

State of California
The Resources Agency
DEPARTMENT OF FISH AND GAME

FISH POPULATION SURVEY, LAGUNITAS CREEK DRAINAGE,
MARIN COUNTY, 1982

by

John W. Emig
Inland Fisheries, Region 3

Anadromous Fisheries Branch

Administrative Report No. 85-05

1985

FISH POPULATION SURVEY, LAGUNITAS CREEK DRAINAGE,
MARIN COUNTY, 1982 1/

by

John W. Emig
Inland Fisheries, Region 3

ABSTRACT

The fish populations of Lagunitas Creek and its major tributaries were surveyed by electrofishing twenty-two 30-m sections in August and September 1982. The steelhead rainbow trout, Salmo gairdneri, population was estimated at 116,691 fish (observed biomass: 44 kg/ha). Their mean size was 84.8 mm FL. Few coho salmon, Oncorhynchus kisutch, were found (estimated population was 1,505 fish; observed biomass: 11 kg/ha). California roach, Lavinia symmetricus, was second in abundance, (estimated 73,562 fish; observed biomass: 16 kg/ha). Threespine stickleback, Gasterosteus aculeatus, was found throughout the drainage (estimated 26,027 fish; observed biomass: 1 kg/ha). Sculpins, Cottus spp., were fourth in numbers, (44,222 fish) but were third in observed biomass (20 kg/ha). The Pacific lamprey, Lampetra tridentata, population was estimated at 46,883 ammocoetes (observed biomass: 7 kg/ha). Carp, Cyprinus carpio, was only 1% of the estimated fish population (4,116), but was second in observed biomass (23 kg/ha). Sacramento sucker, Catostomus occidentalis, had an estimated population of 1,177 fish and an observed density of 9 kg/ha. A few goldfish, Carassius auratus, and bluegill, Lepomis macrochirus, were collected.

The juvenile steelhead population was higher than that found in surveys made in 1970 and 1980, and the mean FL was greater than the mean FL of juveniles collected in 1979. The higher population was probably due to more substantial summer flow releases from Peters Dam (Kent Lake), favorable winter and spring runoff, a decrease of embeddedness of streambed cobble, and prohibition of fishing in most of the drainage. Steelhead populations in upper Lagunitas Creek were equivalent to forecasts made for a summer flow of 3 cfs, but populations in the lower areas were greater than

1/ Anadromous Fisheries Branch Administrative Report

No. _____ submitted _____

anticipated. Coho salmon populations were low and stocking of native strain smolts is recommended. Other recommendations include annual monitoring of the fish populations, development of riparian vegetation in areas where it is lacking, planning for erosion control measures in the watershed, annual clearance of debris jams, and continuation of the present fishing regulations.

Specific survey data for each of the 22 stations sampled are filed by the California Department of Fish and Game, Region 3 Headquarters, 7329 Silverado Trail, Yountville, CA 94599.

INTRODUCTION

Impoundments of the Lagunitas Creek drainage began in 1872 with construction of Lagunitas Dam in the headwaters. Subsequent dams on the mainstem were Alpine (1918), Bon Tempe (1948), and Peters (1954). Nicasio Dam was constructed on Nicasio Creek a major tributary in 1961. Alpine Dam was enlarged in 1942, and enlargement of Peters Dam (Kent Lake) was completed in 1983. The Marin Municipal Water District (MMWD) operates these reservoirs to supply municipal and industrial needs in eastern Marin County. Peters Dam has the greatest capacity, followed by Nicasio, Alpine, Bon Tempe, and Lagunitas (Table 1). Water is transported by pipeline from the Lagunitas Creek sources to San Rafael and other urban areas. The reservoirs eliminated salmonid spawning and nursery areas. Until 1982, only minimal flow releases were made from those reservoirs on the mainstem of Lagunitas Creek. The result has been a degradation of the coho salmon and steelhead trout resources of this highly productive stream.

Construction of an enlarged Peters Dam began in 1979. On October 1, 1979, MMWD agreed with the Department of Fish and Game to provide minimum flows of 3 cfs in summer and 10 cfs in winter of normal water years to maintain the salmon and steelhead resources. This agreement and a water rights application were reviewed by the State Water Resources Control Board. The Board decided to revise conditions relating to all water rights held by MMWD relating to Peters and Nicasio reservoirs. Decision 1582 of the Board requires winter flows of 15 cfs, late spring flows of 6 cfs, and late summer flows of 4 cfs in Lagunitas Creek. The Board based their decision on testimony presented at the hearings, as well as several reports on the resources of Lagunitas Creek prepared by the biological consultant to MMWD (Kelley 1978; Kelley and Reineck 1978; Kelley and Dettman 1980). MMWD contested the Board's decision, but in May 1982, MMWD began releases to maintain summer flows of 3 cfs in mainstem Lagunitas Creek as stated by the agreement with DFG. In subsequent years, releases have been made according to the schedule provided in Decision 1582.

This study was conducted to estimate the fish populations of the drainage as initial information on the effects of the improved flows in 1982.

TABLE 1. Impoundments of the Lagunitas Creek Drainage, Marin County

TYPE	<u>Lagunitas</u>	<u>Bon Tempe</u>	<u>Alpine</u>	<u>Kent</u>	<u>Nicasio</u>
	Earth fill	Earth fill	Concrete	Earth fill	Earth fill
CONSTRUCTION COMPLETION DATE	1872	1948	1942	1983	1961
HEIGHT: m(ft)	15.3(50)	28.7(94)	42.7(140)	68.6(225)	35.1(115)
CAPACITY: hm ³ (acre-feet)	.481(390)	5.30(4,300)	10.98(8,900)	40.1(32,700)	28.01(22,700)
STORAGE ELEVATION: m(ft)	239.1(784)	219.0(718)	197.0(646)	122.0(400)	50.3(165)
SURFACE AREA: ha(ac)	9.31(23)	52.6(130)	88.7(219)	186.2(460)	351.8(869)

STUDY AREA

Lagunitas Creek originates on the north slopes of Mt. Tamalpais, Marin County. It flows some 41 km to discharge into the southern end of Tomales Bay near Pt. Reyes Station. The maximum mean daily discharge in winter has ranged from 29 cfs during the 1976 drought to 10,600 cfs in January 1982. Usually, the winter flow maximum has been between 1200 and 3800 cfs. Summer flows have been approximately 3 cfs, with flow less than 1 cfs during the drought of 1976-77 and in October of some years. The major tributaries are Olema Creek, Nicasio Creek, Devil's Gulch Creek, and San Geronimo Creek. The entire watershed covers approximately 33,700 ha. Fish populations were assessed in the mainstem of Lagunitas Creek from Pt. Reyes Station to just below the junction with San Geronimo Creek, and in the major tributaries except for Nicasio Creek (Figure 1).

Below Peters Dam, Lagunitas Creek flows north through a narrow canyon which is part of Samuel Taylor State Park. A coast redwood, Sequoia sempervirens, and Douglas fir, Pseudotsuga menziesii, forest is the primary vegetation type in this area. The riparian zone contains willow, Salix spp.; red alder, Alnus oregona; bigleaf maple, Acer macrophilum; Oregon ash, Fraxinus oregona; and California bay, Umbellularia californica. Grassland and chaparral are found in upland areas, particularly on ridges and the drier southwest facing slopes. The State Park has high recreational use, because of its pleasant environment and its proximity to the San Francisco metropolitan area. Picnicking, camping, hiking, swimming, biking, and jogging are the major outdoor activities. Before 1982, fishing was permitted during the summer months, but present regulations prohibit all angling in Lagunitas Creek and tributaries above the Highway 1 bridge at Pt. Reyes Station. Fishing was restricted to protect juvenile salmon and steelhead in the rearing areas.

Below the northern State Park boundary, the gradient of Lagunitas Creek declines, and the stream flows through a narrow valley, which broadens as it approaches Tomales Bay. Riparian growth is dense except for areas heavily grazed by cattle. Common species are alder; willow; bay; buckeye, Aesculus californica; oak, Quercus spp.; blackberry, Rubus spp.; poison oak, Rhus diversiloba; and nettle, Urtica californica. A mixed evergreen forest replaces the redwood and fir found in the State Park area. Extensive tracts of grassland are

now
latifolia

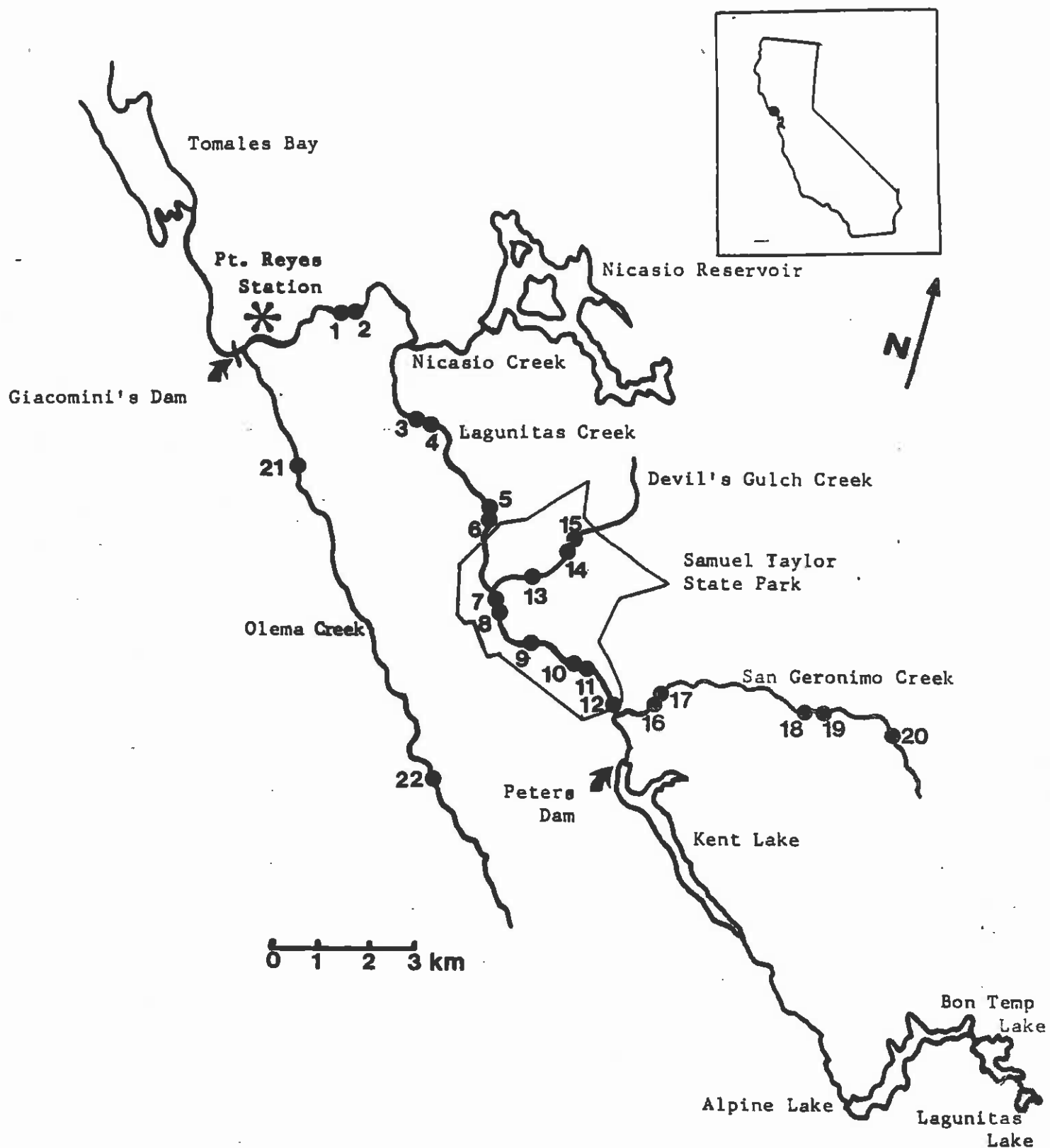


FIGURE I. Map of the Lagunitas Creek drainage, indicating reservoirs, major tributary streams, and sampling stations.

found on ridges and drier upland slopes. Although largely in private ownership, some sections of Lagunitas Creek are within lands of the Golden Gate National Recreation Area. Private lands are used primarily for cattle grazing.

The watershed of Devil's Gulch Creek is primarily within the State Park boundaries. The upland areas are vegetated by grassland and forests of fir and redwood. Bay, alder, and Oregon ash are found along the stream. The stream course is in a narrow canyon with a steep gradient. This is the only stream in the drainage where angling was prohibited for many years prior to 1982.

San Geronimo Creek originates in the northern foothills of Mt. Tamalpais, and flows through a small, linear valley before joining with Lagunitas Creek just below Peters Dam. Willow, alder, bay, and oak are the major riparian species, and the upland areas range from grassland and chaparral on the south facing slopes to mixed evergreen forest on the north facing slopes. Several small towns (Woodacre, San Geronimo, and Lagunitas) are located in the valley and urban development has spread into wooded uplands. A major bedrock outcrop occurs on San Geronimo Creek just above its junction with Lagunitas Creek. Although the stream has formed several large pools in the rock (locally called the "Inkwells"), and salmonids are able to migrate past this obstruction at most flows, they have had difficulties in past years. Roy's Dam in San Geronimo was also a major barrier until 1956, when the Department of Fish and Game constructed a pool and weir fishway to pass salmon and steelhead during spawning migrations. Although functioning, the fishway is of an obsolete design and degradation of the channel below the dam has impaired the ability of fish to locate the fishway. Several other minor migration barriers are caused by road crossings between San Geronimo and Woodacre.

Olema Creek is fed by many small tributaries from canyons on Bolinas Ridge. The stream flows in a northwesterly direction through a narrow valley formed by the San Andreas Rift Zone. The upper watershed is a steep and narrow canyon. The valley and southwest facing slopes are primarily grazing pasture. Northeast slopes are within the Point Reyes National Seashore, and are vegetated by an extensive conifer forest. Vegetation growth along the stream is dense in areas and consists of willow, alder, blackberries, and other typical riparian species.

Public highways are found along San Geronimo, Lagunitas, and Olema creeks, permitting ready access to the streams.

METHODS

Twenty-two stations were selected on Lagunitas Creek and major tributaries (Figure 1). Most of these stations were at the sites where salmonid populations were assessed in 1970 (Coots 1970) and 1980 (Anderson 1980). Coots (1970) sampled 30 m sections, and Anderson (1980) sampled varying lengths of stream section (35-m to 84-m). The 1982 survey used 30-m study sections, with two adjacent stream sections in areas where sections from 53-m to 84-m were sampled by Anderson (1980). Study stations in mainstem Lagunitas Creek were grouped into lower (Stream type 1) and upper (Stream type 2) sections, because of differences in gradient, streambed composition, and riparian habitat. Stream type 1 comprises the area from Giacomini's dam upstream to the State Park boundary (12.4 km) and Stream type 2 is the area from the State Park boundary to below Kent Dam (6.2 km).

The survey method used was the same as reported by Price and Geary (1979) for fish population estimates of streams in the Big Sulphur Creek drainage, Sonoma County. Each station consisted of a 30-m section of stream which was measured and blocked with 6 mm square mesh stop nets. Within a given area, the stations were selected to include representative habitats. For example, if the area had both pools and riffles, the station was delineated to include each of these habitats in approximately the same proportion as found in the area. After placement of the stop nets, measurements were made of temperature, dissolved oxygen, conductivity, and pH. All data were recorded on forms for computer program analysis. A water sample was collected for turbidity analysis in the laboratory.

Following collection of water quality data, a back-pack electrofishing unit (Smith-Root Type 7 or XI) was used to sample the fish population. Each pass was made through the station by beginning at the downstream net and working upstream. The collected fish were identified, counted, and weights were taken by volumetric displacement. Fork length (FL) measurements were made of all steelhead and salmon, and of a sample of the nongame species. A second pass was made with approximately the same effort as the first pass. If the total number of fish taken on the second pass exceeded the maximum necessary for estimating the population within 10% with a 95% confidence interval, a third pass

was made. The population of each species was estimated by one of three methods: (i) summing the totals of the passes, (ii) the method of Seber and LeCren (1967) for two-pass stations, or (iii) the Leslie method (Ricker 1975) for three-pass stations.

After completion of electrofishing, stream widths and depths were measured to characterize the stream habitat. Width measurements were made perpendicular to the flow at each 3 m along the length of the station. At each width transect, the stream depth was measured at the quarter, half, and three-quarter points. Fish cover, streamflow, streambed composition, the pool-riffle-run ratio, and the canopy were estimated. Streamflow measurements at the stations were made with Gurley pygmy meters or a Marsh-McBirney direct reading meter. Station elevations were determined with USGS topographic maps. Photos were taken to record each station with 35 mm slides.

A more detailed description of the sampling methodology is presented by Price and Geary (1979).

RESULTS AND DISCUSSION

In addition to steelhead and coho salmon, the Lagunitas Creek drainage was found to contain Pacific lamprey, California roach, threespine stickleback, sculpin, carp, goldfish, and Sacramento sucker. All except carp and goldfish are common residents of coastal streams. These two species were found in the slower flowing section below Nicasio Reservoir, and probably entered the stream with spillway overflows. Largemouth bass, Micropterus salmoides, are found in the reservoirs and have been collected in the lower area, but were not taken in this survey. Sculpin were difficult to identify and this group was not separated by species.

Estimates of the total population and biomass for each species in the drainage are shown (Tables 2, 3). The steelhead population was highest (116,691), followed by roach (73,562), lamprey (46,883), sculpin (44,222), and stickleback (26,027). Although carp were only 1% of the total fish population (4,116), they were second in observed biomass (23 kg/ha) because they were mostly larger fish. Observed steelhead biomass was the highest (44 kg/ha), followed by sculpin (20 kg/ha), sucker (19 kg/ha), and roach (16 kg/ha). Lamprey, although high in total numbers, were relatively low in biomass (7 kg/ha).

Comparisons of the observed population of salmonids with previous studies indicate an increasing population of steelhead and variable populations of coho salmon (Table 4). The improved populations of steelhead are believed due to the flow releases from Peters Dam, favorable winter and spring runoff, a decrease of embeddedness of streambed cobble (Hecht 1983), and prohibition of fishing in the stream above the Highway 1 crossing near Pt. Reyes Station. The low values for coho salmon in 1982 are believed due to a low population of adult spawners and disruption of spawning by a major storm which occurred in early January 1982. Record precipitation occurred in a 24-hour period and resulted in extremely high flows in the streams of the Lagunitas drainage. The peak flow at the U. S. Geological Survey gauge in lower Lagunitas Creek was estimated at 22,000 cfs on January 4, 1982 (Hecht 1983). The low coho population could also be an artifact of sampling. Electrofishing is less effective in deep pools, which are the preferred habitat of coho salmon. This could produce an underestimation of the coho salmon population.

Mean fork lengths of fish species collected in the Lagunitas drainage are shown (Table 5). All lampreys were ammocoetes with a mean FL of 108.4 mm. Coho salmon ($\bar{x}$ FL = 77.3 mm) and steelhead rainbow trout

TABLE 2. Fish Populations in the Lagunitas Creek Drainage, Marin County, 1982. Drainage Length: 43,500m.

Stream population estimate

<u>Species</u>	<u>Lagunitas Creek</u>	<u>Devil's Gulch Creek</u>	<u>San Geronimo Creek</u>	<u>Olema Creek</u>	<u>Total</u>	<u>Percent</u>
Pacific lamprey	40,469	0	4,420	1,994	46,883	15
Coho salmon	447	635	423	0	1,505	0
Steelhead trout	36,336	7,635	17,420	55,300	116,691	37
Goldfish	138	0	0	0	138	0
Carp	4,116	0	0	0	4,116	1
California roach	37,062	0	15,230	21,270	73,562	23
Sacramento sucker	1,177	0	0	0	1,177	0
Threespine stickleback	7,781	0	526	17,720	26,027	8
Bluegill	0	0	0	222	222	0
Sculpin	19,322	3,869	1,700	19,321	44,222	14
TOTAL					314,543	

-11-

TABLE 3. Observed Fish Biomass Densities in the Lagunitas Creek Drainage, Marin County, 1982.
Drainage Length: 43,500 m.

Species	Biomass density in kg/ha				Percent
	Lagunitas Creek	Devil's Gulch Creek	San Geronimo Creek	Olema Creek	
Pacific lamprey	10	0	4	1	5
Coho salmon	0	3	1	0	0
Steelhead trout	27	50	59	94	25
Goldfish	1	0	0	0	1
Carp	42	0	0	0	33
California roach	8	0	37	36	10
Sacramento sucker	34	0	0	0	13
Threespine stickleback	0	0	0	4	1
Bluegill	0	0	0	1	0
Sculpin	21	17	10	40	12
TOTAL				381	3,166

TABLE 4. Comparison of Juvenile Coho Salmon and Steelhead Populations, Lagunitas Creek Drainage, Marin County, 1982.

Stream station	Observed number of fish per 30-m		
	1970	1980	1982 ^{1/}
Lagunitas 1, 2 (Gallagher Ranch)			
Coho salmon	0	0	0
Steelhead	19	77	13
Lagunitas 3, 4 (Zanardi Ranch)			
Coho salmon	0	1	0
Steelhead	0	13	35
Lagunitas 5, 6 (Jewell)			
Coho salmon	0	5	3
Steelhead	91	13	37
Lagunitas 7, 8 (Taylor Corral)			
Coho salmon	--	24	1
Steelhead	--	54	69
Lagunitas 9 (Campground Bridge)			
Coho salmon	0	0	0
Steelhead	32	74	72
Lagunitas 10, 11 (Irving Bridge)			
Coho salmon	0	8	0
Steelhead	74	23	31
Lagunitas 12 (Shafer Bridge)			
Coho salmon	--	--	0
Steelhead	--	--	53
Devils Gulch 13 (½ mile upstream)			
Coho salmon	--	--	10
Steelhead	--	--	56
Devils Gulch 14, 15 (1 mile upstream)			
Coho salmon	78	42	3
Steelhead	24	86	61
San Geronimo 16, 17 (Lagunitas)			
Coho salmon	0	19	4
Steelhead	47	63	85
San Geronimo 18, 19 (San Geronimo)			
Coho salmon	0	12	0
Steelhead	47	11	35
San Geronimo 20 (Woodacre)			
Coho salmon	17	90	1
Steelhead	25	74	27
Olema Creek 21 (Olema)			
Coho salmon	0	0	0
Steelhead	22	17	40
Olema Creek 22 (Stewart Ranch)			
Coho salmon	0	19	0
Steelhead	1	121	197
TOTALS			
Coho salmon	95	220	22
Steelhead	382	626	861
Combined	477	846	883
MEAN			
Coho salmon	8.6	18.3	1.6
Steelhead	34.7	52.2	61.5
Combined	43.4	70.5	63.0
Sampling sites	11	12	14

^{1/}To be comparable with the data for 1970 and 1980, the values reported are for fish collected on two passes through each station.

TABLE 5. Stream Fish Length Report, Lagunitas Creek Drainage, Marin County, 1982. Entire Drainage ^{1/}

Species	Total collected	Sample size for length	Mean length (mm)	Standard deviation	Length range (mm)
Pacific lamprey	1232	59	108.4	17.1	55-132
Coho salmon	30	30	77.3	6.9	62-91
Steelhead trout	1394	1394	81.6	24.2	51-283
Goldfish ^{2/}	2	2	209.0	-	204-214
Carp	53	31	249.5	15.2	219-288
California roach	686	356	72.7	27.3	16-136
Sacramento sucker	16	16	292.9	89.7	173-500
Threespine stickleback	205	87	38.0	5.8	21-51
Bluegill ^{2/}	1	1	90.0	-	90
Sculpin	535	387	86.0	32.9	32-190

^{1/} Drainage length = 43,500 m.

^{2/} Less than seven observations, only the mean was computed.

($\bar{x}$ FL = 81.6 mm) were primarily juveniles. Goldfish ($\bar{x}$ FL = 209.0 mm), carp ($\bar{x}$ FL = 249.5 mm) and suckers ($\bar{x}$ FL = 292.9 mm) were adults. Other nongame species were roach ($\bar{x}$ FL = 72.7 mm), stickleback ($\bar{x}$ FL = 38.0) and sculpin ($\bar{x}$ FL = 86.0 mm) which ranged from juveniles to adults. The one bluegill taken was 90 mm FL.

Lagunitas Creek

Steelhead rainbow trout were found throughout the stream, but the population was higher in the upper reaches. The total population of steelhead was 36,336 fish, with an observed biomass of 27 kg/ha (Table 6, 7). Pacific lamprey were extremely common, being highest in numbers (40,469 fish), although fifth in observed biomass (10 kg/ha). They were most abundant in the lower section of the stream. Coho salmon were next to lowest in numbers (447 fish), and were found primarily near the northern State Park boundary. Anderson (1980) reported most coho salmon near the mouth of Devil's Gulch Creek, but only one was found in this area. Carp provided the greatest biomass of any species in the stream (estimated 4,116 fish; observed biomass: 42 kg/ha). They were found only at Stations 1 and 2 near Gallagher's Ranch. Suckers were collected primarily at Station 10 in the upper section, near Irving Bridge. Roach and threespine stickleback were taken throughout the stream, with highest concentration at Stations 3 and 4 near Zanardi's Ranch. Sculpin were common residents at all stations sampled.

The mean FL of juvenile steelhead was 84.8 mm (Table 8). They were larger in 1982 than in 1979. Kelley and Dettman (1980) reported the mean FL of the 1979 juveniles as 66 mm, and note that the 1979 juvenile steelhead population was influenced by planting of 30,000 fingerlings from the DFG Mad River Hatchery on July 3. These fish, which comprised most of those sampled in 1979, were of a small size and may not have been adapted to Lagunitas Creek as well as the natural population present there in 1982. The mean flow in summer 1979, was approximately 1 cfs less than the flow in 1982. Most of the 1982 steelhead were less than 100 mm FL (Figure 2).

Kelley and Dettman (1980) forecasted the juvenile steelhead population in Lagunitas Creek at various flows. For the section from San Geronimo Creek to Jewel (5,907 m), they estimated that there would be 17,173

TABLE 6. Fish Populations in Mainstem Lagunitas Creek, Marin County, 1982. Stream Lengths: Stream Type 1, 12,400 m; Stream Type 2, 6,200 m.

Species	Stream type population estimates				Total	Percent
	1	2	Mean	SD		
Pacific lamprey	36,984	3,485	20,234	16,749	40,469	28
Coho salmon	413	34	224	189	447	0
Steelhead trout	18,679	17,657	18,168	511	36,336	25
Goldfish	138	0	69	69	138	0
Carp	4,116	0	2,058	2,058	4,116	3
California roach	32,908	4,154	18,531	14,377	37,062	25
Sacramento sucker	786	391	588	197	1,177	1
Threespine stickleback	6,545	1,236	3,891	2,655	7,781	5
Sculpin	13,533	5,799	9,666	3,867	19,332	13
TOTAL					146,858	

TABLE 7. Observed Fish Biomass Densities in the Lagunitas Creek Drainage, Marin County, 1982.
Stream Length: Stream Type 1, 12,400 m; Stream Type 2, 6,200 m.

Species	Stream type densities in kg/ha			Total	
	1	2	Mean	kg	Percent
Pacific Lamprey	18	2	10	147	7
Coho salmon	1	0	0	4	0
Steelhead trout	22	32	27	259	12
Goldfish	3	0	1	24	1
Carp	84	0	42	1031	47
California Roach	12	4	8	92	4
Sacramento Sucker	56	13	34	413	19
Threespine stickleback	1	0	0	5	0
Sculpin	18	24	21	269	10
TOTAL				2,185	

TABLE 8. Stream Fish Length Report, Lagunitas Creek Drainage, Marin County, 1982. Lagunitas Creek ^{1/}

Species	Total collected	Sample size for length	Mean length (mm)	Standard deviation	Length range (mm)
Pacific lamprey	615	40	109.1	16.8	65-130
Coho salmon	7	7	86.7	2.2	84-91
Steelhead trout	684	684	84.8	19.3	57-241
Goldfish ^{2/}	2	2	209.0	-	204-214
Carp	53	31	249.5	15.2	219-285
California roach	377	167	63.9	30.4	19-131
Sacramento sucker	16	16	292.9	89.7	173-500
Threespine stickleback	115	58	36.8	5.6	21-46
Sculpin	342	220	93.0	37.5	32-190

^{1/} Stream length = 18,600 m.

^{2/} Less than seven observations, only the mean was computed.

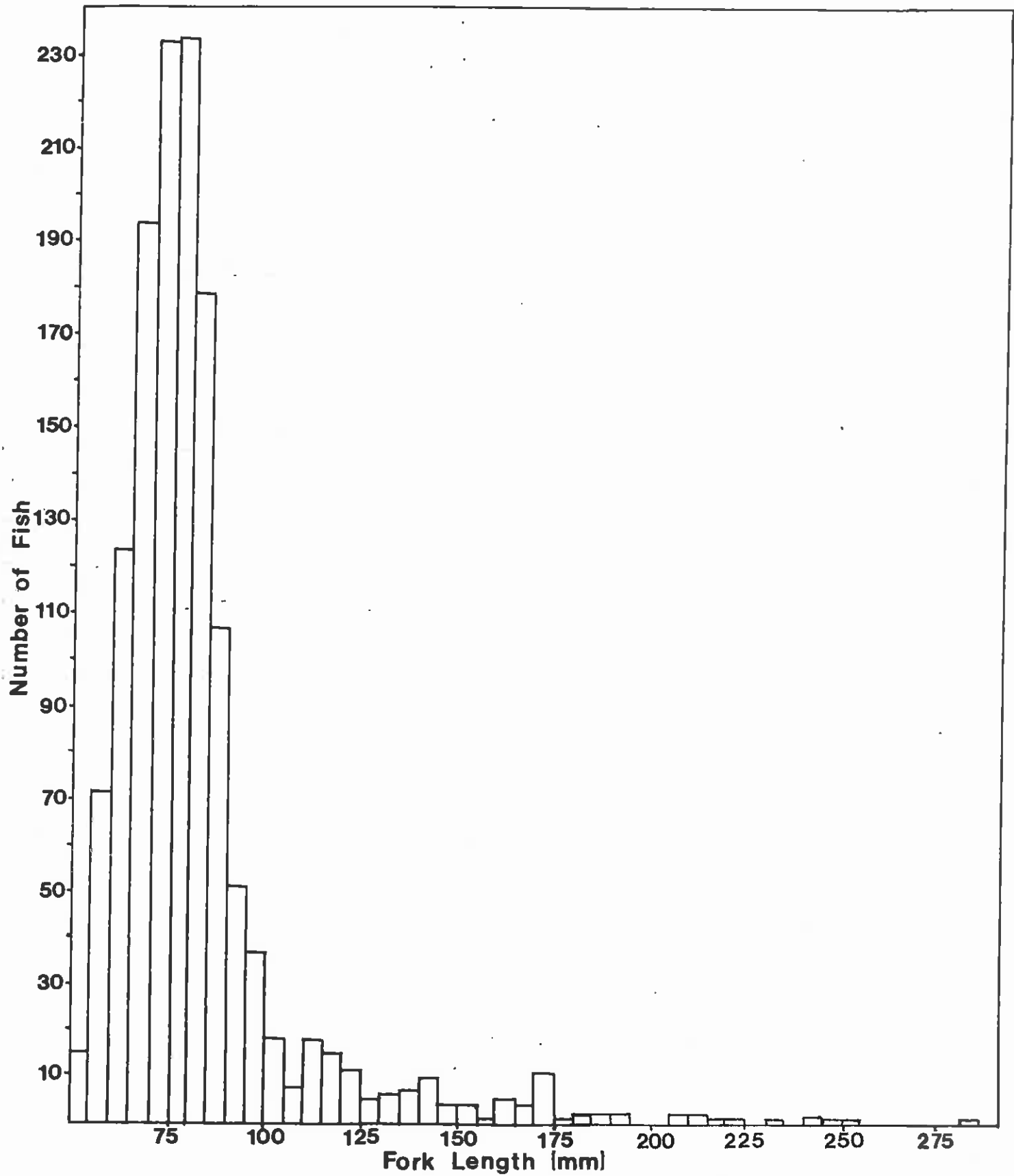


FIGURE 2. Steelhead trout fork length histogram, Lagunitas Creek, Marin County, 1982.

fish at a flow of 3 cfs. The present study findings closely agree with this figure. In the 6,200 m from the State Park boundary near Jewel to just below Peters Dam (Stream type 2), the estimated population is 17,657 young steelhead. For the lower section of Lagunitas Creek, Kelley and Dettman (1980) forecast 4,169 fish from Jewel to Nicasio Creek (5,771 m). The present study estimated 18,679 fish in a larger area (State Park boundary to Giacomini's Dam, 12,400 m). This amounts to approximately twice the production (1.51 fish/m) of that anticipated by Kelley and Dettman (.72 fish/m). Their prediction was to be valid only if substrate conditions remained the same. Data developed in other studies (Hecht 1983) indicate that there has been a decrease of embeddedness of streambed cobble since 1979. This improvement of habitat would result in a higher juvenile standing crop.

Devil's Gulch Creek

Sculpin, coho salmon, and steelhead were taken in Devil's Gulch Creek (Tables 2, 3). The steelhead population was less than that found in 1980, but substantially greater than the 1970 results (Table 4). The coho salmon population was substantially lower than in 1970 and 1980, but was higher than that found in any other stream area during this study. The steelhead population was estimated at 7,635 fish (observed biomass: 50 kg/ha). The coho population was 635 fish (observed biomass: 3 kg/ha) which would be the production of one spawning pair. The sculpin population was estimated at 3,869 fish (observed biomass: 17kg/ha). Coho averaged 72.7 mm FL, steelhead, 74.0 mm FL, and sculpin, 71.8 mm FL (Table 9). This is the only stream in the drainage where roach were not found.

San Geronimo Creek

Six species were found in San Geronimo Creek: lamprey, coho salmon, steelhead trout, California roach, threespine stickleback, and sculpin (Tables 2,3). Steelhead were highest in population (17,420) and observed biomass (59 kg/ha). Steelhead populations were improved over the 1980 results, which were superior to the 1970 population (Table 4). Coho salmon were fewest in numbers of all fish collected (estimated population, 423 fish), but had greater observed biomass (1 kg/ha) than stickleback (526 fish, 0.1 kg/ha). The lowest population of steelhead was found at Station 18 near San Geronimo, and was probably due to low dissolved

TABLE 9. Stream Fish Length^{1/} Report, Lagunitas Creek Drainage, Marin County, 1982.
Devils Gulch Creek^{1/}

Species	Total collected	Sample size for length	Mean length (mm)	Standard deviation	Length range (mm)
Coho salmon	15	15	72.7	4.7	62-80
Steelhead trout	173	178	74.0	24.1	51-253
Sculpin	84	71	71.8	11.9	59-108

^{1/} Stream length = 3,800 m.

TABLE 10. Stream Fish Length^{1/} Report, Lagunitas Creek Drainage, Marin County, 1982.
San Geronimo Creek^{1/}

Species	Total collected	Sample size for length	Mean length (mm)	Standard deviation	Length range (mm)
Pacific lamprey	608	19	106.9	17.6	55-132
Coho salmon	8	8	77.6	4.0	75-85
Steelhead trout	294	294	81.4	35.9	53-283
California roach	227	137	81.3	23.5	16-136
Threespine stickleback	10	10	37.1	2.8	32-41
Sculpin	30	23	104.5	13.4	95-141

^{1/} Stream length = 7,800 m.

TABLE 11. Stream Fish Length^{1/} Report, Lagunitas Creek Drainage, Marin County, 1982.
Olema Creek^{1/}

Species	Total collected	Sample size for length	Mean length (mm)	Standard deviation	Length range (mm)
Steelhead trout	238	238	78.6	15.8	57-167
California roach	82	52	78.5	13.0	28-115
Threespine stickleback	80	19	42.2	5.3	30-51
Bluegill	1	1	90.0	--	90
Sculpin	79	73	73.4	25.4	37-156

^{1/} Stream length = 13,300 m.

oxygen (4.4 mg/l). A debris jam between Stations 18 and 19 contained slash and other organic materials, decomposition of which probably reduced the oxygen level of the stream. California roach were second in total numbers (15,230) and in observed biomass (37 kg/ha). Roach were found primarily in the lower area of the stream and had the highest density of all tributaries in the Lagunitas drainage. Lamprey were more abundant (4,420 fish; observed biomass: 4 kg/ha) than in other tributaries to Lagunitas Creek. Neither lamprey, roach, nor stickleback were taken in the upper station near Woodacre.

Stickleback were found only in the two lowermost stations near Lagunitas, with very low biomass (0.2 and 0.6 kg/ha). Sculpin were found throughout the stream, with greatest numbers and biomass at the upper station near Woodacre (total 1,700 fish; observed biomass: 10 kg/ha).

Fish lengths of all species measured (Table 10) are comparable to other streams in the drainage.

Olema Creek

Olema Creek had the highest estimated numbers of young steelhead (55,300 fish; observed biomass: 94 kg/ha) in the Lagunitas drainage (Tables 2, 3). Nearly half of the steelhead population estimated in the Lagunitas drainage was in Olema Creek. The biomass exceeds the highest level reported for a California stream (92.2 kg/ha in Squaw Creek, Sonoma County by Price and Geary, 1979). However, only two stations were sampled, and this small sample size could have biased the results. The steelhead population is markedly improved over that found in 1970 and 1980 (Table 4).

No coho salmon were noted, just as there were none in 1970. In 1980, however, some were found at the upper station near the Stewart Ranch, and it is possible that they could have been located this year if a more extensive sampling effort were made. Sculpin were second to steelhead in biomass (19,321 fish; observed biomass: 40 kg/ha), and had the highest biomass found in Lagunitas drainage. The California roach population was comparatively high (estimated 21,270 fish; observed biomass: 36 kg/ha). Low numbers of Pacific lamprey were found. One bluegill was found at the uppermost station. Fish lengths are reported (Table 11).

CONCLUSION AND RECOMMENDATIONS

The salmonid population in Lagunitas Creek has changed since previous surveys. Juvenile steelhead are more abundant than they were in 1970 and 1980. This is attributed to increased summer flow releases from Kent Lake, favorable winter and spring runoff, a decrease of embeddedness of streambed cobble, and prohibition of fishing in most of the drainage. The coho salmon population has declined, probably because of a severe storm which occurred in early January during the salmon spawning period. Extensive movement of bedload material occurred, which would disrupt spawning activities, fill in some spawning areas with sediments, erode other spawning areas, and physically damage eggs laid in the gravels (Swanston 1980). Although the storm affected a large area, Marin County experienced the most severe impacts. Steelhead, which spawn later in the spring, escaped the more damaging effects of the storm and were able to take advantage of the habitat provided by the greater than normal runoff during spring and early summer. Summer water releases from Peters Dam added to the habitat during summer and early fall.

The following recommendations are made:

1. An allotment of 100,000 coho salmon smolts should be stocked annually for each of three consecutive years to restore the depleted salmon population. Preferably, these fish should be raised from eggs procured in the Lagunitas Creek drainage. This allotment should be in addition to the 40,000 smolts stocked as mitigation for the Nicasio Project.
2. The sampling stations should be monitored during late summer of each year to assess the effects of the new streamflow releases in Lagunitas Creek.
3. Measures should be implemented to control erosion and stream sedimentation in the Lagunitas Creek drainage.
4. Sections of Lagunitas Creek without riparian vegetation should be replanted with alders, willow, bay, and other species to reduce water temperatures during the summer months. These areas should be fenced to restrict access by cattle.

5. Debris jams should be cleared if they impede salmonid spawning migrations or if they cause low oxygen levels in the stream.

6. The present angling restrictions, prohibiting fishing in the spawning and nursery areas, should continue.

ACKNOWLEDGMENTS

R. Eugene Geary, Biologist, Pacific Gas and Electric Company, arranged for computer analysis of the data. His assistance was invaluable in preparation of this report.

Bill Cox was the crew leader for electrofishing half of the sampling stations and critically reviewed this report. Other Department of Fish and Game personnel participating in collection of data in the field were: Joyce Ambrosius, Phillip Baker, Martha Berthelsen, Anne Pomeroy, Gary Smith, and Don Ward.

Public citizens and personnel from the Golden Gate National Recreation Area who volunteered for field work were: Lawrence Arnt, Nancy Horner, Judd Howell, Duane Nakana, Richard Plant, Lani Waller, Anne West, John West, and Dana Zaccone. This study could not have been completed without their interest, enthusiasm, and willing cooperation.

Preliminary drafts of this report were cheerfully typed by Theresa Fahey and Dara Foreman.

LITERATURE CITED

- Anderson, K. R. 1980. August 1980 fish population sampling, Lagunitas Creek drainage, Marin County. Dept. Fish Game, Memorandum Rept., 6 p. (unpubl.)
- Coots, M. R. 1970. Juvenile steelhead and silver salmon population estimates, San Geronimo, Lagunitas and Olema Creeks, Marin County. Dept. Fish Game, Memorandum Rept., 8 p. (unpubl.).
- Hecht, B. 1983. Substrate enhancement/sediment management study. Lagunitas Creek, Marin County, Phase IIIb. Sediment transport and bed conditions, 1979 - 1982. Rept. to Marin Municipal Water District by HEA, 172p. + Appendix.
- Kelley, D. W. 1978. Investigations on Lagunitas Creek and Tomales Bay. Appendix 2. Aquatic Biology. Marin Municipal Water District, Focused Draft Environmental Impact Report, Raising Kent Lake, 44 p.
- Kelley, D. W. and R. C. Reineck, Jr. 1978. Relationship between streamflow and salmonid rearing habitat in Walker and Lagunitas Creeks, Marin County. D. W. Kelley, Aquatic Biologist, Rept. to Marin Municipal Water District, 19 p.
- Kelley, D. W. and D. H. Dettman. 1980. Relationships Between streamflow, rearing habitat, substrate conditions, and juvenile steelhead populations in Lagunitas Creek, Marin County, 1979. Rept. to Marin Municipal Water District, 23 p. + Appendix.
- Price, D. G. and R. E. Geary. 1979. An inventory of fishery resources in the Big Sulphur Creek drainage. Pacific Gas and Electric Company, Dept. Eng. Resear., San Ramon, CA, Rept. 420-79.2, 49 p. + Appendix.
- Ricker, W. E. 1975. Computation and interpretation of biological statistics of fish populations. Fish Res. Bd. Can. Bull. (191): 382 p.
- Seber, G. A. F., and E. D. LeCren. 1967. Estimating population parameters from catches large relative to the population. J. Anim. Ecol. 36:631-643.
- Swanston, D. N. 1980. Influence of forest and rangeland management on anadromous fish habitat in Western North America. 2. Impact of natural events. USDA Forest Service. General Technical Rept. PNW-104 27 p.