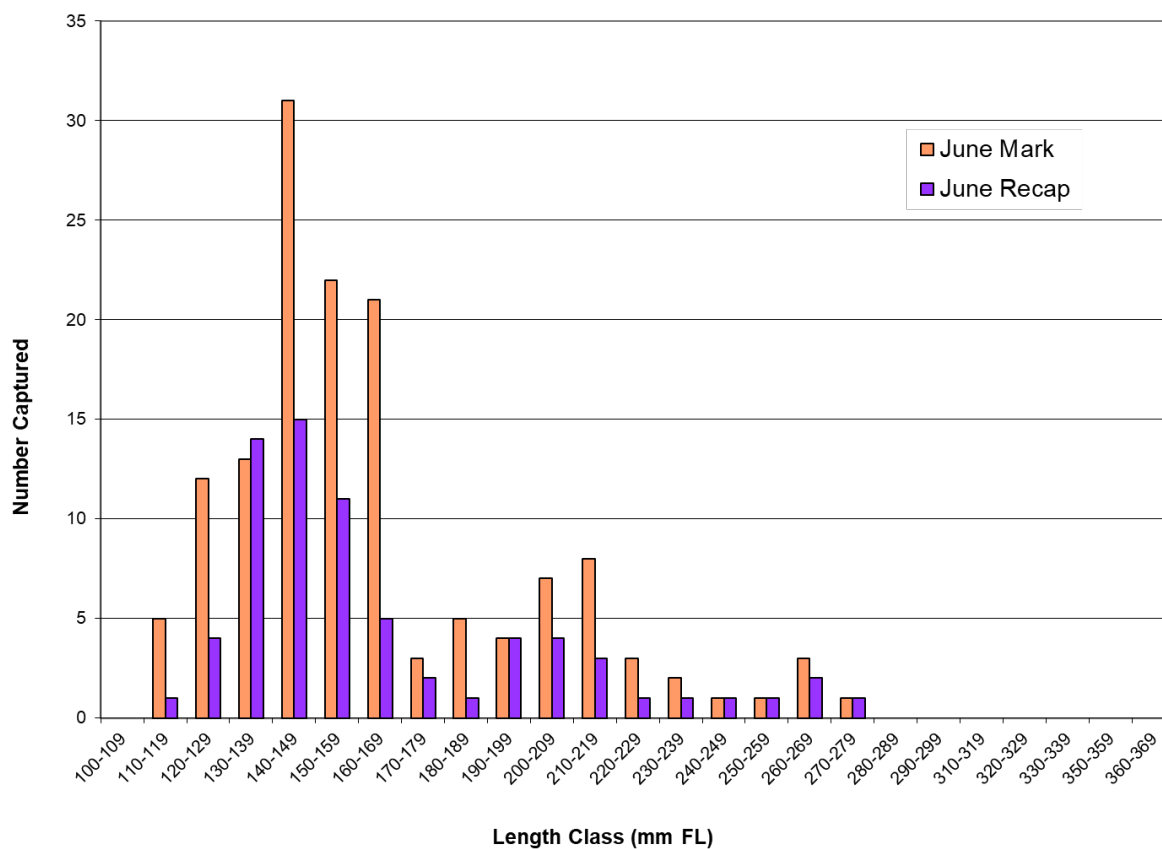


Figure 8. *O. mykiss* length classes in the San Lorenzo River Lagoon, June 2025 for both the mark and recapture periods

San Lorenzo Lagoon July 2025 Survey (July 15-16)

The July survey consisted of a two-day relative abundance assessment without mark-recapture population estimates. On Day 1, sampling was conducted at standard lower lagoon stations (SL-1 and SL-2) near and downstream of the Trestle Bridge. On Day 2, sampling was conducted at the upstream locations (SL-5 and SL-6) upstream of the Riverside Bridge. Station SL-3 was not sampled due to increasing air temperatures, high number of fish captured, and extended processing time required at Station SL-2.

During the second day of sampling, water temperatures approached permit thresholds. According to the Scientific Collecting Permit for this project sampling must cease if surface water temperature exceeds 21°C and tagging is only permitted if at least 50% of the water column is at or below 21°C and dissolved oxygen is greater than or equal to 5 mg/L. To minimize stress and protect fish health, *O. mykiss* captured were processed in the net (scanned for tags and visually assessed for length) and released directly back to the lagoon.

The lagoon breached twice between the June and July surveys, with the second breach occurring three days prior to sampling. At the start of the July survey, the lagoon was closed, with a depth of 4.83 feet, increasing to 5.24 feet by the end of sampling. In contrast, June sampling occurred under open, tidal conditions with depths ranging from 2.81 feet to 1.33 feet. Streamflow in the San Lorenzo River at Santa Cruz (USGS station 11161000) ranged from 15.5 cfs on July 15 to 15.4 cfs on July 16 (Figure 9).

Elevated lagoon water levels resulted in the submergence of the beach area typically used for landing hauls downstream of the Trestle Bridge. As a result, hauls were conducted through deeper water and finished at the shallow shoreline shelf. With lagoon depths approximately 4 feet greater than in June, capture efficiency may have been reduced.

July Site Conditions

- Surface salinity ranged from 0.4 ppt to 1.9 ppt in the upper 0.4 meters (1.3 feet), with higher values near the lagoon mouth (Figure 10). A strong salinity gradient was present between 0.8 meters and 1.2 meters (2.6-3.9 feet), with salinity increasing to 30.0 ppt at depth in the lower lagoon.
- Surface water temperatures ranged from 18.4°C to 20.4°C. Temperatures exceeded 21°C below the halocline, reaching a maximum of 24.3°C at 1.8 meters (5.9 feet) at SL-5. Temperature increases were notably associated with higher salinity at depth.
- Dissolved oxygen concentrations were well-saturated in the upper water column (< 0.8 meters (2.6 feet)). At the halocline, DO increased sharply, reaching near super-saturation (maximum of 17 mg/L), likely due to elevated photosynthesis combined with limited vertical mixing. Below the halocline, DO declined to a minimum of 3.1 mg/L at 2.6 meters (8.5 feet).
- Water clarity (Secchi depth) ranged from 1.25 to 1.7 meters (4.1-5.6 feet) in the lower lagoon and from 1.5 to 1.75 meters (4.9-5.7 feet) upstream of Riverside bridge. Water depths ranged from 1.5 to 2.6 meters (5.7-8.5 feet). Algal abundance was minimal.

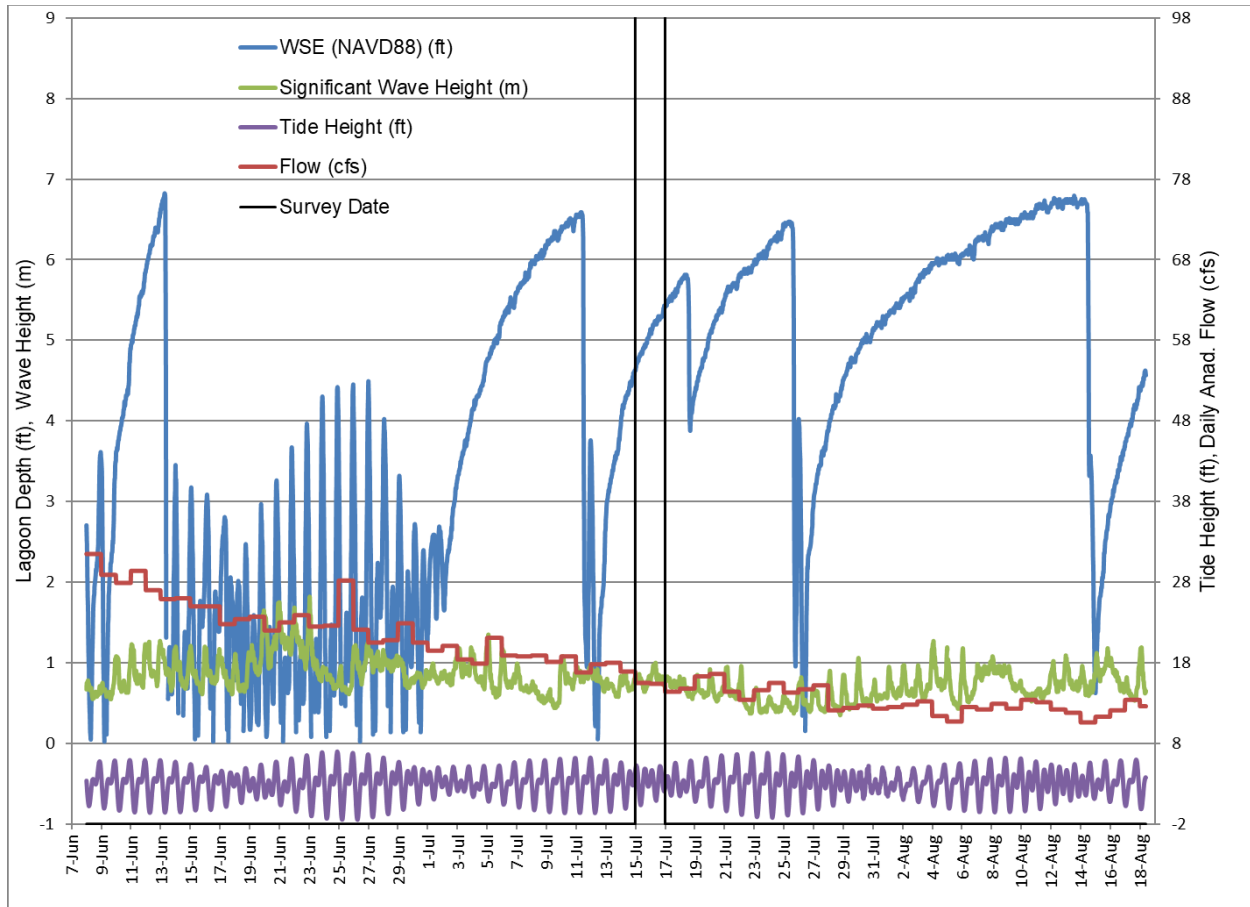


Figure 9. San Lorenzo River Lagoon stage, streamflow, wave height, and tides around July 2025 sample period (Source: lagoon stage from City of Santa Cruz Public Works, streamflow from USGS, wave and tide data from NOAA)

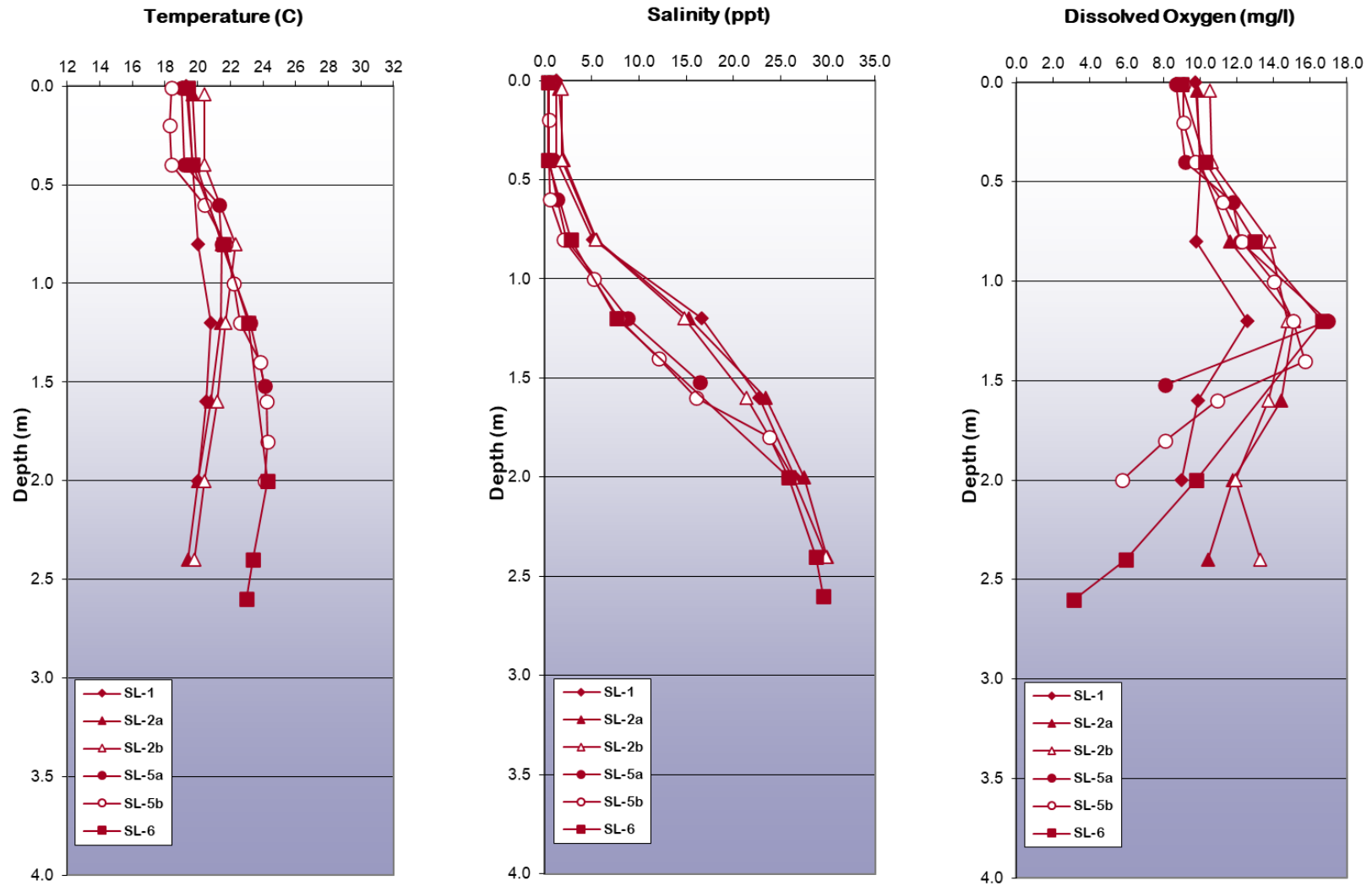


Figure 10. Depth profiles of water quality parameters in the San Lorenzo River Lagoon during July 2025

San Lorenzo Lagoon July 2025 Survey Results

Fifteen seine hauls were completed from July 15-16 across stations SL-1, SL-2, SL-5, and SL-6 (Table 5). Most *O. mykiss* were captured at lower lagoon stations near and downstream of the Trestle Bridge.

High lagoon water levels required modification of sampling methods. As in the site conditions described above, hauls were conducted through deeper water and finished at the canoe rather than on exposed beach. These conditions likely reduced capture efficiency relative to June.

Catch composition was dominated by topsmelt, with *O. mykiss* representing the second most abundant species. Two striped bass, an uncommon occurrence in these surveys, were captured upstream of the Riverside Bridge.

Table 5. Fish catch in the San Lorenzo River Lagoon, July 2025

	SL-1	SL-2	SL-5	SL-6	Grand Total
# Hauls	5	3	3	4	15
<i>Species</i>	<i>Number caught</i>				
<i>O. mykiss</i>	10	42	4	14	70
Northern anchovy		1			1
Topsmelt	79	405	138	127	749
Staghorn sculpin	1				1
Striped bass			2		2
Shiner surfperch	1	2			3
Starry flounder	4			1	5
<i>O. mykiss</i> CPUE	2.0	14.0	1.3	3.5	4.7

Day 2 of sampling had water temperatures higher than permit limits for tagging. *O. mykiss* collected were kept in the net, scanned for tags, visually assessed for length, and released.

O. mykiss abundance (CPUE) was 4.7 fish per haul, representing the fourth lowest value among July surveys conducted between 2010 and 2025. July CPUE was lower than June 2025 (4.7 vs. 5.9).

Four *O. mykiss* captured in July had been tagged in June (Table 6). Growth rates ranged from 0.62 to 0.83 mm/day, with an average of 0.69 mm/day. This exceeds the 2024 average growth rate of 0.38 mm/day for the period between June and August (Table 7).

Table 6. *O. mykiss* tagged in June and recaptured in July 2025

Previous Capture Date	Recapture Date	Initial Capture Location	Recapture Location	Initial Length (mm)	Length at Recapture (mm)	Growth Rate (mm/day)
6/5/2025	7/15/2025	SL-2	SL-1	159	185	0.65
6/3/2025	7/15/2025	SL-1	SL-2	159	185	0.62
6/3/2025	7/15/2025	SL-1	SL-1	209	236	0.64
6/3/2025	7/15/2025	SL-1	SL-2	219	254	0.83
Average						0.69

Lengths and life stage classifications were directly measured for approximately 74% of the *O. mykiss* captured individuals; the remaining 26% were estimated due to temperature related handling constraints. Among evaluated fish, 77% were classified as advanced parr or advanced silvery parr, 18% as parr or advanced parr, and 5% as resident adults. Length distribution was unimodal, with most individuals in the 130-139 mm range (Figure 11).

All *O. mykiss* examined had an adipose fin, indicating natural origin.

Black spot disease (BSD) was observed in 29% of individuals, with light to moderate severity. This prevalence falls within the historical range (8%-72%) observed since 2009.

Table 7. *O. mykiss* Growth Rates for Years Available, San Lorenzo River Lagoon

Year	Period	N	Average Growth (mm/day)	Range (mm/day)
2012	June-Sept	4	0.72	0.58-0.84
2013	June-Sept	2	0.34	0.27-0.41
2014		None captured		
2015		None captured		
2016	June-Sept	21	0.90	0.45-1.14
2017	June-July	35	0.78	0.42-1.16
	July-Aug	18	0.62	0.34-1.00
	Aug-Sept	15	0.40	0.05-0.73
	June-Sept	40	0.46	0.02-0.86
2018	June-July	2	0.98	0.88-1.08
	June-Aug	6	0.55	0.38-0.69
	June-Sept	10	0.39	0.26-0.49
2019	June-July	33	0.56	0.14-1.06
	July-Aug	57	0.45	0.04-0.89
	Aug-Sept	85	0.36	0.00-0.75
	June-Sept	88	0.38	0.03-0.85
2020	June-July	5	0.51	0.27-0.69
	July-Sept	3	0.45	0.25-0.58
	June-Sept	5	0.41	0.22-0.62
2021	June-July	1	0.26	
2022	June-July	2	0.30	0.21-0.38
	July-Aug	1	0.20	
	June-Aug	1	0.18	
2023	June-Jul	2	1.18	1.00-1.37
	June-Aug	4	0.88	0.69-1.04
	June-Sept	6	0.68	0.46-0.85
	July-Sept	7	0.24	0.06-0.48
	Aug-Sept	7	0.21	0.03-0.43
2024	June-Aug	70	0.38	0.13-0.63
	June-Sept	14	0.37	0.16-0.64
	Aug-Sept	18	0.28	0.03-0.46
2025	June-July	4	0.69	0.62-0.83
	June-October	10	0.65	0.40-0.85
	July-October	4	0.48	0.20-0.81

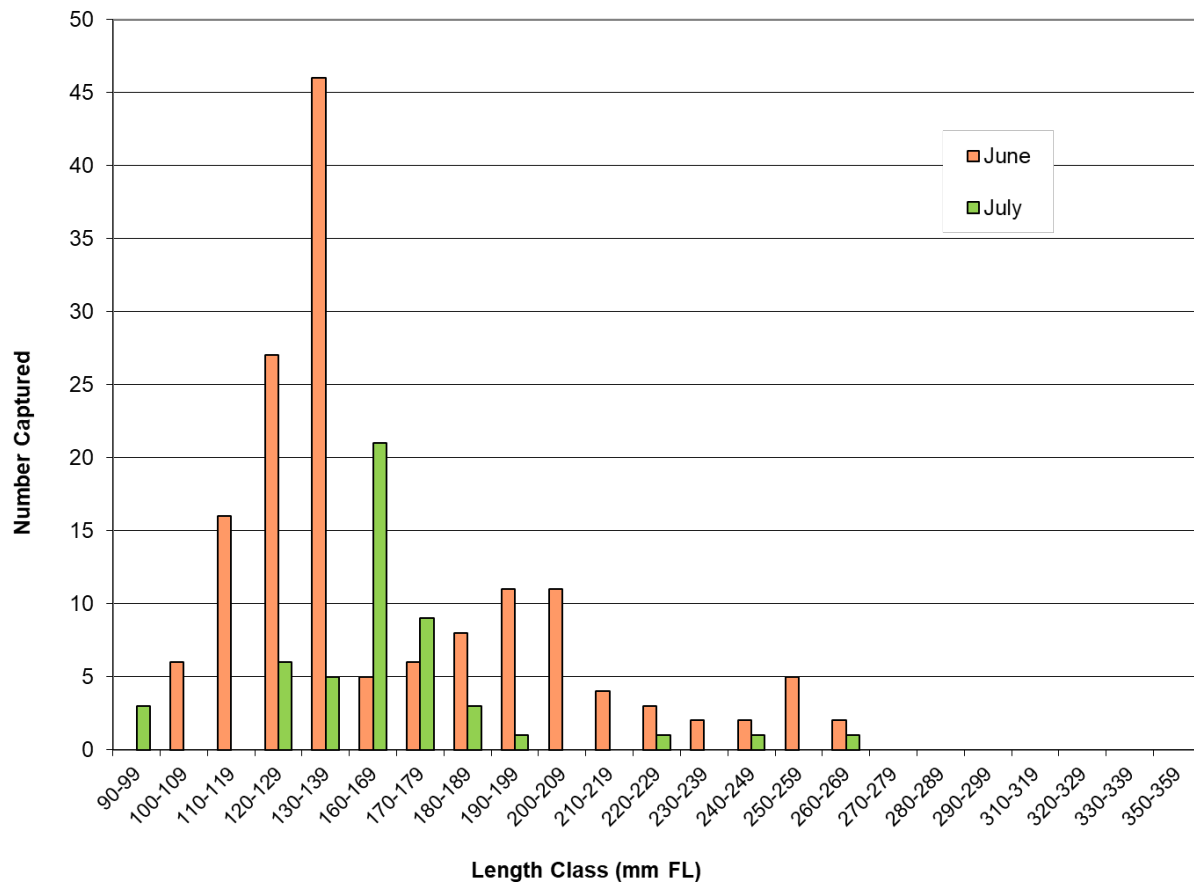


Figure 11. *O. mykiss* length classes in the San Lorenzo River Lagoon, June and July 2025

August/September/Early October 2025

The City of Santa Cruz collects vertical profiles of water quality including temperature, salinity, and dissolved oxygen in the San Lorenzo Lagoon throughout the summer. Profiles collected in August, September, and early October (Figures 12 to 17) were generally obtained within three to seven days prior to lagoon breach events. Seven breach events occurred between the July and October surveys. The vertical profiles consistently indicated elevated water temperatures during this period. Temperature thresholds specified in the Scientific Collecting Permit were exceeded throughout August, September, and early October. As a result, biological sampling was postponed until mid-October when water temperatures declined to acceptable levels.

Table 8 summarizes the timing of vertical profile measurements relative to breach events between July and October 2025. In most cases, profile measurements occurred within several days of the breach event. These repeated closures and breaches indicate a highly dynamic lagoon system during the late summer and early fall. Frequent changes in lagoon connectivity likely influenced habitat availability and fish distribution prior to the October survey.

Table 8. San Lorenzo Lagoon Vertical Profiles and Breaches recorded between July and October 2025 survey events

Vertical profiles measured	Date of Breach
July 15 and 16	July 18
	July 26
August 8	August 15
September 10	September 13
September 16	September 23
September 30	October 3
October 6	-
October 10	-
October 12, 13, and 14	October 14

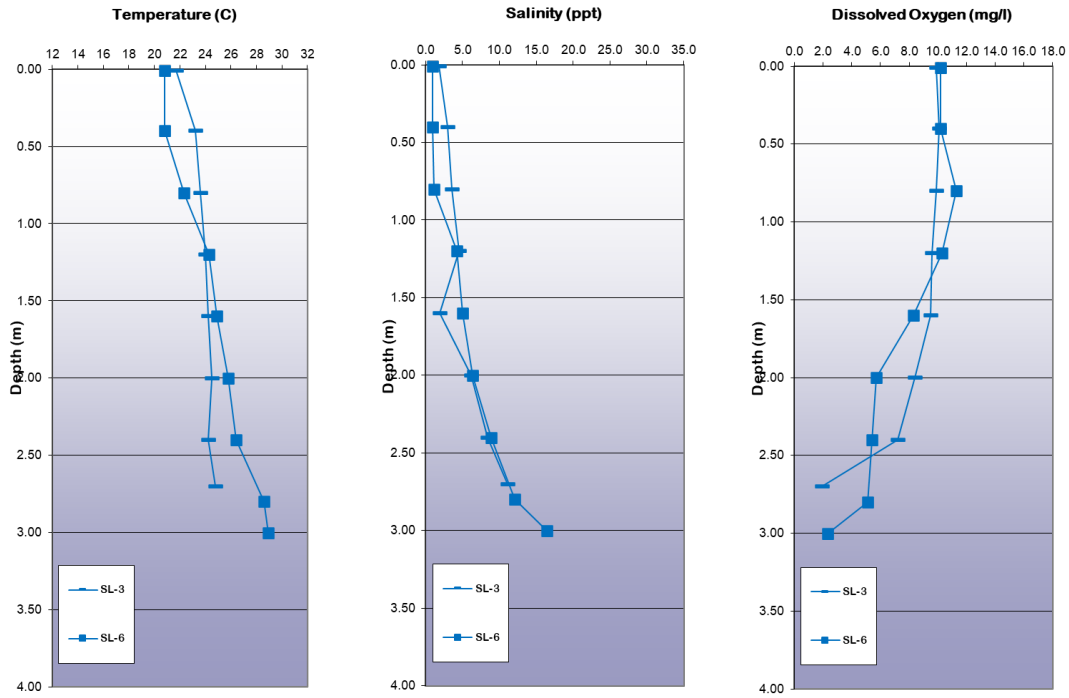


Figure 12. August 8, 2025 San Lorenzo Lagoon vertical profiles. Source: City of Santa Cruz

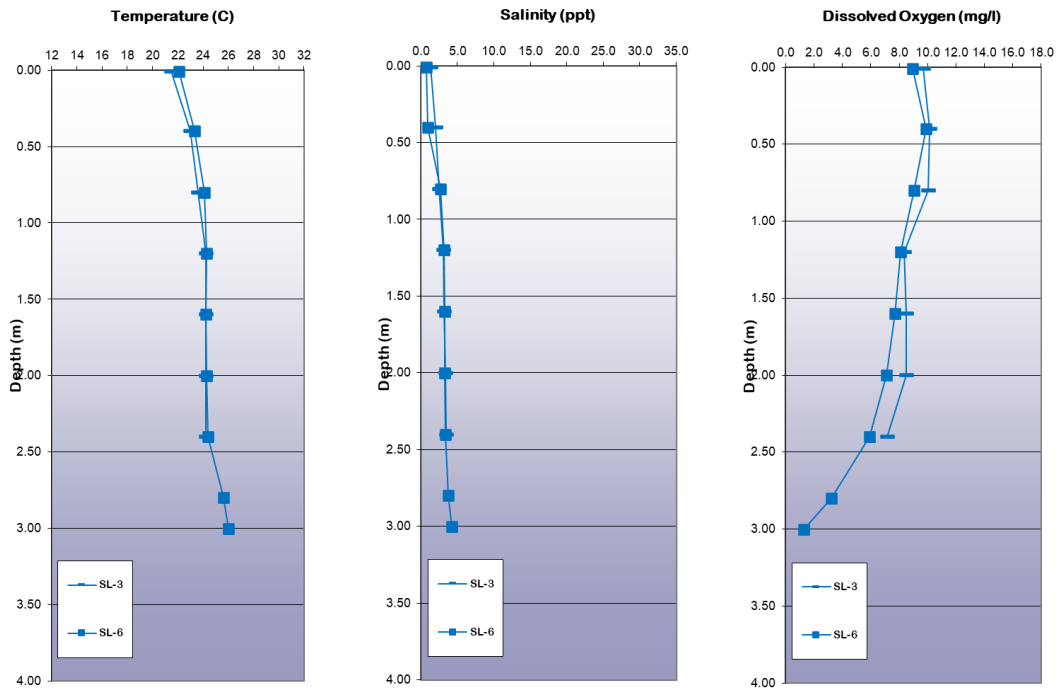


Figure 13. September 10, 2025 San Lorenzo Lagoon vertical profiles. Source: City of Santa Cruz

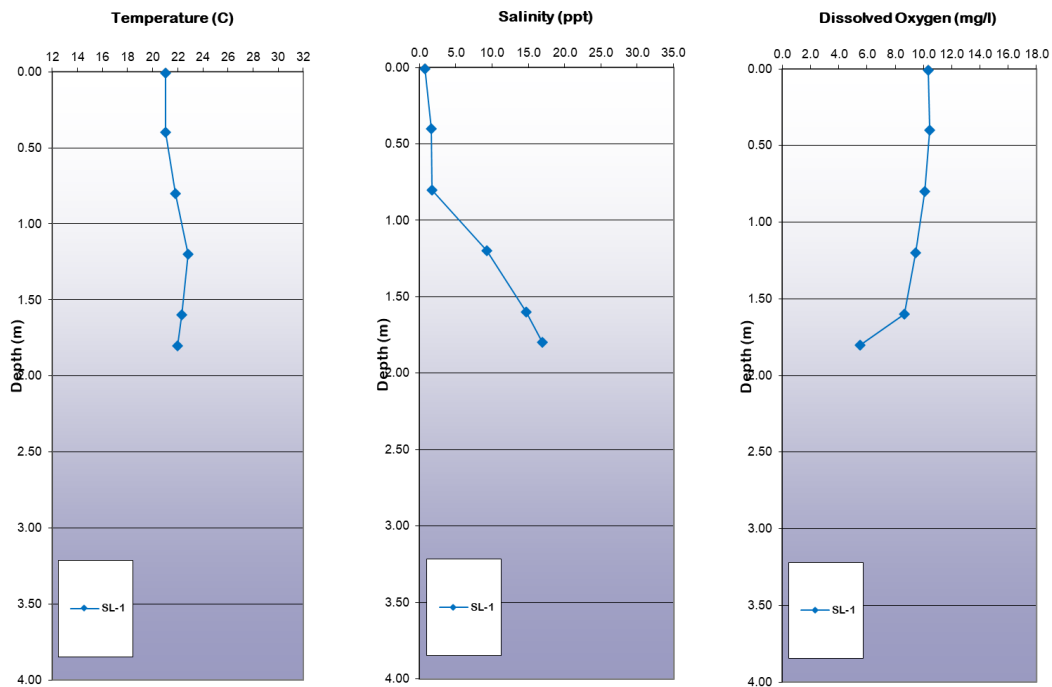


Figure 14. September 16, 2025 San Lorenzo Lagoon vertical profiles. Source: City of Santa Cruz

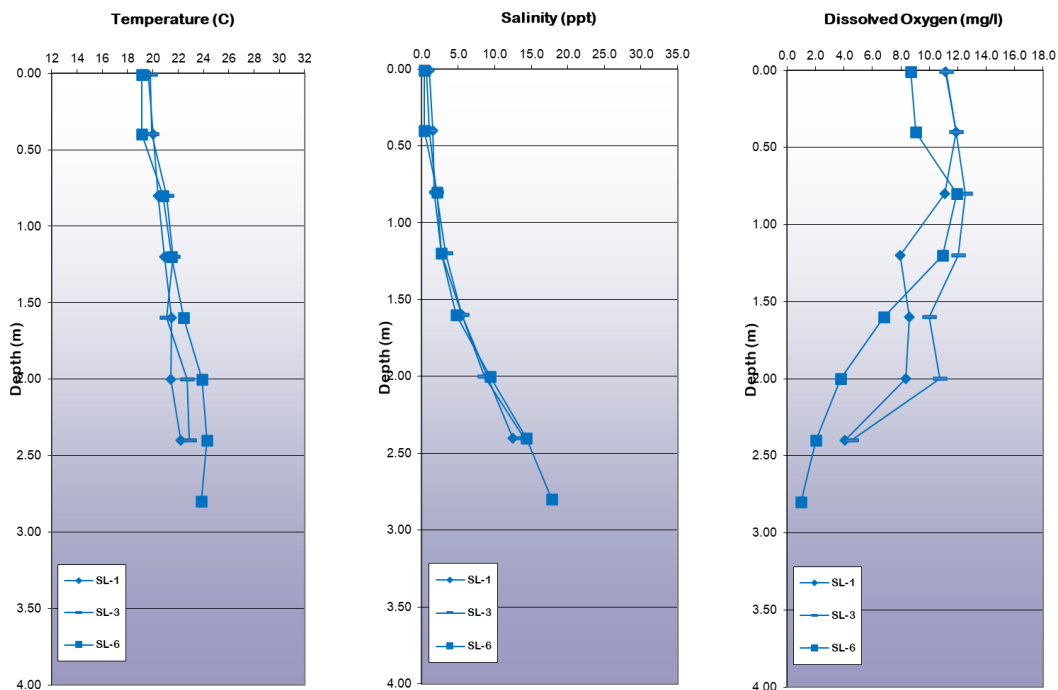


Figure 15. September 30, 2025 San Lorenzo Lagoon vertical profiles. Source: City of Santa Cruz

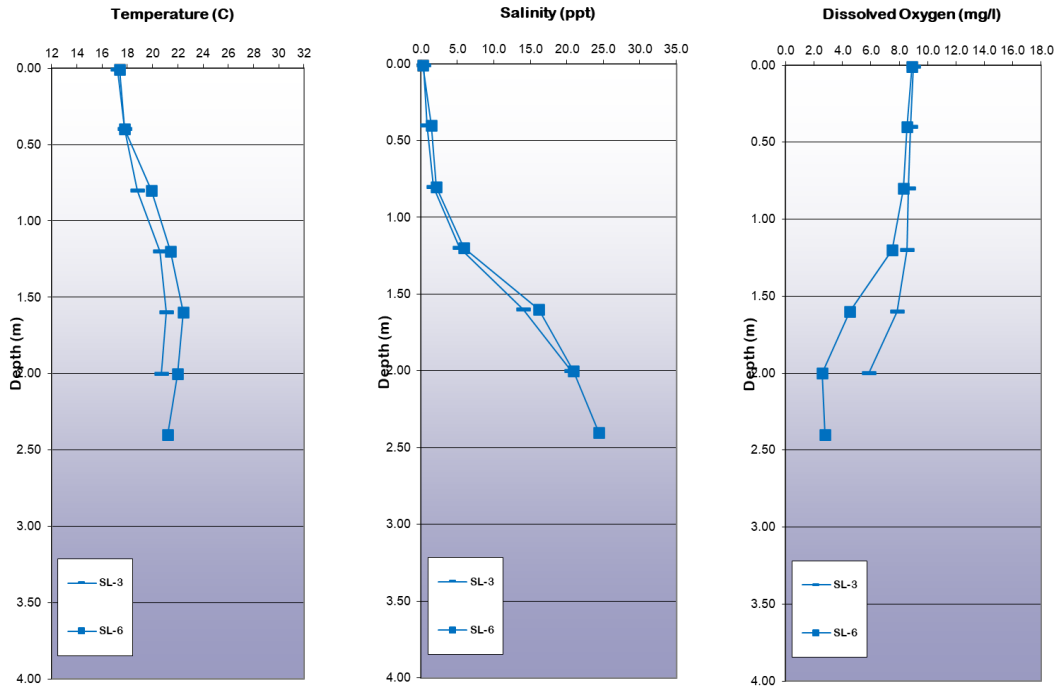


Figure 16. October 6, 2025 San Lorenzo Lagoon vertical profiles. Source: City of Santa Cruz

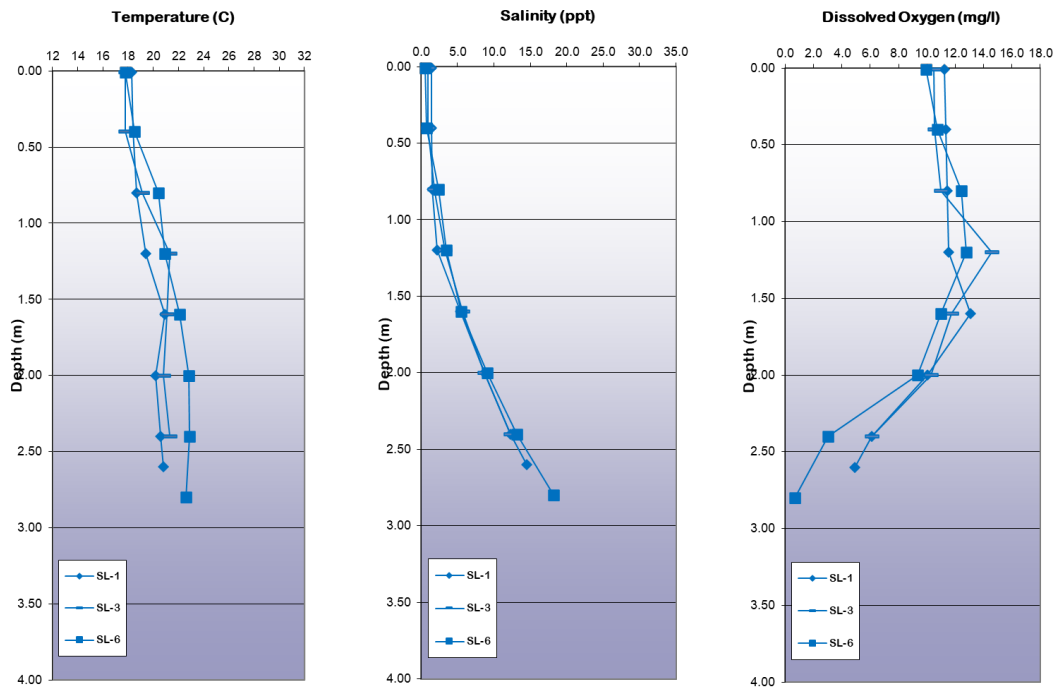


Figure 17. October 10, 2025 San Lorenzo Lagoon vertical profiles. Source: City of Santa Cruz

San Lorenzo Lagoon October 2025 Survey (October 14-17)

A brief rain event immediately prior to the October survey increased streamflow in the San Lorenzo River at Santa Cruz (USGS Station 11161000) from 39.6 cfs to 87.7 cfs (Figure 18). For context, the long-term average October flow (1953-2025) is approximately 16.7 cfs. This increase in flow, elevated the lagoon stage to over 6.2 feet and triggered a breach around midnight on October 14. Following the breach, the lagoon began to close again, and water levels rose. The lagoon remained closed during the two-day mark period (October 14-15) and into the first portion of the recapture period on October 16 (Figures 18-20). On October 16, lagoon stage peaked at 6.87 feet (Figure 21), followed by a second breach during active sampling. This breach caused a rapid drop in water level from 6.87 feet to 0.49 feet within approximately 2.5 hours, including a decline of 5 feet within a single hour (Figure 22). The event occurred during sampling at the Trestle Bridge and resulted in the immediate termination of field operations due to safety concerns and equipment loss. The lagoon remained open on the second day of the recapture period with streamflow of 17.4 cfs.

October Site Conditions

- Prior to the breach, the lagoon salinity was stratified, with freshwater (≤ 3 ppt) in the upper 1.2 meters (3.9 feet) and increasing salinity at depth (Figure 23). Stratification was strongest near the lagoon mouth. After the breach, salinity increased substantially at upstream stations (SL-5 and SL-6) indicating a strong marine influence under open conditions.
- Water temperature showed minimal stratification and increased slightly below 2.0 meters (6.6 feet) prior to the breach. Surface temperatures ranged from 13.7°C to 16.6°C, representing a substantial decrease from summer conditions and falling within a suitable range for *O. mykiss*. Temperatures were not significantly affected by the breach.
- Dissolved oxygen (DO) concentrations were generally well-mixed but decreased with depth. Prior to the breach, surface DO concentrations ranged from 8.2 to 9.4 mg/L, with concentrations remaining above 7 mg/L throughout most of the water column. The lowest DO (5.1 mg/L) was recorded near the substrate at the upstream station. After the breach, DO concentrations decreased slightly (6.8 to 7.2 mg/L) in a shallower, more mixed water column.
- Water clarity (Secchi depth) was reduced prior to the breach with visibility ranging from 0.6 to 0.7 meters in water up to 2.8 meters deep. Following the breach, clarity improved substantially, with the substrate visible at most stations due to reduced water depth.

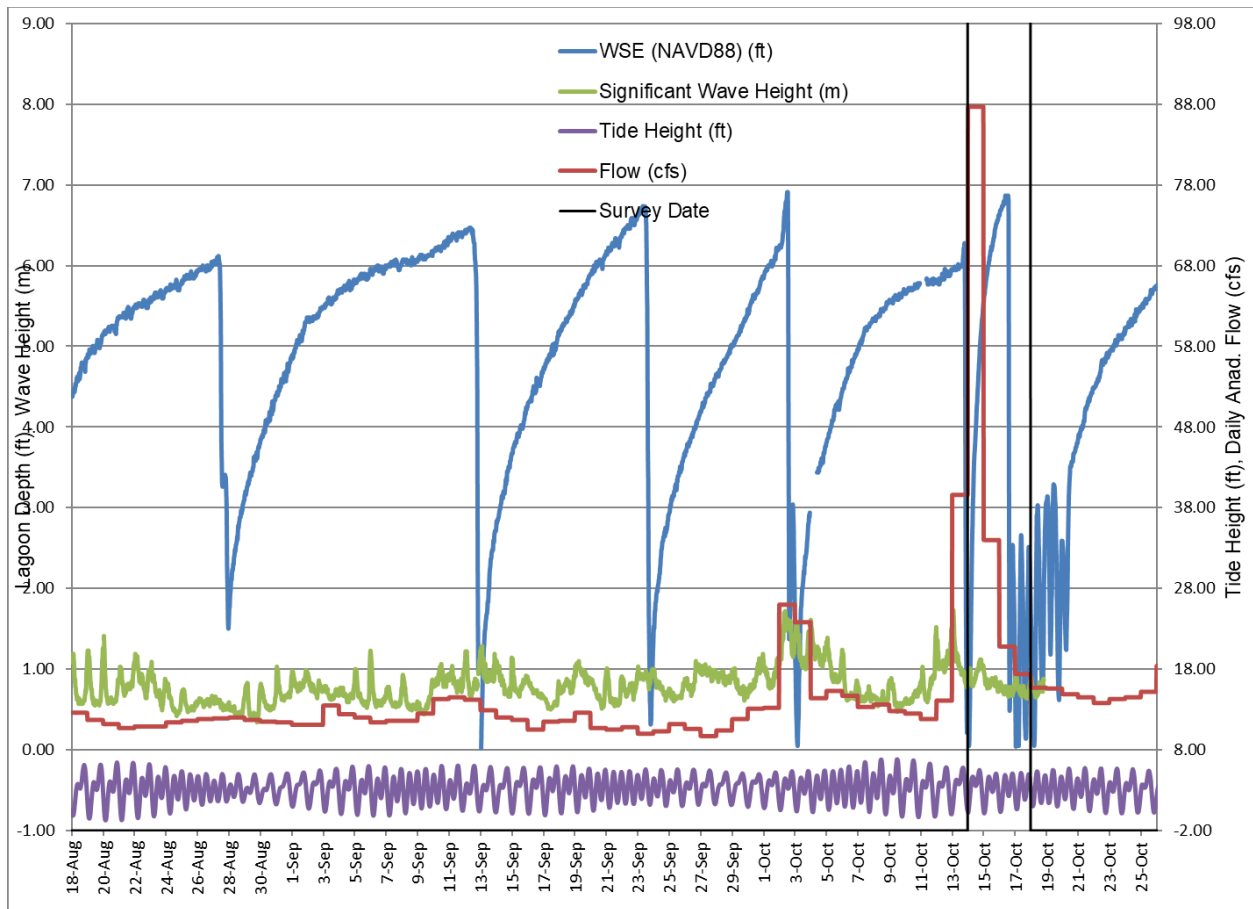


Figure 18. San Lorenzo River Lagoon stage, streamflow, wave height, and tides around October 2025 sample period (Source: lagoon stage from City of Santa Cruz Public Works, streamflow from USGS, wave and tide data from NOAA)



Figure 19. San Lorenzo River Lagoon mouth October 14, 2025 (pre-breach)



Figure 20. San Lorenzo River upstream of Riverside Bridge October 15, 2025 (pre-breach)



Figure 21. San Lorenzo River Lagoon Station SL-2 October 16, 2025 at 1:38pm (pre-breach)



Figure 22. San Lorenzo River Lagoon Station SL-2 October 16, 2025 at 3:20pm (post-breach)

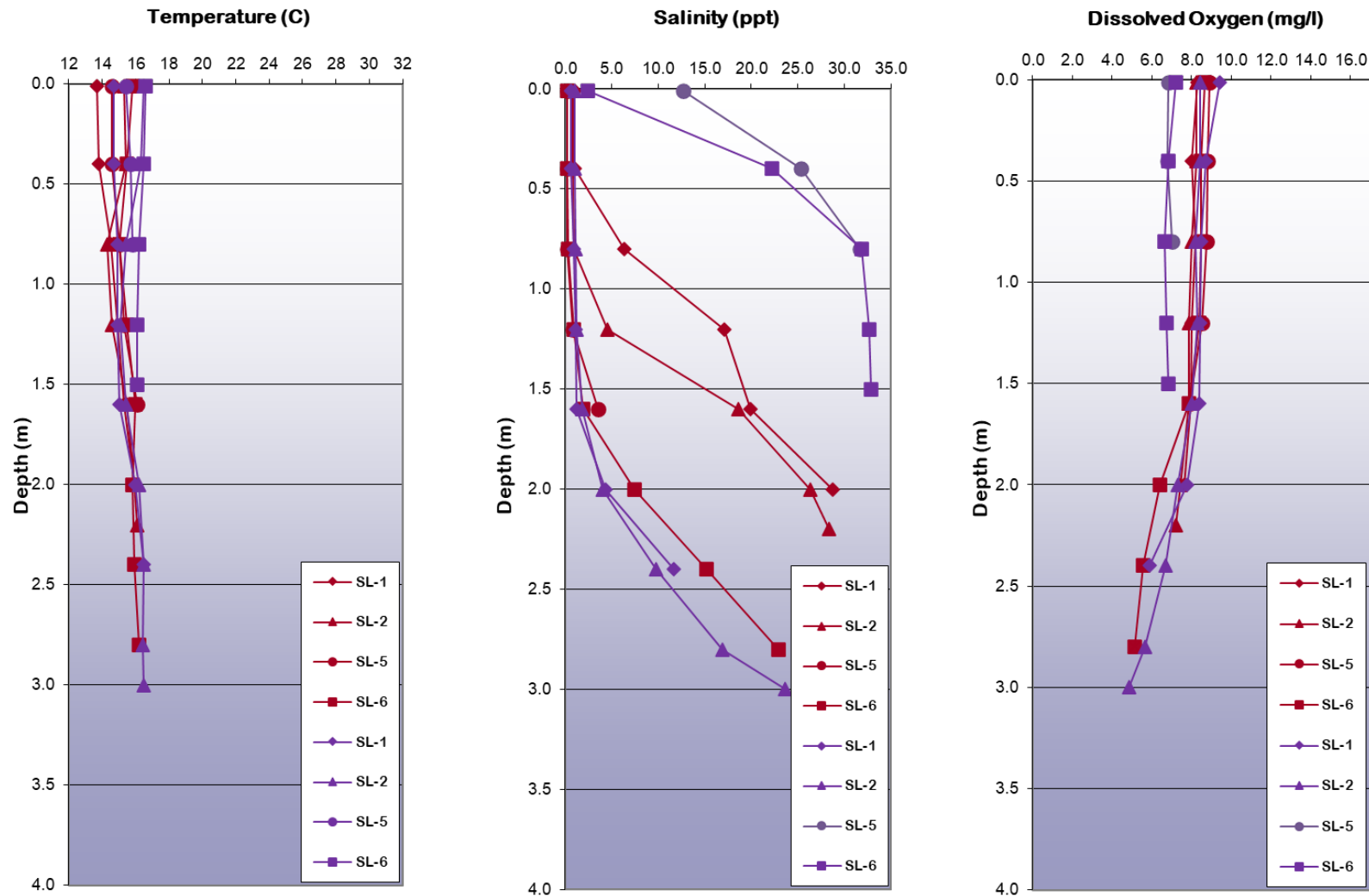


Figure 23. Depth profiles of water quality parameters in the San Lorenzo River Lagoon during October 2025. Profiles plotted in red are October 14-15; profiles in purple are October 16-17

San Lorenzo Lagoon October 2025 Survey Results

Between October 14 and October 17, a total of 30 hauls were completed at the standard sampling stations (SL-1, SL-2, SL-5, and SL-6). The lagoon remained closed during the two-day mark period and early portion of the recapture period. During this time, lagoon depths were high and shoreline beaches were submerged, resulting in relatively deep water (2-3 feet) along the levee banks.

A significant breach occurred during the first day of the recapture period (October 16), interrupting sampling efforts near the Trestle Bridge. Sampling was terminated due to hazardous outflow and equipment loss. As a result, data collection at key lagoon stations was incomplete. On the second day of the recapture period (October 17) lagoon depth decreased by more than 1.5 meters (4.9 feet) compared to pre-breach conditions. Wide sand beaches re-emerged at upstream stations, substantially altering sampling conditions relative to the mark period.

Catch composition was dominated by topsmelt and *O. mykiss* with relatively low numbers of other species (Table 9). However, both catch and recapture data were influenced by the mid-survey breach which altered lagoon depth, salinity, and hydrodynamic conditions.

Table 9. Fish catch in the San Lorenzo River Lagoon, October 2025

	SL-1	SL-2	SL-5	SL-6	Grand Total
# Hauls	11	5	6	8	30
<i>Species</i>	<i>Number caught</i>				
Steelhead	27	29	164	76	296
Pacific sardine	1				1
Topsmelt	12	82	181	998	1,273
Threespine stickleback			1	1	2
Prickly sculpin				1	1
Staghorn sculpin	2		1		3
Barred surfperch	1				1
Starry flounder	2				2
Halibut	1				1
Crab	1	6		1	8
<i>O. mykiss</i> CPUE	2.5	5.8	27.3	9.5	9.9

O. mykiss abundance (CPUE) during the recapture period was calculated at 9.9 fish per haul. However, changes in lagoon configuration and sampling conditions likely affected gear efficiency. Consequently, results from pre- and post-breach sampling periods are not directly comparable.

A notable increase in *O. mykiss* catch was observed at the upstream stations (SL-5 and SL-6) following the breach on October 17 (Table 10). This shift likely reflects changes in fish distribution in response to altered lagoon conditions including marine connectivity, changes in water quality, and reduced lagoon depth.

Table 10. *O. mykiss* San Lorenzo River Lagoon catch by Station and Date, October 2025

	SL-1	SL-2	SL-5	SL-6	Grand Total	Lagoon condition
10/14/2025	9	23			32	Pre-breach
10/15/2025			16	18	34	Pre-breach
10/16/2025	18	6			24	Pre-breach/at least 2 stations near SL-2 not sampled during active breach
10/17/2025			148	58	206	Post-breach
Grand Total	27	29	164	76	296	

Two hundred and ninety-six *O. mykiss* were captured during the October sampling event, two hundred thirty of which were captured during the recap period 10/16 and 10/17. The fourteen *O. mykiss* tagged in June and July that were recaptured in October were used for growth analysis and summarized in Table 11.

Length distribution in October was unimodal, with most individuals measuring between 220 mm and 229 mm (Figure 24).

Growth rates differed by tagging period. Fish tagged in June exhibited higher growth rates through October, with an average increase of 87 mm and a maximum observed growth of 115 mm. In contrast, fish tagged in July exhibited lower growth rates between July and October (Table 11).

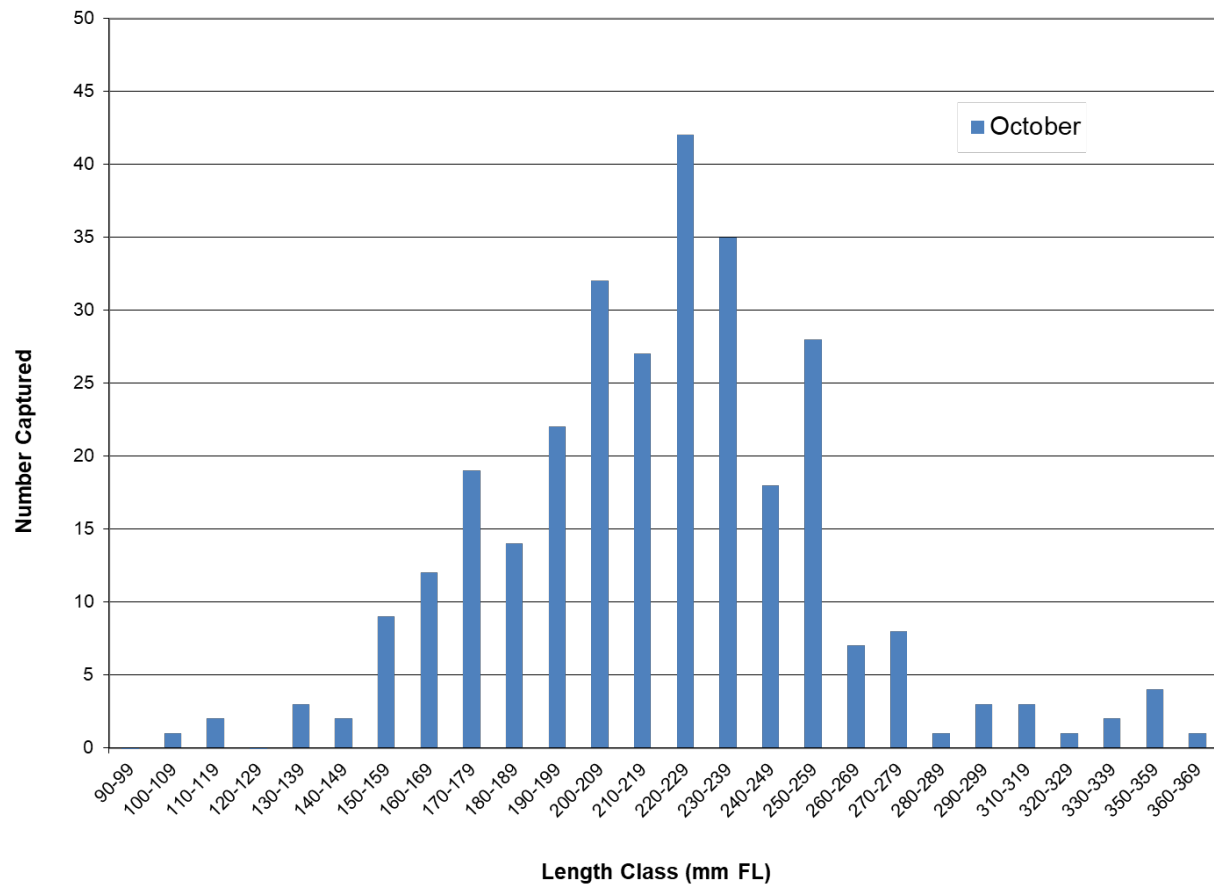


Figure 24. *O. mykiss* length classes in the San Lorenzo River Lagoon, October 2025

Table 11. *O. mykiss* tagged in June and recaptured in October 2025

Previous Capture Date	Recapture Date	Initial Capture Location	Recapture Location	Initial Length (mm)	Length at Recapture (mm)	Growth Rate (mm/day)
6/3/2025	10/15/2025	SL-1	SL-5	134	239	0.78
6/5/2025	10/17/2025	SL-2	SL-5	145	209	0.48
6/5/2025	10/17/2025	SL-2	SL-5	149	256	0.80
6/5/2025	10/17/2025	SL-2	SL-6	152	251	0.74
6/4/2025	10/14/2025	SL-5	SL-1	153	235	0.62
6/5/2025	10/17/2025	SL-2	SL-5	172	250	0.58
6/5/2025	10/17/2025	SL-2	SL-5	190	270	0.60
6/3/2025	10/15/2025	SL-2	SL-6	215	268	0.40
6/4/2025	10/17/2025	SL-5	SL-5	223	338	0.85
6/4/2025	10/17/2025	SL-5	SL-5	235	325	0.67
Average						0.65
7/15/2025	10/17/2025	SL-2	SL-5	168	208	0.43
7/15/2025	10/17/2025	SL-2	SL-5	181	225	0.47
7/15/2025	10/16/2025	SL-2	SL-1	190	265	0.81
7/15/2025	10/17/2025	SL-2	SL-5	276	295	0.20
Average						0.48

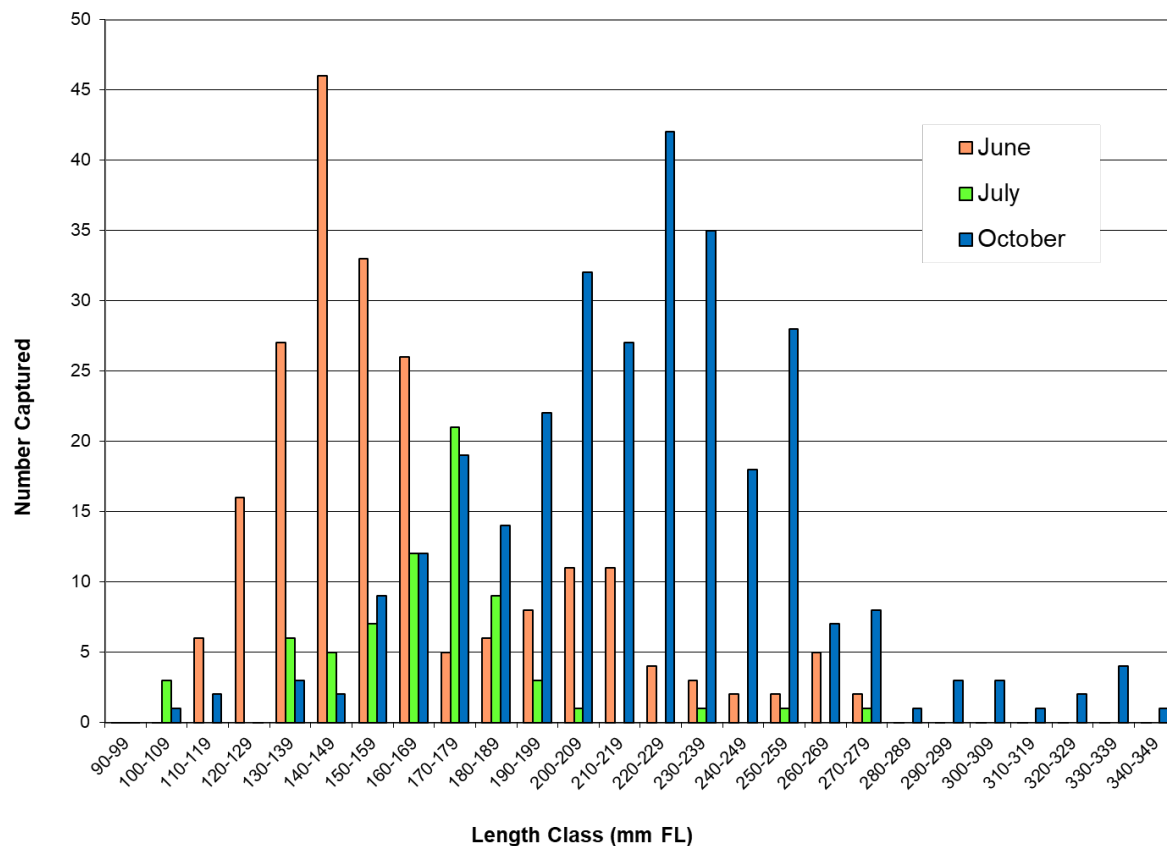


Figure 25. *O. mykiss* length classes in the San Lorenzo River Lagoon, June, July, and October 2025

Life stage composition also shifted toward larger individuals: 4% were classified as parr or advanced parr, 41.5% as silvery parr or advanced silvery parr, and 54.4% as resident adults.

All *O. mykiss* examined retained an adipose fin, indicating natural origin.

Black spot disease (BSD) was observed in 13% of individuals, primarily with light infections, consistent with July observations.

Three *O. mykiss* mortalities were recorded during the October survey, all occurring on October 17 following the breach. No other mortalities were observed during the 2025 sampling season.

October 2025 *O. mykiss* Population Estimate

During the mark period (October 14-15), 66 *O. mykiss* were captured. Of these, three were recaptures from June and one was a recapture from earlier in the mark period. A total of 57 individuals were tagged and released. Four large adults exceeding the tagging limit (> 320 mm) were measured but not tagged and one additional fish (estimated at 150 mm) escaped prior to processing. There were no mortalities during tagging in the mark period.

During the recapture period, 230 *O. mykiss* were captured. Of these, 18 had been tagged during the mark period. Additional recaptures included three individuals tagged earlier in the recapture period and eight individuals tagged in June.

Assuming a closed population, the Peterson estimate (Ricker 1975) yielded a population size of 288 *O. mykiss* with 95% confidence limits of 218 to 379 individuals. This population estimate falls within the lower range of fall population estimates recorded over the past twelve years (Table 2).

However, the reliability of this estimate is limited. The recapture phase was incomplete due to the mid-survey breach and the assumption of a closed population was violated. These factors substantially reduce the confidence in the October population estimate.

Overall, the October survey results were strongly influenced by rapid hydrologic changes, limiting comparability with previous surveys and reducing confidence in the population estimates.



Figure 26. *O. mykiss* (356 mm), no tag adult in San Lorenzo Lagoon, October 14, 2025

Laguna Creek Lagoon

Summary

The winter of 2024-2025 had minor storms through January 2025, but flows generally remained below 3 cfs. Significant storms in February produced high streamflows, i.e., peak of 182 cfs on February 4 and another peak of 397 cfs on February 13. After the February 13 event, baseflows gradually receded and inflow to the lagoon dropped below 8 cfs by February 27, below 4 cfs by mid-April, and remained below 3 cfs by early May (Figure 27) (City of Santa Cruz stream monitoring data, Laguna Creek anadromous gage). Based on stage elevation records, the lagoon appeared to close around the middle of April and subsequent fluctuations generally followed the flow inputs. The lagoon was closed at the time of June sampling and had an extension running parallel to the beach to the northwest, which would eventually intersect the ocean just below the access road. The lagoon remained closed between the June and September surveys. In September, the closed lagoon levels varied little, fluctuating only between 4.0 feet and 4.1 feet during the two days of sampling.

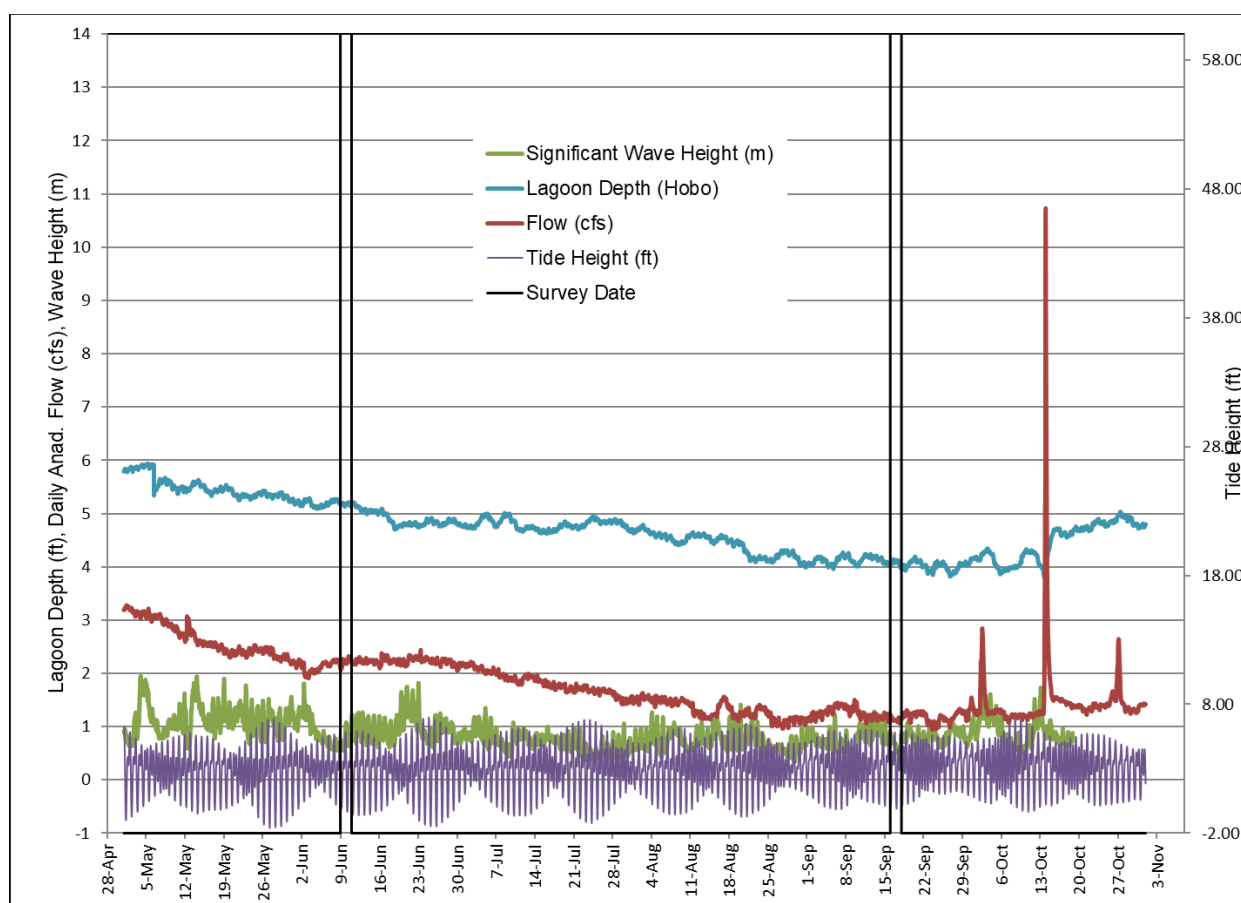


Figure 27. Laguna Creek Lagoon stage, streamflow, wave height, and tides 2025 (Source: lagoon stage from City of Santa Cruz, streamflow from City of Santa Cruz, wave and tide data from NOAA)

O. mykiss abundance (CPUE) was in the lowest third of all of the annual spring survey dates and within the median for the fall surveys (Table 12). Population estimates for the spring surveys were within the mid-range for spring. The fall population estimate was higher than spring and within the upper third for the survey years (Table 13). The lagoon remained closed between the June and September sampling. Catch rates were higher in the fall as compared to spring with greater concentrations of *O. mykiss* mid-lagoon in the deeper waters (Table 14). In the fall the lagoon was approximately one foot lower than in the spring and there may have been a higher capture rate due to a slightly shallower, less extensive lagoon. Three *O. mykiss* captured in June were originally tagged in September 2024. Additionally, two recaps were originally tagged in 2023—one in June 2023 and one in September 2023. In September, four *O. mykiss* originally tagged in 2024 (three from June 2024 and one from September 2024) were captured. As in June, two recaps originally tagged in June 2023 were also captured. No *O. kisutch* were captured in 2025.

Table 12. *O. mykiss* and coho salmon (*O. kisutch*) catch per unit effort for the Laguna Creek 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 2018, HES 2019, HES 2020, HES 2021, HES 2022, HES 2023, HES 2024, Confluence 2025)

	<i>O. mykiss</i> Catch per Unit Effort - Laguna Creek Lagoon				Coho (<i>O. kisutch</i>) Catch per Unit Effort - Laguna Creek Lagoon			
Year	June	July	September	October	June	July	September	October
2004	NS	NS	NS	NS	NS	NS	0	NS
2008	11.0	NS	6.0	NS	0	NS	0	NS
2009	7.0	NS	19.0	NS	0	NS	0	NS
2010	13.0	NS	NS	1.7	0	NS	NS	0
2011	19.8	NS	NS	0.1	0	NS	NS	0
2012	11.3	NS	10.3	NS	0	NS	0	NS
2013	28.0	NS	8.6	NS	0	NS	0	NS
2014	20.0	NS	33.0	NS	0	NS	0	NS
2015	0.1	NS	NS	11.4	0	NS	NS	0
2016	1.1	NS	5.2	NS	0	NS	0	NS
2017	42.8	NS	14.5	NS	0	NS	0	NS
2018	14.3	NS	6.5	NS	0	NS	0	NS
2019	17.0	NS	2.5	NS	0	NS	0	NS
2020	56.8	NS	11.4	NS	1.4	NS	0	NS
2021	8.4	NS	5.4	NS	1.7	NS	1.1	NS
2022	4.4	NS	14.9	NS	0	NS	0	NS
2023	36.4	NS	19.1	NS	0.2	NS	0	NS
2024	50.9	NS	16.7	NS	0	NS	0	NS
2025	9.3	NS	12.8	NS	0	NS	0	NS

NS – Not Sampled

Table 13. *O. mykiss* mark-recapture population estimates in Laguna Creek Lagoon for fish >80 mm FL and <320 mm FL (Source: Annual survey reports 2012-2025)

	<i>O. mykiss</i> mark-recapture population abundance estimates in Laguna Creek Lagoon for fish >80 mm FL and <320 mm FL	
Year	Spring	Fall
2011	300	Early breach, insufficient catch
2012	Open lagoon, insufficient catch	370
2013	499	259
2014	256	828
2015	0	267
2016	45	136
2017	641	548
2018	193	242
2019	Breaching lagoon, insufficient recaps	Open lagoon, insufficient catch
2020	Insufficient recaps, open population(?)	668
2021	Insufficient recaps, open population(?)	245
2022	168	373
2023	563	973
2024	710	665
2025	447	591

Table 14. *O. mykiss* catch per haul for the Laguna Creek Lagoon during 2025

	<i>O. mykiss</i> catch per haul for Laguna Creek Lagoon			
Station	Location	Jun 9-10	Sep 16-17	Overall
LA-1	Lower lagoon	8.3	7.3	8.3
LA-1.5	Mid-lagoon	5.3	17.5	10.2
LA-2	Lagoon channel	14.5	21.5	18.0
LA-3	near YSI station	NS	NS	NS
	Overall	9.3	12.8	11.0

NS = Not Sampled

Laguna Creek Lagoon Site Conditions and Water Quality 2025

June 2025 Survey (June 9-10)

The lagoon remained closed for the duration of the June survey and the stage held at 5.2 feet during that time. Inflow from Laguna Creek fluctuated between 2.06 cfs and 2.32 cfs during the June survey (Figure 28). The outlet channel maintained a northward extension along beach, consistent with patterns observed in 2023 and 2024 (Figure 29, Figure 30). Maximum depths reached 2.15 meters (7.1 feet) specifically along the rock bluff and the upstream marsh edge.

Algal growth was minimal in the lower lagoon and low to moderate in the upstream stations. Invertebrates, e.g., amphipods and mysids, were visible throughout the survey period.

- The lagoon was essentially fresh with salinities less than 0.5 ppt to the bottom (Figure 31).
- Lagoon water temperatures ranged from 16.9°C to 15.2°C (surface to depth) in the mornings and 18.8°C to 15.2°C (surface to depth) in the afternoons (Figure 31). These temperatures were suitable for tagging through the mark and recapture periods.
- Dissolved oxygen concentrations varied with time of day, similar to temperature trends (Figure 31). Dissolved oxygen ranged from 8.9 mg/L to 6.6 mg/L (surface to depth) in the mornings and 7.3 mg/L to 8.8 mg/L (surface to depth) in the afternoons. The slightly higher concentrations in deeper waters in the afternoon are likely due to higher photosynthetic rates of the phytoplankton at depth and vertical mixing.
- Water clarity (Secchi depth) was at or nearly to the bottom substrate at all sampling stations. Secchi depth was to the bottom at LA-1 (2.15 meters (7.1 feet)) and within 0.2 meters (0.6 feet) of the substrate at all the other stations.

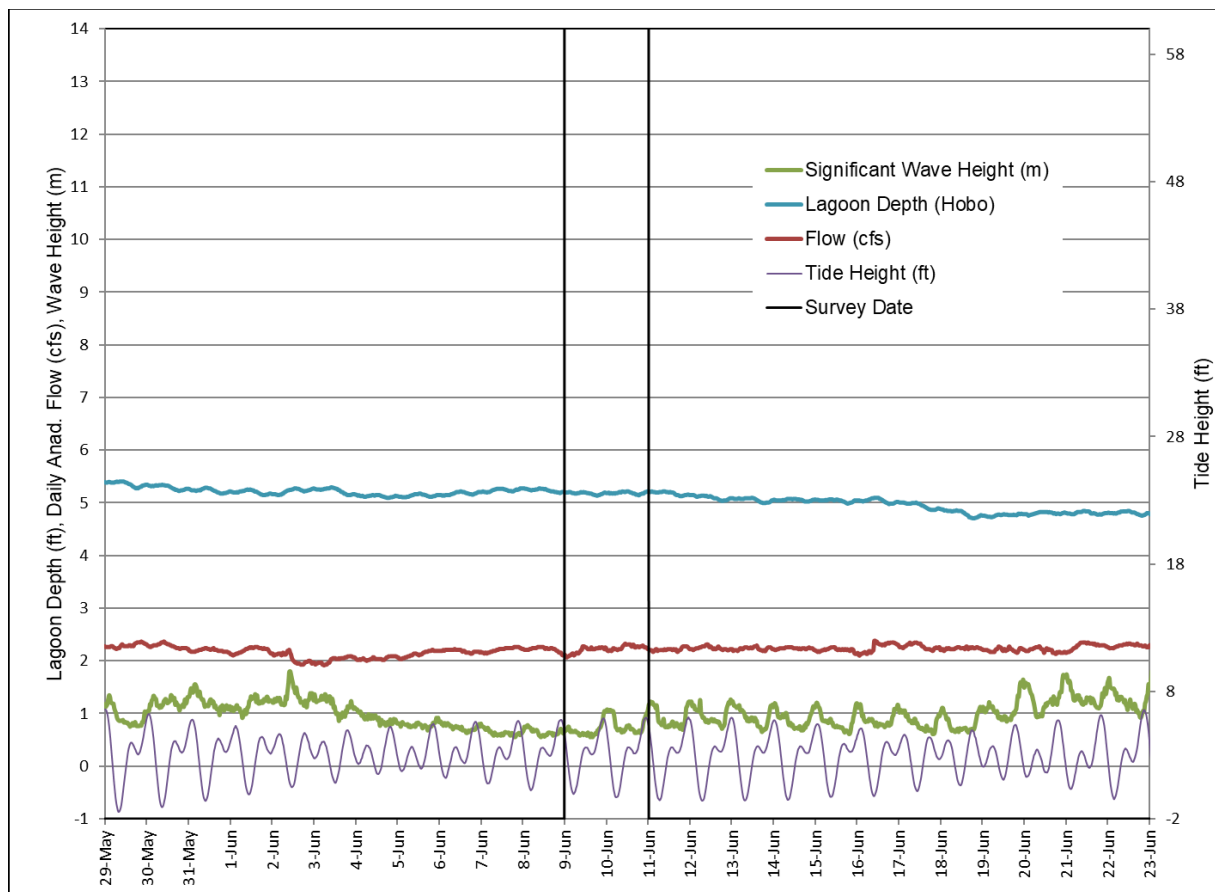


Figure 28. Laguna Creek Lagoon stage, streamflow, wave height, and tides around June 2025 sample period (Source: lagoon stage from City of Santa Cruz Public Works, streamflow from USGS, wave and tide data from NOAA)



Figure 29. Laguna Creek Lagoon, June 9, 2025



Figure 30. Laguna Creek Lagoon near old mouth opening, June 10, 2025

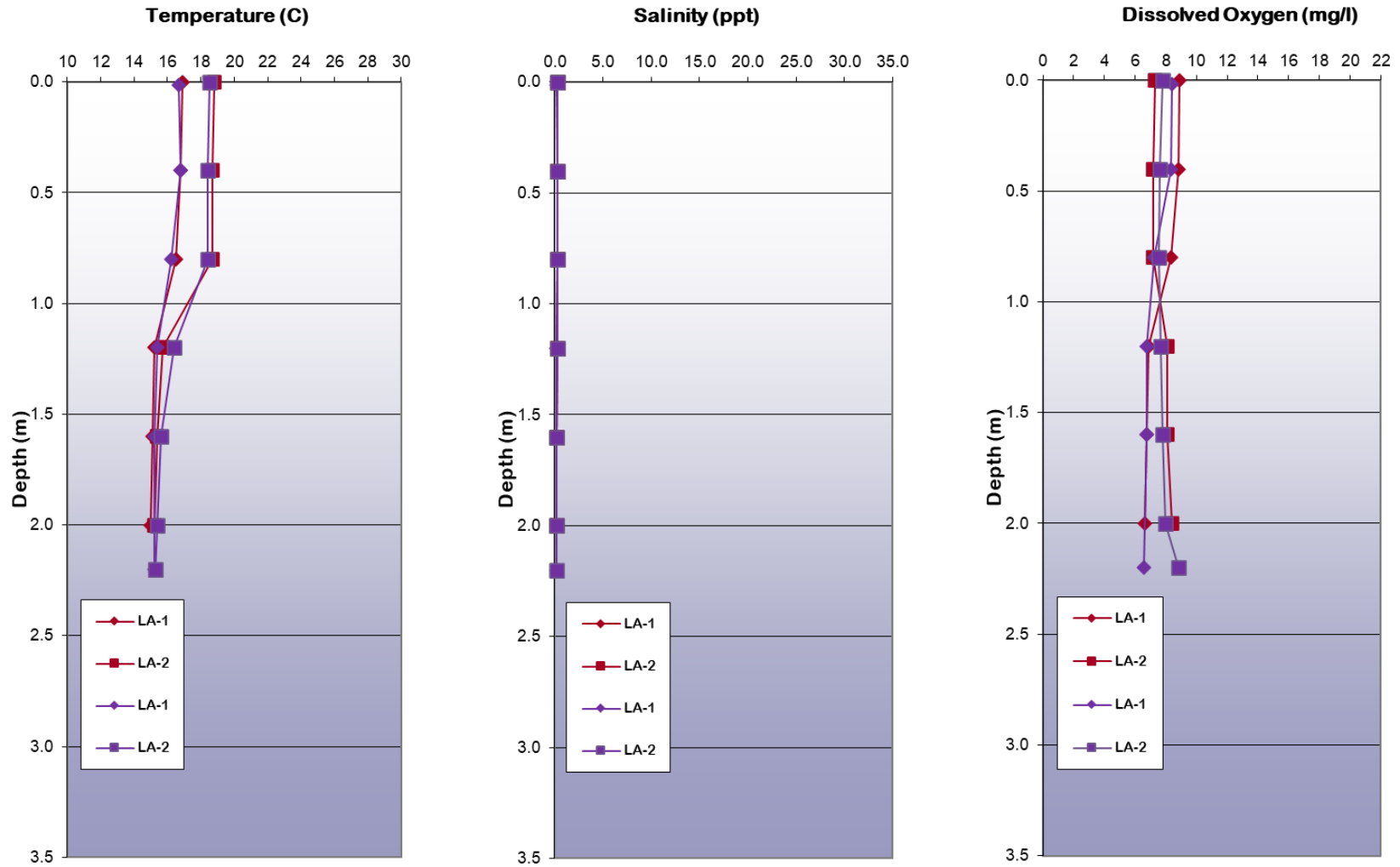


Figure 31. Depth profiles of water quality parameters in Laguna Creek Lagoon during June 2025. Profiles plotted in red are June 9; profiles in blue are June 10

Laguna Creek Lagoon June 2025 Survey Results

- *O. mykiss* were captured and marked on June 9. On June 10, the lagoon was re-sampled and the proportion of re-captured fish was recorded.
- Eight seine hauls were completed on June 9 and seven were completed on June 10. The survey breadth encompassed the lagoon arm along the beach then upstream into the main lagoon.
- The catch contained only *O. mykiss*; no other species were captured in the seining effort (Table 15)
- *O. mykiss* abundance (CPUE) was 9.3 and within the lowest third of all of spring surveys to date (Table 12). This low CPUE follows 2024 where CPUE was 50.9 in June 2024, which was the second highest recorded for the 16 years of June sampling.

Table 15. Fish catch in Laguna Creek Lagoon during June 2025

	LA-1	LA-1.5	LA-2	Grand Total
# Hauls	8	3	4	15
<i>Species</i>	<i>Number caught</i>			
steelhead	66	16	58	140
<i>O. mykiss</i> CPUE	8.3	5.3	14.5	9.3

- The June catch exhibited a wide range of size classes (Figure 32). Twenty-five percent of the *O. mykiss* were characterized as parr/advanced parr; 54% were silvery parr/advanced silvery parr; 16% were shorter, fatter resident adults, and 4% were larger thinner adults. One steelhead was characterized as an ocean adult and one young-of year (YOY) was also captured.
- Three of the four *O. mykiss* that measured greater than 450 mm FL (Figures 33, 34, and 35) were captured in the same haul during the June mark period. These *O. mykiss* did not appear during the recapture period. The second largest *O. mykiss* (Figure 36) was captured and measured during the recapture period.
- Size class distribution was comparable between the mark and recapture periods (Figure 32)

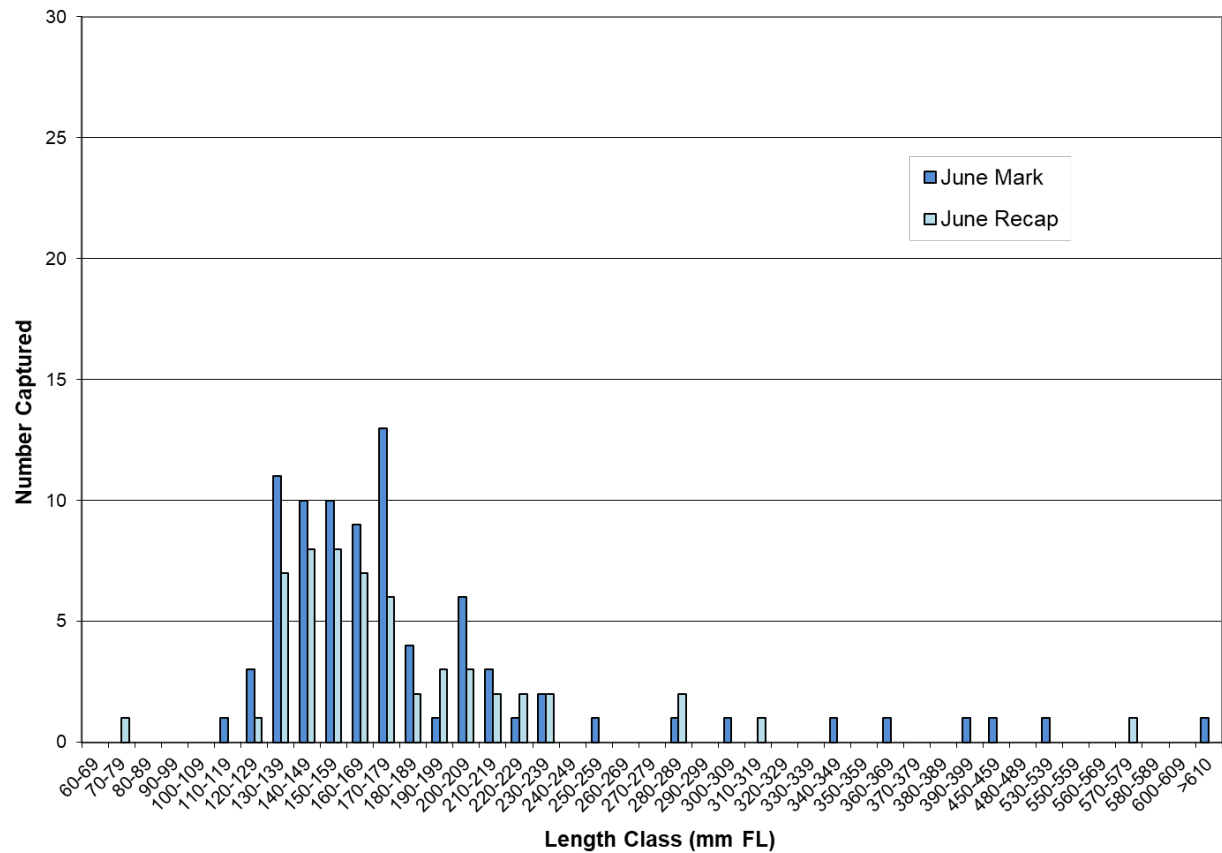


Figure 32. *O. mykiss* length classes in Laguna Creek Lagoon, June 2025



Figure 33. *O. mykiss* Tag 989001040545733, 530mm, captured during mark period Laguna Creek Lagoon June 9, 2025



Figure 34. *O. mykiss*, untagged adult, 620mm, captured during mark period Laguna Creek Lagoon June 9, 2025



Figure 35. *O. mykiss*, untagged adult, 450mm, captured during mark period Laguna Creek Lagoon June 9, 2025



Figure 36. *O. mykiss* Tag 989001045161544, 575mm, captured during recapture period Laguna Creek Lagoon June 10, 2025

- All *O. mykiss* captured and evaluated had an adipose fin present, indicating that they were not of hatchery origin.
- Black spot disease (BSD) was not found on any of the *O. mykiss* examined in June.
- Three *O. mykiss* captured in June 2025 had been tagged in September 2024 (Table 16). The average growth rate was 0.53 mm/day during that period.
- Two *O. mykiss* captured in June 2025 were tagged in 2023 (Table 17). The growth rate averaged 0.47 mm/day over the two years. It is interesting to note that one of these 2023 *O. mykiss* was recaptured three times. It was originally tagged in June 2023 and recaptured in September 2023, June 2024, and June 2025 (Table 17). The largest *O. mykiss* (>450 mm) were all captured in the same haul, which was completed not in the main lagoon but where the lagoon becomes more of a channel between the beach and marsh.
- CPUE was lower during the recapture period (8.0) than the tagging period (10.4).

Table 16. *O. mykiss* tagged in Fall 2024 and captured in June 2025 in Laguna Creek Lagoon

Initial Capture Date	Recapture Date	Initial Capture Loc	Recapture Location	Length when marked	Length in June	Growth Rate
9/23/24	6/9/25	LA-1.5	LA-1	133	305	0.66
9/23/24	6/9/25	LA-1.5	LA-1	171	284	0.44
9/23/24	6/9/25	LA-1.5	LA-1	267	392	0.48
Average						0.53

Table 17. *O. mykiss* tagged in 2023 and recaptured in June 2025 in Laguna Creek Lagoon; growth between recap periods

Initial Capture Date	First Recapture Date	Second Recapture Date	Third Recapture Date	Initial Capture Location	Recapture Location	Length when marked	Length Sept 2023	Length June 2024	Length June 2025	Growth Rate mm/day	Days
6/13/23	9/23/23	-	-	LA-2	LA-2	133	198	-	-	0.64	102
-	-	6/10/24	-		LA-1.5	-	-	296	-	0.38	261
-	-	-	06/09/25		LA-2	-	-	-	360	0.18	364
9/26/23	6/10/25	-	-	LA-2	LA-1	202	-	-	575	0.60	623
Average										0.47	

- A total of 140 *O. mykiss* were captured during the June survey period. On June 9 (mark period) 83 *O. mykiss* were captured. Two *O. mykiss* exceeded the maximum length for tagging (320 mm FL) and therefore were only checked for tags, length, and then released. There were four recaps of individuals tagged during the marking period and one *O. mykiss* escaped the net before tagging. Seventy-six new tags were released.
- On June 10 (recapture period), 57 *O. mykiss* were captured. Nine were recaptures of *O. mykiss* tagged in June 2025. There was one recapture of recapture and one recapture of a tag from September 2023. Seven YOY were observed. Forty-eight new tags were released.
- Two of the recaptured *O. mykiss* were tagged in 2023 (Table 17). Recaptures from two years previous have not been recorded before in Laguna Creek Lagoon.
- Based on the Peterson population estimate (Ricker 1975), which assumes a closed system, the population estimate is 447 *O. mykiss* in the lagoon in June. The 95% confidence limits for this estimate are 246 and 781. This is within the mid-range of abundance estimates recorded in Laguna Creek Lagoon over time (Figure 37).

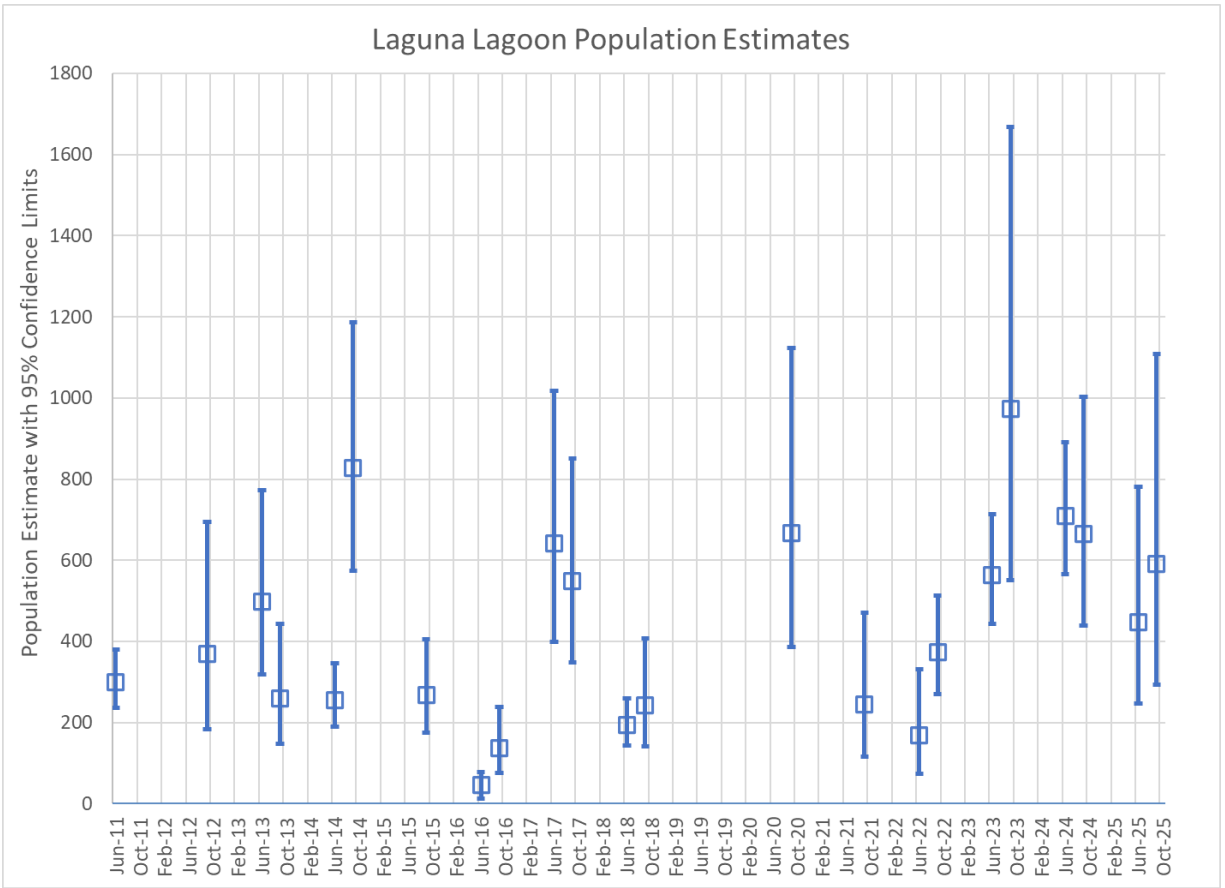


Figure 37. *O. mykiss* population estimates in Laguna Creek Lagoon over time

September 2025 Survey (September 16-17)

September Site Conditions

The lagoon remained closed from the June survey through the September survey and little had changed since the June (Figure 38, Figure 39, Figure 40). The lagoon stage was 4.1 feet during sampling, which was about one foot lower than June. Inflow from Laguna Creek fluctuated slightly between 1.1 cfs and 1.2 cfs during the September survey (Figure 38). The narrow finger of lagoon extending to the northwest was still present and hauls of approximately 450 feet in length were pulled through this area as in June. The maximum depth measured was 1.8 meters (5.9 feet). The deepest water measured was along the bluff rock wall in the lower portion of the lagoon.

- Surface water temperatures ranged between 18.3°C to 19.8°C with the warmer temperatures in the afternoon. The water column was nearly unstratified but slightly cooler by 1°C to 2°C at depth (Figure 41).
- Similar to June, the lagoon salinity measurements were uniform to depth and salinities were less than 0.3 ppt from surface to the bottom (Figure 41).
- Dissolved oxygen concentrations exhibited a diurnal pattern with minimum values recorded during the morning hours and increased in the afternoons. Morning DO profiles ranged from 6.7 mg/L at the surface to 4.9 mg/L at depth. Afternoon concentrations rose to between 8.4 mg/L and 10.4 mg/L (Figure 41). The water column was clear with Secchi visibility extending to the bottom at depths up to 1.8 meters (5.9 feet).

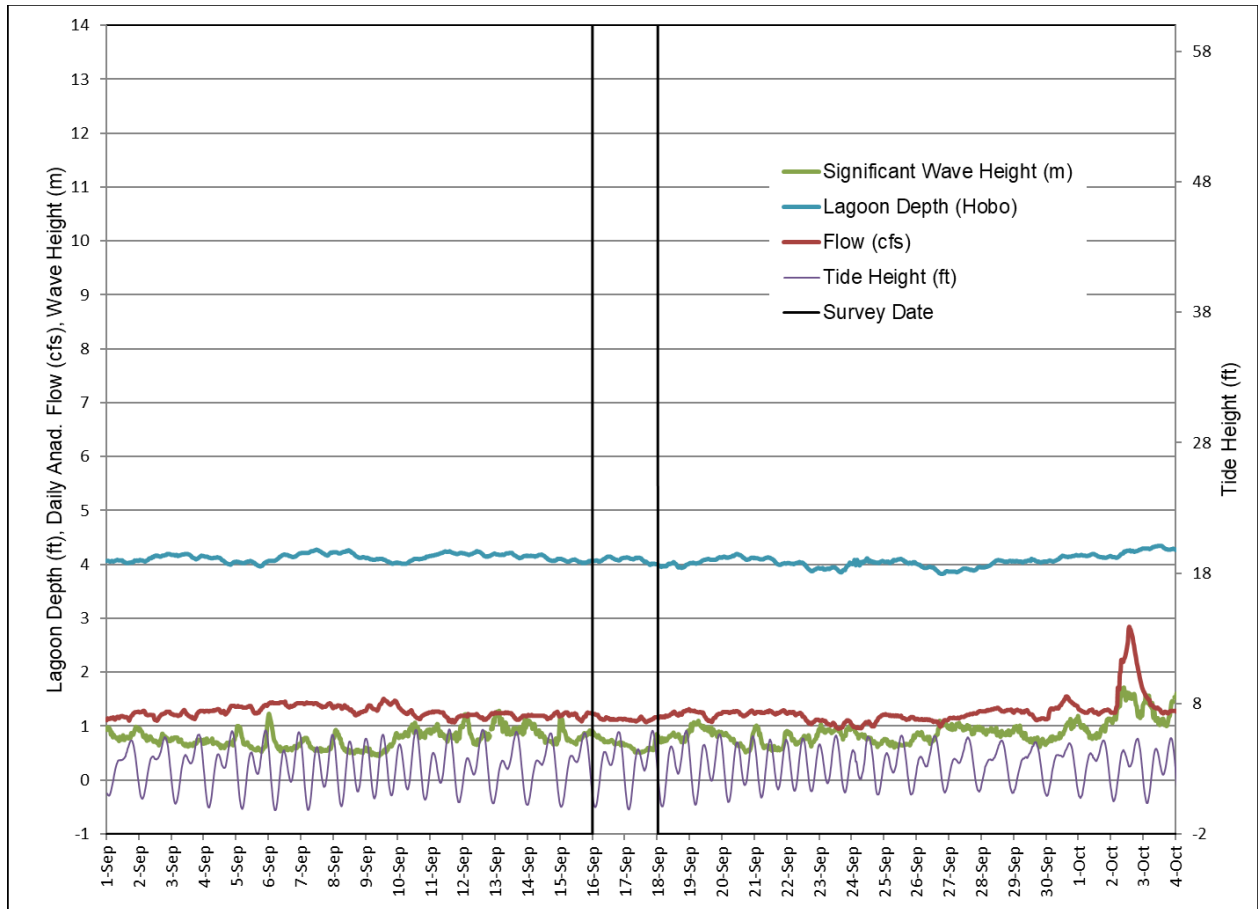


Figure 38. Laguna Creek Lagoon stage, streamflow, wave height, and tides around September 2025 sample period (Source: lagoon stage from Water Resources Management, streamflow from USGS, wave and tide data from NOAA)



Figure 39. Laguna Creek Lagoon, September 16, 2025



Figure 40. Laguna Creek Lagoon, September 16, 2025

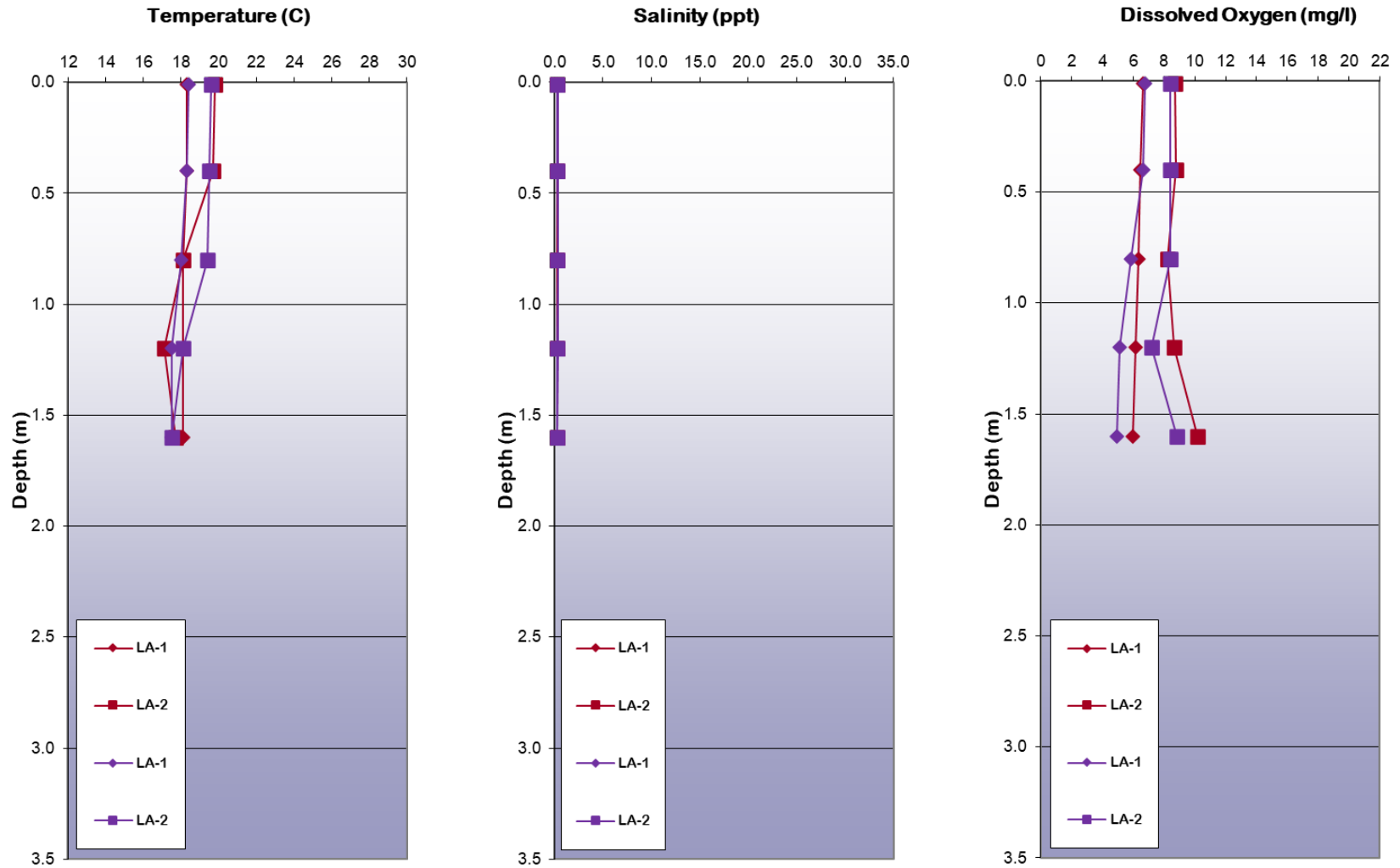


Figure 41. Depth profiles of water quality parameters in Laguna Creek Lagoon during September. Profiles plotted in red are September 16; profiles in purple are September 17

Laguna Creek Lagoon September 2025 Survey Results

- *O. mykiss* were captured and marked on September 16. On September 17 the lagoon was re-sampled and the proportion of re-captured fish was recorded.
- Fourteen seine hauls were completed at the regularly sampled stations (LA-1, LA-1.5, and LA-2) from September 16 to September 17.
- In addition to *O. mykiss*, threespine stickleback, tidewater goby, and staghorn sculpin were present during the September sampling (Table 18). No coho were encountered.

Table 18. Fish catch in Laguna Creek Lagoon, September 2025

	LA-1	LA-1.5	LA-2	Grand Total
# Hauls	8	2	4	14
Species	Number caught			
Steelhead	58	35	86	179
Threespine stickleback	9	2	17	28
Staghorn sculpin	7	-	4	11
Tidewater goby	16	-	10	26
<i>O. mykiss</i> CPUE	7.3	17.5	21.5	12.8

- Overall abundance of *O. mykiss* based on the number caught per seine haul (CPUE) at 12.8 per haul was in the upper half of the range of surveys to date (Table 12). Eight years had lower abundance and five had higher abundance. CPUE in September 2025 was over 30% higher than in June 2025 (Table 19).

Table 19. Laguna Creek Lagoon *O. mykiss* tagged in June 2025 and recaptured in September 2025, annual averages

	Number Recaptured	Average Growth Rate (mm/day)	Range of Growth Rates (mm/day)	Fall CPUE	June CPUE
2012	1	0.86	NA	10.3	11.3
2013	10	0.48	0.22-0.78	8.6	28.0
2014	72	0.43	0.12-0.80	33.0	20.0
2015	1	0.99	NA	11.4	0.1
2016	0	NA	NA	5.2	1.1
2017	13	0.66	0.17-0.89	14.5	42.8
2018	23	0.99	0.87-1.34	6.5	14.3
2019	0	NA	NA	2.5	17.0
2020	4	0.46	0.27-0.62	11.4	56.8
2021	12	0.45	0.12-0.88	5.4	8.4
2022	6	0.69	0.57-0.88	14.9	4.4
2023	65	0.58	0.30-1.04	19.1	36.4
2024	57	0.83	0.45-1.24	16.4	50.9
2025	35	0.57	0.23-0.93	12.8	9.3

NA: not applicable

- Captured *O. mykiss* ranged from 114 mm FL to 600 mm FL, with most individuals measuring between 210 mm FL and 219 mm FL (Figure 42). The four *O. mykiss* greater than 550 mm FL (Figure 43 to Figure 46) were all captured in the same haul during the September mark period but were not encountered again during the September recapture effort.

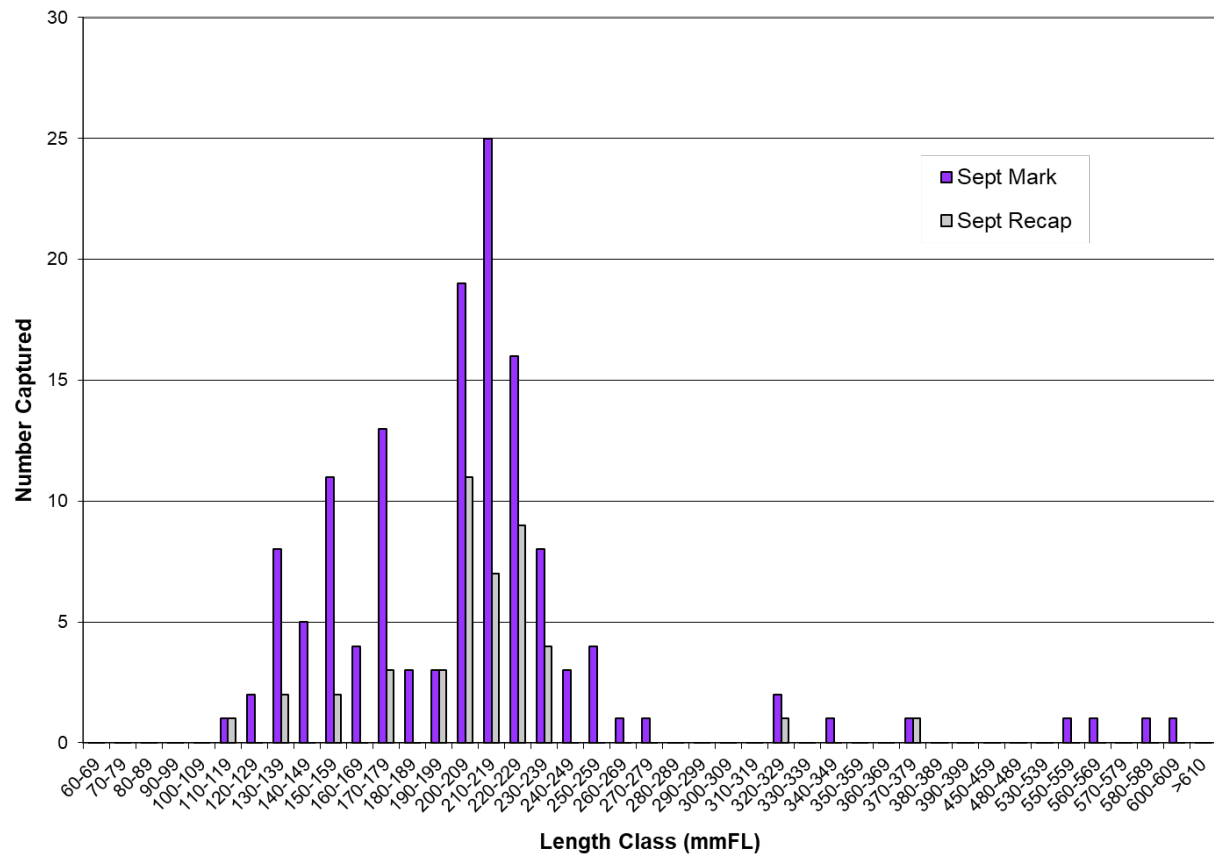


Figure 42. *O. mykiss* length classes in Laguna Creek Lagoon, late summer 2025



Figure 43. *O. mykiss* untagged adult, 550 mm, captured during mark period Laguna Creek Lagoon September 16, 2025



Figure 44. *O. mykiss* untagged adult, 560 mm, captured during mark period Laguna Creek Lagoon September 16, 2025



Figure 45. *O. mykiss* Tag 989001040545733, 580 mm, captured during mark period Laguna Creek Lagoon September 16, 2025



Figure 46. *O. mykiss* Tag 989001040545423, 600 mm, captured during mark period Laguna Creek Lagoon September 16, 2025

- Growth rates of *O. mykiss* tagged in September averaged 0.57 mm per day, which is within the mid-range of growth observed since 2012 (Table 20). Based on observed growth rates, *O. mykiss* captured in June averaged an increase of 50 mm but grew as much as 96 mm between the June and September sampling dates (Figure 47)
- Eight percent of *O. mykiss* examined were classified as parr or advanced parr, 87% were classified as silvery parr or advanced silvery parr, and 5% were classified as adults.
- No coho salmon were captured in September
- All *O. mykiss* captured and evaluated had an adipose fin present, indicating that they were not of hatchery origin.
- Black spot disease (BSD) was not found on any of the *O. mykiss* examined in September.
- There were no mortalities during the September sampling.

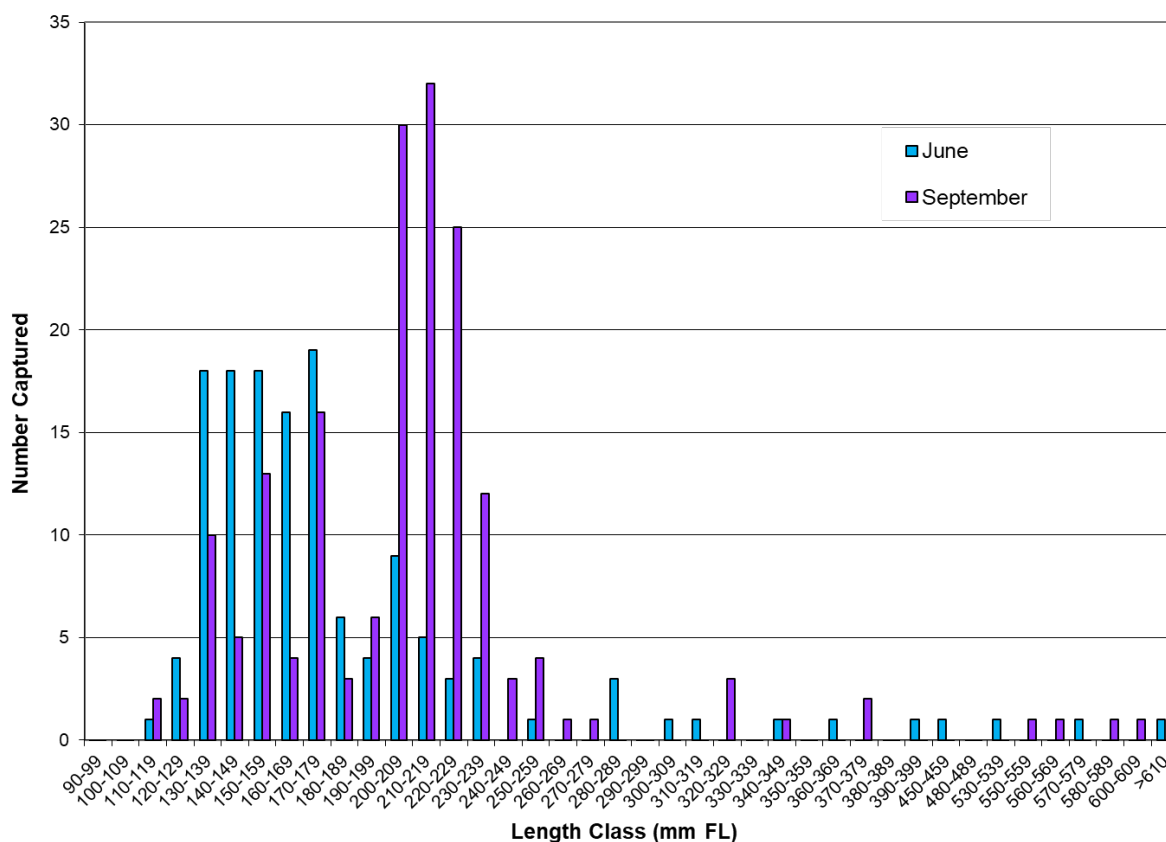


Figure 47. *O. mykiss* length classes in Laguna Creek Lagoon, late summer 2025 compared to spring 2025

Table 20. *O. mykiss* tagged in June 2025 and recaptured in September 2025

Initial Capture Date	Recapture Date	Initial Capture Location	Recapture Location	Length when marked(mm)	Length in Sept (mm)	Growth Rate (mm/day)
06/09/25	9/16/25	LA-1	LA-1	123	219	0.97
06/09/25	9/17/25	LA-1.5	LA-2	130	192	0.62
06/09/25	9/17/25	LA-2	LA-2	139	204	0.65
06/10/25	9/16/25	LA-2	LA-1.5	142	200	0.59
06/09/25	9/17/25	LA-1	LA-2	145	228	0.83
06/09/25	9/16/25	LA-1	LA-2	145	217	0.73
06/09/25	9/16/25	LA-1	LA-1.5	146	218	0.73
06/10/25	9/16/25	LA-2	LA-1	147	197	0.51
06/09/25	9/16/25	LA-1	LA-1	149	217	0.69
06/10/25	9/16/25	LA-1.5	LA-2	153	214	0.62
06/09/25	9/16/25	LA-1	LA-1	153	216	0.64
06/10/25	9/17/25	LA-1.5	LA-2	154	212	0.59
06/09/25	9/16/25	LA-1.5	LA-2	154	211	0.58
06/09/25	9/17/25	LA-1.5	LA-2	155	205	0.50
06/10/25	9/16/25	LA-2	LA-1.5	156	218	0.63
06/10/25	9/16/25	LA-2	LA-1	161	220	0.60
06/09/25	9/16/25	LA-2	LA-2	165	217	0.53
06/09/25	09/16/25	LA-2	LA-1	166	224	0.59
06/09/25	09/17/25	LA-1	LA-2	168	230	0.62
06/09/25	09/16/25	LA-1	LA-1	168	232	0.65
06/10/25	09/17/25	LA-1.5	LA-2	169	219	0.51
06/09/25	09/16/25	LA-2	LA-1	169	211	0.42
06/09/25	09/16/25	LA-1	LA-2	170	233	0.64
06/10/25	09/17/25	LA-2	LA-2	173	215	0.42
06/09/25	09/16/25	LA-1	LA-2	174	239	0.66
06/09/25	09/16/25	LA-1	LA-1	174	224	0.51
06/10/25	09/16/25	LA-2	LA-1.5	175	235	0.61
06/09/25	09/16/25	LA-2	LA-1	175	221	0.46
06/09/25	09/16/25	LA-1	LA-2	177	213	0.36
06/09/25	09/17/25	LA-1	LA-2	183	226	0.43
06/09/25	09/16/25	LA-1	LA-1.5	202	253	0.52
06/09/25	09/16/25	LA-1	LA-2	208	246	0.38
06/09/25	09/16/25	LA-1	LA-1	210	243	0.33
06/09/25	09/16/25	LA-1	LA-2	252	275	0.23
06/09/25	09/16/25	LA-1.5	LA-1.5	530*	580	0.51
Average						0.57

*989001040545733 recaptured 06/09/2025; used June 2025 length in this table

September 2025 *O. mykiss* Population Estimate

- A total of 179 *O. mykiss* were captured during the September survey period—135 were captured during the mark period and 44 during the recapture period. A total of 116 newly tagged *O. mykiss* were introduced into the lagoon during September.
- On September 16 (mark period) 135 *O. mykiss* were captured. Eleven were recaptures from the marking period. Twenty-six were recaptures from June 2025. Three were recaptures from 2024 and two from 2023 (Table 21, Table 22). Three adults exceeded the maximum length for tagging (320 mm FL) and were assessed and released. There was a total of 91 new tags in the lagoon during the mark period. Recaptures of *O. mykiss* tagged two years previously were also observed during the June 2025 sampling.
- On September 17 (recapture period), 44 *O. mykiss* were captured. Six had been tagged on September 16. Three were recaptures from the recapture period. Nine *O. mykiss* in the September 17 sampling were recaptures from the June 2025 sampling and one was a recapture from June 2024 (Table 21). There was a total of 25 individuals newly tagged during the recapture sampling.
- Assuming a closed system, the Peterson population estimate (Ricker 1975) is 591 *O. mykiss* in the lagoon in September. The 95% confidence limits for this estimate are 293 and 1,109. This is within the upper third of population estimates recorded in Laguna Creek Lagoon over time (Figure 37).

Table 21. *O. mykiss* tagged in Spring and Fall 2024 and captured in Fall 2025 in Laguna Creek Lagoon

Initial Capture Date	Recapture Date	Initial Capture Location	Recapture Location	Length when marked (mm)	Length in Sept (mm)	Growth Rate (mm/day)
6/11/24	9/16/25	LA-1.5	LA-2	120	375	0.55
6/11/24	9/17/25	LA-2	LA-1	137	375	0.51
6/10/24	9/16/25	LA-1.5	LA-1	176	322	0.32
9/23/24	9/16/25	LA-1.5	LA-2	206	325	0.33
Average						0.43

Table 22. *O. mykiss* tagged in 2023 and recaptured in 2025 in Laguna Creek Lagoon; growth between recap periods

Initial Capture Date	First Recapture Date	Second Recapture Date	Initial Capture Loc	Recapture Location	Length when marked (mm)	Length June 2025 (mm)	Length Sept 2025 (mm)	Growth Rate (mm/day)
6/13/23	6/9/25	-	LA-1.5	LA-2	164	530	-	0.50
-	-	9/16/25		LA-1.5	-	-	580	0.51
6/13/23	9/16/25	-	LA-2	LA-1.5	171	600	-	0.52
Average								0.51

Appendix A

Table A-1. *O. mykiss* detected 2025-2026 (to date) in water courses outside of the standard Laguna Creek Lagoon monitoring stations

Species	Tag Number	Tag Date	Tag Site	Length at Tagging (mm)	Stage at Tagging	Date Detected	Location Detected	Length at Detection (mm)	Reporting Agency
<i>O. mykiss</i>	989002026966433	9/16/2025	LA-1	200	Partial smolt	3/8/2026	Scott Creek	257	NOAA

Notes:

- All tagging done as part of the City of Santa Cruz steelhead monitoring
- LA = Laguna Creek Lagoon

Table A-2. *O. mykiss* catch per haul for the San Lorenzo River Lagoon during sampling events (data from H.T. Harvey & 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, HES 2022, HES 2023, and HES 2024)

Station	Location	<i>O. mykiss</i> Catch per Haul					
2002						Oct 1	Nov 20
SL-2	RR Trestle						0.0
SL-3	Near YSI Station					5.5	
SL-4	Below Riverside						
SL-5	Riverside Drive						9.0
SL-7	Laurel St.						1.0
SL-8	Soquel Ave.					20.0	0.3
2004			July 6		Sep 21	Sep 29	
SL-1	Near Mouth				0.0	0.0	
SL-2	RR Trestle		24.5			0.5	
SL-3	Near YSI Station		20.0				
SL-4	Below Riverside		0.0				
SL-5	Riverside Drive		62.0		0.0	0.0	
SL-6	U/S Bank Restoration		3.0			0.0	
SL-7	Laurel St.		3.0				
SL-8	Soquel Ave.				0.0	0.0	
2005		Jun 14	Jul 14	Aug 16		Oct 5	
SL-1	Near Mouth	0.0	0.0	1.7		0.0	
SL-2	RR Trestle	28.0	5.3	179.5		0.0	
SL-5	Riverside Drive	0.0	12.3	10.7		62.7	

SL-8	Soquel Ave.	7.7	1.0	0.0		0.0	
2008		Jun 8, 19				Oct 7-8	
SL-1	Near Mouth	0				0	
SL-2	RR Trestle	9				0.25	
SL-3	Near YSI Station	0				0	
SL-5	Riverside Drive	0				0	
SL-6	U/S Bank Restoration	0				0	
SL-8	Soquel Ave.	0				0	
	Overall	2.6				0.1	
2009		Jun 10- 11			Sep 16	Oct 21	
SL-2	RR Trestle	0.75			1.0	0.25	
SL-3	Near YSI Station	0.25					
SL-5	Riverside Drive	0				0	
SL-6	U/S Bank Restoration	0				1.5	
	Overall	0.3			1.0	0.5	
2010		Jun 22- 23	Jul 17			Oct 6-7	
SL-1	Near Mouth	0.0				0	
SL-2	RR Trestle	11.7	0.5			31.3	
SL-3	Near YSI Station		42.5			0	
SL-5	Riverside Drive	0.0				9.0	
SL-6	U/S Bank Restoration	6.0				80.0	

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

Table A-2 (continued)

Station	Location	<i>O. mykiss</i> Catch per Haul					
2012		Jun 7-12			Sep 13-18		
SL-2	RR Trestle	5.2			21.3		
SL-3	Near YSI Station	0.8			17.5		
SL-4	Near Marsh Outlet	0					
SL-5	Riverside Drive	0			3.5		
SL-6	U/S Bank Restoration	0.1			5.0		
	Overall	1.7			14.4		
2013		Jun 6-11	July 17		Sep 12-17		
SL-1	South of Trestle	0.6			13		
SL-2	RR Trestle	0.8	2.2		1.6		

SL-3	Near YSI Station	6	24		1		
SL-4	Near Marsh Outlet	3			2		
SL-5	Riverside Drive	3			5.8		
SL-6	U/S Bank Restoration	0.3			6		
	Overall	2	8.4		4.7		
2014		Jun 5-10	July 17		Sep 11-15		
SL-1	South of Trestle	3.2	0		0		
SL-2	RR Trestle	0.9	3.5		0		
SL-3	Near YSI Station	1.0	0.5		0		
SL-5	Riverside Drive	0.5	0		0		
SL-6	U/S Bank Restoration	0.8	1		0		
SL-8	Water Street				1.1		
	Overall¹	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					

¹ Standard sites only (SL1-SL6) used in Overall calculation

	Overall⁴	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		

Table A-2 (continued)

Station	Location	<i>O. mykiss</i> 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		
2023		Jun 6-9	Jul 18-19	Aug 15-16	Sep 19-22		
SL-1	South of Trestle	0.2	24.3	1.3	1.8		
SL-2	RR Trestle	7.4	44.7	146.0	46.4		
SL-3	Near YSI Station	NS	NS	NS	NS		
SL-5	Riverside Drive	13.5	23.3	30.5	18.3		

SL-6	U/S Bank Restoration	1.8		1.0	17.1		
	Overall	5.8	30.8	46.0	24.1		
2024		June 4-7		Aug 13-14	Sep 17-20		
SL-1	South of Trestle	16.6		8.0	3.5		
SL-2	RR Trestle	91.8		471.0	19.9		
SL-3	Near YSI Station	NS		NS	NS		
SL-5	Riverside Drive	40.8		59.7	25.8		
SL-6	U/S Bank Restoration	14.1		11.0	14.6		
	Overall	33.1		106.8	15.3		
2025		June 3-6	July 15-16			Oct 14-17	
SL-1	South of Trestle	2.5	3.0			2.5	
SL-2	RR Trestle	13.5	14.0			5.8	
SL-3	Near YSI Station	0.0	NS			NS	
SL-5	Riverside Drive	11.2	1.3			27.3	
SL-6	U/S Bank Restoration	1.1	3.5			9.5	
	Overall	5.9	4.7			9.9	

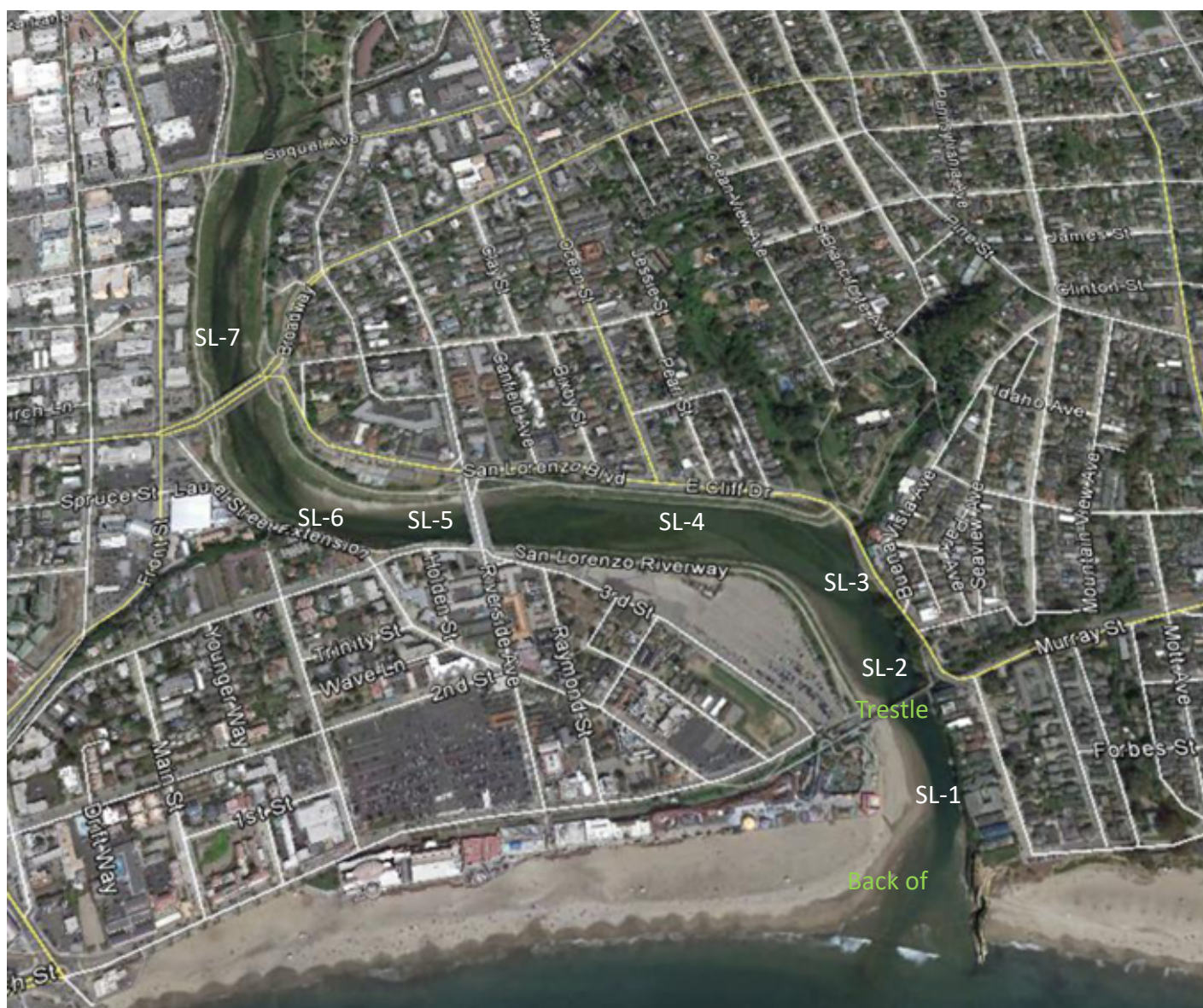


Figure A-1. San Lorenzo River Lagoon sampling stations



Figure A-2. Laguna Creek Lagoon sampling stations



Figure A-3. San Lorenzo River Lagoon – lower lagoon June 3, 2025



Figure A-4. San Lorenzo River Lagoon – lower lagoon sampling at SL-2 June 3, 2025



Figure A-5. San Lorenzo River Lagoon – bay pipefish June 5, 2025



Figure A-6. San Lorenzo River Lagoon striped bass, July 16, 2025



Figure A-7. San Lorenzo River Lagoon – barred surfperch October 14, 2025



Figure A-8. San Lorenzo River Lagoon – *O. mykiss*, no tag, 355mm, caught post-breach upstream of Riverside Bridge October 17, 2025



Figure A-9. Laguna Creek Lagoon Station LA-2 June 9, 2025



Figure A-10. Laguna Creek Lagoon Station LA-1 seining arm in lower lagoon, June 10, 2025

Acknowledgements

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Literature Citations

2NDNATURE. 2006. Comparative Lagoon Ecological Assessment Project (CLEAP) Santa Cruz County, California. Client: Santa Cruz County Resource Conservation District. Funder: California Coastal Conservancy. October 2006. Draft Final Report.

Confluence Restoration Inc. 2025. Santa Cruz Lagoon Study 2024.

H.T. Harvey & Associates. 2003. San Lorenzo Lagoon Steelhead Monitoring Feasibility Study. Prepared by H.T. Harvey & Associates and Scott Cressey. Prepared for: City of Santa Cruz. February 18, 2003.

HES. 2005. DRAFT CLEAP Fish Sampling in San Lorenzo and Laguna Creek Lagoons 2004. Prepared for: California Coastal Conservancy and Santa Cruz County. February 9, 2005.

HES. 2009. City of Santa Cruz Habitat Conservation Plan, Lagoon Fish Population Sampling. Technical Memorandum, January 5, 2009.

HES. 2010. City of Santa Cruz Habitat Conservation Plan, Lagoon Fish Population Sampling. Technical Memorandum, January 15, 2010.

HES. 2011. City of Santa Cruz Habitat Conservation Plan, Lagoon Fish Population Sampling 2010. Technical Memorandum, September 30, 2011.

HES. 2012. City of Santa Cruz Habitat Conservation Plan, Lagoon Fish Population Sampling 2011. Technical Memorandum, December 11, 2012.

HES. 2013. City of Santa Cruz Habitat Conservation Plan, Lagoon Fish Population Sampling 2012. Technical Memorandum, November 15, 2013.

HES. 2014. City of Santa Cruz Habitat Conservation Plan, Lagoon Fish Population Sampling 2013. Technical Memorandum, June 24, 2014.

HES. 2015. City of Santa Cruz Habitat Conservation Plan, Lagoon Fish Population Sampling 2014. Technical Memorandum, June 25, 2015.

HES. 2016. City of Santa Cruz Habitat Conservation Plan, Lagoon Fish Population Sampling 2015. Technical Memorandum, June 28, 2016.

HES. 2017. City of Santa Cruz Habitat Conservation Plan, Lagoon Fish Population Sampling 2016. Technical Memorandum, June 30, 2017.

HES. 2018. City of Santa Cruz Habitat Conservation Plan, Lagoon Fish Population Sampling 2017. Technical Memorandum, June 29, 2018.

HES. 2019. City of Santa Cruz Habitat Conservation Plan, Lagoon Fish Population Sampling 2018. Technical Memorandum, June 27, 2019.

HES. 2020. City of Santa Cruz Habitat Conservation Plan, Lagoon Fish Population Sampling 2019. Technical Memorandum, July 2, 2020.

HES. 2021. City of Santa Cruz Habitat Conservation Plan, Lagoon Fish Population Sampling 2020. Technical Memorandum, June 22, 2021.

HES. 2022. City of Santa Cruz Habitat Conservation Plan, Lagoon Fish Population Sampling 2021. Technical Memorandum, June 17, 2022.

HES. 2023. City of Santa Cruz Habitat Conservation Plan, Lagoon Fish Population Sampling 2022. Technical Memorandum, June 27, 2023.

HES. 2024. City of Santa Cruz Habitat Conservation Plan, Lagoon Fish Population Sampling 2023. Technical Memorandum, June 2024.

Ricker, W.E. 1975. Computation and Interpretation of Biological Statistics of fish Populations. Bulletin of the Fisheries Research Board of Canada. Bulletin 191. Department of the Environment, Fisheries and Marine Service. Ottawa, Canada 1975.