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## TECHNICAL MEMORANDUM

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

**FROM:** Jeff Hagar  
Hagar Environmental Science

**DATE:** June 17, 2022

**PROJECT:** City of Santa Cruz Habitat Conservation Plan, Lagoon Fish Population Sampling 2021

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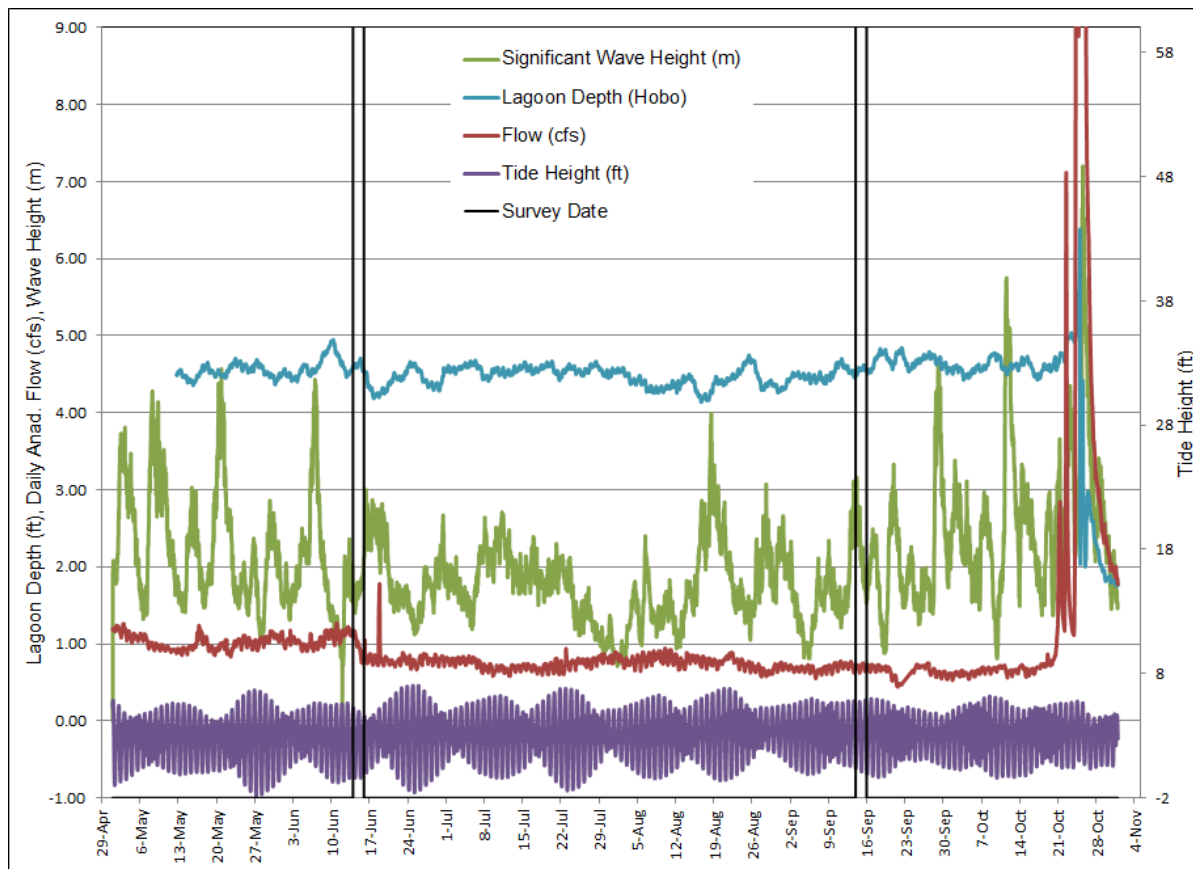
Steelhead (*O. mykiss*) population abundance and life-history characteristics were assessed in Laguna Creek Lagoon and the San Lorenzo River Lagoon during the summer of 2021 by the City of Santa Cruz Water Department and Hagar Environmental Science (HES). Mark-recapture abundance surveys were conducted in the early summer and again in the late summer using a large seine (46 meter [150 foot] long by 2.4 meter [8 foot] deep) to capture fish and PIT tag technology to identify recaptures. The net has a mesh size of 3/8 inch. During the June survey, unusually heavy growths of algae were accumulated in the seine causing it to tear. 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 was deployed in July for the rest of the season.

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. PIT tagging was greatly reduced in July due to warm temperatures. Planned surveys for August were not completed due to excessive temperature in the lagoon. The planned September sampling event was postponed to October due to excessive lagoon temperatures.

# Laguna Creek

## Summary

Water year 2021 was dry. Except for a brief storm in February, flow in Laguna Creek did not exceed 10 cfs (City of Santa Cruz stream monitoring data, Laguna Creek anadromous gage). The lagoon was closed when the water quality monitoring instrumentation was installed on May 12. During the dry season, the lagoon depth remained relatively stable between 4.1 feet and 4.9 feet at the recorder location (Figure 1). Flow at the anadromous gage ranged from 1.2 cfs to 0.46 cfs between May 1 and October 20 (City of Santa Cruz stream monitoring data). An early season storm beginning October 21 resulted in increased runoff and opening of the lagoon on October 25.



**Figure 1. Laguna Creek Lagoon stage, streamflow, wave height, and tides 2021 (Source: lagoon depth from 2<sup>ND</sup> Nature and City of Santa Cruz, streamflow from Balance Hydrologics, wave and tide data from NOAA)**

*O. mykiss* abundance (CPUE) was in the lowest 25% of all annual spring samples and in the lower third of fall samples (Table 1). In June the population was atypical in that it was

comprised of relatively large numbers of larger fish (190 mm or larger) and no young-of-year. The larger fish present in June may have been individuals that would have migrated to the ocean but had limited opportunity due to early lagoon closure. The lagoon closed on March 30 and remained closed until the fall. A few holdovers from 2020 were observed in both June and September. All were characterized as adult/ocean in external appearance in June, as were 19% of the overall catch. In September they were characterized as adult in appearance (typical of stream-reared fish, not ocean-going), as were 20% of the overall catch. One of the fish captured in June had been tagged in September 2020 in the San Lorenzo lagoon. The presence of so many large, adult/ocean type fish in the spring has not been observed in previous surveys. The San Lorenzo tagged fish obviously spent some time in the ocean and the Laguna tagged fish may have as well, given their appearance in June. Growth observed in 2021 was within the range of observations in previous years with the exception of 2018 when exceptionally high growth rates were observed

Coho were captured in the lagoon in June and September, the second consecutive year coho were observed in the lagoon after a period without captures since 2005 (Table 1). The coho were presumed to be yearlings based on their size. It is possible that these fish did not have an occasion to enter the ocean due to early lagoon closure (March 30).

**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, and HES 2021).

	<i>O. mykiss</i> Catch per Haul				Coho ( <i>O. kisutch</i> ) Catch per Haul			
	Jun	Jul	Sep	Oct	Jun	Jul	Sep	Oct
2004		2.4	0			0	0	
2008	11		6		0		0	
2009	7		19		0		0	
2010	13			1.7	0			0
2011	19.8			0.1	0			0
2012	11.3		10.3		0		0	
2013	28		8.6		0		0	
2014	20		33		0			
2015	0.1			11.4	0			0
2016	1.1		5.2		0		0	
2017	42.8		14.5		0		0	
2018	14.3		6.5		0		0	
2019	17.0		2.5		0		0	
2020	56.8		11.4		1.4		0	
2021	8.4		5.4		1.7		1.1	

## Early summer (June 14-15)

### Early summer Site Conditions

- The mouth was closed and the lagoon elevation was high (Figure 2).
- The water depth was up to 5 feet along the rock bluff and the edge of the marsh upstream to the water quality recorder.
- Dense growths of algae slowed the sampling effort, limiting sampling to stations between the beach (LA-1) and the narrow channel between the beach and the marsh (LA 1.5) (Figure 3).
- Inflow from Laguna Creek ranged from 1.2 cfs on the 14th to 0.75 cfs on the 15th (Figure 1).
- The lagoon had fully transitioned to freshwater. Salinity was 0.3 ppt from surface to bottom (Figure 4).
- Temperature was nearly isothermal with only a slight cooling in the deeper water at station LA-1 on June 14. Temperature ranged from 17.1°C to 20.1°C.
- Dissolved oxygen ranged from 9.6 ppt to 12.6 ppt and showed little stratification except for a slight decrease near the bottom at LA-1 on June 14.
- The water column was clear with substrate visible at greatest depth surveyed (1.7 meters or 5.6 feet).

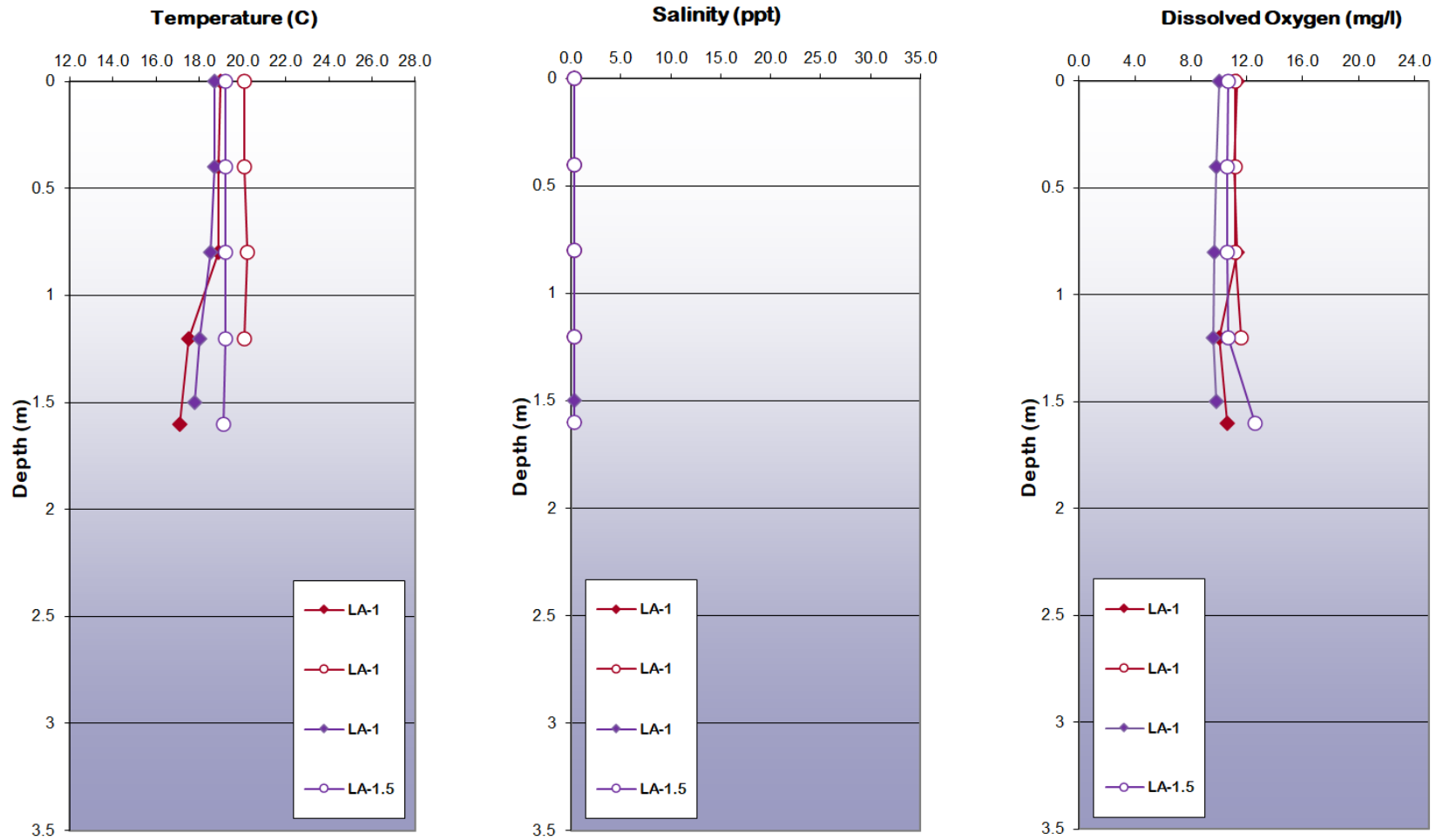


**Figure 2.** Laguna Creek Lagoon, June 14, 2021, ~9:00 am





**Figure 3.** Dense algal growth in Laguna Creek Lagoon, June 14, 2021



**Figure 4. Depth profiles of water quality parameters in Laguna Creek Lagoon during June. Profiles plotted in red are June 14; profiles in blue are June 15**

## Early summer Survey Results

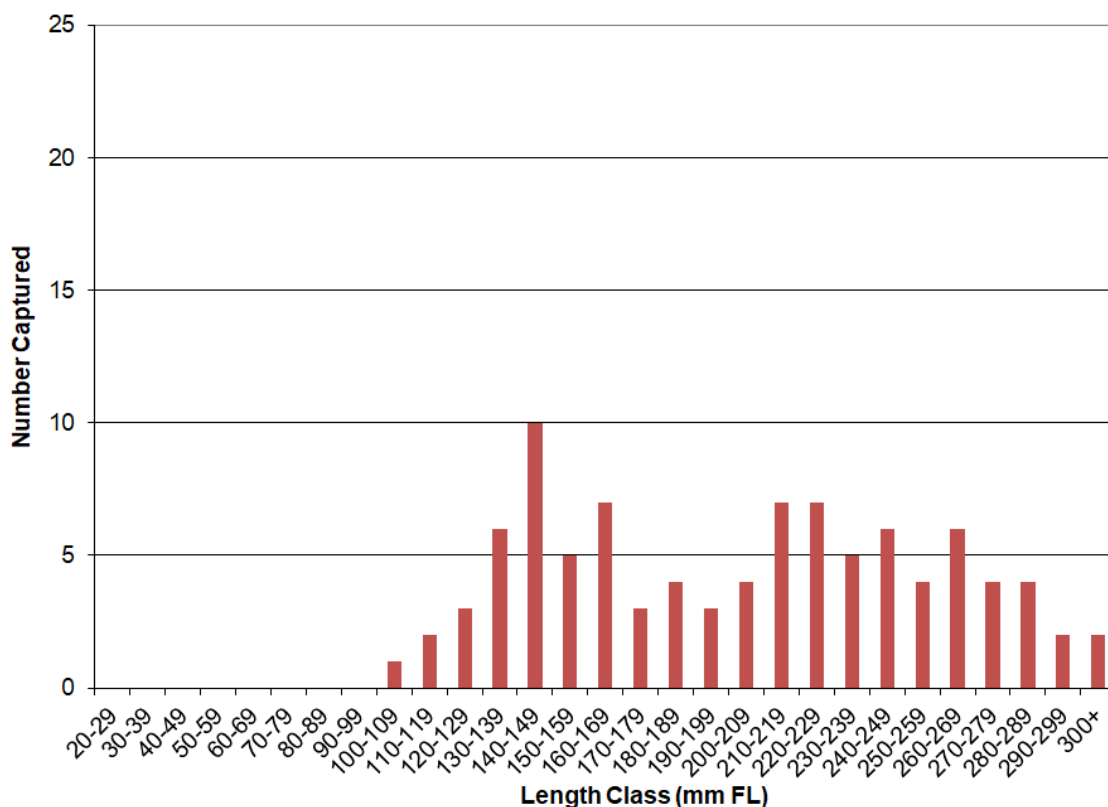
- *O. mykiss* were captured and marked on June 14. On June 15 the lagoon was re-sampled and the proportion of re-captured fish was recorded.
- Five seine hauls were completed on June 14 and six were completed on June 15 between the beach (LA-1) and the narrow channel between the beach and the marsh (LA 1.5).
- In addition to *O. mykiss*, threespine stickleback and staghorn sculpin were abundant (Table 2). Tidewater goby, including abundant fry were observed at most of the seine sites. The 3/8-inch mesh used for steelhead does not effectively retain tidewater goby. A few juvenile starry flounder were captured. Starry flounder were last seen in the lagoon in fall of 2015.

**Table 2. Fish catch in Laguna Creek Lagoon, June 2021**

	LA-1	LA-1.5	LA-2	LA-3	Grand Total
<i># Hauls</i>	10	2	0	0	12
<b><i>Species</i></b>	<b><i>Number Caught</i></b>				
Coho salmon	18	1			19
Steelhead	70	31			101
Threespine stickleback	92	18			110
Staghorn sculpin	37	42			79
Tidewater goby	33	11			Numerous
Starry flounder	6				6
<i>O. mykiss CPUE</i>	7.0	15.5			8.4

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

- *O. mykiss* abundance (CPUE) was in the lowest 25% of all annual spring samples (Table 1).
- No young-of-year steelhead were captured, in sharp contrast to 2020 when the majority of steelhead captured (79%) were less than 80mm FL, likely young-of-year.
- There were two modes to the length distribution for steelhead, one composed of fish from 100 mm FL to about 190 mm FL and one composed of fish larger than about 190 mm (Figure 5). In most of the years surveyed, steelhead larger than 190 mm FL in the spring are rare but in 2021 they made up 57% of the catch.



**Figure 5. *O. mykiss* length classes in Laguna Creek Lagoon, June 2021**

- Two *O. mykiss* captured in June had been tagged in September 2020, one in Laguna Creek lagoon and one in the San Lorenzo River lagoon (Table 3). Both were characterized as adult/ocean in external appearance. The San Lorenzo fish obviously spent some time in the ocean and the Laguna fish may have as well. The San Lorenzo fish had a higher growth rate.

**Table 3. *O. mykiss* captured in June 2021 originally tagged in 2020**

Initial Capture Date	Recapture Date	Initial Capture Location	Recapture Location	Initial Length (mm)	Length at Recapture (mm)	Growth Rate (mm/day)
09/16/20	06/14/21	LA-2	LA-1	166	251	0.31
09/22/20	06/14/21	SL-5	LA-1	166	288	0.46



- Thirty-eight percent of the *O. mykiss* captured were characterized as parr or advanced parr and an equal proportion were characterized as silvery parr or advanced silvery parr. Three percent were characterized as smolts. Twenty-one percent were characterized as adult (2%) or adult/ocean (19%). The presence of so many large, adult/ocean type fish in the spring has not been observed previously. As noted above, one of these fish had been tagged in the San Lorenzo River lagoon in September 2020. This fish, possibly along with others would have entered Laguna Creek during the winter or spring during periods when the lagoon was open between October and the end of March.
- Nineteen juvenile coho salmon were captured, the second consecutive year coho were observed in the lagoon after a period without captures since 2005 (Figure 6).
- Coho ranged from 135 mm FL to 163 mm FL. These were presumed to be yearlings (hatched in 2020). In contrast, coho observed in the lagoon in 2020 were all smaller than 93 mm FL.
- No incidence of *O. mykiss* or coho with black-spot disease or other external parasites, disease, or abnormalities was noted.
- All *O. mykiss* and coho had an adipose fin present.
- The over-wash pond was not sampled.



**Figure 6. Coho salmon, Laguna Creek Lagoon, June 2021**

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

- Seventy-two *O. mykiss* were captured during the mark period (June 14). All 72 were tagged and returned to the lagoon.
- Twenty-nine *O. mykiss* were captured during the recapture period (June 15). None of these had been tagged during the mark period.
- Population estimation is not possible due to lack of recaptures. There is indication that the assumption of a closed population was violated or that tagged fish were not available for recapture due to movement to the upper part of the lagoon which was not sampled due to excessive growth of algae. In addition to the fact that there were many fish tagged and none recaptured, the CPUE for *O. mykiss* dropped from 12 per haul during the marking period to 4.8 per haul during the recapture period (not significantly different, two sample t-test, equal variance, two-tail,  $p \approx 0.9$ ). There were no changes in the lagoon that would have influenced sampling efficiency between the two days.
- Untagged fish captured during the recapture period were tagged in order to collect over-summer information.

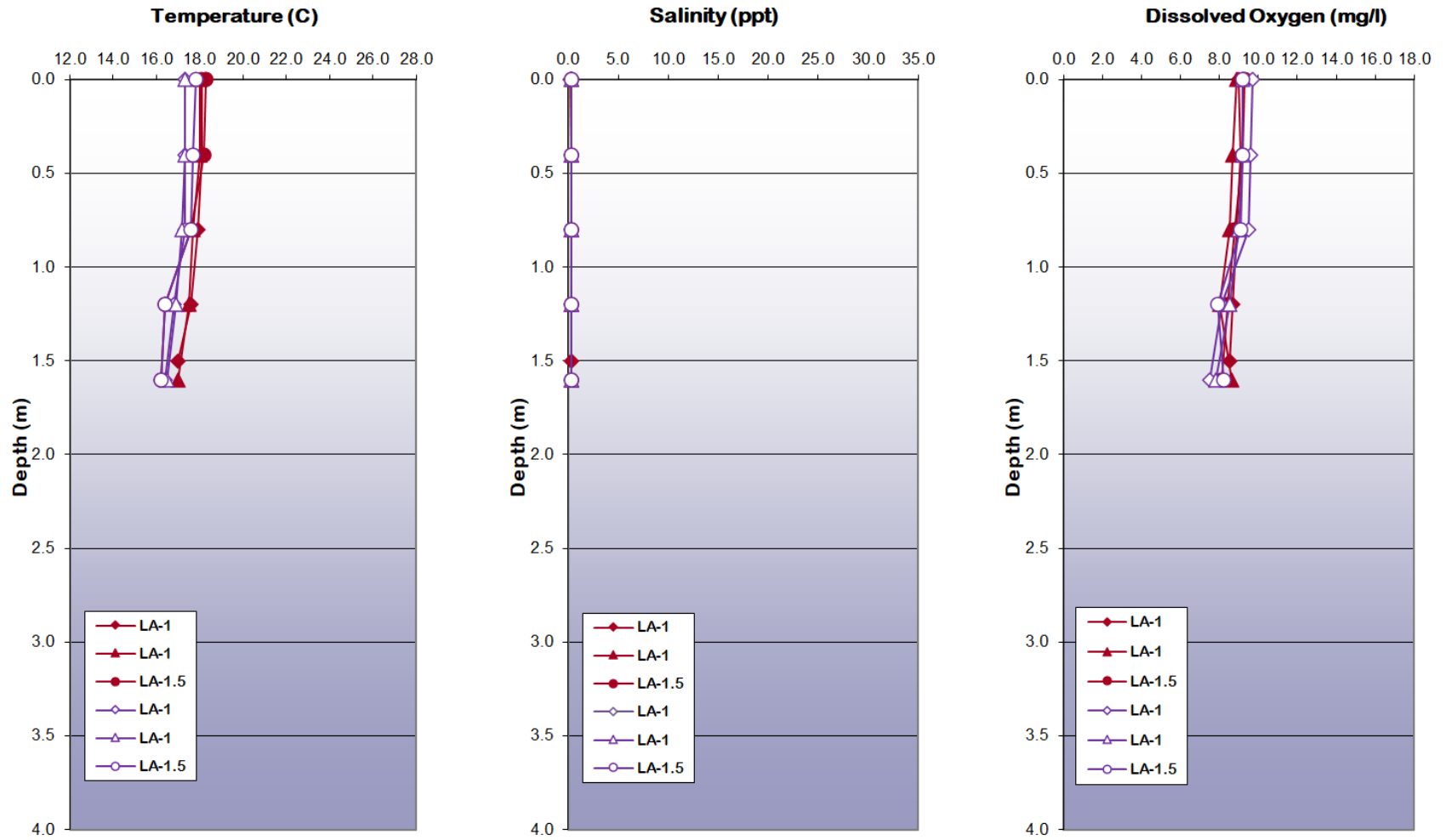
### Late summer (September 14-15)

#### Late summer Site Conditions

- The mouth was closed at the time of the survey with lagoon configuration little changed from June. The lagoon had remained closed and relatively stable since the June survey (2nd Nature and City of Santa Cruz data) (Figure 1, Figure 7).
- Inflow from Laguna Creek during sampling ranged from 0.75 cfs to 0.62 cfs with a peak in the morning and minimum in the late afternoon.
- Maximum depth was 1.6 meters (5.2 feet). The deepest water was available along the rock wall and along the interior marsh edge.
- The lagoon temperature ranged between 16.2°C and 18.3°C and was nearly unstratified but slightly cooler at the greatest depths. Salinity measurements were uniform with depth at 0.3 ppt reflecting full conversion to freshwater of the closed lagoon (Figure 8, center panel). Dissolved oxygen ranged between 7.5 mg/l and 9.7 mg/l and was nearly unstratified but slightly lower at the greatest depths (Figure 8, right panel), likely due to the accumulation of algae.
- The water column was clear with secchi visibility to the bottom at depths to 1.6 meters to 1.7 meters (5.2 feet to 5.6feet)



**Figure 7. Laguna Creek Lagoon, September 14, 2021**



**Figure 8. Depth profiles of water quality parameters in Laguna Creek Lagoon during September. Profiles plotted in red are September 14; profiles in blue are September 15**

## Late summer Survey Results

- *O. mykiss* were captured and marked on September 14. On September 15 the lagoon was re-sampled and the proportion of re-captured fish was recorded.
- Seven seine hauls were completed on each day between the beach (LA-1) and the narrow channel between the beach and the marsh (LA 1.5) (Table 4).
- Species representation was similar to June except staghorn sculpin and starry flounder numbers caught were reduced (Table 4).

**Table 4. Fish catch in Laguna Creek Lagoon, September 2021**

	LA-1	LA-1.5	LA-2	LA-3	Grand Total
<i># Hauls</i>	10	2	2	0	14
<b><i>Species</i></b>	<b><i>Number Caught</i></b>				
Coho salmon	5	4	7		16
Steelhead	14	14	48		76
Threespine stickleback	16				16
Staghorn sculpin		1	1		2
Tidewater goby	many	many	many		numerous
Starry flounder	1				1
<i>O. mykiss CPUE</i>	1.4	7.0	24.0		5.4

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

- Overall abundance of *O. mykiss* based on number caught per seine haul (catch per unit effort or CPUE) at 5.4 per haul was in the lower third for fall surveys to date (Table 1), and less than the 8.4 in June (difference not significant, two sample t-test, unequal variance, two-tail,  $p \approx 0.4$ ).
- *O. mykiss* were most abundant at the most upstream sample location (LA-2) on both survey dates.
- Four *O. mykiss* captured in September had been tagged in 2020 (Table 5). These fish were comparable in length to the two *O. mykiss* tagged in 2020 and recaptured in June (Table 3). They were all characterized as adult in external appearance. Growth rates of these fish between initial tagging and recapture was similar to the June recaptures of 2020 tagged fish.
- Twelve *O. mykiss* tagged in June were recaptured in September. Growth rates were highly variable, ranging from 0.12 to 0.88 mm/day and averaging 0.45 mm/day (Table 6). Growth observed in 2021 was within the range of observations in previous years with the exception of 2018 when exceptionally high growth rates were observed (Figure 9).

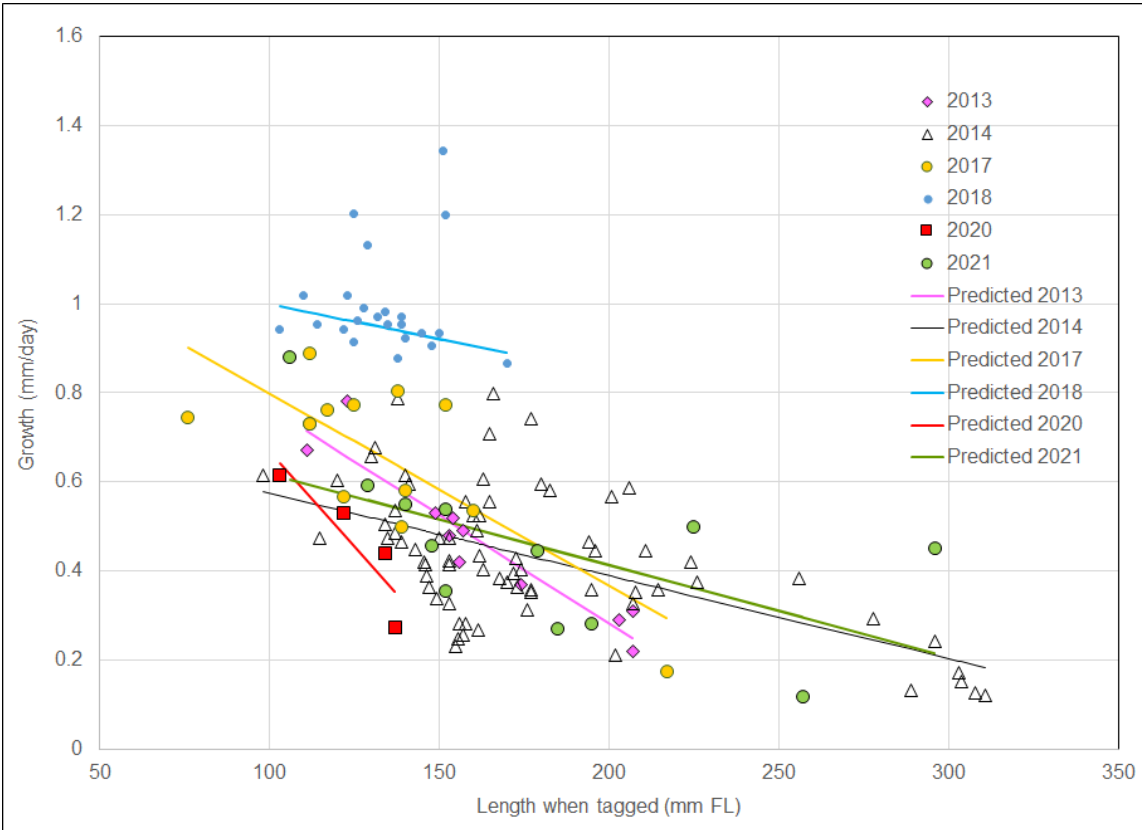
**Table 5. *O. mykiss* captured in September 2021 originally tagged in 2020**

Initial Capture Date	Recapture Date	Initial Capture Location	Recapture Location	Initial Length (mm)	Length at Recapture (mm)	Growth Rate (mm/day)
06/09/20	09/15/21	LA-1	LA-1.5	131	303	0.37
06/09/20	09/14/21	LA-1	LA-1	142	272	0.28
09/15/20	09/15/21	LA-1	LA-1	119	293	0.48
09/15/20	09/15/21	LA-1.5	LA-1.5	145	268	0.34

**Table 6. *O. mykiss* captured in September 2021 originally tagged in June 2021**

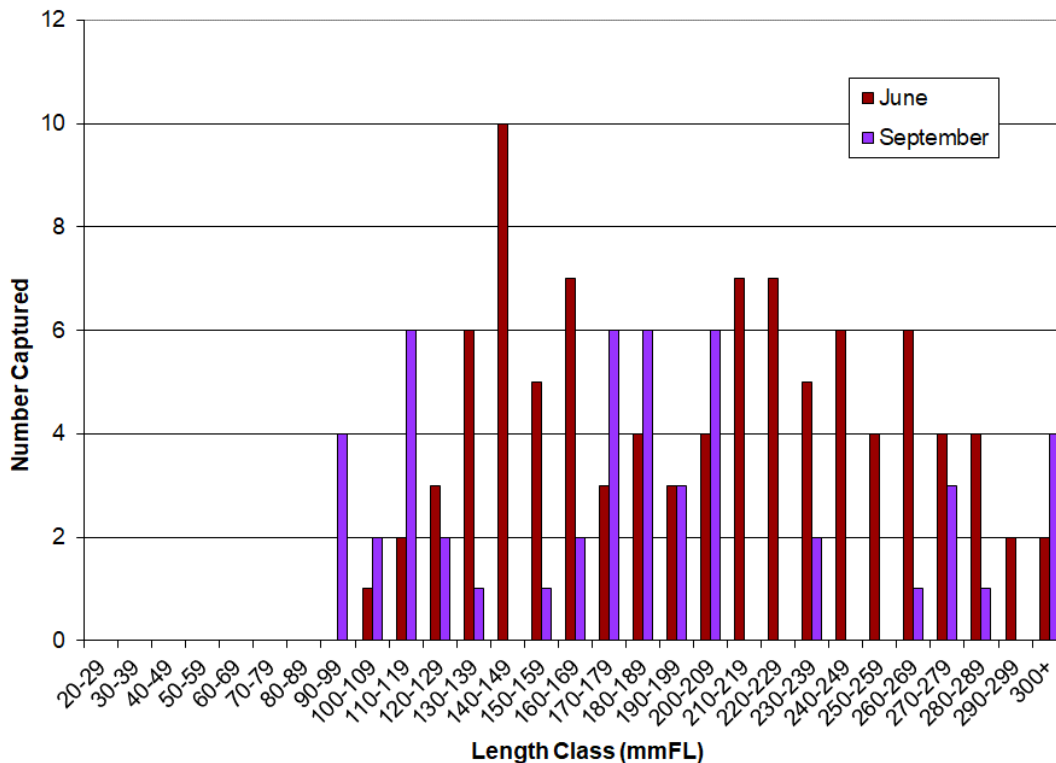
Initial Capture Date	Recapture Date	Initial Capture Location	Recapture Location	Initial Length (mm)	Length at Recapture (mm)	Growth Rate (mm/day)
06/14/21	09/14/21	LA-1	LA-1	106	187	0.88
06/14/21	09/15/21	LA-1.5	LA-1	129	184	0.59
06/15/21	09/14/21	LA-1	LA-1	140	190	0.55
06/14/21	09/14/21	LA-1	LA-2	148	190	0.46
06/14/21	09/15/21	LA-1.5	LA-2	152	185	0.35
06/14/21	09/15/21	LA-1.5	LA-1.5	152	202	0.54
06/14/21	09/14/21	LA-1.5	LA-1.5	179	220	0.45
06/14/21	09/14/21	LA-1	LA-1	185	210	0.27
06/14/21	09/14/21	LA-1	LA-2	195	221	0.28
06/14/21	09/14/21	LA-1	LA-1.5	225	271	0.50
06/14/21	09/15/21	LA-1	LA-2	257	268	0.12
06/14/21	09/15/21	LA-1	LA-2	296	338	0.45





**Figure 9. Laguna Creek Lagoon growth rates of *O. mykiss* tagged in June and recaptured in September**

- Captured *O. mykiss* ranged in length from 97 mm FL to 333 mm FL (Figure 10). The group of 100 mm to 190 mm fish present in June grew into the 180 mm to 220 mm size range in September based on tag recovery data (Table 6). Fish in the 97 mm to 140 mm size class in September likely entered the lagoon after the June survey from rearing areas upstream. Larger fish in the 190 mm to 300 mm size range in June had variable growth rates but became less abundant in September. It is possible they left the lagoon after the June survey, either going upstream or to the upper part of the lagoon as steelhead in other lagoons have been shown to do (Bond et al. 2021, HES 2021, Hayes et al. 2011). The lagoon did not open between the June and September sample dates so fish could not have gone to sea.



**Figure 10. *O. mykiss* length classes in Laguna Creek Lagoon, late summer compared to spring 2021**

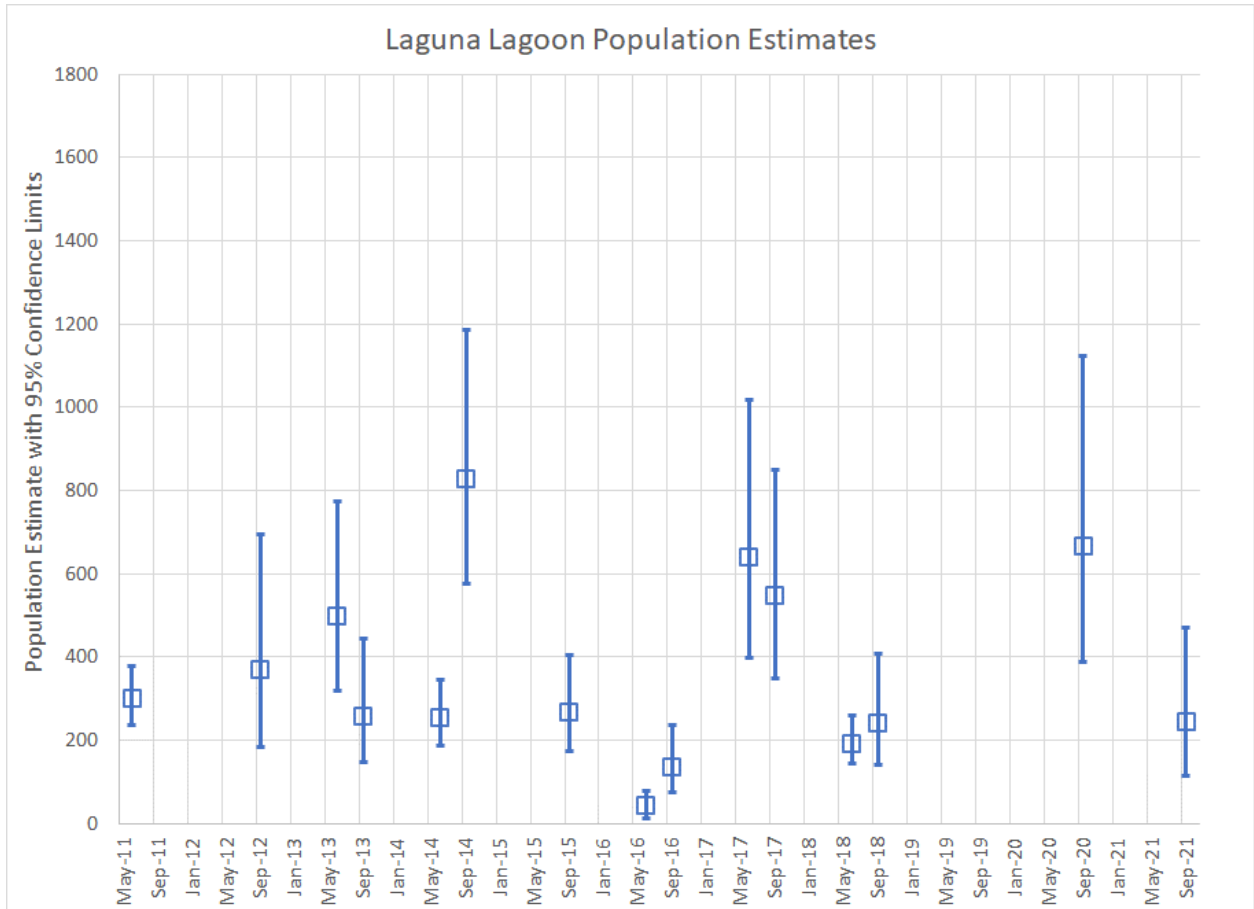
- Sixty-two percent of the *O. mykiss* catch were characterized as parr or advanced parr and 18% were characterized as silvery parr. Twenty percent had the appearance of adult stream fish.
- Sixteen juvenile coho salmon were captured, the second consecutive year coho were observed in the lagoon after a period without captures since 2005 and the first time they have been observed in the fall survey.
- Coho ranged from 156 mm FL to 195 mm FL (average 168 mm FL). As indicated previously, these were presumed to be yearlings (hatched in 2020). None of the coho captured were recaptures from June. Average length of coho in September was greater than in June (147 mm FL in June, range 135-163 mm FL).
- One *O. mykiss* out of 50 examined (not including recaptures) was lightly infected with black-spot disease (BSD), no other external parasites, disease, or abnormalities were noted for either steelhead or coho. Incidence of BSD has been low in Laguna Creek lagoon in past surveys.
- All *O. mykiss* and coho had an adipose fin present.

## Late summer *O. mykiss* Population Estimate

- Thirty-five *O. mykiss* were captured during the marking period on September 14. All were over the 80 mm FL and under the 320 mm FL tagging limits<sup>1</sup>. One of these fish was a recapture from the marking period so there was a total of 34 marked *O. mykiss* released in the lagoon on September 14.
- On September 15, 41 *O. mykiss* were captured, all within the tagging limits. Four *O. mykiss* caught during the recapture period had been tagged on September 14. One additional fish had an obvious tag wound but no tag was read. This was assumed to be a fish from the mark period that had lost the tag since no fish of its length had been tagged during the recapture period but two fish of that size were tagged during the mark period. It was included as a recapture bringing the total to 5.
- Based on the Peterson method (Ricker 1975), the population estimate is 245 *O. mykiss* in the lagoon in mid-September. The 95% confidence limits for this estimate are 116 and 471. This estimate was in the lower range for fall surveys in Laguna to date (Figure 11).
- CPUE was comparable during the mark and recovery periods (5.0 vs. 5.9, not significantly different, two sample t-test, equal variance, two-tail,  $p \approx 0.9$ ).
- The relationship between the population estimates and CPUE was updated with the fall 2021 data point (Figure 12). Least squares regression  $r^2$  is 0.53 and was statistically significant with  $p = 0.002$ . Forcing the relationship through the origin improves the  $r^2$  to 0.86. The relationship changed negligibly with the addition of the 2021 data point.

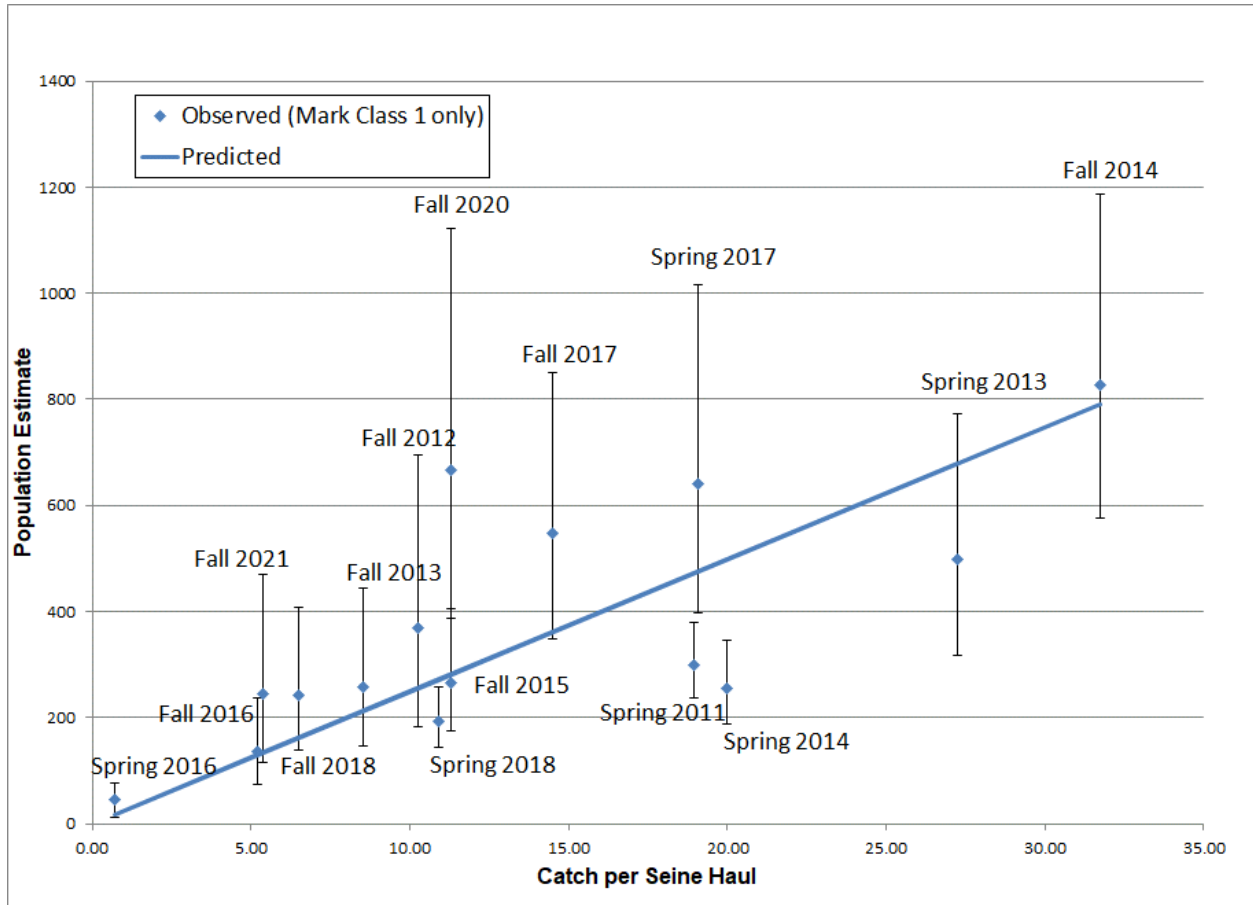
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<sup>1</sup> The tag supplier (Biomark) recommends that body cavity tagging should only be done down to a length of 65mm but due to previous experience with excessive mortality of fish less than 80mm, only fish 80mm FL or larger were tagged. In addition, permits preclude tagging of adult steelhead. Given the presence of fast-growing juveniles in the lagoon, potential maturity and spawning of lagoon reared fish without ocean entry, and early return of small ocean fish, a length of 320mm FL (12.6 inches) was used to delineate adult fish.



**Figure 11. *O. mykiss* population estimates in Laguna Creek Lagoon over time<sup>2</sup>**

<sup>2</sup> 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.



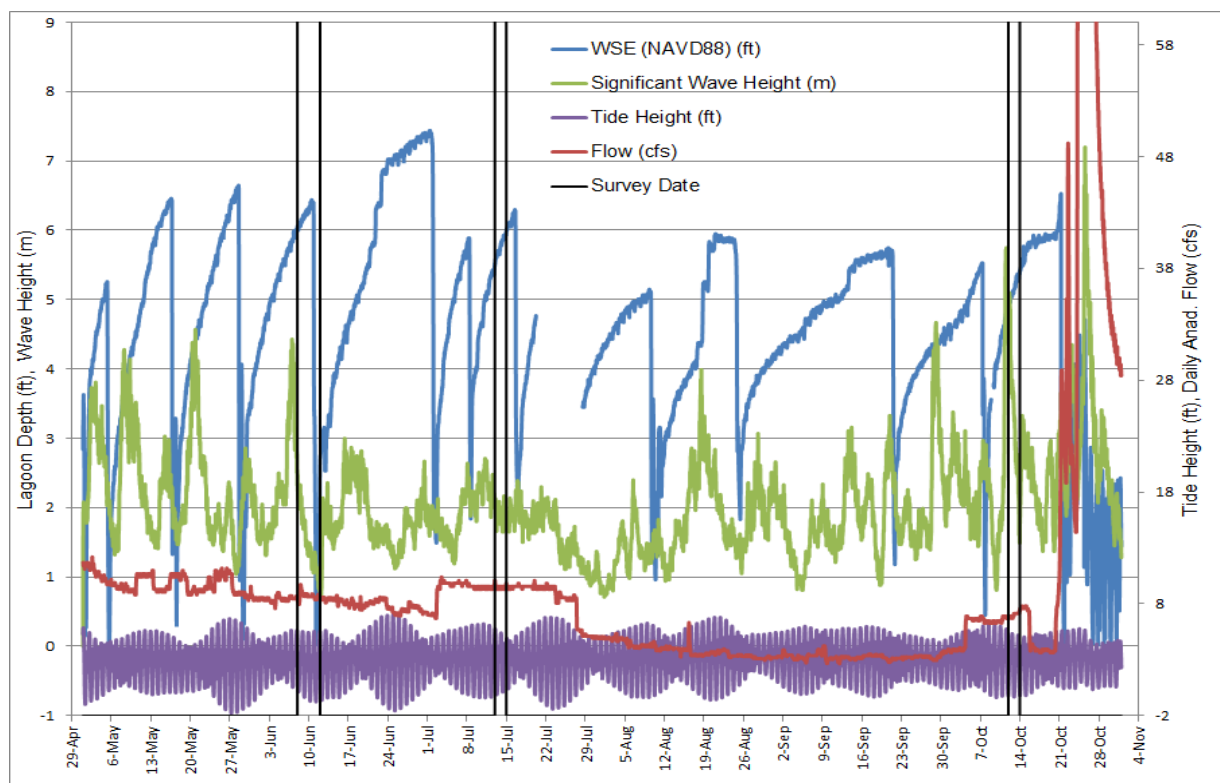
**Figure 12. Relationship between *O. mykiss* population estimate and CPUE in Laguna Creek Lagoon<sup>3</sup>**

<sup>3</sup> 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

Runoff was very limited during the winter of 2020-2021. Except for a single storm in February, flow in the San Lorenzo River at Santa Cruz did not exceed 100 cfs<sup>4</sup>. A containment berm along the east edge of the Boardwalk and extending to the edge of the beach had been constructed by the City, forcing the mouth of the river to lie along San Lorenzo Point. By early May, inflow from the San Lorenzo River had already dropped to around 10 cfs. Inflow dropped below 8 cfs for the first time since 2015, approaching 3 cfs through August and September (Figure 12). The mouth was mechanically opened by the City on 6/10/21, 7/1/22, 7/8/21, 7/16/21, 7/26/21, 8/9/21, 8/24/21, 9/21/21, 10/7/21 (personal communication from Scott Ruble, City of Santa Cruz Public Works Department to Ryan Bassett, City of Santa Cruz Water Department). During closed conditions the lagoon reached relatively high levels (over 6 feet NAVD88) before being breached and draining to very low levels of 0 to 2 feet (Figure 12).



**Figure 13. San Lorenzo River Lagoon stage, streamflow, wave height, and tides 2021 (Source: lagoon stage from City of Santa Cruz Public Works, streamflow from USGS, wave and tide data from NOAA)**

<sup>4</sup> USGS online data:

[https://waterdata.usgs.gov/nwis/wys\\_rpt?dv\\_ts\\_ids=8785&wys\\_water\\_yr=2021&site\\_no=11160500&agency\\_cd=USGS&adr\\_water\\_years=2006%2C2007%2C2008%2C2009%2C2010%2C2011%2C2012%2C2013%2C2014%2C2015%2C2016%2C2017%2C2018%2C2019%2C2020%2C2021&referred\\_module=](https://waterdata.usgs.gov/nwis/wys_rpt?dv_ts_ids=8785&wys_water_yr=2021&site_no=11160500&agency_cd=USGS&adr_water_years=2006%2C2007%2C2008%2C2009%2C2010%2C2011%2C2012%2C2013%2C2014%2C2015%2C2016%2C2017%2C2018%2C2019%2C2020%2C2021&referred_module=)



Conditions in June were generally suitable for *O. mykiss* in the upper 1.2 meters (3.9 feet) of the water column with temperature generally below 21°C, dissolved oxygen of 8 mg/l or more, and low salinity (6ppt or less). By the time of the July survey, high water temperature resulted in suitable conditions for *O. mykiss* only in the upper 0.4 to 0.8 meters (1.3 to 2.6 feet). No sampling was conducted in August and September due to high water temperature.

Abundance of *O. mykiss* in the lagoon dropped to levels not seen since 2015 (Table 5). CPUE was moderate by pre-2016 standards in June and July (Table 7, Table 8). By October, only a few *O. mykiss* were captured. This is in contrast to 2020 when the lagoon supported relatively high abundance of *O. mykiss* with similarly high water temperatures but inflow remaining at 8 cfs or more throughout the summer (Table 7). No population estimates were made since the lagoon was too warm for tagging fish (Table 9).

**Table 7. *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)**

Year	<i>O. mykiss</i> Catch per Haul				
	June	July	August	September	October
2008	2.6				0.1
2009	0.3			1.0	0.5
2010	8.3	21.5			28.25
2011	13				2.5
2012	1.7			14.4	
2013	2	8.4		4.7	
2014	1.2	1.1		0.0	
2015	2.6	0	0		0
2016	39.7	1.0	2.0	7.8	
2017	134.4	452.0	272.0	328.5	
2018	23.3	2.5	6.4	6.3	
2019	92.2	53.4	277.7	228.2	
2020	146.1	120.6		31.0	
2021	4.3	6.3			0.3

**Table 8. *O. mykiss* catch per haul for the San Lorenzo River Lagoon during 2021**

Station	Location	<i>O. mykiss</i> Catch per Haul				
		Jun 8-11	Jul 13-14	Aug*	Oct 12-13	Overall
SL-1	South of Trestle	3.9	1.0	NS	0.0	<b>2.3</b>
SL-2	RR Trestle	4.2	9.7	NS	0.2	<b>4.0</b>
SL-3	Near YSI Station	0.0	NS	NS	0.5	<b>0.3</b>
SL-5	Riverside Drive	7.0	9.5	NS	0.5	<b>5.9</b>
SL-6	U/S Bank Restoration	4.0	6.0	NS	0.3	<b>3.4</b>
	<b>Overall</b>	<b>4.3</b>	<b>6.3</b>	NS	<b>0.3</b>	<b>3.5</b>

NS- Not Sampled

August survey cancelled due to excessive water temperature in the lagoon, September survey moved to October due to excessive water temperature.

**Table 9. *O. mykiss* mark-recapture population abundance estimates in San Lorenzo River Lagoon for fish >80mm FL and <320mm FL**

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

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

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

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

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

<sup>4</sup> No recaptures

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

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

The 2021 season marked a departure from the trend since 2016 of higher abundance of *O. mykiss* in the lagoon in June, and through the summer in most years (Table 7, Table 9). The five consecutive years 2016 through 2020 had the highest June CPUE and population estimates by far of all previous survey years back to 2008. The relatively wet 2017 and 2019 seasons carried a high abundance through the summer into the fall, larger by an order of magnitude than any previous year. Notably, minimum bypass flows were reduced in 2021 to around 5 cfs at the end of July with declines to around 3 cfs by mid-August.

PIT tagging was very limited in 2021 due to warm temperatures in the lagoon that exceeded criteria for safe handling of fish. Only 18 *O. mykiss* were tagged in June and none were tagged in July. One fish tagged in June was recaptured in July. Growth rate for that individual was relatively low at 0.26 mm/day.

## Early summer (June 8-11)

### Early summer Site Conditions

- The lagoon was closed and the stage was high at the beginning of the sampling period (Figure 14, Figure 15). The containment levee created by the City maintained the outlet in a more easterly alignment, against the San Lorenzo bluff.
- The lagoon was mechanically breached by the City on June 10 (personal communication from Scott Ruble, City of Santa Cruz public works to Ryan Bassett, City of Santa Cruz, Water Department). Lagoon stage dropped from 6.4 feet at 8:30 pm on the 10th to 0.0 feet at 7:00 am on the 11<sup>th</sup> (Figure 16). Very low dissolved oxygen levels were present upstream of Riverside Bridge on the morning of June 11 and sampling had to be delayed until 9:00 am when dissolved oxygen increased sufficiently to sample (Figure 17). By 9:45 am water temperature increased above safe levels for seining and sampling was halted for the day.
- Daily average flow at Santa Cruz gage ranged from 8.0 cfs to 9.7 cfs (Figure 13). Mean flow for June between 2004 and 2020 is 34 cfs (historical discharge, USGS site 11161000 San Lorenzo River at Santa Cruz California).
- Downstream of the trestle, the shoreline was conducive to sampling with sand beach exposed but there was a shelf of shallow water (Figure 14). The net was used as a purse seine with a finish at the edge of the shelf. Upstream of the trestle and upstream of Riverside Bridge there was no sand beach with relatively deep (1 to 2 feet) water at the bank. Some algal growths were present but it was not a significant problem for sampling.



**Figure 14. San Lorenzo River Lagoon outlet to mouth June 9, 2021**





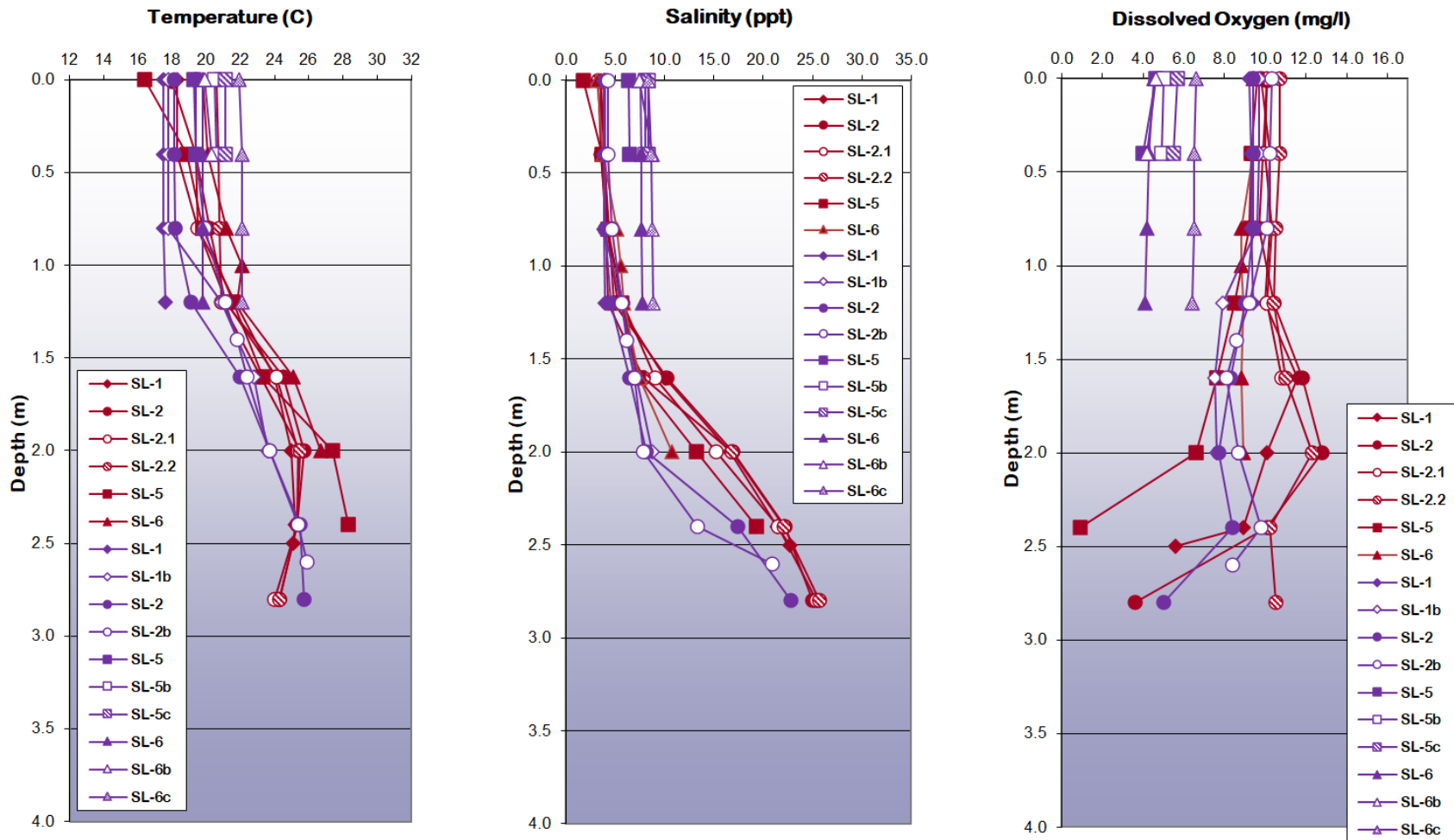
**Figure 15. San Lorenzo River Lagoon near trestle June 9, 2021**



**Figure 16. San Lorenzo River Lagoon upstream of Riverside Bridge morning of June 11, 2021**

- The lagoon was salinity stratified before the breach with surface salinities ranging from 1.7 ppt to 5.7 ppt down to 1.2 meters (3.9 ft.) then increasing at the halocline up to 25.7 ppt at depth (Figure 17, center panel). Salinity de-stratified after the breach at 6.3 ppt to 8.8 ppt in the shallower lagoon (measurements upstream of Riverside Bridge).
- The lagoon had suitable temperature conditions for steelhead in June in at least the upper 1.2 meters (3.9 ft.) (Figure 17, left panel). Surface temperatures ranged from 16.4°C to 20.6°C before the breach. A thermocline was developed from 1.2 meters of depth with temperature increasing to 24.3°C to 28.3°C. Temperature cooled slightly from the 8th through the 11th. Conditions for tagging (half the water column at 21°C or less) were not met though very close.
- Dissolved oxygen was at levels supportive of *O. mykiss* except at the very deepest levels of the lagoon before the breach (Figure 17, right panel). Dissolved oxygen levels generally exceeded 8 mg/L in the surface waters (down to 1.2 meters depth), and generally above 6 mg/l down to 2.4 meters (7.9 feet). On the morning after the breach dissolved oxygen levels were depressed and precluded sampling until 9:00 am when levels increased above 6 mg/l.
- Water clarity was relatively high with secchi disk depth of 1.1 meters to 1.5 meters (3.6 feet to 4.9 feet) in the lower lagoon and to about 2.5 meters (8.2 feet) upstream of Riverside Bridge. After the breach secchi depth was reduced upstream of Riverside Bridge to 1 to 1.2 meters (3.3 feet to 3.9 feet).





**Figure 17. Depth profiles of water quality parameters in the San Lorenzo River Lagoon during June. Profiles plotted in red are June 8-9; profiles in blue are June 10-11**

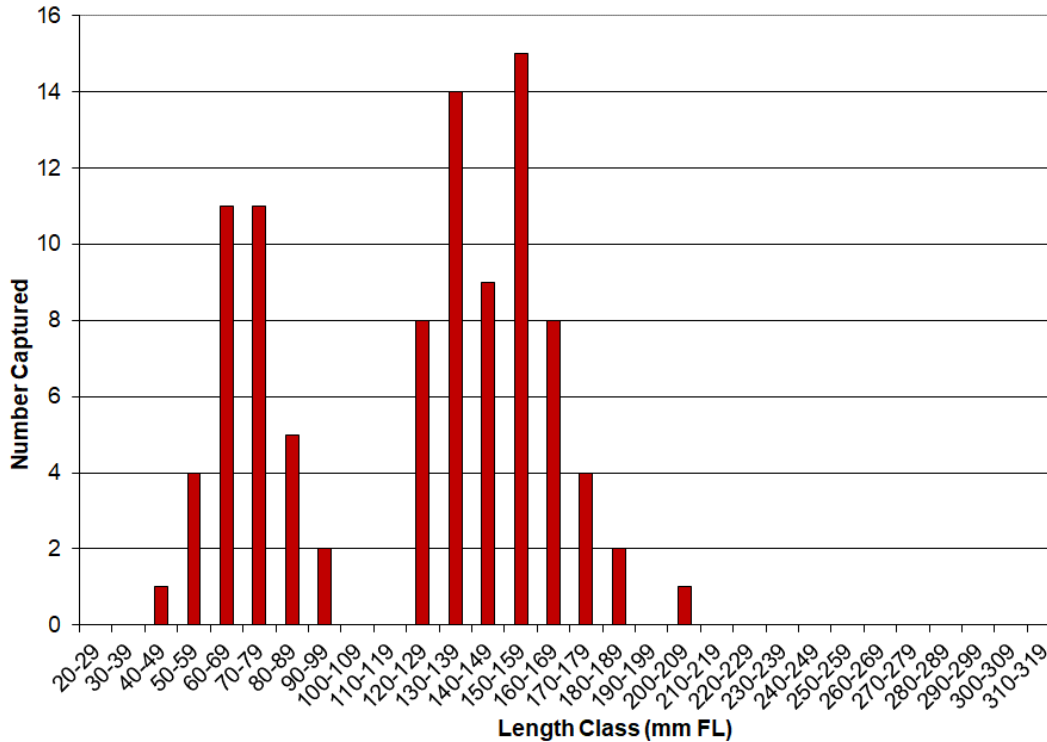
## Early summer Survey Results

- The lagoon was sampled between the beach and upstream of Riverside Bridge on June 8<sup>th</sup> to 9<sup>th</sup> and again on June 10<sup>th</sup> and 11<sup>th</sup>. Due to warm water temperature conditions *O. mykiss* were captured and scanned for tags but not tagged. Fish were released directly from the net. Size was estimated in 10mm length classes. No tagging was conducted during the mark period. Water temperature cooled slightly during the recapture period and fish in hauls earlier in the day (while temperatures remained relatively cool) were tagged for potential growth determination. Only a single haul could be completed on June 11 due to a combination of low dissolved oxygen and warm water following the lagoon breach (see preceding discussion under site conditions).
- Twenty-three seine hauls were completed at regularly sampled stations between the beach and the bend upstream of Riverside Bridge. The catch was dominated by topsmelt and staghorn sculpin (Table 10).
- *O. mykiss* abundance (CPUE) was the lowest since 2015 and greatly reduced from 2020. CPUE tended to be slightly higher upstream of Riverside Bridge (Table 10).
- There were two distinct size classes of *O. mykiss* captured in June; one mode with fish from 40 mm FL to 100 mm FL that were likely young-of-year, and a second mode with likely age 1+ and older fish from 120 mm FL to 190 mm FL (Figure 18).

**Table 10. Fish catch in San Lorenzo River Lagoon, June 2021**

	SL-1	SL-2	SL-3	SL-5	SL-6	Grand Total
<i># Hauls</i>	7	9	1	3	3	<b>23</b>
<b><i>Species</i></b>	<b><i>Number Caught</i></b>					
<i>O. mykiss</i>	27	38	0	21	12	<b>98</b>
Pacific herring	77	4				<b>81</b>
Topsmelt	221	1436		11	10	<b>1678</b>
Threespine stickleback	2	18	5	7		<b>32</b>
Prickly sculpin				1		<b>1</b>
Staghorn sculpin	5	53	25	444	73	<b>600</b>
Shiner surfperch	2					<b>2</b>
Starry flounder	1	1			1	<b>3</b>
<i>O. mykiss CPUE</i>	3.9	4.2	0.0	7.0	4.0	<b>4.3</b>

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



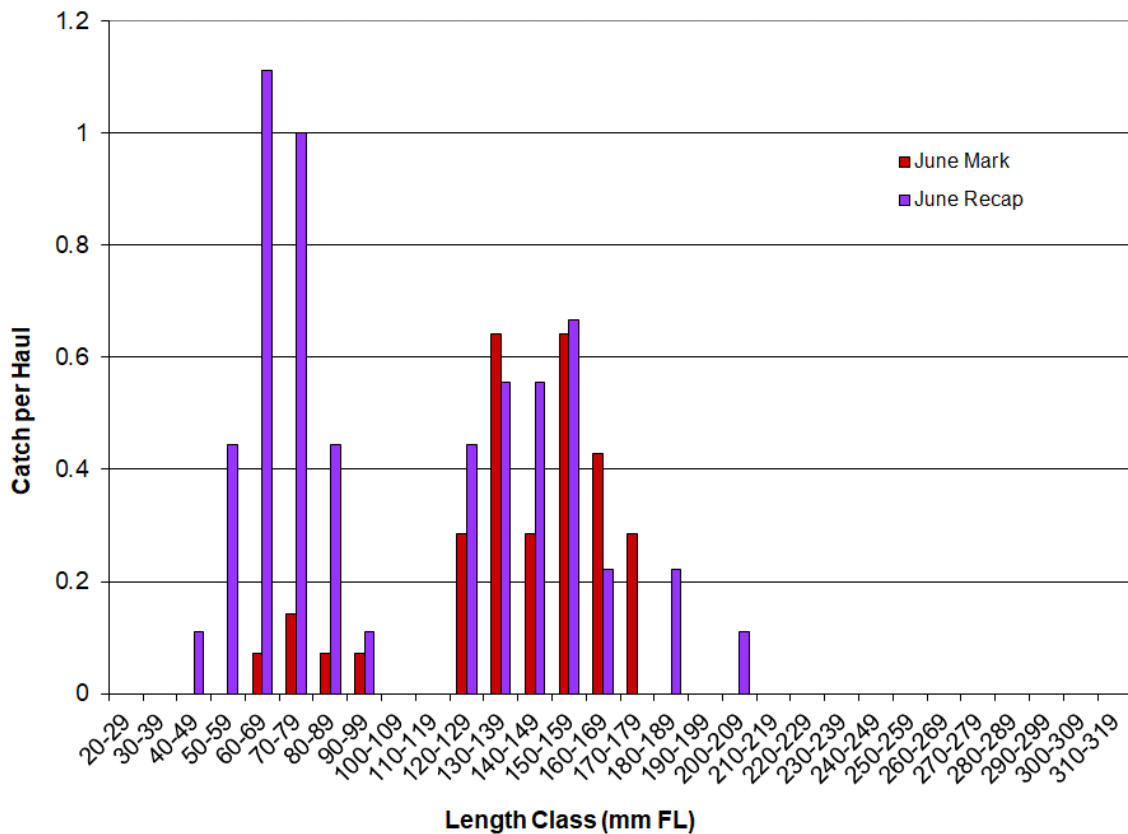
**Figure 18. *O. mykiss* length classes in San Lorenzo River Lagoon, June 2021**

- Handling of *O. mykiss* was reduced due to warm water temperature. Smolt stage was only recorded for 20 individuals. Half were classified as parr or advanced parr and the other half as silvery parr or advanced silvery parr.
- Sixty-seven *O. mykiss* examined for presence of an adipose fin all had an adipose fin present, indicating they were not of hatchery origin.
- Nine percent of *O. mykiss* examined had black-spot disease (BSD) lesions. Incidence of BSD has ranged between 11% and 68% in previous spring surveys since 2010.
- The lagoon breach on June 10/11 resulted in stranding of numerous tidewater goby, staghorn sculpin, and prickly sculpin in puddles upstream of Riverside Bridge (and possibly elsewhere).

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

- A total of 41 *O. mykiss* were captured during the marking period (June 8-9). Only 2 were tagged due to temperature limitations.
- A total of 57 *O. mykiss* were captured during the recapture period. There were no tagged recaptures from the marking period.
- No population estimate is possible due to the low number tagged and since there were no recaptures.

- CPUE was higher during the recapture period than during the marking period (6.3 vs. 2.9) but the difference was not statistically significant (two sample t-test,  $p \approx 0.07$ ).
- There was an apparent shift in the size distribution between the mark and recapture periods with more fish in the 40 mm FL to 100 mm FL size range during the recapture period and catch of fish in the 120 mm FL to 180 mm FL size range little changed between periods (Figure 19). Changes in the size distribution and CPUE can indicate movement of fish in and out of the lagoon and violation of the assumption of a closed population. The two fish tagged during the mark period were both in the 130 mm FL to 139 mm FL size range.



**Figure 19. *O. mykiss* size distributions in San Lorenzo River Lagoon, June 2021 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. High water temperature precluded holding *O. mykiss* for tagging, measuring, or close observation. Fish were counted and released directly from the net. Length was estimated within 10 mm size classes.

#### July Site Conditions

- The lagoon was closed at the time of sampling but had breached on July 8 and before that on July 2 (Figure 13). There had been a 19-day closure following the June survey.
- Inflow from the San Lorenzo River was at 9 cfs to 10 cfs during the sample period but had been at 7 cfs to 8 cfs during the latter part of June (Figure 13). The slightly higher inflow was associated with shorter periods of closure in early July.
- The lagoon stage ranged between 5.6 feet and 5.9 feet during the survey period (City of Santa Cruz data). During the survey, the lagoon was high and wide with extensive very shallow water near shore downstream of the trestle. The net had to be deployed as a purse seine and finished at the edge of the shallow bench at sites downstream of the trestle. Above Riverside Bridge, the net was also deployed as a purse seine and hauls were finished by counting and scanning fish for tags as they were removed from the net and released to minimize stress from processing.
- Lagoon salinity ranged from 1.9 ppt to 4.2 ppt in the surface waters (0 meters to 0.4 meters) at both the lower and upper lagoon locations, with salinity slightly higher in the downstream locations. Salinity began to rise in the halocline at 0.8 meters and reached a maximum of about 27 ppt in the deepest waters (3.2 meters) (Figure 20, middle panel).
- Water temperature ranged from 19.7°C to 21.5°C in the surface 0.4 meters of the water column and increased to 23.9°C to 25.9°C at 1.2 meters (3.9 feet) (Figure 20, left panel).
- Dissolved oxygen was well-saturated in surface waters, ranging from 8.7 mg/l to 10.6 mg/l down to 1.2 meters (3.9 feet) (Figure 20, right panel). Dissolved oxygen did not drop below 6 mg/l until a depth of 1.6 meters (5.2 feet) but some stations remained above 6 mg/l nearly to the bottom.
- Water clarity was lower than in June with the secchi disk readings from 1.3 meters to 1.6 meters (4.3 feet to 5.2 feet) with clarity increasing upstream from the mouth. Algae was thick in the deeper water at the upper lagoon stations including large mats of black decomposing material.

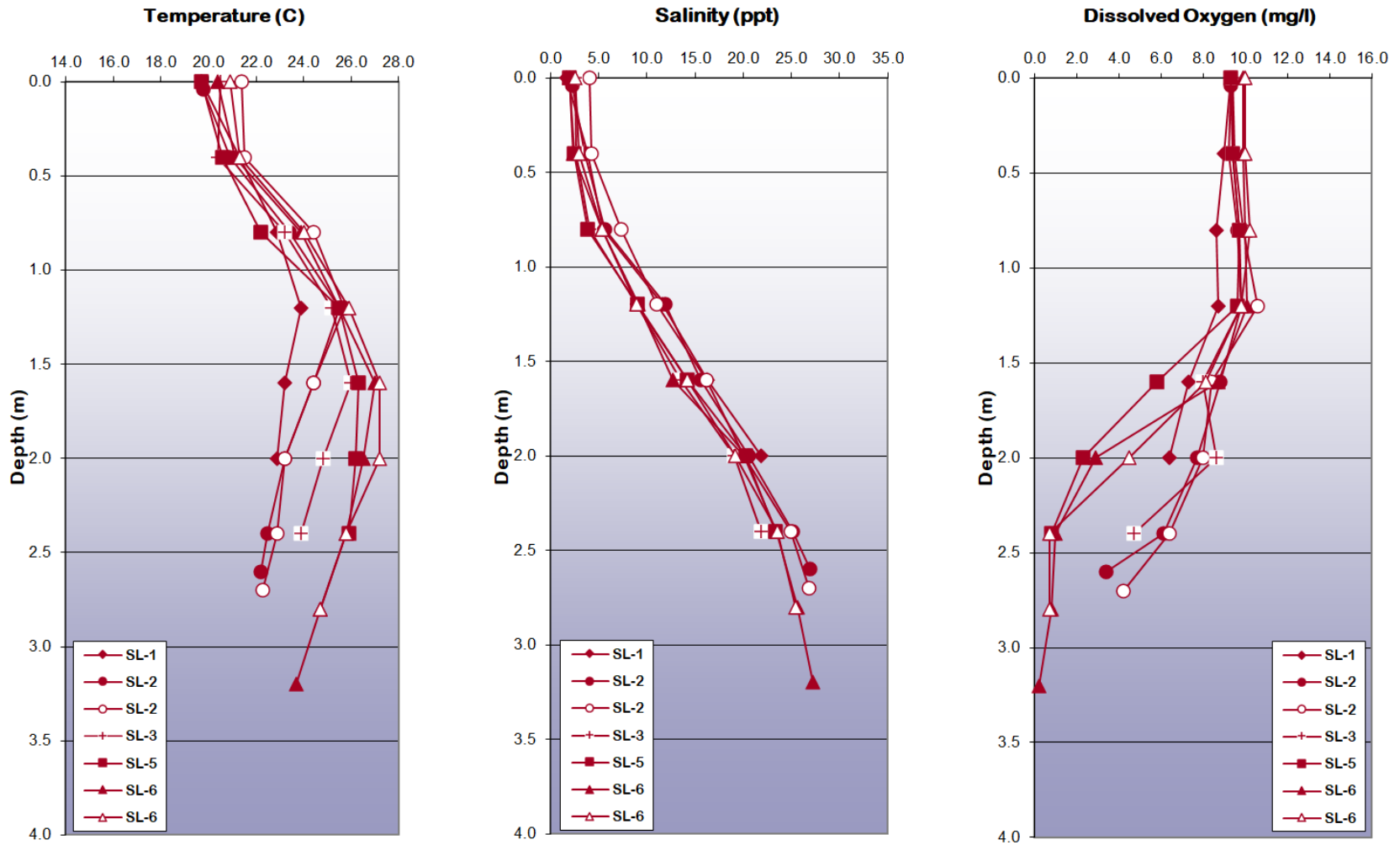


Figure 20. Depth profiles of water quality parameters in the San Lorenzo Lagoon during July 2021 Survey.



## July Survey Results

- Eleven seine hauls were completed between the beach and water quality buoy SL-3, and upstream of Riverside Bridge (Table 11).
- CPUE for *O. mykiss* was up from June (6.4 vs. 4.3) but the difference was not significant (two sample t-test,  $p > 0.10$ ). Topsmelt and staghorn sculpin numbers were down from June and Pacific herring were no longer present (Table 10, Table 11).

**Table 11. Fish catch in San Lorenzo River Lagoon, July 2021**

	SL-1	SL-2	SL-3	SL-5	SL-6	Grand Total
# Hauls	3	3		2	3	<b>11</b>
<b>Species</b>	<b>Number Caught</b>					
<i>O. mykiss</i>	3	29		19	18	69
Northern anchovy	2	3		4	7	16
Topsmelt	46	61		124	83	314
Threespine stickleback	1	1		1	42	45
Bay pipefish	1					1
Staghorn sculpin	3	12		10	38	63
Barred surfperch	1					1
Shiner surfperch	5	1				6
Tidewater goby		1			4	5
shrimp		3		5	6	<b>14</b>
<i>O. mykiss</i> CPUE	1.0	9.7		9.5	6.0	<b>6.3</b>

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

- One *O. mykiss* captured in July had been tagged in June (Table 12). This fish grew at an average rate of 0.26 mm/day. It had been tagged at SL-1 and recaptured at SL-5.
- Both modes of the size distribution shifted to larger sizes in July compared to June (Figure 21). The shift of about 10 mm to 20 mm is consistent with observed growth of the single tag recovery.
- The majority of the catch were not evaluated for smolt stage. The three fish that were examined were all at the parr stage.
- All *O. mykiss* examined (69) had an adipose fin, indicating they were not of hatchery origin.
- Fish were not examined for disease and parasites due to the warm temperatures but two fish were noted to have heavy black spot disease (BSD). Incidence of BSD in the San Lorenzo River Lagoon has ranged between 8% and 72% in annual surveys since 2009.

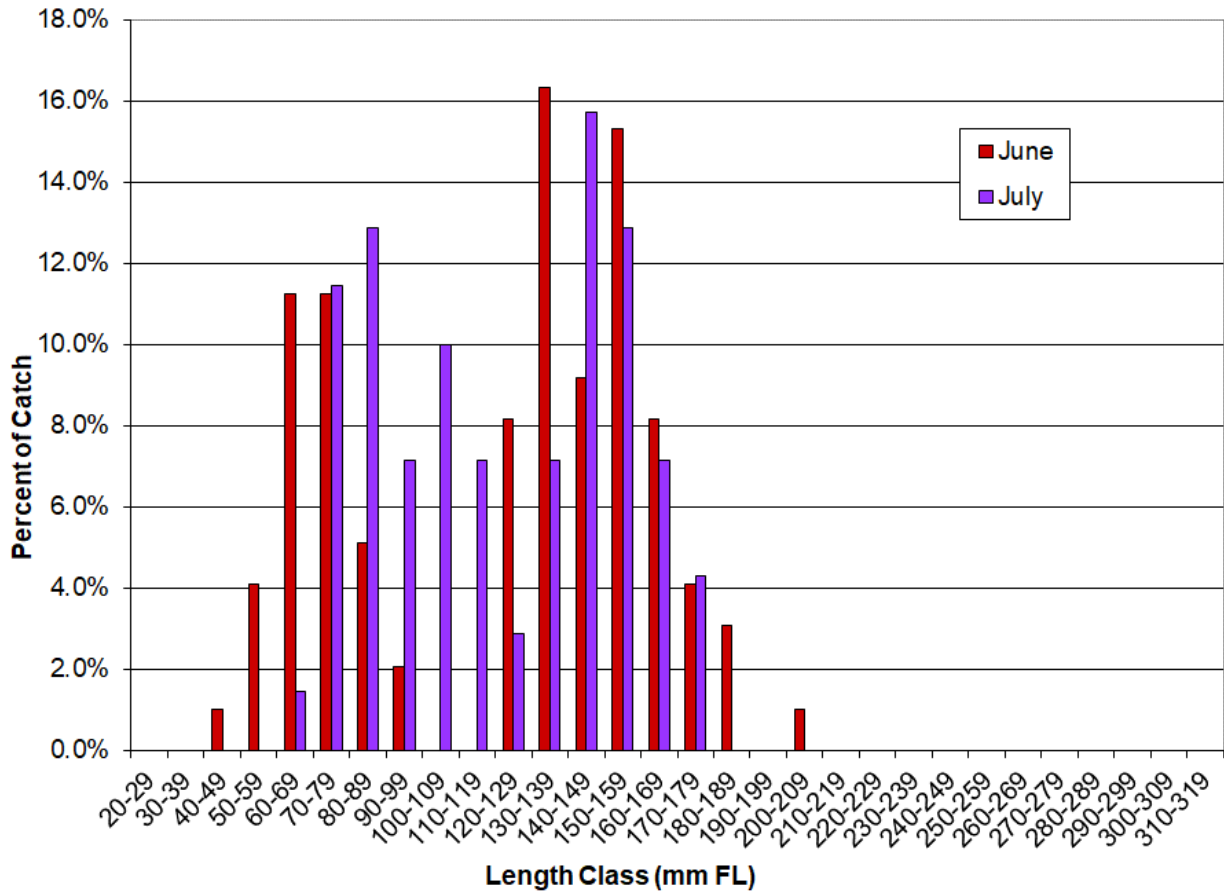


Figure 21. *O. mykiss* length classes in San Lorenzo River Lagoon during June and July 2021

Table 12. *O. mykiss* tagged in June and recaptured in July 2021

Previous Capture Date	Recapture Date	Initial Capture Location	Recapture Location	Initial Length (mm)	Length at Recapture (mm)	Growth Rate (mm/day)
06/10/21	07/14/21	SL-1	SL-5	134	143	0.26

### August Survey

The August survey was planned for August 17-18 but was cancelled due to excessive water temperatures in the lagoon measured on August 12 and 16 (Figure 22). Water temperature exceeded 21°C at all depths except surface at Stations SL-3 and SL-6 by 10:00 am on both dates, violating permit conditions for tagging and measuring<sup>5</sup> (at least half the water column at 21°C or below). Surface temperature on August 16 was 20.6°C at SL-3 and 20.9°C at SL-6 at 9:00-9:30 am and likely would have exceeded the 21°C cutoff for sampling by mid-morning.

The lagoon breached three times between the July survey and mid-August. When water quality was measured on August 12, the lagoon was filling after breaching on August 9 and may have still been open. Stage was about 3.1 feet. Inflow from the San Lorenzo River was about 4 cfs (Figure 13). On August 16 the lagoon level had only risen to 3.9 feet and inflow was still at about 4 cfs. Between August 12 and 16 the lagoon salinity was decreasing and temperature increasing. On August 16 the surface temperature at SL-3 was at 20.6°C at 9:20 am and temperature at a depth of 0.8 meters (2.6 feet) was a lethal 26.3°C. Dissolved oxygen was 6 mg/l or higher down to a depth of 1.6 meters and was increasing from the 12th to the 16th.

### September Survey

The September survey was scheduled for September 16-17 and 20-21. Water quality sampling by the City on September 8 and 17 found temperatures that exceeded CDFW collecting permit conditions<sup>5</sup>. The September 17 water quality sampling found temperatures suitable for sampling but not for tagging and measuring. Surface temperature was 17.5°C at both SL-3 and SL-6 but temperature below the surface increased to over 21°C for the rest of the water column (Figure 23, left panel). Seining was postponed until October in order to allow for tagging and completion of a population estimate.

At the time of the scheduled survey, the lagoon had last breached on August 24. The water surface elevation was at about 5.6 feet and was slowly rising. Inflow from the San Lorenzo River was about 3.2 cfs (Figure 13). Salinity increased with depth but was less than 15 ppt in the upper 1.5 meters (4.9 feet) of the water column (Figure 23, center panel). Dissolved oxygen was mostly over 8 mg/l in the upper 2 meters (6.6 feet) of the water column (Figure 23, right panel).

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<sup>5</sup> 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.

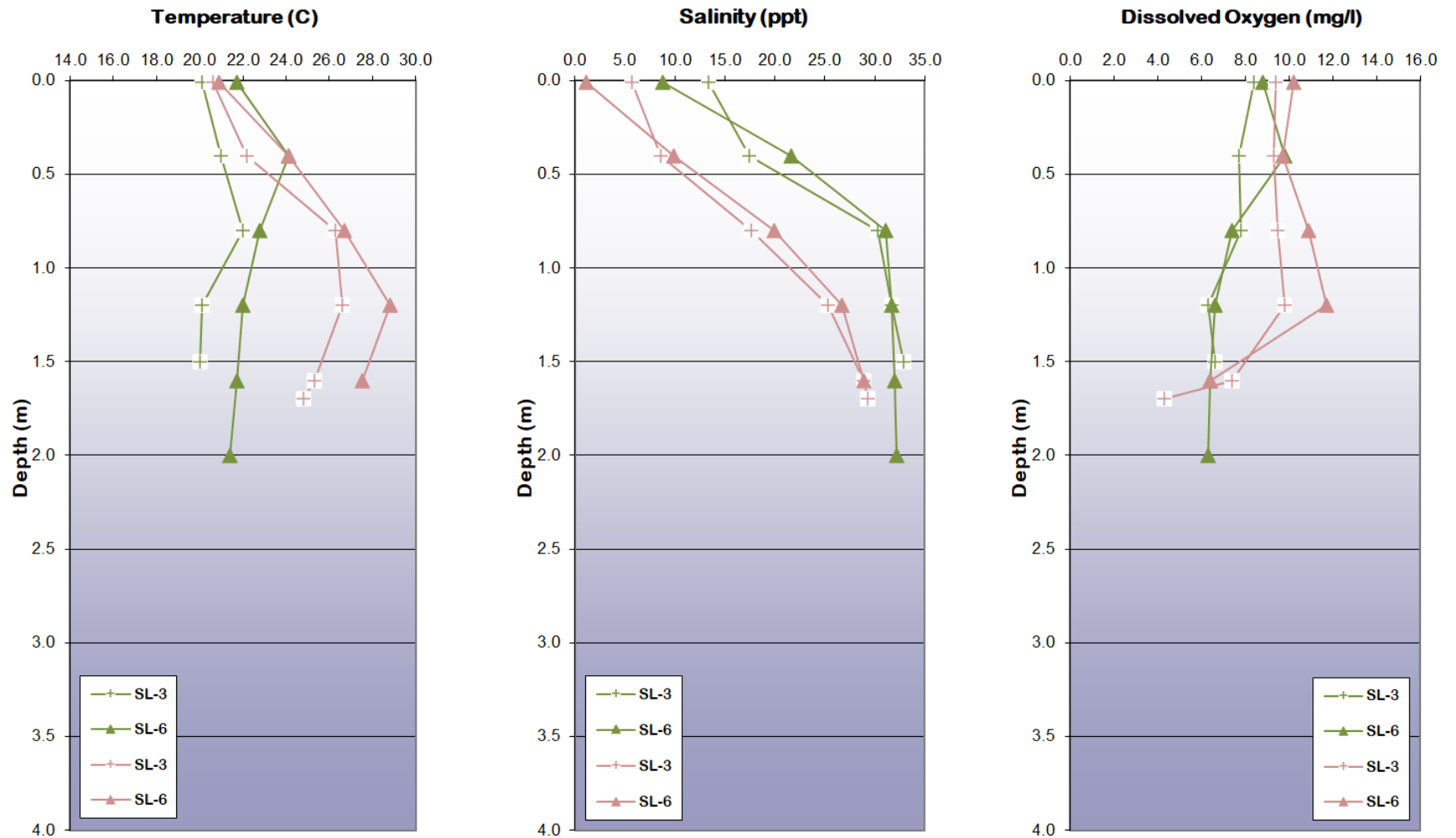


Figure 22. Depth profiles of water quality parameters in the San Lorenzo Lagoon on August 12 (green) and 16 (purple)

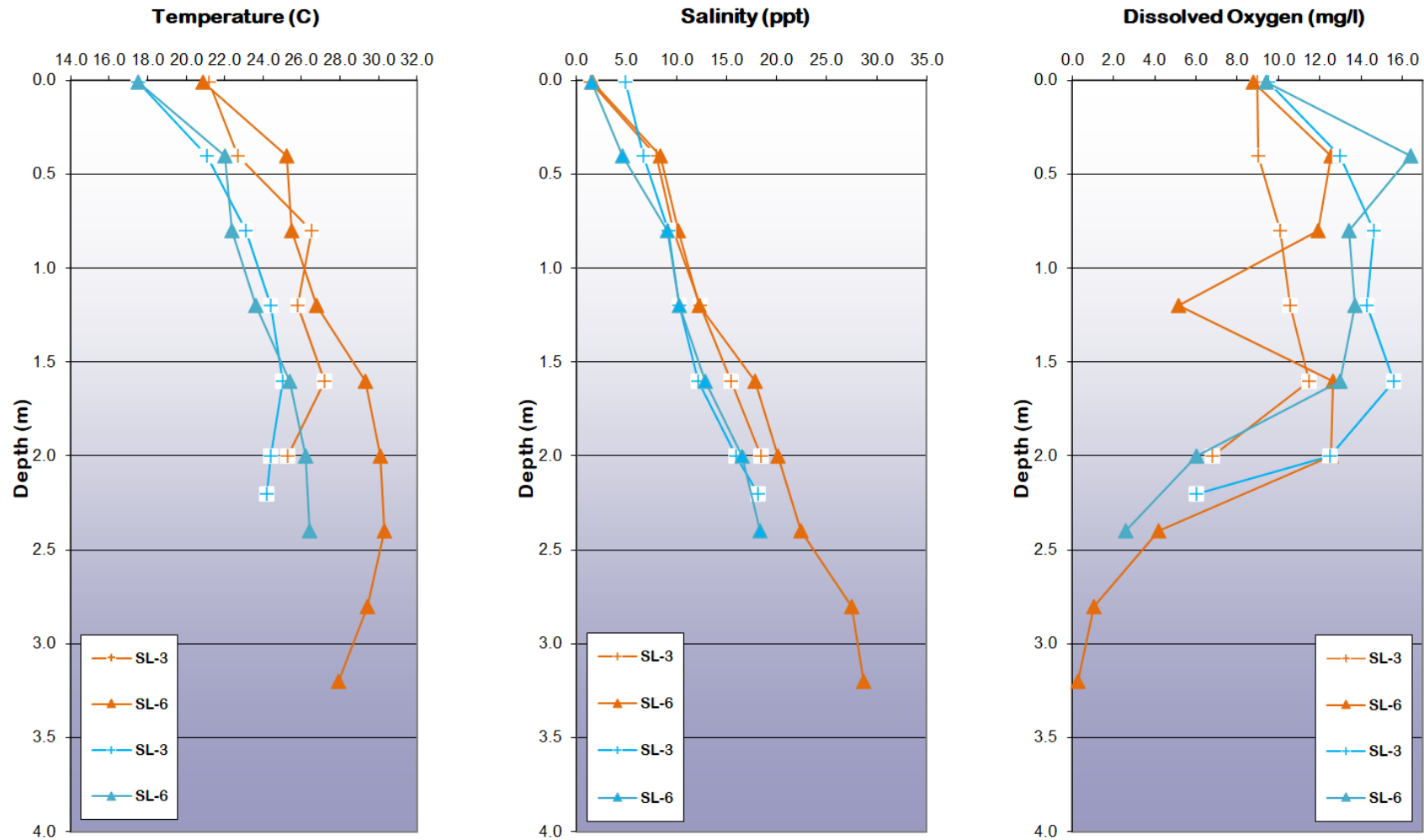


Figure 23. Depth profiles of water quality parameters in the San Lorenzo River Lagoon on September 8 (orange) and 17 (blue)

### Fall (October 12-13)

The fall survey was planned for mid-September but was rescheduled due to high water temperature (Figure 23). The October survey was abbreviated to a two-day effort since insufficient fish were captured during the marking period to complete a population estimate. Sampling was conducted at each of the regularly sampled Stations (SL-1, SL-2, SL-3, SL-5, and SL-6) (Figure 24, Figure 25). The lagoon had undergone several fill and spill cycles since the previous sampling in July. The last breach had occurred on October 7, with re-closure within less than one tidal cycle.

#### Fall Site Conditions

- The lagoon was closed and the water surface elevation ranged from 5.0 to 5.4 feet (NAVD88) during the two-day survey period. Daily average flow at Santa Cruz gage ranged from 6.9 cfs to 7.1 cfs (historical discharge, USGS site 11161000 San Lorenzo River at Santa Cruz California).
- Salinity was stratified with relatively fresh water (2.9 ppt to 8.0 ppt) in the surface 0.8 meters (2.6 feet) and increasing salinity in deeper water (Figure 26, center panel).
- Water temperature was also stratified with a relatively cool layer (12.9°C to 16.7°C) from the surface to 0.8 meters (2.6 feet) depth (Figure 26, left panel). Temperature measurements were mostly below 21°C in water less than 1.5 meters (4.9 feet) deep and were cooler at the stations near the trestle bridge; 21.5°C or less down to 2.4 meters (7.9 feet).
- Dissolved oxygen was well-mixed in the lagoon during the seining with readings of 8 mg/l or higher throughout the water column (Figure 26, right panel).
- The water column was clear with secchi disk readings of 1.9 meters to 2.3 meters (6.2 feet to 7.5 feet). Secchi disk depth was greater upstream of Riverside Bridge than near the trestle.

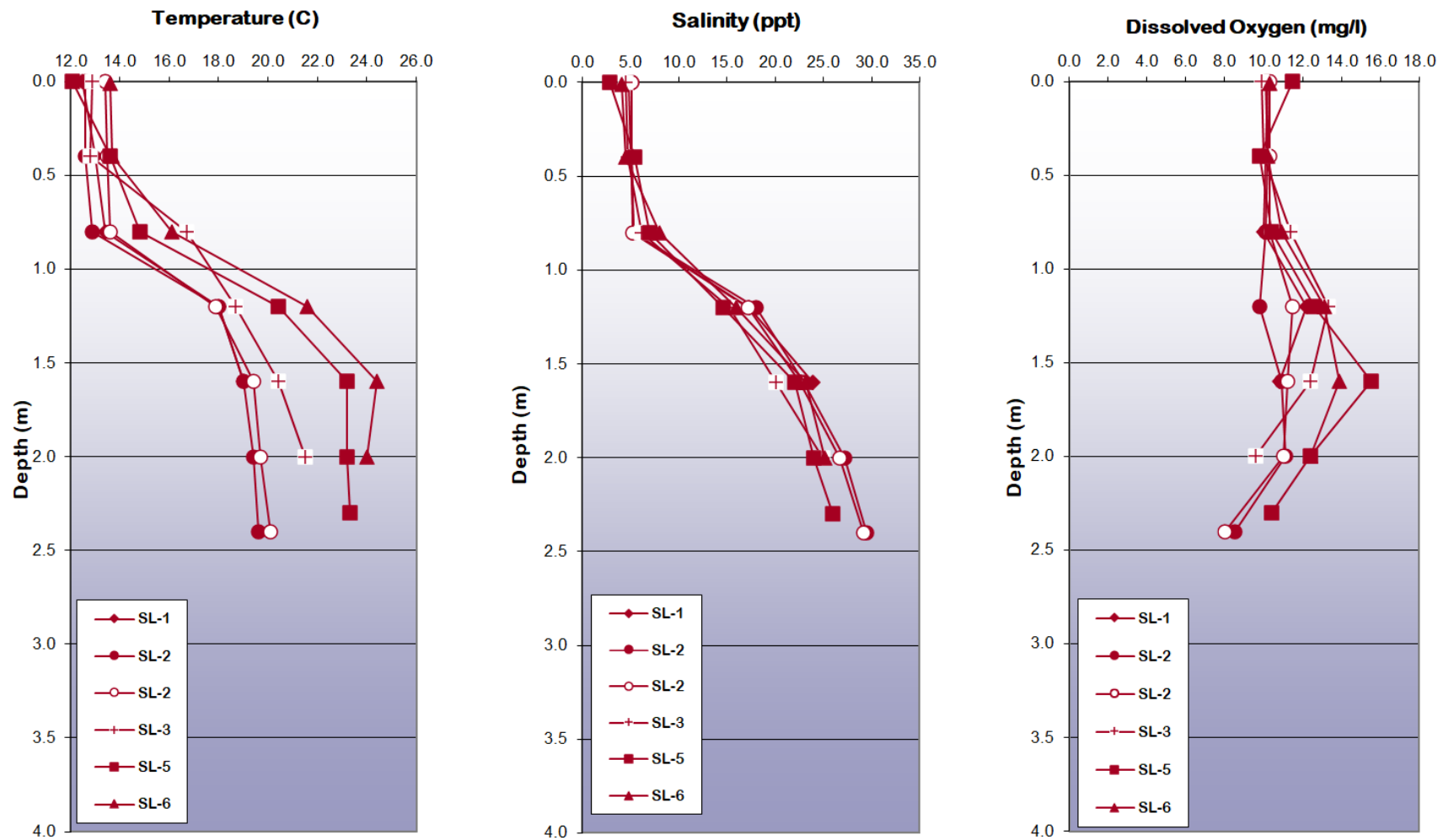




**Figure 24. San Lorenzo River Lagoon Near Trestle October 12**



**Figure 25. San Lorenzo River Lagoon Upstream of Riverside Bridge, October 13**



**Figure 26. Depth profiles of water quality parameters in the San Lorenzo River Lagoon during survey on October 12-13**

## Fall Survey Results

- Fifteen seine hauls were completed at regularly sampled Stations (SL-1, SL-2, SL-3, SL-5, and SL-6).
- Mats of dead algae were present near the substrate upstream of Riverside Bridge at Stations SL-5 and SL-6 and floating algae mats were cleared with a small seine and dip nets before sampling.
- During the marking period, a total of only three *O. mykiss* were captured (one was captured twice). None had been previously tagged. The survey was terminated after the marking period due to the low number of tagged fish.
- CPUE for *O. mykiss* at 0.3 per haul was significantly reduced from June's 4.3 per haul (ANOVA single factor, Tukey HSD,  $\alpha < .05$ ) and July's 6.3 per haul (ANOVA single factor, Tukey HSD,  $\alpha < .01$ ) (Table 7).

**Table 13. Fish catch in San Lorenzo River Lagoon, October 2021**

Species	South of Trestle (SL-1)	Around Trestle (SL-2)	Around Water Quality Station (SL-3)	Upstream of Riverside Bridge (SL-5)	Bend Downstream of Laurel Ave. (SL-6)	Grand Total
<i># Hauls</i>	3	5	2	2	3	<b>15</b>
<i>O. mykiss</i>	0	1	1	1	1	4
Northern anchovy			13			13
Topsmelt	16	150	196	18	5	385
Threespine stickleback	1	1			2	4
crab		3	3			6
<i>O. mykiss CPUE</i>	0.0	0.2	0.5	0.5	0.3	<b>0.3</b>

- The three *O. mykiss* captured were 164 mm, 203 mm, and 395 mm. Since there were no recaptures of fish tagged earlier in the season, we have no information on over-summer growth rates. This number of captures is insufficient to draw any conclusions regarding size distributions, except that the 395 mm fish was anomalous (Figure 27).
- One of the *O. mykiss* captured was somewhat emaciated and had moderate black-spot infestation (Figure 28). Another was robust with adult, non-ocean external appearance (Figure 29). The two smaller *O. mykiss* had the external appearance of silvery parr and advanced silvery parr. All three had an adipose fin.
- There was no fall population estimate due to the low number of fish captured. The relationship between CPUE and population estimates was unchanged (Figure 30).
- Only three other fish species were captured including the frequently occurring topsmelt and threespine stickleback. A few northern anchovy were also captured. This species is occasionally captured in the San Lorenzo River Lagoon.

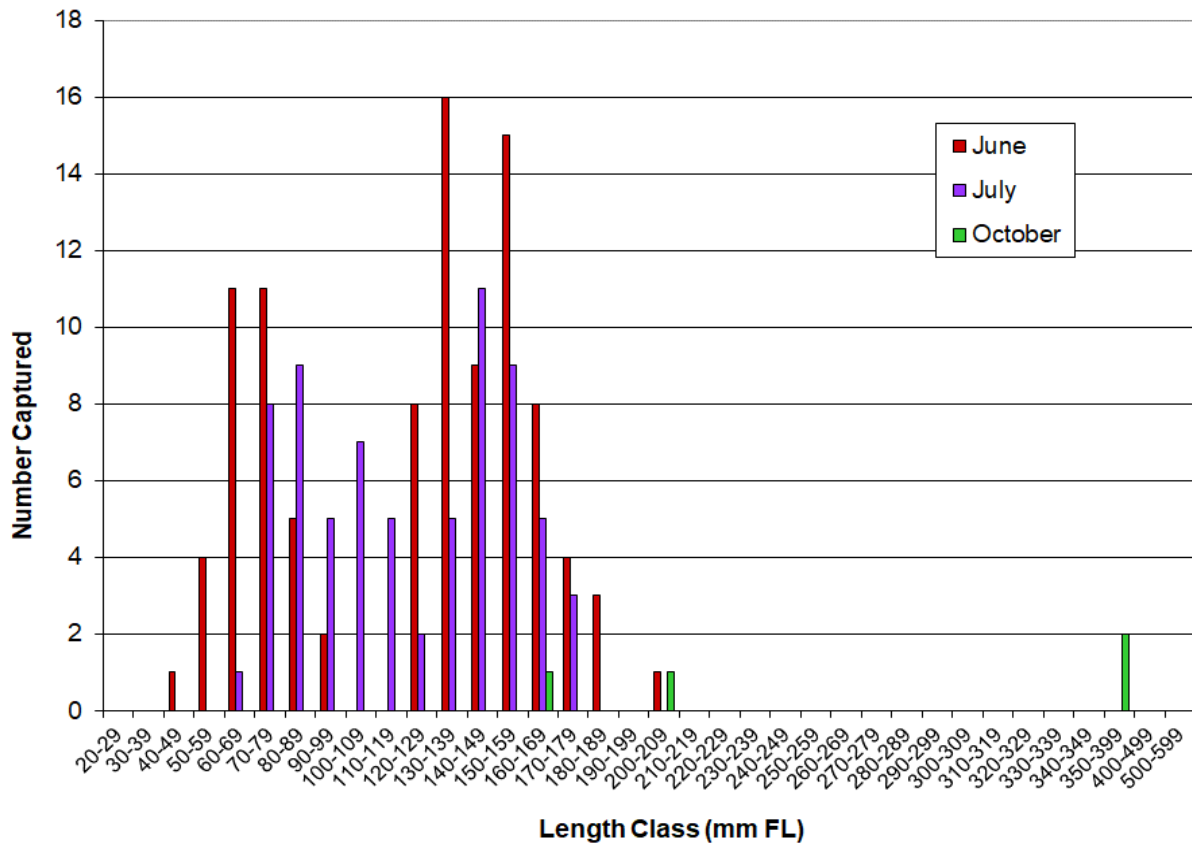


Figure 27. *O. mykiss* length classes in San Lorenzo River Lagoon during different sample periods in 2021

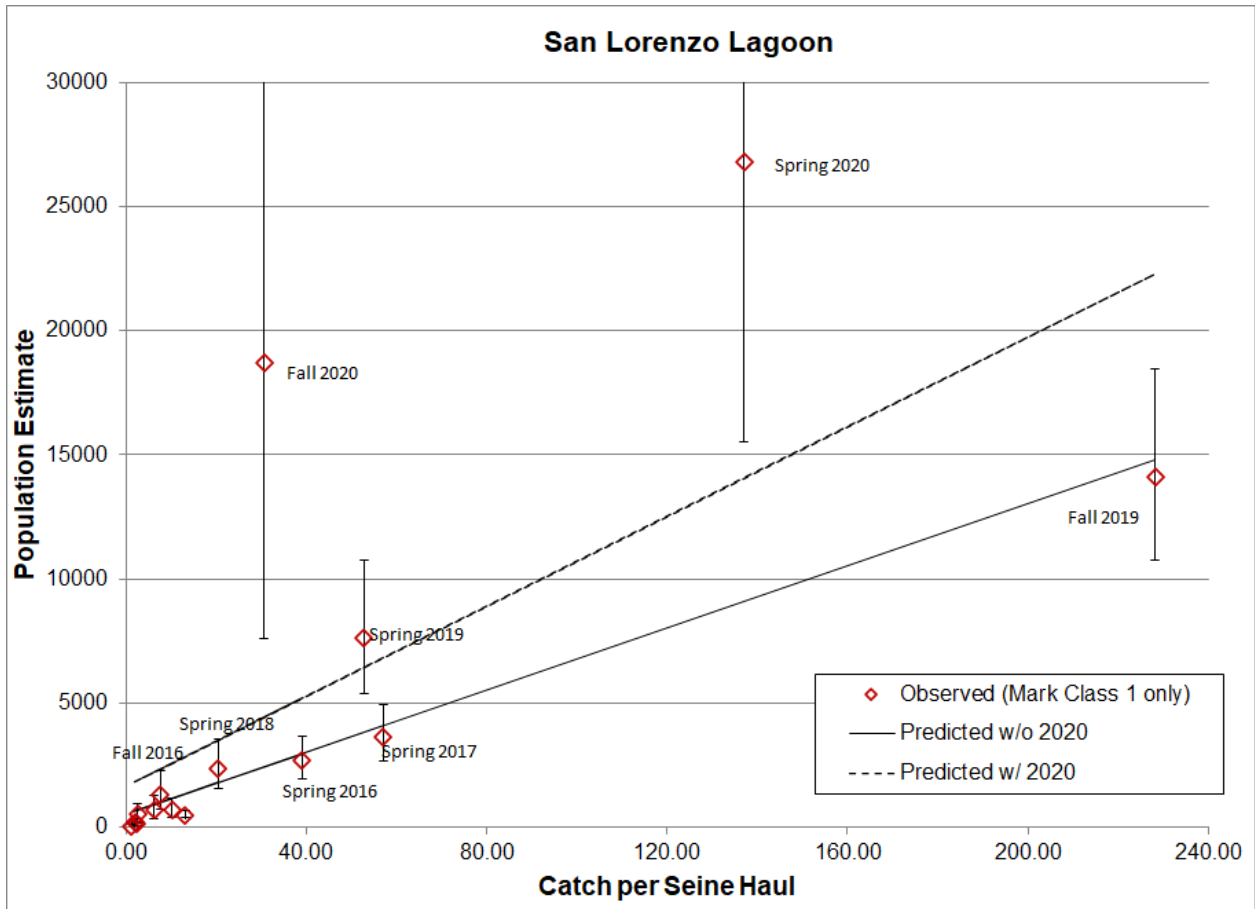


Figure 28. *O. mykiss*, 164 mm FL, October 12, Station SL-3.





**Figure 29. *O. mykiss*, 395 mm FL, October 13, Station SL-5 and SL-6.**



**Figure 30. Relationship between *O. mykiss* population estimate and CPUE in the San Lorenzo River Lagoon<sup>6</sup>**

<sup>6</sup> The Early Summer 2013 and Early Summer 2015 estimates are likely biased due to the small number of marked fish and small number of recaptures. Population estimates are not available for Late Summer 2013 and Early Summer 2014 due to low recapture rates and indications that the assumption of closed population was violated (2013) or lack of recaptures (2014). No *O. mykiss* were captured in Late Summer 2014 and Late Summer 2015 so CPUE was zero and populations were also assumed to be near zero. CPUE values adjusted to reflect portion of population in tagging size range only.



## Felton PIT tag monitoring

- PIT tag detections at the NOAA PIT tag antenna at Felton were provided by the NOAA Santa Cruz lab (J. Kiernan, NOAA Fisheries Santa Cruz, personal communication, May 4, 2022). Only 20 *O. mykiss* were tagged in the San Lorenzo Lagoon in 2021. None of these fish had been recorded at Felton by April 1, 2022.
- One tag from Laguna Lagoon, implanted in a 124 mm, parr-stage *O. mykiss* on September 15, 2021 was recorded at Felton on March 11, 2022.
- Past observations at Felton indicate that the majority of *O. mykiss* tagged in the lagoon are observed at Felton in the same year they are tagged (Table 14). The number of tagged *O. mykiss* observed at Felton does not appear to be related to the number tagged in the lagoon (Total in Table 14 compared to Number Tagged).
- Consistently, a few *O. mykiss* tagged in Laguna Creek are observed at Felton (Table 15). The common pattern is for tags implanted in June or September to be observed at Felton in November of the same year or March of the following year, and in one case both.
- Lagoon tags have been observed at Felton every month of the year but are most frequently observed in November, December, and March (Table 16).

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

Year Tagged	Number Tagged	Number of Observations at Felton <sup>7</sup>							
		2016	2017	2018	2019	2020	2021	2022	Total
2016	508	142	27	23	15	2			209
2017	924		86	55	31	5	1		178
2018	593			43	25	7	5		80
2019	2098				129	78	22	3	232
2020	691					4	17	1	22
2021	20								0
Grand Total		142	113	121	200	96	45	4	721

<sup>7</sup> Includes tags that were observed multiple times

**Table 15. *O. mykiss* tagged in the Laguna Creek Lagoon and later observed at Felton**

Year Tagged	Number Tagged	Number of Observations at Felton					
		2016	2017	2018	2021	2022	Grand Total
2016	87	1					1
2017	335		1	1			2
2020	269				1		1
2021	175				1	1	2
Grand Total		1	1	1	2	1	6

**Table 16. Tagged *O. mykiss* observed at Felton by month**

Month	Number of Observations at Felton							
	2016	2017	2018	2019	2020	2021	2022	Grand Total
Jan		2	16	14	7	3	1	<b>43</b>
Feb		1	9	11	18	8	1	<b>48</b>
Mar		15	36	24	52	20	2	<b>149</b>
Apr		4	10	13	11	9		<b>47</b>
May		1	4	7	3	2		<b>17</b>
Jun	2			1	2			<b>5</b>
Jul	6	5	12	1	1			<b>25</b>
Aug	2	3	3	2				<b>10</b>
Sep		3	1	3				<b>7</b>
Oct	13		1	2		1		<b>17</b>
Nov	90	78	14		1			<b>183</b>
Dec	29	1	15	122	1	2		<b>170</b>
Total	142	113	121	200	96	45	4	721

## Appendix A

**Table A-1. *O. mykiss* catch per haul for the San Lorenzo River Lagoon during sampling events (data from H.T. Harvey and Associates 2003, 2NDNATURE 2006, Ellen Freund (NOAA Fisheries), HES 2005, HES 2009, HES 2010, HES 2011, HES 2012, HES 2013, HES 2014, HES 2015, HES 2016, HES 2017, HES 2018a, HES 2019, and HES 2020)**

Station	Location	<i>O. mykiss</i> Catch per Haul					
<b>2002</b>						Oct 1	Nov 20
SL-2	RR Trestle						0.0
SL-3	Near YSI Station					5.5	
SL-4	Below Riverside						
SL-5	Riverside Drive						9.0
SL-7	Laurel St.						1.0
SL-8	Soquel Ave.					20.0	0.3
<b>2004</b>			July 6		Sep 21	Sep 29	
SL-1	Near Mouth				0.0	0.0	
SL-2	RR Trestle		24.5			0.5	
SL-3	Near YSI Station		20.0				
SL-4	Below Riverside		0.0				
SL-5	Riverside Drive		62.0		0.0	0.0	
SL-6	U/S Bank Restoration		3.0			0.0	
SL-7	Laurel St.		3.0				
SL-8	Soquel Ave.				0.0	0.0	
<b>2005</b>		Jun 14	Jul 14	Aug 16		Oct 5	
SL-1	Near Mouth	0.0	0.0	1.7		0.0	
SL-2	RR Trestle	28.0	5.3	179.5		0.0	
SL-5	Riverside Drive	0.0	12.3	10.7		62.7	
SL-8	Soquel Ave.	7.7	1.0	0.0		0.0	
<b>2008</b>		Jun 8, 19				Oct 7-8	
SL-1	Near Mouth	0				0	
SL-2	RR Trestle	9				0.25	
SL-3	Near YSI Station	0				0	
SL-5	Riverside Drive	0				0	
SL-6	U/S Bank Restoration	0				0	
SL-8	Soquel Ave.	0				0	
	<b>Overall</b>	<b>2.6</b>				<b>0.1</b>	
<b>2009</b>		Jun 10-11			Sep 16	Oct 21	
SL-2	RR Trestle	0.75			1.0	0.25	
SL-3	Near YSI Station	0.25					
SL-5	Riverside Drive	0				0	
SL-6	U/S Bank Restoration	0				1.5	
	<b>Overall</b>	<b>0.3</b>			<b>1.0</b>	<b>0.5</b>	
<b>2010</b>		Jun 22-23	Jul 17			Oct 6-7	
SL-1	Near Mouth	0.0				0	
SL-2	RR Trestle	11.7	0.5			31.3	
SL-3	Near YSI Station		42.5			0	
SL-5	Riverside Drive	0.0				9.0	
SL-6	U/S Bank Restoration	6.0				80.0	
	<b>Overall</b>	<b>7.7</b>	<b>21.5</b>			<b>28.25</b>	
<b>2011</b>		Jun 9-14				Oct 13-18	
SL-2	RR Trestle	11.7				1.7	
SL-3	Near YSI Station	7.8				5.7	
SL-4	Near Marsh Outlet	16.0				1.0	
SL-5	Riverside Drive	48.5				2.2	
SL-6	U/S Bank Restoration	0.5				0.3	
	<b>Overall</b>	<b>13</b>				<b>2.5</b>	

**Table A-1 (continued)**

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

<sup>8</sup> Standard sites only (SL1-SL6) used in Overall calculation

**Table A-1 (continued)**

Station	Location	<i>O. mykiss</i> Catch per Haul					
		Jun 7-12	Jul 16-17	Aug 14-15	Sep 20-25		
<b>2018</b>							
SL-1	South of Trestle	12.8	5.3	8.5	8.8		
SL-2	RR Trestle	20.5	0.0	1.5	6.0		
SL-3	Near YSI Station	11.0	0.5	0.0	3.0		
SL-5	Riverside Drive	59.8	2.5	14.5	3.0		
SL-6	U/S Bank Restoration	14.8	2.8	5.3	7.3		
	<b>Overall</b>	<b>23.3</b>	<b>2.5</b>	<b>6.4</b>	<b>6.3</b>		
<b>2019</b>		Jun 13-18	Jul 16-17	Aug 13-14	Sep 19-24		
SL-1	South of Trestle	1.0	10.0	49.7	7.2		
SL-2	RR Trestle	55.8	95.7	440.0	509.0		
SL-3	Near YSI Station				35.0		
SL-5	Riverside Drive	274.4	59.0	457.5	462.3		
SL-6	U/S Bank Restoration	40.5	22.0		66.6		
	<b>Overall</b>	<b>92.2</b>	<b>53.4</b>	<b>277.7</b>	<b>228.2</b>		
<b>2020</b>		11-16 Jun	Jul 7-8	Aug 19-20*	Sep 17-22		
SL-1	South of Trestle	70.5	29.5	NS	0.1		
SL-2	RR Trestle	75.0	369.0	NS	30.1		
SL-3	Near YSI Station	155.0	NS	NS	NS		
SL-5	Riverside Drive	257.0	70.5	NS	19.0		
SL-6	U/S Bank Restoration	207.3	13.5	NS	83.8		
	<b>Overall</b>	<b>146.1</b>	<b>120.6</b>	NS	<b>30.7</b>		
<b>2021</b>		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	
	<b>Overall</b>	<b>4.3</b>	<b>6.3</b>	<b>NS</b>	<b>NS</b>	<b>0.3</b>	





Figure A-1. Laguna Creek Lagoon sampling stations

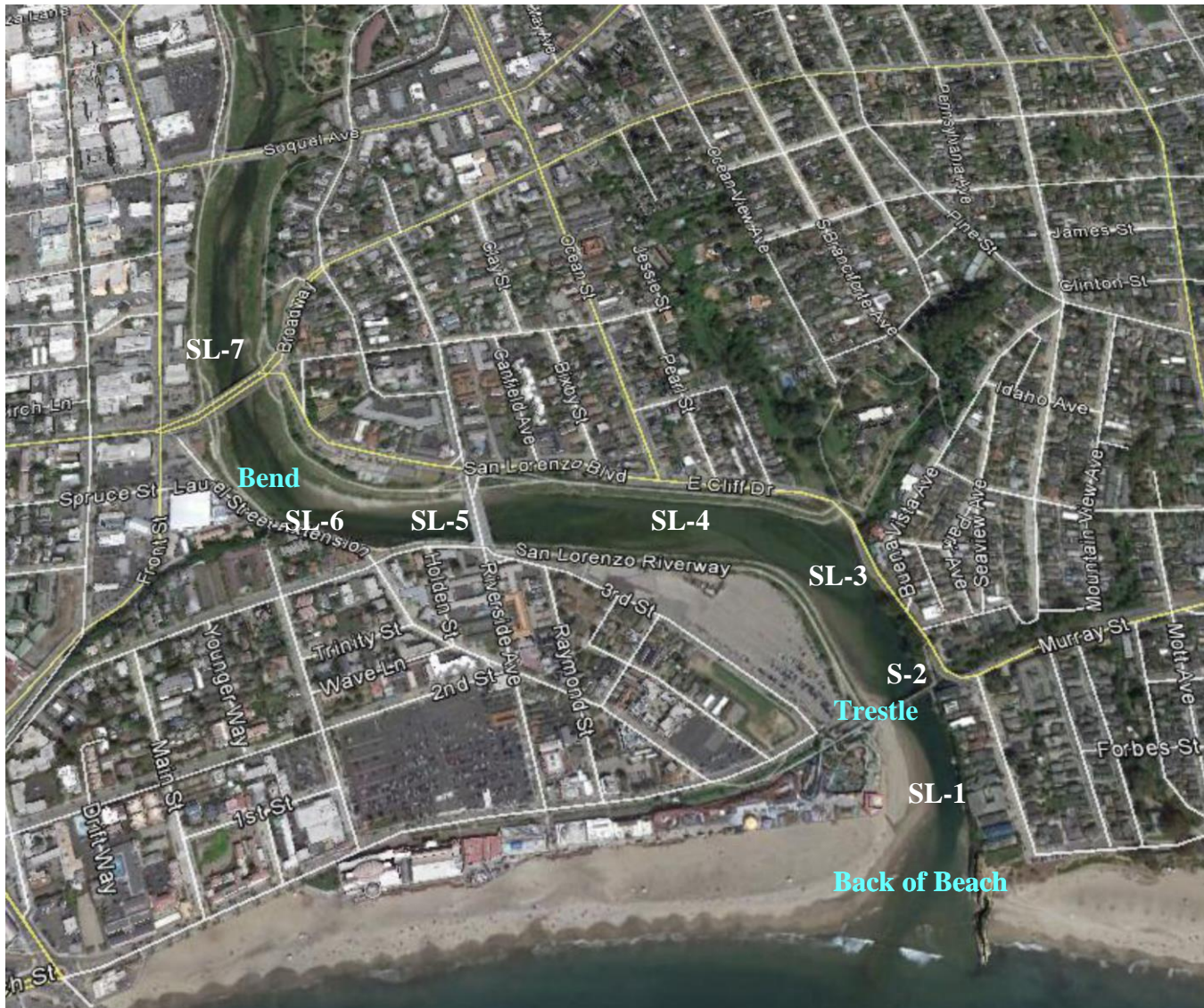


Figure A-2. San Lorenzo River Lagoon sampling stations

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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.
- Bond, R.M., J.D. Kiernan, A.K. Osterback, C.H. Kern, A.E. Hay, J.M. Meko, M.E. Daniels, and J.M. Perez. 2021. Spatiotemporal Variability in Environmental Conditions Influences the Performance and Behavior of Juvenile Steelhead in a Coastal California Lagoon. *Estuaries and Coasts* (2021). <https://doi.org/10.1007/s12237-021-01019-9>
- Hayes, S.A., M. H., Bond, C. V. Hanson, A.W. Jones, A. J. Amman, J. A. Harding, A. L. Collins, J. Perez, and R. B. MacFarlane. 2011. Down, Up, Down and "smolting" twice? Seasonal movement patterns by juvenile steelhead in a coastal watershed with a bar closing estuary. *Canadian Journal of Fisheries and Aquatic Sciences* 68:1341-1350.
- 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. 2018a. City of Santa Cruz Habitat Conservation Plan, Lagoon Fish Population Sampling 2017. Technical Memorandum, June 29, 2018.

- HES. 2018b. San Lorenzo River Temporary Outlet Channel (TOC) – July 18, 2018, Biological Monitoring. Technical Memorandum, July 31, 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.
- 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.