

**LAGUNITAS CREEK
COHO SALMON
SPAWNER SURVEY REPORT
FALL & WINTER 1995-96**

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SUMMARY

We began a coho salmon (*Oncorhynchus kisutch*) spawner survey on Lagunitas Creek on 13 November 1995 and walked the stream from the platform bridge at Tocaloma to Kent Dam. Subsequent foot surveys covered the sections between Kelley's Tocaloma Site to just downstream of the town of Jewell, and from the confluence of Devil's Gulch to Kent Dam (Figure 1). Devil's Gulch and San Geronimo Creeks were surveyed beginning 18 December (Figure 1), when stream flows in the tributaries became sufficient to allow fish passage. The surveys were terminated after the 22 and 23 January, 1996 survey, when coho spawning was thought to be over for the season because few new coho moved into the system with the storm which occurred the week prior to the survey.

During the survey we observed a total of 365 live coho and 86 redds, 279 of these coho were observed in Lagunitas Creek along with 70 redds, 45 coho and 10 redds were observed in Devil's Gulch and 41 coho and 6 redds were observed in San Geronimo Creek (Table 1). We also took fin and or muscle tissue samples from 24 dead coho that we found on Lagunitas Creek. These samples were sent to Bodega Marine Laboratory for genetic analysis.

Based on our observations during this survey artificial freshet flows released in the absence of precipitation did not appear to provide the benefits to adult coho salmon that were envisioned by the State Water Resources Control Board (SWRCB), because the freshets do not appear to be effective in instigating upstream movement unless coupled with a natural rainfall event (Figure 3).

METHODS

Stream sections were walked weekly by a two person crew. On 13 November, we walked the section upstream from the platform bridge to Kent Dam on Lagunitas Creek in order to locate

spawning coho salmon and their redds. On 20 and 27 November the surveys began at a riffle just downstream of road mile marker (rmm) 20.03 (Bratovich & Kelley's (1988) Tocaloma Site) to just downstream of the town of Jewell and from the confluence of Devil's Gulch to Kent Dam. The sections from the platform bridge to rmm 20.03 and from Jewell to Devil's Gulch were not surveyed because there are no spawning gravels in these areas, and deep pools and overhanging vegetation make it difficult to see fish. On 5 December, the entire stream upstream of rmm 20.03 was walked to make certain that no fish or redds were being overlooked in the sections not surveyed. Since no fish or redds were found on 5 December in the section from Jewell to Devil's Gulch, this section was omitted during subsequent surveys. In addition to the Lagunitas Creek sections, the downstream most 1.5 miles of Devil's Gulch and the downstream most 2.5 miles of San Geronimo Creek were walked beginning 18 December. Because past surveys indicated that there was relatively little spawning in the lower 2.5 miles of San Geronimo Creek (Bratovich & Kelley 1988), subsequent surveys on San Geronimo Creek consisted of spot checking the lower 2.5 miles and walking the next 2.0 miles upstream, adjacent to the Golf Course. (Figure 1)

Fish carcasses were measured, tissue samples were taken for genetic studies, sex was recorded and fish were milked to determine if they had spawned. Live fish were noted and redds were mapped and marked. Each redd was marked in the stream with a 3 inch metal washer painted international orange and with blue and white striped flagging on adjacent riparian vegetation, so that they were not counted as new redds in subsequent surveys. Washers were labeled with the redd site number and the date. Flagging was similarly labeled and included the location of the redd from the flagged vegetation. Redds were considered complete if they had a definite tail spill gravel pile, large areas where digging had occurred were marked with flagging so that they could be checked for completeness during subsequent surveys.

RESULTS

A summary of the results of the survey are located in Table 1 and Figures 2 & 3. A total of 86 redds were located during the survey in Lagunitas Creek, San Geronimo Creek and Devil's Gulch. This was more redds than during a 1983-84 survey when 44 redds were located, but less than in 1982-83 when 139 redds were located (Bratovich and Kelley 1988). The distribution of redds was similar in 1995-96 to the other two surveys, with the majority of redds being located on Lagunitas Creek between the confluence with Devil's Gulch and Shafter Bridge. More redds were located between Shafter Bridge and Kent Dam than in the previous years, presumably because of the spawning gravels added to that section. Fewer redds were located in San Geronimo Creek (6 redds) than in 1982-83 (51 redds) or 1983-84 (7 redds), likely because the main high flow event in early January of 1996 was so high that the coho migrated into tributaries of San Geronimo Creek. Many coho were reported spawning in Woodacre Creek this year. Fewer redds were located in Devil's Gulch (10 redds) than in 1982-83 (23 redds) or 1983-84 (11 redds), probably because the survey did not extend past the State Park boundary this year as in the past. Coho were reported in Devil's Gulch upstream the State Park boundary after the early January storm (E. Gerstung, DFG, pers. comm). A summary of the weekly findings follows.

On 13 November we found a total of 3 live spawning coho salmon, 1 dead male coho, 1 jawbone and 7 redds. All of the live fish had fungus and decayed fins and were therefore suspected to have been in the stream for at least a couple weeks. One of the live coho, the dead male and two of the redds were located between rmm 20.03 and a group of houses approximately one mile downstream of Jewell. The other fish and redds were located between the Irving Bridge and the Shafter Bridge. One of these redds was first observed on 26 October 1995 along with three live coho. We did not observe any fish or new redds until the 5 December survey.

Streambed gravel cleaned during redd construction aged quickly. Within a week after the last live fish was observed at a redd site, the difference between the cleaned and uncleaned gravel was not obvious. The streambed was covered with what appeared to be a combination of silt

and brown algae, which covered all the surrounding substrate. Spawning fish had cleaned off this sediment and the redds appeared brighter than the rest of the gravels in the stream during the first survey. This phenomenon, in addition to marking the redds, assisted the field crews by reducing the probability of double counting redds during subsequent surveys.

On 15 November, flows were increased from 20 to 35 cfs for three days in order to attract fish into Lagunitas Creek from the ocean and estuary. The absence of fish in the stream during the two subsequent surveys on 20 and 27 November, indicates that the artificial freshet did not attract fish into the stream. No precipitation occurred before or after the time of this first artificial freshet.

On 1 December, flows were increased from 20 to 35 cfs for three days again, this time the increased flows were in conjunction with 1 inch of precipitation and high tides. On December 4, there was 55 cfs flowing in the State Park reach of Lagunitas Creek and 62 cfs at the Gallagher Ranch (D. Roxon, MMWD, pers. comm.). During the survey on 5 December, 13 new redds and at least 31 fresh coho (brightly colored and no fungus or decaying fins) were observed in Lagunitas Creek. Four of these redds and 8 fish were in the section between rmm 20.03 and Jewell, 3 redds and 10 fish were in the section between Devil's Gulch and Irving Bridge, and 6 redds and 13 fish were in the section between Irving Bridge and Shafter Bridge. No redds or fish were found between Jewell and Devil's Gulch or between Shafter Bridge and Kent Dam. Several of the same riffles used by earlier fish were being used by these new fish.

On 8 December a series of large storms first hit the California coast. On 9 December, Bill Cox (DFG) surveyed the section between Shafter Bridge and Kent Dam and observed 19 live coho. On the same day, Eric Gerstung (DFG) surveyed Devil's Gulch, which had apparently just become accessible, and observed 73 coho moving upstream. Our next scheduled survey was for 11 December, but stream flow and turbidity were too high to survey Lagunitas Creek or the tributaries. Streamflow was nearly 2000 cfs in Lagunitas Creek on 12 December (D. Roxon, MMWD, pers, comm.) and did not subside enough to survey the stream until 14

December. A survey was planned for 15 December, but another storm raised flow to 200 cfs in Lagunitas Creek. Flow and turbidity subsided enough to conduct a survey on 17 December. During this survey a total of 22 new redds, 106 live coho, and one dead coho were observed. Four of these redds and 9 live fish were in the section between rmm 20.30 and Jewell; 6 redds and 33 live fish were in the section between Devil's Gulch and Irving Bridge; 5 redds, 38 live fish and the one dead male was found between Irving Bridge and Shafter Bridge; and 7 redds and 26 live fish were in the section between Shafter Bridge and Kent Dam. None of the redds marked during previous surveys were visible and only one orange marker was found. It appeared that the previously constructed redd sites were either buried with gravels or scoured.

On 18 December, Devil's Gulch and San Geronimo creeks were surveyed. We found 6 new redds and 19 live coho in Devil's Gulch and 2 new redds and 12 live coho in San Geronimo Creek. The fish in Devil's Gulch were located within the upstream one mile of the one and a half mile section. The fish in San Geronimo Creek were located at two sites, by the MMWD pumping station across from the Lagunitas Post Office and in Forest Knolls near the Forest Knolls Post Office. A local resident reported fish spawning in Woodacre Creek, a tributary to San Geronimo Creek. San Geronimo Creek was turbid during the survey and fish in water deeper than one foot may have been missed because we could not see them through the turbid water.

During the survey on December 26 a total of 12 new redds, 39 live coho, 4 dead coho, and 1 live steelhead were observed on Lagunitas Creek. Five of these redds and 8 live coho were in the section between rmm 20.30 and Jewell; 4 redds and 15 live coho were in the section between Devil's Gulch and Irving Bridge; 2 redds, 11 live coho and 1 steelhead were found between Irving Bridge and Shafter Bridge; and 1 redd and 5 live coho and the 4 dead coho were in the section between Shafter Bridge and Kent Dam. We found 1 new redd and 6 live coho on Devil's Gulch and 2 new redds and 5 live coho on San Geronimo Creek during this survey.

On December 30 and 31 there was a small storm that caused the flow in Lagunitas Creek to increase from 20 cfs to 40 cfs (D. Roxon, MMWD, pers. comm.). The increase in flow lasted long enough to eliminate the requirement for an artificial freshet in January. During the January 2 and 3 survey a total of 5 new redds, 51 live coho, and 17 dead coho were observed on Lagunitas Creek. Three of the redds, 11 live coho, and 2 dead coho were in the section between rmm 20.30 and Jewell; 1 redd, 4 live coho, and 1 dead coho were in the section between Jewell and Devil's Gulch, a section which has been surveyed twice previously and no fish or redds were observed prior to this survey; 1 redd, 18 live coho, and 5 dead coho were in the section between Devil's Gulch and Irving Bridge; no new redds, 14 live coho, and 6 dead coho were found between Irving Bridge and Shafter Bridge; and 3 new redds, 3 live coho, and 3 dead coho were in the section between Shafter Bridge and Kent Dam. We found 1 new redd and 11 live coho on Devil's Gulch and 1 new redd, 9 live coho and 10 dead coho on San Geronimo Creek during this survey. No steelhead were observed during this survey.

On January 8 and 9 a total of 9 new redds, 17 live coho, 4 dead coho were observed on Lagunitas Creek. One of these redds and 5 live coho and one dead coho were in the section between rmm 20.30 and Jewell; 4 redds and 8 live coho and 2 dead coho were in the section between Devil's Gulch and Irving Bridge; 3 coho redds and two possible steelhead redds, 3 live coho and 1 dead coho were found between Irving Bridge and Shafter Bridge; and 1 redd and 1 live coho were in the section between Shafter Bridge and Kent Dam. We found 1 new redd and 6 live coho on Devil's Gulch and 3 live coho on San Geronimo Creek during this survey.

During the survey on January 14 and 15 a total of 2 new redds and 6 live coho were observed on Lagunitas Creek. Two fish were in a pool in the section between rmm 20.30 and Jewell, both redds and 4 live coho were in the section between Devil's Gulch and Irving Bridge, no new redds or live or dead fish were observed from Irving Bridge upstream to Kent Dam. We

found 1 new redd and 1 live coho on Devil's Gulch and 1 new redd and 1 live coho on San Geronimo Creek during this survey.

On 16 January another series of storms moved into California and during the 22 and 23 January survey, flows and turbidities were high. In the riffle and run habitats fish were visible, but in pool habitats it was more difficult to see. During this survey 10 new redds and a total of 7 live fish and no dead fish were observed. Because of the turbidity, positive identification of the fish was difficult, but at least 2 of these fish were suspected to be steelhead and 2 were positively identified as coho. Two of these fish were located in the section of Lagunitas Creek between Devil's Gulch and Irving Bridge and 2 were between Irving Bridge and Shafter Bridge. Two fish were observed in Devil's Gulch and 1 in San Geronimo Creek.

It is suspected that some of the fish were being recounted in subsequent surveys based on the increase in decay and the decrease in new redds observed each week, however, it is also assumed that many fish were being missed between the surveys and even during some surveys when visibility is low due to high turbidities.

CONCLUSIONS

The coho spawner surveys on Lagunitas Creek, Devil's Gulch and San Geronimo Creek conducted in 1995-96 have provided some insight into the effectiveness of the artificial freshets being released under the State Water Resources Control Board Order No. WR95-17. Based upon our observations this fall and winter, artificial freshet flows released in the absence of precipitation did not appear to provide the benefits to adult coho salmon that were envisioned by SWRCB. The freshets do not appear to be effective unless coupled with a natural rainfall event. Artificial freshets released in the absence of rainfall events did not result in the upstream migration of adult coho salmon into Lagunitas Creek. Coho salmon either entered Lagunitas Creek before freshets were provided, during a rainstorm in concert with an artificial

freshet, and during storms with no artificial freshets. Thus, the early artificial freshets did not appear to be effective in initiating or facilitating adult fish passage to spawning habitat.

These results are consistent with the testimony given during the State Water Board Hearings (1992) by fisheries experts Bill Cox (DFG) and Don Kelley (MMWD). Typically, fish move upstream into small coastal streams in association with natural storm events. In small California coastal streams, coho typically do not migrate upstream until the first substantial storm in late fall or winter. The storms appear to provide the cue for coho salmon to approach the coast and enter these streams. The storms are usually accompanied by a drop in barometric pressure, changes in sea state, increase in tidal height, and an increase in streamflow and/or turbidity. Any one or combination of these factors may trigger coho salmon to enter freshwater and begin spawning activity.

The first report of coho salmon in Lagunitas Creek came on October 27. No artificial freshets had been provided. Streamflows were increased from approximately 10 cfs to 20 cfs on October 15 (D. Roxon, MMWD, pers. comm.), as required by the Decision 1582. October is generally very early for returning coho salmon along the coast of California. Speculation is that the early spawners were hatchery fish, regardless, the presence of adult coho salmon in Lagunitas Creek in late October demonstrate that coho salmon can pass upstream, at least to Shafter Bridge, at flows as low as 20 cfs. During the hearing Mr. Kelley estimated that a flow of 35 cfs was needed to provide passage based on hydraulic measurements of critical riffles. However, he and Mr. Lifton (consultant to MMWD) indicated that the estimate of 35 cfs was conservative, and therefore adequate passage may be provided at lower flows. It is possible that the increase in flow to 20 cfs and/or the removal of Giacomini Dam in mid-October mimiced a runoff event that triggered coho in the estuary to migrate upstream. In any case, in October 1995, fish migrated to spawning areas in the State Park Reach at flows lower than those thought required for passage.

The first artificial freshet was released on November 15 as required by the Board's Order No. WR95-17. Although the flows in Lagunitas Creek ranged from 28 to 40 cfs during the three day period from November 15 to November 18, no coho salmon were found during the spawning surveys conducted on November 20, nor on November 27. On December 1st, the next artificial freshet was released. On December 3, a small storm event occurred in Lagunitas Creek. Streamflows reached 62 cfs on December 4. The subsequent survey indicated that, after a natural storm event, more than 30 fish were seen, and 13 new redds were located and marked in mainstem Lagunitas Creek. The December 17 survey was conducted after a week of storms. Over 100 live adult coho salmon were found in Lagunitas, and for the first time in the fall of 1995, adult coho salmon (over 30) were found in its tributaries, San Geronimo and Devil's Gulch creeks. The tributaries are unregulated and were not previously accessible to coho salmon due to low streamflow. It seems clear from these data that coho salmon respond best to natural storm events and the early artificial freshets provide little benefit.

Coho salmon populations are influenced by several factors related to the timing of migration and spawning, including predation (and poaching), sedimentation of redds, and scour by high flows. Unlike other coastal streams that are blocked by sand bars during portions of the year, Lagunitas Creek is connected to Tomales Bay by a continuously open estuary, and coho salmon are free to move upstream anytime during the fall when streamflows provide access. Typically, coho salmon enter streams when natural freshets occur. The higher flows provide better migration conditions, the turbidity may provide some protection from predators, and spawning areas in the tributaries become accessible. Adult coho salmon that move into the stream prior to natural runoff events during periods of low run-off in the fall are exposed to a higher risk of poaching and predation. Fish that migrate during natural storm events can take advantage of the increase in water depth and turbidity to hide from some predators and poachers.

A more important consideration is access to tributary streams. Early migrating fish can only spawn in the mainstem of Lagunitas Creek because streamflow in the tributaries is too low to provide upstream passage and spawning habitat. Access to spawning areas in the tributaries is controlled by tributary flow and is unaffected by mainstem flow including artificial freshets. Redds constructed in the mainstem may be susceptible to sedimentation (covering of the redd with fine sediments from the first storm of the season) or scour by major storm events. On the December 17th survey we noted that some of the early redds constructed in the mainstem were buried under sediment and others appeared to have been scoured. Redds constructed in tributary streams are less prone to scour due to the small size of the watersheds.

In addition to better incubation conditions, spawning in the tributaries appears to be linked with improved production. The population sampling conducted in the fall to assess juvenile salmonid abundance provides data on the relative merits of spawning in mainstem versus tributary habitat. In reviewing the flow record and abundance of juvenile coho salmon collected in the fall of 1993 and 1995, it becomes clear that large storms, especially when they occurred in late winter or early spring, likely caused scour in Lagunitas Creek resulting in low abundance of juvenile coho salmon in Lagunitas Creek. In contrast, juvenile coho were more abundant in the tributaries, Devil's Gulch and San Geronimo Creek than in the mainstem. In 1994, no large storm events (and no scouring flows) occurred, and abundance was high in mainstem Lagunitas Creek. Because fish were also able to access the tributaries in 1994, production for the basin as a whole was high. It is probable that during the high flows that occurred during this spawning season, many coho which moved far upstream in Devil's Gulch and into tributaries of San Geronimo Creek were missed during the surveys. Juvenile sampling in 1996 would provide additional verification that tributaries contribute important spawning habitat, especially in years with large storms.

Based on our observations to date in Lagunitas Creek, salmon life history requirements, and local hydrology, we recommend that artificial freshets for the purpose of attracting upstream

migrants be limited to late December releases in dry years when no significant rain has fallen before this time. This recommendation is based on the following rational:

- Given the channel conditions in the fall of 1995, coho salmon can access spawning habitat in the mainstem of Lagunitas Creek at flows as low as 20 cfs.
- Artificial freshets in early fall, before coho typically migrate, will not contribute significantly to improving spawning success, and may, in fact, act to reduce survival of the adults because the relative risk of predation and poaching in the stream at the low fall flows is greater than in the estuary;
- Artificial freshets in Lagunitas Creek do not facilitate access to the tributary streams, which contain important spawning habitat. Attracting spawners into Lagunitas Creek before natural storms occur limits the spawning potential of the watershed;
- Coho that spawn early in the season run the risk of having redds washed out from subsequent storms. Artificially attracting spawners into Lagunitas Creek early in the fall unreasonably places any resulting redds at risk from subsequent storms; and
- Artificial freshets in the absence of a triggering storm event, do not appear to be effective in bringing adult coho salmon into Lagunitas Creek.

CITATIONS AND PERSONAL COMMUNICATIONS

Bratovich, P.M. and D.W. Kelley. 1988. Investigations of the salmon and steelhead in Lagunitas Creek, Marin County, California. Report prepared for Marin Municipal Water District.

Cox, Bill. Fisheries Biologist, California Department of Fish and Game.

Gerstung, Eric. Fisheries Biologist, California Department of Fish and Game.

Roxon, Dana. Hydrologist, Marin Municipal Water District.

State Water Resources Control Board. 1992. Public Hearing re: Diversion of Water from Lagunitas Creek in Marin County.

Table 1. Results of the Coho Salmon Spawning Survey in the Lagunitas Creek Basin in 1995-96.

Date	Artificial Freshet	Storm	Fish and Redds found by Reach in Lagunitas Creek								Devils Gulch ²		San Geronimo Creek ²		Total	
			rmm 20.03 to Jewell		Devils Gulch to Irving Bridge		Irving Bridge to Shafter Bridge		Shafter Bridge to Kent Dam		Coho	Redds	Coho	Redds	Coho	Redds
			Coho	Redds	Coho	Redds	Coho	Redds	Coho	Redds						
27-Oct ¹	No	No	NS	NS	NS	NS	4	1	NS	NS	-	-	-	-	4	1
13-Nov	No	No	3	2	None	None	2	5	None	None	-	-	-	-	5	7
20-Nov	Yes	No	None	None	None	None	None	None	None	None	-	-	-	-	None	None
27-Nov	No	No	None	None	None	None	None	None	None	None	-	-	-	-	None	None
5-Dec	Yes	Yes	8	4	10	3	13	6	None	None	-	-	-	-	31	13
17, 18-Dec	No	Yes	9	4	33	6	39	5	26	7	19	6	12	2	138	30
26-Dec	No	No	8	5	15	4	11	2	9	1	6	1	5	2	54	15
2, 3-Jan	No	Yes	13	3	23	1	20	0	6	0	11	1	19	1	92	6
8, 9-Jan	No	No	5	1	8	4	3	3	1	1	6	1	3	0	26	10
14, 15-Jan	No	No	2	0	4	2	0	0	0	0	1	1	1	1	8	4
22, 23-Jan	No	Yes	0	0	2	0	2	0	0	0	2	0	1	0	7	0
Total			48	19	95	20	94	22	42	9	45	10	41	6	365	86

¹The systematic surveys did not start until 13 November. Tom Taylor reported salmon spawning about midway between Irving and Shafter Bridges. Lanette Davis confirmed this observation on 1 November, and found two females and one male coho, as well as two redds at the location where the spawners were reported.

²Prior to the December 18 survey Devil's Gulch and San Geronimo creeks were not accessible to migrating fish because streamflow in the tributaries was too low

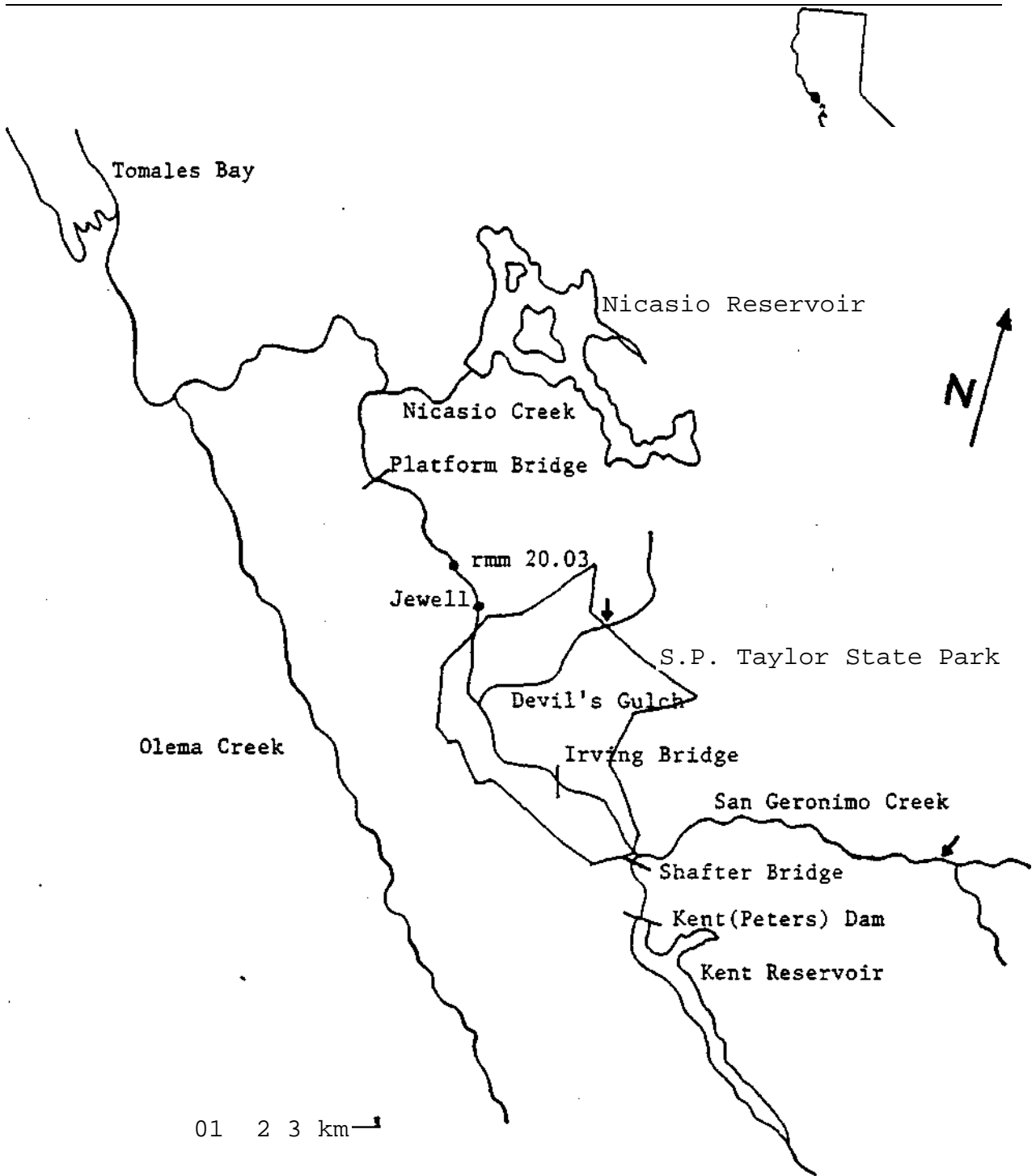


Figure 1. Map of Spawner Survey Reaches on Lagunitas Creek and Tributaries. (Arrow denotes end of survey reach on tributaries)

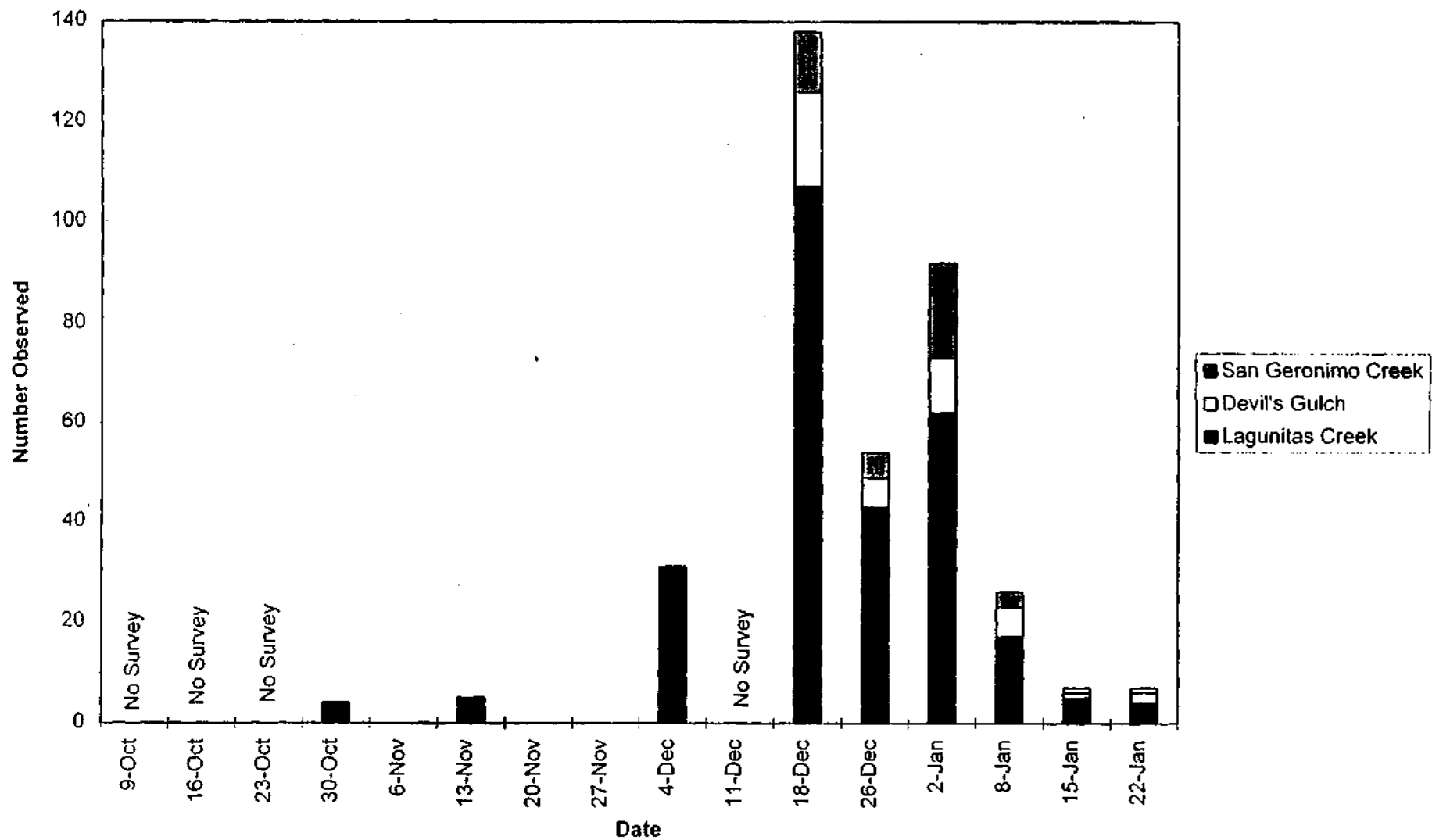


Figure 2. Live Coho Salmon Observed on Lagunitas Creek, Devil's Gulch and San Geronimo Creek in 1995-96.

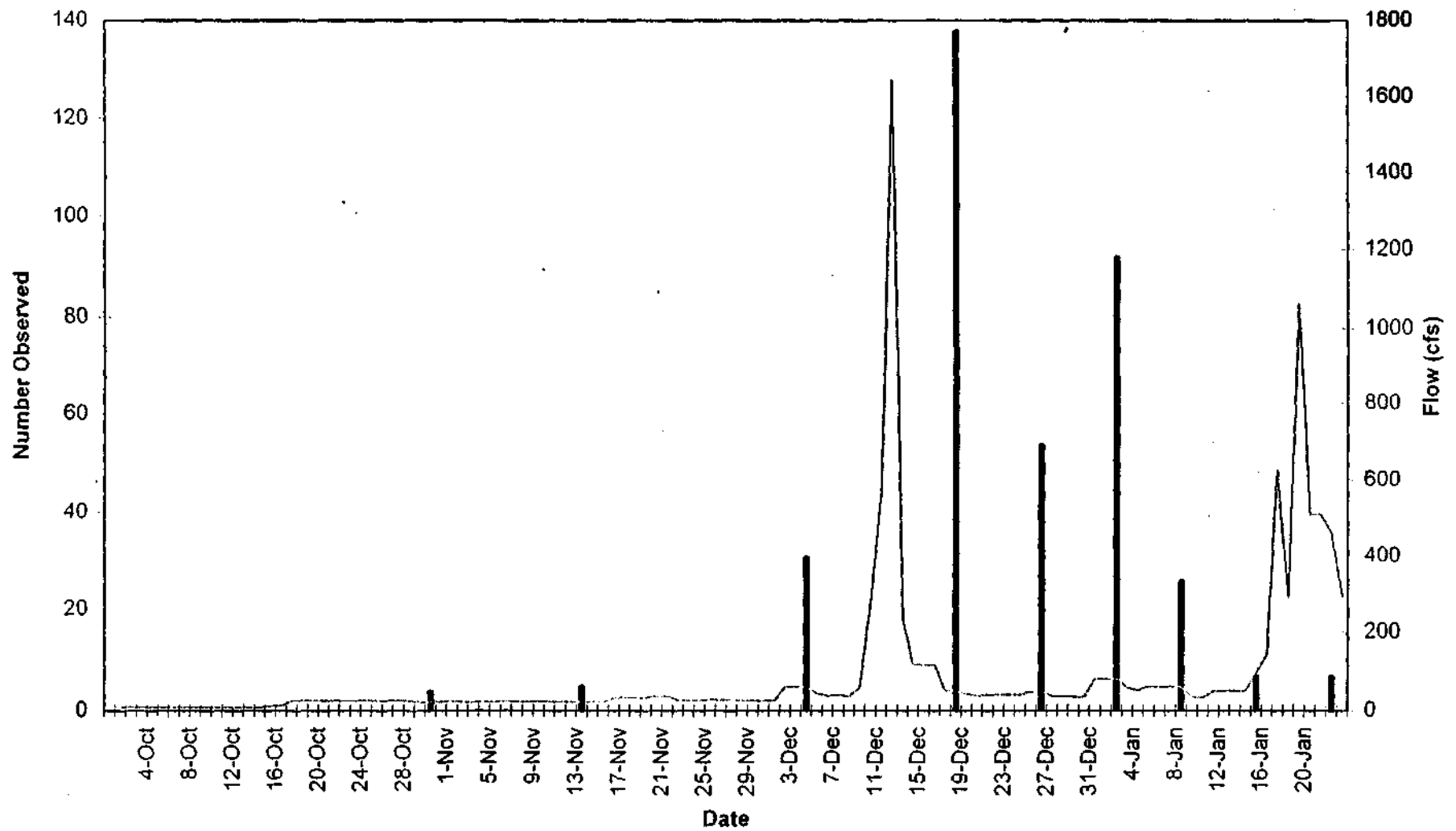


Figure 3. Live Coho Salmon Observed on Lagunitas Creek, Devil's Gulch and San Geronimo Creek and the Corresponding Flows at the Gallagher Ranch