SMOLT MONITORING IN THE LAGUNITAS CREEK WATERSHED – 2019

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MARIN WATER

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Cover image: The Lagunitas Creek rotary screw trap being checked during high water.

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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. From late March through mid-May the trap was monitored cooperatively by staff and volunteers from the Marin Municipal Water District (MMWD) and the Watershed Stewards Program (WSP). In addition, a smolt trap was operated on Olema Creek by National Park Service (NPS) staff.

In 2019 the RST was operational for 49 days. It was disabled for nine days between March 23 and April 1, and high flows in mid-May resulted in an early end to the monitoring season. For the season, a total of 4,652 Coho Salmon smolts were captured and 11,246 (±2,164) Coho Salmon smolts were estimated to have emigrated past the trap. This was the third highest smolt estimate on record. The previous fall 16,568 Coho Salmon fry were estimated to reside upstream of the RST, yielding a winter survival rate of 68%. Coho Salmon smolt emigration from Olema Creek was estimated at 407 (± 523). The total emigration from the watershed was estimated at 11,653 (± 2,226) Coho Salmon smolts.

A total of 486 steelhead smolts were captured at the RST and an estimated 3,827 (± 1,985) steelhead smolts emigrated past the trap. The steelhead estimate was roughly average for the monitoring period. Chinook Salmon were observed for the sixth year in a row, and the RST captured 792 Chinook Salmon smolts. A somewhat below average estimate of 2,217 (±335) Chinook Salmon were estimated to have migrated past the trap. Lastly, successful reproduction of Chum Salmon was documented in Lagunitas Creek for the first time. A single Chum Salmon fry was captured during the first week of trap operation.

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, and available data suggest that steelhead runs are similar in size. Chinook Salmon (*O. tshawytscha*) also spawn in Lagunitas Creek in most years, and smolts have been observed in eight of the last 14 years.

MMWD 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 MMWD, 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 during the 1982-83 and 1983-84 spawning seasons, and have been conducted annually since 1995-96. 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 MMWD on San Geronimo Creek. Water temperature monitoring has been performed by MMWD since the early 1990s. Lagunitas Creek streambed conditions are monitored annually and salmonid habitat is quantified approximately every five years.

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

Lagunitas Creek Monitoring

A rotary screw trap (RST) with a five-foot diameter cone was installed on March 19, 2019 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 spring of 2019 was unusually wet, which resulted in challenging conditions at the beginning and end of the monitoring season. High stream flows required the trap to be disabled for nine days during the first two weeks of trapping. On three occasions trapping was hampered by either gear malfunctions or excessive debris in the cone, resulting from high flows. For seven days high flows resulted in the cone rotation speed rising above the target range of three to eight revolutions per minute (RPM). On April 30, in anticipation of a seasonal reduction in stream flows, plywood baffles were installed in front of the cone to increase the cone rotation speed and improve trap efficiency. A late-season storm brought an early end to the monitoring season on May 16, after the trap was operational for 49 days.

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 moved either toward or away from the cascade to maintain cone speeds in the target range. A qualitative description of debris removed from the live box was recorded daily. Each day, captured fish were removed from the trap and identified by species. 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 downstream of the point of capture. Coho Salmon smolts were scanned for passive integrated transponder (PIT) tags, implanted the previous fall. Steelhead 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 smolt characteristic development. 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. Downstream migrating fry of all species that were less than 70 mm long were tallied into five-millimeter length bins and not 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. Up to ten smolts per species per day were given a fin clip unique to the week (Table 1) and 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, 2019

Week	Date	Mark Applied
1	March 18 to March 24	lower caudal clip (LC)
2	March 25 to March 31	dorsal & lower caudal clip (DLC)
3	April 1 to April 7	lower and upper caudal clip (LUC)
4	April 8 to April 14	lower caudal clip (LC)
5	April 15 to April 21	dorsal & lower caudal clip (DLC)
6	April 22 to April 28	lower and upper caudal clip (LUC)
7	April 29 to May 5	lower caudal clip (LC)
8	May 6 to May 12	dorsal & lower caudal clip (DLC)
9	May 13 to May 19	lower and upper caudal clip (LUC)

MMWD operates a PIT tag antenna upstream of the RST to detect PIT-tagged Coho Salmon and investigate rates of overwinter survival in different parts of the Lagunitas Creek watershed. In 2018, 359 juvenile Coho Salmon were implanted with PIT tags. Of these, 105 Coho Salmon between 61 and 70 mm were implanted with 8 mm full duplex (FDX) tags, while larger fish were implanted with 12 mm half duplex (HDX) tags. Fish with HDX tags can be detected using a handheld scanner as well as by the antenna. The antenna cannot detect FDX tags and therefore FDX tags can only be detected at the RST. Unfortunately the antenna electronics were damaged during the winter of 2018-19 and were not repaired in time for the 2019 smolt monitoring season. Scanning Coho Salmon at the RST was the only way to detect PIT tags.

Olema Creek Monitoring

A fyke/pipe trap was installed by NPS staff on April 2 and was in operation for 46 days and partially operational for five days. The trap design was based on traps used by CDFW on the Noyo River (Gallagher 2000). The trap was checked daily, and no more than 30 Coho Salmon smolts (or up to 50% of the catch that day) were anesthetized with MS-222 (Tricaine Methanesulfonate) and marked with PIT tags. Marked smolts were released immediately after recovering from anesthetization at a predetermined site approximately 100 m or at least three habitat units above the trap site. After being measured, all recaptured smolts and unmarked smolts were released immediately in low velocity areas below the trap. Studies using similar methods of marking and tagging have demonstrated little marking mortality (Greis and Letcher 2002) and a study using the same trapping methodology on five northwestern California streams revealed that trap mortality was less than one percent for smolts and less than three percent for fry (Manning 2001).

Salmonids were identified to species and life stage (fry, parr, smolt, or adult) prior to being measured. Coho and Steelhead that are less than one year old and can be identified by the presence of distinct parr marks and small body size were categorized as Young-of-Year (YoY).

Age 1+ steelhead and Coho Salmon were separated into the following morphological categories: 1+(older than one year in age, parr marks present, only used for steelhead) or smolt (faint or absent parr marks, silver body, deciduous scales, black fin margins). A random sub-sample of up to ten Coho Salmon smolts and steelhead parr and smolts were measured to the nearest millimeter (fork length), and weighed to the nearest 0.01 g using an electronic scale. All fish that were anesthetized and marked were also measured and weighed. Any adult steelhead encountered in the trap were released downstream immediately without being measured. Random sub-samples of ten Coho Salmon YoY and ten steelhead YoY were measured daily and individuals greater than 40 mm were weighed to the nearest 0.01 g using an electronic scale. Up to ten individuals of each non-salmonid species were also randomly selected, measured, and weighed. Sub-samples were obtained by taking blind scoops out of the holding bucket with a small aquarium dip net. After processing, each fish is placed in an aerated recovery bucket, keeping larger sculpin in separate buckets to avoid predation on smaller fish. Fish in the recovery bucket were monitored to ensure sedated fish recover fully before being released.

In addition to smolt trapping, a PIT tag antenna array was installed upstream of the Olema Creek smolt trap (Figure 1). For more detailed descriptions of smolt trapping methods, please refer to SOP (standard operating procedure) 3, SOP 4, SOP 6, SOP 9, and SOP 11 of the San Francisco Bay Area Network Salmonid Monitoring Protocol version 4.0 (Reichmuth et al. 2010).

Data Analysis

The efficiency of the Lagunitas Creek rotary screw trap and populations of Coho Salmon and steelhead smolts were estimated using Darroch Analysis with Rank Reduction (DARR) 2.0.2 software (Bjorkstedt 2005, 2010) from 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 4,652 Coho Salmon smolts, 486 steelhead smolts, and 792 Chinook Salmon smolts in 2019. Two resident rainbow trout were captured. An estimated 11,246 Coho Salmon smolts emigrated from Lagunitas Creek during the monitoring period (Table 2). Additionally, 40 young-of-the-year Coho Salmon were captured, along with 18 age 2+ Coho Salmon smolts. The remaining Coho Salmon catch was comprised of 1+ fish (1-2 years old) (Table 3). The highest estimated passage occurred during the week of April 2, with 4,076 Coho Salmon smolts passing through and around the RST (Figure 2). The highest catch for a single day occurred on April 4 when 529 Coho Salmon smolts were captured. The weekly trap efficiency for Coho Salmon smolts varied from 29% to 72% (mean 48%) (Figure 3). Coho Salmon smolts averaged 114 mm fork length (FL) and weighed an average of 16.0 g.

Table 2. Estimated smolt emigration from Lagunitas Creek, 2006-2019.

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)

During the monitoring period, an estimated 3,827 steelhead smolts emigrated from Lagunitas Creek (Table 2). The peak of emigration occurred during the week of April 1, with an estimated 1,528 steelhead smolts (Figure 2). The highest catch for the season occurred on March 21 and 22, with 41 steelhead smolts captured on both days. The weekly trap efficiency for steelhead smolts ranged from 7% to 76% (mean 29%) (Figure 3).

For the season the steelhead catch was comprised of 33% fry, 18% age 1+, 38% age 2+ and 11% older steelhead (Table 3). Age 1+ steelhead were easily distinguished from YOY, but overlapped in size with Age 2+ steelhead. An indistinct break in the size distribution between 175 and 185 mm appeared to differentiate Age 3+ steelhead from younger fish. We classified 486 steelhead as fully-smolted, while 79 steelhead, ranging between 93 and 168 mm, were classified as "transitional" due to their mix of juvenile and smolt characteristics. Transitional steelhead were not included in the emigration estimate, since some of these fish may not have emigrated.

Table 3. Salmonids captured in the Lagunitas Creek rotary screw trap by length and week, 2019.

Coho

Week:	1	2	3	4	5	6	7	8	9
Dates	3/18 3/24	3/25 3/31	4/1 4/7	4/8 4/14	4/15 4/21	4/22 4/28	4/29 5/5	5/6 5/12	5/13 5/19
Length (mm)	**Age 0+**								
20-24									
25-29									
30-34	1	1	2					1	
35-39	2		2	2				1	
40-44			4		1	3			
45-49				1	1	1			
50-54				1		3			
55-59			1			3			
60-64	**Age 1+**				1	2	1		
65-69								2	1
70-74									1
75-79									1
80-84									
85-89	1								
90-94	4		1	1	1		1		
95-99	2	1	4	6		4	2	2	
100-104	2		4	8	6	6	7	18	5
105-109	1	2	21	14	19	12	12	16	7
110-114	6	6	14	19	23	17	25	18	7
115-119	4	1	6	18	19	13	17	15	4
120-124	3		5	11	11	9	9	5	
125-129	4	2	4	3	3	3	2	1	
130-134	3	4		3	1	1	1		
135-139	1	4			1	1			
140-144	1				1				
145-149	2	1							
150-154	**Age 2+**		1	1	1				
155-159					3				
160-164						2			
165-169									
170-174						1			
175-179									
180-184									
185-189									
190-194									
195-199									
200+									

Totals	1	2	3	4	5	6	7	8	9	%
Age 0+	3	1	9	4	3	12	1	4	3	7%
Age 1+	31	20	59	83	85	66	76	75	23	90%
Age 2+	4	5	1	1	4	3	0	0	0	3%
Age 3+	0	0	0	0	0	0	0	0	0	0%

Steelhead

Week:	1	2	3	4	5	6	7	8	9
Dates	3/18 3/24	3/25 3/31	4/1 4/7	4/8 4/14	4/15 4/21	4/22 4/28	4/29 5/5	5/6 5/12	5/13 5/19
Length (mm)	**Age 0+**								
20-24				18	3	1	3	1	
25-29		2	4	45	5	5	7	7	
30-34			1	2	2		1		
35-39			1	1	3	1	3	4	3
40-44				2	3	1	3	3	1
45-49	**Age 1+**				1	2	4	5	1
50-54						1	5	7	5
55-59						3	2	9	6
60-64								3	3
65-69				1				3	5
70-74	1								2
75-79			1					1	
80-84		1		2	1				
85-89			2	2	1		1	1	
90-94			1	3	2	1			
95-99				2	3			1	1
100-104			2	3	3	6	2	2	2
105-109			1	1		2			1
110-114	1			1	3	2		3	2
115-119	1		1	2	4	1	3	3	1
120-124		1	2	2	3			2	1
125-129		1	1		4		2	4	1
130-134	**Age 2+**			3	2			3	
135-139			3	3	2	3	1		
140-144	2		3	1	6	6	5	2	
145-149			3	4	5	7	2		
150-154	1		4	18	13	8	4	2	1
155-159	4		6	2	10	5	1		2
160-164	2	1	3	7	6	3	4		2
165-169	6	1	8	3	6	6	1	4	1
170-174	2		4	5	2	3			1
175-179	4	1	5	1		1	2		
180-184	3	1	1	2	1				1
185-189	1	1	5		1	3			
190-194	2		4	1	1	5	1	**Age 3+**	
195-199	5				4	2	1		
200+	3		2		3	7		1	

Totals	1	2	3	4	5	6	7	8	9	%
Age 0+	0	2	6	68	17	14	28	42	26	33%
Age 1+	3	3	11	19	26	12	8	20	9	18%
Age 2+	17	2	39	47	50	42	20	8	8	38%
Age 3+	18	3	12	3	10	17	2	1	0	11%

Chinook

Week:	1	2	3	4	5	6	7	8	9
Length (mm)									
35-39	**Age 0+**								
40-44	2		1	1					
45-49	4		1	2	1				
50-54	2			2		1			
55-59			5	3	7		2		2
60-64			15	10	3	4	9	4	2
65-69			2	20	10	6	7	5	2
70-74			4	9	24	13	13	4	3
75-79				1	8	20	19	18	6
80-84				1	4	13	14	19	10
85-89	**Age 1+**				1	3	8	21	7
90-94			1			1	1	1	4
95-99			1					1	1
100+					1				
Totals	8	0	32	49	59	62	75	75	43

Steelhead smolts averaged 164 mm FL and weighed 47.4 g on average. We captured two heavily spotted *O. mykiss* (204 and 290 mm) that appeared to be resident rainbow trout.

An estimated 2,217 Chinook Salmon smolts emigrated from Lagunitas Creek, with a peak emigration of 394 during the week of April 29. The weekly trap efficiency for Chinook Salmon ranged from 18% to 48% (mean 32%) (Figure 3). Chinook Salmon smolts were 73 mm in length and weighed 4.4 g on average. We detected, for the first time, three age 1+ Chinook Salmon smolts, ranging in length from 92 to 105 mm (Table 3). A reexamination of past smolt data found small numbers of age 1+ Chinook Salmon in 2006 and 2017, although these were not identified as such at the time.

Non-salmonid fish species included the following native and non-native species, in order of abundance: Southern Coastal Roach (*Hesperoleucus venustus subditus*), Threespine Stickleback (*Gasterosteus aculeatus*), sculpin spp. (*Cottidae*), Bluegill (*Lepomis macrochirus),* White Crappie (*Pomoxis annularis*), Golden Shiner (*Notemigonus crysoleucas*), Black Crappie (*Pomoxis nigromaculatus*), Goldfish (*Carassius auratus*), Pacific Lamprey (*Lampetra tridentata*), Channel Catfish (*Ictalurus punctatus*), Sacramento Sucker (*Catostomous occidentalis*), Green Sunfish (*Lepomis cyanellus*), Yellowfin Goby (*Acanthogobius flavimanus*), and Largemouth Bass (*Micropterus salmoides*).

Lagunitas Creek PIT Tag Antenna

During the summer of 2018 PIT tags were implanted into 359 juvenile Coho Salmon. The damaged PIT tag antenna failed to detect any tagged Coho Salmon. The RST captured 27 HDX-tagged Coho Salmon (11%) and 12 FDX-tagged Coho Salmon (11%). Detection rates were similar between fish tagged in each creek (Table 4).

Table 4. PIT-tagged Coho Salmon detections

Tag Type	Tagging Location	Fish Tagged in 2018	Antenna Detections	Antenna Detection Rate	RST Detections	Total Detections	Total Detection Rate
HDX	Lagunitas Creek	227	0	0%	24	24	11%
	San Geronimo Cr.	5	0	0%	0	0	0%
	Devil's Gulch	22	0	0%	3	3	14%
	All	254	0	0%	27	27	11%
FDX	Lagunitas Creek	36	NA	NA	3	3	8%
	San Geronimo Cr.	21	NA	NA	3	3	14%
	Devil's Gulch	48	NA	NA	6	6	13%
	All	105	NA	NA	12	12	11%
All	Lagunitas Creek	263	0	0%	27	27	10%
	San Geronimo Cr.	26	0	0%	3	3	12%
	Devil's Gulch	70	0	0%	9	9	13%
	All	359	0	0%	39	39	11%

Olema Creek Monitoring

The Coho Salmon smolt estimate from Olema Creek was 407 ±523. This was the second-lowest estimate for the period of smolt monitoring, which began in 2004.

DISCUSSION

Sampling conditions and emigration timing

Smolt monitoring was hampered by high stream flows for two weeks following the RST installation on March 19. The trap was first disabled on March 22 ahead of a large storm and re-engaged on March 26 for only a day. High flows caused multiple ropes to break and a metal support to crack, so monitoring was suspended again for a week until flows receded below 100 cfs on April 2. During these first two weeks 95 Coho Salmon and 84 steelhead were captured but no marked Coho Salmon were recaptured. Trap efficiency for Coho Salmon couldn't be estimated and likely resulted in a significant underestimation of the Coho Salmon outmigration during this period. Had the RST been operational and had Coho Salmon catches been similar to those on March 22 and 26, an additional 300-400 Coho Salmon may have been caught, increasing the outmigration estimate by at least 1,000. Similarly, had we continued to catch roughly 40 steelhead smolts per day, as we did on March 21 and 22, the steelhead outmigration estimate could have been significantly larger. The Coho Salmon and steelhead outmigration estimates should therefore be viewed as quite conservative. Catches of Chinook Salmon remained low until after the RST was operating reliably, so the early disruptions likely had little impact on the outmigration estimate.

On April 4, shortly after re-engaging the RST, the Coho Salmon catch peaked at 529 smolts. This record-breaking catch coincided with the new moon on April 5 (Figure 2) and as the moon's illumination increased and flows decreased, catches of Coho Salmon declined. Daily catches of Chinook Salmon were low during the full moon in mid-April and peaked during the new moon in early May. Steelhead emigration timing was not strongly associated with moon phase, peaking during both the new and full moons.

The low population estimate for Coho Salmon on Olema Creek may have been the result of a second channel that formed around the smolt trap location. That channel was only discovered late in the smolt monitoring season and appeared to be conveying about half of the flow of Olema Creek. It likely also conveyed a significant number of Coho Salmon smolts (Michael Reichmuth, Personal Communication).

Age and size of salmonids

In 2019 age 1+ Coho Salmon smolts were easily distinguishable by size from all of the young-of-the-year (YOY) Coho Salmon captured and no YOY Coho Salmon were described as "transitional" or smolts. In summary we did not find evidence that any YOY Coho Salmon emigrated from Lagunitas Creek in 2019. We did identify 13 Coho Salmon smolts that appeared to be age 2+ based on their lengths of between 140 and 170 mm (Table 3).

Age 1+ steelhead were easily distinguishable by length from YOY steelhead and age 2+ steelhead (Table 3). Even age 3+ steelhead, comprising 11% of measured steelhead, formed a distinct size class through much of the monitoring season. Only eight individual steelhead were identified as age 1+ smolts.

The observation of three age 1+ Chinook Salmon identifies a life history variant that was heretofore unknown to exist in Lagunitas Creek. A review of past smolt monitoring data identified an additional three age 1+ Chinook Salmon over multiple years, so this is clearly a rare life history. To date no juvenile Chinook Salmon have been observed during summer snorkel or electrofishing surveys.

Smolt abundance trends and implications for winter survival

The 2019 Coho Salmon emigration from the Lagunitas Creek watershed was both above average in size and a slight increase from three years earlier (Figure 4). Of the 16,568 juvenile Coho Salmon estimated to reside upstream of the Lagunitas smolt trap in 2018, 68% survived through the winter. This was very similar to the survival rates of the previous two years.

Previous analyses identified a negative correlation between the frequency of moderate stream flows and Coho Salmon overwinter survival. A hypothesis was proposed that flows of this magnitude required fish to expend significant amounts of energy, but were not large enough to inundate floodplains and deliver terrestrial invertebrates (i.e., energy) to the fish. Data from 2018-19 do not support this hypothesis. Frequent storms produced many moderate stream flow events and yet juvenile Coho Salmon survived well. The mean length of juvenile Coho Salmon in 2018 was no larger than in 2017, so survival does not appear to be based on physical condition.

PIT tag data was used to investigate whether survival dynamics differed between Lagunitas Creek and the tributaries. Data collected since 2012 suggest that Coho Salmon winter survival in Lagunitas Creek has not been strongly influenced by stream flows. However, winter survival in San Geronimo Creek and Devil's Gulch appears to be enhanced by longer periods of elevated flows (less than 50 cfs as measured at the Samuel P. Taylor gage). One hypothesis is that these elevated flows may improve feeding opportunities by dislodging benthic macroinvertebrates or delivering terrestrial invertebrates. This would suggest that food could be a limiting factor for Coho Salmon winter survival, at least in the tributaries. This pattern is not seen when the population is considered as a whole.

Looking at the whole Coho Salmon population, winter survival appears to be fluctuating in phases, with fairly constant survival rates over the last five years. Figure 5 shows the relationship between juvenile Coho Salmon abundance and smolt abundance the following year for four time periods (2002-2005, 2006-2011, 2012-2014, and 2015-2019). The earliest smolt data we have (2006-2011) shows what looks like a winter carrying capacity of approximately 6,000 juvenile Coho Salmon. Since 2015 survival rates have remained between 57% and 72%, independent of abundance. Back-calculating smolt abundance between 2002 and 2005 using spawner data indicates that winter survival rates may have been in a similar range in those years, before falling during the winter of 2005-06. That year was marked by a large flood event and smolt numbers remained low through 2011. The "New Year's Flood" of 2005-06 may have delivered enough fine sediment to suppress macroinvertebrate populations and impose a carrying capacity on the Coho Salmon population for the next few years. Perhaps Coho Salmon survival has now returned to the rates that occurred before that flood event. Evidence appears to be building that Coho Salmon winter survival may be strongly influenced by food availability. Macroinvertebrate monitoring in Lagunitas Creek has been very limited to date, and increasing that effort may hold the key to understanding and improving Coho Salmon survival.

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

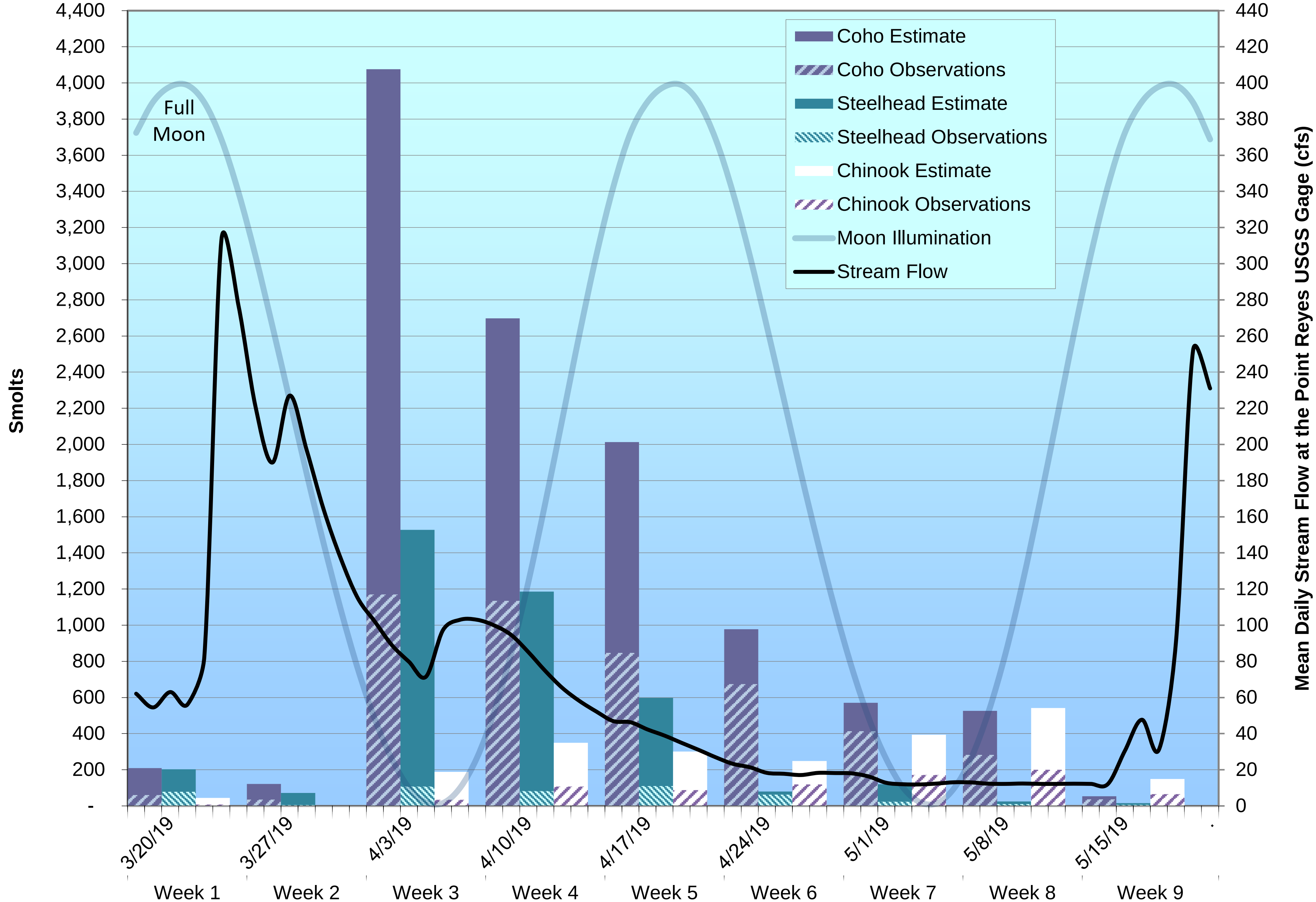

Figure 2. Lagunitas Creek smolt emigration, lunar cycle, and stream flow.

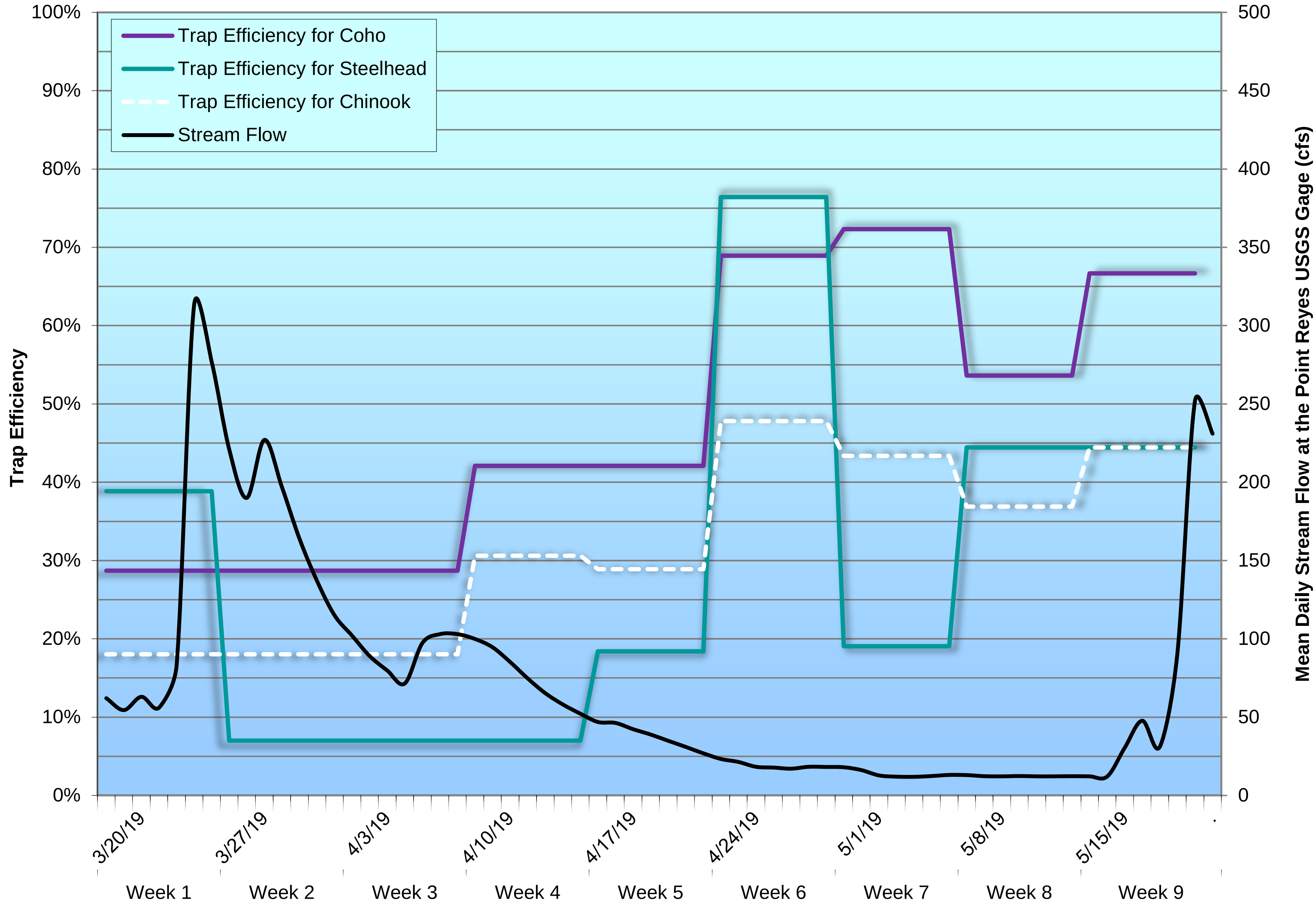

Figure 3. Weekly trap efficiency and Lagunitas Creek stream flow.

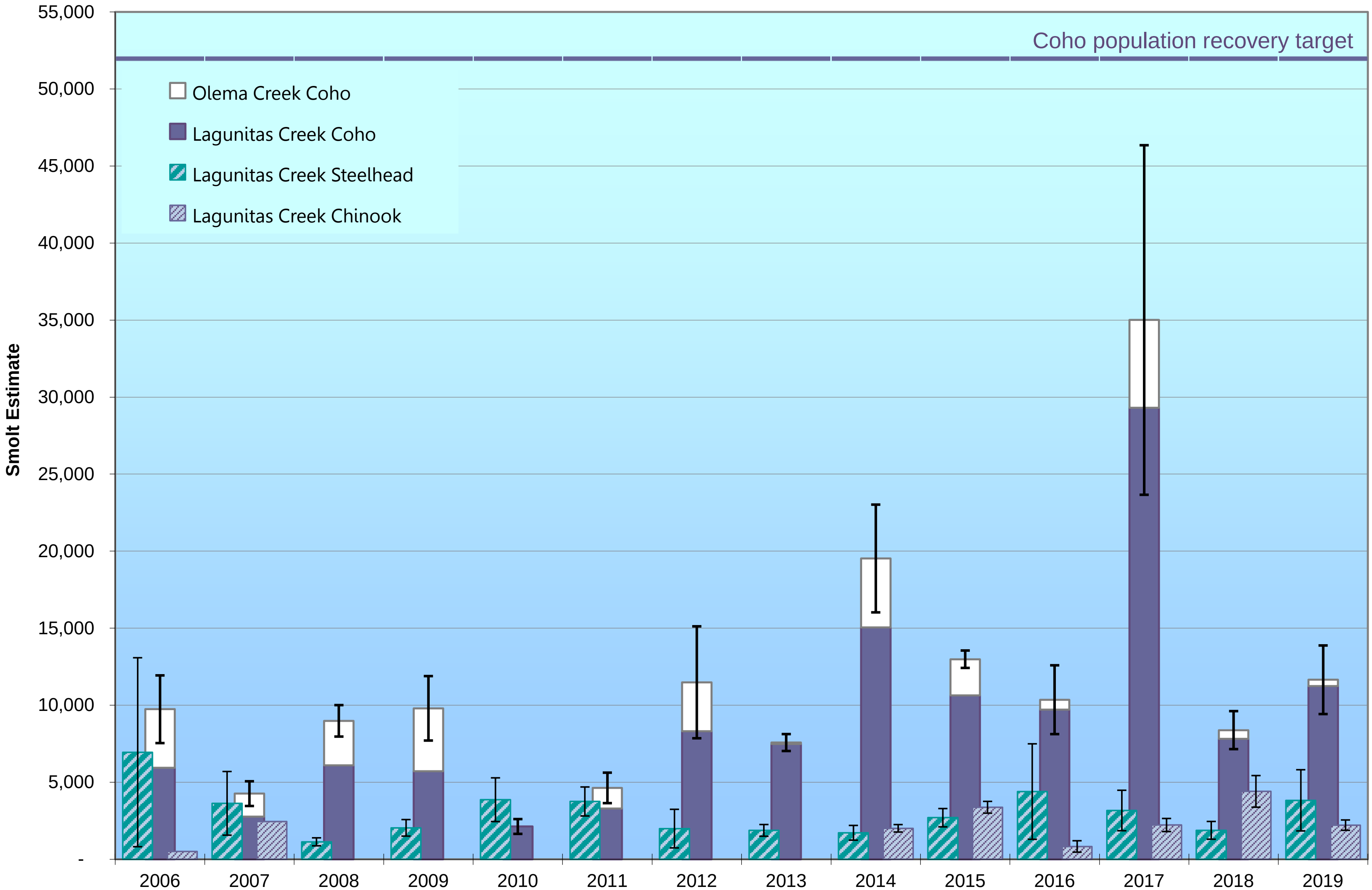

Figure 4. Lagunitas Creek smolt emigration estimates.

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

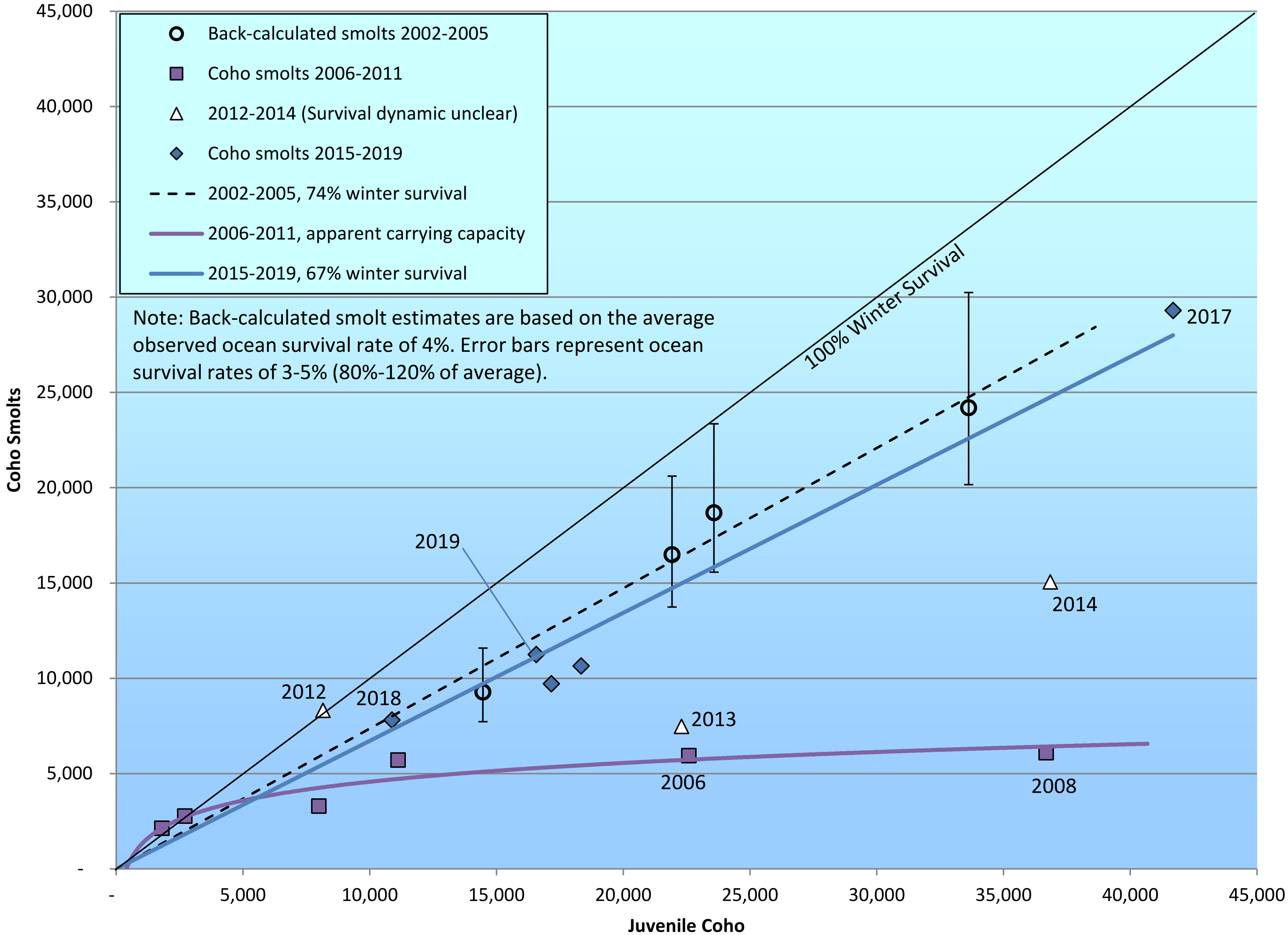

Figure 5. Juvenile Coho Salmon abundance and subsequent smolt abundance (smolt year shown).