



SMOLT MONITORING IN THE LAGUNITAS CREEK WATERSHED – 2022

Eric Ettlinger, Aquatic Ecologist
Jonathan Koehler, Fisheries Program Manager
Emily Cox, Watershed Stewards Program
Kalvin Joe, Watershed Stewards Program

Marin Water
220 Nellen Avenue, Corte Madera, CA 94925
(415) 945-1193

In association with the National Park Service

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EXECUTIVE SUMMARY

Downstream migrating salmonid smolts were sampled using a rotary screw trap (RST) in lower Lagunitas Creek, near Point Reyes Station (Figure 1). Smolt monitoring has been conducted annually since 2006 at that location, with the exception of 2020, when the pandemic prevented monitoring. From late March through early June the trap was monitored cooperatively by staff and volunteers from Marin Water and the Watershed Stewards Program (WSP). In addition, a smolt trap was operated on Olema Creek by National Park Service (NPS) staff.

In 2022 the RST was operational for 50 days. It was disabled for 23 days (eight weekends) between March 22 and June 2. For the season, a total of 6,838 Coho Salmon smolts were captured and 16,632 ($\pm 1,780$) Coho Salmon smolts were estimated to have emigrated past the trap. This estimate was significantly larger than average. In the fall of 2021, 31,360 juvenile Coho Salmon were estimated to reside upstream of the RST, yielding an estimated winter survival rate of 53%.

A total of 355 steelhead smolts were captured at the RST and an estimated 1,525 (± 529) steelhead smolts emigrated past the trap. The steelhead smolt estimate was approximately half of average. The RST also captured 1,054 Chinook Salmon smolts and 3,166 (± 406) were estimated to have migrated past the trap.

INTRODUCTION

Lagunitas Creek is a regionally important coastal stream for Coho Salmon (*Oncorhynchus 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.

Marin Water has conducted annual smolt surveys on Lagunitas Creek since 2006, as well as in 1983, 1984 and 1985. Summer and fall electrofishing surveys for juvenile Coho Salmon and steelhead were conducted in Lagunitas Creek starting in 1970 and annually since 1993. Since 2012 juvenile Coho Salmon captured during these surveys have been implanted with passive integrated transponder (PIT) tags. This represents one of the longest data records for juvenile salmonids in coastal streams of California. Surveys have been 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). Systematic Coho Salmon adult spawner surveys began in 1982 and have been conducted annually since 1995. Since the early 1980s, stream flows in Lagunitas Creek have been monitored daily by United States Geological Survey gages located in Samuel P. Taylor State Park and near Point Reyes Station. A separate gage is maintained by Marin Water on San Geronimo Creek. Water temperature has been monitored continuously since the early 1990s. Lagunitas Creek streambed conditions are monitored annually and salmonid habitat is quantified approximately every five years.

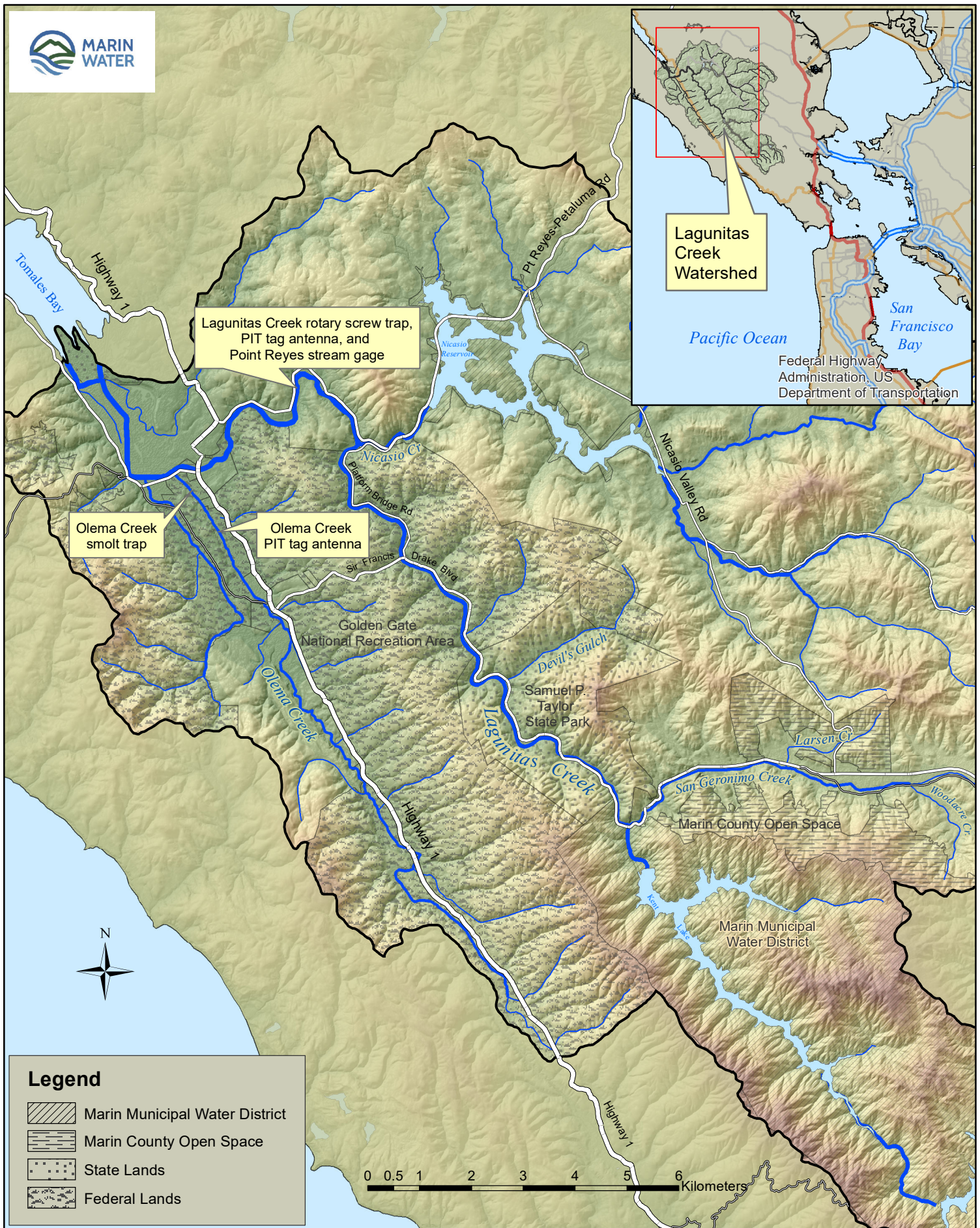


Figure 1. Smolt monitoring locations in the Lagunitas Creek watershed.

This project 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.

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

- What are the trends in Coho Salmon and steelhead smolt abundance?
- What are salmonid overwinter survival rates, 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

A rotary screw trap (RST) with a five-foot diameter cone was installed on March 21, 2022 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 50 days, generally Tuesday through Friday, between March 21 and June 2, 2022. The trap was operated Monday through Friday during the late-March new moon and the week following the April new moon. For two weeks 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 checked for marks such as fin clips, 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 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. Fry of all species that were less than 40 mm

long were tallied but not measured or weighed. 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. For coho and Chinook, up to 20 smolts per day were given a fin clip unique to the week (Table 1). Up to 20 steelhead smolts per day were implanted with PIT tags. 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.

Table 1. Marking schedule at the Lagunitas Creek smolt trap, 2022

Week	Date	Mark Applied
1	March 21 to March 27	lower caudal clip (LC)
2	March 28 to April 3	dorsal & lower caudal clip (DLC)
3	April 4 to April 10	lower caudal and anal fin clip (LCAC)
4	April 11 to April 17	lower caudal clip (LC)
5	April 18 to April 24	dorsal & lower caudal clip (DLC)
6	April 25 to May 1	lower caudal and anal fin clip (LCAC)
7	May 2 to May 8	lower caudal clip (LC)
8	May 9 to May 15	dorsal & lower caudal clip (DLC)
9	May 16 to May 22	lower caudal and anal fin clip (LCAC)
10	May 23 to May 25	lower caudal clip (LC)
11	May 26 to June 2	No mark

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. In summer 2021, 218 juvenile Coho Salmon were implanted with PIT tags during electrofishing surveys. In 2022, 305 steelhead smolts and 100 age 2+ coho smolts were implanted with PIT tags during smolt monitoring.

Data Analysis

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

Lagunitas Creek Rotary Screw Trap

The Lagunitas Creek RST captured 6,838 Coho Salmon smolts (Table 2) and 139 young-of-the-year Coho Salmon. An estimated 16,632 Coho Salmon smolts emigrated from Lagunitas Creek during the monitoring period. The highest estimated passage occurred during the week of May 2 with 4,929 Coho Salmon smolts passing through and around the RST (Figure 2). The highest catch for a single day occurred on May 2 when 467 Coho Salmon smolts were captured. The weekly trap efficiency for Coho Salmon smolts varied from 20% to 66% (mean 45%) (Figure 3). Coho Salmon smolts averaged 108 mm fork length (FL) and weighed an average of 13.5 g.

Table 2. Estimated smolt emigration from Lagunitas Creek, 2006-2022.

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

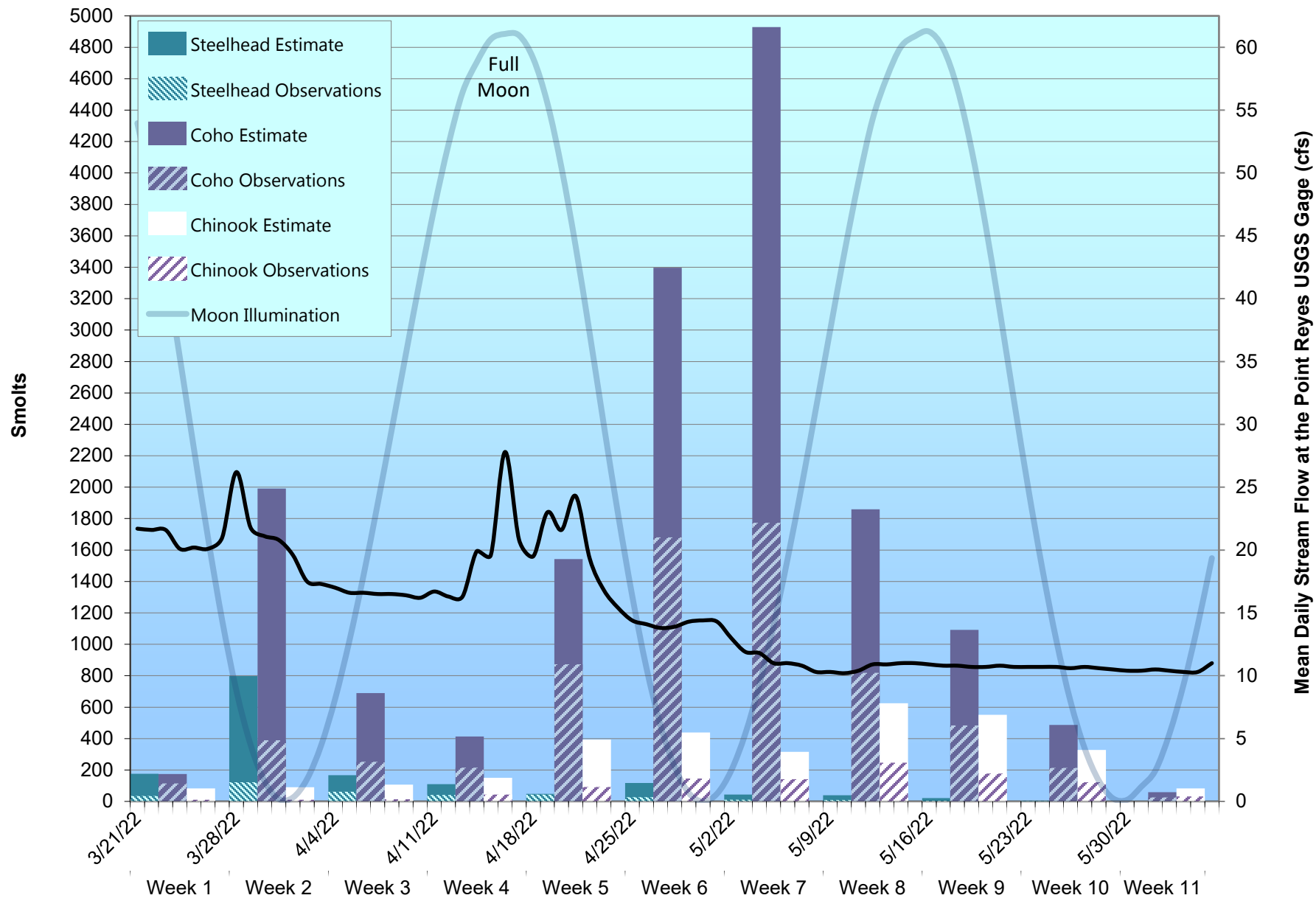


Figure 2. Lagunitas Creek smolt emigration, lunar cycle, and stream flow.

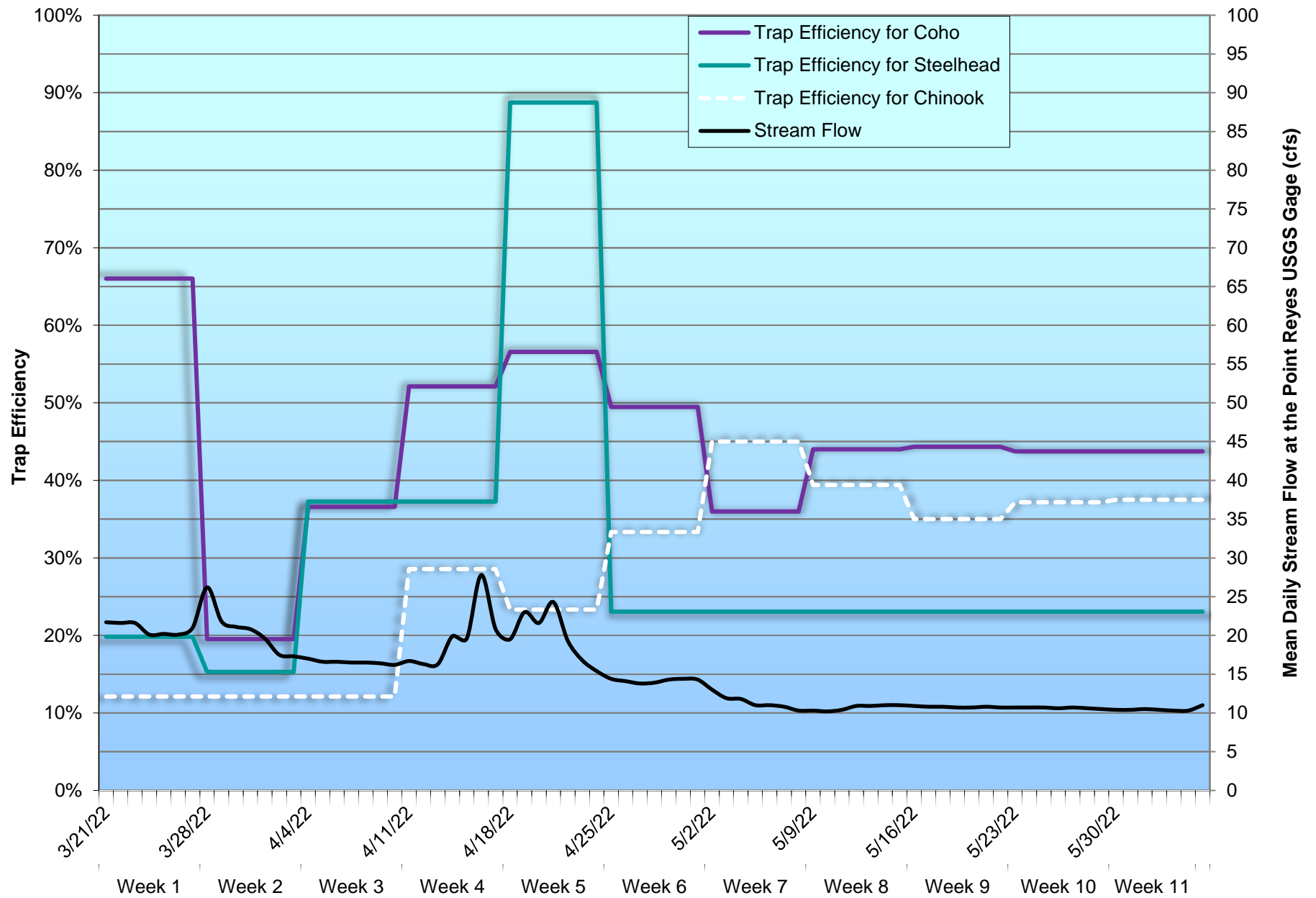


Figure 3. Weekly trap efficiency and Lagunitas Creek stream flow.

The RST also captured 354 steelhead smolts, 151 fry, three adults, and 370 parr and transitionals. An estimated 1,525 steelhead smolts emigrated in 2022, with 798 smolts emigrating during the week of March 28. The peak catch of 84 steelhead smolts occurred on March 29. The trap efficiency for steelhead varied between 29% and 56% (mean 38%). Steelhead smolts averaged 176 mm in fork length and weighed an average of 55.3 g.

During the monitoring period, 1,054 Chinook smolts were captured and 3,166 smolts were estimated to emigrate from Lagunitas Creek. Peak emigration occurred during the week of May 9 when an estimated 624 Chinook passed through and around the RST. The peak of 75 Chinook smolts was caught on May 18. Trap efficiency for Chinook varied between 12% and 45% (mean 29%). The average length of Chinook smolts was 72 mm, and the average weight was 4.1 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: Southern Coastal Roach (*Hesperoleucus venustus subditus*), sculpin spp. (*Cottidae*), Threespine Stickleback (*Gasterosteus aculeatus*), Pacific Lamprey (*Lampetra tridentata*), Bluegill (*Lepomis macrochirus*), Sacramento Sucker (*Catostomus occidentalis*), and Green Sunfish (*Lepomis cyanellus*). The season was notable for the very low abundance of non-native fish. Non-fish captures included Signal Crayfish (*Pacifastacus leniusculus*) and a record 664 California Freshwater Shrimp (*Syncaris pacifica*).

Lagunitas Creek PIT Tag Antenna

During the summer of 2021 PIT tags were implanted into 218 juvenile Coho Salmon. We detected 61 (28%) of these tagged coho during the smolt monitoring period (Table 3).

Table 3. PIT-tagged Coho Salmon detections

Tagging Location	Fish tagged in 2021	Antenna Detections	Antenna Detection Rate	Additional RST Detections	Total Detections	Total Detection Rate
Lagunitas Creek	198	39	20%	11	50	25%
San Geronimo Cr.	19	11	58%	0	11	58%
Devil's Gulch	1	0	0%	0	0	0%
All	218	50	23%	11	61	28%

DISCUSSION

Sampling conditions and emigration timing

Mean daily flows remained below 30 cubic feet per second (cfs) and the cone rotation speed remained within the target range of three to eight RPM for the entire monitoring period. Catches of all three salmonid species started at low levels and increased during the first weeks of monitoring (Figure 2), suggesting that monitoring began early enough to capture the early phases of smolt emigration. By the end of the monitoring period, the steelhead outmigration

was complete, and daily catches of coho and Chinook were low, indicating that monitoring in 2022 successfully sampled the bulk of all salmonid outmigrants.

As has been observed in previous years, the lunar cycle played an important role in migration timing. Steelhead catches peaked on March 29, two days before the new moon (Figure 2). Between April 19 and May 6, the RST was operated seven days per week in anticipation of a surge of coho smolts coinciding with the April 29 new moon. Catches of coho peaked on May 2. The Chinook outmigration did not coincide with the new moon, and in fact peaked on May 18, three days after the full moon.

Age and migration status of salmonids

Age 1+ Coho Salmon smolts were easily distinguishable by size from young-of-the-year (YOY), and very few were classified as “transitional.” We detected four PIT-tagged age 2+ smolts, but for the most part, we could not differentiate Age 2+ fish from younger smolts (Table 4). In fact, one age 2+ coho smolt tagged in 2020 was only 107 mm in length.

Appearance played a significant role in classifying steelhead migrants. Of the 333 steelhead measuring at least 130 mm in length, 20% were classified as either parr or transitionals based on their appearance. Seven of these fish were detected at the Lagunitas Creek antenna between August, 2022 and January, 2023, while no steelhead classified as smolts were detected after the monitoring period. These observations support the use of both length and appearance for classifying steelhead migrants.

Smolt abundance trends and implications for winter survival

The 2022 Coho Salmon emigration from Lagunitas Creek was the second largest on record (Figure 4). Of the 31,360 juvenile Coho Salmon estimated to reside upstream of the Lagunitas smolt trap in 2021, 53% appear to have survived through the winter. However, this survival rate is at odds with the 28% detection rate of PIT tagged coho. We estimate that the antenna detected 80% of tags, yielding a winter survival rate of 35%, which is still significantly lower than the abundance-based estimate. While we may have underestimated juvenile abundance in 2021, we have no way of knowing which estimate was closest to the actual survival rate.

A possible driver of winter survival is water turbidity, which hampers the hunting ability of visual predators like Common Mergansers (*Mergus merganser*). Common Mergansers are the primary avian predators of juvenile salmonids and smolts in some West Coast watersheds (Stephenson and Fast 2005, Wood 1987) and are commonly seen in Lagunitas Creek. In 2021-22, a long dry spell resulted in 60 consecutive days of stream flows below 80 cfs. Similar dry spells preceded the smolt emigrations of 2013, 2014, 2020, and 2021, and may have been responsible for poor winter survival rates of between 34% and 42% in those years. Our tag-based survival estimate of 35% fits well with this hypothesis, while our abundance-based estimate of 53% would be uncharacteristically high. A factor that complicates this analysis is that the water released from Kent Lake in 2021-22 was unusually turbid, due to torrential rains

Table 4. Salmonids captured in the Lagunitas Creek rotary screw trap by length and week, 2022.

Coho											
Week:	1	2	3	4	5	6	7	8	9	10	11
Dates	3/21	3/28	4/4	4/11	4/18	4/25	5/2	5/9	5/16	5/23	5/30
Dates	3/27	4/3	4/10	4/17	4/24	5/1	5/8	5/15	5/22	5/29	6/5
Length (mm)	Age 0+										
< 40		3		2	2	3			3		
40-44											
45-49					1	3		2	1	1	
50-54					1		5				1
55-59				Age 1+	1	3	5	1	1	2	
60-64								1		2	1
65-69							1		3	3	
70-74									3	1	2
75-79								1		4	4
80-84	1	1	1	1	1		1	1	1		2
85-89	1	2				2		1	3	7	5
90-94	6	4	4	1	1	8	9	2	8	13	10
95-99	16	16	9	7	9	13	15	9	21	23	4
100-104	19	12	12	21	11	28	25	32	20	11	4
105-109	12	13	19	19	24	31	31	25	9	8	
110-114	2	12	18	14	26	32	15	25	7	4	
115-119	3	7	8	8	20	19	9	5	4	3	
120-124		6	9	6	22	9	6	2	2	1	
125-129	3	1	11	1	6	1	2	3	1	Age 2+	
130-134	4	3	11	1	1	3	3	3	7		
135-139	2	5	3		2		2	2	1	5	
140-144	2	1	1			2		1		3	
145-149			1		2						2
150+											
Totals											
Age 0+	0	3	0	3	5	9	11	4	11	13	10
Age 1+	60	73	80	77	114	142	111	103	75	70	23
Age 2+	11	10	27	2	11	6	7	9	8	2	9
Age 3+	0	0	0	0	0	0	0	0	0	0	0

Chinook											
Week:	1	2	3	4	5	6	7	8	9	10	11
Length (mm)	Age 0+										
< 40		1		1		2					
45-49			1			1	1			1	
50-54				2	2	2	2	1	1	2	3
55-59	3	2	2	6	2	7	2	5	4	6	3
60-64	3	3		9	17	12		7	10	5	6
65-69	3	3	7	7	17	27	17	12	13	11	3
70-74	1	2	1	12	24	29	16	20	19	16	6
75-79		1		5	18	24	34	30	21	21	8
80-84				2	7	10	17	23	7	10	2
85-89			Age 1+		2	2	13	2	2	7	2
90-94						1		1	2		
95-99											
100-104											
105-109											
110+											
Totals											
Age 0+	10	12	13	44	89	117	101	101	80	80	31
Age 1+	0	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	10	11
Dates	3/21	3/28	4/4	4/11	4/18	4/25	5/2	5/9	5/16	5/23	5/30
Dates	3/27	4/3	4/10	4/17	4/24	5/1	5/8	5/15	5/22	5/29	6/5
Length (mm)	Age 0+										
< 40		2		6	5	27	20	13	28	34	11
40-44			1				2	1			
45-49								2	3	6	1
50-54						1	1	1	2	2	4
55-59							1	3	3	2	1
60-64								3	6	6	7
65-69						1	2	4	3	4	
70-74									3	2	2
75-79										1	1
80-84											
85-89											
90-94											
95-99											
100-104			1					1			
105-109			1							1	
110-114			1	3							
115-119	2			2							
120-124			1	1	1			2	1		1
125-129			Age 2+	4			1				2
130-134			4	1				1		1	
135-139			4		1	4	2	1		1	
140-144	1	3	4	2	4	3	1	2		1	
145-149		1	5	4	7	6	2				
150-154	5	5	5	4	8	3	1			1	
155-159	1	5	11	7	15	4	5	1			
160-164	4	6	5	2	11	1	2	1	2		
165-169	4	7	8	5	6	3	2			1	
170-174	2	6	6	7	8						
175-179	3	6	4	2	3	2				1	
180-184	2	5	2	2	4				1	1	
185-189	2	4	1	1		1		2			
190-194	4	1	1	1							
195-199		2	2	2							
200-204	2	1	1								
205-209		1									
210-214	2										
215-219	1	3	2		1						
220-224		1	1	1							
225-229											
230-234		1									
235-239											
240-244											
245-249											
250-254											
255-259											
260-264	1										
265-269			1								
270-274	1										
275-279		1									
280-284											
285-289	1										
290-294											
295-299	1										
300+											
Totals											
Age 0+	0	2	1	6	6	30	33	34	50	52	21
Age 1+	0	0	3	6	1	1	3	1	2	5	0
Age 2+	32	61	61	40	70	25	15	7	7	0	0
Age 3+	7	6	4	1	1	0	0	0	0	0	0

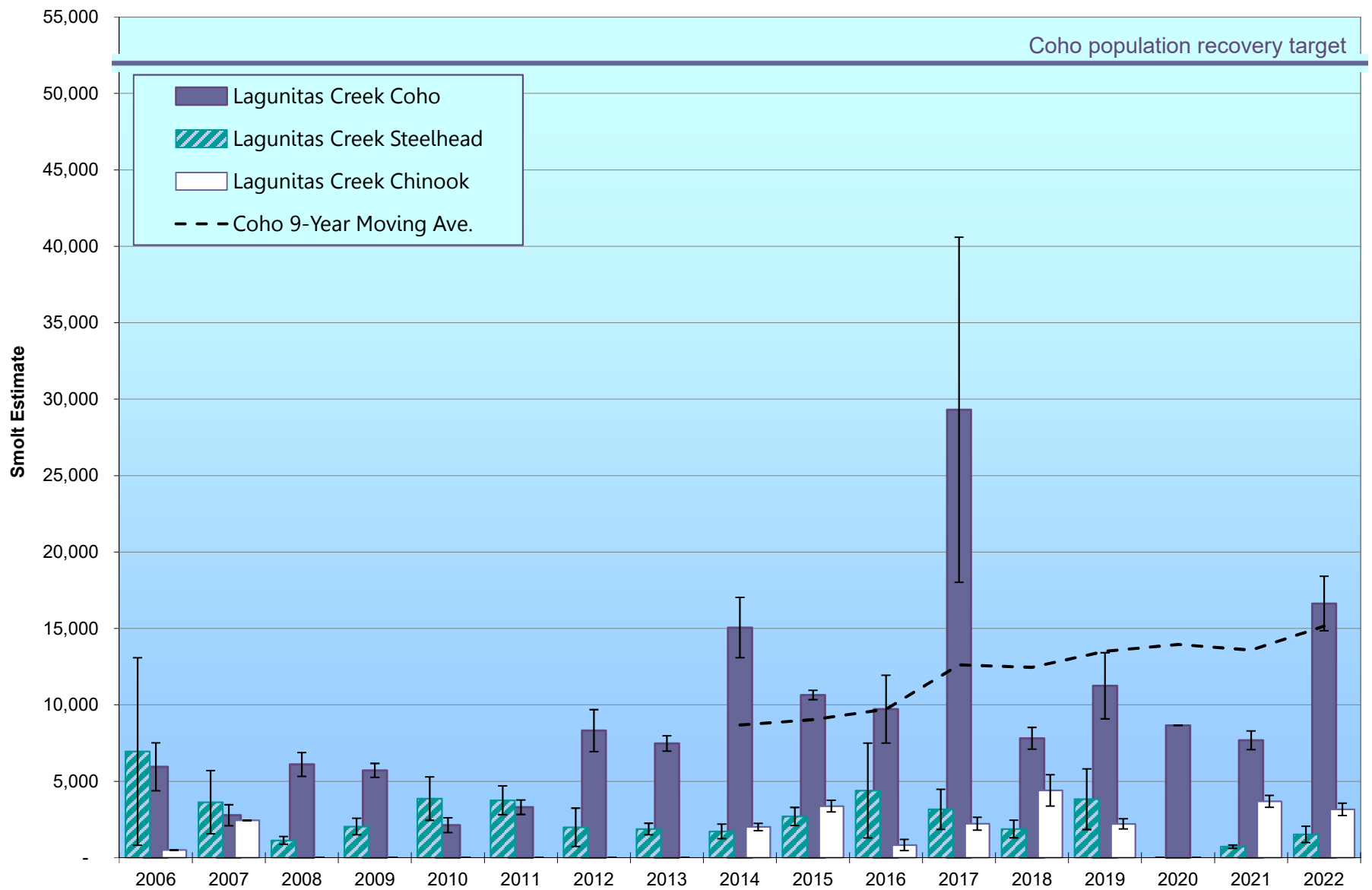


Figure 4. Lagunitas Creek smolt emigration estimates.

Note: The coho recovery target assumes an ocean survival rate of at least 5%, resulting in 2,600 adult returns.

falling on the mostly empty reservoir in October of 2021. This turbidity may have hampered predation, despite the long dry spell.

While the steelhead smolt estimate of 1,525 (± 529) was one of the lowest on record, it was similar to the estimated abundance of age 1+ steelhead in 2021 (1,183 ± 386). This suggests a very high survival rate for this small steelhead cohort. Overwintering steelhead, being larger than coho, appear to be less vulnerable to avian predators.

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