2021 Juvenile Salmonid Monitoring Report

Lagunitas Creek Watershed

August 2022

MARIN WATER

Acknowledgements

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Cover Photo: Marin Water fisheries staff electrofishing a site on Lagunitas Creek

EXECUTIVE SUMMARY

In summer 2021, Marin Water conducted surveys for juvenile Coho Salmon (*Oncorhynchus kisutch*) and steelhead (*O. mykiss*) in the Lagunitas Creek watershed. This was the 29th consecutive year (1993-2021) that juvenile sampling has been conducted at the same thirteen index reaches, which include seven reaches in Lagunitas Creek, four in San Geronimo Creek, and two in Devil's Gulch (Study Area). Each index reach included a combination of habitat types, consisting of pools, runs, glides, and riffles, that were sampled independently. The purpose of Marin Water's annual juvenile monitoring is to provide long-term trend data for Coho Salmon and steelhead and support management and recovery of these species.

A total of 962 juvenile Coho and 458 juvenile steelhead were observed/captured via snorkel and electrofishing surveys between July 26 and October 6, 2021. The juvenile observation/capture data were used to calculate juvenile abundance estimates for each index reach, and a total population estimate for the overall Study Area based on proportions of habitat types present.

The 2021 juvenile Coho Salmon population estimate for the Study Area was 31,360 (± 7,393), which was much higher than the long-term average of 18,606 for all sampling years since 2003. This represents an 89% increase for the year class, as compared to the 2018 parent generation. The eight mainstem Lagunitas Creek sites accounted for 98% (N=30,857) of the 2021 juvenile Coho population estimate, which was the highest-ever estimate for that portion of the Study Area. By contrast, little spawning and extensive stream drying resulted in some of the lowest juvenile Coho Salmon abundances ever estimated for San Geronimo Creek (N=485) and Devil's Gulch (N=18). The National Park Service (NPS) calculated a juvenile Coho population estimate of 9,075 (± 2,747) for neighboring Olema Creek. The 2021 Olema Creek juvenile Coho estimate was the highest ever observed for the year class.

The 2021 juvenile steelhead (ages 0+ and 1+) population estimate for the entire Study Area was 13,962 (± 2,573). This was by far the lowest juvenile steelhead estimate on record, and it was much lower than the long-term average of 55,065 for all sampling years since 2003. The eight Lagunitas Creek sites accounted for 83% (N=11,570) of the 2021 juvenile steelhead estimate. For the first time since monitoring began, no juvenile steelhead were observed in Devil's Gulch.

Juvenile Coho from Lagunitas Creek had a mean fork length of 65 mm, which was below the long-term average. Coho from San Geronimo Creek had an average fork length of 68 mm, which was slightly above the long-term average. Age 0+ (young of year) steelhead were also smaller than average in Lagunitas Creek and larger than average in San Geronimo Creek. The largest age 0+ steelhead captured in Lagunitas Creek were 94-106 mm fork length, and 81-82 mm in San Geronimo Creek. The variation in size of juvenile salmonids from year to year may be attributed to survey timing, rearing densities, and/or limited flow conditions in dry years. A total of 218 juvenile Coho were PIT tagged in summer 2021 as part of an ongoing effort to assess overwinter survival and track fish movements within the watershed.

INTRODUCTION

Coho Salmon in the Lagunitas Creek watershed are within the Central California Coast Evolutionarily Significant Unit (CCC ESU) and are listed as "endangered" under both the federal and state Endangered Species Acts (ESA). Lagunitas Creek is within the Central California Coast Distinct Population Segment (CCC DPS) for steelhead and are listed as "threatened" under the federal ESA. In accordance with the Lagunitas Creek Stewardship Plan (Marin Water 2011), the goal of Marin Water's juvenile salmonid monitoring program is to provide long-term population data for Lagunitas Creek and to support recovery and management of these species.

Salmonid monitoring in the Lagunitas Creek watershed was initiated by the California Department of Fish and Wildlife (CDFW) in 1970. At that time, nine index reaches were established within Lagunitas Creek, San Geronimo Creek and Devil's Gulch. These index reaches were monitored again in 1980 and 1982, and six of the reaches were monitored through most of the 1980s. Beginning in 1993, Marin Water began annual monitoring of the original nine reaches and added four additional sites. Marin Water has continued monitoring salmonids annually at these thirteen index reaches, representing one of the longest-running salmonid datasets for the California coast.

In 1999, the National Park Service (NPS) began juvenile salmonid monitoring in index reaches of Olema Creek, a neighboring tributary that joins Lagunitas Creek in its estuary. In 2003, NPS initiated a program of annual systematic snorkel surveys in addition to their index reach monitoring. Additional data and details for Olema Creek monitoring efforts are available from the NPS.

MONITORING LOCATIONS

Between July 26 and October 6, 2021, Marin Water conducted juvenile salmonid surveys in a total of 13 index reaches, including seven in Lagunitas Creek, four in San Geronimo Creek, and two in Devil's Gulch (Figure 1). The index reaches in Lagunitas Creek included LG-2, LG-3u, LG-5, LG-7, LG-9, LG-15.86, and LG-12. The index reaches in San Geronimo Creek included SG-1, SG-2, SG-3, and SG-4. Index reaches in Devil's Gulch included DG-1 and DG-2. Reaches SG-3, SG-4, and DG-2 were completely dry and unable to be surveyed in 2021.

Each index reach consisted of a combination of representative habitat types, consisting of pools, glides, riffles, and runs (Table 1). The following criteria were used to categorize each habitat type:

Pool - relatively deep, slow-moving water, pronounced area of bed scour

Glide - relatively shallow, slow moving water, lacking a pronounced area of bed scour

Riffle - relatively shallow, fast-moving water, substrate mostly gravel-cobble

Run - relatively deep, fast moving water, substrate mostly bedrock-boulder

Figure 1. Juvenile salmonid monitoring locations within the Lagunitas Creek Watershed. Note: the National Park Service (NPS) conducts juvenile salmonid monitoring via snorkel surveys in Olema Creek.

Table 1. 2021 juvenile salmonid sampling reaches, survey methods, and habitat types.

Stream	Index Reach	2021 Survey Method	Sampling Sites (Habitat Type)			
			Pool	Riffle	Run	Glide
Lagunitas Creek	LG-2	Snorkel	2	-	-	-
	LG-3u	Snorkel	2	-	-	-
	LG-5	Snorkel	2	-	-	-
	LG-7	Snorkel	2	-	-	-
	LG-9	Electrofish	-	2	1	1
	LG-15.86	Snorkel	2	-	-	-
	LG-12	Electrofish	1	1	1	-
San Geronimo Creek	SG-1	Electrofish	2	-	1	-
	SG-2	Electrofish	1	-	-	-
Devil's Gulch	DG-1	Electrofish	2	2	-	1
Total:			**16**	**5**	**3**	**2**

METHODS

All fish capture and handling was conducted in accordance with Marin Water's state and federal permits (NOAA Section 10(a)(1)(A), CDFW CESA MOU, CDFW Scientific Collecting Permit, USFWS Section 10(a)(1)(A)). Captured fish were placed into aerated buckets containing fresh stream water. All non-salmonid fishes were counted, identified to species, and held in aerated buckets for release. Sculpin were placed in separate buckets to prevent predation during holding. Juvenile lampreys were classified as "eyed" (macrothalmia) or ammocoetes depending on physical morphology.

Prior to electrofishing each site, block nets were installed at the downstream and upstream ends of each habitat unit to prevent fish from escaping. Habitat characteristics, including unit length, width, depth, substrate composition, shelter ratings, and bank vegetation were collected for each site. Water temperatures were measured using hand-held digital thermometers.

Backpack electrofishers (ETS Electrofishing Systems Model ABP-3) were used to make a minimum of two passes through each habitat unit. Each site was electrofished from the downstream net to the upstream net, and then back downstream again to complete one pass. A total of two to four passes were made at each site depending upon catch rates and habitat conditions. One or two electrofishers were used, depending on the width of the site, and one or two people used dip-nets to capture immobilized fish.

All captured Coho and up to twenty steelhead per sampling site were sedated and measured for fork length to the nearest millimeter (mm) and weight to the nearest 0.1 gram. Any additional steelhead were simply counted and placed in separate aerated buckets for release. Marin Water's prior analysis of fish scales and growth patterns were used to group juvenile steelhead into age classes within each stream. Steelhead were classified as age 0+ (young-of-year) or age 1+ according to the following size breaks:

	Lagunitas Creek	San Geronimo and Devil's Gulch
Age 0+	< 110mm fork length	< 90 mm fork length
Age 1+	≥ 110mm fork length	≥ 90 mm fork length

Passive Integrated Transponder (PIT) tags were implanted in as many juvenile Coho Salmon as possible. A minimum size threshold of 60 mm and 2.7 grams was used as a cutoff for tagging. Fish between 60 and 69 mm fork length received 8-10 mm tags and fish that were 70 mm or larger received a 12 mm tag.

After processing, all Coho and steelhead were placed in black recovery buckets containing fresh aerated stream water. Recovered fish were then transferred to mesh baskets lined with netting (live cars) located in the stream outside of the sampling unit. Large sculpin were placed into separate live cars to avoid predation. Aerators were installed on live cars when fish densities were high. Once sampling was completed, all fish were released back into the habitat unit from which they were captured.

Snorkel surveys were conducted according to the protocol outlined in Adams et al. (2011). Depending on creek width and visibility, a team of two or three divers surveyed each sampling unit. The divers entered the water at the downstream limit of the unit and proceeded together in an upstream direction. Individuals of each fish species were visually identified and counted in each habitat type (glide, pool, run). Riffles were not snorkeled. Observations were recorded on dive slates. For steelhead, the age of individuals was estimated using the age 0+ and age 1+ size breaks described above for each sampling reach. One crewmember recorded data at the completion of each snorkeling pass. The highest total count for each salmonid species after two passes was used as the abundance estimate for each habitat unit.

Data Analysis

The capture/observation data from each site (Appendix A) were entered into *MicroFish 3.0* software (Van Deventer and Platts 1989). Outputs from this program were used to calculate juvenile Coho Salmon, age 0+ steelhead, and age 1+ steelhead abundance estimates and 95% CI error estimates for each habitat unit sampled (Appendix B). These abundance estimates were then extrapolated to the entire Study Area based on Marin Water's most recent habitat survey data from 2016. The 2016 habitat survey classified each stream into proportions of pool, glide, run, riffle, cascade, and dry segments. The proportion of each of these habitat types was multiplied by the 2021 abundance estimates to generate a total juvenile population estimate for the Study Area (Appendix C). Cascades and dry units were excluded from the extrapolation since these habitat types were not present in any of the index reaches, provide limited (or no) salmonid habitat value, and comprised just 0.5% of the stream length within the Study Area.

Additional juvenile monitoring data are available for Lagunitas Creek dating back as far as 1970. However, due to significant changes in methodology and stream morphology over time, we are only including data from the 1990s forward as part of the trend analyses presented in this report.

RESULTS AND DISCUSSION

Juvenile Captures/Observations

In 2021, a total of 962 juvenile Coho Salmon and 458 juvenile steelhead were captured/observed within the Study Area (Table 2). Assuming a three-year lifecycle for Coho, the 2021 year class was notably higher than the 2018 parent generation (Figure 2). The total number of steelhead captures/observations in 2021 was much lower than in previous years, representing just 28% of the long-term average (Figure 3).

The record high number of juvenile Coho Salmon observed in Lagunitas Creek during summer 2021 was likely due to a combination of two main factors. Firstly, the 2020/2021 Coho spawning season was exceptionally dry, which limited access to tributaries and thus resulted in an estimated 83% of the Coho run spawning in mainstem Lagunitas Creek. Secondly, the absence of any significant winter storms likely resulted in very high egg-to-fry survival. By contrast, only 7% of the 2020-21 adult Coho run spawned in San Geronimo Creek and just 2% of the run spawned in Devil's Gulch. These low spawner abundances combined with dry conditions throughout the summer of 2021 resulted in very low numbers of juvenile Coho in these two tributary streams.

Table 2. Juvenile salmonids captured/observed in Lagunitas Creek, San Geronimo Creek, and Devil's Gulch in 2021.

Stream	Index Reach	Juvenile Coho	Age 0+ Steelhead	Age 1+ Steelhead	Total Steelhead	Total Salmonids
Lagunitas Creek	LG-2	133	65	8	73	206
	LG-3u	134	19	7	26	160
	LG-5	146	32	3	35	181
	LG-7	128	30	8	38	166
	LG-9	66	131	2	133	199
	LG-15.86	174	12	5	17	191
	LG-12	158	54	11	65	223
	LG Total	**939**	**343**	**44**	**387**	**1,326**
San Geronimo Creek	SG-1	2	51	4	55	57
	SG-2	20	15	1	16	36
	SG-3*	0	0	0	0	0
	SG-4*	0	0	0	0	0
	SG Total	**22**	**66**	**5**	**71**	**93**
Devil's Gulch	DG-1	1	0	0	0	1
	DG-2*	0	0	0	0	0
	DG Total	**1**	**0**	**0**	**0**	**1**
Total All Sites		**962**	**409**	**49**	**458**	**1,420**

*Dry at time of survey

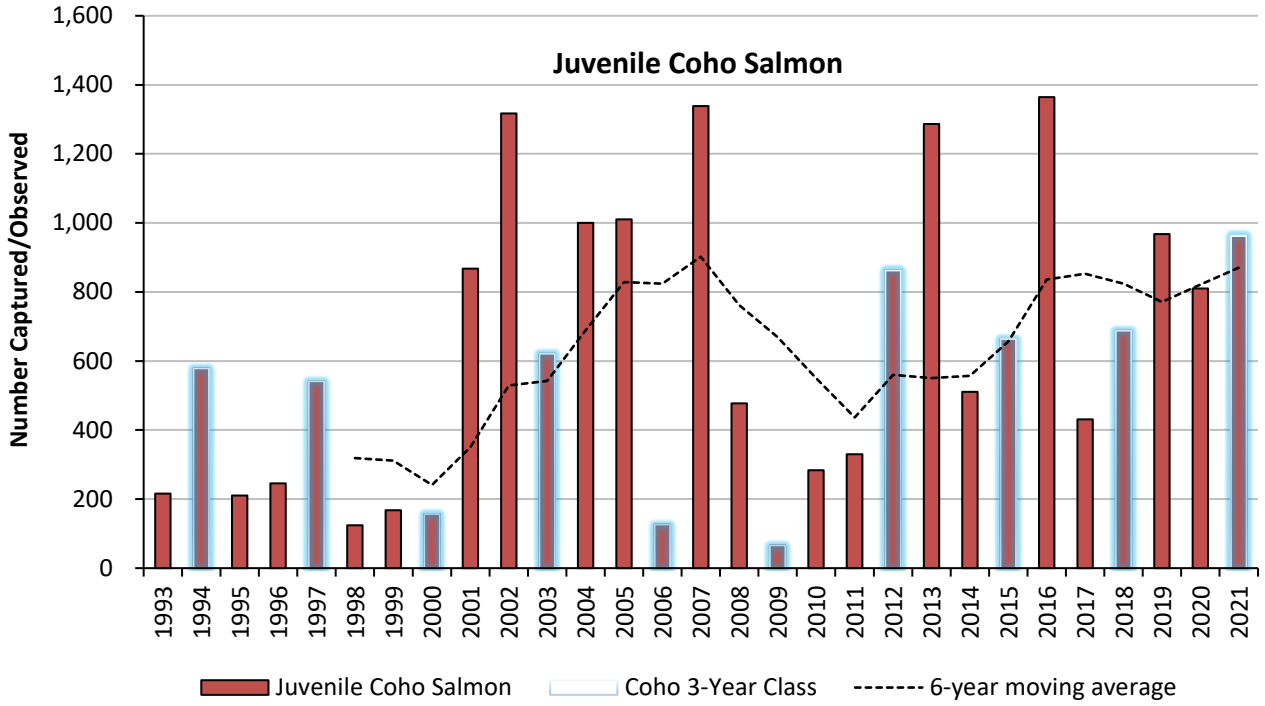


Figure 2. Total juvenile Coho Salmon captures/observations in Lagunitas Creek, San Geronimo Creek, and Devil's Gulch index reaches from 1993 to 2021. Note: the 6-year moving average corresponds to two average Coho life cycles.

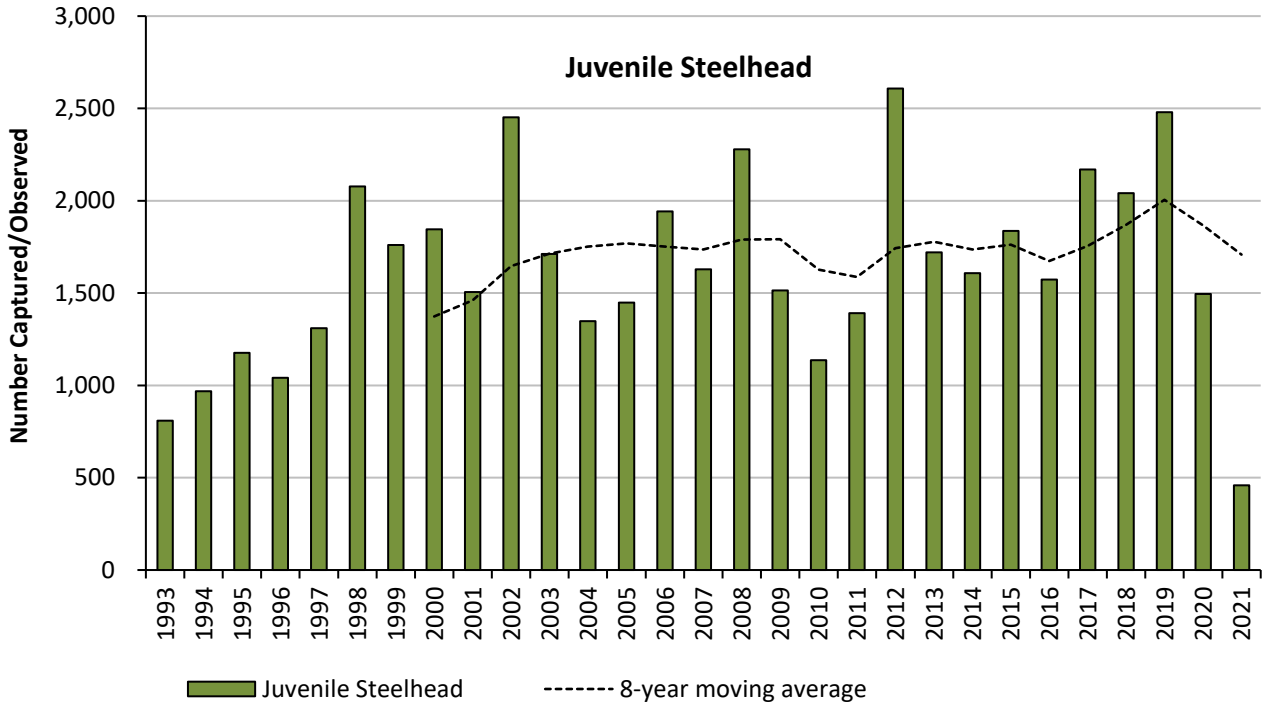


Figure 3. Total juvenile steelhead captures/observations in Lagunitas Creek, San Geronimo Creek, and Devil's Gulch index reaches from 1993 to 2021. Note: the 8-year moving average corresponds to two average steelhead life cycles.

The 2021 juvenile steelhead abundance estimates for the Study Area were the lowest on record, with fewer than half as many fish as the previous low set in 2010. For the first time ever, juvenile steelhead were not detected in Devil's Gulch. Potential explanations for the low abundance of juvenile steelhead include limited tributary spawning, desiccation of redds, and high fry mortality. The 2020-21 steelhead run was smaller than average, but not dramatically so, and no stream had record-low numbers of redds. Some redds may have become desiccated as a result of low tributary flows, and drying of these streams during the summer likely further reduced steelhead survival. However, these factors do not explain the low steelhead abundance in Lagunitas Creek, where an average number of redds was observed, and regulated flow releases from Kent Lake were adequate to keep those redds fully inundated through spring. Steelhead survival has not been correlated with high densities of juvenile Coho Salmon, and there is no evidence that predation of steelhead fry was higher than in previous years.

The low numbers of juvenile steelhead observed in 2021 may have been, at least in part, due to an increase in the number of sites surveyed via snorkeling rather than electrofishing. Historically, all index reaches were sampled by electrofishing. However, in 2021 a permit restriction limited electrofishing only to sites where California freshwater shrimp had not been encountered previously. Marin Water has found snorkeling to be less effective for counting juvenile steelhead due to their ability to hide and elude observation. Steelhead numbers were low in both reaches that were electrofished and those that were snorkeled in 2021. It is therefore not clear to what extent the low numbers of juvenile steelhead observed reflect an actual decline in abundance or simply reduced detection efficiency.

Juvenile Population Estimates

The 2021 expanded juvenile Coho Salmon population estimate for Lagunitas Creek, San Geronimo Creek, and Devil's Gulch was 31,360 (± 7,393). This represents an 89% increase for the year class, as compared to the 2018 parent generation, and it was higher than the long-term moving average (Figure 4).

Mainstem Lagunitas Creek accounted for 98% (N=30,857) of the overall 2021 juvenile Coho abundance estimate. This was the highest-ever abundance estimate calculated for mainstem Lagunitas Creek since monitoring began (Figure 6). By contrast, limited spawning and exceptionally low flow conditions resulted in some of the lowest juvenile Coho Salmon abundance estimates ever calculated for both San Geronimo Creek (N=485) and Devil's Gulch (N=18).

The National Park Service (NPS) calculated a juvenile Coho abundance estimate of 9,075 (± 2,747) for Olema Creek based on similar snorkeling and habitat survey data. The NPS 2021 juvenile Coho abundance estimate for Olema Creek was the highest on record for that year class since monitoring began in 2004.

The 2021 juvenile steelhead abundance estimate was 13,962 (± 2,573) for Lagunitas Creek, San Geronimo Creek, and Devil's Gulch (Figure 5). The 2021 juvenile steelhead estimates for all sites were the lowest since monitoring began and well below the long-term moving average (Figure 7). The eight mainstem Lagunitas Creek index reaches accounted for 83% (N=11,570) of the 2021 juvenile steelhead abundance estimate. NPS did not calculate a juvenile steelhead abundance estimate for Olema Creek in 2021.

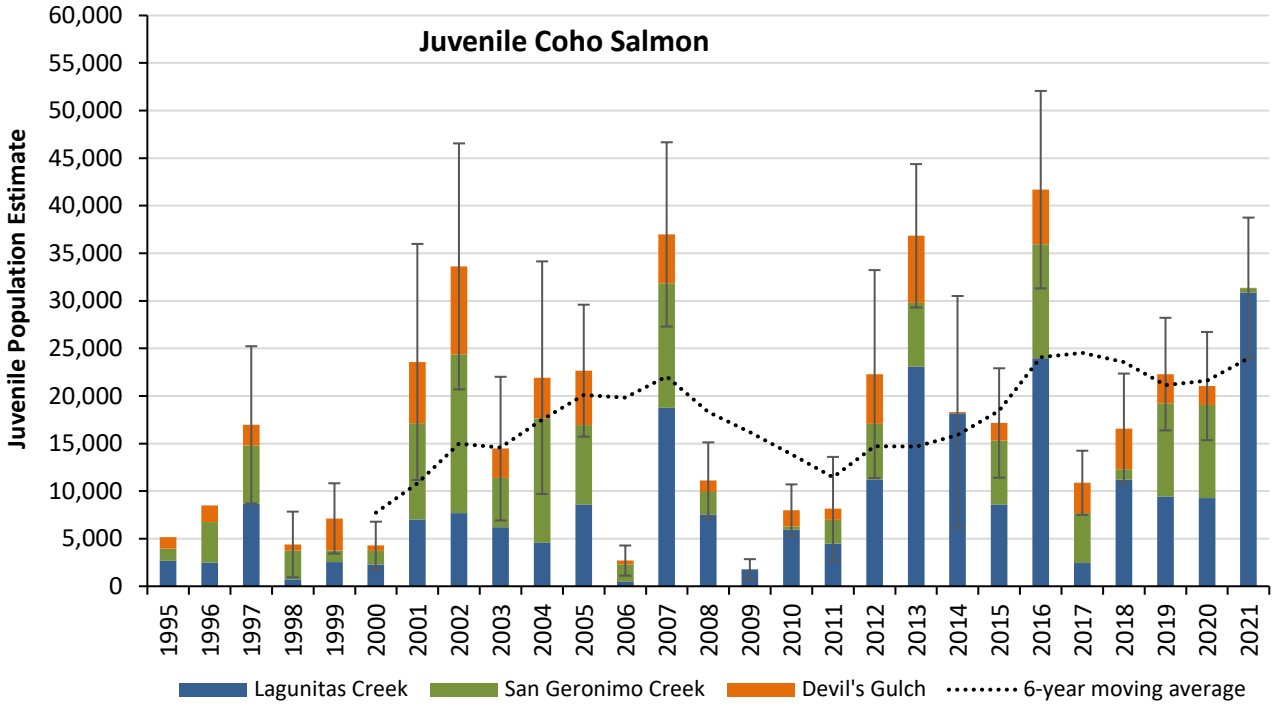


Figure 4. Juvenile Coho Salmon population and 95% CI estimates for Lagunitas Creek, San Geronimo Creek, and Devil's Gulch from 1995 to 2021. Note: the 6-year moving average corresponds to two average Coho life cycles.

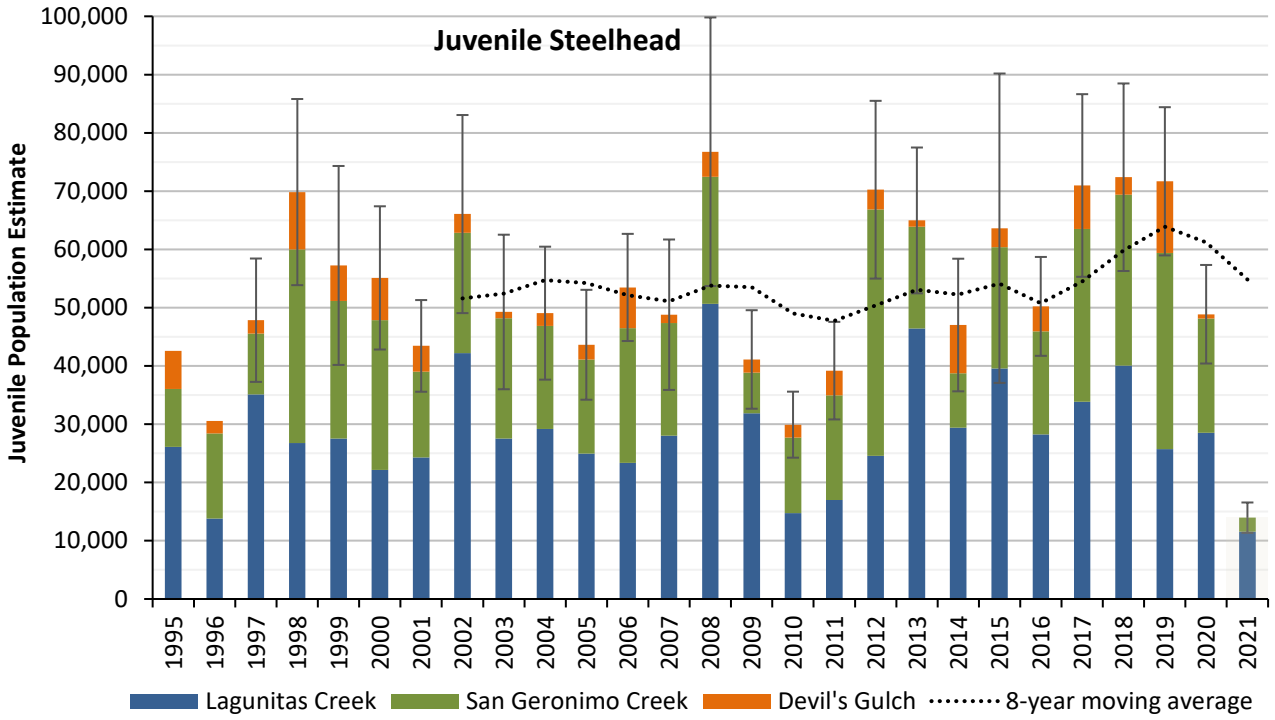
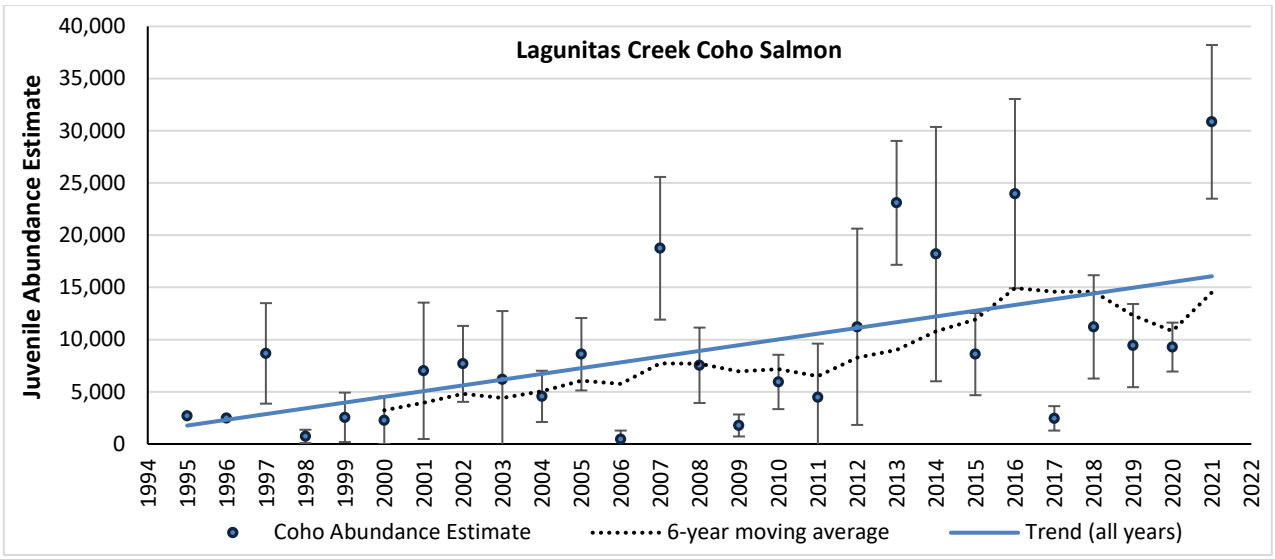
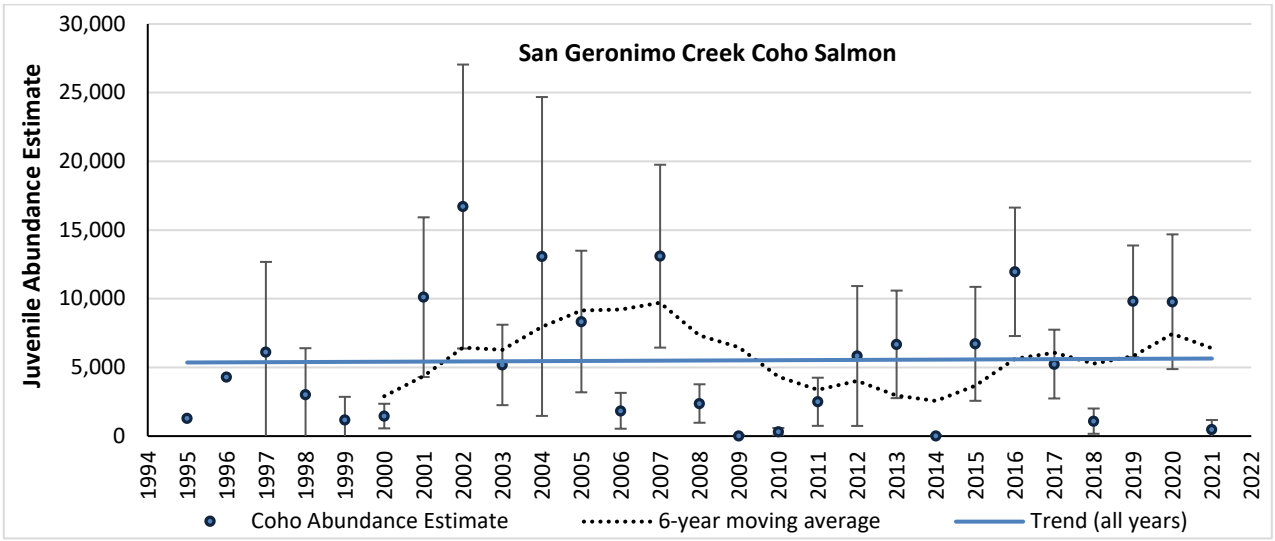


Figure 5. Juvenile steelhead population and 95% CI estimates for Lagunitas Creek, San Geronimo Creek, and Devil's Gulch from 1995 to 2021. Note: the 8-year moving average corresponds to two average steelhead life cycles.





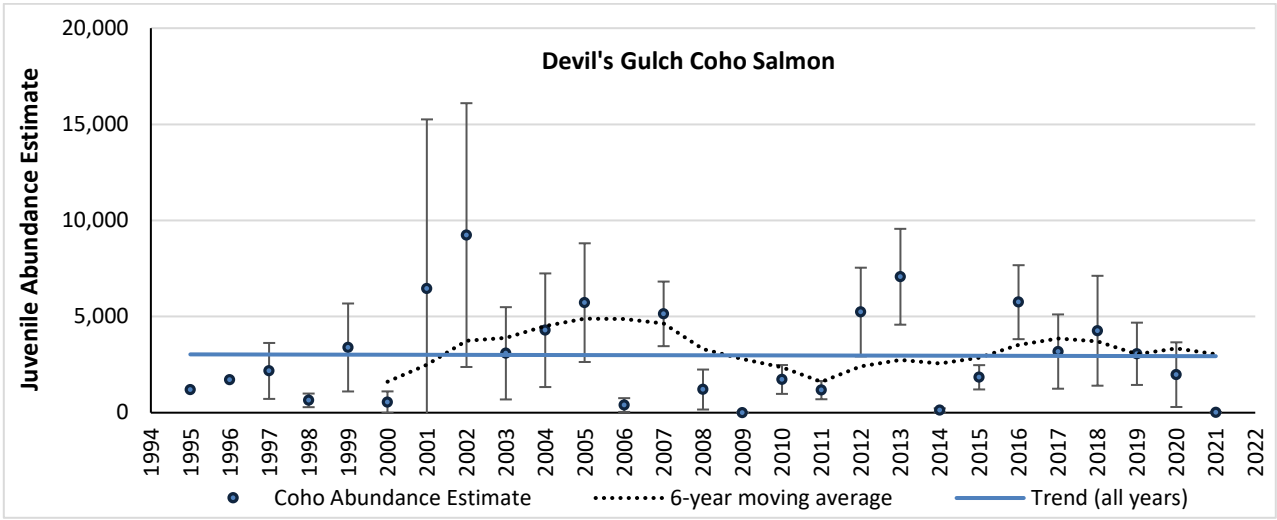


Figure 6. Juvenile Coho abundance and 95% CI estimates, moving averages, and trends for Lagunitas Creek, San Geronimo Creek, and Devil's Gulch from 1995-2021.

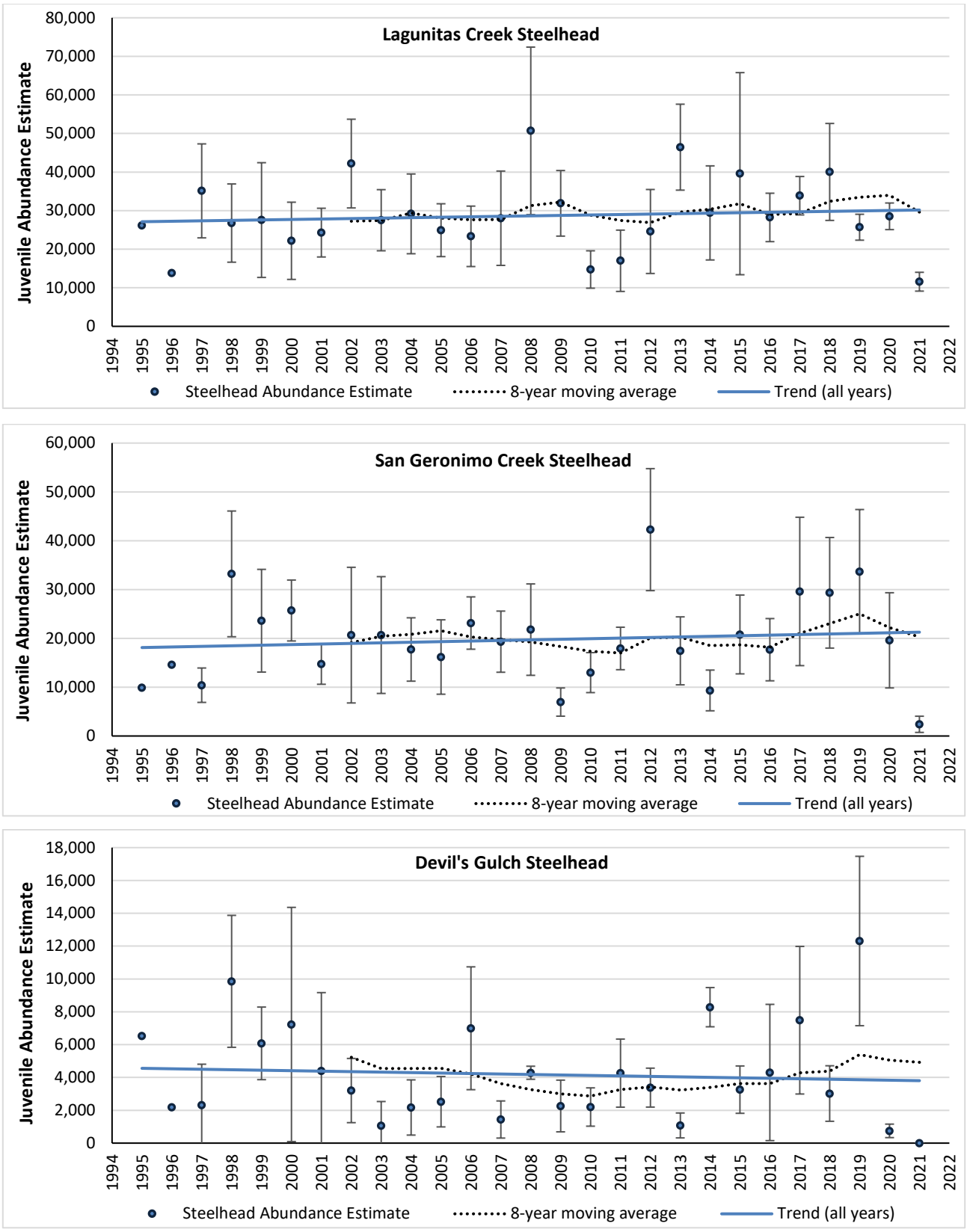


Figure 7. Juvenile steelhead abundance and 95% CI estimates, moving averages, and trends for Lagunitas Creek, San Geronimo Creek, and Devil's Gulch from 1995-2021.

Juvenile Salmonid Size

A total of 368 juvenile Coho and 167 steelhead were measured during the 2021 sampling season. Coho Salmon in Lagunitas Creek had a mean fork length of 65 mm, which was the lowest value ever observed (Figure 8). As shown in Figure 8, juvenile Coho Salmon tend to be larger in mainstem Lagunitas Creek than in either San Geronimo Creek or Devil's Gulch. Marin Water has analyzed this phenomenon and found that juvenile Coho growth rates, and thus average size, in all three creeks appears to be density dependent (Marin Water 2020). It is therefore likely that the high Coho rearing densities observed in Lagunitas Creek in 2021 contributed to their smaller-than-average size. By contrast, juvenile Coho Salmon in San Geronimo Creek were slightly larger than average in 2021 with a mean fork length of 68 mm, perhaps due to the unusually low densities observed there.

In 2021, young-of-year (age 0+) steelhead were smaller than average in Lagunitas Creek, but larger than average in San Geronimo Creek (Figure 9). The largest age 0+ steelhead encountered had fork lengths between 94-106 mm in Lagunitas Creek, and between 81-82 mm in San Geronimo Creek. No juvenile steelhead were captured or observed within the Devil's Gulch sampling reaches in 2021. Marin Water has analyzed age 0+ steelhead growth data in previous years and found that growth rates are weakly associated with overall juvenile salmonid densities (all species and ages), stream flow patterns during the spring, and the timing of adult steelhead spawning during the previous winter (Marin Water 2020).

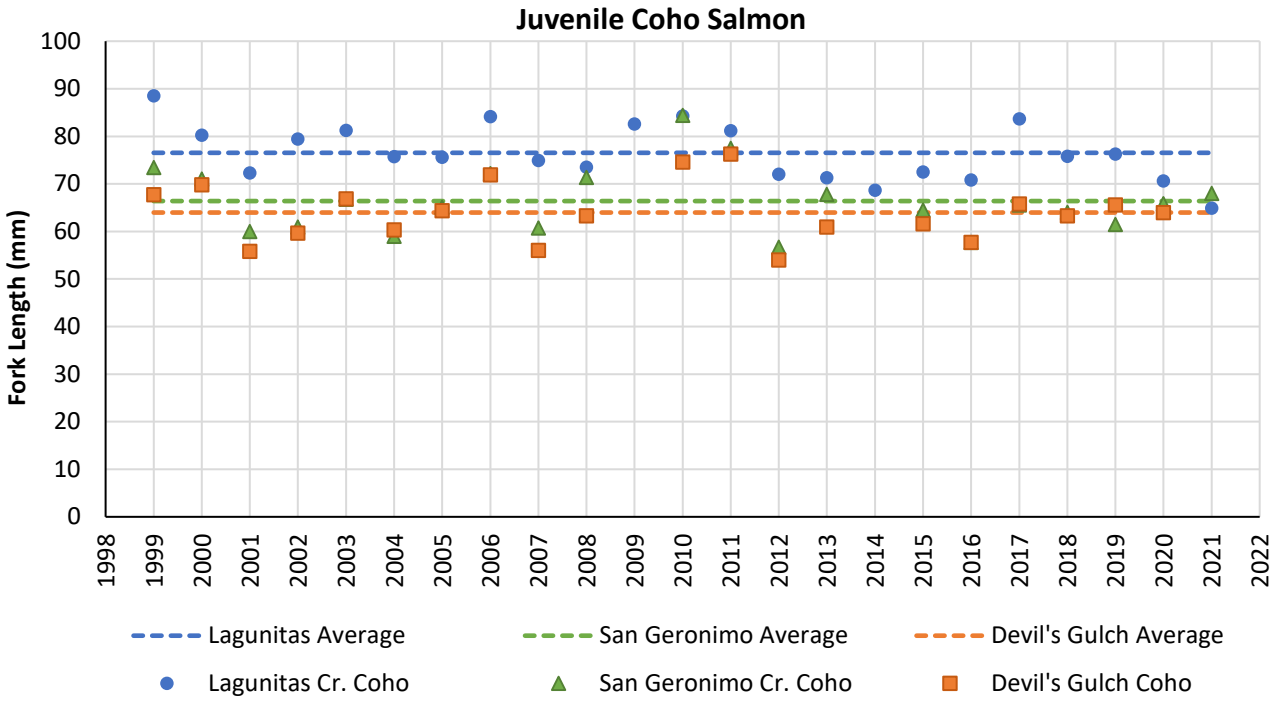


Figure 8. Annual mean lengths of juvenile Coho Salmon captured in Lagunitas Creek, San Geronimo Creek, and Devil's Gulch 1999-2021, and average mean length for each stream over the same period.

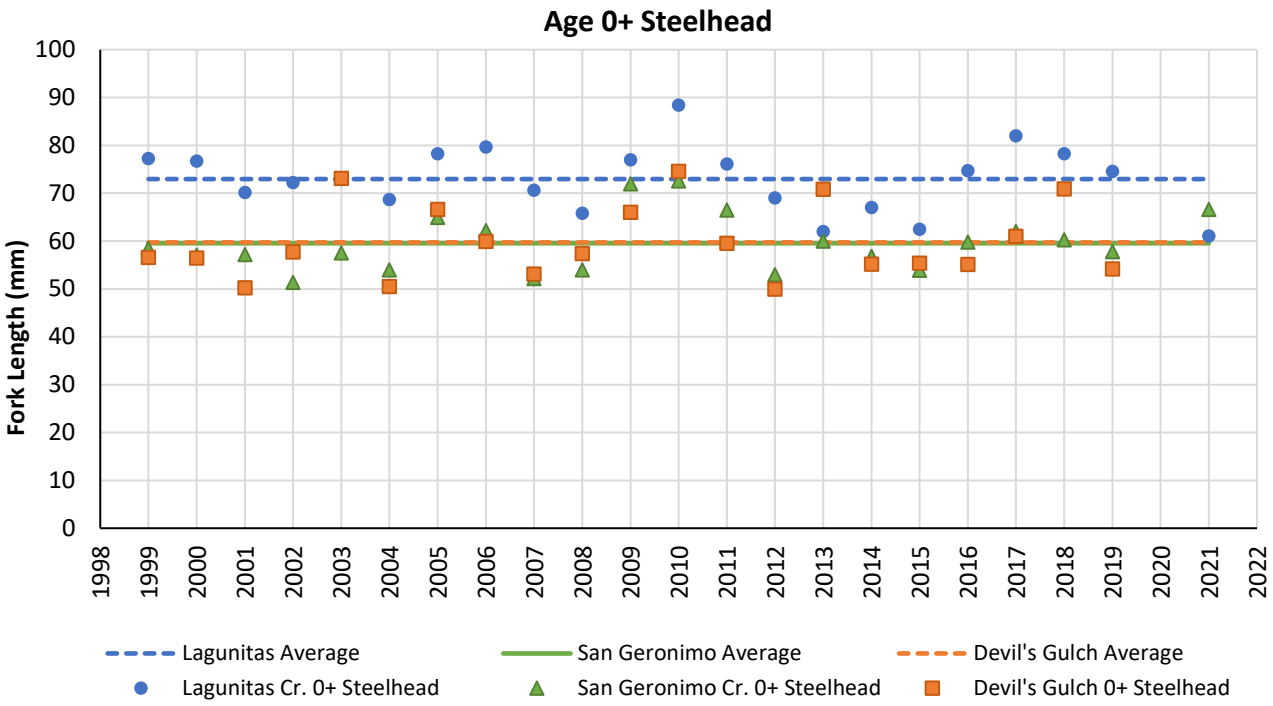


Figure 9. Annual mean lengths of age 0+ (young-of-year) steelhead captured in Lagunitas Creek, San Geronimo Creek, and Devil's Gulch 1999-2021, and average mean length for each stream over the same period. Note: San Geronimo Creek and Devil's Gulch have the same long-term average value of 60mm.

Habitat Conditions

More than half of the index reach habitats in San Geronimo Creek were dry in 2021. Within the remnant pools at reaches SG-3 and SG-4, the only fish species observed were Threespine Stickleback and Tomales Roach. In Devil's Gulch, index reach DG-2 was completely dry. Other habitats in these streams were unusually shallow and covered by floating aquatic vegetation (e.g., duckweed). In Lagunitas Creek, habitat conditions were similar to those observed in previous years. Releases from Kent Lake kept flows in Lagunitas Creek, as measured at the USGS Samuel P. Taylor State Park streamgage, at or above six cubic feet per second (cfs) throughout the summer.

The 2016 Lagunitas Creek habitat typing survey classified the stream as 53% pools, 7% riffles, 30% runs, and 10% glides by length. In 2021, the index reaches were categorized as 56% pools, 12% riffles, 7% runs, and 25% glides by length.

The overall habitat composition of San Geronimo Creek in 2016 was 43% pools, 11% riffles, 42% runs, and 4% glides by length. In 2021, the index reaches consisted of 71% pools, 12% riffles, 17% runs, and 0% glides by length.

The overall habitat composition of Devil's Gulch in 2016 was 34% pools, 30% riffles, 32% runs, and 4% glides by length. In 2021, the index reaches were categorized as 59% pools, 21% riffles, 20% runs, and 0% glides by length.

Other Species Observed

Four non-salmonid native fish species were observed/captured in 2021, including Tomales Roach (*Hesperoleucus venustus subditus)*, Threespine Stickleback (*Gasterosteus aculeatus*), Pacific Lamprey (*Entosphenus tridentatus*), and sculpin (*Cottus sp.*) (Table 3). No non-native fish species were encountered. Total numbers of Roach, Pacific Lamprey and sculpin captured were unusually low. By contrast, Threespine Stickleback were exceptionally abundant. Sacramento Sucker, a native fish species that was regularly captured/observed in Lagunitas Creek through 2013, was not encountered for the eighth consecutive year.

Table 3. Non-salmonid species captured/observed during juvenile sampling in Lagunitas Creek, San Geronimo Creek, and Devil's Gulch from 1997-2021.

Year	Native Fishes					Non-Native Fishes			Other Aquatic Species			
	Sculpin species	Tomales Roach	Threespine Stickleback	Pacific Lamprey	Sacramento Sucker	Largemouth Bass	Bluegill	Green Sunfish	CA Giant Salamander	Rough-Skinned Newt	CA Freshwater Shrimp	Bullfrog
1997	215	396	178	220	1	0	0	0	0	0	2	0
1998	220	285	218	312	2	0	0	0	1	0	3	0
1999	219	278	219	335	2	0	1	1	6	1	24	0
2000	147	118	352	374	0	0	0	0	12	0	51	0
2001	230	364	841	777	4	0	0	0	8	0	32	0
2002	198	30	587	771	1	0	0	0	5	0	7	0
2003	340	86	338	983	63	1	0	0	13	0	0	2
2004	347	101	320	664	6	0	0	0	4	0	3	0
2005	458	166	153	859	12	0	0	0	7	0	6	0
2006	492	523	521	778	56	0	0	0	10	0	3	0
2007	328	277	475	945	16	0	0	0	6	0	5	0
2008	266	406	283	435	3	0	0	0	6	0	9	0
2009	297	241	543	775	6	0	4	4	12	0	8	0
2010	121	190	713	495	2	0	0	0	11	0	2	2
2011	221	283	403	348	0	0	0	0	13	0	4	1
2012	210	292	559	299	1	0	0	0	5	0	9	1
2013	185	108	861	285	1	0	0	0	1	0	3	0
2014	179	69	384	319	0	0	0	0	11	0	11	0
2015	101	201	785	923	0	0	0	0	1	0	11	0
2016	544	157	1005	794	0	0	15	2	11	1	4	0
2017	1045	189	1440	522	0	0	9	0	7	0	4	2
2018	640	79	675	539	0	0	0	0	6	0	10	0
2019	255	102	756	605	0	0	2	0	6	0	13	2
2020	212	131	572	590	0	0	0	0	5	1	4	1
2021	107	95	1071	231	0	0	0	0	0	0	0	0
Mean	**303**	**207**	**570**	**567**	**7**	**< 1**	**1**	**< 1**	**7**	**< 1**	**9**	**< 1**

CONCLUSIONS

- For the first time since regular juvenile monitoring began in the 1990's, several index reaches in San Geronimo Creek and Devil's Gulch were dry and therefore unable to be sampled.
- Juvenile Coho abundance was higher than average for the overall Study Area, although the vast majority (98%) of these fish were observed in Lagunitas Creek, while the tributaries had very few juvenile Coho.
- Juvenile steelhead abundance was much lower than average, continuing a downward trend from the previous year. The reason for this decline is unknown, but it may be attributed to ongoing drought conditions and/or reduced detection efficiency as a result of conducting more snorkel surveys in 2021 in lieu of electrofishing some sites.
- Juvenile Coho in Lagunitas Creek were much smaller than average, while they were slightly larger than average in San Geronimo Creek. Too few Coho were measured from Devil's Gulch to obtain an accurate average. High rearing densities in Lagunitas Creek likely contributed to their smaller-than-average size.
- Young-of-year steelhead (age 0+) in Lagunitas Creek were much smaller than average, while they were slightly larger than average in San Geronimo Creek.

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APPENDICES

Appendix A. 2021 Fish Captures/Observations by Index Reach

Appendix B. 2021 Juvenile Salmonid Abundance Estimates by Sample Site

Appendix C. 2021 Index Reach Extrapolated Juvenile Salmonid Population Estimates

631 Glide	Pass		Total
Species	1	2	
0+ Steelhead	13	8	21
1+ Steelhead	1	0	1
Coho Salmon	162	43	205
Lamprey (macro)	7	7	14
Lamprey (ammo)	4	5	9
Stickleback	59	48	107
Roach	19	15	34
Sculpin	5	2	7

LG-2 1st, Pool*	Pass		Max.
Species	1	2	
0+ Steelhead	30	33	33
1+ Steelhead	1	3	3
Coho Salmon	43	47	47

* Snorkel survey.

LG-2 2nd, Pool*	Pass		Max.
Species	1	2	
0+ Steelhead	32	31	32
1+ Steelhead	5	4	5
Coho Salmon	86	84	86

LG-3u 1st, Pool*	Pass		Max.
Species	1	2	
0+ Steelhead	15	9	15
1+ Steelhead	2	5	5
Coho Salmon	90	100	100

* Snorkel survey.

LG-3u 2nd, Pool*	Pass		Total
Species	1	2	
0+ Steelhead	1	4	4
1+ Steelhead	0	2	2
Coho Salmon	33	34	34

* Snorkel survey.

LG-5 1st, Pool*	Pass		Max.
Species	1	2	
0+ Steelhead	16	17	17
1+ Steelhead	2	1	2
Coho Salmon	30	30	30

*Snorkle survey

LG-5 2nd, Pool*	Pass		Max.
Species	1	2	
0+ Steelhead	16	12	16
1+ Steelhead	1	1	1
Coho Salmon	115	116	116

*Snorkle survey

LG-7 1st, Pool*	Pass		Max.
Species	1	2	
0+ Steelhead	8	6	8
1+ Steelhead	7	10	10
Coho Salmon	67	70	70

* Snorkel survey.

LG-7 2nd, Pool*	Pass		Max.
Species	1	2	
0+ Steelhead	16	20	20
1+ Steelhead	1	1	1
Coho Salmon	50	58	58

* Snorkel survey.

LG-9 1st, Riffle	Pass		Total
Species	1	2	
0+ Steelhead	23	11	34
1+ Steelhead	0	0	0
Coho Salmon	3	1	4
Sculpin	2	2	4

LG-9 2nd, Run	Pass		Total
Species	1	2	
0+ Steelhead	16	8	24
1+ Steelhead	0	0	0
Coho Salmon	6	2	8
Lamprey (ammo)	2	2	4
Lamprey (macro)	5	2	7
Sculpin	7	2	9

LG-9 3rd, Riffle	Pass		Total
Species	1	2	
0+ Steelhead	26	15	41
1+ Steelhead	0	0	0
Coho Salmon	0	1	1
Lamprey (macro)	1	1	2
Lamprey (ammo)	0	1	1
Sculpin	2	1	3

LG-9 4th, Glide	Pass			Total
Species	1	2	3	
0+ Steelhead	15	12	5	32
1+ Steelhead	0	2	0	2
Coho Salmon	29	15	19	63
Lamprey (macro)	19	19	9	47
Lamprey (ammo)	1	5	5	11
Sculpin	10	5	5	20
Stickleback	1	3	2	6

LG-15.86 1st, Pool*	Pass		Max.
Species	1	2	
0+ Steelhead	10	12	12
1+ Steelhead	5	3	5
Coho Salmon	133	174	174

* Snorkel survey

LG-15.86 2nd, Pool*	Pass		Max.
Species	1	2	
0+ Steelhead	6	7	7
1+ Steelhead	1	0	0
Coho Salmon	225	203	225

* Snorkel survey

LG-12 1st, Pool	Pass			Total
Species	1	2	3	
0+ Steelhead	13	5	2	20
1+ Steelhead	4	2	0	6
Coho Salmon	59	33	15	107
Stickleback	14	13	10	37
Lamprey (ammo)	15	23	13	51
Lamprey (macro)	21	14	5	40
Roach	1	0	0	1
Sculpin	14	14	7	35

LG-12 2nd, Run	Pass		Total
Species	1	2	
0+ Steelhead	10	5	15
1+ Steelhead	0	2	2
Coho Salmon	42	5	47
Lamprey (ammo)	4	2	6
Lamprey (macro)	9	7	16
Stickleback	1	3	4
Sculpin	5	2	7

LG-12 3rd, Riffle	Pass		Total
Species	1	2	
0+ Steelhead	12	7	19
1+ Steelhead	2	1	3
Coho Salmon	2	2	4
Lamprey (ammo)	1	2	3
Lamprey (macro)	5	2	7
Sculpin	17	5	22

SG-1 1st, Pool	Pass		Total
Species	1	2	
0+ Steelhead	15	8	23
1+ Steelhead	3	0	3
Coho Salmon	2	0	2
Lamprey (ammo)	1	0	1
Lamprey (macro)	1	0	1
Roach	0	1	1
Stickleback	4	1	5

SG-1 2nd, Glide	Pass		Total
Species	1	2	
0+ Steelhead	10	0	10
1+ Steelhead	1	0	1
Coho Salmon	0	0	0
Lamprey (ammo)	1	0	1
Lamprey (macro)	0	1	1
Stickleback	0	2	2

SG-1 3rd, Pool	Pass		Total
Species	1	2	
0+ Steelhead	18	0	18
1+ Steelhead	0	0	0
Coho Salmon	0	0	0
Lamprey (ammo)	3	5	8
Stickleback	10	2	12

SG-2 Single Pool	Pass		Total
Species	1	2	
0+ Steelhead	14	1	15
1+ Steelhead	1	0	1
Coho Salmon	18	2	20
Stickleback	27	14	41
Roach	32	16	48
Lamprey (ammo)	0	1	1

SG-3 Single Pool	Pass		Total
Species	1	2	
0+ Steelhead	0	0	0
1+ Steelhead	0	0	0
Coho Salmon	0	0	0
Stickleback	447	186	633
Roach	4	7	11

SG-4 2nd, Pool	Pass	Total
Species	1	
0+ Steelhead	0	0
1+ Steelhead	0	0
Coho Salmon	0	0
Stickleback	224	224

DG-1 1st, Pool	Pass	Total
Species	1	
0+ Steelhead	0	0
1+ Steelhead	0	0
Coho Salmon	0	0

DG-1 2nd, Riffle	Pass	Total
Species	1	
0+ Steelhead	0	0
1+ Steelhead	0	0
Coho Salmon	0	0

DG-1 3rd, Glide	Pass	Total
Species	1	
0+ Steelhead	0	0
1+ Steelhead	0	0
Coho Salmon	0	0

DG-1 4th, Riffle	Pass	
Species	1	Total
0+ Steelhead	0	0
1+ Steelhead	0	0
Coho Salmon	0	0

DG-1 5th, Pool	Pass	
Species	1	Total
0+ Steelhead	0	0
1+ Steelhead	0	0
Coho Salmon	1	1

LAGUNITAS CREEK

Site: **LG-2** Sequence: **1st** Habitat: **Pool**

	Snorkel Count	Population Estimate	Lower Confidence Interval	Upper Confidence Interval	Standard Deviation
0+ Steelhead	33	33	NA	NA	NA
1+ Steelhead	3	3	NA	NA	NA
Coho	47	47	NA	NA	NA

Site: **LG-2** Sequence: **2nd** Habitat: **Pool**

	Snorkel Count	Population Estimate	Lower Confidence Interval	Upper Confidence Interval	Standard Deviation
0+ Steelhead	32	32	NA	NA	NA
1+ Steelhead	5	5	NA	NA	NA
Coho	86	86	NA	NA	NA

LG-2	Total	Population Estimate
0+ Steelhead	65	65
1+ Steelhead	8	8
Coho	133	133

Site: **LG-631** Sequence: **1st** Habitat: **Glide**

	Catch	Population Estimate	Lower Confidence Interval	Upper Confidence Interval	Standard Deviation
0+ Steelhead	21	27	10	44	17
1+ Steelhead	1	1	1	1	0
Coho	205	219	206	232	13

Glides	Total	Population Estimate
0+ Steelhead	21	27
1+ Steelhead	1	1
Coho	205	219

Site: **LG-3u** Sequence: **1st** Habitat: **Pool**

	Snorkel Count	Population Estimate	Lower Confidence Interval	Upper Confidence Interval	Standard Deviation
0+ Steelhead	15	15	NA	NA	NA
1+ Steelhead	5	5	NA	NA	NA
Coho	100	100	NA	NA	NA

Site: **LG-3u** Sequence: **2nd** Habitat: **Pool**

	Snorkel Coun	Population Estimate	Lower Confidence Interval	Upper Confidence Interval	Standard Deviation
0+ Steelhead	4	4	NA	NA	NA
1+ Steelhead	2	2	NA	NA	NA
Coho	34	34	NA	NA	NA

LG-3u	Total	Population Estimate
0+ Steelhead	19	19
1+ Steelhead	7	7
Coho	134	134

Site: **LG-5** Sequence: **1st** Habitat: **Pool**

	Snorkel Count	Population Estimate	Lower Confidence Interval	Upper Confidence Interval	Standard Deviation
0+ Steelhead	17	17	NA	NA	NA
1+ Steelhead	2	2	NA	NA	NA
Coho	30	30	NA	NA	NA

Site: **LG-5** Sequence: **2nd** Habitat: **Pool**

	Snorkel Coun	Population Estimate	Lower Confidence Interval	Upper Confidence Interval	Standard Deviation
0+ Steelhead	16	16	NA	NA	NA
1+ Steelhead	1	1	NA	NA	NA
Coho	116	116	NA	NA	NA

LG-5	Total	Population Estimate
0+ Steelhead	33	33
1+ Steelhead	3	3
Coho	146	146

Site: **LG-7** Sequence: **1st** Habitat: **Pool**

	Snorkel Count	Population Estimate	Lower Confidence Interval	Upper Confidence Interval	Standard Deviation
0+ Steelhead	8	8	NA	NA	NA
1+ Steelhead	10	10	NA	NA	NA
Coho	70	70	NA	NA	NA

Site: **LG-7** Sequence: **2nd** Habitat: **Pool**

	Snorkel Count	Population Estimate	Lower Confidence Interval	Upper Confidence Interval	Standard Deviation
0+ Steelhead	20	20	NA	NA	NA
1+ Steelhead	1	1	NA	NA	NA
Coho	58	58	NA	NA	NA

LG-7	Total	Population Estimate
0+ Steelhead	28	28
1+ Steelhead	11	11
Coho	128	128

Site: **LG-9** Sequence: **1st** Habitat: **Riffle**

	Catch	Population Estimate	Lower Confidence Interval	Upper Confidence Interval	Standard Deviation
0+ Steelhead	34	41	26	56	**15.3**
1+ Steelhead	0	0	0	0	0.0
Coho	4	4	2	6	2.0

Site: **LG-9** Sequence: **2nd** Habitat: **Run**

	Catch	Population Estimate	Lower Confidence Interval	Upper Confidence Interval	Standard Deviation
0+ Steelhead	24	28	17	38	10.7
1+ Steelhead	0	0	0	0	0.0
Coho	8	8	6	10	2.0

Site: **LG-9** Sequence: **3rd** Habitat: **Riffle**

	Catch	Population Estimate	Lower Confidence Interval	Upper Confidence Interval	Standard Deviation
0+ Steelhead	41	56	27	85	**29.6**
1+ Steelhead	0	0	0	0	0.0
Coho	1	1	1	1	0.0

Site: **LG-9** Sequence: **4th** Habitat: **Glide**

	Catch	Population Estimate	Lower Confidence Interval	Upper Confidence Interval	Standard Deviation
0+ Steelhead	32	39	25	53	14.3
1+ Steelhead	2	2	-11	15	13.3
Coho	63	111	29	193	**83.7**

LG-9	Total	Population Estimate
0+ Steelhead	131	164
1+ Steelhead	2	2
Coho	76	124

Site: **LG-12** Sequence: **1st** Habitat: **Pool**

	Catch	Population Estimate	Lower Confidence Interval	Upper Confidence Interval	Standard Deviation
0+ Steelhead	20	20	18	22	2.0
1+ Steelhead	5	5	4	6	1.0
Coho	107	122	106	138	**16.3**

Site: **LG-12** Sequence: **2nd** Habitat: **Run**

	Catch	Population Estimate	Lower Confidence Interval	Upper Confidence Interval	Standard Deviation
0+ Steelhead	16	20	6	34	**14.3**
1+ Steelhead	1	1	1	1	0.0
Coho	47	47	45	49	2.0

Site: **LG-12** Sequence: **3rd** Habitat: **Riffle**

	Catch	Population Estimate	Lower Confidence Interval	Upper Confidence Interval	Standard Deviation
0+ Steelhead	19	24	9	38	**14.8**
1+ Steelhead	3	3	0	6	3.1
Coho	4	4	-1	9	5.1

LG-12	Total	Population Estimate
0+ Steelhead	55	64
1+ Steelhead	9	9
Coho	158	173

Site: **LG-15.86** Sequence: **1st** Habitat: **Pool**

	Snorkel Count	Population Estimate	Lower Confidence Interval	Upper Confidence Interval	Standard Deviation
0+ Steelhead	12	12	NA	NA	NA
1+ Steelhead	5	5	NA	NA	NA
Coho	174	174	NA	NA	NA

Site: **LG-15.86** Sequence: **2nd** Habitat: **Pool**

	Snorkel Count	Population Estimate	Lower Confidence Interval	Upper Confidence Interval	Standard Deviation
0+ Steelhead	7	7	NA	NA	NA
1+ Steelhead	1	1	NA	NA	NA
Coho	225	225	NA	NA	NA

LG-15.86	Total	Population Estimate
0+ Steelhead	19	19
1+ Steelhead	6	6
Coho	399	399

SAN GERONIMO CREEK

Site: **SG-1** Sequence: **1st** Habitat: **Pool**

	Catch	Population Estimate	Lower Confidence Interval	Upper Confidence Interval	Standard Deviation
0+ Steelhead	23	28	14	42	**14.3**
1+ Steelhead	3	3	3	3	0.0
Coho	2	2	2	2	0.0

Site: **SG-1** Sequence: **2nd** Habitat: **Run**

	Catch	Population Estimate	Lower Confidence Interval	Upper Confidence Interval	Standard Deviation
0+ Steelhead	10	10	10	10	0.0
1+ Steelhead	1	1	1	1	0.0
Coho	0	0	0	0	0.0

Site: **SG-1** Sequence: **3rd** Habitat: **Pool**

	Catch	Population Estimate	Lower Confidence Interval	Upper Confidence Interval	Standard Deviation
0+ Steelhead	18	18	18	18	0.0
1+ Steelhead	0	0	0	0	0.0
Coho	0	0	0	0	0.0

SG-1	Total	Population Estimate
0+ Steelhead	51	56
1+ Steelhead	4	4
Coho	2	2

Site: **SG-2** Sequence: **1st** Habitat: **Pool**

	Catch	Population Estimate	Lower Confidence Interval	Upper Confidence Interval	Standard Deviation
0+ Steelhead	15	15	14	16	1.0
1+ Steelhead	1	1	1	1	0.0
Coho	20	20	19	21	1.0

SG-2	Total	Population Estimate
0+ Steelhead	15	15
1+ Steelhead	1	1
Coho	20	20

Site: **SG-3** Sequence: **1st** Habitat: **Pool**

	Catch	Population Estimate	Lower Confidence Interval	Upper Confidence Interval	Standard Deviation
0+ Steelhead	0	0	0	0	**0.0**
1+ Steelhead	0	0	0	0	**0.0**
Coho	0	0	0	0	**0.0**

Site: **SG-3** Sequence: **2nd** Habitat: **Riffle**

	Catch	Population Estimate	Lower Confidence Interval	Upper Confidence Interval	Standard Deviation
0+ Steelhead	0	0	0	0	**0.0**
1+ Steelhead	0	0	0	0	**0.0**
Coho	0	0	0	0	**0.0**

SG-3	Total	Population Estimate
0+ Steelhead	0	0
1+ Steelhead	0	0
Coho	0	0

Site: **SG-4** Sequence: **1st** Habitat: **Pool**

	Catch	Population Estimate	Lower Confidence Interval	Upper Confidence Interval	Standard Deviation
0+ Steelhead	0	0	0	0	**0.0**
1+ Steelhead	0	0	0	0	**0.0**
Coho	0	0	0	0	**0.0**

Site: **SG-4** Sequence: **2nd** Habitat: **Pool**

	Catch	Population Estimate	Lower Confidence Interval	Upper Confidence Interval	Standard Deviation
0+ Steelhead	0	0	0	0	**0.0**
1+ Steelhead	0	0	0	0	**0.0**
Coho	0	0	0	0	**0.0**

SG-4	Total	Population Estimate
0+ Steelhead	0	0
1+ Steelhead	0	0
Coho	0	0

DEVIL'S GULCH

Site: **DG-1** Sequence: **1st** Habitat: **Pool**

	Catch	Population Estimate	Lower Confidence Interval	Upper Confidence Interval	Standard Deviation
0+ Steelhead	0	0	0	0	0.0
1+ Steelhead	0	0	0	0	0.0
Coho	0	0	0	0	0.0

Site: **DG-1** Sequence: **2nd** Habitat: **Riffle**

	Catch	Population Estimate	Lower Confidence Interval	Upper Confidence Interval	Standard Deviation
0+ Steelhead	0	0	0	0	0.0
1+ Steelhead	0	0	0	0	0.0
Coho	0	0	0	0	0.0

Site: **DG-1** Sequence: **3rd** Habitat: **Glide**

	Catch	Population Estimate	Lower Confidence Interval	Upper Confidence Interval	Standard Deviation
0+ Steelhead	0	0	0	0	0.0
1+ Steelhead	0	0	0	0	0.0
Coho	0	0	0	0	0.0

Site: **DG-1** Sequence: **4th** Habitat: **Riffle**

	Catch	Population Estimate	Lower Confidence Interval	Upper Confidence Interval	Standard Deviation
0+ Steelhead	0	0	0	0	**0.0**
1+ Steelhead	0	0	0	0	**0.0**
Coho	0	0	0	0	**0.0**

Site: **DG-1** Sequence: **5th** Habitat: **Pool**

	Catch	Population Estimate	Lower Confidence Interval	Upper Confidence Interval	Standard Deviation
0+ Steelhead	0	0	0	0	**0.0**
1+ Steelhead	0	0	0	0	**0.0**
Coho	1	1	0	0	**0.0**

DG-1	Total	Population Estimate
0+ Steelhead	0	0
1+ Steelhead	0	0
Coho	1	1

Lagunitas Creek - Nicasio Creek to Peters Dam

Total Habitat:

	Length (m)	% of Total
Pool	6,995	53%
Run	3,965	30%
Riffle	874	7%
Glide	1,298	10%
Total	13,133	100%

*Note: Does not include 327 m of cascades, side channels, and dry habitat.

Electrofishing and Snorkel Sites:

	Length (m)	% of Total
Pool	329.7	56%
Run	41.5	7%
Riffle	71.5	12%
Glide	144.7	25%
Total	587.4	100%

Fish Population Estimates from Sites Sampled: (see Appendix B)

	0+ SH	1+ SH	Coho
Pool	184	40	1062
Run	48	1	55
Riffle	121	3	9
Glide	66	3	330
Total	419	47	1456

Number of Fish per Habitat Type in the Stream Segment:

0+ SH			
Pool = 184 fish/329.7 m =>0.558 fish/m x 6995 m of pool =	3,904	+/-	783
Run = 48 fish/41.5 m =>1.157 fish/m x 3965 m of run =	4,586	+/-	870
Riffle = 121 fish/71.5 m =>1.692 fish/m x 874 m of riffle =	1,480	+/-	1,723
Glide = 66 fish/144.7 m =>0.456 fish/m x 1298 m of glide =	592	+/-	876
	10,562	+/-	2,085
1+ SH			
Pool = 40 fish/329.7 m =>0.121 fish/m x 6995 m of pool =	849	+/-	228
Run = 1 fish/41.5 m =>0.024 fish/m x 3965 m of run =	96	+/-	104
Riffle = 3 fish/71.5 m =>0.042 fish/m x 874 m of riffle =	37	+/-	184
Glide = 3 fish/144.7 m =>0.021 fish/m x 1298 m of glide =	27	+/-	171
	1,008	+/-	355
Coho			
Pool = 1062 fish/329.7 m =>3.221 fish/m x 6995 m of pool =	22,530	+/-	5,130
Run = 55 fish/41.5 m =>1.325 fish/m x 3965 m of run =	5,255	+/-	4,395
Riffle = 9 fish/71.5 m =>0.126 fish/m x 874 m of riffle =	110	+/-	99
Glide = 330 fish/144.7 m =>2.281 fish/m x 1298 m of glide =	2,961	+/-	2,923
	30,857	+/-	7,361

San Geronimo Creek - Mouth to Dickson Weir (Upstream of Woodacre Creek)

Total Habitat:

	Length (m)	% of Total
Pool	2,936	43%
Run	2,819	42%
Riffle	781	12%
Glide	241	4%
Total	6,776	100%

*Note: Does not include 418 m of cascades, side channels, and dry habitat.

Electrofishing Sites:

	Length (m)	% of Total
Pool	133.2	71%
Run	32.3	17%
Riffle	21.9	12%
Glide	0.0	0%
Total	187.4	100%

Fish Population Estimates from Sites Sampled: (see Appendix B)

	0+ SH	1+ SH	Coho
Pool	61	4	22
Run	10	1	0
Riffle	0	0	0
Glide	0	0	0
Total	71	5	22

Number of Fish per Habitat Type in the Stream Segment:

0+ SH			
Pool = 61 fish/133.2 m => 0.458 fish/m x 2936 m of pool =	1,344	+/-	1,507
Run = 10 fish/32.3 m => 0.31 fish/m x 2819 m of run =	873	+/-	-
Riffle = 0 fish/21.9 m => 0 fish/m x 781 m of riffle =	-	+/-	-
	2,217	+/-	1,507
1+ SH			
Pool = 4 fish/133.2 m => 0.03 fish/m x 2936 m of pool =	88	+/-	152
Run = 1 fish/32.3 m => 0 fish/m x 2819 m of run =	87	+/-	-
Riffle = 0 fish/21.9 m => 0 fish/m x 781 m of riffle =	-	+/-	-
	175	+/-	152
Coho			
Pool = 22 fish/133.2 m => 0.165 fish/m x 2936 m of pool =	485	+/-	688
Run = 0 fish/32.3 m => 0 fish/m x 2819 m of run =	-	+/-	-
Riffle = 0 fish/21.9 m => 0 fish/m x 781 m of riffle =	-	+/-	-
	485	+/-	688

Devils Gulch - Mouth to 3,287 meters upstream.

Total Habitat:

	Length (m)	% of Total
Pool	1,063	34%
Run	1,013	32%
Riffle	953	30%
Glide	135	4%
Total	3,163	100%

*Note: Does not include 124 m of cascade and dry habitats.

Electrofishing Sites:

	Length (m)	% of Total
Pool	60.6	52%
Run	20.0	17%
Riffle	21.0	18%
Glide	15	13%
Total	116.2	100%

Fish Population Estimates from Sites Sampled: (see Appendix B)

	0+ SH	1+ SH	Coho
Pool	0	0	1
Run	0	0	0
Riffle	0	0	0
Total	0	0	1

Number of Fish per Habitat Type in the Stream Segment:

0+ SH

Pool = 0 fish/60.6 m => 0 fish/m x 1063 m of pool =	0	+/-	-
Run = 0 fish/20 m => 0 fish/m x 1013 m of run =	0	+/-	-
Riffle = 0 fish/21 m => 0 fish/m x 953 m of riffle =	0	+/-	-
	0	+/-	-

1+ SH

Pool = 0 fish/60.6 m => 0 fish/m x 1063 m of pool =	0	+/-	-
Run = 0 fish/20 m => 0 fish/m x 1013 m of run =	0	+/-	-
Riffle = 0 fish/21 m => 0 fish/m x 953 m of riffle =	0	+/-	-
	0	+/-	-

Coho

Pool = 1 fish/60.6 m => 0.017 fish/m x 1063 m of pool =	18	+/-	50
Run = 0 fish/20 m => 0 fish/m x 1013 m of run =	0	+/-	-
Riffle = 0 fish/21 m => 0 fish/m x 953 m of riffle =	0	+/-	-
	18	+/-	50