Abundance of Steelhead and Coho Salmon in the Lagunitas Creek Drainage, Marin County, California

Prepared for:

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1. Summary

Abundance of juvenile steelhead and coho salmon has been monitored by electrofishing at established sites in Lagunitas Creek, Devil's Gulch and San Geronimo Creek since 1970. This report reviews the long-term data set established by the California Department of Fish and Game and continued by the Marin Municipal Water District. We examine the record for long term trends and changes in abundance that may correspond to different management approaches or other natural or human-caused events. We also discuss some of the limitations of the data.

2. Introduction

Marin Municipal Water District (MMWD) presently supports an active resource management program for anadromous salmonids in the Lagunitas Creek drainage. As part of this program, MMWD has implemented Decision 1582 issued by the State Water Resources Control Board (SWRCB). Since 1982, MMWD increased summer and fall flows in Lagunitas Creek downstream of Kent Dam and provided increased flows for upstream fish passage. In 1992, MMWD began working with the California Department of Fish and Game (DFG) on habitat improvements including sediment control in the watershed, managing release water temperatures downstream of Kent Dam and implementing a riparian management plan and numerous habitat improvement projects to increase the amount of woody debris in the stream channels. In 1993, MMWD began monitoring juvenile steelhead and coho salmon populations in the Lagunitas Creek at sites previously established and monitored by DFG. MMWD has continued these cooperative activities into 1995.

Steelhead and coho salmon populations have declined throughout the West from California north along the Pacific Coast. This regional decline is believed to be caused by several factors including over-harvest, poor ocean rearing conditions or watershed

changes that have detrimentally influenced migration, spawning, incubation, or rearing habitat for juvenile fish. These factors may be working singly or in combination. Both steelhead and coho salmon are being considered for listing by the National Marine Fisheries Service under the Endangered Species Act. Coho salmon populations in the Central California Coast ESU, which includes Lagunitas Creek, are being proposed as "endangered". Coho runs south of San Francisco Bay have been declared as "endangered" under the State Endangered Species Act, and those to the north of the Bay as "threatened". Steelhead are presently undergoing a status review by the NMFS.

As fisheries management activities shift to focus on the rehabilitation of these species on a coast-wide basis, long-term data can provide important information to determine the success of applying various management practices. Lagunitas Creek was first surveyed in 1970 and the surveys continued intermittently to 1995. This is one of the longer electrofishing data sets available for juvenile fish on a California coastal stream. This period included some significant events in the management of anadromous fish in the Lagunitas Creek watershed, such as the increase in summer and fall streamflow beginning in 1983 resulting from the enlargement of Kent Dam. In 1992, MMWD initiated a sediment control program in the Lagunitas Creek watershed, began managing temperatures in the release water downstream of Kent Dam and started a riparian management program and habitat improvement projects to increase the amount of woody debris in the stream channels.

For this report, we examined available historical data from fish sampling done by DFG and by consultants for MMWD to examine changes in the abundance of juvenile steelhead and coho salmon in Lagunitas Creek and tributaries over time. The primary objective of this report was to address the following questions:

1. Has juvenile steelhead and coho salmon abundance declined or increased in recent years in Lagunitas Creek, Devil's Gulch, and San Geronimo Creek and have the trends in the different streams been similar?

2. Has juvenile steelhead and coho salmon abundance increased from current MMWD management practices?

This report also contains information on habitat typing done on Lagunitas Creek in 1992 and San Geronimo Creek and Devil's Gulch in 1995. The habitat composition of the stream reaches is compared to the habitat composition of the fish sampling sites to determine if the sites are representative of the total habitat in the streams.

3. Methods

3.1. Fish Population Data

Fish population data were obtained from DFG for the years 1970, 1980, 1982 through 1988, and 1990 (Appendix 3). DFG data from 1970, 1980 and 1982 were obtained from data summary tables as no original data sheets are available. For these three years, it was not possible to distinguish between young-of-the-year and yearling steelhead, so numbers are reported as total steelhead. DFG data from 1983 through 1988 and 1990 were obtained from original data sheets. For many of the years and sites within years, habitat data was missing from these data sheets. Other fish population data were obtained from MMWD for 1993 through 1995 (Sierra Fisheries Consultants 1993, Trihey & Associates, Inc. 1994 and 1995). Gaps in the data exist. No sampling was conducted from 1971-1979 and in 1981, 1989, 1991 and 1992, and various sites were not sampled in many of the years in which sampling was conducted. The available data are shown in Table 1.

Fish population data were collected using multiple pass electrofishing at approximately the same sites established by DFG in 1970. For the 1970-1990 data, DFG used either a two or three-pass method for collecting the fish. The number of passes varied within years and may have been related to time constraints rather than fish depletion with successive passes. In 1993, two to four-passes were done and in 1994-1995 three to six-

passes were done. The number of passes varied within and among sites and was dependent on depletion. Population estimates for sites can be made with good depletion results. However, total catch per 30 meters, rather than population estimates, were used for statistical analysis of the data for all years because of the lack of original data for the first three years of sampling (Table 2). Without data on fish caught per electrofishing pass, it is not possible to make population estimates.

Parametric analysis of variance (ANOVA) and, in one case, a non-parametric Kruskal Wallis tests were used to determine if there was a significant difference in juvenile steelhead and coho salmon numbers in Lagunitas Creek, San Geronimo Creek, and Devil's Gulch (Table 3). The first set of tests were done to determine if the implementation of D-1582 had an effect on fish populations. Years pre-implementation (1970-1982) were compared to the years post-implementation (1983-1995). The second set of tests were done to determine if habitat improvements done to address stream limiting factors, such as rearing and spawning habitat, had an effect on fish populations. Years pre-habitat improvement (1970-1990) were compared to years post-habitat improvement (1993-1995).

A second analysis was done for the years 1993 through 1995, for which data was collected at all or nearly all sites and the data sets were therefore complete enough to make data extrapolations. For the purposes of this analysis steelhead were grouped as 0+ (young-of-the-year) or 1+ (yearlings or older) based upon size at time of capture. Individual fish lengths were compiled from all sites and size distribution was examined for age groups. Based upon the distribution we determined that all fish less than 120mm fork length would be considered as 0+ and all fish greater than 120mm fork length would be considered as 1+ for the purpose of making the population estimates. Capture data on steelhead and coho was entered in Microfish 3.0, a population estimating program designed for use with depletion data (Van Deventer & Platts 1989). Population estimates of 0+ steelhead, 1+ steelhead and coho were made for individual habitat units (1995 data

only) and for each site. These numbers were then expressed as number of fish per foot of that particular habitat type or number of fish per foot for the entire site.

In 1995, individual habitat units (pools, runs and riffles) within each site were sampled separately. Because of this, we were able to make population estimates in two ways: based on average density per channel length, as done in 1993 and 1994, and based on average density per channel length of stream habitat. For habitat based sampling, the density estimates were multiplied by the number of feet of the same habitat type in the applicable stream reach. For site based sampling, the density estimates were averaged for all sites within the stream reach and this average density was multiplied by the number of feet in the stream reach. This approach was used so that the estimates could be compared to the 1993 and 1994 estimates, and so that the 1995 and all future estimates could be improved by considering the different habitat preferences of coho salmon and steelhead trout. Habitat typing data from 1992 (ENTRIX) was used to extrapolate population estimates on Lagunitas Creek and data from 1995 (Trihey & Associates, Inc.) was used to extrapolate population estimates on San Geronimo Creek and Devil's Gulch.

3.2. Habitat Composition

Habitat typing was done in 1992 on Lagunitas Creek (Appendix 2) and in 1995 on Devil's Gulch and San Geronimo Creeks (Appendix 1). Habitats surveyed were categorized into pool, run or riffle. To determine if the habitat composition within the sample sites were representative of the streams, the habitat composition of stream reaches were compared to the habitat composition of the sampled sites. Habitat composition of individual sites were recorded in 1994 and 1995, but was not consistently recorded in all earlier years.

4. Results

4.1. Fish Abundance

Long-term trends for steelhead based on the average density of the total catch, indicate that the abundance of steelhead in Lagunitas Creek has been variable between 1970 and 1995. Steelhead abundance for the period of record was relatively low in 1970, increased in 1982, dropped in 1983, was relatively stable during the drought years of 1987-1990 and increased in 1994. The highest abundance of record occurred in 1994. In Devil's Gulch, there was also no clear trend. Abundance was low in 1970, high in 1980, relatively stable in the early 80's but dropped dramatically during the drought years of 1987-1990. Abundance increased in 1993, dropped in 1994 and was the highest for the period of record in 1995. The three highest abundance years in Devil's Gulch occurred in 1995, 1980 and 1993. San Geronimo Creek showed a pattern similar to Devil's Gulch with moderate abundance in 1970 and 1980 increasing in 1982 then dropping to low abundance during the drought years. The abundance increased in 1993, dropped in 1994 and increased again in 1995. The three highest abundance years occurred in 1995, 1993 and 1982 (Figure 1).

Coho salmon have consistently shown low abundance in Lagunitas Creek. Some of this may be the result of under sampling pool habitat, but may also be an indication of low coho densities. No coho were found in Lagunitas Creek in 1970. Moderate numbers occurred in 1980, but low abundance occurred during the early to mid 1980's. Abundance increase in 1988 but dropped again to low abundance by 1993. The highest abundance of coho salmon occurred in 1994 followed by a decrease in 1995, but 1995 was still the second highest year on record. Devil's Gulch had the highest abundance of coho salmon in 1970 with a moderate abundance in 1980. The abundance dropped to low numbers in 1982 and 1983, increased in 1984, dropped to the all time low in 1985, stayed low in 1986, increased in 1987 and 1988, dropped again in 1990 and increased to moderately high abundance from 1993 to 1995. San Geronimo Creek had low abundance

of coho salmon in 1970. Abundance increased in 1980, dropped to low abundance from 1982 to 1984, increased in 1985, remained low in 1986 and 1987, increased in 1988, dropped to low abundance in 1990 and increased to the highest three years of record from 1993-95 (Figure 2).

Statistical analysis indicated that there was no significant difference in either steelhead or coho salmon abundance between the years pre- and post-implementation of D-1582 (Table 3, Figures 3 & 4). The general trend seems to indicate that the mean number of fish per 30 meters is higher for the 1983-1995 period compared to the 1970-1982 period in Lagunitas Creek and generally lower for the 1983-1995 period compared to the 1970-1982 period in the tributaries. This indicates that, although the number of fish is not significantly different, the trends differ in Lagunitas Creek from the tributaries, perhaps because of current MMWD increased flow practices.

There was no significant difference in steelhead and coho salmon abundance between pre- and post-habitat improvements (Figures *5 &* 6), except for coho in San Geronimo Creek (Figure 6). There were significantly more coho in San Geronimo Creek in 1993-1995 compared to 1970-1992. Although the number of fish per 30 meters did not differ significantly elsewhere, in every instance there were more fish in the 1993-1995 period compared to the 1970-1990 period. The abundance of steelhead was about 1.5 to 2.0 times higher in 1993-1995 compared to 1970-1990. The abundance of coho was from 2 to 10 times higher in 1993-1995 compared to 1970-1990. The lack of statistically different results could possibly be a result of high variance around the mean, indicating that the within year effect could be more important than the grouped year effect.

The extrapolation analysis done for the 1993 through 1995 data indicated that 1994 coho abundance was substantially higher than either 1993 or 1995 in Lagunitas Creek, San Geronimo Creek, and Devil's Gulch. Coho population estimates in 1995 were higher than in 1993 for Lagunitas Creek and lower for the tributaries (Table 4). Population estimates for 0+ steelhead indicated that there were fewer of these fish in 1995 in

Lagunitas Creek stream reaches and more in the tributaries than in 1993 or 1994 (Table 4). Population estimates by stream segment showed that 1+ steelhead were more abundant in 1994 than 1993 or 1995 in Lagunitas Creek. Abundance in 1995 in the lower segment (Segment 1) of San Geronimo Creek was lower than 1994 but higher than 1993. The upstream segment of San Geronimo Creek showed similar abundance between 1993 and 1994, but was substantially lower than 1995. Devil's Gulch showed highest abundance in 1994 with one third as many fish in 1993. In 1995 abundance was about one-fifth that of 1994 (Table 4).

Table 1. Fish per 30 meters of Stream for Lagunitas Creek, Devil's Gulch and San Geronimo Creek.

Site	Species	1970	1971-79	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
Lagunitas Creek		LG-1/2		LG-1/2		LG-1/2													
1	Coho	0	.	0	.	0	0	0	0	.	-	-	.	.	.	.	0	1	0
	0+SH	N/A	-	N/A	.	N/A	1	22	37	.	-	-	.	.	-	.	30	91	8
	1+SH	N/A	-	N/A	-	N/A	1	0	0	-	-	.	-	-	-	.	0	7	1
	Total SH	22	.	17	-	41	2	22	37	-	-	.	-	-	.	-	30	98	9
		LG-3/4		LG-3/4		LG-3/4													
3	Coho	0	-	19	-	0	0	0	0	0	0	0	.	0	-	-	0	22	0
	0+ SH	N/A	.	N/A	.	N/A	22	59	51	28	83	60	.	67	.	-	63	140	58
	1+ SH	N/A	-	N/A	.	N/A	6	3	2	5	7	3	-	4	-	-	1	9	4
	Total SH	1	.	121	.	197	28	62	53	33	90	63	-	71	-	-	64	149	62
		LG-5/6		LG-5/6		LG-5/6													
5	Coho	0	-	0	-	0	-	-	-	.	-	-	-	-	-	-	0	13	7
	0+SH	N/A	-	N/A	-	N/A	-	-	-	-	-	-	-	-	-	-	96	205	187
	1+SH	N/A	-	N/A	-	N/A	-	.	-	-	-	-	.	-	-	-	1	3	7
	Total SH	19	-	77	-	16	-	-	-	-	.	-	-	.	-	-	97	208	194
		LG-7/8		LG-7/8		LG-7/8	LG-7/8	LG-7/8	LG-7/8	LG-7/8	LG-7/8	LG-7/8		LG-7/8					
7	Coho	0	-	5	.	3	2	3	5	0	2	9	-	3	-	-	0	1	-
	0+SH	N/A	-	N/A	.	N/A	33	40	85	89	44	54	-	42	-	-	29	34	.
	1+SH	N/A	-	N/A	.	N/A	15	10	6	4	11	5	-	10	-	-	0	5	-
	Total SH	91	.	13	.	47	48	50	91	93	55	59	.	52	.	-	29	39	.
9	Coho	0	-	8	.	0	.	-	.	-	-	.	-	.	-	-	0	7	1
	0+SH	N/A	-	N/A	-	N/A	.	-	-	-	-	-	-	-	.	-	38	78	30
	1+SH	N/A	-	N/A	-	N/A	-	-	-	-	-	-	-	-	.	-	1	0	1
	Total SH	74	.	23	-	24	.	.	.	.	.	.	-	.	.	.	39	78	31
12	Coho	.	.	.	-	0	.	.	.	-	-	-	-	-	.	.	1	51	0
	0+SH	.	.	.	.	N/A	.	.	.	.	.	.	.	.	.	.	47	104	26
	1+SH	-	.	-	.	N/A	.	.	.	.	.	.	.	.	.	.	0	6	6
	Total SH	.	.	.	-	61	-	-	-	-	-	-	-	-	-	-	47	110	32
15.86	Coho	.	-	.	.	.	.	-	.	.	.	.	-	-	-	.	.	193	41
	0+SH	.	.	.	.	-	.	.	.	.	.	.	.	-	.	-	-	70	46
	1+SH	.	.	.	.	.	-	.	.	.	.	.	-	-	-	-	-	12	6
	Total SH	-	-	.	.	.	.	-	.	-	.	-	-	-	-	-	-	82	52
Devil's Gulch																			
DG-1	Coho	.	.	.	.	10	9	3	0	3	36	75	.	9	-	.	66	91	42
	0+SH	.	-	.	-	N/A	55	4	32	62	22	11	.	2	-	.	55	18	90
	1+SH	.	.	.	-	N/A	16	38	3	11	5	6	-	3	-	-	0	2	2
	Total SH	.	.	-	.	56	61	42	35	73	27	17	.	5	.	.	55	20	92
		DG-2/3		DG-2/3		DG-2/3													
DG-2	Coho	78	-	42	.	3	9	36	0	1	1	36	-	1	-	-	20	27	5
	0+SH	N/A	.	N/A	.	N/A	33	24	47	31	31	10	-	14	-	.	62	26	102
	1+SH	N/A	.	N/A	.	N/A	10	3	3	5	5	3	.	3	-	-	3	1	0
	Total SH	24	.	86	.	61	43	27	50	36	36	13	-	17	-	-	65	27	102
San Geronimo Creek		SG-1/2		SG-1/2		SG-1/2													
SG-2	Coho	0	-	19	-	4	-	-	-	-	-	-	-	-	-	-	2	6	1
	0+SH	N/A	.	N/A	.	N/A	.	-	.	.	.	-	-	-	.	-	98	13	85
	1+SH	N/A	.	N/A	.	N/A	.	-	-	-	.	.	-	-	-	-	1	2	3
	Total SH	47	-	63	-	103	-	-	-	-	.	-	-	-	-	-	99	15	88
SG-3	Coho	-	-	-	.	-	.	-	.	-	-	.	-	-	-	-	3	40	1
	0+SH	-	-	.	.	-	.	-	-	-	.	.	.	.	-	-	30	13	14
	1+SH	-	-	-	-	-	-	-	-	-	-	-	-	-	-	.	10	18	1
	Total SH	-	-	-	.	.	.	.	-	-	.	-	-	.	.	-	40	31	15
		SG-3/4		SG-3/4		SG-3/4													
SG-4	Coho	0	-	12	-	0	1	0	12	1	1	17	-	0	-	-	107	116	61
	0+SH	N/A	-	N/A	.	N/A	6	20	26	7	27	6	.	4	-	.	64	19	121
	1+SH	N/A	.	N/A	.	N/A	16	5	19	1	5	6	.	8	.	.	14	0	7
	Total SH	47	.	11	.	36	22	25	45	8	32	12	-	12	-	.	78	19	128

N/A: Data on year class is not available.

- : Years or sites within years which were not sampled.

Table 2. Average Densities in Fish per 30 meters at All Sites Sampled in a Given Year.

Steelhead

Lagunitas Creek		Devil's Gulch		San Geronimo Creek	
Year	Fish/30m	Year	Fish/30m	Year	Fish/30m
1970	41	1970	24	1970	47
1980	37	1980	86	1980	37
1982	64	1982	59	1982	70
1983	26	1983	52	1983	22
1984	45	1984	35	1984	25
1985	60	1985	43	1985	45
1986	63	1986	55	1986	8
1987	73	1987	15	1987	32
1988	61	1988	15	1988	12
1990	62	1990	11	1990	12
1993	52	1993	60	1993	72
1994	109	1994	24	1994	22
1995	63	1995	97	1995	77

Coho

Lagunitas Creek		Devil's Gulch		San Geronimo Creek	
Year	Fish/30m	Year	Fish/30m	Year	Fish/30m
1970	0	1970	78	1970	0
1980	3	1980	42	1980	16
1982	1	1982	7	1982	2
1983	1	1983	9	1983	1
1984	1	1984	20	1984	0
1985	2	1985	0	1985	12
1986	0	1986	4	1986	1
1987	1	1987	19	1987	1
1988	5	1988	44	1988	17
1990	2	1990	5	1990	0
1993	1	1993	43	1993	37
1994	41	1994	59	1994	54
1995	8	1995	24	1995	21

Table 3. Statistical Analysis Comparing Fish Densities Pre and Post Management.

Question 1. Was there a significant difference in populations from the implementation of D-1582?

Figure 1.	1970-1982	n=3		1983-1995	n=10		
Steelhead	Mean	95% Confidence Interval		Mean	95% Confidence Interval		P Value
		Lower	Upper		Lower	Upper	
Lagunitas Creek	47.3	11.13	85.53	61.4	46.28	76.51	0.31
Devil's Gulch	56.3	-20.98	133.56	40.7	21.63	59.77	0.41
San Geronimo Creek	51.3	9.3	93.37	39.7	15.16	50.24	0.25
Figure 2.							
Coho Salmon	Mean	95% Confidence Interval		Mean	95% Confidence Interval		P Value
		Lower	Upper		Lower	Upper	
Lagunitas Creek	1.3	-2.46	5.13	6.2	-2.71	15.11	0.53
Devil's Gulch	42.3	-45.86	130.52	22.7	8.45	36.95	0.23
San Geronimo Creek	6	-15.66	27.66	14.4	1.15	27.65	0.47

Question 2. Was there a significant difference in populations when limiting factors were addressed?

Figure 3.	1970-1990	n=10		1993-1995	n=3			
Steelhead	Mean	95% Confidence Interval		Mean	95% Confidence Interval			P Value
		Lower	Upper		Lower	Upper		
Lagunitas Creek	53.2	42.51	63.87	74.67	-0.45	149.7		0.11
Devil's Gulch	39.5	22.26	56.73	60.3	-30.34	151.04		0.26
San Geronimo Creek	31	15.66	44.86	57	-18.55	132.55	kW	0.1
Figure 4.								
Coho Salmon	Mean	95% Confidence Interval		Mean	95% Confidence Interval			P Value
		Lower	Upper		Lower	Upper		
Lagunitas Creek	1.6	0.52	2.7	16.7	-36.4	69.73		0.12
Devil's Gulch	22.8	5.09	40.51	42	-1.53	85.53		0.24
San Geronimo Creek	5	-0.04	10.04	37.3	-3.66	78.33		0.0003

Note: Parametric ANOVA was used excepted were noted KW, when a non-parametric Kruskal Wallis test was used.

Table 4. Comparison of 1993, 1994 and 1995 Population Estimates

Lagunitas Creek - Segment 2 - Tocaloma Reach

	1993*	1994*	1995**	
Type	w/o Habitats	w/o Habitats	w/o Habitats	w/ Habitats
0+SH	16,426	22,265	14,130	13,624
1+SH	164	1,692	844	812
Coho	0	2,565	377	299

Lagunitas Creek - Segment 3 - State Park Reach

	1993*	1994*	1995**	
Type	w/o Habitats	w/o Habitats	w/o Habitats	w/ Habitats
0+SH	13,576	21,271	9,976	9,581
1+SH	82	1,653	880	850
Coho	82	17,606	2,875	2,387

San Geronimo Creek - Segment 1

	1993*	1994*	1995**	
Type	w/o Habitats	w/o Habitats	w/o Habitats	w/ Habitats
0+SH	9,285	853	7,930	6,642
1+SH	95	429	292	297
Coho	189	521	49	54

San Geronimo Creek - Segment 2

	1993*	1994*	1995**	
Type	w/o Habitats	w/o Habitats	w/o Habitats	w/ Habitats
0+SH	4,873	1,537	6,644	2,807
1+SH	1,054	922	360	167
Coho	4,697	6,629	2,946	1,232

Devil's Gulch

	1993*	1994*	1995**	
Type	w/o Habitats	w/o Habitats	w/o Habitats	w/ Habitats
0+SH	4,079	1,360	6,549	6,484
1+SH	101	327	67	39
Coho	2,820	4,029	1.510	1,192

*1993 and 1994 estimates based on extrapolations from average density per channel length.

**1995 estimates based on extrapolations from average density within a habitat type extrapolated to length of that habitat type in the stream reach.

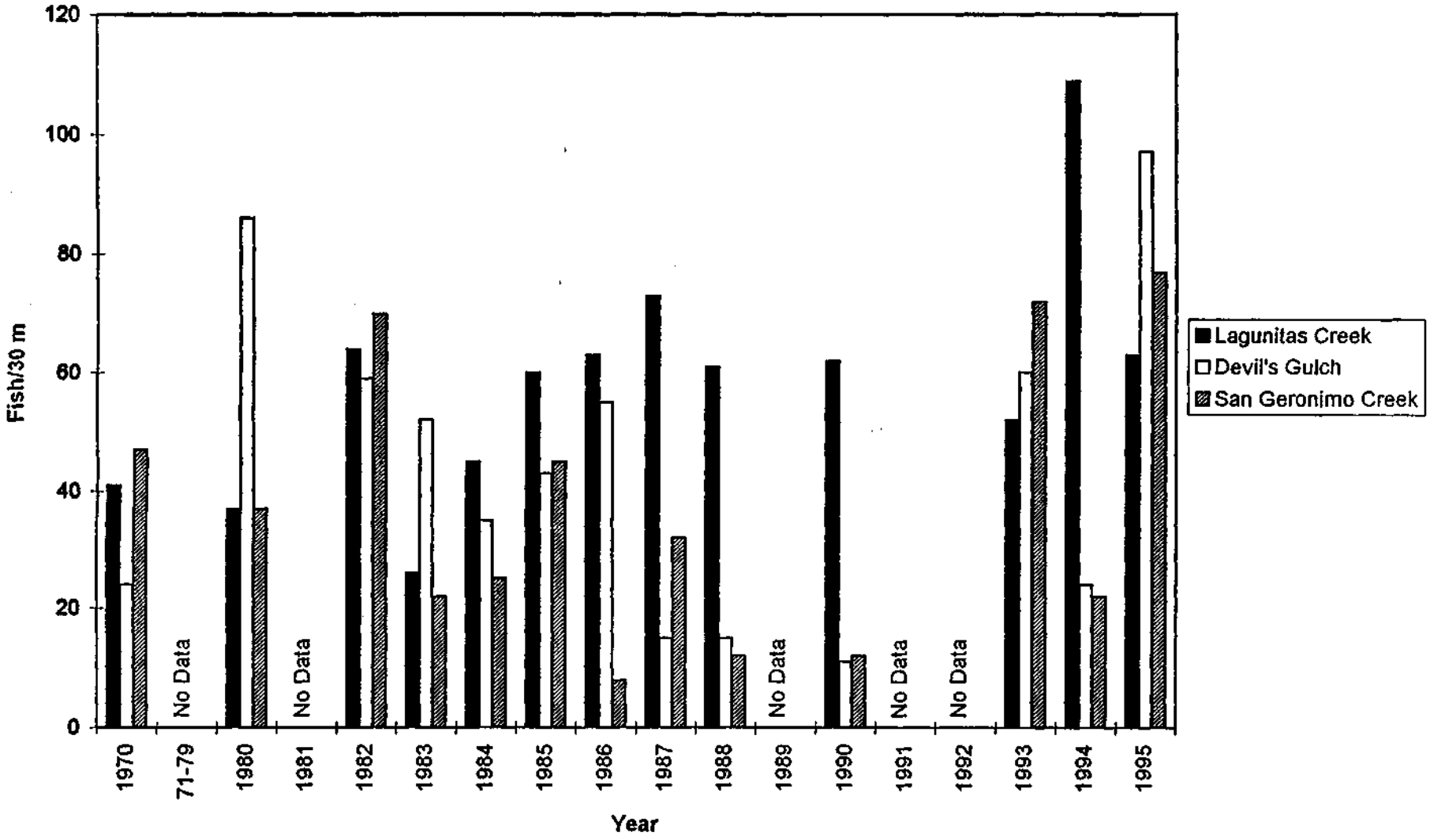

Figure 1. Steelhead Abundance in Lagunitas Creek, Devil's Gulch and San Geronimo Creek by Year

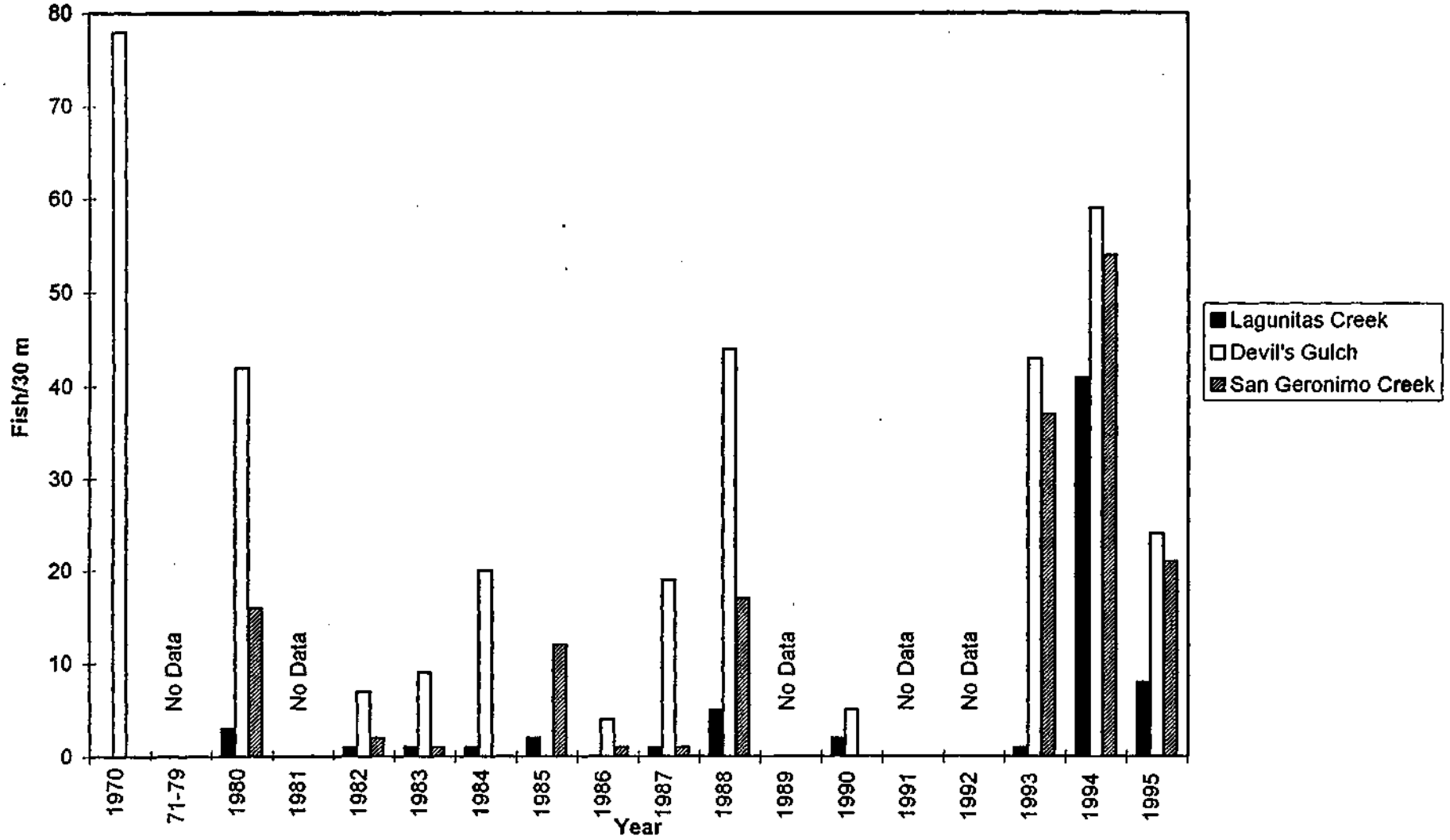

Figure 2. Coho Abundance in Lagunitas Creek, Devil's Gulch and San Geronimo Creek by Year

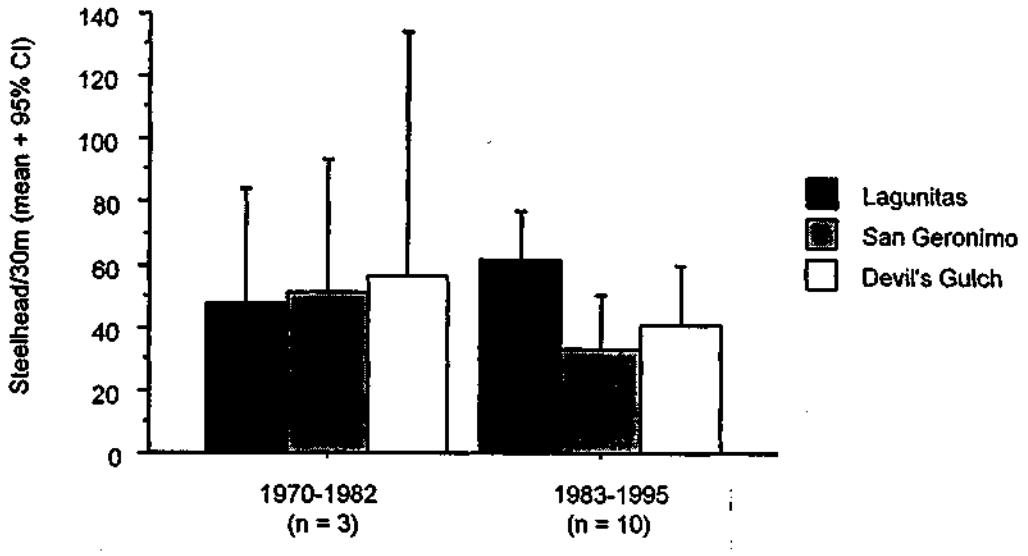

Figure 3. Comparison of the Steelhead Densities in Lagunitas Creek, San Geronimo Creek, and Devil's Gulch Before and After Implementation of D-1582.

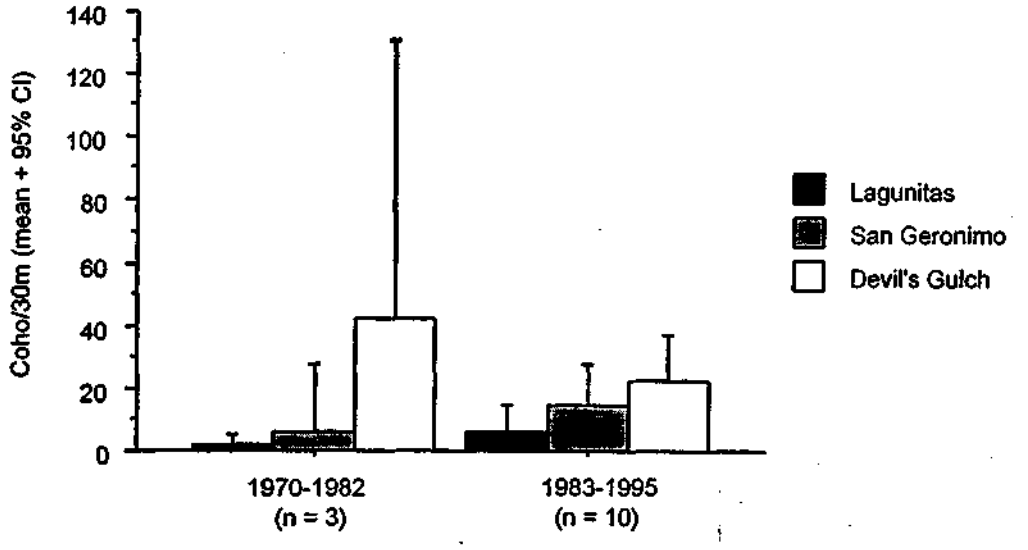

Figure 4. Comparison of the Coho Densities in Lagunitas Creek, San Geronimo, and Devil's Gulch Before and After Implementation of D-1582.

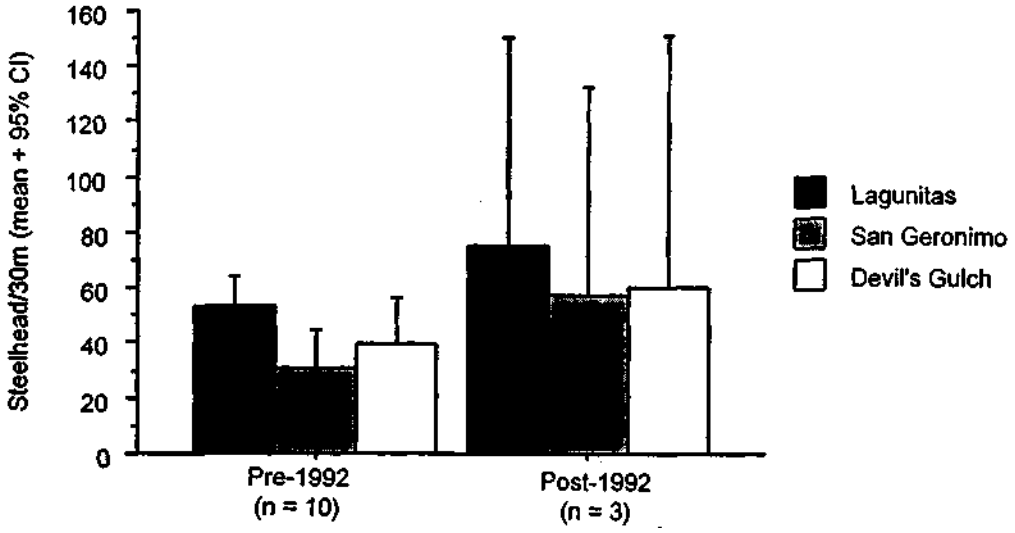

Figure 5. Comparison of the Steelhead Densities in Lagunitas Creek, San Geronimo Creek and Devil's Gulch Before and After Habitat Improvements Addressing Limiting Factors.

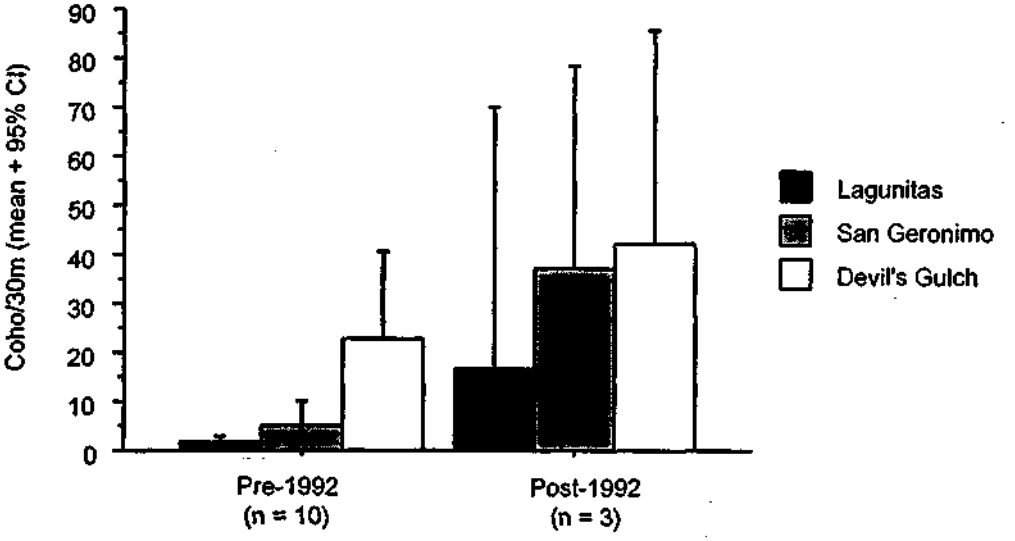

Figure 6. Comparison of the Coho Densities in Lagunitas Creek, San Geronimo Creek and Devil's Gulch Before and After Habitat Improvements Addressing Limiting Factors.

4.2. Habitat Composition

We found that in 1995 the habitat composition of the fish sampling sites was representative of the habitat composition of the stream or stream segment. For example, the amount of pool habitat sampled in Devil's Gulch, Lower San Geronimo Creek and Lagunitas Creek was nearly equal to the amount of pool habitat found in the survey of these reaches. It should be noted, however, that there is some indication from the DFG data sheets that the habitat composition within individual sites has changed over the years. Habitat changes may in part be due to different observers and due to the refinement of habitat typing methods during the study period. No quantitative differences are reported here because of the uncertainty of the consistency among years and because the habitat types were not recorded on the data sheets in most years. Pool habitat may have been undersampled in past years. Pool habitat units were added to the sample universe in 1994 and 1995.

Because juvenile coho salmon preferentially use pool habitat, but juvenile steelhead are typically found in all habitat types, over or under-sampling pool habitat in a given stream or stream segment may over- or under-estimate coho salmon abundance. It would likely have a lesser effect on young-of-the-year steelhead. However, older juvenile steelhead may be under-estimated since they also preferentially utilize pools.

Lagunitas Creek

Lagunitas Creek between the Green Bridge (Highway 1) and the Shafter Bridge is approximately 56,600 feet (10.7 miles) in length. Within this 10.7 miles there are three identified stream segments.

Segment 1 extends from Highway 1 upstream to Nicasio Creek, a distance of approximately 3.5 miles. Segment 1 has not been habitat surveyed. Fish sampling Sites 1 and 2 are located in this segment. In 1994 and 1995, field observations indicated that Site 1 did not reflect the overall habitat in Segment 1. Site 1 contained 74% pool, 9% riffle,

and 17% run. Also, the stream reach containing Site 1 was modified to reduce flooding of an adjacent pasture. This modification occurred between the 1993 and the 1994 fish population surveys. The original habitat composition of Site 1 before the modification is unknown. The habitat composition of Site 2 is unknown. Much of the habitat in Segment 1 is composed of long, wide and deep pools. These areas are not only difficult to sample using conventional backpack electrofishing methods, but are not typically represented by Site 1.

Segment 2 extends from the confluence of Nicasio Creek upstream to the confluence with Cheada Creek, a distance of approximately 2.5 miles. This segment consists of approximately 40% pool, 15% riffle, and 45% run (Figure 7). This segment is represented by electrofishing Sites 3 through 6. In 1995, the combined habitat composition of Sites 3 and 5 was approximately 33% pool, 16% riffle, and 51% run (Figure 8). The habitat composition of Sites 4 and 6 is unknown because they were not habitat typed when sampled and their exact locations are unclear. Based on the 1992 habitat survey data, pool habitat in this reach was slightly under-represented from 1993 through 1995.

Segment 3 extends from the downstream State Park boundary upstream to Shafter Bridge, a distance of approximately 4.7 miles. This segment consists of approximately 46% pool, 12% riffle, and 42% run (Figure 9). This segment is represented by electrofishing Sites 7 through 12. Habitat composition data is not available for Sites 8, 10, and 11. The habitat composition of Sites 7, 9, 12 and 15.86, sampled in 1994, was approximately 30% pool, 18% riffle, and 52% run. The combined habitat composition of Sites 9, 12 and 15.86, sampled in 1995, was approximately 54% pool, 20% riffle, and 26% run (Figure 10). In 1995, Site 7 was not sampled and an additional pool was added to Site 9. Pool habitat was slightly over-represented in the 1995 sampling.

Devil's Gulch

Habitat composition in Devil's Gulch Creek was surveyed in 1995 from Sir Francis Drake Blvd. to near the State Park boundary, a distance of approximately 1.5 miles. The lower 475 feet of Devil's Gulch Creek is primarily bedrock cascade and is atypical of the rest of the creek and was not represented in the fish population sampling sites. The habitat composition of the other 6,925 feet was 27% pool, 45% riffle, and 28% run (Figure 11). In 1995, the habitat composition of the two electrofishing sites DG-1 and DG-2 (formally Sites 13 and 15) was 27% pool, 30% riffle, and 43% run (Figure 12). In 1995, pool habitat was not under-represented in Devil's Gulch, but riffle habitat was under-represented and run habitat was over-represented.

San Geronimo Creek

Habitat composition in San Geronimo Creek was surveyed in 1995 from its mouth near Shafter Bridge upstream to an impassable fish barrier near Woodacre, a distance of approximately 4 miles. The lower 4,100 feet of San Geronimo Creek (from its mouth to Lagunitas Street Bridge) was eliminated from the habitat composition percentages because it was atypical of the remainder of the creek and is not represented by the electrofishing sites. Thus, the total stream length used to report the habitat compositions approximately 3.5 miles, and that length was divided into two segments.

Segment 1 extends from the Lagunitas Street Bridge upstream to Lagunitas School, a distance of approximately 9,000 feet. This segment was approximately 30% pool, 25% riffle, and 45% run (Figure 13). This segment is represented by sample Site SG-2 (formally Site 17). In 1995, the habitat composition of this electrofishing site was approximately 30% pool, 10 % riffle, and 60% run, indicating that the sampling sites were representative of the pool habitat in the segment (Figure 14).

Segment 2 extends from Lagunitas School upstream to the impassable fish barrier in Woodacre, a distance of approximately 9,000 feet. This segment was approximately 37%

pool, 28% riffle, and 35% run (Figure 15). This segment is represented by electrofishing Sites SG-3 and SG-4 (formally Sites 18 and 19). The habitat composition of these electrofishing sites, in 1995 was approximately 89% pool, 11% riffle, and 0% run, indicating that pool habitat was over sampled (Figure 16). However, in late summer, riffle habitats are almost non-existent, with the flow going subsurface, so pools and standing runs are the only remaining features containing fish.

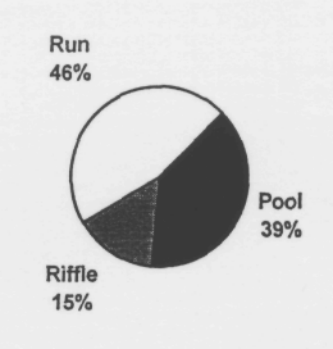

Figure 7. Percent of Habitat Types in Segment 2 of Lagunitas Creek.

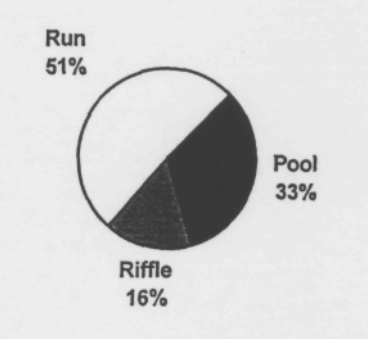

Figure 8. Percent of Habitat Types Sampled in 1995 at Sites 3 and 5 Combined.

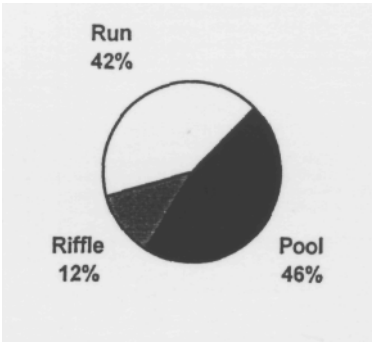

Figure 9. Percent of Habitat Types in Segment 3 of Lagunitas Creek.

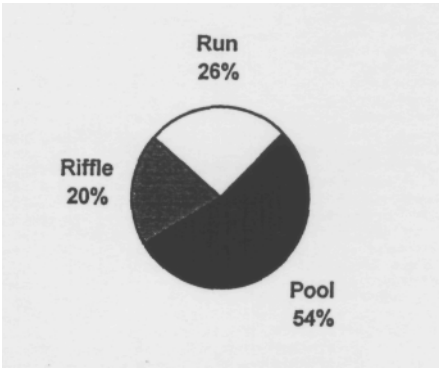

Figure 10. Percent of Habitat Types Sampled in 1995 at Sites 9, 12 and 15.86 Combined.

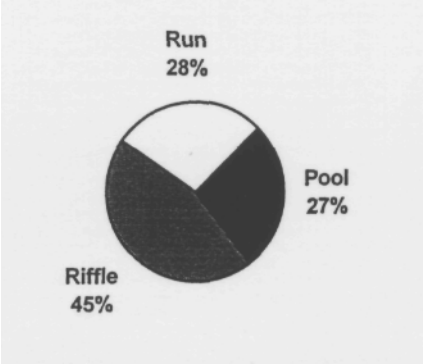

Figure 11. Percent of Habitat Types in Devil's Gulch.

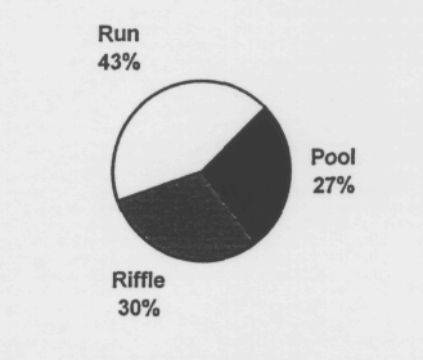

Figure 12. Percent of Habitat Types Sampled in 1995 at Sites DG-1 and DG-2 Combined.

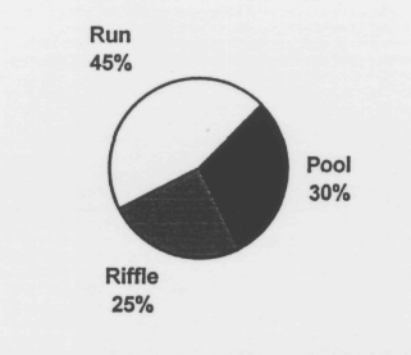

Figure 13. Percent of Habitat Types in Segment 1 of San Geronimo Creek.

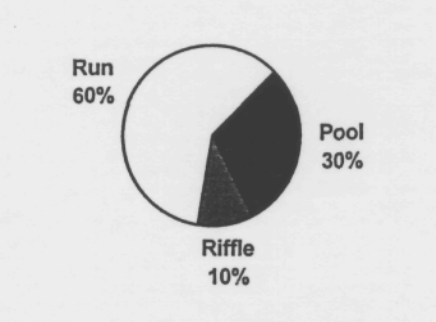

Figure 14. Percent of Habitat Types Sampled in 1995 at Site SG-2.

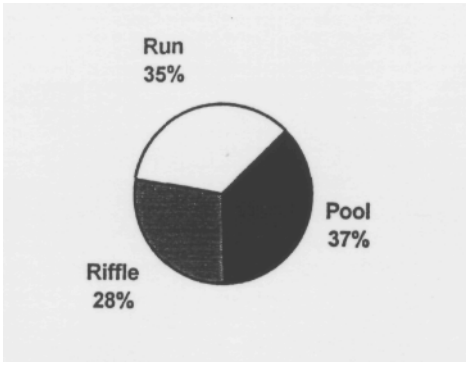

Figure 15. Percent of Habitat Types in Segment 2 of San Geronimo Creek.

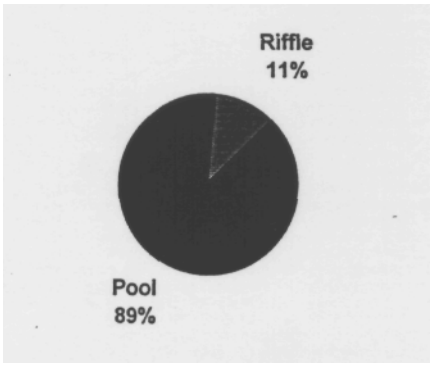

Figure 16. Percent of Habitat Types Sampled in 1995 at Sites SG-3 and SG-4 Combined.

5. Conclusions

The distribution of sampling effort over the time of surveys appears to have under sampled preferred coho salmon habitat in Lagunitas Creek. This likely under represents coho abundance data during the period of record and also may under represent age 1+ and older steelhead. This is not a problem for the tributary streams where over sampling pool habitat has occurred. This results from fall sampling when riffles are either dry or too shallow to hold fish and all the remaining fish are found in the runs and pools. In spite of these problems, the abundance estimates of coho salmon and steelhead between 1970 and 1995 appear reasonable when considering the effects of floods and droughts with life history traits of the two species.

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 likely caused scour in Lagunitas Creek resulting in low abundance of juvenile coho salmon in Lagunitas Creek. In contrast, good abundance of juvenile coho were found in the tributaries, Devil's Gulch and San Geronimo Creek. No large storm events (and no scouring flows) occurred in 1994, 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.

The effects of droughts and floods in combination with increased flow regimes or other non-flow related habitat improvements and in combination with the different life history strategies make it difficult to show a statistically significant relationship between cause and effect. However, there does appear to be recent improvements in the abundance of both steelhead and coho salmon in the Lagunitas Creek and the tributaries within the last three years. The noticed improvement in fish abundance for the last three years could be explained by the increased flow regime beginning in 1983 if population recovery lag-time is taken into consideration. Any improvements in rearing conditions should not be expected to be noticed for at least 3 years (when the beneficiaries of the improvements

return to spawn) and probably not for a minimum of 6 to 9 years (enough time for several generations to be exposed to improved conditions). Other environmental factors, which are beyond our control, such as El nino events (poor ocean rearing conditions), droughts, floods, and debris flows also affect the ability of fish populations to rebound.