

**LAGUNITAS CREEK
COHO SALMON
SPAWNER SURVEY REPORT
FALL & WINTER 1998-99
(3rd Draft)**

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LIST OF ACRONYMS

California Department of Fish and Game	CDFG
California Department of Parks and Recreation	State Parks
cubic feet per second	cfs
Ecologically Significant Unit	ESU
Endangered Species Act	ESA
Marin Municipal Water District	MMWD
National Marine Fisheries Service	NMFS
National Park Service	NPS
Samuel P. Taylor State Park	S.P. Taylor
State Water Resources Control Board	SWRCB
United States Geological Survey	USGS

EXECUTIVE SUMMARY

We conducted coho salmon (*Oncorhynchus kisutch*) spawner surveys on Lagunitas Creek between 9-November-1998 and 4-February-1999. Surveys were conducted on the mainstem of Lagunitas Creek between Tocaloma Bridge and Peters Dam. Surveys were also conducted on San Geronimo Creek starting on 4-December-1998. Devil's Gulch surveys were conducted by the National Park Service starting on 5-December. Spawner surveys were terminated after 4-February-1999 when the coho spawning run had essentially ended and high flows after that date precluded further surveys.

During the survey, a total of 184 redds and 123 live coho were observed. 92 of these redds and 56 of the coho were observed in Lagunitas Creek, 46 redds and 24 coho were observed in San Geronimo Creek, and 32 redds and 32 coho were observed in Devil's Gulch. The remaining 14 redds and 11 coho were observed by volunteers in Larsen and Arroyo Road Creeks (2 small tributaries to San Geronimo Creek). We also took fin and muscle samples from 10 of 14 carcasses we found in Lagunitas Creek and San Geronimo Creek. These samples were sent to Bodega Marine Laboratory for genetic analysis.

This year's spawning run was weaker than the runs of the previous two years but stronger than the 1995/'96 run. Last year we observed 253 redds and 428 coho. In 1996/'97 we observed 254 redds and 549 coho. The fish that spawned this year were in the same year class as those that spawned in 1995/'96. The strength of this year class has shown improvement since 1995/'96 when 86 redds and 365 coho were observed.

The first coho was observed in Lagunitas Creek on 23-November. The majority of live coho and redd construction in the Lagunitas Creek drainage occurred in the month of January. Water releases from Kent Lake as part of mandatory upstream migration flows seem to have been effective at bringing coho upstream. In particular, the upstream migration flow of 1-3-January was followed by dramatic increases in the numbers of coho and redds observed.

1.0 INTRODUCTION

1.1 Background

Lagunitas Creek originates on the north slope of Mount Tamalpais and flows in a northwesterly direction for 25 miles where it discharges into Tomales Bay (Figure 1). San Geronimo Creek, Nicasio Creek, and Olema Creek are the major tributaries to Lagunitas Creek. Devil's Gulch, which flows through National Park and State Park land before entering Lagunitas Creek, usually has perennial surface flows in addition to some good habitat characteristics which make it a good coho producing stream. Other tributaries to Lagunitas Creek that are known to support spawning coho include McIsaac and Cheda Creeks. Woodacre, Larsen and Arroyo Road Creeks are tributaries to San Geronimo Creek and provide some coho spawning habitat. Much of the land within the watershed is publicly owned by either California State Parks, the National Park Service, or Marin Municipal Water District (MMWD).

MMWD is a public agency that diverts water from the Lagunitas Creek drainage in Marin County, California to provide water to residents of central and southern Marin. MMWD operates four reservoirs on Lagunitas Creek including Lake Lagunitas, Bon Tempe Lake, Alpine Lake and Kent Lake. In addition, Nicasio Reservoir stores water on Nicasio Creek. MMWD diversions are permitted and regulated by the California State Water Resources Control Board (SWRCB). The MMWD reservoirs have altered flows in Lagunitas Creek by reducing peak winter storm flows and increasing summer low flows (SWRCB 1995). Natural runoff patterns in Lagunitas Creek were characterized by high "flashy" winter storm flows and low summer flows, with substantial year to year variation in total runoff. In its 1995 Order WR95-17, the SWRCB required MMWD to provide minimum stream flows at the United States Geological Survey (USGS) stream gauge in Samuel P. Taylor State Park for the benefit of the aquatic resources in Lagunitas Creek. The normal year flow requirements on Lagunitas Creek are outlined in Table 1. In addition to requiring minimum stream flows, the SWRCB order also called for four upstream migration flows. An upstream migration flow is a continuous flow of at least 35 cfs for 3 days as measured at the USGS gauge in the State Park. Three-day upstream migration flows are required on 15-November, 1-December, 1-January, and 1-February in the absence of a natural storm event in the month preceding those target dates.

The SWRCB also ordered MMWD to develop and implement a fisheries monitoring workplan as well as a sediment and riparian management plan for the Lagunitas Creek watershed (SWRCB 1995). In 1996, MMWD prepared the *Aquatic Resources Monitoring Workplan for the Lagunitas Creek Drainage, Marin County, California: Final Report* (MMWD 1996). In 1997, MMWD prepared the *Lagunitas Creek Sediment and Riparian Management Plan: Final* (MMWD 1997).

Table 1. Normal water year minimum flow requirements on Lagunitas Creek at S.P. Taylor State Park.

Time Period		Flow (cfs)
1/15-November*	- 31-December	20
1-January	- 15-March	25
15-March	- 31-March	20
1-April	- 30-April	16
1-May	- 15-June	12
16-June	- 1/15-November*	8

* The minimum flow of 20 cfs in November is to begin following the first storm that produces a “trigger” flow of 25 cfs at the USGS gauge at S.P. Taylor State Park. In the absence of a storm causing a “trigger” flow, the 20 cfs requirement will become effective on 15-November of each year.

One element of MMWD’s aquatic resource monitoring workplan is to conduct coho spawner surveys on the Lagunitas Creek system. MMWD sponsored coho spawner surveys on Lagunitas Creek, Devil’s Gulch, and San Geronimo Creek during the 1982/’83, 1983/’84, 1995/’96, 1996/’97 and 1997/’98 seasons. During the years between 1984 and 1995, one to a few day spawner surveys were conducted by CDFG (and ENTRIX in 1992), which gave a snapshot look at the spawning season. The objectives of the spawner surveys are to determine the distribution and range of spawning and the relative spawner abundance within the watershed. This information will track the annual spawning run in Lagunitas Creek. It will also help satisfy one of the goals of the aquatic resource monitoring plan, which is to determine if MMWD management activities (water releases, sediment control, and riparian restoration) are improving habitat utilization and, ultimately, the abundance of coho salmon returning to the Lagunitas Creek watershed.

1.2 Coho Salmon Life History and Status

Coho salmon are anadromous fishes, spending their adult life in the ocean, migrating into freshwater streams to spawn, rearing at least partially in freshwater, and migrating to the ocean as smolts. Most coho salmon from California streams 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 (Shapalov and Taft 1954). Unlike other salmonids in California, this three year cycle is fairly rigid and spawning years with relatively poor reproductive success can result in poor spawning runs three years later (D.W. Kelley & Associates and ENTRIX 1992). Coho can also be grouped in year classes of three year increments (i.e. 1994 and 1997 young-of-the-year coho are from the same year class). Adult coho begin to arrive near the mouth of Lagunitas Creek in late summer and fall to begin acclimation to freshwater before they migrate upstream (Bratovich and Kelley 1988). The spawning period is generally from mid-November to mid-January but adult coho have been observed as early as mid-October and as late as early February.

Coho salmon usually spawn at the heads of riffles with gravel substrate (Moyle 1976). Females may excavate small test pits (or “diggings”) in the gravel substrate before deciding on a site to lay her eggs. Once decided, she will dig a larger pit (called a “redd”)

where she deposits her eggs. Often more than one male will fertilize the eggs before the female covers the eggs with additional gravels (Moyle 1976). Following spawning, the female may guard the redd for up to two weeks before dying (Groot and Margolis 1991). Juvenile coho emerge from the gravel the following spring and usually rear in the stream for one year before migrating to the ocean (Moyle 1976). The majority of coho return as three year old fish, however, "jacks" return as sexually mature, two year old males (Groot and Margolis 1991).

Coho salmon in the Central California Coast Evolutionarily Significant Unit (which includes the Lagunitas Creek watershed) have been listed as "threatened" under the federal Endangered Species Act (61 FR 56138). Likewise, the present population in Lagunitas Creek has been significantly reduced from historical levels (Brown et al 1995). Recent surveys, however, may indicate an upward trend in the coho salmon population. Spawner surveys from the mid-1980's indicated that approximately 100 coho spawned annually in Lagunitas Creek and its tributaries (D.W. Kelley & Associates and ENTRIX 1992), while the 1995/'96 coho spawner survey indicated at least 300 coho spawned in the mainstem of Lagunitas Creek alone and the watershed total was probably around 500 (Trihey & Associates, Inc 1996a). During the 1996/'97 spawning season 549 adult coho were spotted in the Lagunitas Creek drainage with a total watershed estimate of around 1,000 coho (Trihey & Associates 1997). Last year, while the number of coho redds observed was nearly equal to those seen in 1996/'97, the number of coho observed declined to 430 and the watershed total was most likely less than the previous year (MMWD 1998).

2.0 METHODS

Stream sections were walked every week by a two person crew except during the short week of Christmas and during two weeks in January when time constraints and high flows prevented surveys. Surveys were conducted by Gregory Andrew, Melissa Diamont and Jessica Sisco. Krista Hodson, Jim Killeen and Ron Nerviani provided assistance during three surveys. Each stream section was surveyed from the downstream end to the upstream end. We divided the mainstem of Lagunitas Creek into three sections: 1) Tocaloma Bridge to Devil's Gulch (approximately 2.5 miles) and 2) Devil's Gulch to Shafter Bridge (approximately 3.0 miles) and 3) Shafter Bridge to Peters Dam (approximately 0.5 miles). We always walked sections 2 and 3 on the same day. The mainstem of San Geronimo Creek was walked from its mouth to the confluence of Woodacre Creek, approximately 4 miles upstream. Two small tributaries to San Geronimo Creek, Larsen and Arroyo Road Creeks, were surveyed by volunteers. Roy's Dam is a significant landmark 3 miles upstream of the mouth of San Geronimo Creek where fish must swim through a fish ladder to migrate upstream of the dam. Devil's Gulch was surveyed from its mouth to a fork at 1.3 miles by National Park Service biologists. The section of Lagunitas Creek from its mouth to Tocaloma Bridge was not surveyed because deep pools and overhanging vegetation made it difficult to observe fish and because this section has not been been systematically surveyed in previous years.

During the surveys we recorded observations of redds, live adult coho, coho carcasses, diggings and adult steelhead. Live fish were recorded as male or female, their condition noted (color, wear marks, hooked jaw, etc) and their location in relation to landmarks such as tributaries or bridges was noted. All observed spawning activity was also recorded. We recorded the sex and length of recovered carcasses and collected tissue samples so that genetic analyses could be performed by Bodega Bay Marine Lab. We attempted to determine if these coho carcasses had spawned by inspecting for retained eggs or milt. Other information recorded during each survey included: survey start and stop times, air and water temperature, weather conditions, and qualitative observations of stream flow, water clarity and visibility.

We assigned a number to each redd and marked its location in the field by hanging colored tape on adjacent vegetation. Redds were marked so no redd would be double counted during subsequent surveys and so any additional redds near that site could be distinguished. Each redd was flagged with red, striped flagging and yellow flagging. We labeled each flag with the date, the number of the redd, location of the redd with respect to the channel (i.e. mid-channel, left or right bank, etc), and the number of coho, if any, observed on the redd. If it was determined that a female made a small “test” pit and not a redd, the site was recorded as a “digging” and flagged with only yellow flagging. We also marked redd locations on a copy of the USGS topographic quadrangle map for each survey date (Appendix A).

The data on live coho and redds were compiled and compared to previous years. Rainfall and streamflow data were also compiled so we could analyze the numbers of coho relative to changes in streamflow.

We had no way of positively determining if we were recounting the same fish during subsequent surveys or missing fish during the intervals between surveys. We attempted to survey upstream stream sections before downstream sections to reduce the possibility of recounting the same fish moving upstream. For example, we surveyed San Geronimo Creek first, Devil’s Gulch to Peters Dam next, and then Tocoloma Bridge to Devil’s Gulch. Most surveys on each section were conducted at least 6 days and usually more than 10 days apart.

3.0 RESULTS

3.1 Live Coho Salmon, Redds, and Carcasses

We observed a total of 184 redds and 123 live coho during the spawner surveys in Lagunitas Creek, San Geronimo Creek (including tributaries), and Devil's Gulch (Table 2). A total of 254 redds and 430 live fish were recorded last year. There was a 71% decrease in live coho observed from last year, and a 28% decrease in the number of redds located (Figure 5). There were 62 fewer redds in San Geronimo Creek and 20 fewer redds in Devil's Gulch. Lagunitas Creek, however, saw an increase of 12 redds. The relative proportions of redds in each creek are shown in Figure 6.

The 1996/'97 spawning survey (two years ago) recorded 549 live coho and located 254 redds. The 1995/'96 spawning survey located 365 live coho but only 86 redds were located. Two tributaries to San Geronimo Creek, Arroyo Road and Larsen Creeks, were not surveyed during these spawning seasons.

The lower, middle, and upper sections of Lagunitas Creek are Tocaloma Bridge to Devil's Gulch, Devil's Gulch to Shafter Bridge, and Shafter Bridge to Peters Dam, respectively (Figure 1). We observed 39 redds in the first section, 50 redds in the middle section, and 3 redds in the upper section (Table 2). We also observed 36 live coho in the lower section, 16 live coho in the middle section, and 4 live coho in the upper section.

The section of San Geronimo Creek from its mouth to Roy's Dam had 38 redds and 17 live coho. The section above Roy's Dam to Woodacre Creek had 8 redds and 7 live coho (Table 2). Surveys in Devil's Gulch recorded 32 redds and 32 coho. Volunteers surveyed Arroyo Road and Larsen Creeks, tributaries to San Geronimo Creek. Arroyo Road Creek had 12 redds and 11 live coho. Larsen Creek had 2 redds but no coho observed. This is a decrease from the total of 14 redds and 44 live coho observed in these two creeks last year, the first year these tributaries were surveyed. The proportion of redds built in San Geronimo Creek was the lowest since 1995/'96 (Figure 6). Only 33% of coho redds were located in San Geronimo Creek this year, compared with 50% in Lagunitas Creek. Devil's Gulch had 17% of the redds, similar to the proportion it had in 1996/'97 and 1997/'98.

We located a total of 21 coho carcasses from the Lagunitas Creek system with 6 coho carcasses from Lagunitas Creek, 8 carcasses from San Geronimo Creek, 6 carcasses from Devil's Gulch and 1 carcass from Arroyo Road Creek. Genetic tissue samples were collected from 4 coho carcasses in San Geronimo Creek and 6 coho carcasses in Lagunitas Creek.

COHO SPAWNER SURVEY DATA

1998/99 SURVEY RESULTS

Compiled by: Marin Municipal Water District

Updated 10-Mar-99

SURVEY DATE	LAGUNITAS CREEK						SAN GERONIMO CREEK						TOTAL					
	Tocaloma-Devils Gulch			Devils Gulch-Shafter			Shafter-Peters			Mouth-Roys Dam						Above Roys Dam		
	Live Coho	Carcasses	Redds	Live Coho	Carcasses	Redds	Live Coho	Carcasses	Redds	Live Coho	Carcasses	Redds	Live Coho	Carcasses	Redds	Live Coho	Carcasses	Redds
9-Nov-98	0	0	0	-	-	-	-	-	-	-	-	-	-	-	-	0	0	0
12-Nov-98	-	-	-	0	0	3	0	0	0	-	-	-	-	-	-	0	0	3
19-Nov-98	0	0	0	-	-	-	-	-	-	-	-	-	-	-	-	0	0	0
20-Nov-98	-	-	-	0	0	1	0	0	0	-	-	-	-	-	-	0	0	1
23-Nov-98*	1															1		
24-Nov-98*	14															14		
25-Nov-98**	0	1	0	3	0	1	-	-	-	-	-	-	-	-	-	3	1	1
4-Dec-98	-	-	-	1	0	0	0	0	0	6	0	9	-	-	-	7	0	9
8-Dec-98	0	0	5	-	-	-	-	-	-	-	-	-	5	0	1	5	0	6
10-Dec-98	-	-	-	-	-	-	-	-	-	1	0	8	-	-	-	1	0	8
14-Dec-98	-	-	-	-	-	-	-	-	-	2	0	5	2	0	3	4	0	8
16-Dec-98	-	-	-	3	0	9	-	-	-	-	-	-	-	-	-	3	0	9
18-Dec-98	-	-	-	-	-	-	1	0	1	-	-	-	-	-	-	1	0	1
23-Dec-98	0	0	9	0	0	5	0	0	0	-	-	-	-	-	-	0	0	14
5-Jan-99	12	1	10	-	-	-	-	-	-	-	-	-	-	-	-	12	1	10
6-Jan-99	-	-	-	9	1	18	-	-	-	-	-	-	-	-	-	9	1	18
7-Jan-99	-	-	-	-	-	-	3	0	2	-	-	-	-	-	-	3	0	2
8-Jan-99	-	-	-	-	-	-	-	-	-	8	6	9	0	0	0	8	6	9
27-Jan-99	9	1	15	-	-	-	-	-	-	-	-	-	-	-	-	9	1	15
28-Jan-99	-	-	-	0	2	13	0	0	0	-	-	-	-	-	-	0	2	13
3-Feb-99	-	-	-	-	-	-	-	-	-	0	0	2	0	0	4	0	0	6
4-Feb-99	-	-	-	-	-	-	-	-	-	0	2	5	-	-	-	0	2	5
SUB-TOTAL	36	3	39	16	3	50	4	0	3	17	8	38	7	0	8	80	14	138
	DEVIL'S GULCH SURVEYS^															32	6	32
SUB-TOTAL																112	20	170
	LARSEN CREEK SURVEYS^^															0	0	2
	ARROYO ROAD CREEK SURVEYS^^															11	1	12
TOTAL																123	21	184

Notes:

(-) Indicates that the spawner survey did not cover the area on that date.

* Observation of live coho was by Al Pisciotta at a single location in Lagunitas Creek.

** Observation of live coho and redd in the Devil's Gulch-Peters Dam reach was at a single location at Samuel P. Taylor Park; this entire reach was not surveyed on 25-Nov-98.

^ Devil's Gulch Surveys conducted by National Park Service on 5-Dec-98, 15-Dec-98, 24-Dec-98, 14-Jan-99, 28-Jan-99, and 3-Feb-99.

^^ Larsen Creek and Arroyo Road Creek surveys conducted by volunteers from the Salmon Protection and Watershed Network.

- 1 Steelhead observed in San Geronimo Creek on 8-J. - 2 Steelhead observed in Devil's Gulch on 3-Feb-99. - 3 Steelhead observed in Lagunitas Creek on 27-Jan-99.

Table 2. Results of the Coho Salmon Spawner Survey in the Lagunitas Creek Basin, 1998-1999.

3.2 Streamflows, Water Releases and Correlated Spawning Activity

Water releases from Kent Lake were fairly constant at 8 cfs from 1-July to 16-November-1998 when MMWD increased water releases to 36 cfs to create an upstream migration flow between 16- and 18-November (Figure 2). This flow was the first of the season to raise the streamflow in Lagunitas Creek above 25 cfs and triggered the SWRCB requirement to maintain a flow of 20 cfs thereafter (hence this flow is also called a “trigger” flow). The second 3-day upstream migration flow was released coinciding with storms starting on 21- and 27-November which dropped more than 10 inches of rain. Streamflow increased enough following these storms to allow water releases by MMWD to drop to 1 cfs before increasing again slowly to 17.5 cfs by 12-December. Releases remained at this level until 1-January when 30 cfs was released for 3 days to create the last upstream migration flow. Releases dropped to and remained at 25 cfs until the next big storm on 20-January when releases again dropped to 1 cfs. Releases fluctuated between 1 and 15 cfs based on rainfall for the remainder of the spawner survey.

The first storm of the season dropped 1.8 inches of rain on 6-November-1998 but had little effect on streamflows measured at Samuel P. Taylor State Park. The first three coho redds were observed following this storm (Figure 3). The first adult coho were observed following the trigger flows starting on 16-November (Figure 4). The storms starting on 21-November were followed by increasing numbers of redds while the number of observed coho remained low. Very little rain fell between 5-December and 14-January and the number of new redds observed declined after 16-December. The upstream migration flow of 1-3-January was followed by dramatic increases in the numbers of coho and redds observed, reaching the highest levels of the season. Storms starting on 14-January dropped 7.5 inches of rain over 10 days, increasing streamflow to 160 cfs on 20-January, the highest flows of the spawning season. Redds and spawners were again numerous following this storm. The last storm of the spawning season dropped 2 inches of rain on 31-January, raising streamflows to 93 cfs, with the numbers of redds and spawners declining to 11 and 2, respectively.

4.0 DISCUSSION

The 1998/99 coho spawner year class has been the weakest of the three coho year classes being tracked since detailed annual surveys were started in 1995. The 184 redds observed this year is far fewer than the 254 redds observed in both 1996/97 and 1997/98 (Figure 5). However, this spawning run was stronger than the 1995/96 spawning run which was the same year class. Comparing this spawning run with the 1995/96 run is problematic for two reasons. First, the 1995/96 surveys did not cover sections of Lagunitas and San Geronimo Creeks assumed to contain poor spawning habitat. This year we observed 29% of all redds in these stream sections, indicating that they do indeed contain good spawning habitat. Second, Larsen and Arroyo Road Creeks were not surveyed in 1995/96 and these creeks produced 14 redds this year. When redds in these stream sections are not included in the total count, the remaining number of redds is 117.

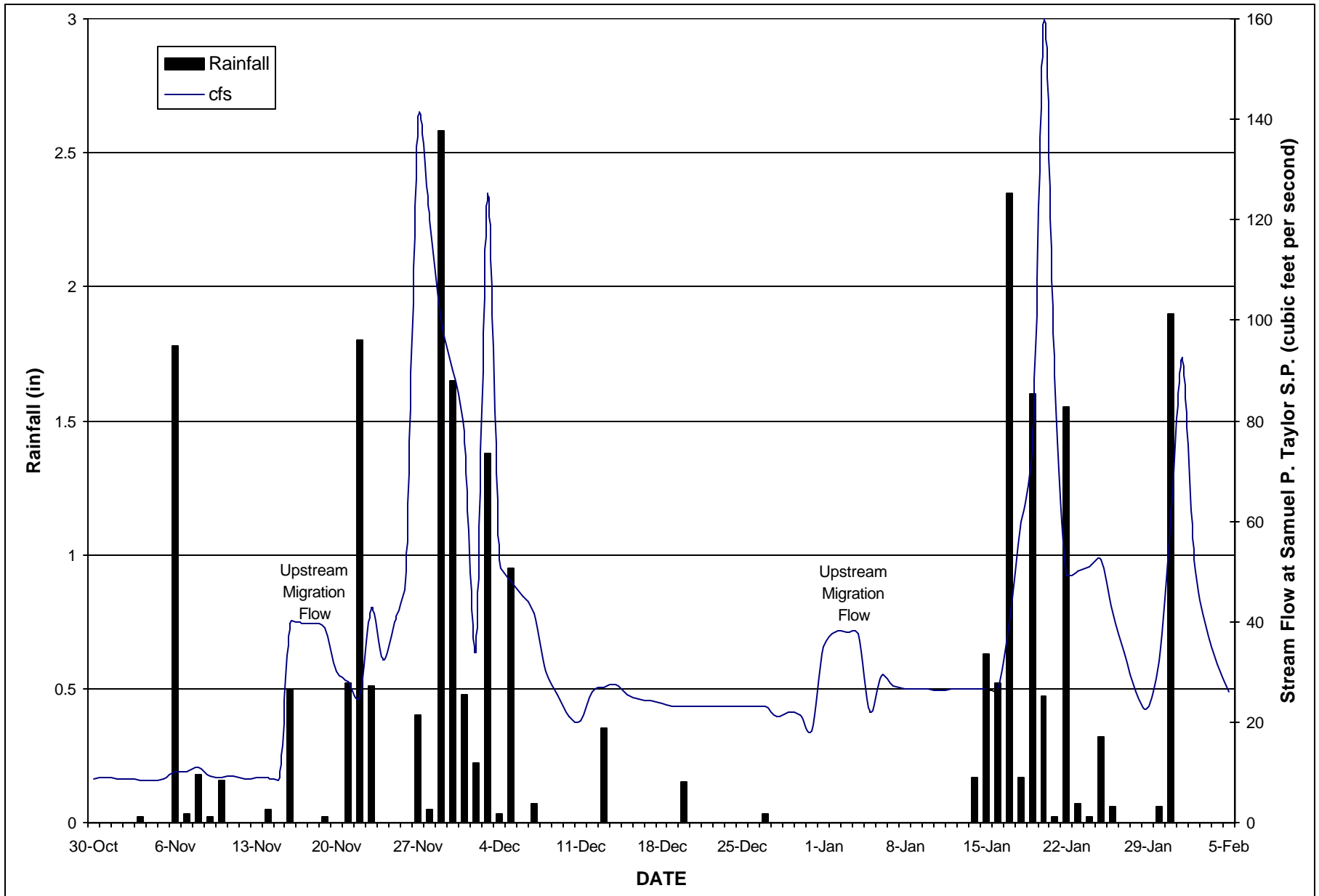


Figure 2. Rainfall and Lagunitas Creek Stream Flow, Spawning Season 1998-1999.

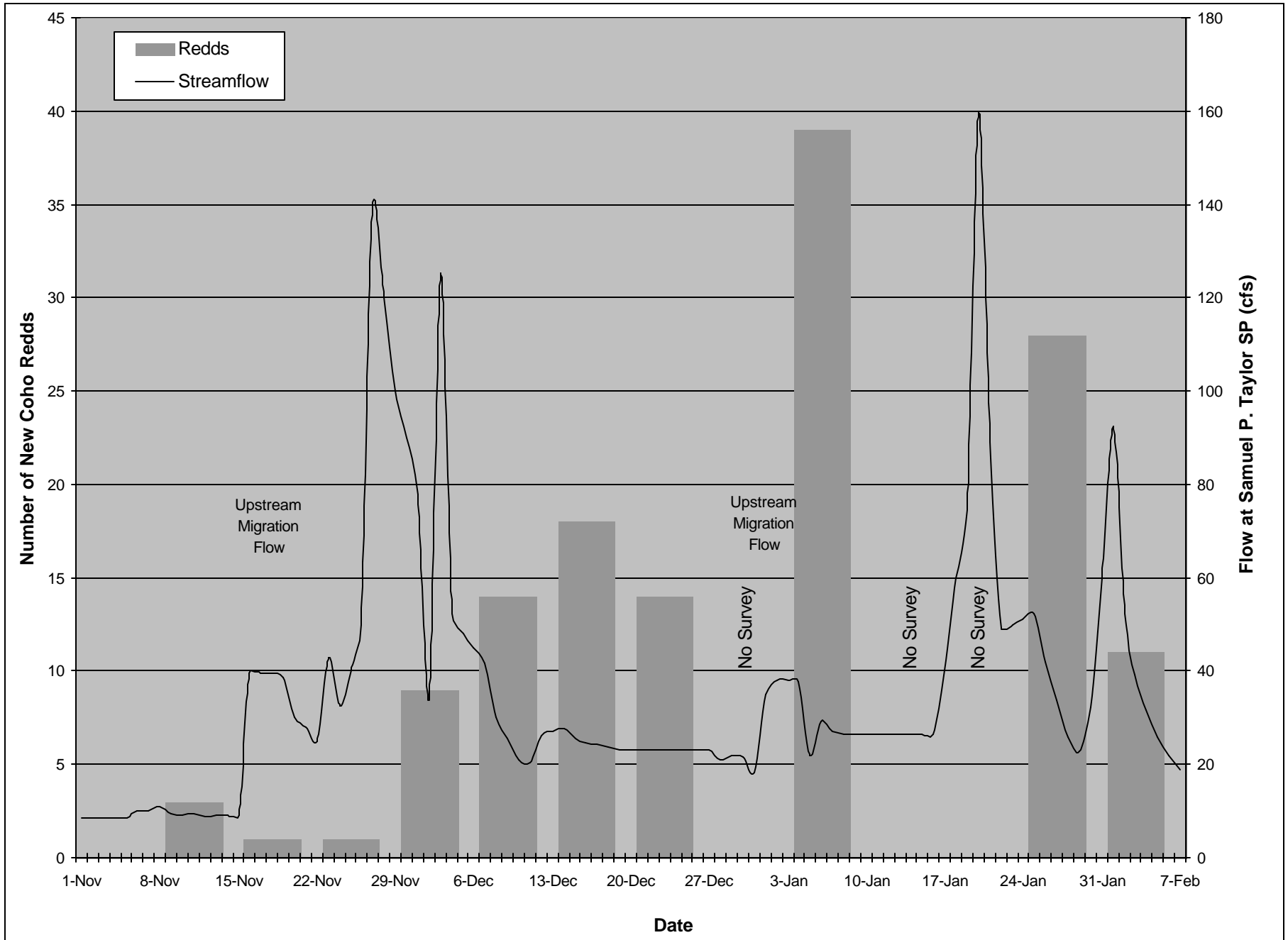


Figure 3. Coho Redd Observations, Spawning Season 1998-1999.

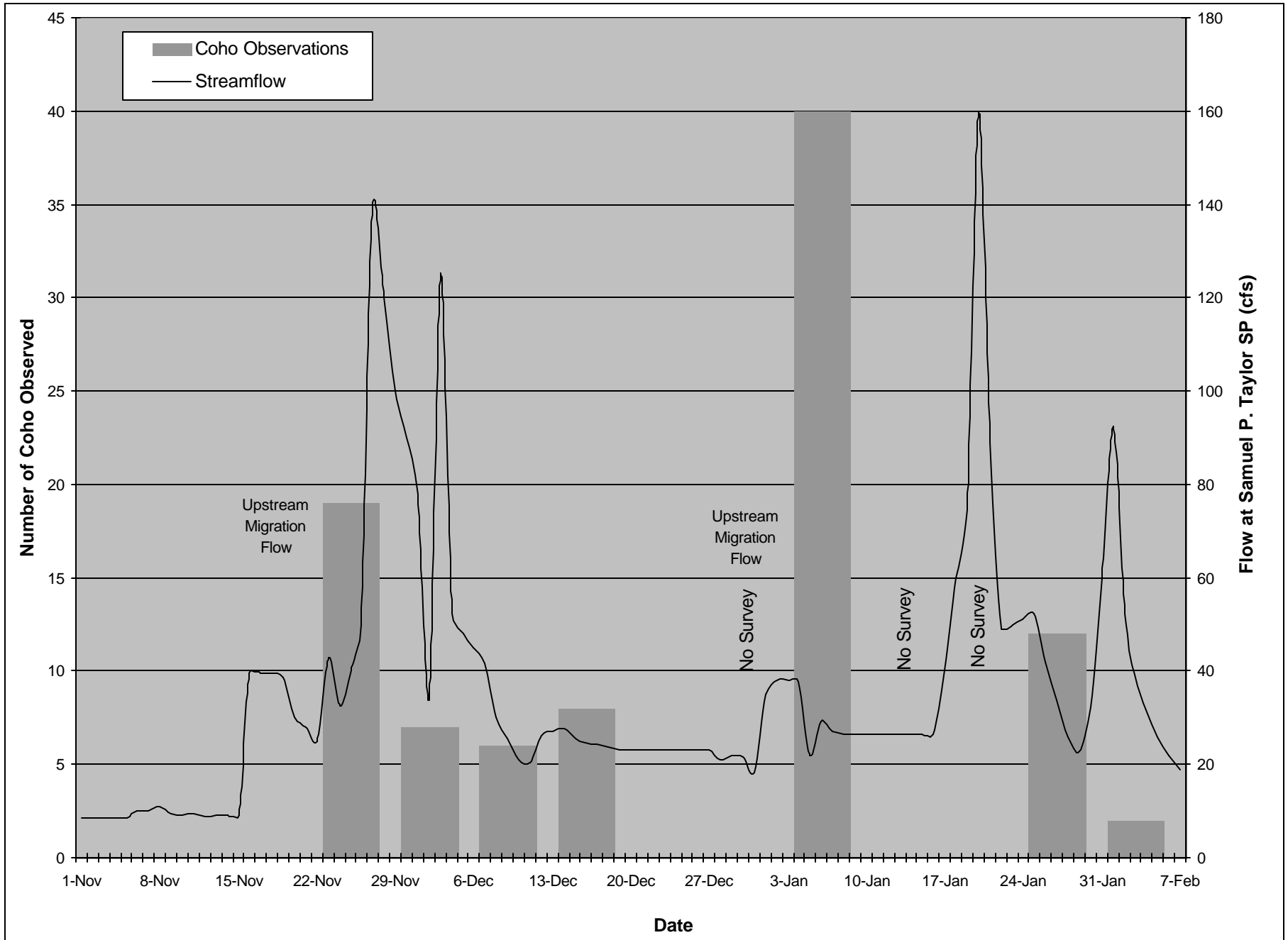


Figure 4. Live Coho Observations, Spawning Season 1998-1999.

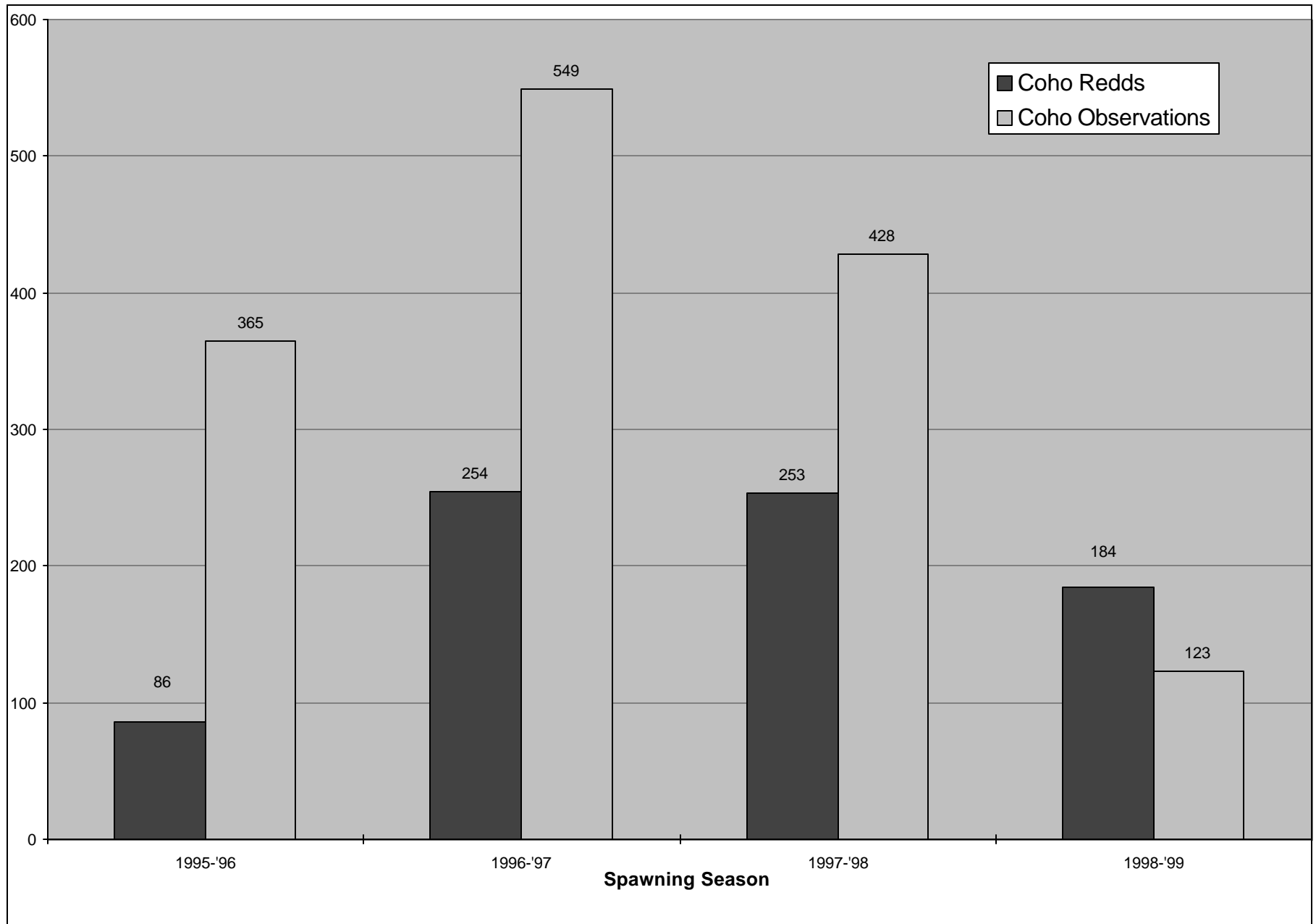


Figure 5. Coho Redds and Live Coho Observations in the Lagunitas Creek Watershed, Spawning Seasons 1995/'96-1998/'99

This is a 36% increase in redds from 1995/'96.

In 1996 the population size of juvenile coho in this year class was estimated at 16,130 juvenile coho, more than double the 1993 estimate (Trihey & Associates, 1996b). The combination of large increases in juvenile population estimates and redd numbers may indicate an increase in the population size of this year class.

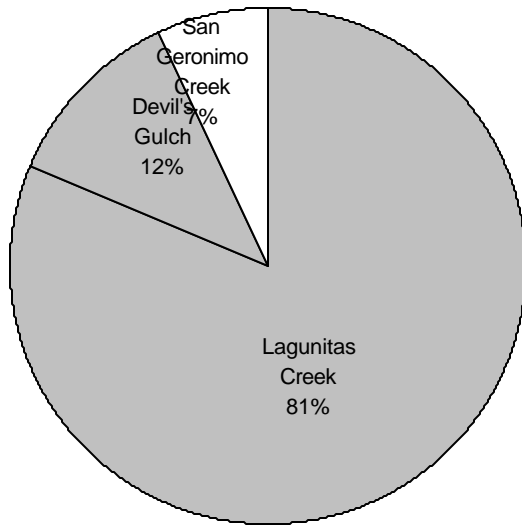
While the number of redds has improved from three years ago, the number of spawners is the lowest observed during the past four survey seasons (Figure 5). We did not observe coho on the majority of redds in Lagunitas and San Geronimo Creeks. In previous years the number of coho observed has averaged 2.7 times the number of redds counted, whereas this year there were 33% fewer coho than redds. One explanation for this undercount may simply be lack of survey personnel. In previous years multiple surveyors were available to count coho and redds, whereas this year only one biologist performed the majority of surveys. While the number of redds can be accurately estimated with only one person, counting fish may require additional personnel. In addition, fish may have spawned in the interval between surveys and the timing of our surveys may not have captured this activity.

Lagunitas Creek has shown a steady decrease in the number of live coho observed over the last four spawning seasons. In the 1995/'96 season, 279 coho were observed in Lagunitas Creek and 56 coho were observed this season; an 80% decrease. San Geronimo Creek produced the fewest number of observed coho in the past four years, with only 35 coho recorded. This is similar to the 41 live coho observed in San Geronimo Creek in 1995-96, but far fewer than the 271 and 196 live coho observed in 1996-97, and 1997-98, respectively. A similar pattern exists for Devil's Gulch, where this year's 32 live coho was similar to the 41 seen in 1995-96, but far less than the 98 and 79 live coho seen during the 1996-97 and 1997-98 seasons, respectively.

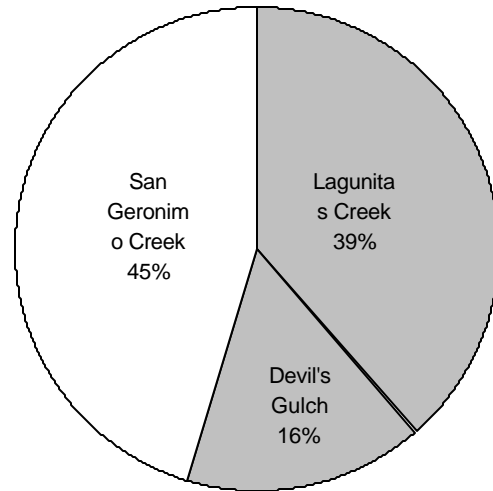
The timing of this year's run was the latest in the last four spawning seasons (Figure 7). The peak of the run occurred during the first week of January, three weeks later than last year and five weeks later than in 1996/'97. The most likely explanation for this delayed run was the exceptionally dry December, which has been the peak of the run in previous years. The lack of rain and resulting low stream flows may have prevented, or at least discouraged, coho from moving upstream. The upstream migration flow of 1-3-January worked well at attracting fish upstream where they built 39 redds the following week.

This year was the first effective test of upstream migration flows. In 1996/'97, surveys did not coincide with upstream migration flows so the reaction of coho to these flows could not be observed. Last year the upstream migration flows coincided with storm events, masking their effectiveness. This year two of the three upstream migration flows did not coincide with storm events and surveys were conducted following each flow event. The week following the first upstream migration (or "trigger") flow, the number of observed coho increased from zero to 19 while the number of new redds remained at one. This may indicate that while a small number of coho used the increased flows to move upstream,

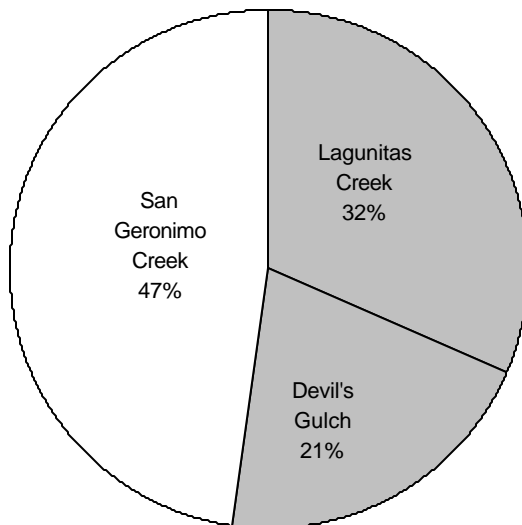
1995-1996



1996-1997



1997-1998



1998-1999

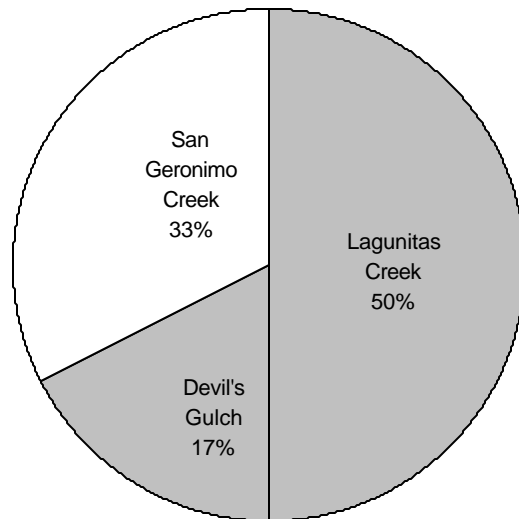


Figure 6. Coho Redd Locations in the Lagunitas Creek Watershed, Spawning Seasons 1995/96-1998/99

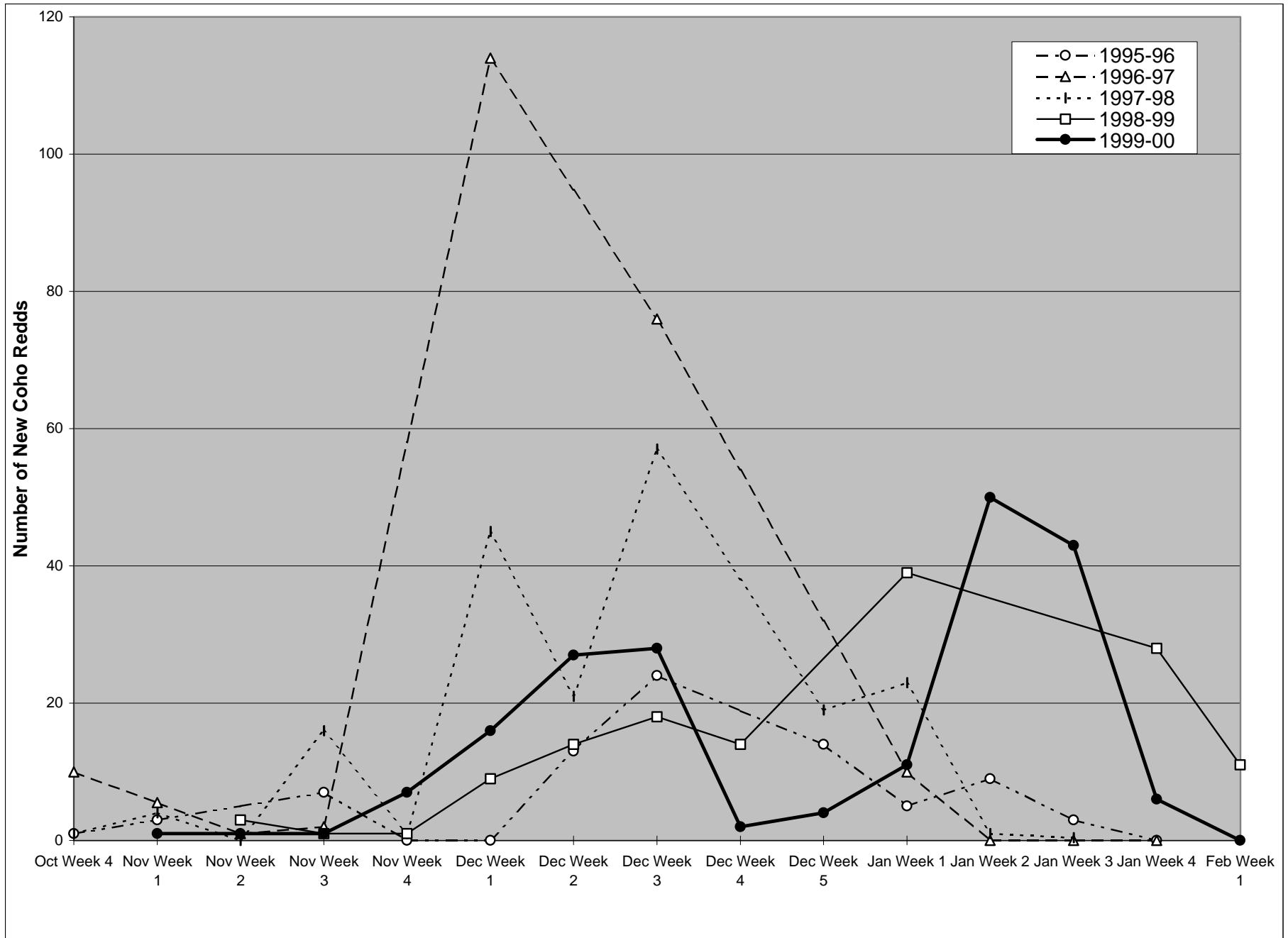


Figure 7. Timing of Coho Spawning Activity in Lagunitas and San Geronimo Creeks, Spawning Seasons 1995/96-1999/2000.

they were not yet ready to spawn. The second upstream migration flow, starting on 25-November, coincided with the first significant storm events of the season. The number of redds observed increased dramatically the following week, but this is likely the result of the storms. The third upstream migration flow produced the most significant results. No significant rain had fallen between 5- and 31-December when the upstream migration release nearly doubled the Lagunitas Creek streamflow. Within 5 days 10 new redds and 12 spawners had been observed. By the end of the week a total of 39 redds and 40 spawners had been recorded. It seems clear that the third upstream migration flow was much more effective at moving fish upstream than the first flow.

A possible consequence of the upstream migration flows is an increase in the proportion of redds built in Lagunitas Creek. In the week following the third upstream migration flow, 30 new redds were observed in Lagunitas Creek compared with only 9 new redds in San Geronimo Creek (Table 2), which is a larger bias than was observed during the rest of the spawning run. The number of new redds built in Devil's Gulch that week is unknown because surveys were not conducted immediately following the upstream migration flow. The disparity in location of redds may be due to the low flow (<6 cfs) coming out of San Geronimo Creek which may have prevented passage for many fish. The implication of this is that upstream migration flows at times when passage to tributaries is impeded may result in a higher proportion of redds being built in Lagunitas Creek. Since Lagunitas Creek suffers the highest peak streamflows and subsequent bed movement, upstream migration flows that do not coincide with storm events may place coho redds and eggs at greater risk of being destroyed.

The lower proportion of redds in San Geronimo Creek this year compared to the past two years (Figure 6) may be partly due to the lack of rain and restricted access during the peak of the spawning season. Devil's Gulch had roughly the same proportion of redds as the previous three seasons, indicating that this tributary was as accessible as in previous years.

Determining the total number of spawners entering the Lagunitas Creek system is a challenging task. The 123 live coho observed is certainly far less than the total number of spawners in the system. A common method of estimating the number of spawners is to assume that there should be two fish for each redd, which would produce an estimate of 368 spawners. This assumption may be problematic since female coho may dig more than one redd and males tend to outnumber females (Groot and Marcolis 1991). Given the problems involved with estimating the total number of spawners, documenting the observed trends in spawner and redd numbers may be more useful. The most cautious summary of the number of spawners this year, based on observed fish and redds, is that it was lower than the past two years and most likely higher than in 1995/'96.

The 1998/'99 coho spawning run will hopefully produce an abundance of juvenile coho. However, a major threat to the survival of the developing juveniles is the scouring or burial of redds during high stream flows. On 6-February-1999, a storm dropped 6.75 inches of rain, raising the streamflow at Point Reyes Station to 5,420 cfs. The flow through Samuel

P. Taylor State Park was probably higher than 3,000 cfs but the gauge in the park was not read that day (a Saturday). This flow may have been sufficient to scour or bury redds in the creek. Survivorship of juvenile coho through the winter, spring and summer will be assessed during the 1999 juvenile salmonid survey. If survivorship during this period is high, chances are good that the 1998 spawner year class will show continued improvement when it returns in 2001.

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APPENDIX A

USGS 7.5 minute quadrangle topographic maps with redd locations on Lagunitas and San Geronimo Creeks.