TECHNICAL MEMORANDUM

TO: Chris Berry
City of Santa Cruz Water Department

FROM: Jeff Hagar
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DATE: April 8, 2011

PROJECT: City of Santa Cruz Habitat Conservation Plan, Lagoon Fish Population Sampling 2010

Fish population and steelhead rearing were assessed in Laguna Creek lagoon and the San Lorenzo River lagoon during the summer of 2010 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 large seines. In the San Lorenzo River lagoon additional sampling was conducted in late July in conjunction with testing hydroacoustic equipment for fish population assessment. In Laguna Creek a 100 foot long by 6 foot deep seine with a bag and ¼ inch mesh was used. In the San Lorenzo River lagoon we used both the 100 foot seine and a 150 foot long by 8 foot deep seine with ¼ inch mesh. The larger seine was used in deeper water and at higher lagoon stages. A summary of the results of the survey follows.

Laguna Creek

Spring (June 22)

- Site Conditions
    - Mouth open, lagoon at very low stage with maximum depths 1 to 2.5 feet for each seine haul. Lagoon habitat limited to an area between the upper pond outlet and the neck (Figure 1). Flowing, stream-like habitat was present from the neck to mouth and upstream of the water quality station. There was evidence of multiple breaches at the mouth (Figure 2). City staff reported mouth was closed during visit on June 2, 2010. On the evening of June 23 (about 20:03), the mouth had closed (high tide was at 20:40) and the lagoon was about half full. Waves were washing over the sandbar into the lagoon. At 14:30 on June 24, the mouth was closed with the lagoon surface only a few inches below the sandbar. Water quality monitoring by the City and 2NDNATURE indicated that the lagoon had breached in mid-May slightly after monitoring began; was open through the end of May; closed, refilled and breached again in early June; was open for a couple of days; closed, refilled, and breached again just before the June 22 sampling date. The monitoring data shows the lagoon breached at least one more time in early July but was stable after mid-August (missing data between July 20 and August 17).
    - Depth to maximum of 2.5 feet near pond outlet.
    - Tides: 0.4 feet at 2:00am, 3.6 feet @ 9:33, 2.5 feet @ 13:32

- Salinity 2.6 at surface, 22.2 at bottom near pond outlet at 9:20 am.
- Temperature 14-15 C at surface, 15.8 C at bottom at 9:20 am.
- DO 7.99 in freshwater layer; 4.1 in higher salinity layer at bottom.
- Water somewhat turbid.
- Overwash pond was full

Figure 1. Laguna lagoon, June 22, 2010.

Figure 2. Mouth of Laguna lagoon, June 22, 2010 showing multiple breach terraces.

- Survey results
  - Started seining at pond outlet working toward beach. Seining conditions unusual due to low stage, normally make a long haul through LA-2 all the way to beach, this time we did 3 separate hauls onto muddy lagoon margin.
  - 100 ft. by 6 ft by ¼ inch mesh bag seine:
    - 3 hauls
    - Steelhead catch included 40 fish in 3 hauls (all at station LA-2) with fish ranging from 68mm to 192mm fork-length (Table 1, Figure 3). The majority (85%) were between 90 and 169 mm fork-length. The 192 mm fish was characterized as “smolty”.
  - A net was placed at the “neck during seining to prevent fish movement. Following seining a number of juvenile steelhead (approximately 10-25 in number) were congregated downstream of this net in the outlet channel. The channel was shallow (0.8 feet deep or less) and sandy all the way to the beach.
  - Tidewater goby were also captured.
  - The overwash pond was sampled superficially with a dip net. There were tidewater goby present as well as abundant mysids. There was a deep silt substrate and dense filamentous aquatic plant growth.

Table 1. Fish catch in Laguna Creek lagoon, June 2010.

Species	LA-1	LA-1.5	LA-2	LA-3	Grand Total
	100 ft by 6 ft bag seine				
# Hauls	*NS*	*NS*	*3*	*NS*	*3*
Steelhead			40		40
Tidewater goby			42		42
Staghorn sculpin			54		54
Stickleback			2000+		2000+
Prickly sculpin			present		
			2136		2136

NS = Not Sampled, too shallow
Note: See Figures at end of document for sample site locations.

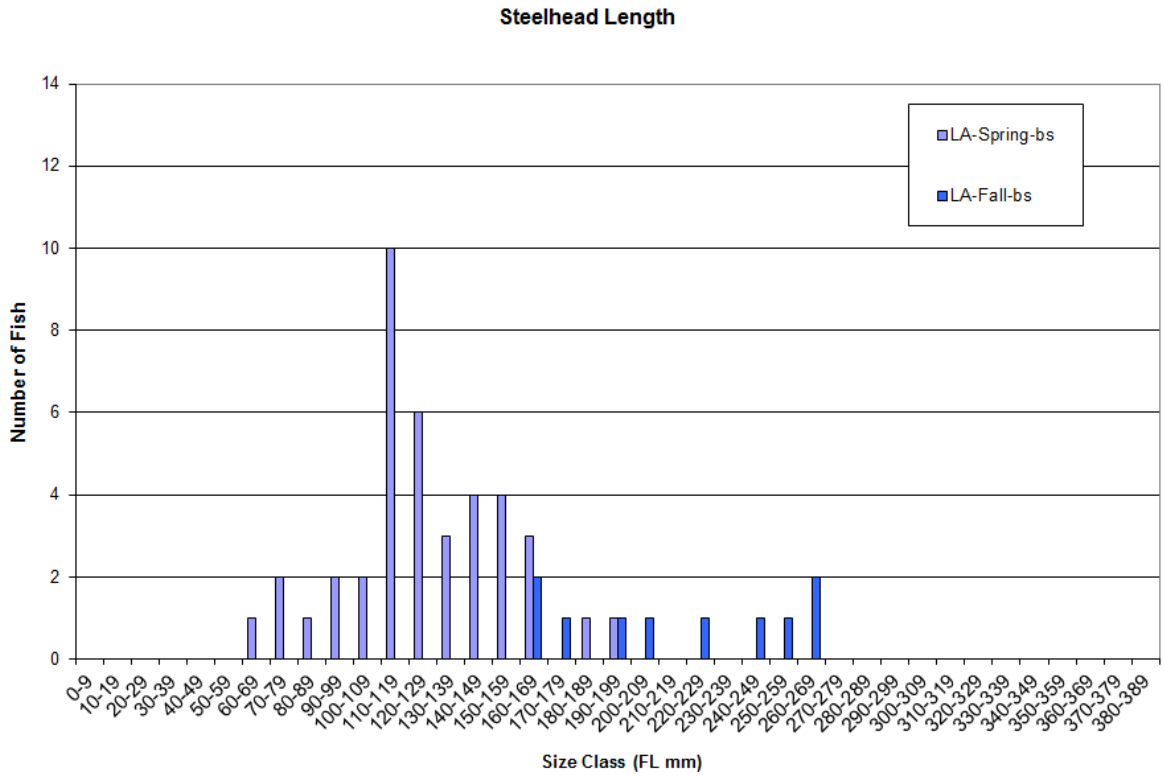

Figure 3. Steelhead length classes in Laguna Creek Lagoon.

Fall (October 5)

- Site Conditions
    - Mouth closed, stage high (Figure 4). Water quality monitoring by the City and 2NDNATURE indicated that the Laguna lagoon had filled and breached at least twice since the June 22 sampling event.
    - Depth to about 5 feet near mouth and up to about 7 feet near YSI site.
    - Temperature 15-17.5 C at surface
    - Visibility good.

Figure 4. Laguna lagoon, October 5, 2010.

- Survey results
  - 100 ft. by 6 ft by ¼ inch mesh bag seine:
    - 6 hauls
    - Steelhead catch included relatively few fish of very large size. Steelhead ranged from 160mm to 250mm (FL). CPUE for steelhead was very low in the fall sampling (Table 3) although the presence of very large, fast growing, and healthy individuals indicates good rearing conditions. This is also consistent with density dependence in growth rates seen in nearby Scott Creek lagoon (Sean Hayes, National Marine Fisheries Service, personal communication). Scale samples were collected from 6 of these and age determinations were completed by Michelle Leicester of CDFG. Aged fish were 0+ and 1+ (Table 4). There was a mix of 0+ and 1+ fish, some of comparable size, indicating a diversity of life-history patterns. Given the unstable lagoon conditions in 2010 with numerous breach events, it is possible that there was a lot of movement between the lagoon and upstream areas. Hayes et al. (in prep.) found movement out of Scott Creek lagoon back upstream in the fall when water quality conditions in the lagoon deteriorated. All of the 0+ fish showed very good growth rates, reaching smolt-size in a single season. One individual, at 267 mm, showed extremely good growth (Figure 5), The 1+ fish have first year growth consistent with stream rearing,
  - Tidewater goby were not targeted for sampling but were captured at Site 1.5
  - An adult California red-legged frog was seen perched on bedrock wall along the edge of the lagoon near the mouth

Table 2. Fish catch in Laguna Creek lagoon, October 2010.

Species	LA-1	LA-1.5	LA-2	Grand Total
	100 ft by 6 ft bag seine			
# Hauls	*2*	*3*	*1*	*6*
Steelhead	4	1	5	10
Tidewater goby		Several		Several
Staghorn sculpin	1			1
Stickleback	200-300	200-300	5-10	hundreds
Prickly sculpin		1		1
	Observed			
CRLF	1			

Figure 5. O. mykiss from Laguna lagoon, October 5, 2010, 267mm 0+.

Table 3. Steelhead and coho salmon catch per seine haul in Laguna Creek lagoon at consistently sampled sites (data from 2NDNATURE 2006b, Ellen Freund (NOAA Fisheries), HES 2005, HES 2009, and HES 2010).

	Location	Steelhead Catch per Haul						Coho Catch per Haul		
2004		May	Jun	Jul	Sep	Oct	Nov	May	Jul	Sep
	LA-1			0						
	LA-1.5			0	0					
	LA-2									
	LA-3			0	0					
	LA-4.5									
	LA-5			7	0					
	LA-6			5	0					
2005										
	LA-1	0		9.3	33		46	5.5	0	0
	LA-1.5									
	LA-2	0		16	50		5	14	6	0
	LA-3	7		40	51		15	30	6	0.5
	LA-4.5									
	LA-5	26		25	8		0	24	6	0
	LA-6	11		10	0		0	32	7	0
2008										
	LA-1		1		0.5					
	LA-1.5		18		10.5					
	LA-2		22		15					
	LA-3		0		0					
	LA-4.5				0					
	LA-5				0					
	LA-6				3					
	Overall		***11***		***6***					
2009										
	LA-1		8		34					
	LA-1.5		8		21					
	LA-2		10		10					
	LA-3		0		0					
	Overall		***7***		***19***					
2010										
	LA-1					2				
	LA-1.5					0.3				
	LA-2		13			5				
	Overall		***13***			***1.7***				

Table 4. Results of Age Determination of Juvenile Steelhead in Laguna Creek Lagoon, October 2010 (courtesy of Michelle Leicester, CDFG).

Capture Location	Length (mm FL)	Age	Notes
Site 3	161	0+	Transition at 87 mm FL
Site 3	167	1+	85 mm FL @ annulus
Site 3	178	1+	Annulus @ 104 mm FL, plus transition
Site 3	193	0+	
Site 3	203	1+	Annulus or transition @ 90 mm FL
Site 1	267	0+	False annulus @ 211 mm FL

San Lorenzo River

Spring (June 23-24)

- Site Conditions
    - Lagoon open, stage low, visibility fair-good (Figure 6).
    - Salinity 2-4 ppt at surface and 29-30 ppt at the bottom;
    - Surface and bottom temperatures were 17-18°C;
    - Surface DO ranged from 5.7 to 8.7 mg/l and bottom DO was from 1.7 to 4.3.

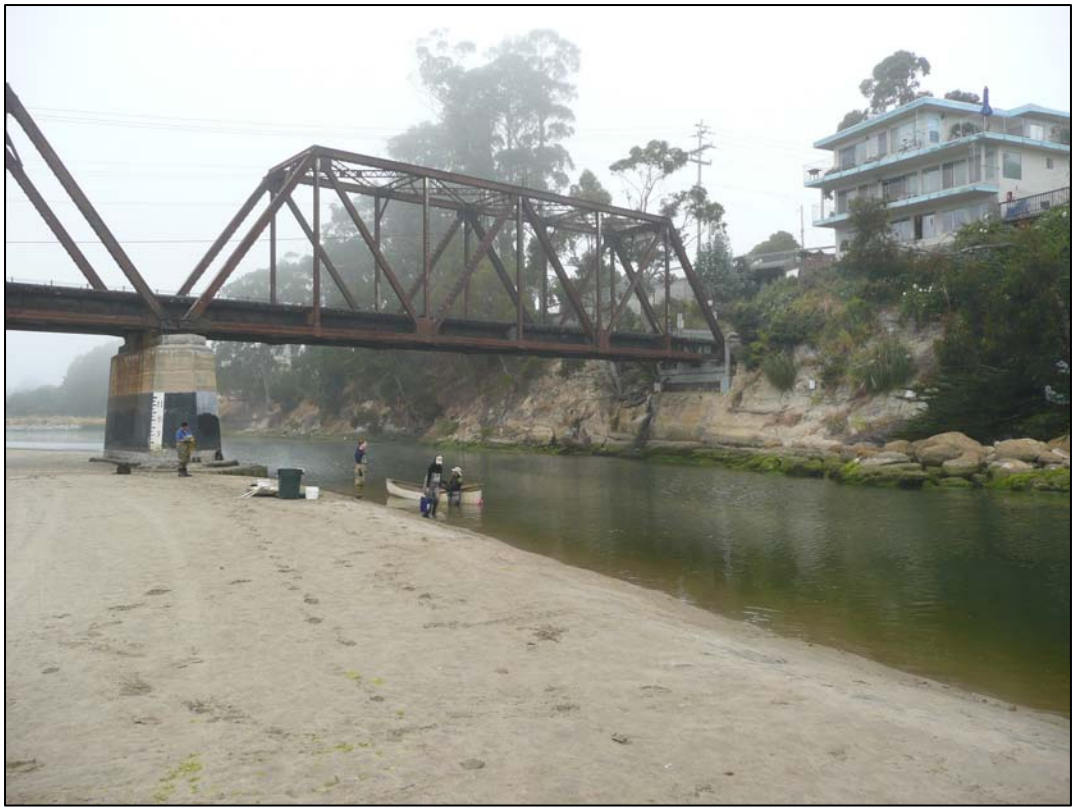

Figure 6. San Lorenzo lagoon, June 23, 2010.

- Survey results
  - 100 ft. by 6 ft by ¼ inch mesh bag seine:
    - 10 hauls
    - Steelhead were moderately abundant around the railroad trestle and upstream of Riverside Bridge (Table 5). Two size classes of steelhead present: ~50-110mm and ~130-190mm (Figure 6). Smaller size class was downstream of trestle and upstream of Riverside, larger size class was around trestle.
    - Catch of other species diverse (Table 5).
  - 150 ft. by 8 ft by 1/4 inch purse seine
    - 2 hauls near railroad trestle
    - Steelhead moderately abundant, Catch per haul about three times higher than bag seine catch per haul at same location. All steelhead in ~130-190mm size range (Figure 7).

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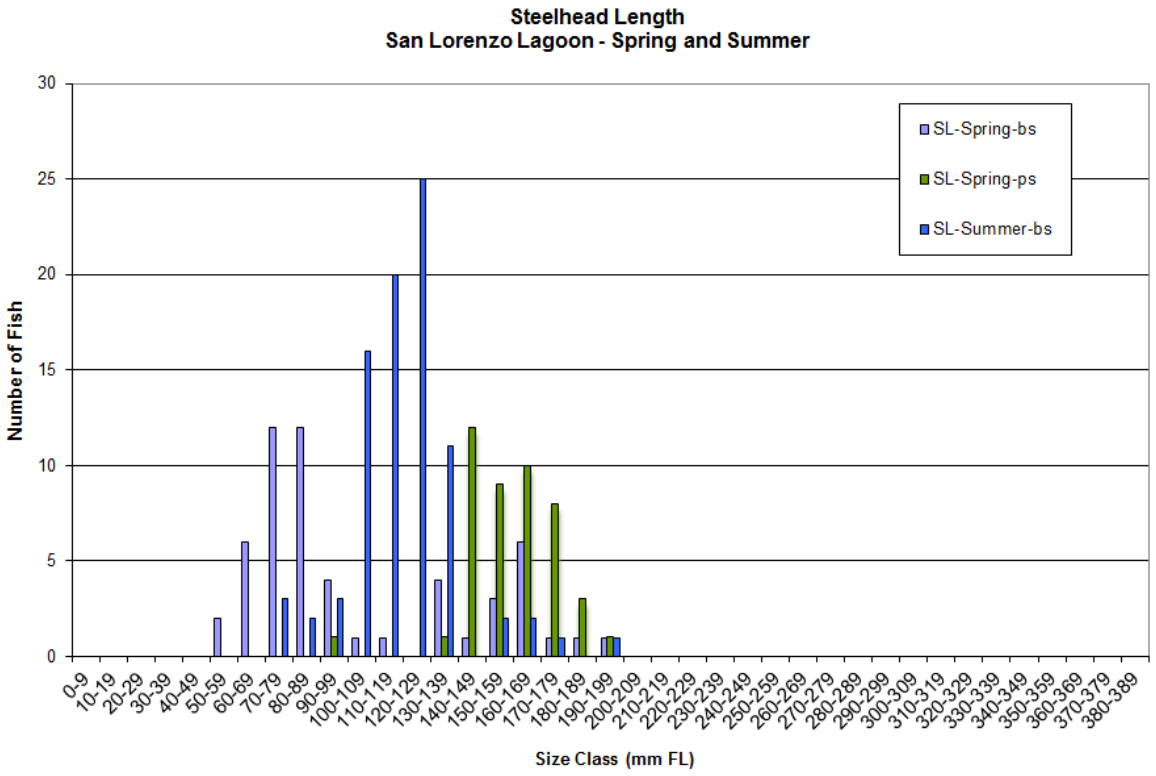
Table 5. Fish catch in San Lorenzo River lagoon, June 2010.

Species	Between Trestle and Mouth (1)	Around Trestle (2)	Between Trestle and WQ site (3)	Upstream of Riverside Bridge (5)	Bend near Laurel Ave. (6)	Grand Total
	100 ft by 6 ft bag seine					
# Hauls	*1*	*5*	*0*	*2*	*2*	*10*
Steelhead		37			18	55
arrow goby				1	2	3
Topsmelt		present		Present	Present	Present
Staghorn sculpin				Present	Present	Present
prickly sculpin				Present	Present	Present
Sculpin	1	present		Present	Present	Present
starry flounder	1	present			Present	Present
shiner surfperch	2	present			Present	Present
Sacramento sucker					Present	Present
Stickleback				Present		Present
Amphipods				Present		Present
Isopods				Present		Present
Pachygrabsis				Present		Present
Clam				Present		Present
	150 ft by 8 ft purse seine					
# Hauls	*0*	*2*	*0*	*0*	*0*	*2*
Steelhead		45				45
Striped bass		1				1
starry flounder		present				Present
shiner surfperch		present				Present



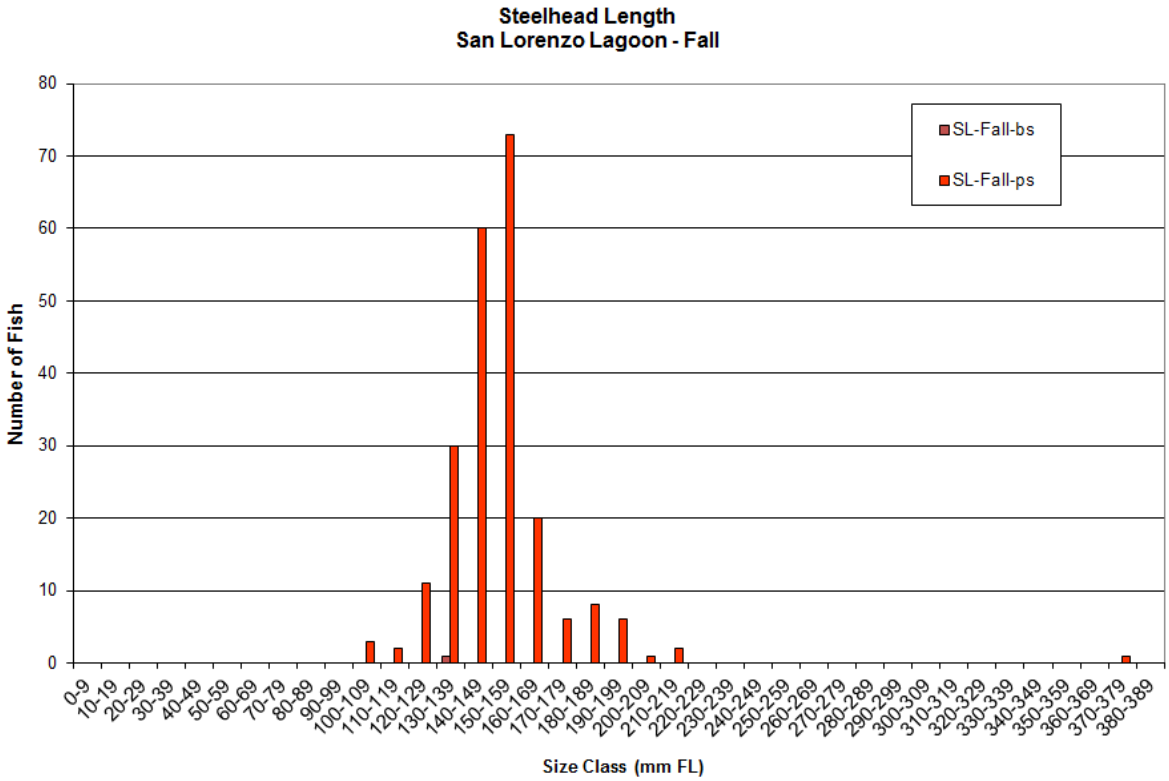


Figure 7. Steelhead length classes in San Lorenzo Lagoon.

Summer (July 21)

- Site Conditions
    - Lagoon open, breached night of July 20/21, stage low (Figure 8).
    - Water quality conditions reflective of recent breach with inflow of cold seawater at lower levels with warm lagoon/river water outflow at the surface.
    - Surface waters were warm (19.4-21°C), poorly oxygenated (4.9-6.6 mg/l), and moderate salinity (7.6-8.7 ppt). Bottom water was cool (15.5-16.2°C), well oxygenated (7.7-7.8 mg/l), and high salinity (27-28 ppt).
    - Water quality monitoring conducted by the City and 2NDNATURE indicated the lagoon had been mostly open since May 15 with two very brief periods of closure in early July and just before sampling on July 21.

Figure 8. San Lorenzo lagoon, July 21, 2010.

- Survey results
  - 100 ft. by 6 ft by ¼ inch mesh bag seine:
    - 4 hauls near trestle and water quality monitoring site (site 3) in conjunction with test of Biosonics hydroacoustic equipment.
    - Large numbers of steelhead juveniles and topsmelt (Table 6). Steelhead were predominantly near site 3, and mostly in the 100-140 mm size class (Figure 7).

Table 6. Fish catch in San Lorenzo River lagoon, July 2010, lagoon open.

Species	Between Trestle and Mouth (1)	Around Trestle (2)	Between Trestle and WQ site (3)	Upstream of Riverside Bridge (5)	Bend near Laurel Ave. (6)	Grand Total
	100 ft by 6 ft bag seine					
# Hauls	*0*	*2*	*2*	*0*	*0*	*4*
Steelhead		1	85			86
Topsmelt		0	112			112
Staghorn sculpin			4			4
prickly sculpin			2			2
Stickleback			2			2

Fall (October 6-7, mouth closed)

- Site Conditions
    - Lagoon closed, lagoon stage high (Figure 9).
    - Water quality monitoring conducted by the City and 2NDNATURE indicated repeated filling and breaching cycles of one to two weeks duration with some periods of open lagoon between cycles since July.
    - Salinity ~2-3ppt at surface and 3-12ppt at the bottom;
    - Surface temperature ~15-19°C, bottom temperature ~21-23°C.
    - Surface DO ~10-10.5 mg/l and bottom DO ~1.5-2 mg/l.
    - Visibility fair.
    - Sampling difficult due to high lagoon stage, lack of beach areas.

Figure 9. San Lorenzo lagoon, October 6, 2010.

- Survey results
  - 100 ft. by 6 ft by ¼ inch mesh bag seine:
    - 4 hauls, around trestle.
    - Few fish, 1 steelhead juvenile. Species diversity low (Table 7).
    - 6 ft net depth may have been less effective for steelhead at this high lagoon stage.
  - 150 ft. by 8 ft by 1/4 inch purse seine
    - 4 hauls near railroad trestle, 1 near WQ site, 3 near Riverside Bridge
    - Steelhead very abundant at trestle and upstream of Riverside. Catch per haul among highest for all sampling events (Table 8). Majority of steelhead in ~120-180mm size range (Figure 6). Scale samples were collected from 15 of these and age determinations were completed by Michelle Leicester of CDFG (Table 9). Aged fish were predominantly young-of-year (0+), with two 1+ individuals. Young-of-year ranged from 103 to 159 mm FL with one 216 mm individual. The largest 1+ fish (375 mmFL) had apparently spent time in the ocean. Five of the 0+ fish showed evidence of late summer reduced growth attributed to stress. The age data is consistent with other studies and assumptions that lagoons can provide excellent rearing habitat where steelhead juveniles can reach smolt size (~150 mm FL range) in a single season compared to two or more in stream-type habitats. All juvenile steelhead observed in the lagoon in the fall were large enough to be expected to smolt in the spring (Figure 6).
    - Species diversity much reduced from spring sample.

Table 7. Fish catch in San Lorenzo River lagoon, October 2010, lagoon closed.

Species	Between Trestle and Mouth (1)	Around Trestle (2)	Between Trestle and WQ site (3)	Upstream of Riverside Bridge (5)	Bend near Laurel Ave. (6)	Grand Total
	100 ft by 6 ft bag seine					
# Hauls	*1*	*4*	*0*	*0*	*0*	*5*
Steelhead		1				1
Topsmelt		194				194
Stickleback		4				4
	150 ft by 8 ft purse seine					
# Hauls	*0*	*4*	*1*	*1*	*1*	*7*
Steelhead		249		9	80	338
Topsmelt		abundant	abundant	abundant	abundant	abundant

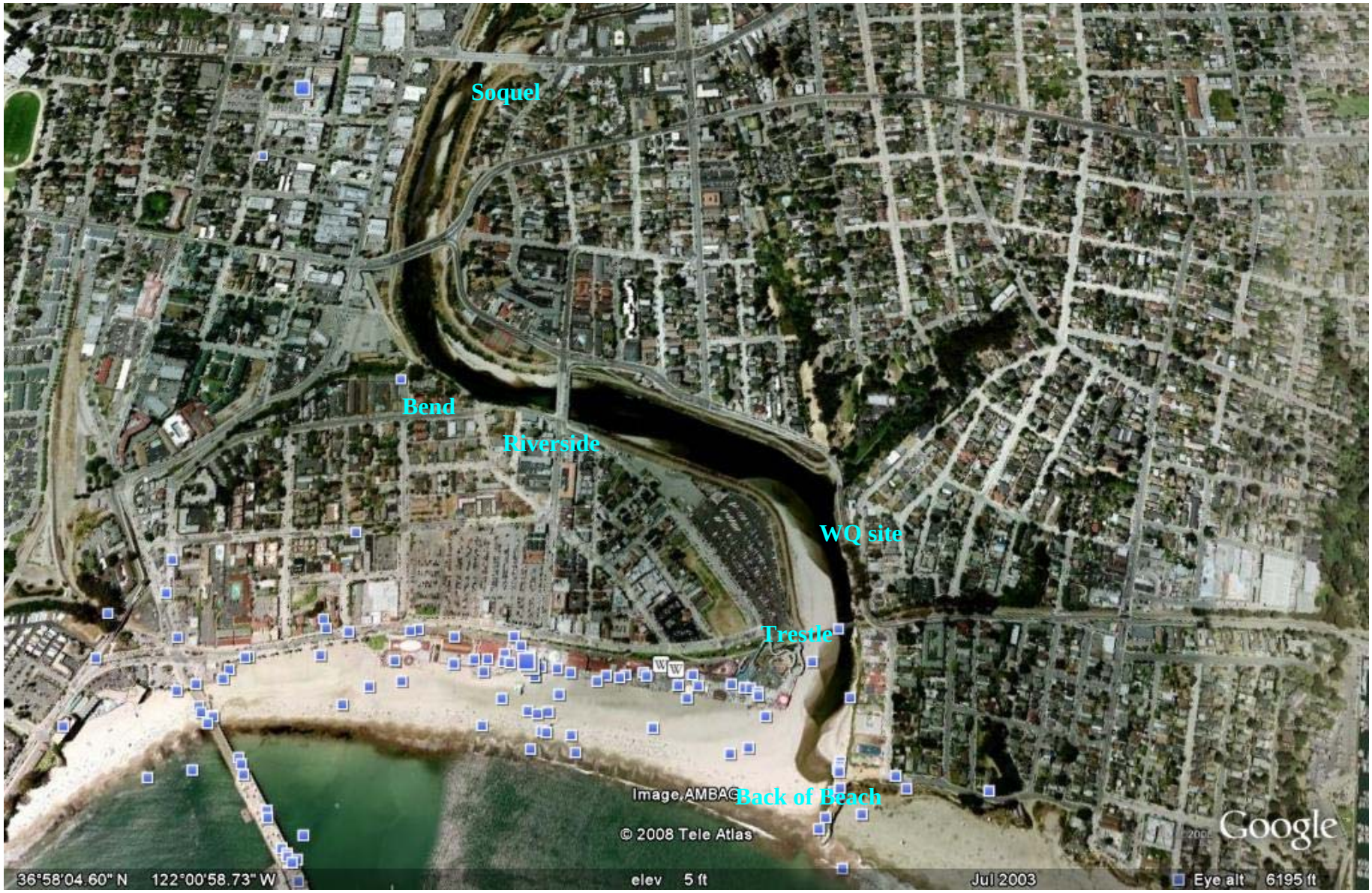
Table 8. Steelhead catch per haul for the San Lorenzo River lagoon during recent sampling events (data from H.T. Harvey aand Associates 2003, 2NDNATURE 2006, Ellen Freund (NOAA Fisheries), HES 2005, HES 2009, and HES 2010).

Site	Location	Steelhead Catch per Haul					
2002						1 Oct	20 Nov
SL-2	RR Trestle						0.0
SL-3	Near YSI Site					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 Site		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				.3	
SL-3	Near YSI Site	0				0	
SL-5	Riverside Drive	0				0	
SL-6	U/S Bank Restoration	0				0	
SL-8	Soquel Ave.	0				0	
2009		10-11 Jun			16 Sep	21 Oct	
SL-2	RR Trestle	0.75			1	0.25	
SL-3	Near YSI Site	0.25					
SL-5	Riverside Drive	0				0	
SL-6	U/S Bank Restoration	0				1.5	
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 Site		42.5			0	
SL-5	Riverside Drive	0.0				9.0	
SL-6	U/S Bank Restoration	9.0				80.0	

Table 9. Results of Age Determination of Juvenile Steelhead in San Lorenzo River Lagoon, October 2010 (courtesy of Michelle Leicester, CDFG).

Capture Location	Length (mm FL)	Age	Notes
SL-2	103	0+	
SL-2	103	0+	false annulus—late summer stress
SL-2	122	0+	false annulus—late summer stress
SL-2	130	0+	
SL-2	135	0+	
SL-2	136	0+	
SL-2	142	0+	false annulus—late summer stress
SL-2	143	0+	late false annulus—stress
SL-2	146	0+	
SL-2	158	0+	probable transition at 99 mm FL
SL-2	159	0+	
SL-2	159	0+	false annulus—late summer stress
SL-2	194	1+	(or transition) 76 mm FL @ annulus/transition
SL-2	216	0+	transition @ 82 mm FL
SL-2	375	1+	stream 1 year + spring growth + fast growth (ocean)

Laguna Creek Lagoon sampling sites.



San Lorenzo River lagoon sampling sites.

Literature Citations

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