
TECHNICAL MEMORANDUM

TO: Chris Berry
City of Santa Cruz Water Department

FROM: Jeff Hagar
Hagar Environmental Science

DATE: June 24, 2014

PROJECT: City of Santa Cruz Habitat Conservation Plan, Lagoon Fish Population Sampling 2013

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 2013 by the City of Santa Cruz Water Department and Hagar Environmental Science (HES). Surveys were conducted in the early summer and again in the fall using a large seine (150 ft. long by 8 ft. deep). In 2013 an additional one-day survey was conducted in the San Lorenzo Lagoon during July. Mark-recapture abundance estimates for *O. mykiss* were completed in both lagoons during both the June and September sampling periods using PIT tags. 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 (in the San Lorenzo Lagoon there were two days between the mark and the recapture period). During July only catch per unit effort (CPUE) was assessed, no PIT tagging was implemented. A summary of the results of the survey follows.

Laguna Creek

Summary

The lagoon had already closed when monitoring equipment was installed on May 16 (Figure 1). The date of closure is unknown. It likely closed early due to dry conditions and low inflow. The lagoon did not close until July in both 2012 and 2011. The lagoon stage was relatively high throughout the monitoring period in 2013 with the over-wash pond connected with the main channel just south of the water quality station (Figure 2).

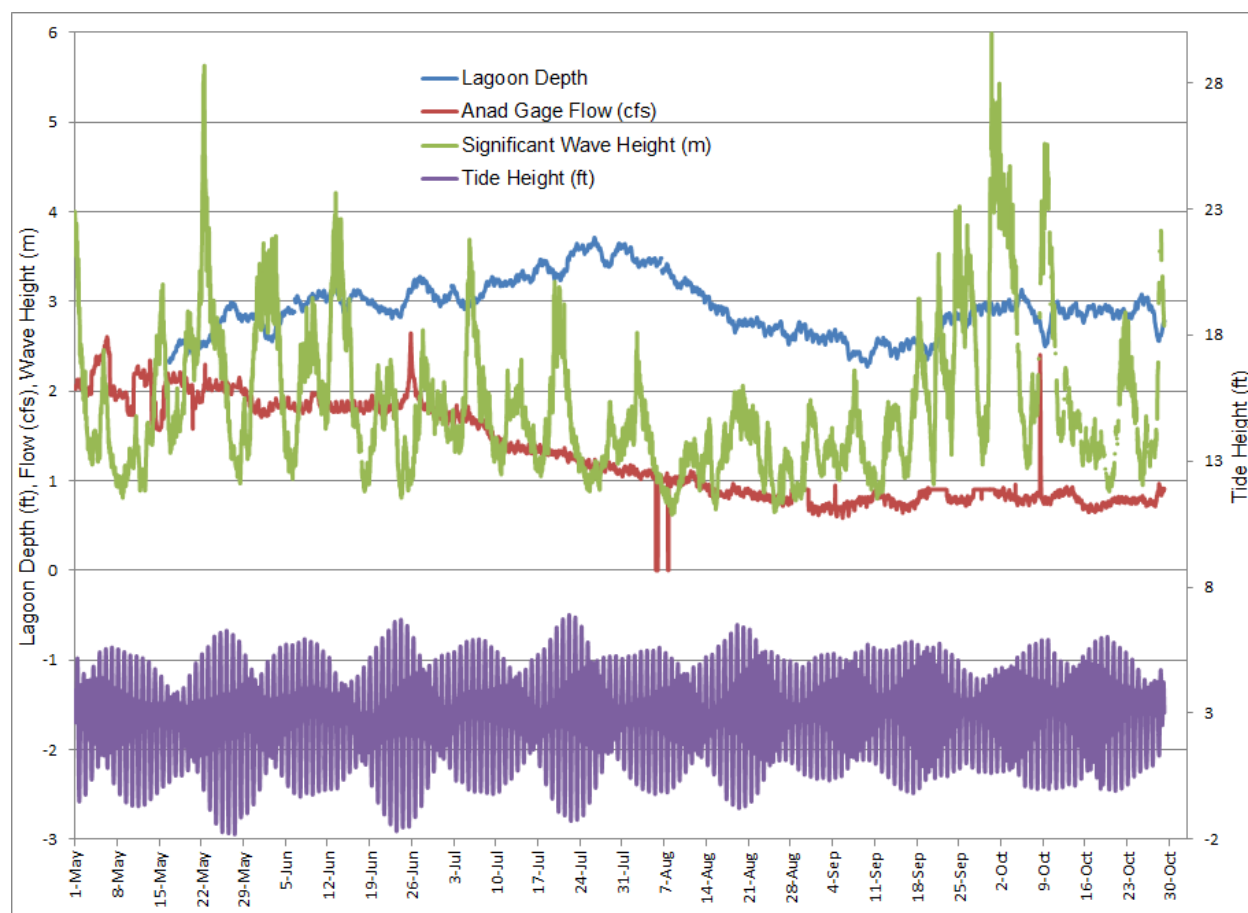


Figure 1. Laguna Creek Lagoon stage, streamflow, wave height, and tides 2013, preliminary data (Source: lagoon stage from 2ND Nature, streamflow from Balance Hydrologics, wave and tide data from NOAA)

Large numbers of large *O. mykiss* were present in the lagoon in June and declined over the summer. These were likely fish that were prevented from going to sea by early closure of the lagoon. CPUE and population estimate in June were the highest observed to date and the

majority of fish were smolt-size (140-190mm) or larger. Only 8% of the catch had the external appearance of smolts, though 62% were characterized as silvery parr. By September the number of *O. mykiss* had declined with the population estimate about half the number in June. The larger *O. mykiss* size classes were less abundant than in the June survey, indicating that these fish had left the lagoon or perished. On the other hand, smaller fish in the 110-170mm mode must have migrated into the lagoon after June since fish that would have grown into this size class were at low abundance in June.

Spring (June 4-5)

Spring Site Conditions

- o Mouth closed, lagoon stage high (Figures 2-4). The surface area at the ocean end was extensive with a narrow arm to the northwest along the beach. The backwater pond was connected with the main channel near the water quality buoy. Stage recorded at the water quality buoy was 2.8 to 2.9 feet during sampling.
- o Inflow from Laguna Creek at 1.8 to 1.9 cfs.
- o Maximum depth to about 6 feet.
- o Lagoon fresh throughout, salinity 0.3 ppt or less, temperature ranging from 15.6°C to 16.9°C at surface and 14.3°C to 14.5°C at the bottom; dissolved oxygen 9.2 mg/l or more (saturation 93% to over 100%).
- o The water column was clear with substrate visible at all locations (to 6 feet).
- o The over-wash pond was full and connected to main lagoon at channel south of water quality buoy.



Figure 2. Overview of Laguna Creek Lagoon, June 5, 2013



Figure 3. Laguna Creek Lagoon, June 4, 2013 near Station 2



Figure 4. Laguna Creek Lagoon, June 5, 2012, for comparison

Spring Survey Results

- o *O. mykiss* were captured and tagged on June 4. On June 5 the lagoon was re-sampled and the proportion of re-captured fish was recorded.
- o Eight seine hauls were completed between the beach and the water quality monitoring station (LA-3) (Table 1).
- o CPUE for *O. mykiss* highest since sampling started in 2004 (Table 2).
- o The majority of the catch included two or possibly three size classes of *O. mykiss*: 120-170mm or 200mm FL, and 200-240mm or 250 mm FL or larger (Figure 5). Typically, *O. mykiss* in Laguna Creek Lagoon are between 90 and 170mm FL in June. In 2013, 63% of the total catch was 170mm FL or larger. Previous age and growth analyses of *O. mykiss* captured in June 2011 indicated that fish from about 95-160mm FL had just completed their first year of growth while two larger fish (223 and 234mm FL) were age 2+ or 3+. It is possible that many larger *O. mykiss* that would have migrated as smolts were trapped by early closure of the lagoon. A small number of *O. mykiss* were captured at lengths of 50-69mm. These are presumed to be young-of-year (yoy).
- o A limited number of scales were collected for age determination (Table 3). Four samples from the 120- 170mm length mode were all assigned to age 1+. A 241 mm and 318mm length fish were also assigned to age 1+. It is likely that both these individuals entered the lagoon as yoy to reach this size at age 1+. The 318mm fish had actually been tagged the previous fall (September 11) at a length of 207mm (Table 4). Length at annulus of this fish was estimated at 240mm, yielding another 33mm of growth after initial capture. Three *O. mykiss* at lengths of 280-300mm were assigned to age 2+. Based on second year growth rates (Table 3), it appears that these three spent at least a portion of the previous year in the lagoon. One of these fish had been tagged in the lagoon in September 2012 at a length of 171mm (Table 4).
- o The catch consisted of twenty-nine percent parr, 62% silvery parr or advanced silvery parr, 8% smolts, and 1 fish that had adult coloration.
- o Two *O. mykiss* tagged in the fall of 2012 were recaptured in spring 2013. Growth rate over the intervening period was 0.41 and 0.42mm/day. Scale samples were taken from both at time of recapture (Table 4).
- o Sea lice were present on approximately 3% of *O. mykiss* captured. *Salmonicola* was also observed.
- o All *O. mykiss* had an adipose fin intact.
- o The over-wash pond was not sampled.

Table 1. Fish catch in Laguna Creek Lagoon, June 2013

Species	LA-1	LA-2	LA-3	Grand Total
	June 4 and 5			
<i># Hauls</i>	5	2	1	8
<i>O. mykiss</i>	142	48	32	222
Threespine stickleback	10			10
Staghorn sculpin	4	4	1	9
<i>O. mykiss CPUE</i>	28	24	32	28

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

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

	<i>O. mykiss</i> Catch per Haul				Coho Catch per Haul			
	Jun	Jul	Sep	Oct	Jun	Jul	Sep	Oct
2004		2.4	0			0	0	
2008	11		6		0		0	
2009	7		19		0		0	
2010	13			1.7	0			0
2011	19.8			0.1	0			0
2012	11.3		10.3		0		0	
2013	28		8.6		0		0	

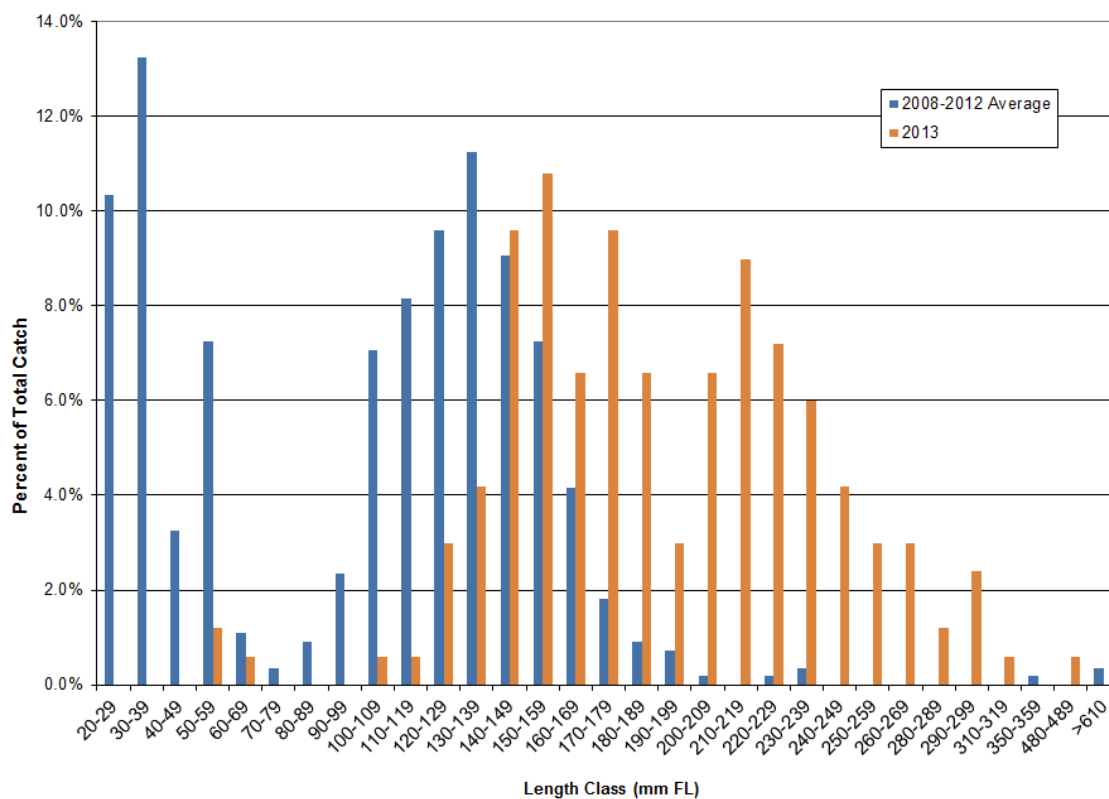


Figure 5. June *O. mykiss* length classes in Laguna Creek Lagoon in 2013 compared to 2008-2012 average

Table 3. Results of Age Determination of Juvenile *O. mykiss* in Laguna Creek Lagoon, 2013 (courtesy of Jon Jankovitz, California Department of Fish and Wildlife (CDFW))

Date	Length (mm FL)	Age	Length at Annulus 1	Length at Annulus 2	Length at Annulus 3
5-Jun	128	1+	76		
4-Jun	135	1+	73		
4-Jun	149	1+	74		
4-Jun	155	1+	91		
4-Jun	241	1+	112		
4-Jun	281	2+	123	214	
4-Jun	283	2+	91	241	
4-Jun	297	2+	93	258	
4-Jun	318	1+	240		
10-Sep	142	yoy			
11-Sep	199	1+	83		
10-Sep	237	1+	105		

*tagged in September 2012

+tagged in June

Table 4. Laguna Creek *O. mykiss* tagged in September 2012 and recaptured in June 2013

Initial Capture Date	Recapture Date	Initial Length	Length at Recapture	Growth Rate (mm/day)
9/11/2012	6/4/2013	207	318	0.42
9/11/2012	6/4/2013	171	281	0.41

Spring *O. mykiss* Population Estimate

- o A total of 135 *O. mykiss* were captured on June 4. Three were 65mm or less and were not tagged. One was 483mm FL and was released untagged (fish larger than 370mm FL are not tagged). Thirty *O. mykiss* captured on June 4 had also been tagged on June 4. Therefore, a total of 101 *O. mykiss* were uniquely marked by insertion of a PIT tag in the abdominal cavity during the mark period.
- o On June 5, a total of 87 *O. mykiss*, all between 65mm FL and 370mm FL, were captured. Of these, 17 had been marked on June 4.
- o Population estimate using the Petersen method (Ricker 1975) is 499 *O. mykiss* between 65 and 370mm FL in the lagoon on June 5. The 95% confidence limits for this estimate are 318 and 773.

Fall (September 10-11)

Fall Site Conditions

- o Mouth was closed, stage high (stage read 4.14 ft. at WQ gage, shows about 2.5 ft. for sampling dates in 2nd Nature data). (Figure 6).
- o The lagoon had remained closed since the June survey. Water quality monitoring data indicates periods of slightly elevated bottom salinity in early June and mid-July lasting for one to two weeks (2nd Nature preliminary data), likely due to waves overtopping the beach. The lagoon remained closed through the end of the year. Stage was relatively stable through the summer at 2.5 to 3.5 feet (Figure 1).
- o Higher DO levels at Station 2 than downstream stations, especially at bottom. Bottom DO was about 5 mg/l downstream of Station 2. Could result from seepage of high nutrient/low DO water from pond into main lagoon.
- o Coldest, most oxygenated water on bottom at Station 2-3



Figure 6. Laguna Creek Lagoon, September 11, 2013.

Fall Survey Results

- o *O. mykiss* were captured and marked on September 10. On September 11 the lagoon was re-sampled and the proportion of re-captured fish was recorded.
- o Six seine hauls were completed on September 10 and 7 hauls on September 11 between beach (LA-1) and water quality monitoring station (WQ Station) (Table 5).
- o Overall abundance of *O. mykiss* based on number caught per seine haul (catch per unit effort or CPUE) was within the range of previous years surveys (Table 2).

- o *O. mykiss* ranged in size from 110mm to 500mm (FL). There were two modes in the length distribution: 110mm to 170mm and 170mm to 220mm with a few outliers up to 270mm (Figure 7).
- o The larger *O. mykiss* size classes were less abundant than in the June survey, indicating that these fish had left the lagoon (gone back upstream?) or perished. On the other hand, the 110-170mm mode must have migrated into the lagoon after June since fish that would have grown into this size class were at low abundance in June (Figure 7).
- o The majority of *O. mykiss* in size classes of 180mm or larger had the external coloration and appearance of adult stream fish (no parr marks, not particularly silvery, not thin, no blackened caudal margin, and “rainbow” coloration). The rest were characterized as parr (48% of catch) or silvery parr (15% of catch).
- o Many *O. mykiss* captured in September in the smaller length mode (110mm to 169mm in Figure 7) could have been yoy based on age determination of one individual at 142 mm (Table 3). Age of two individuals in the larger mode (170mm to 249 mm, Table 7) was determined as 1+ (Table 3).
- o Ten *O. mykiss* captured in September had been tagged in June and one had been tagged in fall 2012. Growth rates for these fish ranged from 0.22mm/day to 0.78mm/day for fish tagged in June with growth rate inversely related to fish size in June (Table 6). Growth of the single individual marked in September 2012 and recaptured in September 2013 was only 0.29mm/day. Growth rate in Laguna Creek Lagoon in 2013 was lower than that observed in the San Lorenzo Lagoon during 2012 for larger fish (the San Lorenzo fish could have also spent some time in the ocean as the lagoon breached repeatedly in 2012).
- o The over-wash pond was not sampled.
- o Sea lice were present on approximately 20% of the *O. mykiss* captured.
- o All *O. mykiss* had an adipose fin intact.
- o Majority of *O. mykiss* were captured upstream of the backwater pond outlet in water with higher DO content.

Table 5. Fish catch in Laguna Creek Lagoon, September 2013

Species	LA-1	LA-1.5	LA-2	LA-3	Grand Total
# Hauls	4	4	4	1	13
<i>O. mykiss</i>	12	15	85		112
threespine stickleback	329	216	199	31	775
Prickly sculpin	1				1
tidewater goby	9				9
<i>O. mykiss</i> CPUE	3	3.75	21.25	0	8.6

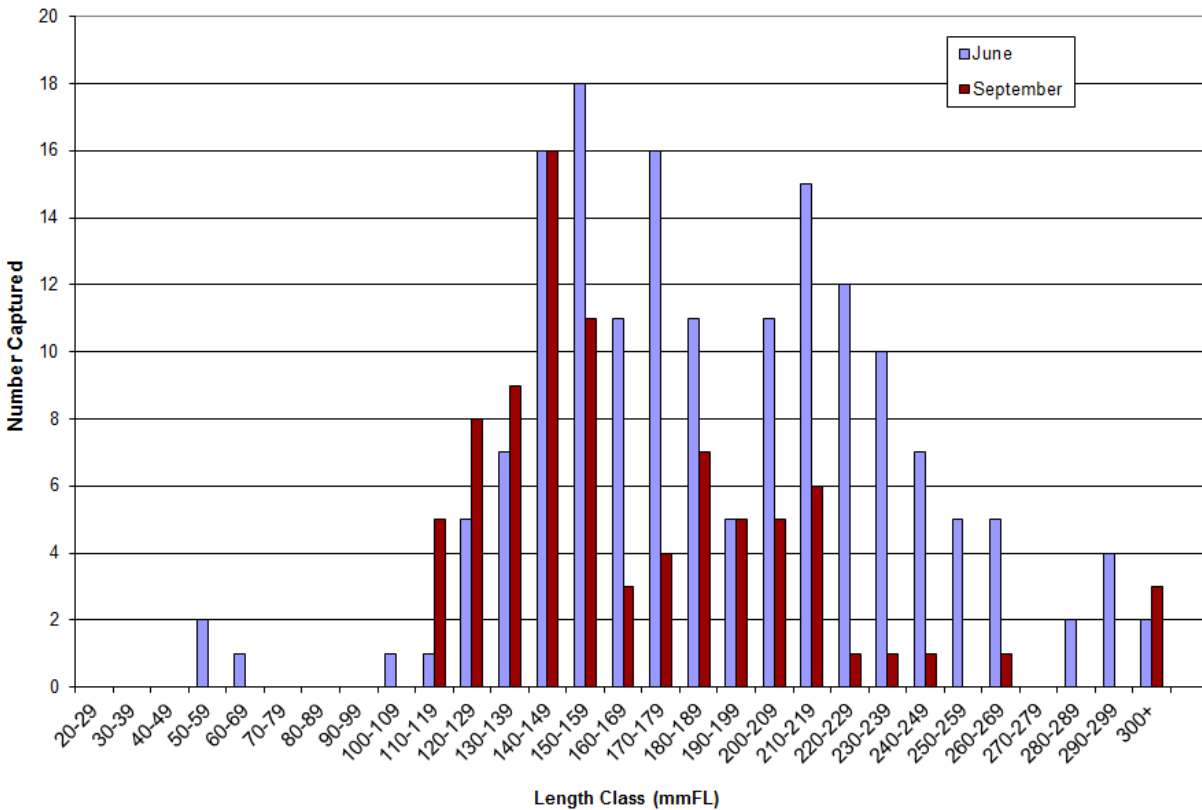


Figure 7. *O. mykiss* length classes in Laguna Creek Lagoon, 2013

Table 6. Laguna Creek Lagoon *O. mykiss* tagged in June and recaptured in September

Initial Capture Date	Recapture Date	Initial Length	Length at Recapture	Growth Rate (mm/day)
6/5/2013	9/10/2013	111	176	0.67
6/5/2013	9/11/2013	123	199*	0.78
6/4/2013	9/10/2013	149*	201	0.53
6/5/2013	9/10/2013	153	200	0.48
6/5/2013	9/10/2013	154	205	0.52
6/4/2013	9/11/2013	156	198	0.42
6/4/2013	9/11/2013	157	206	0.49
6/4/2013	9/11/2013	174	211	0.37
6/4/2013	9/11/2013	207	229	0.22
6/4/2013	9/10/2013	207	237*	0.31
9/11/2012	9/11/2013	203	308	0.29

*scale sample collected

Fall *O. mykiss* Population Estimate

- o All *O. mykiss* captured on September 10 were larger than 50mm FL and all were marked by insertion of a PIT tag in the abdominal cavity (fish smaller than 50mm FL are too small to mark). A total of 61 *O. mykiss* were marked.
- o On September 11, a total of 46 *O. mykiss*, all larger than 50mm FL, were captured. One 500mm fish was also captured but excluded from the analysis since fish over 320mm were not marked. Of the 45 eligible *O. mykiss* captured, 10 had been marked on September 10.
- o Population estimate using the Petersen method (Ricker 1975) is 259 *O. mykiss* larger than 50mm in the lagoon on September 11. The 95% confidence limits for this estimate are 147 and 444. The fall population estimate is just over 50% (52%) of the population estimate in the spring. Based on the length frequency distribution (Figure 7), many of the largest fish in spring were no longer in the lagoon in the fall. Since the mouth was closed throughout the intervening period, they either went upstream or were lost to predation in the lagoon.
- o Recapture rate for *O. mykiss* tagged in September was 10 out of 61 tagged or about 16%. If the same recapture rate is applied to the ten June-tagged fish captured in September, it is estimated that there could have been 62 June-tagged fish still in the lagoon in September. This would be about 38% of the 163 fish tagged in June and is consistent with the decline in catch. The difference in the population estimate could be explained if 62% of fish in June either left the lagoon or were lost to predation but new untagged fish entered the lagoon after June (as appears to be the case based on length frequency distributions).

San Lorenzo River

Summary

The San Lorenzo River Lagoon was very dynamic during the summer of 2013 with 12 fill and spill breaching cycles between mid-May and mid-October. Five of these events were followed by open, tidal lagoon sequences of varying lengths from 4 to 9 days. Steelhead use of the lagoon also appeared dynamic. In early June, there was relatively low abundance of smolt sized *O. mykiss* in an initially open lagoon with growing abundance of smaller fish (primarily yoy based on scale analysis) after the lagoon closed midway through the sampling period. In July there was an increase in abundance of the smaller size class and a decline in the larger size class present in June. In mid-October, the lagoon was again open and a large group of large *O. mykiss* (200-500mm) including many adipose clipped individuals was present in the lower lagoon. These fish had not been present earlier in the spring or early summer. The adipose clipped fish were very likely fish released by the Monterey Bay Salmon and Trout Project (MBSTP) in early April at Ben Lomond and Highland County Park (MBSTP 2013). Large *O. mykiss* also entered the lagoon in 2011, prior to the September survey (HES 2013). After the lagoon closed again, midway through the sampling period, this group of large fish was gone; no *O. mykiss* larger than 150mm were captured after the lagoon closed and CPUE was one-fifth pre-closure levels. The lagoon was not a closed system during either sampling period and while the spring estimate may be reasonably good at the time it was made, there was apparently emigration occurring. It was not possible to get a population estimate for the fall due to low recapture rates and apparent violation of the assumption of a closed population. Growth rate estimates were limited to only two recoveries and these both indicated lower growth rates than have been observed previously in the lagoon.

Spring (June 6-7, 10-11)

Spring Site Conditions

- o City of Santa Cruz monitoring data shows that the lagoon was open through March. The first breach occurred on April 24 with subsequent breach events on May 4, May 8, and May 27 (Chris Cave, personnel communication, Wastewater Collection/Flood Control Manager, City of Santa Cruz, 22 January, 2014).
- o Lagoon was open on June 6 but closed on June 7 with high swell (Figure 8). It reopened on the afternoon of June 11, just as sampling was being completed. Flow at Santa Cruz gage was 12 cfs on June 6 through 10, dropping to 11 cfs on the 11th (USGS provisional data).
- o Lagoon stage was relatively low but there was little beach available for seining between RR and WQ Station and around Riverside Bridge.
- o Relatively cool (15.5-16.9°C), well-oxygenated (8-8.4 mg/l), and moderate salinity (12-24 ppt) surface layer above 1.3 feet depth during sampling on June 6-7 with high salinity (33-34 ppt), low to high oxygen (3.6-8.7 mg/l), and cool (12.4-16.1°C) bottom layer from 1.3 to 6.6 feet depth. Similar upstream of Riverside Bridge but with the

surface layer slightly deeper (between 1.3 and 2.6 feet), fresher (~1.5 ppt), warmer (15.9-17.4°C), and more oxygenated (8.2-9.0 mg/l).

- o On June 10 and 11, after lagoon closed, the fresh surface layer thickened down to between 2.6 and 3.9 feet, became slightly warmer (16.5 to 19.8°C), and more oxygenated (9.0-16 mg/l). The bottom layer was freshening slightly with temperature maxima near the halocline and diminishing oxygen in the deepest waters.
- o Water level increased between lagoon closure on June 7 and the last sampling on June 11 when the lagoon was very full with no margin for completing seine hauls except for a small area near the trestle.

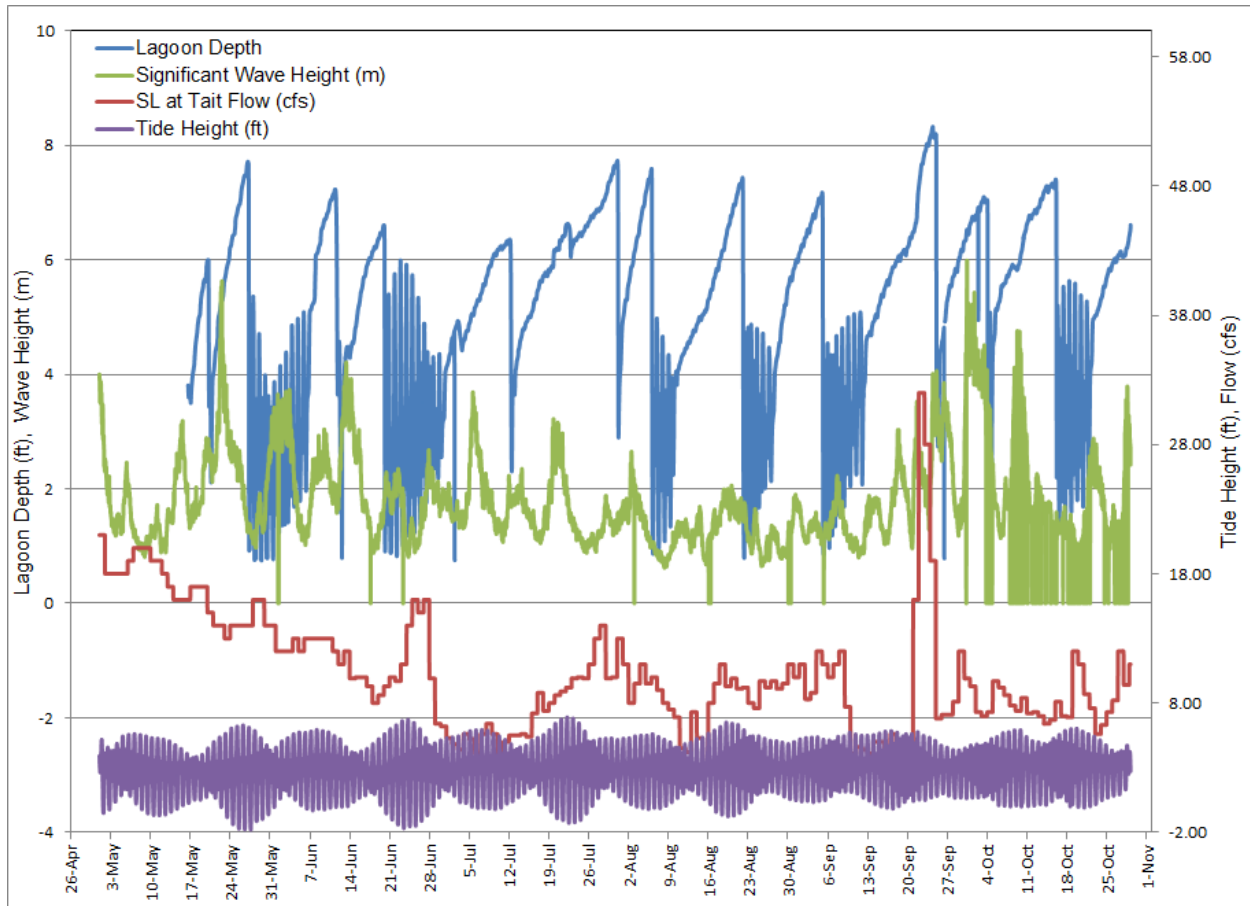


Figure 8. San Lorenzo Lagoon stage, streamflow, wave height, and tides 2013, preliminary data (Source: lagoon stage from 2ND Nature, streamflow from USGS, wave and tide data from NOAA)

Spring Survey Results

- o *O. mykiss* were captured and marked on June 6 and 7 and the lagoon was resampled on June 10 and 11. Untagged *O. mykiss* captured on June 10 and 11 were also tagged for over-summer information.
- o Completed 27 hauls between the beach and the bend upstream of Riverside Bridge.
- o *O. mykiss* were most abundant between the railroad bridge and the WQ Station and upstream of Riverside Bridge (Table 7).
- o Very low abundance and primarily smolt-size (130-170mm FL) *O. mykiss* during mark period (June 6 and 7). The lagoon closed on June 7, and during recapture period (June 10-11) CPUE increased and smaller size classes (60-120mm FL) appeared in the catch. CPUE was 0.7 fish per haul (fph) on June 6-7 and 3.2 fph on June 10-11. We conclude that *O. mykiss* were moving into the lagoon between the mark and recapture periods, particularly in smaller size classes. The increased lagoon stage would have resulted in extension of the lagoon further upstream, possibly entraining rearing juveniles in the previously flowing reach.
- o The majority of *O. mykiss* between 90 and 110mm in length were parr while those between 120 and 180mm were characterized as silvery parr. None of the *O. mykiss* captured appeared to be in smolt condition.
- o All 52 *O. mykiss* examined had an adipose fin, indicating they were not of hatchery origin.
- o *O. mykiss* captured in June were primarily age yoy and 1+ based on scale analysis. The larger mode of the size distribution (130-169 mm in Figure 8) was primarily 1+ while the smaller mode (~60-109 mm) were primarily yoy (Table 8 and Figure 9).

Table 7. Fish catch in San Lorenzo River Lagoon, June 2013

Species	South of Trestle (1)	Around Trestle (2)	Between Trestle and WQ site (3)	Marsh Outlet (4)	Upstream of Riverside Bridge (5)	Bend near Laurel Ave. (6)	Grand Total
<i># Hauls</i>	4	6	5	3	6	3	27
Pacific herring	2					18	20
<i>O. mykiss</i>	2	4	20	9	18	1	54
Topsmelt	1172	604	679	151	1627	77	4310
Threespine stickleback	5	4	2	2	7		20
Bay pipefish	4	2	1		1		8
Prickly sculpin	1	1			1		3
Staghorn sculpin	63	191	16	11	88	43	412
Sculpin sp.	7	12	155		3	2	179
Shiner surfperch					1		1
Rock crab	3	15	1				19
Dungeness crab	28	12					40
<i>O. mykiss CPUE</i>	0.5	0.7	4	3	3	0.3	2

Table 8. Results of Age Determination of Juvenile *O. mykiss* in San Lorenzo Lagoon, June 2013
(courtesy of Jon Jankovitz, CDFW)

Date	Length (mm FL)	Age	Length at Annulus 1
10-Jun	90	yoy	
10-Jun	91	yoy	
10-Jun	93	Yoy	
10-Jun	135	1+	66
7-Jun	136	1+	74
7-Jun	144	1+	61
10-Jun	161	1+	75

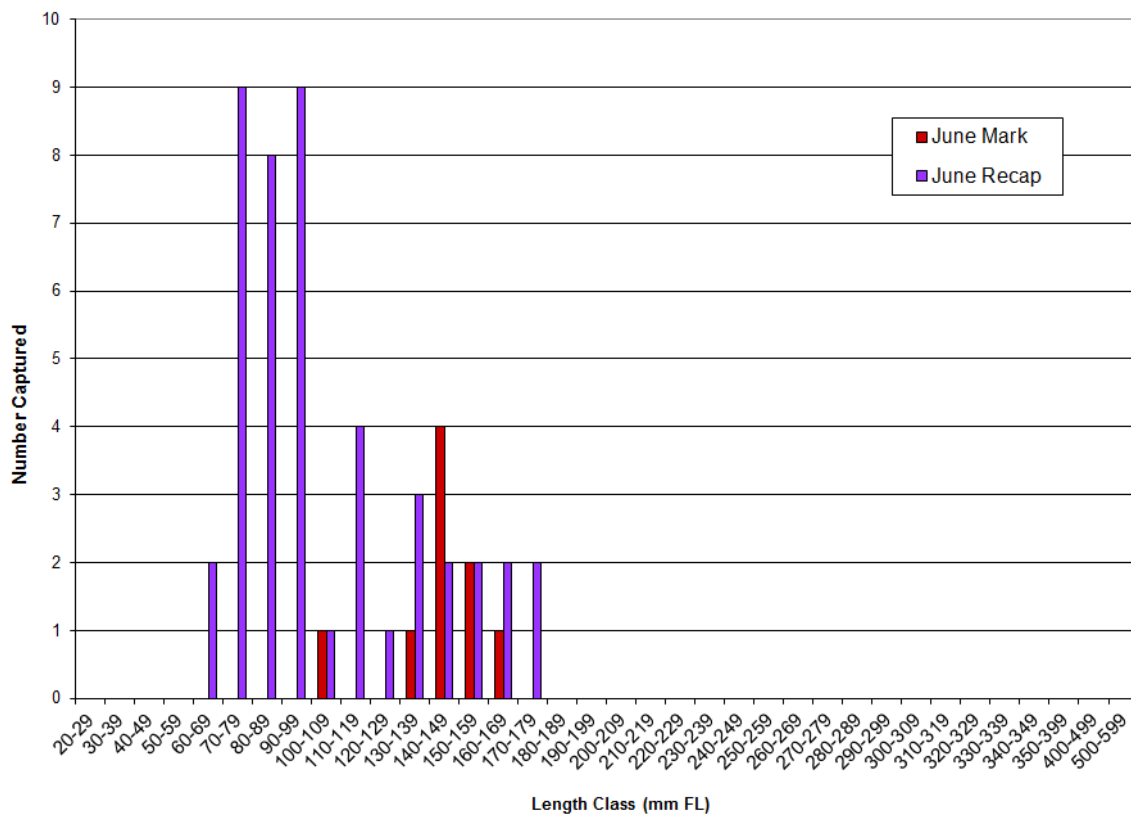


Figure 9. Spring 2013 *O. mykiss* length classes in San Lorenzo Lagoon during mark and recapture periods

Spring *O. mykiss* Population Estimate

- o A total of only 9 *O. mykiss* were captured during the marking period. All were larger than 50mm and smaller than 320mm. One fish was captured twice. A total of 8 *O. mykiss* were marked with PIT tags on June 6 and 7.
- o Forty-five *O. mykiss* were captured during the recapture period. Only one of these had been tagged during the marking period.
- o Population estimate using the Petersen method (Ricker 1975) is 207 *O. mykiss* larger than 50mm FL in the lagoon in June. This does not include *O. mykiss* larger than 320mm FL. The 95% confidence limits for this estimate are 62 and 361. The estimate is likely biased due to the small number of marked fish and small number of recaptures. As previously indicated, there is also evidence that *O. mykiss* were moving into the lagoon during the survey.
- o All untagged fish captured during the recapture period were tagged in order to collect over-summer information. None of these was recaptured during the recapture period.

Summer (July 17)

The July survey was a one-day relative abundance survey requested by CDFW. In order to minimize potential harmful effects during potentially stressful mid-summer conditions, captured fish were not tagged and no population estimation was conducted. Sampling was only conducted at Stations 2 and 3, around the trestle and up to the WQ Station.

Summer Site Conditions

- o The lagoon was closed at the time of sampling. Preliminary data show daily average flow at Santa Cruz gage of 8.8 cfs, fluctuating between 4 and 14 cfs in the weeks before and after (USGS provisional data). After opening during the June survey, the lagoon closed again between June 15 and June 20, then was open and tidal through June 30, closed until July 12 when it breached, then began gradually refilling almost immediately.
- o The lagoon stage was relatively high with little beach available for seining between the trestle and WQ Station. Maximum depth was about 9.8 feet.
- o Water column was salinity stratified with a reverse thermocline. Surface salinity was about 2.5 ppt and bottom salinity was 31 ppt. Surface temperature was coolest at 18-19°C with maximum temperature in mid-water (3.9-5.2 feet deep) of 24.8-25.6°C. Dissolved oxygen was 8-9 mg/l at the surface and 0-4 mg/l at the bottom. Maximum dissolved oxygen levels were in the thermal maximum strata at 0.8 to 1.6 feet deep.

Summer Survey Results

- o The July survey was a one-day relative abundance survey requested by CDFW. In order to minimize potential harmful effects during potentially stressful mid-summer conditions, captured fish were not tagged and no population estimation was conducted. No scales were taken.
- o Completed 7 hauls between the beach and the water quality buoy (Table 9). Ended sampling at 12:45 due to high temperature (21°C).
- o Catch rates (CPUE) were substantially greater (~4x) than in June (Table 10). This indicates a net inflow of *O. mykiss* to the lagoon between early June and mid-July.
- o Dominant size class for *O. mykiss* was 70-130mm (Figure 10). This mode of the size-class distribution corresponds to the smaller mode present in June with the difference in mean size potentially attributable to growth during the intervening period. The larger mode present in June (approximately 120-180mm) was less abundant, with many of these presumably having migrated to sea (Figure 10).
- o The majority of *O. mykiss* (95%) were characterized as parr or silvery parr. Two *O. mykiss* (158 and 181mm) had the appearance of smolts and one of 438mm had the appearance of an ocean fish.
- o All 58 *O. mykiss* examined had an adipose fin, indicating they were not of hatchery origin.
- o There were no recaptures of fish tagged in June.

- o Most *O. mykiss* captured in July were likely large yoy at lengths from ~100 mm to ~130 mm based on size distribution and scales read in June (Table 8 and Figure 10), with lower abundance of age 1+ and older fish.

Table 9. Fish catch in San Lorenzo River Lagoon, July 2013

Species	Around Trestle (2)	Between Trestle and WQ Station (3)	Grand Total
<i># Hauls</i>	5	2	7
Pacific herring	2		2
<i>O. mykiss</i>	11	48	59
Topsmelt	464	485	949
Threespine stickleback	1	15	16
Prickly sculpin		2	2
Staghorn sculpin	1	14	15
Shiner surfperch	107	18	125
Walleye surfperch	5		5
Crab	2		2
<i>O. mykiss CPUE</i>	2.2	24	8.4

Table 10. *O. mykiss* catch per haul for the San Lorenzo River Lagoon during 2013

Station	Location	<i>O. mykiss</i> Catch per Haul					
2013		6-11 Jun	17 July		Sep 12-17		
SL-1	South of Trestle	0.6			13		
SL-2	RR Trestle	0.8	2.2		1.6		
SL-3	Near YSI Station	6	24		1		
SL-4	Near Marsh Outlet	3			2		
SL-5	Riverside Drive	3			5.8		
SL-6	U/S Bank Restoration	0.3			6		
	Overall	2	8.4		4.7		

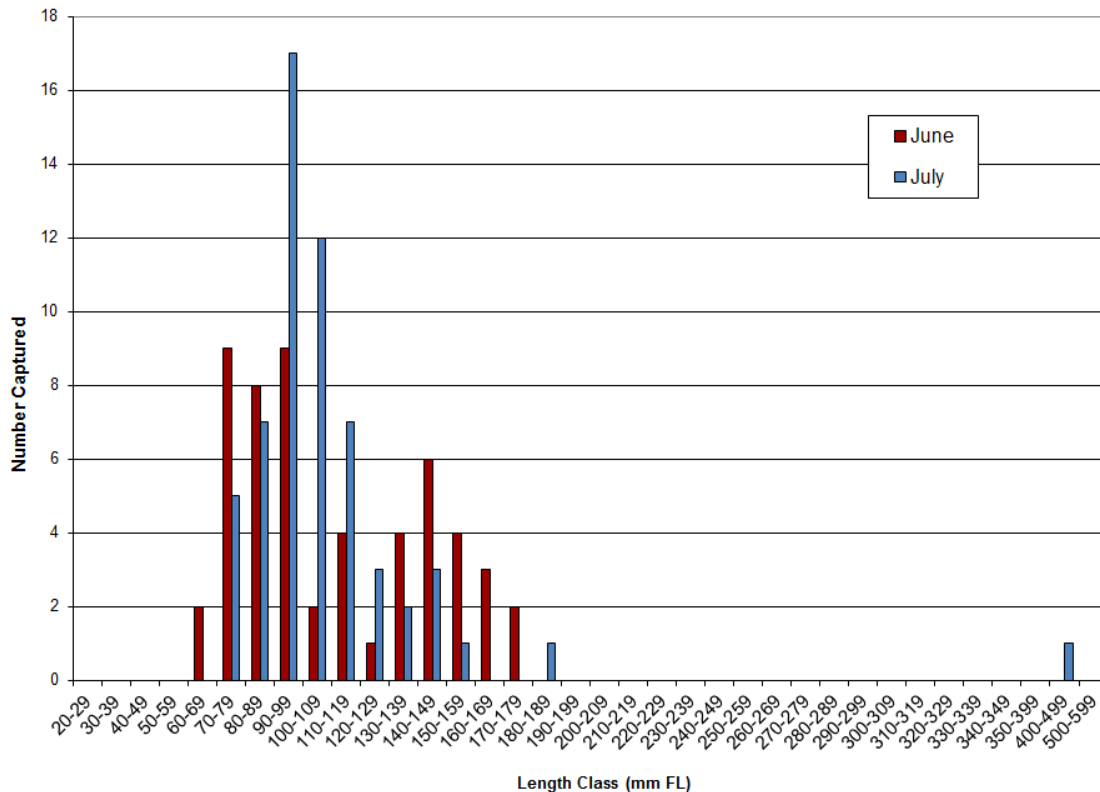


Figure 10. *O. mykiss* length classes in San Lorenzo Lagoon, June and July 2013

Fall (September 12-13 and 16-17)

Fall Site Conditions

- o Lagoon was open on September 12 and 13 during the mark period and had been open since September 5 (Figure 8). Previously, it had closed and reopened four times since the July 17 survey, with brief periods of tidal conditions (4 to 7 days) after opening. It closed by the beginning of the recapture period on September 16. The water level was relatively high throughout the sampling period with maximum depth at about 8.2 feet. The water was relatively clear; the secchi disk was clearly visible on the bottom in 7.5 feet of water on September 12. After the lagoon closed secchi depth declined slightly to about 4.6 feet.
- o On September 12 and 13 the water column was stratified for salinity and temperature with relatively cool surface temperature (16.1-20°C depending on time of day). Salinity was high throughout the water column, ranging from 23.2 ppt at the surface to 33.5 ppt at the bottom. Dissolved oxygen was high throughout the water column ranging from 8.75 mg/l at the surface to 7.3 mg/l at the bottom. There was a thin freshwater layer at the surface at Riverside Bridge and upstream.

- o After closure, the freshwater surface lens extended downstream to the trestle and to a depth of about 1.3 feet. A warm, high oxygen layer began to develop just below the freshwater with temperature increasing to about 23.5°C and dissolved oxygen at 10-19 mg/l.

Fall Survey Results

- o *O. mykiss* were captured and marked on September 12 and 13 and the lagoon was resampled on September 16 and 17 to recapture marked fish.
- o Completed 28 seine hauls between beach and bend upstream of Riverside Bridge.
- o Species diversity was low with very abundant topsmelt and moderately abundant *O. mykiss* representing nearly the entire catch (Table 11).
- o *O. mykiss* were captured at all stations but catch was greatest south of the trestle and upstream of Riverside Bridge (Table 11).
- o CPUE for *O. mykiss* higher than June but lower than July (Table 10).
- o *O. mykiss* size classes included a mode of smaller fish from about 90-150mm (Figure 11) that could have been the same cohort present in the June recapture period and in July with the increase in length resulting from growth over the intervening period (~20mm from July and ~30mm from June, or about 0.5 and 0.3mm/day respectively).
- o There was also a group of larger *O. mykiss* from 200 to 500mm in length that were not present earlier in the summer (Figure 11). Of *O. mykiss* 240mm or larger, 27 out of 49 were missing the adipose fin, indicating they were of hatchery origin. These are very likely fish released by the Monterey Bay Salmon and Trout Project (MBSTP) in early April at Ben Lomond and Highland County Park (MBSTP 2013).
- o The group of large *O. mykiss* (240-500mm FL) was present in the lagoon on September 12 and 13 but none were captured on September 16 and 17, after the lagoon closed (Figure 12). In fact no *O. mykiss* larger than 150mm were captured after the 13th. CPUE was 7.9 before the lagoon closed and 1.5 afterward. These observations suggest that there was a movement of *O. mykiss* out of the lagoon around the time it was closing.
- o Two *O. mykiss* tagged in June were recaptured in September (Table 12). Growth rates for these fish were 0.27mm/day and 0.41mm/day. These growth rates are lower than observed in 2012 (0.58 to 0.84mm/day) and 2011 (0.5 to 0.7mm/day) over the same time period, and previously measured growth rates of 0.40-0.90mm/day measured in 2005 (2NDNATURE 2006),
- o Analysis of scale samples revealed that *O. mykiss* present in September in the smaller length mode were primarily yoy while the larger mode was mostly age 1+ (Table 13). Two of the three largest 1+ fish likely spent the previous season (2012 in the lagoon as well based on length at annulus (Table 13); the third was adipose clipped and likely was released by MBSTP in the in the San Lorenzo River in the spring of 2013.

- o 48% of *O. mykiss* captured in September were characterized as parr, 9% were characterized as silvery parr, and 40% had the appearance of “stream adult” fish (no parr marks, not particularly silvery, not thin, no blackened caudal margin, and “rainbow” coloration). Parr were all less than 150mm FL, silvery parr were 130mm to 200mm, and “adults” were 200 to 420mm.
- o Twenty-seven out of 127 *O. mykiss* had clipped adipose fins. All clipped fish were larger than 240mm FL.
- o Sea lice were observed on several *O. mykiss*, all over 230mm FL. Blackspot disease was observed on several *O. mykiss*, mostly on fish 180mm FL or less.
- o There were no obvious associations of *O. mykiss* catch with salinity or dissolved oxygen. *O. mykiss* were caught across the full range of surface salinity (0.8 ppt to 27.3 ppt). Equivalent numbers of *O. mykiss* were caught where surface salinity was over 25 ppt and under 5 ppt. Bottom salinities were all between 31.2 and 32.4 ppt. Surface DO was at least 8.2 mg/l at all sample stations. *O. mykiss* were captured at sites with bottom DO from 0.5 mg/l (19% of catch) to 12.9 mg/l (15 % of catch). A substantial portion of the catch (45%) was associated with the coolest temperature available (16.1°C surface and 14.5°C bottom). This was just ocean-ward of the trestle while the lagoon was still open. *O. mykiss* were captured across the full range of water temperature available (up to 20°C surface and 23.9°C bottom).

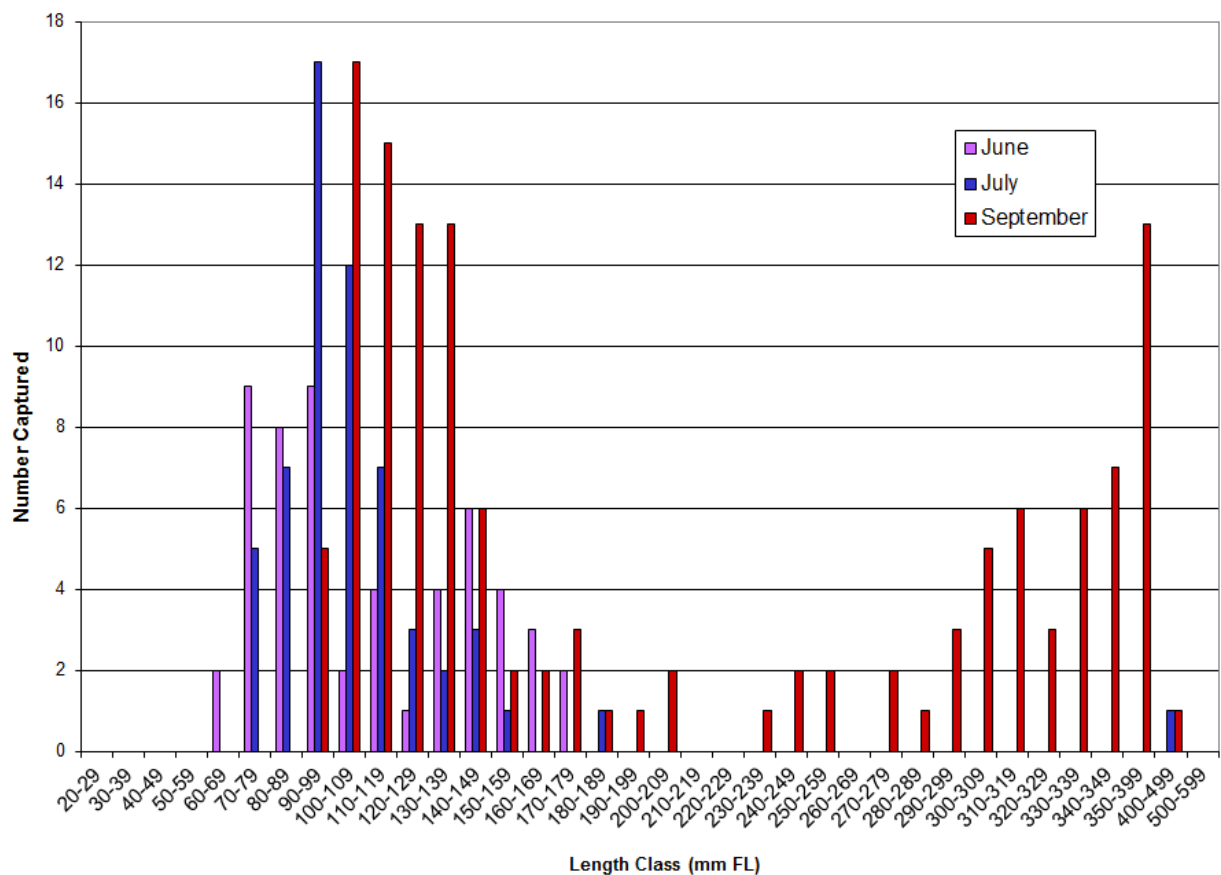


Figure 11. *O. mykiss* length classes in San Lorenzo Lagoon by sample period, 2013.

Table 11. Fish catch in San Lorenzo River Lagoon, September 2013

Species	South of Trestle (1)	Around Trestle (2)	Between Trestle and WQ Station (3)	Marsh Outlet (4)	Upstream of Riverside Bridge (5)	Bend near Laurel Ave. (6)	Grand Total
<i># Hauls</i>	4	7	4	3	6	4	28
Northern anchovy		1					1
<i>O. mykiss</i>	52	11	4	6	35	24	132
Topsmelt	1889	3176	1718	1078	654	948	9463
Threespine stickleback					4	11	15
Bay pipefish	1						1
Staghorn sculpin						1	1
Crab	7	4	9	11	1	1	33
Jellyfish		1				1	2
<i>O. mykiss CPUE</i>	13	1.6	1	2	5.8	6	4.7

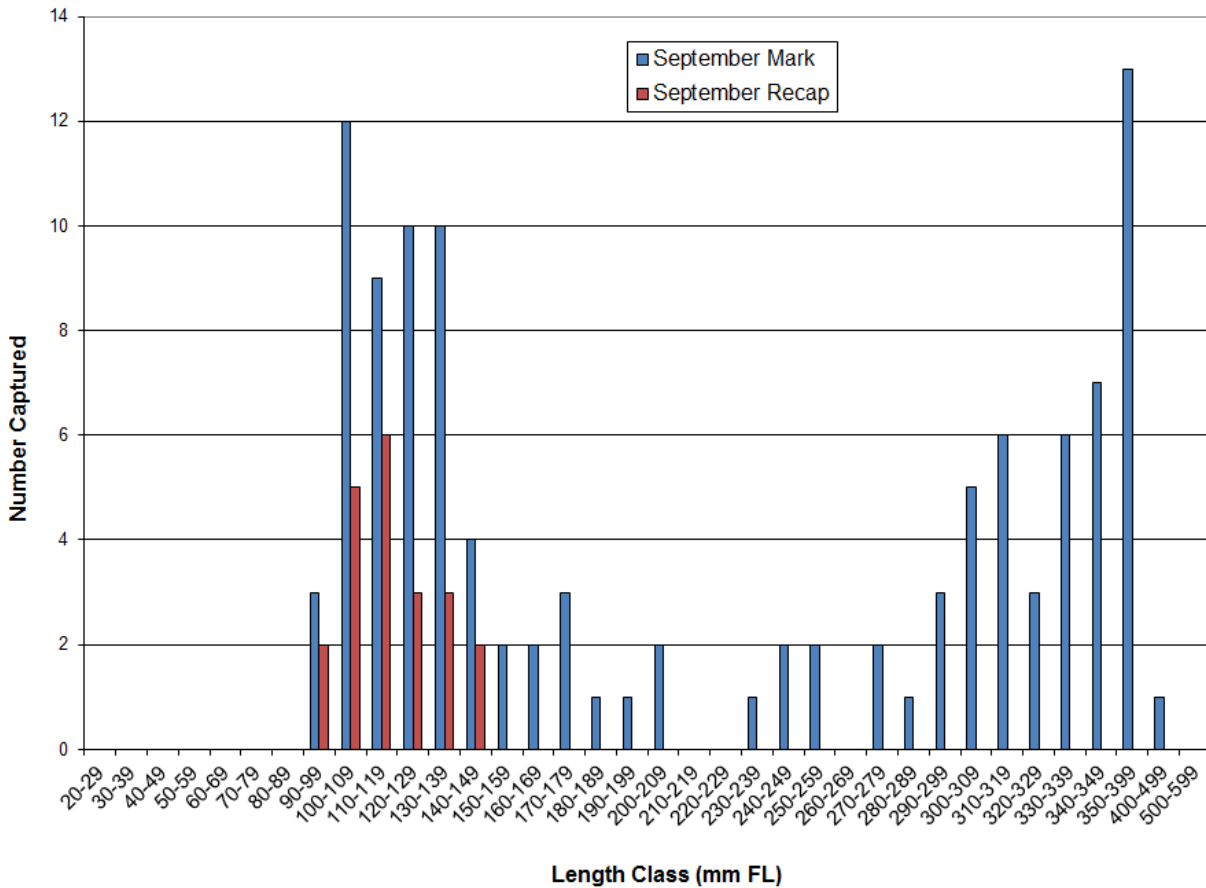


Figure 12. *O. mykiss* length classes in San Lorenzo Lagoon in September, 2013

Table 12. San Lorenzo *O. mykiss* tagged in June and recaptured in September

Initial Capture Date	Recapture Date	Initial Length	Length at Recapture	Growth Rate (mm/day)	Original Capture Location	Recapture location
6/7/2013	9/12/2013	143	169	0.27	5	1
6/11/2013	9/12/2013	94	132	0.41	4	2

Table 13. Results of Age Determination of Juvenile *O.mykiss* in the San Lorenzo Lagoon, September 2013 (courtesy of Jon Jankovitz, CDFW)

Date	Length (mm FL)	Age	Length at Annulus 1	Length at Annulus 2
13-Sep	92	yoy		
13-Sep	98	yoy		
13-Sep	108	yoy		
12-Sep	114	yoy		
13-Sep	121	yoy		
12-Sep	124	yoy		
13-Sep	204	1+/2+?	70	93?
13-Sep	207	1+	76	
13-Sep	300	1+	126	
13-Sep	313*	1+	156	
13-Sep	318	1+	120	

*Adipose clipped

Table 14. *O.mykiss* catch per haul for the San Lorenzo River Lagoon during recent sampling events (data from H.T. Harvey and Associates 2003, 2NDNATURE 2006, Ellen Freund (NOAA Fisheries), HES 2005, HES 2009, HES 2010, HES 2011, HES 2012, and HES 2013)

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

Table 14 (continued)

Station	Location	<i>O. mykiss</i> Catch per Haul					
2012		7-12 Jun			Sep 13-18		
SL-2	RR Trestle	5.2			21.3		
SL-3	Near YSI Station	0.8			17.5		
SL-4	Near Marsh Outlet	0					
SL-5	Riverside Drive	0			3.5		
SL-6	U/S Bank Restoration	0.1			5.0		
	Overall	1.7			14.4		
2013		6-11 Jun	17 July		Sep 12-17		
SL-1	South of Trestle	0.6			13		
SL-2	RR Trestle	0.8	2.2		1.6		
SL-3	Near YSI Station	6	24		1		
SL-4	Near Marsh Outlet	3			2		
SL-5	Riverside Drive	3			5.8		
SL-6	U/S Bank Restoration	0.3			6		
	Overall	2	8.4		4.7		

Fall *O. mykiss* Population Estimate

- *O. mykiss* captured were marked on September 12 and 13 by PIT tag. Fish larger than 320mm FL were not marked. All fish captured were at least 90mm FL.
- A total of 70 *O. mykiss* were marked on September 12 and 13 and returned to the lagoon.
- On September 16 and 17, a total of 21 *O. mykiss* were captured, all were less than 320mm FL. Only one of these fish had been marked on September 12 and 13.
- We suspect that a large number of *O. mykiss* left the lagoon as it was closing between September 13 and September 16. This is based on marked changes in the size distribution (Figure 12) and the CPUE as previously described.
- Based on the evidence that the population was not closed from the mark to the recapture period, population estimation using the Petersen method would not be valid.
- The relationship between population estimate and CPUE was updated with the 2013 data. Surveys to date continue to show a relatively good correlation between the two parameters (Figure 13).

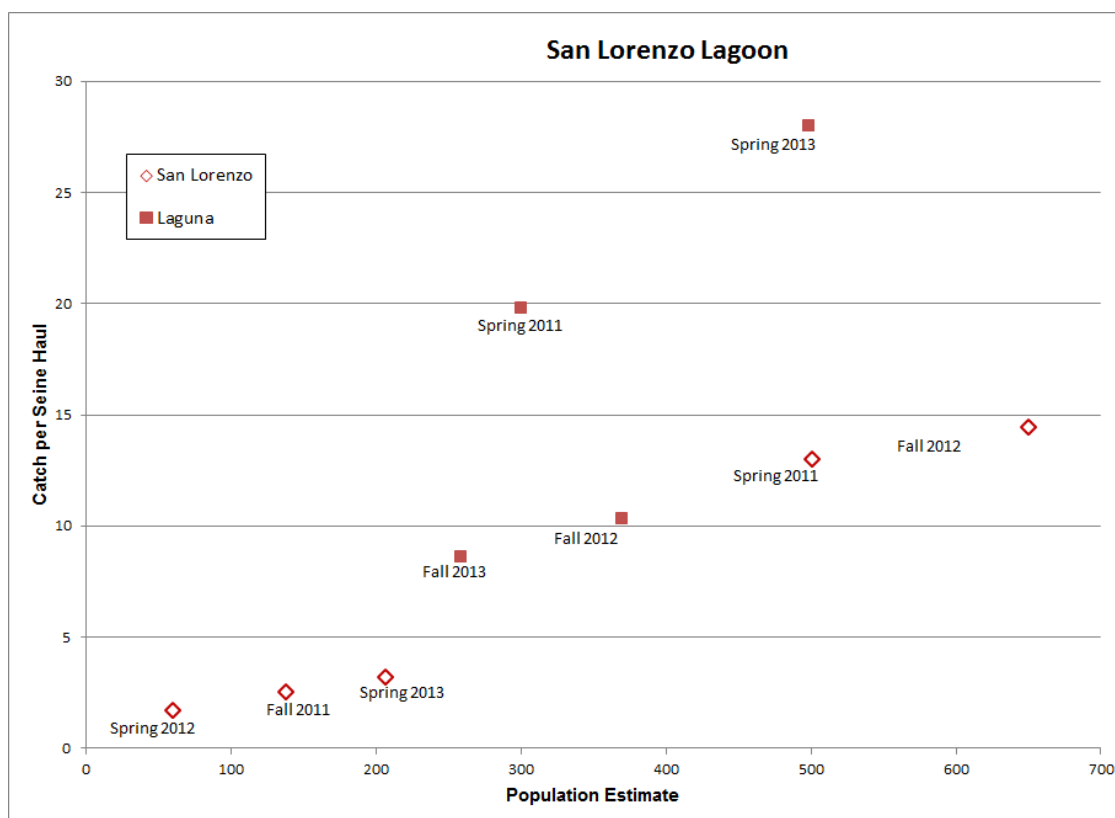


Figure 13. Relationship between *O. mykiss* population estimate and CPUE in Laguna Creek Lagoon and the San Lorenzo River Lagoon



Figure 14. Laguna Creek Lagoon sampling stations

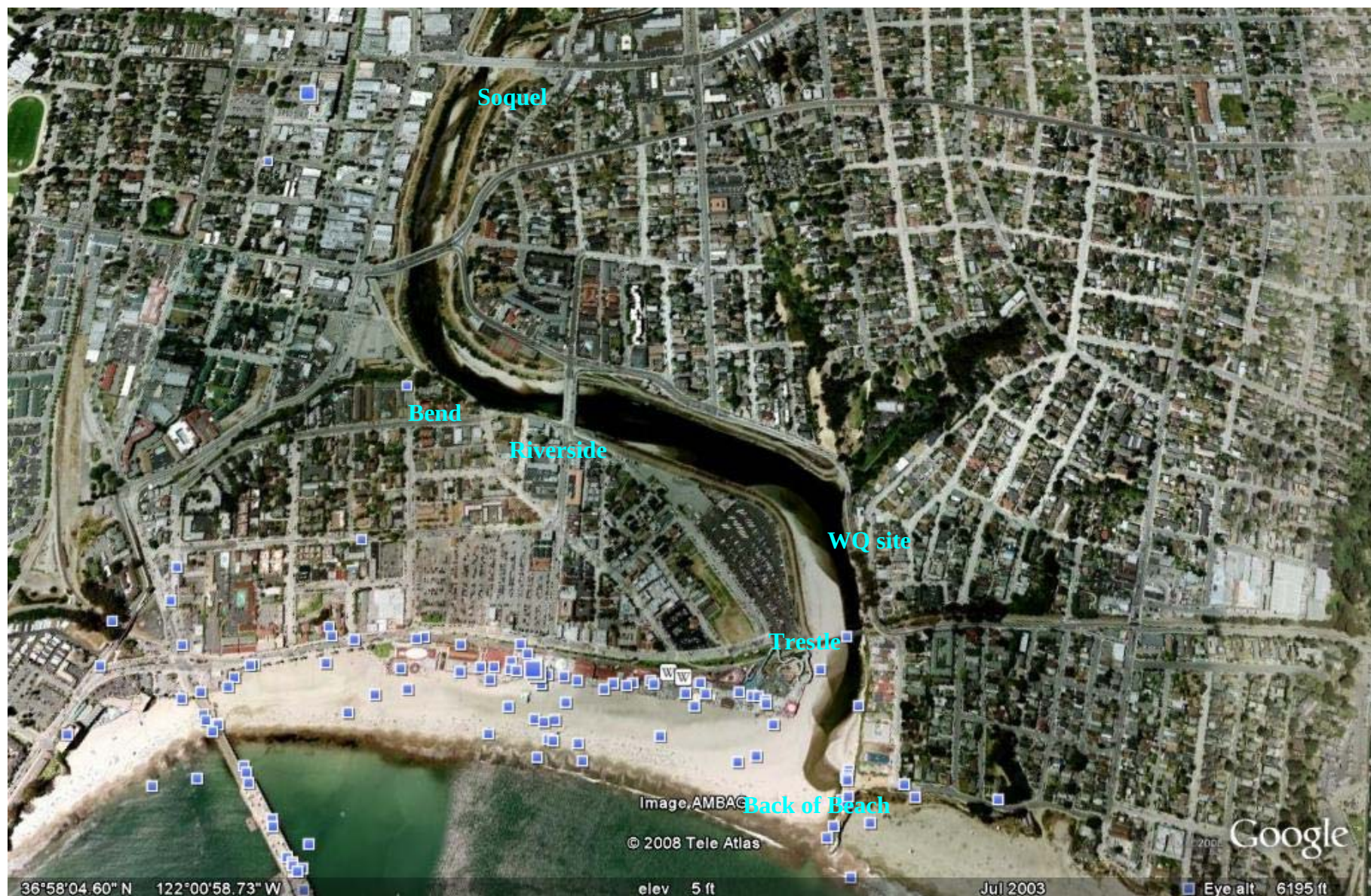


Figure 15. San Lorenzo River Lagoon sampling stations

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