JUVENILE SALMONID AND SMOLT MONITORING
IN THE LAGUNITAS CREEK WATERSHED – 2022-2023

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Acknowledgements

Cover image: A smolt-sized juvenile Coho Salmon captured in October, 2022

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EXECUTIVE SUMMARY

This report summarizes two salmonid monitoring efforts conducted by Marin Water in 2022 and 2023. Between August 12 and October 14, 2022, Marin Water staff and Watershed Stewards Program members estimated the abundance of juvenile Coho Salmon (Oncorhynchus kisutch) and steelhead (O. mykiss) in the Lagunitas Creek Study Area, which consists of Lagunitas Creek and two of its main tributaries, San Geronimo Creek and Devil's Gulch. Downstream-migrating salmonid smolts were monitored between April 4 and June 1, 2023 using a rotary screw trap (RST) in lower Lagunitas Creek, near Point Reyes Station (Figure 1). These two surveys were performed in accordance with Marin Water's Lagunitas Creek Stewardship Plan (MMWD 2011) and the data collected are used to estimate survival rates of these species during critical life stages.

Through a combination of electrofishing and snorkeling, the 2022 juvenile Coho Salmon population was estimated at 108,624 (± 21,810). This was by far the highest abundance estimate on record, following nearly ideal stream flow conditions during spawning, incubation and fry emergence. Stream flows in the fall of 2021 were adequate to allow adult Coho Salmon to spawn throughout the Study Area, and the ensuing low stream flows promoted very high egg-to-fry survival. In April of 2022, moderate rains ensured that fry could emerge from their redds, some of which had been exposed by low flows. In Olema Creek, the National Park Service estimated a population of 42,948 (± 5,785), which was also a record. Steelhead abundance in the study area was well below average, with an estimate of 29,728 (± 5,303).

The record Coho Salmon cohort was monitored again as they migrated to Tomales Bay in the spring of 2023. Marin Water estimates that 26,730 (± 4,388) Coho Salmon smolts emigrated past our rotary screw trap (RST) in lower Lagunitas Creek, near Point Reyes Station (Figure 1). An estimated 23,500 (± 7,628) Coho Salmon smolts emigrated from Olema Creek. The watershed estimate of 50,230 (± 8,801) Coho Salmon smolts was the highest on record, and overwinter survival was estimated at 33%.

An estimated 850 (± 498) steelhead smolts emigrated from Lagunitas Creek in 2023, which was one of the lowest estimates on record. The Chinook Salmon emigration was also below average, with 1,064 (± 267) smolts leaving Lagunitas Creek.

INTRODUCTION

Lagunitas Creek is a regionally important coastal stream for Coho Salmon (Oncorhychus kisutch) and steelhead (O. mykiss), with recent Coho Salmon escapement estimates averaging approximately 500 individuals, while steelhead runs are somewhat smaller. Chinook Salmon (O. tshawytscha) also spawn in Lagunitas Creek and smolts have been observed in most years.

Salmonid surveys are conducted cooperatively between Marin Water, the California Department of Fish and Wildlife (CDFW), the National Park Service (NPS), the Marin Resource Conservation District, the Watershed Stewards Program (WSP), and the Salmon Protection and Watershed Network (SPAWN). Summer and fall electrofishing surveys for juvenile Coho Salmon and steelhead were conducted in Lagunitas Creek starting in 1970 and annually since 1993. This represents one of the longest data records for juvenile salmonids in coastal streams of California. Systematic Coho Salmon adult spawner surveys began in 1982 and have been conducted annually since 1995. Marin Water has conducted annual smolt surveys on Lagunitas Creek since 2006, as well as in 1983, 1984 and 1985. Since 2012, juvenile Coho Salmon have been implanted with passive integrated transponder (PIT) tags. Other data collection activities include stream flow monitoring conducted by the United States Geological Survey at gages in

Samuel P. Taylor State Park and Point Reyes Station. Another stream gage is maintained by Marin Water on San Geronimo Creek. Marin Water has also monitored water temperature continuously since the early 1990s. Lagunitas Creek streambed conditions are monitored annually and salmonid habitat is quantified approximately every five years.

Juvenile salmonid and smolt monitoring is being conducted in collaboration with NPS, which conducts similar monitoring surveys in Olema Creek. NPS has monitored salmonid smolt emigration from Olema Creek since 2004, and smolt monitoring was conducted on a tributary to Olema Creek between 1998 and 2004.

Salmonid monitoring in the Lagunitas Creek watershed is intended to answer the following questions:

- What are the abundance trends in Coho Salmon and steelhead at each life stage?
- What are the survival rates between freshwater life stages, what factors influence those rates, and do those rates differ between subwatersheds?
- What are Coho Salmon marine survival rates and how do these rates compare to other populations in the region?

METHODS

Juvenile Salmonid Survey

Juvenile salmonid population estimates were produced by estimating the numbers of fish, using a combination of electrofishing, seining, and snorkeling, at established index reaches in Lagunitas Creek and two of its tributaries, San Geronimo Creek and Devil's Gulch. Index reach fish abundance estimates were then extrapolated to produce population estimates for the study area, which includes 13.4 km of Lagunitas Creek, 7.2 km of San Geronimo Creek, and 3.3 km of Devil's Gulch. In Lagunitas Creek, the habitats downstream of the confluence with Nicasio Creek (5.9 km) were not included in our analyses because existing juvenile index reaches do not accurately represent this section of creek. For San Geronimo Creek and Devil's Gulch, salmonid populations were estimated for the anadromous reaches of the main stems. The most recent habitat typing survey of Lagunitas Creek, San Geronimo Creek, and Devil's Gulch was completed in 2022. The habitat typing survey classified habitats as pool, glide, run, riffle, cascade, and dry. The small number of cascades and dry habitats have been excluded from our population extrapolations. Side channel habitats were also excluded because the index reaches did not adequately represent these habitats.

Eight index reaches in Lagunitas Creek, four in San Geronimo Creek, and two in Devil's Gulch were sampled between August 12 and October 14, 2022 (Figure 1). Each index reach consisted of one or more riffle, run, glide, or pool habitat units. The index reaches in Lagunitas Creek were (in a downstream to upstream listing): LG-2, LG-3, LG-5, LG-7, LG-8, LG-9, LG-15, and LG-12. The index reaches in San Geronimo Creek were: SG-1, SG-2, SG-3, and SG-4. Index reaches in Devil's Gulch were DG-1 and DG-2. These reaches have been sampled annually for juvenile salmonids since the 1990s, with the exception LG-2 (added in 2002), and LG-8 (added in 2017).

Electrofishing was conducted in compliance with National Marine Fisheries Service guidelines (NMFS 2000). Prior to electrofishing a sample site, block nets were erected at the downstream and upstream ends of each habitat unit to prevent fish migration during sampling. ETS Electrofishing Systems ABP-3 backpack electrofishers were used to make a minimum of two passes through each habitat. Electrofishers

were set to a pulse rate of 60 Hz and a duty cycle of 25%. Voltages ranged from 140 to 240 volts depending on water depth and conductivity (expressed as microSiemens/cm (mS)), measured prior to electrofishing. One or two electrofishers were used at each of the sample habitats (depending on the width of the site) with one or two people using dip-nets to capture immobilized fish. Netted fish were placed into buckets containing fresh stream water, carried by the electrofishing surveyor. Habitat units were sampled from the downstream net to the upstream net and then back downstream again to complete one pass.

After each pass, aerators were placed in catch buckets and sculpin were moved into separate buckets to reduce predation on salmonids. All fish were identified to species, except for sculpin (*Cottus spp.*), which were identified only to genus. Non-salmonids such as Southern Coastal Roach (*Hesperoleucus veustus subditus*), Pacific Lamprey (*Entosphenus tridentata*), Sacramento Sucker (*Catostomus occidentalis*), sculpin, Threespine Stickleback (*Gasterosteus aculeatus*), and California Giant Salamander (*Dicamptodon ensatus*) were counted but not measured. Juvenile lamprey were classified as "eyed" or macrothalmia (if they had eyes, well-developed sucking mouths and silver coloring) or ammocoetes (if they lacked smolt features).

Coho Salmon and steelhead were anesthetized using tricaine methanesulfonate (MS-222) and measured in millimeters (mm). All Coho Salmon were weighed to the nearest tenth of a gram, while at least 20 steelhead were weighed at each index reach. In the field, steelhead captured in Lagunitas Creek are considered to be 1+ steelhead (one to three years old) when they exceed 110 mm in fork length, and those smaller are considered to be 0+ steelhead (young-of-the-year; <1 year old). Steelhead captured in San Geronimo Creek and Devil's Gulch that are 90 mm or larger are considered to be in the 1+ age class. Scale samples are typically taken from several steelhead in Lagunitas Creek ranging from 95 to 110 mm in order to estimate a more accurate size break between 0+ and 1+ steelhead. In San Geronimo Creek and Devil's Gulch, scales are typically collected from steelhead ranging from 85 to 95 mm. Scales are obtained by scraping the side of the fish above the lateral line and behind the dorsal fin. Subsequently ages are determined for each steelhead by viewing the scales under a microscope and counting their annuli (yearly rings). When annuli are indistinct and age class cannot be determined, size breaks (natural gaps in the size range) are used to determine age class.

Our intent, if time allowed, was to implant all Coho Salmon at least 60 mm fork length and at least 2.7 grams in weight with passive integrated transponder (PIT) tags to estimate over-winter survival. A PIT tag was inserted into the abdominal cavity of anesthetized Coho Salmon just anterior to the pectoral fins. Fish between 60 and 69 mm fork length received a 9 mm full duplex (FDX) tag and fish ≥ 70 mm received a 12 mm FDX tag.

After handling, all fish were first transferred into a black recovery bucket containing cool, aerated stream water and then transferred to live cars (holding pens consisting of a mesh basket lined with netting), which had been placed in the stream, outside of the block netted habitat unit. Large sculpin were placed into separate live cars to avoid predation of salmonids. Aerators were installed on live cars when fish densities were high. Once sampling was completed, captured fish were released back into the habitat unit from which they were captured.

In addition to fish data, we collected habitat data including length, width, depth, substrate composition, shelter ratings, and bank vegetation. Water temperatures were measured at each sample site using hand held digital thermometers. Water temperatures and stream flow were also being recorded, independently, at the USGS stream gage at Samuel P. Taylor State Park (upstream of the mouth of Devil's Gulch and sample site LG-7).

Snorkel surveys followed procedures outlined in Adams et al. (2011). Depending on creek width and visibility, two or three divers surveyed each sample unit. The divers entered the water at the downstream limit of the sample unit and proceeded together in an upstream direction. Individuals of each fish species were counted in each habitat type (glide, pool, run), and observations were recorded on dive slates. For steelhead, the age of individuals was visually estimated as either young-of-the-year or older, where 105 mm total length was the approximate cutoff between these age classes. One crew member totaled and recorded observation data at the completion of each pass. The highest total count for each salmonid species after two or three passes was used to estimate salmonid abundance for each habitat unit.

Smolt Survey

A rotary screw trap (RST) with a five-foot diameter cone was installed on April 3, 2023 in lower Lagunitas Creek, approximately 2.1 miles above the Highway 1 Bridge in Point Reyes Station. The trap was situated in a pool directly downstream of a small bedrock cascade, and was in the same location as has been used since 2006. The bedrock cascade concentrates enough flow to operate the RST in the otherwise low gradient reach of the creek.

The RST was in operation for a total of 40 days, generally Tuesday through Friday, between April 4 and June 1, 2023. For 18 days bracketing the April new moon, the trap was operated seven days per week. At the start of each day, trap function was visually inspected and the rotation speed of the trap cone was recorded. The trap was occasionally realigned relative to the cascade to maintain cone speeds in the target range of three to eight revolutions per minute (RPM). A qualitative description of debris removed from the live box was recorded daily. Each day, captured fish were removed from the trap and identified to the species level.

Salmonid smolts and parr were visually inspected for signs of smoltification, measured, weighed, allowed to recover, and then released approximately 200 m downstream of the point of capture. Coho Salmon and steelhead smolts were scanned for passive integrated transponder (PIT) tags. Steelhead at least 130 mm in length were generally called smolts, although some fish displaying characteristics intermediate between parr and smolts (e.g., some loss of scales, some silver color, fading parr marks, etc.) were classified as "transitional." These transitional steelhead could not be assumed to be emigrating and were not included in the smolt estimate. Coho Salmon were classified as fry, transitionals, or smolts based on the degree of smoltification. Young-of-the-year Coho Salmon displaying smolt characteristics (e.g., silvery appearance) were classified as smolts. All Chinook Salmon were assumed to be emigrating and classified as smolts. Adult steelhead that appeared unspawned were released upstream of the bedrock cascade. Spawned steelhead (kelts) were immediately released off the trap.

The proportion of migrating fish captured each week (trap efficiency) was determined by recapturing previously marked fish. Up to 20 Coho Salmon and steelhead smolts per day were implanted with PIT tags, while up to 20 Chinook Salmon were given a fin clip. Marked fish were released approximately 300 m upstream. Some of these fish were subsequently recovered at the trap a second time and served as the basis for calculating trap efficiencies.

Marin Water operates a PIT tag antenna upstream of the RST, primarily to detect PIT-tagged coho smolts and investigate rates of overwinter survival in different parts of the Lagunitas Creek watershed. Each summer, juvenile Coho Salmon are implanted with PIT tags during electrofishing surveys.

Data Analysis

Juvenile Coho Salmon and steelhead capture data were tallied by sample site (Appendix A) and entered into MicroFish 3.0 software (Van Deventer and Platts 1989). Output from this program was used to calculate population estimates of Coho Salmon, 0+ steelhead, and 1+ steelhead for each habitat unit (Appendix B). Habitat typing completed in 2022 throughout the Lagunitas Creek Study Area allowed for a comparison of the habitat composition of the index reaches to the habitat composition of the streams or stream reaches. Juvenile salmonid population sizes were estimated by extrapolating fish densities in individual habitats (pool, glide, run, riffle) to entire streams based on the proportions of habitat types within those streams (Appendix C). Salmonid densities in each habitat type were multiplied by the linear length of the same habitat type in the applicable stream. The extrapolated population estimates from this year's survey can be compared to the annual juvenile salmonid surveys conducted since 1995, when we began estimating salmonid populations using habitat proportions.

The stream segments used in estimating the juvenile salmonid populations of the Lagunitas Creek study area have changed multiple times over the years. New sample sites have been added, one was abandoned, and the stream reaches represented by these sites have also changed over the years. Finally, the size of the study area has changed multiple times, influencing the estimated populations. These methodological changes are described in detail in Appendix D.

In addition to salmonid abundance, we assessed fish condition using Fulton's Condition K. K was calculated using the formula $K = 10^5 W / L^3$, where W is weight in grams and L is fork length in millimeters.

Darroch Analysis with Rank Reduction (DARR) 2.0.2 software (Bjorkstedt 2005, 2010) was used to calculate the efficiency of the Lagunitas Creek rotary screw trap and population (emigration) estimates for coho, Chinook, and steelhead smolts using mark-recapture data. The DARR 2.0.2 software was developed to allow populations of downstream migrants to be estimated using mark-recapture data, particularly in small watersheds. This program applies a set of algorithms to stratified mark-recapture data to produce an abundance estimate while defining the variability in capture probability and the distribution of recaptured individuals within the strata.

RESULTS

Juvenile Salmonid Observations

Juvenile Coho Salmon typically spend approximately 18 months in freshwater (including incubation) and 18 months in the ocean, returning to spawn in their natal stream in their third year (Shapovalov and Taft 1954). Therefore, Coho Salmon can be grouped into year classes of three-year increments. In 2022 we observed 3,555 juvenile Coho Salmon at our index reaches, which was in increase of 266% over what was observed in 2019 (Table 1). Compared to 2019, coho observations in Lagunitas Creek, San Geronimo Creek, and Devil's Gulch increased by 325%, 161%, and 435%, respectively. The total number of steelhead observed at our index reaches in 2022 was 831, which was approximately half of the average since 1993. By age class, we observed 763 young of the year steelhead and 68 1+ steelhead.

Incidental mortalities from our sampling effort (Table 2) consisted of 42 Coho Salmon (1.4% of captured fish) and 17 steelhead (2.3% of captured fish). The coho and steelhead mortality rates were similar to the long-term average. During the sampling efforts between 1997 and 2021, Coho Salmon mortality rates ranged from 0.0% to 3.6% of captured Coho Salmon and the steelhead mortality rates ranged from

1.1% to 2.8% of captured steelhead (Table 3). This year's salmonid mortalities represent less than 0.06% of both the Coho Salmon and steelhead populations.

Juvenile Salmonid Population Estimates and Survival

The 2022 juvenile Coho Salmon population estimate, extrapolated from Coho Salmon abundance at the index reaches, was 108,624 (± 21,810) for the study area. This was by far the highest estimate on record and nearly five times higher than three years earlier (Table 4). Estimated egg-to-fry survival of this cohort was 17.3%, which was also a record. In Olema Creek (surveyed by NPS), the Coho Salmon population was estimated at 42,948 (± 5,785), which was nearly five times higher than three years earlier. Record Coho Salmon abundance was observed in all streams (Figure 2).

The 2022 juvenile steelhead population estimate (0+ and 1+) was 29,728 (± 5,303) for the study area, which was 57% of average (Figure 3). Steelhead abundance was nearly average in Lagunitas Creek, a third of average in Devil's Gulch, and a record low in San Geronimo Creek. The steelhead population of Olema Creek was not estimated.

Another measure of abundance is the density of fish, expressed as either fish per square meter (Appendix E), or fish per linear meter, which has been used to estimate salmonid populations for the entire study area back to 1970 (Figure 4). Over the last decade, the Coho Salmon population estimates based only on density have been eight-times greater than during the 1980s. The steelhead population appears to have increased by roughly 50% during that period.

Juvenile Coho Salmon and Steelhead Condition

Coho Salmon tend to be longer in Lagunitas Creek than in San Geronimo Creek or Devil's Gulch and their growth rates in all three creeks appear to be density dependent (Figure 5). In 2022, record densities of Coho Salmon were observed in each stream, and their sizes were exceptionally small. Coho in Devil's Gulch were the smallest ever recorded, averaging only 52 mm.

Young-of-the-year steelhead growth is weakly associated with steelhead and Coho Salmon densities, spring stream flows, and the average date of steelhead spawning. In 2022 YOY steelhead were smaller than average in Lagunitas Creek, but longer than average in San Geronimo Creek and Devil's Gulch. We weighed 1,109 Coho Salmon and 397 steelhead to assess their condition. Condition Factor (K) was found to be 1.11 for Coho Salmon and 1.16 for steelhead, on average. Average Coho Salmon condition by stream was 1.13 in Lagunitas Creek, 1.09 in San Geronimo Creek and 1.12 in Devil's Gulch. Steelhead condition was 1.16 in Lagunitas Creek, 1.06 in San Geronimo Creek, and 1.18 in Devil's Gulch.

Other Species Encountered During Juvenile Monitoring

In addition to Coho Salmon and steelhead, four other native fish species were observed: sculpin, Southern Coastal Roach, Threespine Stickleback, and Pacific Lamprey. Five Bluegill, a non-native fish species, were also encountered. The sculpin were not identified to species but were most likely Prickly Sculpin (Cottus asper). Other, less common sculpin species may include Coast Range Sculpin (C. aleuticus) and Riffle Sculpin (C. gulosus) (Page and Burr 1991). Sculpin numbers hit an all-time low in 2022, while roach and lamprey numbers were below average. Finally, 48 California Freshwater Shrimp were captured, which was the highest catch since 2000.

Lagunitas Creek Rotary Screw Trap

The Lagunitas Creek RST captured 7,588 Coho Salmon smolts (Table 5) and 22 young-of-the-year Coho Salmon. An estimated 26,730 Coho Salmon smolts emigrated from Lagunitas Creek during the monitoring period. The highest estimated passage occurred during the week of April 24, when 7,080 Coho Salmon smolts passed through and around the RST (Figure 6). The highest catch for a single day occurred on April 27, when 901 Coho Salmon smolts were captured. The weekly trap efficiency for Coho Salmon smolts varied from 10% to 50% (mean 26%) (Figure 7). Coho Salmon smolts averaged 105 mm fork length (FL) and weighed an average of 12.6 g.

The RST also captured 118 steelhead smolts, 13 fry, three adults, and 116 parr and transitionals. An estimated 850 steelhead smolts emigrated in 2023, with 172 smolts emigrating during the week of April 10. The peak catch of 17 steelhead smolts occurred on April 16. The trap efficiency for steelhead varied between 6% and 40% (mean 19%). Steelhead smolts averaged 158 mm in fork length and weighed an average of 40.9 g.

During the monitoring period, 260 Chinook smolts were captured and 1,064 smolts were estimated to emigrate from Lagunitas Creek. Peak emigration occurred during the week of May 22 when an estimated 476 Chinook passed through and around the RST. The peak of 50 Chinook smolts was caught on May 26. Trap efficiency for Chinook varied between 20% and 25% (mean 22%). The average length of Chinook smolts was 79 mm, and the average weight was 5.6 g. No Age 1+ Chinook were observed in 2022.

Non-salmonid fish species included the following native and non-native species, in order of abundance: sculpin spp. (*Cottidae*), Southern Coastal Roach (*Hesperoleucus venustus subditus*), Threespine Stickleback (*Gasterosteus aculeatus*), Bluegill (*Lepomis macrochirus*), Golden Shiner (*Notemigonus crysoleucas*), crappie (*Pomoxis spp.*), catfish (likely *Ameiurus catus*), Goldfish (*Carassius auratus*), Pacific Lamprey (*Lampetra tridentata*), and Largemouth Bass (*Micropterus salmoides*). Non-fish captures included California Freshwater Shrimp (*Syncaris pacifica*), Signal Crayfish (*Pacifastacus leniusculus*) and Northwestern Pond Turtle (*Actinemys marmorata*).

Lagunitas Creek PIT Tag Antenna

During the summer of 2022 PIT tags were implanted into 735 juvenile Coho Salmon. We detected 163 (22%) of these tagged coho during the smolt monitoring period (Table 6).

DISCUSSION

Juvenile Salmonid Abundance

The primary factors driving the juvenile Coho Salmon population in the Lagunitas Creek Study Area are adult abundance, winter stream flows that scour redds, and spring flows that displace newly-emerged fry. These factors were all favorable in 2021-22. Frequent early rains allowed a large coho migration to spawn throughout the watershed. Their eggs incubated undisturbed during an exceptionally dry winter. Spring rains rewetted redds that were in danger of drying out, but were not heavy enough to displace newly-emerged fry. This confluence of favorable conditions resulted in record juvenile coho abundance.

The conditions that benefitted Coho Salmon were not as favorable for steelhead. Low winter stream flows confined most steelhead spawning to Lagunitas Creek. Limited spawning in San Geronimo Creek and Devil's Gulch resulted in exceptionally low juvenile steelhead abundance in those streams.

Smolt Monitoring Conditions and Emigration Timing

High stream flows delayed trap installation until April 3 – an exceptionally late installation date. The full moon then likely suppressed smolt emigration rates during the first week of trapping (Figure 6). Ordinarily, our PIT tag antennas would provide some data on smolt emigration rates prior to trap installation, but all three antennas were damaged by high flows on March 10. The Lagunitas and San Geronimo antennas were fully disabled and the Devil's Gulch antenna was partially disabled, so even approximating smolt emigration rates is impossible.

Changing flow conditions during the first two weeks required daily trap adjustments and resulted in poor trap efficiency (Figure 7). After April 17 stream flows remained below 30 cubic feet per second (cfs) and the cone rotation speed remained roughly within the target range of three to eight RPM. Catches of coho smolts ramped up quickly during the second half of April, coinciding with the approaching new moon (Figure 6). Our coho catch peaked with a record 901 smolts on April 27, before dropping quickly as the moon turned full. The coho catch rose to a smaller peak on May 10 and then declined for the rest of the monitoring period.

The RST is inefficient at catching steelhead smolts when operated out of the fastest flows, as was the case until late April. Steelhead catches peaked on April 16 with only 16 smolts, and the 118 smolts captured for the monitoring period was a record low. Catches sometimes peak in March, and we likely missed much of this year's smolt emigration.

Unusually low numbers of Chinook smolts were captured in 2023, but this was unrelated to trap operation. Daily catches reached double digits only on May 17, a full month after the trap was running most efficiently. The peak catch of 41 Chinook smolts occurred on May 26, with only two days remaining in the monitoring period. While Chinook Salmon emigration rates were likely low thereafter, a significant part of the small emigration may have gone uncounted.

Age and Salmonid Migration Status

Very few young-of-the-year (YOY) Coho Salmon were observed during smolt monitoring, and a distinct size break was observed between these fish and small age 1+ smolts (Table 7). "Transitional" coho, which were difficult to classify in the field, made up less than one percent of the catch. We also observed a clear size break between age 1+ and age 2+ coho, along with the first evidence of age 3+ Coho Salmon smolts. A juvenile coho tagged in July of 2020 was detected by the Lagunitas Creek PIT tag antenna in May of 2022 and again on April 28, 2023. This individual was unlikely returning to spawn in late April, and stream flows were too low to simply wash this tag over the antenna. In addition, two coho exceeding 170 mm in length were also captured in the RST, which, had they been steelhead, would have placed them in the age 3+ size class (Table 7).

We defined steelhead smolts as being at least 130 mm in length, which was supported by a clear size break between age 1+ and age 2+ steelhead at that length (Table 7). Of the 273 steelhead captured, only 15 could not be classified as either parr or smolts and were classified as "transitionals." We observed one example of fast steelhead growth during the monitoring period. A steelhead smolt tagged on May 1

and measured at 141 mm in length was remeasured on May 31 at 170 mm in length, for a growth rate of one millimeter per day.

Smolt Abundance Trends and Implications for Winter Survival

The 2023 Coho Salmon emigration from Lagunitas Creek was a close second to the record emigration of 2017 (Figure 8). However, the inclusion of record numbers of Olema Creek smolts makes the full watershed emigration one for the record books. NPS staff estimated that 23,500 Coho Salmon smolts emigrated from Olema Creek, following a record juvenile population of nearly 43,000 in 2022. That indicates a winter survival rate of 55%, compared with an apparent survival rate of 33% for the watershed as a whole. Interestingly, 25 smolts captured by NPS were originally PIT tagged elsewhere in the watershed, with more of these non-natal smolts likely remaining undetected. Based on the efficiency of the Olema Creek smolt trap, we've calculated that 8% of juvenile coho from outside Olema Creek were potentially included in the Olema Creek emigration. Put another way, over 8,000 of the estimated 23,500 Olema Creek coho smolts likely originated in other streams. The number of Coho Salmon downstream of our smolt trap when monitoring began is an important consideration when discussing winter survival rates.

Of the more than 100,000 juvenile Coho Salmon residing upstream of the Lagunitas smolt trap in 2022, only 25% appear to have emigrated from Lagunitas Creek. This matches closely with the 22% of PIT-tagged fish detected during the monitoring period, but is far below what was expected. We have previously observed that Coho Salmon winter survival is negatively correlated with the duration of low winter flows (Ettlinger et al. 2023). We hypothesize that long periods of low flows increase water clarity and predation. The longest period of flows less than 100 cfs during the winter of 2022-23 was 37 days, and under those conditions winter survival was expected to exceed 60%. Potential explanations for the apparently poor survival include:
- Thousands of coho overwintered in Olema Creek.
- Many thousands of coho emigrated prior to the installation of the Lagunitas and Olema Creek smolt traps.
- Tens of thousands of juvenile coho died by unknown causes.
- A combination of the above.

Much of the steelhead emigration may have been missed due to the late trap installation. Whiles we have only operated the smolt trap in March for an average of nine days since 2006, those days have contributed about 20% of all steelhead smolt catches. Regardless, the available data indicate that this was an exceptionally small smolt emigration. Last year we documented one of the lowest abundances of age 1+ steelhead on record. Back in 2021, the young-of-the-year steelhead estimate was by far the smallest on record. By all measures, this is a very small steelhead cohort.

The small Chinook Salmon emigration was something of a surprise given the record number of redds and adult Chinook documented in 2022. Significant numbers of Chinook smolts may have continued to emigrate through June, although our observations through May did not portend an above-average, or even average, emigration. More likely, high stream flows scoured many Chinook redds and resulted in exceptionally poor incubation survival.

CONCLUSIONS

The juvenile salmonid and smolt monitoring in 2022 and 2023 revealed the impacts of unusual weather conditions on each species. The exceptionally wet winter of 2022-23 seemed to result in exceptionally few Chinook Salmon smolts. The cohort of steelhead emigrating in 2023 had the opposite problem. An above average number of steelhead adults were observed in 2021, but extraordinary drought conditions hampered spawning and contributed to the lowest juvenile abundance estimate on record. Only Coho Salmon seem to have benefitted from recent unusual weather. The winter of 2021-22 started wet and ended dry, which produced ideal spawning and incubation conditions, and resulted in record juvenile Coho Salmon abundance. Despite below-average overwinter survival, this cohort continued to break records during emigration, and may break records again when it returns in 2024.

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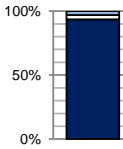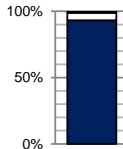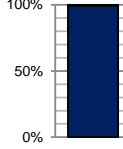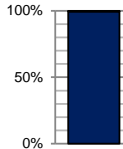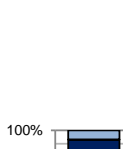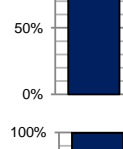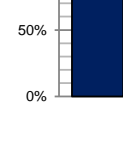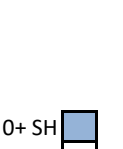
Table 1. Juvenile Salmonid Observations by Index Reach

	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
LG-2																
0+ SH	36	61	63	28	31	59	58	52	70	92	76	59	80	160	65	83
1+ SH	3	4	10	6	6	9	4	8	7	8	17	9	12	11	8	11
All SH	39	65	73	34	37	68	62	60	143	100	93	68	92	171	73	94
Coho	59	34	2	18	27	65	100	31	18	141	15	66	67	28	133	179
LG-3																
0+ SH	43	59	57	45	43	64	62	30	52	45	53	58	79	101	19	30
1+ SH	10	2	17	17	16	24	21	12	21	19	7	10	14	17	7	8
All SH	53	61	74	62	59	88	83	42	73	64	60	68	93	118	26	38
Coho	113	48	24	34	23	48	104	18	42	106	2	26	53	37	134	60
LG-5																
0+ SH	127	225	107	61	39	69	50	30	36	47	110	81	99	36	32	100
1+ SH	6	5	7	10	8	6	8	2	5	9	26	14	9	5	3	6
All SH	133	230	114	71	47	75	58	32	41	56	136	95	108	41	35	106
Coho	39	52	19	68	2	71	146	81	105	141	36	78	18	50	146	204
LG-7																
0+ SH	169	314	224	139	65	138	127	178	130	147	180	243	121	62	30	137
1+ SH	13	15	14	15	5	16	12	12	15	24	27	14	13	5	8	10
All SH	182	329	238	154	70	154	139	190	145	171	207	257	134	67	38	147
Coho	116	38	8	20	3	44	57	102	41	86	29	55	18	21	128	116
LG-8																
0+ SH	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	85	519	5	110	21	104
1+ SH	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0	0	0	1	1	0
All SH	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	85	519	5	111	22	104
Coho	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0	32	4	71	205	150
LG-9																
0+ SH	338	480	194	141	184	446	466	351	433	235	168	463	295	365	131	119
1+ SH	6	2	11	7	1	6	2	6	12	6	14	16	14	8	2	4
All SH	344	482	205	148	185	452	468	357	445	241	182	479	309	373	133	123
Coho	51	11	0	1	0	3	12	7	30	6	0	24	4	21	66	162
LG-12																
0+ SH	107	226	305	60	189	151	207	113	202	137	74	102	106	119	54	118
1+ SH	5	2	8	5	2	7	5	7	6	3	4	3	4	13	11	6
All SH	112	228	313	65	191	158	212	120	208	140	78	105	110	132	65	124
Coho	178	123	9	50	45	71	114	150	44	102	20	103	136	53	158	366
LG-15																
0+ SH	71	115	130	21	36	53	85	158	95	93	13	16	24	28	12	36
1+ SH	1	0	4	4	8	4	4	7	12	9	12	5	3	4	5	1
All SH	72	115	134	25	44	57	89	165	107	102	25	21	27	32	17	37
Coho	38	52	3	11	85	77	58	113	57	96	11	97	56	63	174	278
Lagunitas Creek Total																
All SH	935	1510	1151	559	633	1052	1111	966	1162	874	866	1612	878	1045	409	773
Coho	594	358	65	202	185	379	591	502	337	678	113	481	356	344	1144	1515

2022 Assemblage

2022 Coho Year Class

Legend: 0+ SH, 1+ SH, Coho

Note: 0+ SH (young-of-the-year steelhead) = <1 year old; 1+ SH = 1-3 year old steelhead.

Table 1. Juvenile Salmonid Observations by Index Reach

	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
SG-1																
0+ SH	262	268	32	36	91	577	240	109	314	240	458	367	372	74	51	6
1+ SH	9	10	5	13	12	6	11	7	12	11	19	12	8	14	4	7
All SH	271	278	37	49	103	583	251	116	326	251	477	379	380	88	55	13
Coho	66	7	0	3	6	1	8	0	3	66	25	14	34	27	2	185
SG-2																
0+ SH	168	120	84	257	223	531	178	137	52	178	323	253	437	156	15	2
1+ SH	38	1	25	22	22	41	30	35	18	30	25	32	33	49	1	10
All SH	206	121	109	279	245	572	208	172	70	208	348	285	470	205	16	12
Coho	224	5	1	2	15	6	138	0	81	191	45	30	122	129	20	164
SG-3																
0+ SH	50	54	61	51	94	107	28	16	63	28	86	53	104	55	0	0
1+ SH	20	15	7	15	16	27	12	4	5	12	13	12	11	17	0	2
All SH	70	69	68	66	110	134	40	20	68	40	99	65	115	72	0	2
Coho	45	7	0	2	34	74	48	1	55	66	48	1	138	91	0	338
SG-4																
0+ SH	69	93	47	81	88	91	38	15	57	38	100	82	45	130	0	1
1+ SH	22	1	9	11	20	27	12	2	5	12	9	7	19	22	0	1
All SH	91	94	56	92	108	118	50	17	62	50	109	89	64	152	0	2
Coho	162	40	0	7	30	139	62	0	65	114	56	2	164	169	0	508
San Geronimo Creek Total																
All SH	638	562	270	486	566	1407	549	325	526	549	1033	818	1029	517	71	29
Coho	497	59	1	14	85	220	256	1	204	437	174	47	458	416	22	1195
DG-1																
0+ SH	22	103	68	32	76	54	7	151	54	115	254	80	318	1	0	27
1+ SH	4	6	16	17	14	14	14	11	14	6	14	14	10	16	0	1
All SH	26	109	84	49	90	68	21	162	68	121	268	94	328	17	0	28
Coho	125	11	0	32	33	155	246	5	75	135	34	59	50	20	1	370
DG-2																
0+ SH	26	96	3	36	96	60	26	151	60	36	81	23	239	2	0	0
1+ SH	4	2	7	6	7	21	14	4	21	15	7	13	11	26	0	1
All SH	30	98	10	42	103	81	40	155	81	51	88	36	250	28	0	1
Coho	122	49	0	36	27	108	194	3	48	114	110	133	108	101	0	475
Devil's Gulch Total																
All SH	56	207	94	91	193	149	61	317	149	172	356	130	578	45	0	29
Coho	247	60	0	68	60	263	440	8	123	249	144	192	158	121	1	845
Study Area Totals																
0+ SH	1488	2214	1375	988	1255	2400	1572	1491	1618	1425	2061	2399	2324	1399	430	763
1+ SH	141	65	140	148	137	208	149	117	153	149	194	161	161	208	50	68
All SH	1629	2279	1515	1136	1392	2608	1721	1608	1837	1574	2255	2560	2485	1607	480	831
Coho	1338	477	66	284	330	862	1287	511	664	1364	431	720	972	881	1167	3555

2022 Assemblage

Legend: 0+ SH, 1+ SH, Coho

2022 Coho Year Class

Note: 0+ SH (young-of-the-year steelhead) = <1 year old; 1+ SH = 1-3 year old steelhead.

Table 2. Juvenile Salmonid Mortalities at Electrofishing Index Reaches in the Lagunitas Creek Study Area, 2022.

Index Reach	Coho Catch	Steelhead Catch	Coho Mortalities	Steelhead Mortalities	Percentage of Coho Mortalities	Percentage of Steelhead Mortalities
LG-3	60	38	0	2	0.0%	5.3%
LG-7	118	147	10	6	8.5%	4.1%
LG-8	150	104	2	1	1.3%	1.0%
LG-9	81	228	2	4	2.5%	1.8%
LG-12	361	124	13	3	3.6%	2.4%
SG-1	186	14	1	0	0.5%	0.0%
SG-2	164	12	0	0	0.0%	0.0%
SG-3	338	2	3	0	0.9%	0.0%
SG-4	521	2	5	0	1.0%	0.0%
DG-1	614	59	4	1	0.7%	1.7%
DG-2	476	1	2	0	0.4%	0.0%
Total	**3069**	**731**	**42**	**17**	**1.4%**	**2.3%**

Note: Catch totals do not include habitat units surveyed by snorkeling.

Table 3. Juvenile Salmonid Mortalities, 1997-2022

Year	Coho Salmon			Steelhead		
	Captured	Mortalities	%	Captured	Mortalities	%
1997	541	7	1.3%	1,309	36	2.8%
1998	124	1	0.8%	2,078	59	2.8%
1999	168	6	3.6%	1,761	37	2.1%
2000	157	2	1.3%	1,913	26	1.4%
2001	868	20	2.3%	1,588	30	1.9%
2002	1,296	26	2.0%	2,415	56	2.3%
2003	606	14	2.3%	1,677	29	1.7%
2004	965	22	2.3%	1,299	35	2.7%
2005	918	23	2.5%	1,395	30	2.2%
2006	126	1	0.8%	1,889	28	1.5%
2007	1,377	20	1.5%	1,633	37	2.3%
2008	443	8	1.8%	2,212	43	1.9%
2009	45	0	0.0%	1,390	16	1.2%
2010	198	3	1.5%	1,068	19	1.8%
2011	289	4	1.4%	1,354	24	1.8%
2012	797	5	0.6%	2,540	54	2.1%
2013	1,187	29	2.4%	1,659	37	2.2%
2014	480	12	2.5%	1,548	28	1.8%
2015	646	20	3.1%	1,720	46	2.7%
2016	1,223	32	2.6%	1,474	16	1.1%
2017	416	8	1.9%	2077	29	1.4%
2018	525	10	1.9%	1952	42	2.2%
2019	845	12	1.4%	2361	38	1.6%
2020	696	14	2%	1227	26	2.1%
2021	462	6	1.3%	290	5	1.7%
2022	3069	42	1.4%	731	17	2.3%
Mean	**710**	**13**	**1.8%**	**1637**	**32**	**2.0%**

Table 4. Juvenile Salmonid Population Estimates in the Lagunitas Creek Study Area

Lagunitas Creek

	0+ Steelhead	1+ Steelhead	Total Steelhead	Coho	
2004	28,232	931	29,163	4,560	
2005	23,517	1,413	24,930	8,597	
2006	22,188	1,150	23,338	463	
2007	26,961	1,070	28,031	18,745	
2008	50,021	661	50,682	7,539	
2009	30,020	1,875	31,895	1,777	
2010	13,081	1,656	14,737	5,943	2022 Coho Year Class
2011	15,881	1,116	16,997	4,484	
2012	23,330	1,262	24,592	11,228	
2013	45,228	1,224	46,452	23,096	
2014	27,234	2,175	29,409	18,188	
2015	37,337	2,246	39,583	8,607	
2016	25,546	2,691	28,237	23,980	
2017	30,647	3,224	33,871	2,455	
2018	38,249	1,781	40,030	11,217	
2019	23,571	2,125	25,696	9,427	
2020	26,865	1,665	28,530	9,282	
2021	10,562	1,008	11,570	30,857	
2022	25,974	1,352	27,326	40,323	
Mean	27,032	1,563	28,595	10,037	

San Geronimo Creek

	0+ Steelhead	1+ Steelhead	Total Steelhead	Coho	
2004	16,363	1,358	17,721	13,076	
2005	15,093	1,084	16,177	8,341	
2006	21,969	1,166	23,135	1,842	
2007	17,041	2,280	19,321	13,098	
2008	20,768	1,019	21,787	2,372	
2009	5,927	1,023	6,950	20	
2010	11,404	1,579	12,983	317	2022 Coho Year Class
2011	16,255	1,674	17,929	2,499	
2012	39,912	2,357	42,269	5,832	
2013	16,208	1,233	17,441	6,678	
2014	8,251	1,079	9,330	22	
2015	19,742	1,052	20,794	6,716	
2016	16,498	1,180	17,678	11,959	
2017	28,185	1,425	29,610	5,243	
2018	28,170	1,163	29,333	1,089	
2019	32,119	1,559	33,678	9,812	
2020	17,173	2,420	19,593	9,781	
2021	2,217	175	2,392	485	
2022	441	661	1,102	46,000	
Mean	17,699	1,327	19,026	6,948	

Devil's Gulch

	0+ Steelhead	1+ Steelhead	Total Steelhead	Coho	
2004	1,821	350	2,171	4,289	
2005	2,204	319	2,523	5,724	
2006	6,616	380	6,996	397	
2007	1,290	148	1,438	5,140	
2008	4,137	150	4,287	1,204	
2009	1,727	535	2,262	0	
2010	1,590	609	2,199	1,728	2022 Coho Year Class
2011	3,854	410	4,264	1,172	
2012	2,721	660	3,381	5,235	
2013	731	346	1,077	7,070	
2014	8,050	231	8,281	123	
2015	2,737	521	3,258	1,841	
2016	3,940	362	4,302	5,748	
2017	7,072	414	7,486	3,179	
2018	2,464	557	3,021	4,262	
2019	11,989	322	12,311	3,063	
2020	42	705	747	1,978	
2021	0	0	0	18	
2022	1,242	39	1,281	22,301	
Mean	3,652	425	4,077	3,676	

Study Area Total

	0+ Steelhead	1+ Steelhead	Total Steelhead	Coho	
2004	46,416	2,639	49,055	21,925	
2005	40,814	2,816	43,630	22,662	
2006	50,773	2,696	53,469	2,702	
2007	45,292	3,498	48,790	36,983	
2008	74,926	1,830	76,756	11,115	
2009	37,674	3,433	41,107	1,797	
2010	26,075	3,844	29,919	7,988	2022 Coho Year Class
2011	35,990	3,200	39,190	8,155	
2012	65,963	4,279	70,242	22,295	
2013	62,167	2,803	64,970	36,844	
2014	43,535	3,485	47,020	18,333	
2015	59,816	3,819	63,635	17,164	
2016	45,984	4,233	50,217	41,687	
2017	65,904	5,063	70,967	10,877	
2018	68,883	3,501	72,384	16,568	
2019	67,679	4,006	71,685	22,302	
2020	44,080	4,790	48,870	21,041	
2021	12,779	1,183	13,962	31,360	
2022	27,657	2,052	29,709	108,624	
Mean	48,383	3,314	51,697	20,661	

Table 5. Estimated smolt emigration from Lagunitas Creek, 2006-2023

Year	Survey Start	Survey End	Coho Salmon		Steelhead		Chinook Salmon	
			Observed	Estimated	Observed	Estimated	Observed	Estimated
2006	3/21	6/9	1,342	5,946 (±1,570)	308	6,949 (±6,133)	237	504
2007	3/15	5/30	611	2,776 (±692)	475	3,632 (±2,066)	775	2,445
2008	3/18	6/5	2,532	6,101 (±780)	449	1,134 (±259)	0	0
2009	3/10	6/5	3,150	5,711 (±461)	646	2,041 (±537)	0	0
2010	3/17	5/27	631	2,129 (±480)	651	3,867 (±1,419)	0	0
2011	4/1	5/20	1,684	3,300 (±470)	829	3,753 (±941)	0	0
2012	3/26	5/31	4,339	8,315 (±1,372)	251	1,991 (±1,252)	0	0
2013	3/19	6/7	4,942	7,479 (±504)	684	1,876 (±380)	0	0
2014	3/11	6/4	8,415	15,055 (±1,974)	448	1,720 (±478)	1,229	2,011 (±241)
2015	3/19	6/9	7,373	10,643 (±596)	814	2,699 (±594)	2,005	3,376 (±382)
2016	3/16	5/24	3,428	9,719 (±2,225)	371	4,396 (±3,099)	191	833 (±370)
2017	3/14	5/26	5,550	29,306 (±11,286)	524	3,164 (±1,313)	925	2,224 (±425)
2018	3/30	5/25	4,883	7,812 (±715)	536	1,879 (±576)	1,509	4,407 (±1027)
2019	3/20	5/16	4,652	11,246 (±2,164)	486	3,827 (±1,985)	792	2,217 (±335)
2021	3/24	5/28	4,422	7,684 (±615)	316	722 (±108)	1,759	3,691 (±388)
2022	3/22	6/2	6,838	16,632 (±1,780)	354	1,525 (±529)	1,054	3,166 (±406)
2023	4/4	6/1	7,588	26,730 (±4,388)	118	850 (±498)	260	1,064 (±267)

Table 6. PIT-Tagged Coho Salmon Detections

Tagging Location	Coho Tagged in 2022	Coho Detected in 2023	Detection Rate
Lagunitas Creek	350	72	21%
San Geronimo Creek	274	61	22%
Devil's Gulch	111	30	27%
All	735	163	22%

Table 7. Salmonids Captured in the Lagunitas Creek Rotary Screw Trap by Length and Week, 2023.

Coho Salmon

Week:	1	2	3	4	5	6	7	8	9	
Dates	4/3 4/9	4/10 4/16	4/17 4/23	4/24 4/30	5/1 5/7	5/8 5/14	5/15 5/21	5/22 5/28	5/29 6/4	
Length (mm) — Age 0+										
< 40										
40-44		1								
45-49		5		1						
50-54										
55-59		1		1						
60-64		1		1	1					
65-69 — Age 1+										
70-74		1	1							
75-79		2	1	1						
80-84	1	5	1		1	2	1	1		
85-89	1	10	6	1	4	3	5	3	1	
90-94		9	10	6	8	12	10	8	6	
95-99	5	17	14	17	21	16	29	26	12	
100-104	4	14	30	21	30	18	16	27	19	
105-109	6	16	30	21	29	23	12	12	2	
110-114	3	13	27	32	15	8	9	4	3	
115-119	4	11	10	17	1	5	1	2		
120-124	2	6	5	3	1		1			
125-129	2	3	5	1						
130-134	1	3	2	3						
135-139 — Age 2+			3			3	1			
140-144			1		1					
145-149			1	1						
150-154			1							
155-159										
160-164			1	1						
165-169	1	1								
170-174										
175-179	2				Age 3+					
180+										
Totals										
Age 0+	0	8	0	3	1	0	0	0	0	1%
Age 1+	29	110	142	123	110	87	84	83	43	96%
Age 2+	0	0	7	2	1	3	1	0	0	2%
Age 3+	3	1	0	0	0	0	0	0	0	0%

Chinook Salmon

Week:	1	2	3	4	5	6	7	8	9	
Length (mm)										
< 40										
45-49										
50-54		1								
55-59		3								
60-64		2				1				
65-69		4					1			
70-74		1	2		1		3	2	1	
75-79					2		3	7	5	
80-84		2				1	10	28	10	
85-89		1		1	1	5	21	27	16	
90-94						2	10	13	6	
95-99							4	2	2	
100-104								1		
105+										
Totals										
Age 0+	0	14	2	1	4	9	52	80	40	100%
Age 1+	0	0	0	0	0	0	0	0	0	0%

Note: Age classifications are based on this year's length histograms as well as historical size distributions.

Steelhead

Week:	1	2	3	4	5	6	7	8	9	
Dates	4/3 4/9	4/10 4/16	4/17 4/23	4/24 4/30	5/1 5/7	5/8 5/14	5/15 5/21	5/22 5/28	5/29 6/4	
Length (mm) — Age 0+										
< 40										
40-44										
45-49										
50-54							1			
55-59	1						1	2		
60-64								3		
65-69 — Age 1+								6		
70-74	1								1	
75-79	1	1								
80-84			1		1					
85-89		1	3	2	1	1				
90-94	1	2		1	1		2			
95-99			5	4	1	1	1			
100-104	1	1		1		1	2			
105-109	1	1	5	2	2	2	1	1		
110-114			2	3	4	2	2			
115-119	2		2		2	2	2	1		
120-124			2	2	2		1	1		
125-129		1	6	4	3					
130-134	2			1						
135-139		3	3	3	2		1	Age 2+		
140-144	1		1	6	3	1				
145-149	1	2	5	7	2	1				
150-154		5	5	8	3					
155-159	2	1	4	7	2					
160-164	1	1	4	2	1					
165-169		4	3	4	3					
170-174	2	2	2		3				1	
175-179	2	2	4					Age 3+		
180-184	1	1			1					
185-189										
190-194	1			1						
195-199			1							
200-204										
205-209										
210-214										
215-219										
220-224										
225-229										
230-234										
235-239										
240-244										
245-249										
250-254										
255-259										
260-264										
265-269										
270-274										
275-279										
280-284										
285-289										
290-294										
295-299										
300+										
Totals										
Age 0+	3	0	0	0	0	0	2	11	1	7%
Age 1+	7	7	21	20	20	9	11	4	0	40%
Age 2+	7	12	25	37	20	2	1	0	1	43%
Age 3+	6	9	7	1	1	0	0	0	0	10%
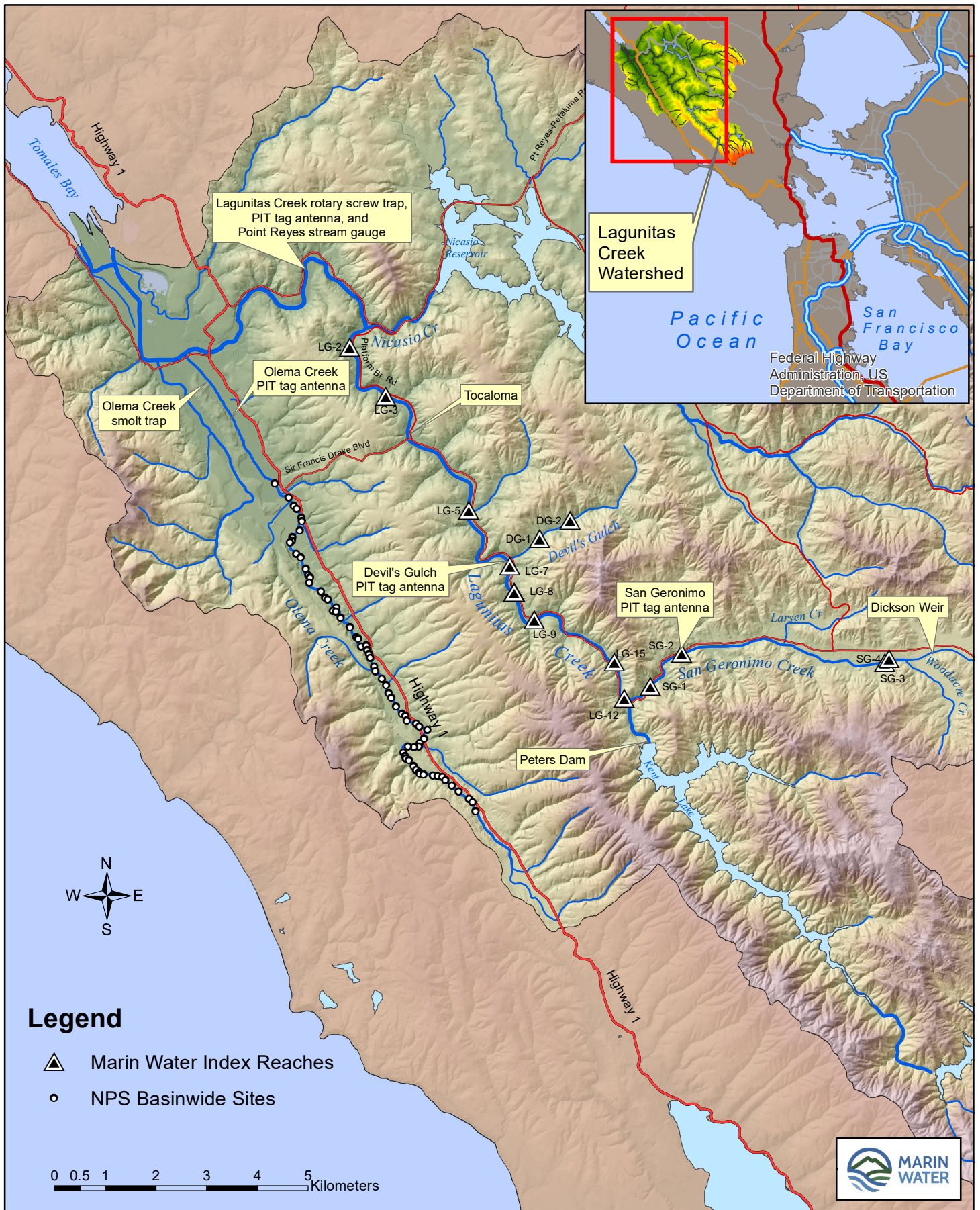
Figure 1. Lagunitas Creek Juvenile Salmonid and Smolt Monitoring Locations
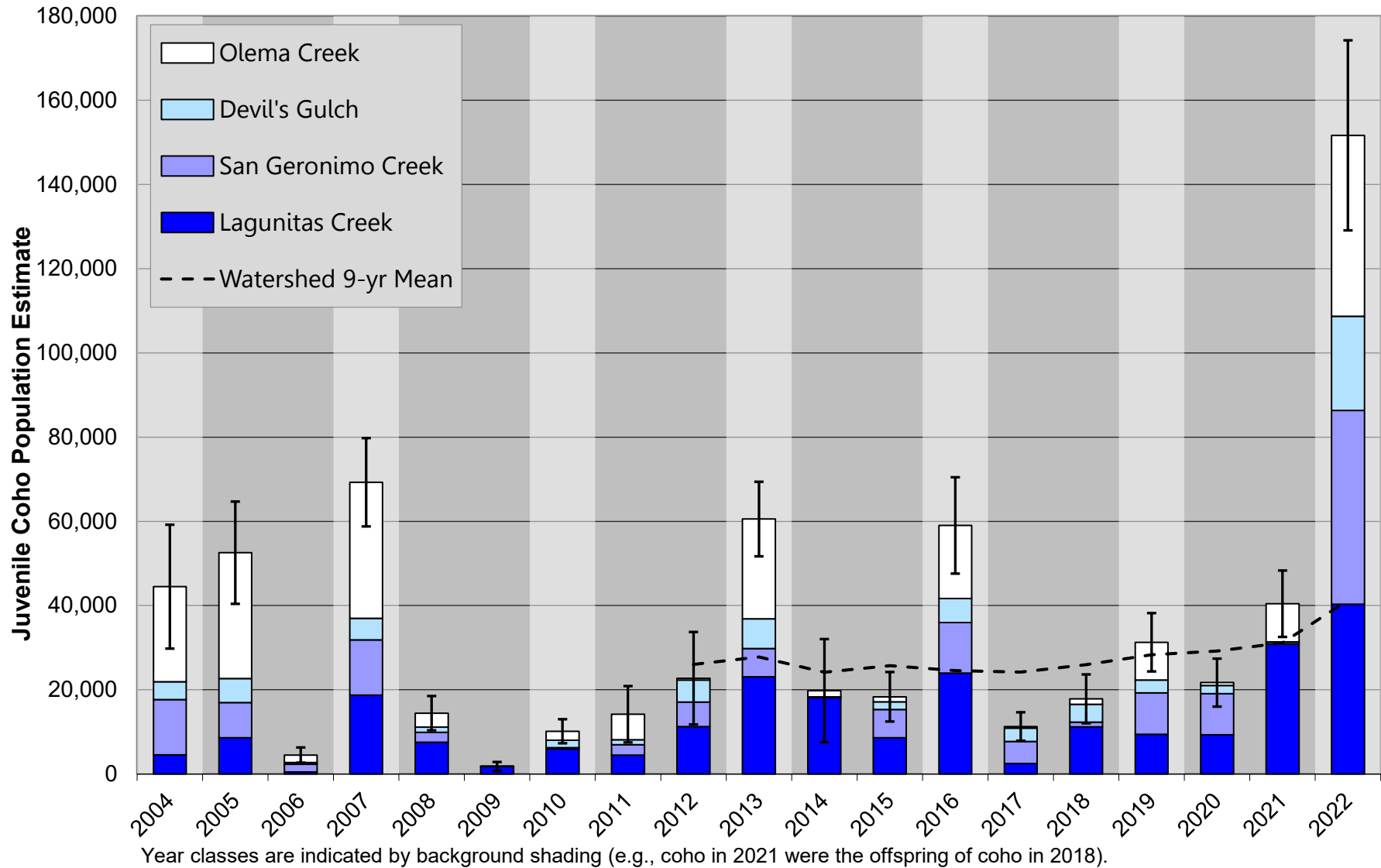
Figure 2. Juvenile Coho Population Estimates.
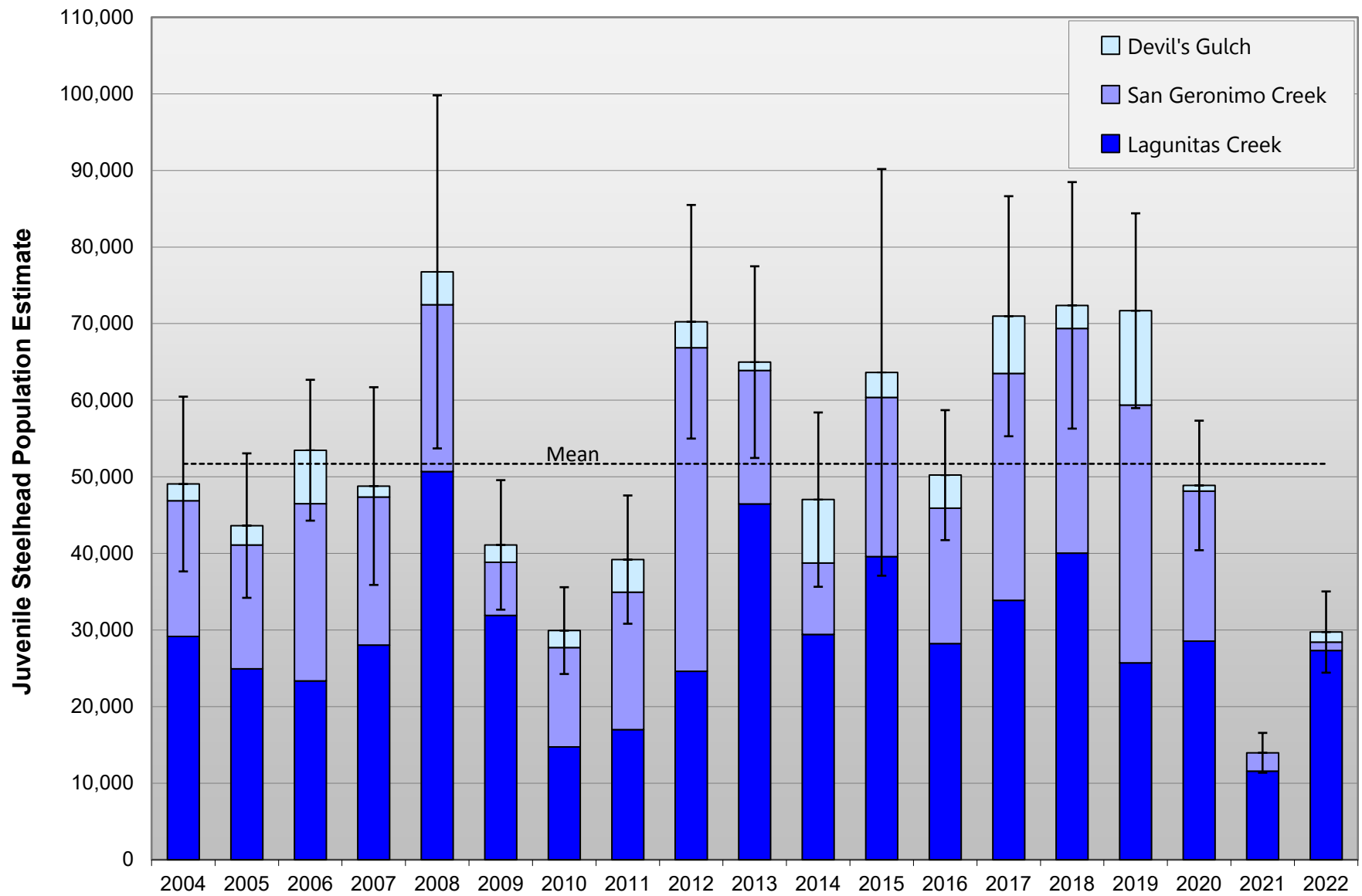
Figure 3. Juvenile Steelhead Population Estimates.
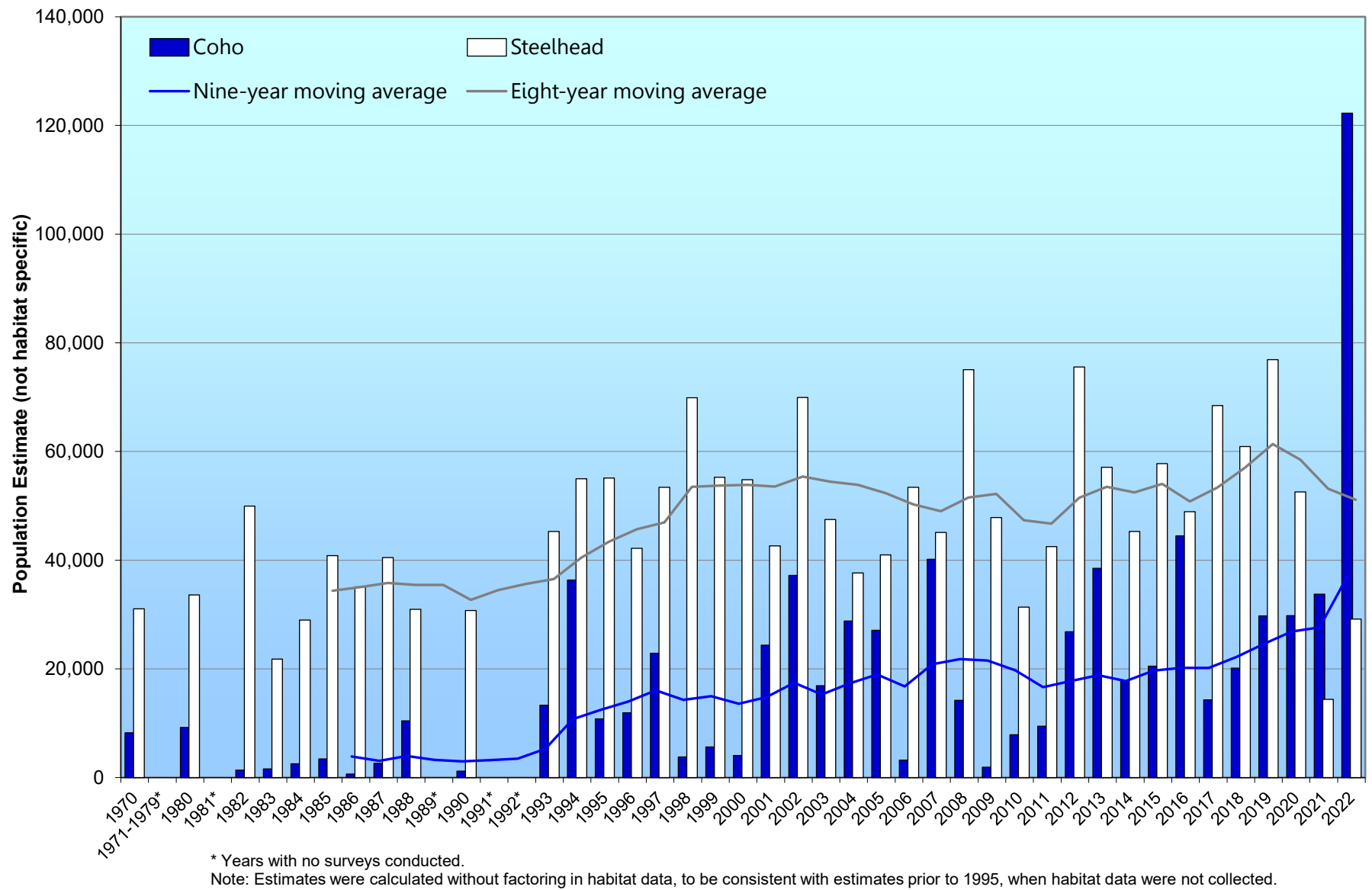
Figure 4. Population Estimates, Based Exclusively on Density Data from Index Reaches.

* Years with no surveys conducted.
Note: Estimates were calculated without factoring in habitat data, to be consistent with estimates prior to 1995, when habitat data were not collected.

20
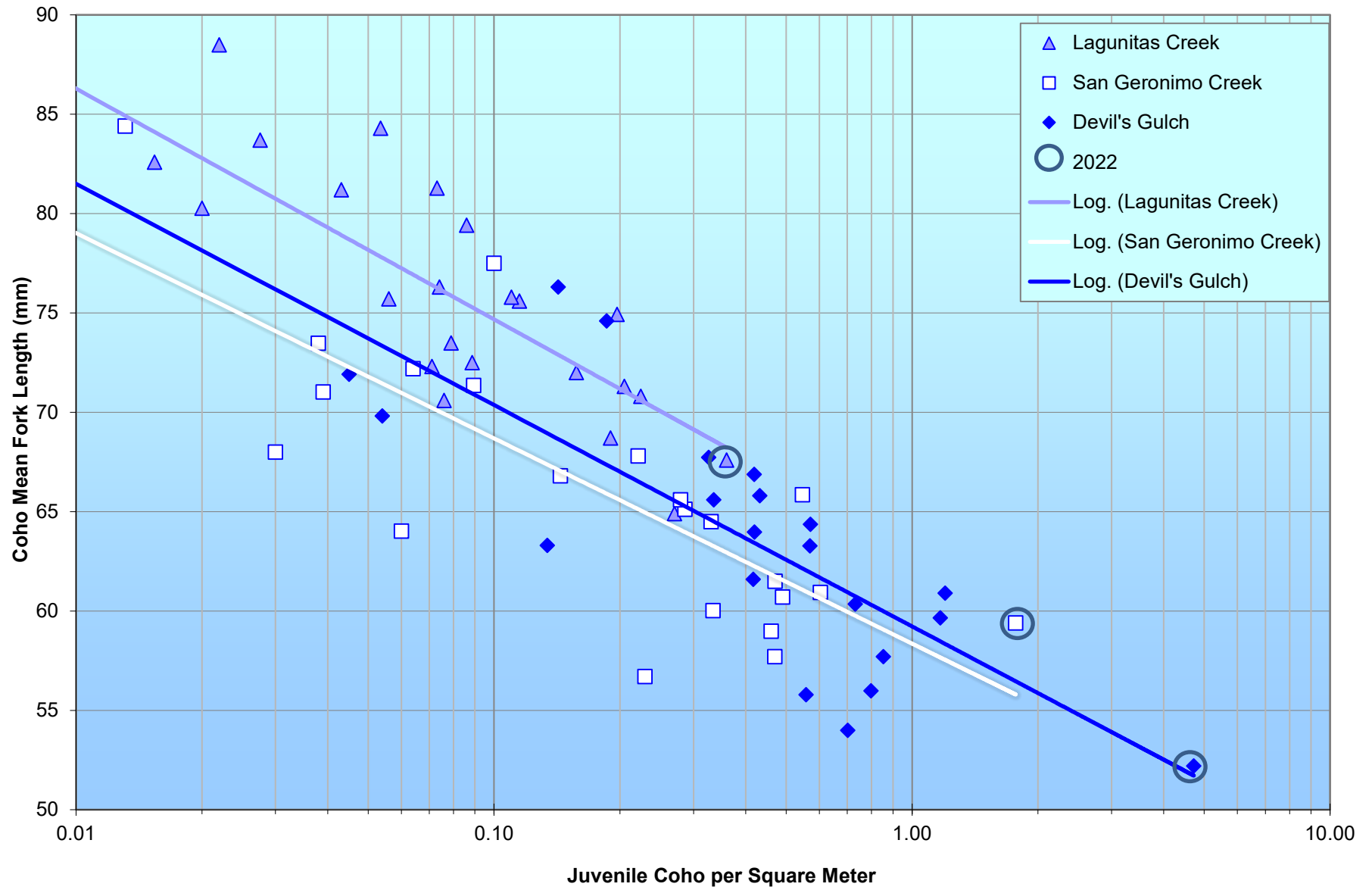
Figure 5. Coho Salmon Lengths vs. Densities in Index Reaches, 1999-2022
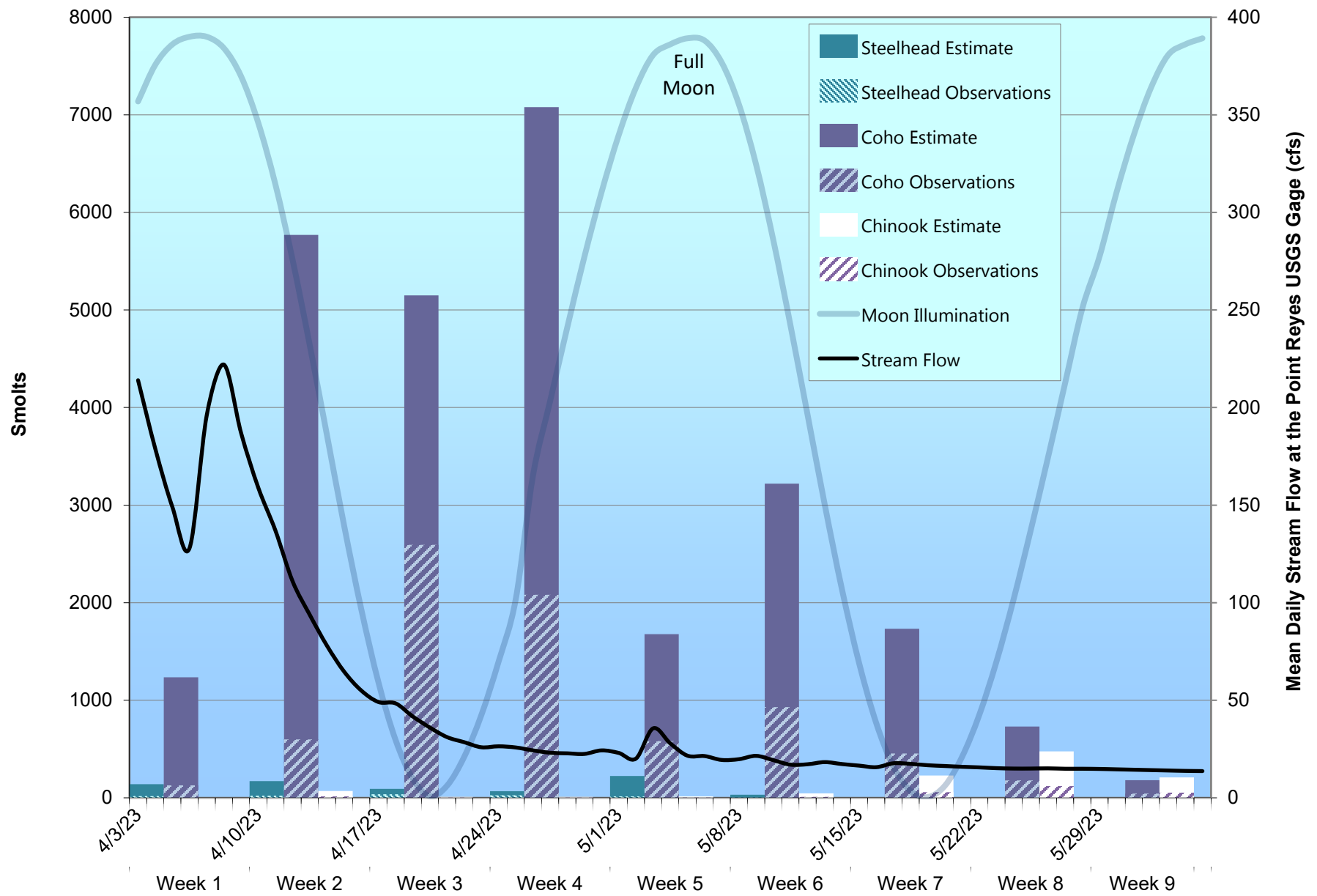
Figure 6. Lagunitas Creek smolt emigration, lunar cycle, and stream flow.
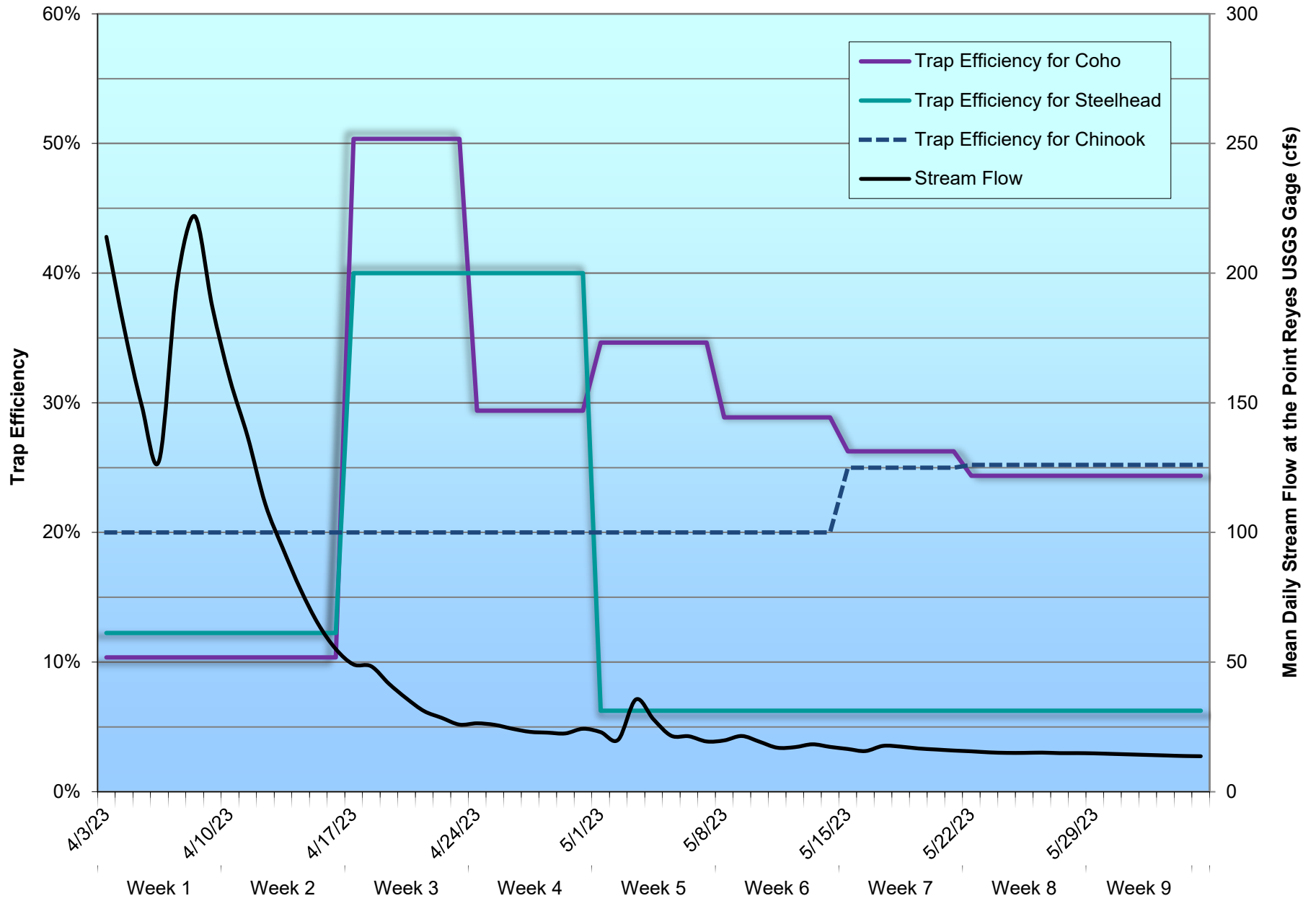
Figure 7. Weekly trap efficiency and Lagunitas Creek stream flow.
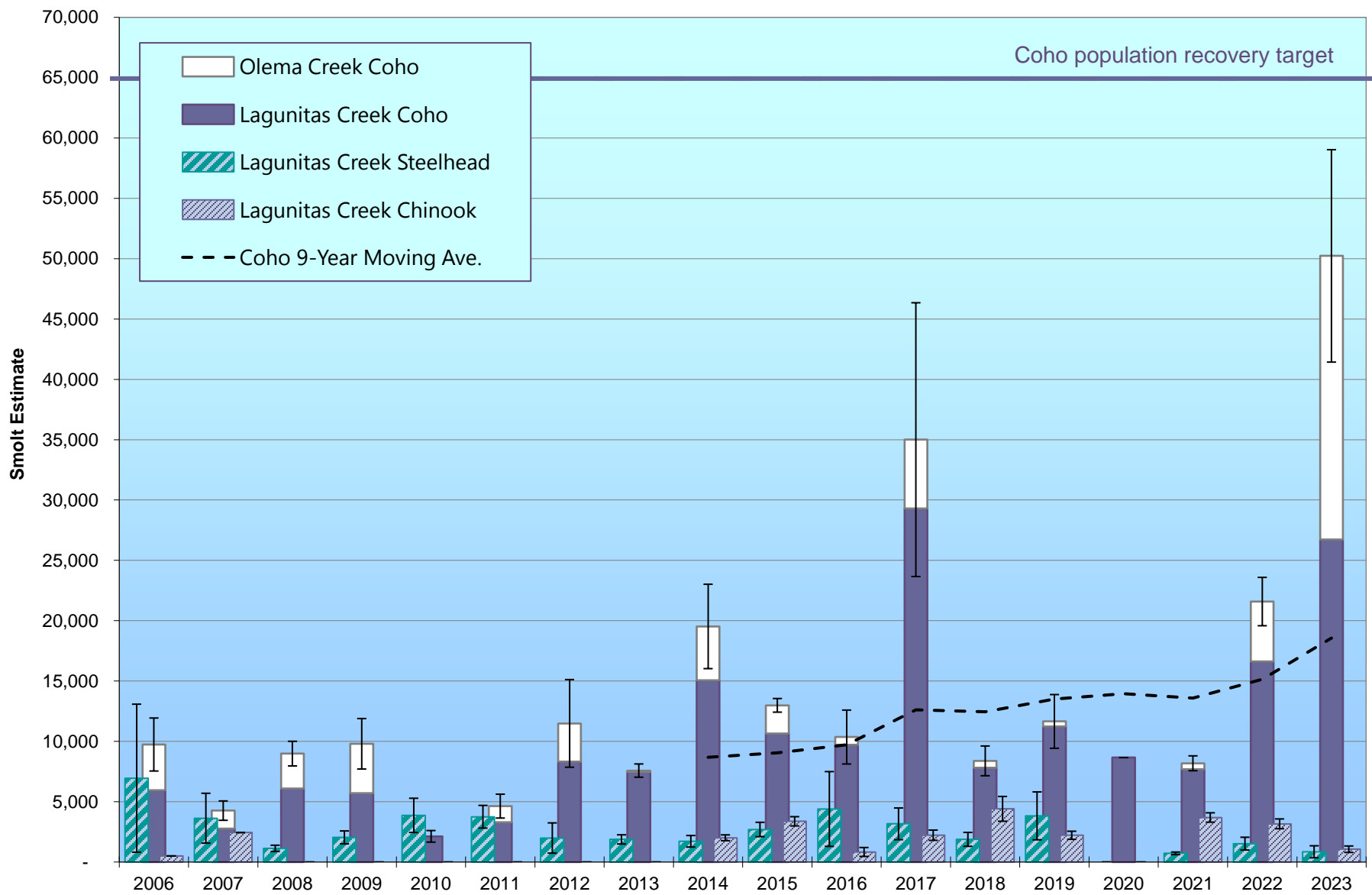
Figure 8. Lagunitas Creek smolt emigration estimates.

Note: The coho recovery target assumes an ocean survival rate of at least 4%, resulting in 2,600 adult returns.

LG-2 1st, Pool*	Pass		Max.
Species	1	2	
0+ Steelhead	29	20	29
1+ Steelhead	2	4	4
Coho Salmon	67	82	82

* Snorkel survey.

LG-2 2nd, Glide*	Pass		Max.
Species	1	2	
0+ Steelhead	19	28	28
1+ Steelhead	4	2	4
Coho Salmon	32	44	44

* Snorkel survey.

LG-2 3rd Pool*	Pass		Max.
Species	1	2	
0+ Steelhead	22	26	26
1+ Steelhead	3	3	3
Coho Salmon	69	53	69

* Snorkel survey.

LG-3 1st, Pool	Pass		Total
Species	1	2	
0+ Steelhead	21	8	29
1+ Steelhead	6	3	9
Coho Salmon	41	19	60
Sculpin	3	8	11
Lamprey (macro)	46	46	92
Lamprey (amo)	22	33	55
Freshwater Shrimp	2	1	3
Roach	10	4	14
Stickleback	6	3	9

LG-5 1st Run*	Pass		Max.
Species	1	2	
0+ Steelhead	38	62	62
1+ Steelhead	4	2	4
Coho Salmon	48	56	56

* Snorkel survey.

LG-7 1st, Pool	Pass		Total
Species	1	2	
0+ Steelhead	21	11	32
1+ Steelhead	2	2	4
Coho Salmon	67	15	82
Lamprey (adult)	1	0	1
Lamprey (macro)	8	4	12
Lamprey (amo)	11	11	22
Roach	28	13	41
Sculpin	1	0	1
Stickleback	6	7	13
Freshwater Shrimp	19	4	23

LG-5 2nd Pool*	Pass		Max.
Species	1	2	
0+ Steelhead	38	37	38
1+ Steelhead	2	1	2
Coho Salmon	148	142	148

* Snorkel survey.

LG-7 2nd, Riffle	Pass		Total
Species	1	2	
0+ Steelhead	45	14	59
1+ Steelhead	2	0	2
Coho Salmon	5	2	7
Lamprey (macro)	3	0	3
Lamprey (amo)	3	2	5
Roach	3	0	3

LG-7 3rd, Run	Pass		Total
Species	1	2	
0+ Steelhead	29	18	47
1+ Steelhead	2	1	3
Coho Salmon	16	13	29
Lamprey (macro)	10	1	11
Lamprey (amo)	7	3	10
Stickleback	7	3	10
Roach	3	7	10

LG-8 1st, Glide	Pass			Total
Species	1	2	3	
0+ Steelhead	52	33	19	104
1+ Steelhead	0	0	0	0
Coho Salmon	92	36	22	150
Stickleback	56	45	43	144
Lamprey (amo)	41	31	28	100
Lamprey (macro)	15	17	18	50
Roach	15	4	5	24
Freshwater Shrimp	9	4	1	14

LG-9 4th, Pool	Pass			Total
Species	1	2	3	
0+ Steelhead	77	25	17	119
1+ Steelhead	2	2	0	4
Coho Salmon	42	8	9	59
Lamprey (macro)	0	8	2	10
Lamprey (amo)	5	10	6	21
Sculpin	0	1	0	1
Roach	2	3	1	6
Freshwater Shrimp	0	0	2	2
Stickleback	18	10	5	33

LG-9 5th, Glide	Pass			Total
Species	1	2	3	
0+ Steelhead	51	44	9	104
1+ Steelhead	1	0	0	1
Coho Salmon	18	3	1	22
Lamprey (amo)	4	6	2	12
Lamprey (macro)	6	7	3	16
Stickleback	14	8	6	28
Roach	1	0	0	1
Freshwater Shrimp	0	1	0	1
Sculpin	3	1	1	5

LG-12 1st, Pool	Pass			Total
Species	1	2	3	
0+ Steelhead	27	7	5	39
1+ Steelhead	1	2	0	3
Coho Salmon	114	75	34	223
Stickleback	24	17	7	48
Lamprey (amo)	43	17	31	91
Lamprey (macro)	13	11	7	31
Bluegill	1	2	2	5
Roach	16	11	6	33
Sculpin	13	11	3	27

LG-12 2nd, Run	Pass			Total
Species	1	2	3	
0+ Steelhead	20	13	6	39
1+ Steelhead	0	0	0	0
Coho Salmon	72	42	19	133
Lamprey (amo)	70	48	38	156
Lamprey (macro)	3	7	0	10
Freshwater Shrimp	3	2	0	5
Roach	2	1	0	3
Stickleback	8	4	2	14
Sculpin	4	2	2	8

LG-12 3rd, Riffle	Pass		Total
Species	1	2	
0+ Steelhead	31	9	40
1+ Steelhead	1	2	3
Coho Salmon	5	0	5
Lamprey (amo)	4	2	6
Lamprey (macro)	2	0	2
Sculpin	3	1	4

LG-15 1st Pool*	Pass			Max.
Species	1	2	3	
0+ Steelhead	15	33	36	36
1+ Steelhead	1	1	1	1
Coho Salmon	129	272	278	278

* Snorkel survey.

SG-1 1st, Pool	Pass			Total
Species	1	2	3	
0+ Steelhead	4	1	1	6
1+ Steelhead	8	0	0	8
Coho Salmon	132	31	6	169
Lamprey (amo)	2	3	3	8
Lamprey (macro)	1	0	0	1
Stickleback	18	8	12	38

SG-1 2nd, Riffle	Pass	Total
Species	1	
0+ Steelhead	0	0
1+ Steelhead	0	0
Coho Salmon	1	1
Stickleback	9	9

SG-1 3rd, Glide	Pass	Total
Species	1	
0+ Steelhead	0	0
1+ Steelhead	0	0
Coho Salmon	3	3
Stickleback	12	12

SG-1 4th, Glide	Pass		Total
Species	1	2	
0+ Steelhead	0	0	0
1+ Steelhead	0	0	0
Coho Salmon	12	1	13
Lamprey (amo)	1	2	3
Stickleback	16	14	30

SG-2 1st, Pool	Pass			Total
Species	1	2	3	
0+ Steelhead	2	1	0	3
1+ Steelhead	4	4	1	9
Coho Salmon	62	58	44	164
Stickleback	15	13	19	47
Roach	6	4	3	13
Lamprey (amo)	1	1	0	2

SG-3 1st, Pool	Pass			Total
Species	1	2	3	
0+ Steelhead	1	1	0	2
1+ Steelhead	0	0	0	0
Coho Salmon	247	56	35	338
Stickleback	117	61	34	212
Roach	16	1	1	18

SG-4 1st, Pool	Pass			Total
Species	1	2	3	
0+ Steelhead	0	0	0	0
1+ Steelhead	0	0	0	0
Coho Salmon	199	91	45	335
Stickleback	86	42	25	153
Roach	0	1	0	1

SG-4 2nd, Glide	Pass	Total
Species	1	
0+ Steelhead	0	0
1+ Steelhead	0	0
Coho Salmon	4	4
Stickleback	10	10

SG-4 3rd, Pool	Pass		Total
Species	1	2	
0+ Steelhead	1	0	1
1+ Steelhead	1	0	1
Coho Salmon	180	2	182
Stickleback	61	0	61
Roach	5	0	5

DG-1 1st, Pool	Pass			Total
Species	1	2	3	
0+ Steelhead	7	3	2	12
1+ Steelhead	0	0	0	0
Coho Salmon	89	81	21	191

DG-1 2nd, Riffle	Pass	Total
Species	1	
0+ Steelhead	0	0
1+ Steelhead	0	0
Coho Salmon	7	7

DG-1 3rd, Pool	Pass		Total
Species	1	2	
0+ Steelhead	12	4	16
1+ Steelhead	1	0	1
Coho Salmon	122	40	162
Roach	2	0	2

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

DG-1 5th, Pool	Pass				Total
Species	1	2	3	4	
0+ Steelhead	2	5	3	1	11
1+ Steelhead	1	0	0	0	1
Coho Salmon	28	38	24	19	109
Roach	0	4	1	0	5

DG-1 6th, Glide	Pass		Total
Species	1	2	
0+ Steelhead	13	5	18
1+ Steelhead	0	0	0
Coho Salmon	118	26	144
Sculpin	1	0	1

DG-2 1st, Glide	Pass		Total
Species	1	2	
0+ Steelhead	0	0	0
1+ Steelhead	0	0	0
Coho Salmon	105	17	122

DG-2 2nd, Riffle	Pass		Total
Species	1	2	
0+ Steelhead	0	0	0
1+ Steelhead	0	0	0
Coho Salmon	21	4	25

DG-2 3rd, Pool	Pass		Total
Species	1	2	
0+ Steelhead	0	0	0
1+ Steelhead	0	0	0
Coho Salmon	129	28	157
Sculpin	1	1	2

DG-2 5th, Pool	Pass			Total
Species	1	2	3	
0+ Steelhead	0	0	0	0
1+ Steelhead	1	0	0	1
Coho Salmon	99	49	24	172
Sculpin	19	11	0	30

LAGUNITAS CREEK

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

	Snorkel Count	Population Estimate	Lower Confidence Interval	Upper Confidence Interval	Standard Deviation
0+ Steelhead	29	29	NA	NA	NA
1+ Steelhead	4	4	NA	NA	NA
Coho	82	82	NA	NA	NA

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

	Snorkel Count	Population Estimate	Lower Confidence Interval	Upper Confidence Interval	Standard Deviation
0+ Steelhead	28	28	NA	NA	NA
1+ Steelhead	4	4	NA	NA	NA
Coho	44	44	NA	NA	NA

Site: **LG-2**   Sequence: **3rd**   Habitat: **Pool**

	Snorkel Count	Population Estimate	Lower Confidence Interval	Upper Confidence Interval	Standard Deviation
0+ Steelhead	26	26	NA	NA	NA
1+ Steelhead	3	3	NA	NA	NA
Coho	69	69	NA	NA	NA

LG-2	Total	Population Estimate
0+ Steelhead	83	83
1+ Steelhead	11	11
Coho	195	195

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

	Catch	Population Estimate	Lower Confidence Interval	Upper Confidence Interval	Standard Deviation
0+ Steelhead	29	32	24	40	NA
1+ Steelhead	9	9	6	12	NA
Coho	60	73	53	93	NA

LG-3	Total	Population Estimate
0+ Steelhead	29	32
1+ Steelhead	9	9
Coho	60	73

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

	Snorkel Count	Population Estimate	Lower Confidence Interval	Upper Confidence Interval	Standard Deviation
0+ Steelhead	62	62	NA	NA	NA
1+ Steelhead	4	4	NA	NA	NA
Coho	56	56	NA	NA	NA

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

	Snorkel Count	Population Estimate	Lower Confidence Interval	Upper Confidence Interval	Standard Deviation
0+ Steelhead	38	38	NA	NA	NA
1+ Steelhead	2	2	NA	NA	NA
Coho	148	148	NA	NA	NA

LG-5	Total	Population Estimate
0+ Steelhead	100	100
1+ Steelhead	6	6
Coho	204	204

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

	Catch	Population Estimate	Lower Confidence Interval	Upper Confidence Interval	Standard Deviation
0+ Steelhead	32	40	22	58	18.4
1+ Steelhead	4	4	-1	9	5.1
Coho	82	85	79	91	6.1

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

	Catch	Population Estimate	Lower Confidence Interval	Upper Confidence Interval	Standard Deviation
0+ Steelhead	59	64	55	73	9.2
1+ Steelhead	2	2	2	2	0.0
Coho	7	7	5	9	2.0

Site: **LG-7**   Sequence: **3rd**   Habitat: **Run**

	Catch	Population Estimate	Lower Confidence Interval	Upper Confidence Interval	Standard Deviation
0+ Steelhead	47	69	27	111	**42.9**
1+ Steelhead	3	3	0	6	3.1
Coho	29	57	-29	143	**87.8**

LG-7	Total	Population Estimate
0+ Steelhead	138	173
1+ Steelhead	9	9
Coho	118	149

Site: **LG-8**　　　Sequence: **1st**　　　Habitat: **Glide**

	Catch	Population Estimate	Lower Confidence Interval	Upper Confidence Interval	Standard Deviation
0+ Steelhead	104	131	102	160	**29.6**
1+ Steelhead	0	0	0	0	0.0
Coho	150	165	151	179	**14.3**

LG-8	Total	Population Estimate
0+ Steelhead	104	131
1+ Steelhead	0	0
Coho	150	165

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

	Catch	Population Estimate	Lower Confidence Interval	Upper Confidence Interval	Standard Deviation
0+ Steelhead	119	128	118	138	10.2
1+ Steelhead	4	4	2	6	2.0
Coho	59	61	56	66	**5.1**

Site: **LG-9**　　　Sequence: **5th**　　　Habitat: **Glide**

	Catch	Population Estimate	Lower Confidence Interval	Upper Confidence Interval	Standard Deviation
0+ Steelhead	104	119	102	136	17.3
1+ Steelhead	1	1	1	1	0.0
Coho	22	22	21	23	1.0

LG-9	Total	Population Estimate
0+ Steelhead	223	247
1+ Steelhead	5	5
Coho	81	83

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

	Catch	Population Estimate	Lower Confidence Interval	Upper Confidence Interval	Standard Deviation
0+ Steelhead	39	40	36	44	4.1
1+ Steelhead	3	3	0	6	3.1
Coho	223	270	236	304	**34.7**

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

	Catch	Population Estimate	Lower Confidence Interval	Upper Confidence Interval	Standard Deviation
0+ Steelhead	39	45	34	56	11.2
1+ Steelhead	0	0	0	0	0.0
Coho	133	154	134	174	20.4

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

	Catch	Population Estimate	Lower Confidence Interval	Upper Confidence Interval	Standard Deviation
0+ Steelhead	40	42	37	47	5.1
1+ Steelhead	3	3	-5	11	8.2
Coho	5	5	5	5	0.0

LG-12	Total	Population Estimate
0+ Steelhead	118	127
1+ Steelhead	6	6
Coho	361	429

Site: **LG-15**   Sequence: **1st**   Habitat: **Pool**

	Snorkel Count	Population Estimate	Lower Confidence Interval	Upper Confidence Interval	Standard Deviation
0+ Steelhead	36	36	NA	NA	NA
1+ Steelhead	1	1	NA	NA	NA
Coho	278	278	NA	NA	NA

LG-15	Total	Population Estimate
0+ Steelhead	36	36
1+ Steelhead	1	1
Coho	278	278

SAN GERONIMO CREEK

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

	Catch	Population Estimate	Lower Confidence Interval	Upper Confidence Interval	Standard Deviation
0+ Steelhead	6	6	4	8	2.0
1+ Steelhead	8	8	8	8	0.0
Coho	169	170	167	173	3.1

Site: **SG-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	1	1	0	0	0.0

Site: **SG-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	3	3	3	3	0.0

Site: **SG-1**   Sequence: **4th**   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	13	13	12	14	1.0

SG-1	Total	Population Estimate
0+ Steelhead	6	6
1+ Steelhead	8	8
Coho	186	187

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

	Catch	Population Estimate	Lower Confidence Interval	Upper Confidence Interval	Standard Deviation
0+ Steelhead	3	3	2	4	1.0
1+ Steelhead	9	9	6	12	3.1
Coho	164	164	75	713	**325.5**

Note: The coho estimate of 394 was deemed unlikely, so the total catch was used.

SG-2	Total	Population Estimate
0+ Steelhead	3	3
1+ Steelhead	9	9
Coho	164	164

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

	Catch	Population Estimate	Lower Confidence Interval	Upper Confidence Interval	Standard Deviation
0+ Steelhead	2	2	-3	7	5.1
1+ Steelhead	0	0	0	0	0.0
Coho	338	349	340	358	9.2

SG-3	Total	Population Estimate
0+ Steelhead	2	2
1+ Steelhead	0	0
Coho	338	349

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	335	372	349	395	**23.5**

Site: **SG-4**   Sequence: **2nd**   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	4	4	4	4	0.0

Site: **SG-4**   Sequence: **3rd**   Habitat: **Pool**

	Catch	Population Estimate	Lower Confidence Interval	Upper Confidence Interval	Standard Deviation
0+ Steelhead	1	1	1	1	0.0
1+ Steelhead	1	1	1	1	0.0
Coho	182	182	182	182	0.0

SG-4	Total	Population Estimate
0+ Steelhead	1	0
1+ Steelhead	1	0
Coho	521	558

DEVIL'S GULCH

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

	Catch	Population Estimate	Lower Confidence Interval	Upper Confidence Interval	Standard Deviation
0+ Steelhead	12	12	9	15	3.1
1+ Steelhead	0	0	0	0	0.0
Coho	191	232	200	264	**32.7**

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	7	7	7	7	0.0

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

	Catch	Population Estimate	Lower Confidence Interval	Upper Confidence Interval	Standard Deviation
0+ Steelhead	16	16	13	19	3.1
1+ Steelhead	1	1	1	1	0.0
Coho	162	180	163	197	17.3

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	1	1	1	1	0.0

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

	Catch	Population Estimate	Lower Confidence Interval	Upper Confidence Interval	Standard Deviation
0+ Steelhead	11	14	2	26	12.2
1+ Steelhead	1	1	1	1	0.0
Coho	109	109	59	389	**168.4**

Note: A coho estimate of 224 was deemed unlikely, so the total catch was used.

Site: **DG-1**   Sequence: **6th**   Habitat: **Glide**

	Catch	Population Estimate	Lower Confidence Interval	Upper Confidence Interval	Standard Deviation
0+ Steelhead	18	19	14	24	5.1
1+ Steelhead	0	0	0	0	0.0
Coho	144	150	142	158	8.2

DG-1	Total	Population Estimate
0+ Steelhead	57	61
1+ Steelhead	2	2
Coho	614	679

Site: **DG-2** Sequence: **1st** 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	122	124	120	128	4.1

Site: **DG-2** 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	25	25	23	27	2.0

Site: **DG-2** Sequence: **3rd** 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	157	164	156	172	8.2

Site: **DG-2** 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	1	1	1	1	0.0
Coho	172	194	175	213	19.4

DG-2	Total	Population Estimate
0+ Steelhead	0	0
1+ Steelhead	1	1
Coho	476	507

Lagunitas Creek - Nicasio Creek to Peters Dam

Total Habitat:

	Length (m)	% of Total
Pool	5,889	45%
Run	2,839	22%
Riffle	2,709	21%
Glide	1,610	12%
Total	13,048	100%

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

Electrofishing and Snorkel Sites:

	Length (m)	% of Total
Pool	251.2	52%
Run	66.1	14%
Riffle	48.5	10%
Glide	116.5	24%
Total	482.3	100%

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

	0+ SH	1+ SH	Coho
Pool	369	30	1066
Run	176	7	267
Riffle	106	5	12
Glide	278	5	231
Total	929	47	1576

Number of Fish per Habitat Type in the Stream Segment:

0+ SH

Pool = 369 fish/251.2 m =>1.469 fish/m x 5889 m of pool =	8,651	+/-	2,926
Run = 176 fish/66.1 m =>2.663 fish/m x 2839 m of run =	7,560	+/-	1,534
Riffle = 106 fish/48.5 m =>2.186 fish/m x 2709 m of riffle =	5,922	+/-	2,700
Glide = 278 fish/116.5 m =>2.386 fish/m x 1610 m of glide =	3,843	+/-	3,102
	25,974	+/-	5,047

1+ SH

Pool = 30 fish/251.2 m =>0.119 fish/m x 5889 m of pool =	703	+/-	213
Run = 7 fish/66.1 m =>0.106 fish/m x 2839 m of run =	301	+/-	246
Riffle = 5 fish/48.5 m =>0.103 fish/m x 2709 m of riffle =	279	+/-	176
Glide = 5 fish/116.5 m =>0.043 fish/m x 1610 m of glide =	69	+/-	114
	1,352	+/-	388

Coho

Pool = 1066 fish/251.2 m =>4.244 fish/m x 5889 m of pool =	24,991	+/-	7,935
Run = 267 fish/66.1 m =>4.039 fish/m x 2839 m of run =	11,469	+/-	6,675
Riffle = 12 fish/48.5 m =>0.247 fish/m x 2709 m of riffle =	670	+/-	247
Glide = 231 fish/116.5 m =>1.983 fish/m x 1610 m of glide =	3,193	+/-	4,226
	40,323	+/-	11,200

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

Total Habitat:

	Length (m)	% of Total
Pool	3,879	57%
Run	275	4%
Riffle	1,316	19%
Glide	1,315	19%
Total	6,786	100%

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

Electrofishing Sites:

	Length (m)	% of Total
Pool	120.5	72%
Run	0.0	0%
Riffle	13	8%
Glide	33.3	20%
Total	166.8	100%

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

	0+ SH	1+ SH	Coho
Pool	12	18	1237
Run	0	0	0
Riffle	0	0	1
Glide	0	0	20
Total	12	18	1258

Number of Fish per Habitat Type in the Stream Segment:

0+ SH

Pool = 12 fish/120.5 m => 0.1 fish/m x 3879 m of pool =	386 +/-	402
Riffle = 0 fish/13 m => 0 fish/m x 1316 m of riffle =	0 +/-	0
Glide = 0 fish/33.3 m => 0 fish/m x 1315 m of glide =	0 +/-	0
	386 +/-	402

1+ SH

Pool = 18 fish/120.5 m => 0.149 fish/m x 3879 m of pool =	580 +/-	777
Riffle = 0 fish/13 m => 0 fish/m x 1316 m of riffle =	0 +/-	0
Glide = 0 fish/33.3 m => 0 fish/m x 1315 m of glide =	0 +/-	0
	580 +/-	777

Coho

Pool = 1237 fish/120.5 m => 10.266 fish/m x 3879 m of pool =	39,825 +/-	18,322
Riffle = 1 fish/13 m => 0.077 fish/m x 1316 m of riffle =	101 +/-	0
Glide = 20 fish/33.3 m => 0.601 fish/m x 1315 m of glide =	790 +/-	333
	40,716 +/-	18,325

Devils Gulch - Mouth to 3,294 meters upstream.

Total Habitat:

	Length (m)	% of Total
Pool	894	32%
Run	70	2%
Riffle	1,037	37%
Glide	816	29%
Total	2,816	100%

*Note: Does not include 478 m of cascade and dry habitats.

Electrofishing Sites:

	Length (m)	% of Total
Pool	68.3	52%
Run	0.0	0%
Riffle	41.8	32%
Glide	22.4	17%
Total	132.5	100%

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

	0+ SH	1+ SH	Coho
Pool	42	3	879
Run	0	0	0
Riffle	0	0	33
Glide	19	0	274
Total	61	3	1186

Number of Fish per Habitat Type in the Stream Segment:

0+ SH

Pool = 42 fish/68.3 m => 0.615 fish/m x 894 m of pool =	550	+/-	512
Riffle = 0 fish/41.8 m => 0 fish/m x 1037 m of riffle =	0	+/-	0
Glide = 19 fish/22.4 m => 0.848 fish/m x 816 m of glide =	692	+/-	1,212
	1,242	+/-	1,315

1+ SH

Pool = 3 fish/68.3 m => 0.044 fish/m x 894 m of pool =	39	+/-	35
Riffle = 0 fish/41.8 m => 0 fish/m x 1037 m of riffle =	0	+/-	0
Glide = 0 fish/22.4 m => 0 fish/m x 816 m of glide =	0	+/-	0
	39	+/-	35

Coho

Pool = 879 fish/68.3 m => 12.87 fish/m x 894 m of pool =	11,506	+/-	3,188
Riffle = 33 fish/41.8 m => 0.789 fish/m x 1037 m of riffle =	819	+/-	1,237
Glide = 274 fish/22.4 m => 12.232 fish/m x 816 m of glide =	9,977	+/-	1,659
	22,301	+/-	3,801

Juvenile salmonid populations for the Lagunitas Creek study area have been estimated since 1993. These estimates have applied to different lengths of streams sampled, ranging from 19.7 to 43.8 total stream kilometers (Table D-1). The streams were also divided into reaches in previous years, with populations being estimated for separate reaches. This section will detail what constituted the study area over the years and how populations were estimated.

Table D-1. Lengths of streams included in the study area, by year

Years	Lengths of Stream in Study Area (km)			
	Lagunitas	San Geronimo	Devil's Gulch	Total
1993-1994	17.3	5.5	2.1	24.9
1995-1996	12.1	5.5	2.1	19.7
1997	13.3	6.7	2.1	22.1
1998-2002	12.6	7.2	3.3	23.1
2003-2005	12.7	7.2	3.1	23.0
2006-2010	13.3	7.7	3.4	24.4
2011-2015	13.3	7.6	3.3	24.2
2013-2014 (GRTS)	19.4	7.6	3.3	43.8*
2016-2022	13.4	7.2	3.3	23.9

* Stream length includes Olema Creek

For the 1993 and 1994 juvenile surveys, Trihey & Associates (1995b) estimated salmonid abundance in three segments of Lagunitas Creek between Highway 1 and Shafter Bridge, and did not differentiate habitat types. All future population estimates were based on fish densities in pools, runs and riffles, and extrapolated based on the proportion of those habitats in the sample reaches. For the 1995 and 1996 surveys, Trihey & Associates (1995c, 1996) excluded the section of creek below Nicasio Creek because they determined that sample site LG-1 did not accurately reflect the habitat composition of that section of creek. For the 1997 and 1998 surveys, the creek upstream of Nicasio Creek was divided into two new sections and sample site LG-1 was included. Starting in 1999 and continuing through 2016, Lagunitas Creek was treated as a single segment, extending from Nicasio Creek to Peters Dam. In 2013 and 2014 Generalized Random Tesselation Stratified (GRTS) sampling was conducted in the reach of Lagunitas Creek between Highway 1 and Nicasio Creek. Salmonid population estimates were generated for the entire watershed, including this lower reach of Lagunitas Creek and Olema Creek.

San Geronimo Creek surveys prior to 1997 eliminated the lower 1.2 km of San Geronimo Creek (from its mouth to the Lagunitas Street Bridge) and divided the remainder of the creek into two segments (Trihey & Associates 1995b, 1995c, and 1996). Since 1997 salmonid populations have been estimated for the creek from its mouth to the confluence with Woodacre Creek.

Prior to 1998, the salmonid populations of Devil's Gulch were estimated for the lower 2.2 km of stream, based on habitat typing data collected in 1995. Since 1998, we have estimated salmonid populations for the lower 3.4 km of Devil's Gulch. Estimating pre-1998 populations for all of Devil's Gulch is difficult due to the lack of habitat data for the upper section for those years.

Appendix E. Juvenile Salmonids per Square Meter

Coho Salmon

Year	|	Lagunitas Creek Riffle	Run	Pool	Glide	Mean	|	San Geronimo Creek Riffle	Run	Pool	Glide	Mean	|	Devil's Gulch Riffle	Run	Pool	Glide	Mean	|	Watershed Average Riffle	Run	Pool	Glide	Mean
1998		0.0	0.0	0.0	N/A	0.0		0.0	0.0	0.1	N/A	0.1		0.0	0.0	0.1	N/A	0.1		0.0	0.0	0.0	N/A	0.0
1999		0.0	0.0	0.0	N/A	0.0		0.0	0.0	0.0	N/A	0.0		0.0	NA	0.5	N/A	0.3		0.0	0.0	0.1	N/A	0.0
2000		0.0	0.0	0.0	N/A	0.0		0.0	0.0	0.1	N/A	0.0		0.0	0.0	0.1	N/A	0.1		0.0	0.0	0.0	N/A	0.0
2001		0.0	0.0	0.1	N/A	0.1		0.0	0.0	0.4	N/A	0.3		0.1	0.4	0.7	N/A	0.6		0.0	0.0	0.2	N/A	0.2
2002		0.0	0.1	0.1	N/A	0.1		0.0	NA	0.7	N/A	0.6		0.0	0.5	1.5	N/A	1.2		0.0	0.1	0.3	N/A	0.2
2003		0.0	0.0	0.1	N/A	0.1		0.0	0.1	0.2	N/A	0.1		0.0	0.4	0.7	N/A	0.4		0.0	0.1	0.2	N/A	0.1
2004		0.0	0.1	0.1	N/A	0.1		0.0	0.0	0.6	N/A	0.5		0.0	0.7	0.9	N/A	0.7		0.0	0.1	0.2	N/A	0.2
2005		0.0	0.0	0.2	N/A	0.1		0.0	0.0	0.4	N/A	0.3		0.0	0.6	1.1	N/A	0.6		0.0	0.1	0.3	N/A	0.2
2006		0.0	0.0	0.0	N/A	0.0		0.0	0.0	0.1	N/A	0.1		0.0	0.0	0.1	N/A	0.0		0.0	0.0	0.0	N/A	0.0
2007		0.0	0.1	0.2	0.3	0.2		0.0	0.4	0.6	N/A	0.5		0.1	0.6	1.2	N/A	0.8		0.0	0.2	0.3	0.3	0.3
2008		0.0	0.0	0.1	0.0	0.1		0.0	0.0	0.1	N/A	0.1		0.0	0.1	0.2	N/A	0.1		0.0	0.0	0.1	0.0	0.1
2009		0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	N/A	0.0		0.0	0.0	0.0	N/A	0.0		0.0	0.0	0.0	0.0	0.0
2010		0.0	0.0	0.1	0.0	0.1		0.0	0.0	0.0	N/A	0.0		0.0	0.1	0.4	N/A	0.2		0.0	0.0	0.1	0.0	0.1
2011		0.0	0.0	0.1	0.1	0.0		0.0	0.0	0.1	0.3	0.1		0.0	0.1	0.3	N/A	0.1		0.0	0.0	0.1	0.2	0.1
2012		0.0	0.0	0.2	N/A	0.2		0.0	N/A	0.4	0.0	0.2		0.1	0.6	1.0	N/A	0.7		0.0	0.1	0.3	0.0	0.2
2013		0.0	0.1	0.3	0.4	0.2		0.0	0.0	0.7	0.0	0.2		0.0	1.0	1.6	N/A	1.2		0.0	0.1	0.5	0.3	0.3
2014		0.0	0.5	0.2	0.3	0.2		0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	N/A	0.0		0.0	0.4	0.1	0.2	0.1
2015		0.0	0.1	0.1	0.1	0.1		0.0	0.1	0.4	0.0	0.3		0.0	0.2	0.6	N/A	0.4		0.0	0.1	0.2	0.1	0.1
2016		0.0	0.2	0.3	0.3	0.2		0.0	0.4	0.5	N/A	0.5		0.0	1.2	0.9	N/A	0.9		0.0	0.3	0.4	0.3	0.3
2017		0.0	0.0	0.0	0.0	0.0		0.0	0.1	0.4	0.0	0.3		0.0	0.1	0.6	N/A	0.4		0.0	0.0	0.1	0.0	0.1
2018		0.0	0.0	0.2	0.0	0.1		0.0	0.0	0.1	N/A	0.1		0.0	0.6	0.6	N/A	0.6		0.0	0.1	0.2	0.0	0.1
2019		0.0	0.0	0.1	0.0	0.1		0.0	0.0	0.7	N/A	0.5		0.1	0.2	0.6	N/A	0.3		0.0	0.0	0.2	0.0	0.1
2020		0.0	0.0	0.1	0.1	0.1		0.0	0.0	0.7	N/A	0.6		0.0	0.2	0.5	N/A	0.4		0.0	0.0	0.3	0.1	0.2
2021		0.0	0.2	0.4	0.2	0.3		0.0	0.0	0.0	N/A	0.0		0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.3	0.2	0.2
2022		0.1	0.7	0.5	0.2	0.4		0.0	0.0	2.3	0.0	1.8		0.9	0.0	4.1	0.0	4.7		0.1	0.1	1.0	0.2	0.6
Mean		0.0	0.1	0.1	0.1	0.1		0.0	0.1	0.4	0.1	0.3		0.1	0.3	0.7	0.0	0.6		0.0	0.1	0.2	0.1	0.2

Steelhead

Year	|	Lagunitas Creek Riffle	Run	Pool	Glide	Mean	|	San Geronimo Creek Riffle	Run	Pool	Glide	Mean	|	Devil's Gulch Riffle	Run	Pool	Glide	Mean	|	Watershed Average Riffle	Run	Pool	Glide	Mean
1998		0.2	0.4	0.2	N/A	0.3		0.1	1.0	0.9	N/A	0.8		1.3	1.0	1.4	N/A	1.3		0.2	0.5	0.4	N/A	0.4
1999		0.3	0.2	0.3	N/A	0.3		0.3	1.5	0.6	N/A	0.7		0.4	NA	0.6	N/A	0.6		0.3	0.5	0.4	N/A	0.4
2000		0.4	0.3	0.1	N/A	0.2		0.2	1.1	0.6	N/A	0.6		0.3	0.4	1.0	N/A	0.7		0.4	0.5	0.3	N/A	0.3
2001		0.4	0.5	0.2	N/A	0.2		0.1	1.3	0.4	N/A	0.4		0.3	0.3	0.4	N/A	0.4		0.3	0.6	0.2	N/A	0.3
2002		0.6	0.5	0.4	N/A	0.5		0.4	NA	0.8	N/A	0.7		0.1	0.6	0.4	N/A	0.4		0.5	0.4	0.5	N/A	0.5
2003		0.3	0.3	0.2	N/A	0.3		0.2	1.3	0.5	N/A	0.5		0.0	0.1	0.2	N/A	0.1		0.3	0.5	0.3	N/A	0.3
2004		0.5	0.4	0.1	N/A	0.3		0.3	0.6	0.3	N/A	0.4		0.2	0.5	0.1	N/A	0.3		0.4	0.4	0.2	N/A	0.3
2005		0.3	0.3	0.2	N/A	0.3		0.3	0.6	0.4	N/A	0.4		0.2	0.3	0.3	N/A	0.3		0.3	0.4	0.3	N/A	0.3
2006		0.4	0.3	0.2	N/A	0.2		0.3	1.2	0.5	N/A	0.6		0.5	0.5	0.7	N/A	0.6		0.4	0.5	0.3	N/A	0.3
2007		0.4	0.4	0.2	0.2	0.2		0.3	1.3	0.5	N/A	0.6		0.1	0.3	0.2	N/A	0.2		0.4	0.6	0.2	0.2	0.3
2008		0.6	0.6	0.4	0.2	0.4		0.2	1.4	0.8	N/A	0.9		0.0	0.6	0.6	N/A	0.5		0.5	0.8	0.5	0.2	0.5
2009		0.4	0.4	0.3	0.0	0.3		0.1	0.1	0.3	N/A	0.2		0.0	0.1	0.6	N/A	0.3		0.3	0.3	0.3	0.0	0.3
2010		0.2	0.1	0.2	0.0	0.1		0.1	0.1	0.5	N/A	0.5		0.1	0.3	0.3	N/A	0.2		0.1	0.1	0.2	0.0	0.2
2011		0.3	0.2	0.1	0.0	0.1		0.1	0.7	0.7	0.4	0.7		0.4	0.4	0.6	N/A	0.5		0.3	0.3	0.3	0.1	0.3
2012		0.5	0.3	0.1	N/A	0.2		0.9	N/A	1.5	1.4	1.4		0.4	0.4	0.5	N/A	0.4		0.6	0.3	0.4	1.4	0.5
2013		0.5	0.7	0.2	0.4	0.4		0.1	0.1	0.6	1.4	0.5		0.0	0.2	0.2	N/A	0.2		0.4	0.6	0.3	0.6	0.4
2014		0.4	1.4	0.2	0.2	0.3		0.0	0.3	0.4	0.1	0.3		0.3	1.2	1.2	N/A	1.1		0.3	1.2	0.3	0.2	0.3
2015		0.6	0.5	0.2	0.5	0.3		0.2	1.2	0.9	0.7	0.8		0.3	0.4	0.7	N/A	0.6		0.5	0.6	0.4	0.5	0.4
2016		0.4	0.4	0.2	0.1	0.3		0.1	1.1	0.5	N/A	0.6		0.5	0.9	0.5	N/A	0.6		0.3	0.6	0.3	0.1	0.3
2017		0.5	0.5	0.2	0.2	0.2		0.4	2.8	1.3	1.0	1.4		0.3	1.2	0.9	N/A	1.0		0.4	1.1	0.4	0.3	0.4
2018		0.3	0.5	0.2	0.6	0.3		0.4	1.1	1.0	N/A	1.0		0.2	0.2	0.5	N/A	0.4		0.3	0.6	0.4	0.6	0.5
2019		0.3	0.3	0.2	0.0	0.2		0.8	1.4	0.7	N/A	0.8		0.4	0.8	1.8	N/A	1.2		0.4	0.6	0.4	0.0	0.4
2020		0.0	0.0	0.1	0.0	0.1		0.0	0.0	0.7	N/A	0.5		0.1	0.2	0.6	N/A	0.3		0.0	0.0	0.2	0.0	0.1
2021		0.2	0.2	0.1	0.0	0.1		0.0	0.1	0.1	N/A	0.1		0.0	0.0	0.0	0.0	0.0		0.2	0.1	0.1	0.0	0.1
2022		0.5	0.4	0.2	0.2	0.2		0.0	0.0	0.1	0.0	0.0		0.0	0.0	0.2	0.0	0.3		0.3	0.3	0.2	0.2	0.2
Mean		0.4	0.4	0.2	0.2	0.3		0.2	0.9	0.6	0.7	0.6		0.3	0.5	0.6	0.0	0.5		0.3	0.5	0.3	0.3	0.3