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State of California
The Resources Agency
Department of Fish and Game

MOKELUMNE RIVER FISH INSTALLATION ANNUAL REPORT FOR 1970-71 SEASON[1]/

by

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SUMMARY

This is the seventh annual report of the Mokelumne River Fish Installation. It covers the period of operation from July 1, 1970 to June 30, 1971.

Construction of the Installation was completed in 1964. The purpose of the project was to compensate for loss of spawning area and rearing area of fall-run king (chinook) salmon, Oncorhynchus tshawytscha, and steelhead trout, Salmo gairdnerii, caused by Camanche Dam.

The Installation is made up primarily of two parts: a spawning channel for natural spawning and rearing of salmon, and a hatchery for artificial spawning and rearing of steelhead trout.

From October 21 to December 31, 1970, 925 adult salmon were received at the Installation and 908 were placed in the spawning channel. By the end of the spawning season we had recovered 894 dead salmon from the channel of which 305 were females. From these an estimated 1,328,178 eggs were deposited in the gravel, and 564,670 young salmon were counted out of the channel. This is an egg-to-outmigrant survival of 42.5%.

No female salmon were artificially spawned this season.

Two hundred fifteen adult steelhead were received from October 22, 1970 to March 23, 1971. Thirty-nine females were spawned, and 167,158 eggs collected. The average number of eggs per female was 4,286. An additional 251,550 steelhead eggs were received from Nimbus Hatchery, for a total of 418,708 eggs of the 1971 brood year.

From July 1, 1970, to January 31, 1971, 152,862 fingerling steelhead from the 1970 brood year were planted in Camanche Reservoir. Then in the spring of 1971, an additional 107,972 fish of the same year class were planted in the Mokelumne River as yearlings.

1/ Anadromous Fisheries Branch Administrative Report No. 72-9. Submitted June 1972.

INTRODUCTION

This is the seventh annual report of the Mokelumne River Fish Installation and covers the period of operation from July 1, 1970 to June 30, 1971. The Installation was first operated on January 1, 1964. A summary of results of each year's salmon and steelhead operation is presented in Tables 1a and 1b.

The Installation is located on the south bank of the Mokelumne River at the base of Camanche Dam in San Joaquin County. It is about 23 miles northeast of Stockton (Figure 1). Camanche Dam is presently the upper limit of anadromous fish migration in the river. About 61 river miles downstream from the dam, the Mokelumne River enters the San Joaquin River.

The Installation was constructed to compensate for the loss of fall-run king salmon and steelhead trout spawning and rearing area which were inundated by Camanche Dam. The Installation is operated by the California Department of Fish and Game. East Bay Municipal Utility District paid construction costs and also pays the annual operating and maintenance costs.

DESCRIPTION OF INSTALLATION

A detailed description was given in the first annual report (Groh, 1965). A summary of the operation is as follows:

The Installation is made up of two parts: (1) a spawning channel for natural spawning and rearing of fall-run king salmon, and (2) hatchery and rearing pond facilities for artificial spawning and rearing of steelhead trout. Fish enter the fishway at the base of Camanche Dam and ascend to the holding pond. A mechanical sweep crowds the fish to the upper end of the pond where they are mechanically lifted and deposited in a tank of anesthetic to be sorted and counted. From there, steelhead are placed in a holding tank, salmon are released into the spawning channel, and any unwanted fish are returned to the river.

The steelhead are held until they are ready for artificial spawning. After being spawned, they are returned to the river and the eggs are hatched in incubators. When fry reach feeding stage, they are transferred to hatchery troughs for a short time after which they are moved outside to rearing ponds. The fish are held for about one year and then released into the Mokelumne River. The hatchery and pond facilities have a capacity of 100,000 yearlings.

The salmon spawning channel is 6,800 feet long by 20 feet wide at the bottom. It consists of two loops of equal length, each containing two channels with spawning sections and resting pools (Figure 2). Each loop can be operated independently. Not enough adults have been available to warrant operating both loops and only the upper loop has been used for spawning since the channel was first operated in the fall of 1964.

TABLE 1-a

King Salmon Spawning Channel Annual Summaries--
Mokelumne River Fish Installation 1964-65 through 1970-71 Seasons

Season	Number of females released in channel	Number females prespawning mortality	Potential number of eggs	Estimated egg deposition	Number of outmigrants	Estimated Percent Production	
						Of potential eggs	Of eggs deposited
1964-65	178	3	947,100	927,300	73,540	7.8	7.9
1965-66	33	1	157,043	150,883	76,435	48.7	50.6
1966-67	85	4	399,758	387,562	76,796	19.2	19.8
1967-68	93	0	490,186	487,220	177,542	36.2	36.4
1968-69	159	38	568,984	557,326	37,866	6.7	6.8
1969-70	314	77	1,183,953	1,164,430	497,130	42.0	42.7
1970-71	305	36	1,352,125	1,328,178	564,670	41.8	42.5

TABLE 1-b

Steelhead Hatchery Annual Summaries--
Mokelumne River Fish Installation 1963-64 through 1970-71 Seasons

Season	Number native fish received	Number females spawned	Number eggs taken	Number eggs from Nimbus	Total eggs	Number planted as fingerlings	Number planted as yearlings
1963-64	15	*	*	*	436,300	None	None
1964-65	30	Not recorded	55,300	315,450	370,750	163,280	92,520
1965-66	30	8	30,970	331,400	362,370	131,420	84,410
1966-67	17	3	13,524	164,600	178,125	94,520	74,630
1967-68	103	13	34,869	331,200	366,069	0	82,203
1968-69	24	4	25,580	301,240	326,820	125,760	101,207
1969-70	134	14	33,300	300,810	334,110	137,695	122,822
1970-71	215	39	167,158	251,550	418,708	152,862	107,972

* Adult steelhead from Nimbus Hatchery and Mokelumne River Fish Installation were spawned together to obtain a total of 436,300 eggs.

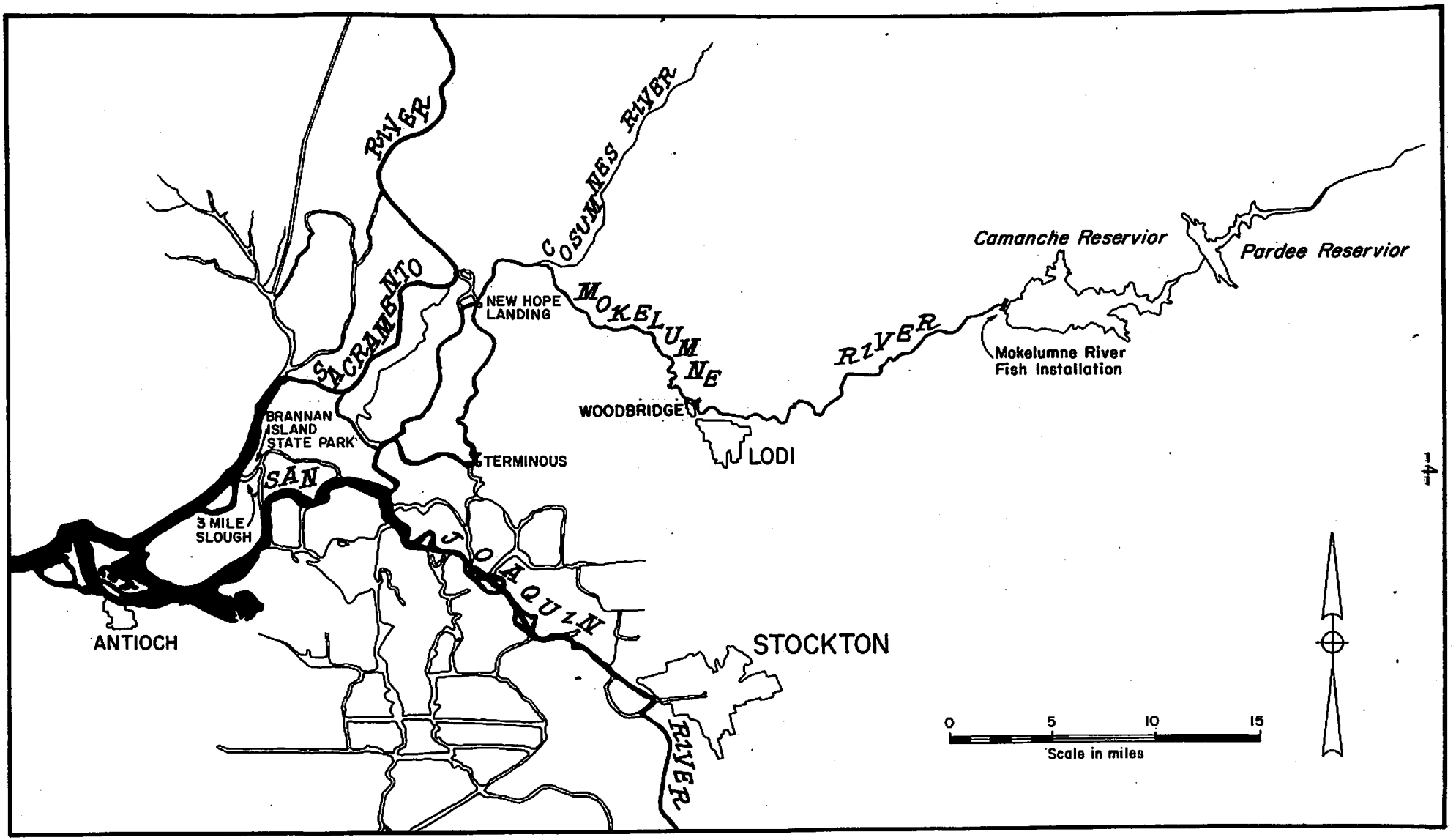

Figure 1. Map showing location of the Mokelumne River Fish Installation

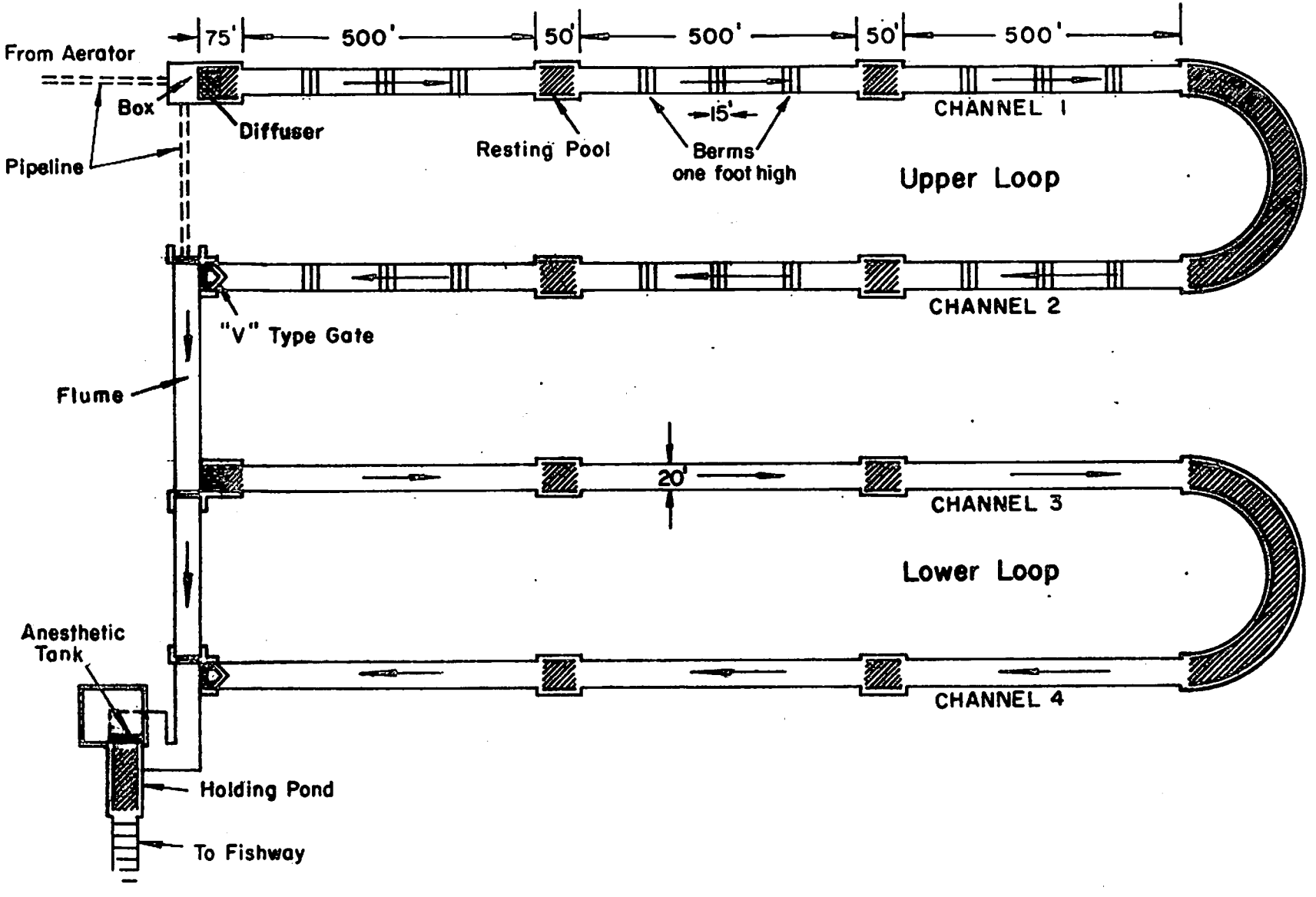

Figure 2. Diagram of the Mokelumne River Spawning Channel (not to scale).

The channel is designed to operate during spawning at a flow of 69 cfs. At this flow the average depth is 1.5 feet and the average velocity is 2 feet per second.

After spawning has been completed, water is allowed to flow through the lower loop and this section is then available for use by the young salmon. A migrant fish trap is installed at the lower end of channel four for enumeration purposes.

Aluminum bar racks, located between the holding pond and the flume leading to the spawning channel, prevent predator fish from entering the channel from the river. Another set of racks is located at the diffuser where water enters the channel to prevent predator fish from entering the channel from Camanche Lake and also to prevent escapement of out-migrants into the intake water supply.

KING SALMON MAINTENANCE PROGRAM

Spawning Season 1970 Brood Year

The spawning channel was in good condition at the start of the 1970 season; no gravel cleaning was required. The gravel berms that had been constructed for the 1968-69 season were rebuilt before the first fish was received. These berms are of uniform size, one foot higher in elevation than the channel bottom, perpendicular to the sides of the channel, 15 feet wide, and 150 feet apart. Their purpose is to curtail superimposition of redds.

On October 13, 1970, water was released into the spawning channel. The flow was maintained between 55 and 60 cfs throughout the spawning season.

Salmon were received at the Installation from October 21 through December 21, 1970. During this period 925 adult salmon were received; 908 of these were retained. Altogether 377 entered of their own volition and 548 were hauled from the trap at Woodbridge Dam. All 377 "volunteers" were given a cursory examination for condition, marks, and sex; 360 were placed in the spawning channel, and 17 unsuitable individuals were returned to the river. The 548 fish from Woodbridge Dam were unloaded directly into the spawning channel without being examined.

Carcass Recovery 1970 Brood Year

Dead salmon were removed daily. The majority were recovered near the V-trap at the lower end of channel two, and some were taken from the resting pools and the sides of the channel. All carcasses were measured and cut open for examination. The condition of the gonads was recorded, and any unspawned eggs were counted.

Of the 908 salmon retained in the spawning channel, 894 carcasses were recovered including 305 females, 578 males, and 11 of unidentifiable sex. Of the 305 females, 36 (11.8%) died without spawning.

Estimated Egg Deposition 1970 Brood Year

Length-fecundity data from 18 females sampled in the 1966 run were used to estimate the number of eggs deposited in the gravel. Data were fitted to the linear model $y = a + bx$ by the least squares method where y = number of eggs, x = fork length in inches, and a and b are constants. The regression line which represented this sample was $\hat{y} = -4,983.99 + 350.24x$. This equation was applied to the 269 females that spawned in the channel and resulted in an estimated potential of 1,352,125 eggs (Appendix A). Subtracting the unspawned eggs (23,947)[2/] gives a total estimate of 1,328,178 eggs deposited.

Downstream Migrant Production 1970 Brood Year

On January 5, 1971, the flow in the spawning channel was reduced to 12 cfs where it remained for the duration of the downstream migration season. Determination of the number of voluntary out-migrants was accomplished by screening the entire flow at the end of channel four. The screen and trap used last year were used again this year.

The screen was provided with two four-inch diameter pipes which allowed fish to pass from the channel into the trap. These pipes can be opened and closed depending on when or how many fish are to be trapped.

No recycling or retaining of king salmon fingerlings was done this year. There were 518,035 out-migrants trapped, and when the channel was shut off on June 16 the remaining 46,635 fish were seined out. This gave a season total of 564,670 migrants (Figure 3).

Weight samples of out-migrants were taken weekly. The size of the out-migrants ranged from 80 per ounce in early January to about 15 per ounce by the middle of June (Figure 3).

Two methods were used to determine numbers of out-migrants: (1) An actual count was made if the number of fish was small, and (2) fish were weighed and the number in a 16 ounce sample was counted to calculate the number of fish trapped during the period of heavy migration.

During the season 564,670 migrants were trapped, including 15,478 sac fry. This in an egg-to-out-migrant survival of 42.5%. Of the 564,670 trapped, 15,496 died from mechanical or handling causes, and 9,563 were lost to Sacramento River Chinook Disease. Thus, egg-to-out-migrants-planted survival was 539,611 fish, or 40.6%.

The out-migrants were planted in the Mokelumne River at two locations: (1) 492,976 about 1/4-mile downstream from the Installation, and (2) 46,635 at New Hope Landing.

2/ Includes only eggs left in the body cavities of those females which spawned.

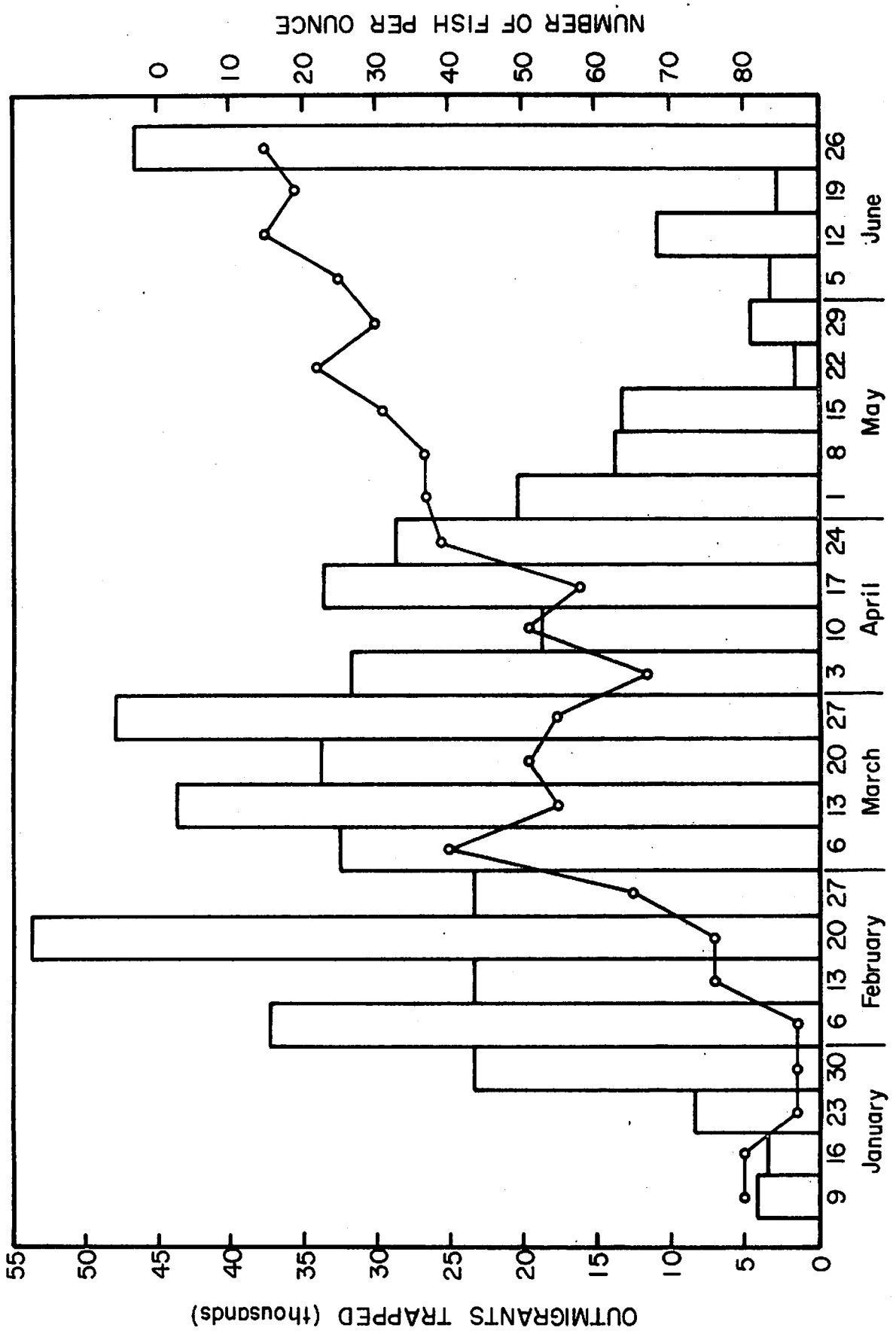

Figure 3. Numbers and size of king salmon leaving Mokelumne River Spawning Channel by weekly periods, 1970-71 season.

Mark Recoveries

There were 13 marked king salmon recoveries. The mark recovery information is summarized in the following table.

Mark	Brood year	Origin	Number released	Area released	Date released	Number 1970-71 recoveries
LV	1967	Mokelumne River Fish Installation	12,720	At hatchery	Apr. 1969	6
RV	"	"	19,039	"	May 1969	2
Ad-An	"	Feather River Hatchery	50,400	Rio Vista	Jan. 1969	3
An	"	unknown	-	-	-	1
LP	"	"	-	-	-	1

Salmon Aging

The ages of 14 adult salmon were determined from scale samples, and are summarized as follows:

Mark	Fork length (inches)	Age	Mark	Fork length (inches)	Age
LV	19.50	2	RV	26.00	3
No mark	19.75	2	LV	27.00	3
"	21.25	2	"	28.50	3
"	21.75	2	"	29.00	3
"	23.00	2	Ad-An	32.00	3
LV	23.25	3	"	33.75	3
Ad-An	25.75	3	No mark	35.00	4

Disease

Sacramento River Chinook Disease caused the death of 9,563 1970 brood year king salmon (1.7% of fingerling production). This is the second year since 1969 that SRCD has been observed at Mokelumne River Fish Installation. The diseased fish were observed in the trap. It is possible that additional mortalities occurred in the spawning channels where low SRCD losses would not be apparent. Although actual mortalities due to SRCD may be somewhat greater than 1.7%, the disease is not a serious problem. No other disease problems were noted during this report period.

STEELHEAD MAINTENANCE PROGRAM

Hatchery Operation 1971 Brood Year

The first adult steelhead this season entered the Installation on October 22, 1970, and the last on March 23, 1971. During this period 215 fish were received: 97 males and 118 females. The males averaged 23.25 inches and the females 24.00 inches fork length. Thirty-nine females were spawned and yielded 167,158 eggs; an average of 4,286 eggs per female. Seventy-nine females were too green to hold and were returned to the river unspawned. An additional 251,550 eggs were obtained from Nimbus Hatchery. This supplement was necessary to make sure that at least 100,000 yearlings would be raised.

Planting 1970 Brood Year

The 1970 brood year steelhead survived well; 334,110 eggs were obtained and 260,834 fish were planted (78.0%). As the steelhead grew the capacity of the ponds was reached and some of the fingerlings had to be removed. From September 20, 1970, to October 20, 1971, 152,862 of these fingerlings were planted in Camanche Lake. Planting dates, release sites, and size at release were as follows:

Planting of 1970 Brood Year Steelhead in Camanche Lake

Date	Number released	Size at release	Release site
9-22-70	40,004	73/lb	1/2 mile below Pardee Dam
9-23-70	64,978	53/lb	"
10-19-70	24,130	38/lb	South shore
10-20-70	13,950	31/lb	"
10-20-70	9,800	28/lb	"

In November of 1970, and in January and March of 1971, 107,972 yearlings were released at two locations in the Mokelumne River (Table 2). The objective of this experiment was to determine the best location for releasing yearling steelhead.

Marking and Adult Recoveries

Of the 152,862 fingerling steelhead of the 1970 brood year released in Camanche Reservoir, 40,004 were marked by removal of the right ventral and left pectoral fins (RV-LP), and 112,858 were released without marking.

The 107,972 steelhead yearlings from the 1970 brood year were marked and planted in the Mokelumne River as follows: (i) 46,452 LV and 9,000 Ad-LV in Three-Mile Slough at Brannan Island State Park, and (ii) 46,520 RV and 6,000 Ad-RV in the Mokelumne River at New Hope Landing.

TABLE 2

Summary of Mokelumne River Marked Steelhead Releases, July 1, 1968, to June 30, 1971, with Recovery Data*

Release Data						Recovery Data	
Mark	Brood year	Date	Area	Number	Size at release	1969-70 Recoveries	1970-71 Recoveries
Ad	1968	3/69	Three-Mile Slough	22,579	6.7/lb	3	15
LV	"	"	"	40,951	8.2/lb	15	36
RV	"	"	New Hope Landing	37,677	"	11	56
RP	1969	11/69	Camanche Reservoir	29,700	18/lb	-	0
LM	"	3/70	Terminous	35,100	9/lb	-	
LV	"	"	Three-Mile Slough	42,922	5.5/lb	-	3
Ad-LV	"	"	"	980	5/lb	-	0
RV	"	"	New Hope Landing	42,840	5.1/lb	-	0
Ad-RV	"	"	"	980	5/lb	-	0
LV-LP	1970	9/70	Camanche Reservoir	40,004	73/lb	-	-
Ad-LV	"	11/70	Three-Mile Slough	9,000	8.0/lb	-	-
Ad-RV	"	"	New Hope Landing	6,000	8.0/lb	-	-
LV	"	1/71 & 3/71	Three-Mile Slough	46,452	7.5/lb & 4.7/lb	-	-
RV	"	"	New Hope Landing	46,520	6.7/lb & 4.7/lb	-	-

* Does not include mark recoveries of unknown origin.

A total of 115 marked adults were recovered at the hatchery, 111 of which originated at Mokelumne River Fish Installation (Table 2). The origins of the four remaining marked adults (one RV-RP, one LV-RV, one Ad, and one RP) are unknown. The final analysis of current steelhead marking experiments will be accomplished after returns of the 1970 brood year are complete, in 1974.

Marked steelhead were measured to the nearest 1/4 inch fork length. Scale samples were taken from 32 of the marked fish (Table 3). Brood years were determined from lengths and scale samples.

Disease

There were no significant disease problems affecting steelhead during this report period.

WATER TEMPERATURES

Water temperatures were taken throughout the season by means of a continuous temperature recorder located near the entrance to the spawning channel. Water temperatures ranged from 57 F during the early part of the spawning season to 48 F during the later part of the season. Very little difference in water temperatures occurred in any 24-hour period. The daily temperature variation was no more than three degrees during the entire season (Appendix B).

Copper and Zinc Analysis

Water samples were collected daily in acid-rinsed plastic bottles with teflon-lined caps. Two milliliters of 6N nitric acid was added to the bottles prior to collection of samples. These acidified water samples were analyzed for copper and zinc by atomic absorption flame photometry. The detection limit for copper and zinc by the method used is 0.01 ppm.

The greatest concentration of copper observed was 0.13 ppm on June 25, 1971. From January 17 to January 31, it was 0.02 ppm. The rest of the year the copper concentration was 0.01 ppm or smaller. The greatest observed concentration of zinc was 3.1 ppm on June 25, 1971. The rest of the year the zinc concentration ranged from 0.01 to 0.15 ppm (Appendix C).

PUBLIC RELATIONS

During the 1970-71 fiscal year, an estimated 20,000 people visited the Installation. Tours of the Installation were conducted for many special interest groups, and talks were given to sportsman clubs and civic organizations.

TABLE 3

Ages of Marked Steelhead Recovered at the
Mokelumne River Fish Installation
1970-71 Season

Date recovered	Inches fork length	Sex	Mark	Number annuli		Age
				Stream	Sea	
November						
18	25.00	M	RV	Scales regenerated		
"	24.75	M	LV	1	1	3
25	25.75	M	RV	1	1	3
28	23.75	F	RP	1	1	3
December						
2	26.00	M	RV	1	1	3
5	22.25	M	LV	1	1	3
7	24.00	F	RV	1	1	3
8	23.25	M	RV	1	1	3
"	27.00	F	LV	1	1	3
11	26.25	F	LV	1	1	3
16	26.75	M	LV	1	1	3
17	29.00	F	LV	1	1	3
"	24.50	M	LV	1	1	3
"	26.75	M	RV	1	1	3
20	27.50	F	RV	1	1	3
27	26.00	F	RV	1	1	3
"	27.50	M	RV-RP	1	1	3
"	27.00	M	LV	1	1	3
30	26.00	F	LV-RV	1	1	3
January						
1	25.50	F	RV	1	1	3
7	25.25	M	RV	1	1	3
"	26.25	F	LV	1	1	3
13	30.00	M	RV	1	1	3
14	25.25	M	RV	1	1	3
"	27.25	M	RV	1	1	3
18	13.50	M	LV	1	-0-	2
"	27.00	M	RV	1	1	3
19	26.25	M	RV	1	1	3
"	26.75	F	LV	1	1	3
21	28.50	M	LV	1	1	3
29	26.75	F	LV	1	1	3
"	27.50	M	LV	1	1	3

APPENDIX A

Potential Number of Eggs Contained in 269 Female Salmon Using the Mokelumne River Spawning Channel in 1970-71 Season

Length inches	Estimated number of eggs per female based on length	Number of fish	Potential number of eggs contained in channel fish
20.00	2020.81	1	2,021
20.75	2283.49	1	2,283
21.00	2371.05	1	2,371
21.25	2458.61	1	2,459
22.00	2721.29	5	13,606
22.50	2896.41	3	8,689
23.00	3071.53	2	6,143
23.25	3159.09	2	6,318
23.50	3246.65	5	16,233
23.75	3334.21	3	10,003
24.00	3421.77	5	17,109
24.25	3509.33	1	3,509
24.50	3596,89	4	14,388
24.75	3684.45	3	11,053
25.00	3772.01	6	22,632
25.25	3859.57	4	15,438
25.50	3947.13	7	27,630
25.75	4034.69	5	20,173
26.00	4122.25	9	37,100
26.25	4209.81	3	12,629
26.50	4297.37	8	34,379
26.75	4384.93	6	26,310
27.00	4472.49	10	44,725
27.25	4560.05	10	45,601
27.50	4647.61	7	32,533
27.75	4735.17	2	9,470
28.00	4822.73	10	48,227
28.25	4910.29	5	24,551
28.50	4997.85	10	49,979
28.75	5085.41	5	25,427

APPENDIX A (Continued)

Length inches	Estimated number of eggs per female based on length	Number of fish	Potential number of eggs contained in channel fish
29.00	5172.97	9	46,557
29.25	5260.53	8	42,084
29.50	5348.09	9	48,133
29.75	5435.65	6	32,614
30.00	5523.21	9	49,709
30.25	5610.77	2	11,222
30.50	5698.33	6	34,190
30.75	5785.89	3	17,358
31.00	5873.45	3	17,620
31.25	5961.01	2	11,922
31.50	6048.57	11	66,534
31.75	6136.13	2	12,272
32.00	6223.69	7	43,566
32.25	6311.25	1	6,311
32.50	6398.81	7	44,792
32.75	6486.37	5	32,432
33.00	6573.93	11	72,313
33.50	6749.05	5	33,745
33.75	6836.61	3	20,510
34.00	6924.17	2	13,848
34.25	7011.73	1	7,012
34.50	7099.29	5	35,496
34.75	7186.85	2	14,374
35.00	7274.41	3	21,823
35.25	7361.97	1	7,362
36.00	7624.65	1	7,625
36.25	7712.21	1	7,712
	TOTALS	269	1,352,125

APPENDIX B

Water Temperature Data at Mokelumne River Fish Installation 1970-71 Season

Water Temperature (°F)

Date		Max.	Min.	Date		Max.	Min.	Date		Max.	Min.
1970											
July	1	55	54	Aug.	9	56	55	Sept.	16	56	55
	2	55	54		10	56	55		17	56	55
	3	55	54		11	56	55		18	56	55
	4	55	54		12	56	55		19	57	56
	5	55	54		13	56	55		20	57	56
	6	55	54		14	56	55		21	57	56
	7	55	54		15	56	55		22	57	56
	8	55	54		16	56	54		23	57	56
	9	55	54		17	56	55		24	57	56
	10	55	54		18	56	55		25	57	56
	11	55	54		19	56	55		26	57	56
	12	55	54		20	56	55		27	57	56
	13	55	54		21	56	55		28	57	56
	14	55	54		22	56	55		29	57	56
	15	55	54		23	56	55		30	57	56
	16	55	54		24	56	55	Oct.	1	57	56
	17	55	54		25	56	55		2	57	56
	18	55	54		26	56	55		3	57	56
	19	55	54		27	56	55		4	57	56
	20	55	54		28	56	55		5	57	56
	21	55	54		29	56	55		6	57	56
	22	55	54		30	56	55		7	57	56
	23	55	54		31	56	55		8	57	56
	24	55	54	Sept.	1	56	55		9	57	56
	25	55	54		2	56	55		10	57	56
	26	56	55		3	56	55		11	57	56
	27	56	55		4	56	55		12	57	56
	28	56	55		5	56	55		13	57	56
	29	56	55		6	56	55		14	57	56
	30	56	55		7	56	55		15	57	56
	31	56	55		8	56	55		16	57	56
Aug	1	56	55		9	56	55		17	57	56
	2	56	55		10	56	55		18	57	56
	3	56	55		11	56	55		19	57	56
	4	56	55		12	56	55		20	57	56
	5	56	55		13	56	55		21	57	56
	6	56	55		14	56	55		22	57	56
	7	56	55		15	56	55		23	57	56
	8	56	55								

APPENDIX B (Continued)

Water Temperature (°F)

Date	Max.	Min.	Date	Max.	Min.	Date	Max.	Min.
1970						1971		
Oct. 24	57	56	Dec. 4	57	56	Jan. 13	51	51
25	57	56	5	57	56	14	51	50
26	57	56	6	57	56	15	51	51
27	57	56	7	57	56	16	51	51
28	57	56	8	57	56	17	51	50
29	57	56	9	57	56	18	51	50
30	57	56	10	57	56	19	51	50
31	57	56	11	57	56	20	50	50
Nov. 1	57	56	12	57	56	21	50	49
2	57	56	13	57	56	22	51	50
3	57	56	14	57	56	23	51	50
4	57	56	15	56	55	24	50	49
5	57	56	16	56	55	25	51	49
6	57	56	17	56	55	26	51	49
7	57	56	18	56	55	27	50	50
8	57	56	19	56	55	28	50	50
9	57	56	20	56	54	29	50	50
10	57	56	21	54	54	30	50	50
11	57	56	22	55	54	31	50	50
12	57	56	23	55	54	Feb. 1	50	50
13	57	56	24	54	53	2	51	50
14	57	56	25	54	54	3	51	50
15	57	56	26	55	54	4	50	50
16	57	56	27	54	53	5	51	50
17	57	56	28	54	52	6	50	50
18	57	56	29	54	53	7	50	50
19	57	56	30	54	52	8	50	50
20	57	56	31	53	52	9	50	50
21	57	56	1971			10	50	50
22	57	56	Jan. 1	54	53	11	50	49
23	57	56	2	54	53	12	50	49
24	57	56	3	54	52	13	50	48
25	57	56	4	54	52	14	50	48
26	57	56	5	54	52	15	50	48
27	57	56	6	53	52	16	50	49
28	57	56	7	53	52	17	50	49
29	57	56	8	53	51	18	50	48
30	57	56	9	52	51	19	50	48
Dec. 1	57	56	10	52	51	20	50	49
2	57	56	11	52	51	21	51	50
3	57	56	12	52	51	22	52	50

APPENDIX B (Continued)

Water temperature (°F)

Date	Max.	Min.	Date	Max.	Min.	Date	Max.	Min.
1971								
Feb. 23	50	49	Apr. 5	51	49	May 16	53	52
24	50	50	6	51	50	17	53	51
25	51	50	7	52	50	18	53	50
26	52	50	8	52	50	19	53	50
27	52	52	9	52	50	20	53	51
28	52	51	10	52	50	21	53	51
Mar. 1	52	50	11	52	50	22	53	50
2	52	50	12	52	49	23	53	50
3	52	51	13	52	50	24	53	50
4	52	50	14	52	50	25	53	51
5	52	50	15	52	50	26	53	52
6	52	50	16	52	50	27	53	53
7	52	50	17	52	51	28	53	52
8	52	50	18	52	50	29	53	52
9	52	50	19	52	50	30	53	51
10	50	50	20	52	51	31	54	52
11	50	50	21	52	50	June 1	54	52
12	53	52	22	52	51	2	54	52
13	52	50	23	52	51	3	53	52
14	52	50	24	52	51	4	53	51
15	52	50	25	52	50	5	53	51
16	52	50	26	52	50	6	53	50
17	52	50	27	52	50	7	53	51
18	52	50	28	52	50	8	53	51
19	52	50	29	52	50	9	54	52
20	52	49	30	52	50	10	53	51
21	51	49	May 1	52	51	11	53	51
22	51	50	2	52	51	12	53	51
23	51	50	3	52	51	13	53	51
24	51	50	4	52	51	14	53	51
25	50	50	5	52	51	15	53	50
26	52	50	6	52	50	16	53	51
27	52	50	7	52	51	17	53	51
28	52	49	8	52	52	18	53	51
29	52	49	9	52	50	19	54	52
30	52	50	10	52	50	20	54	52
31	52	50	11	52	50	21	54	51
Apr. 1	52	50	12	52	50	22	54	52
2	52	49	13	52	50	23	54	52
3	52	49	14	52	50	24	54	52
4	52	49	15	52	50	25	54	52
						26	54	53
						27	54	52
						28	54	52
						29	54	52
						30	54	52

APPENDIX C

Concentrations of Copper and Zinc in Water Samples

Date		Copper ppm	Zinc ppm	Date		Copper ppm	Zinc ppm
1971							
Jan.	1	0.01	0.02	Feb.	11	< 0.01	0.14
	2	0.01	0.03		12	< 0.01	0.10
	3	0.01	0.02		13	< 0.01	0.11
	4	0.01	0.02		14	< 0.01	0.10
	5	0.01	0.03		15	< 0.01	0.10
	6	0.01	0.03		16	< 0.01	0.10
	7	0.01	0.02		17	< 0.01	0.11
	8	0.01	0.02		18	< 0.01	0.10
	9	0.01	0.02		19	< 0.01	0.10
	10	0.01	0.02		20	< 0.01	0.09
	11	0.01	0.02		21	< 0.01	0.08
	12	0.01	0.02		22	< 0.01	0.01
	13	0.01	0.02		23	< 0.01	0.08
	14	0.01	0.02		24	< 0.01	0.07
	15	0.01	0.02		25	< 0.01	0.08
	16	0.01	0.02		26	< 0.01	0.06
	17	0.02	0.02		27	< 0.01	0.06
	18	0.02	0.04		28	< 0.01	0.06
	19	0.02	0.06				
	20	0.02	0.08	Mar.	1	0.01	0.06
	21	0.02	0.08		2	0.01	0.06
	22	0.02	0.13		3	0.01	0.05
	23	0.02	0.13		4	0.01	0.05
	24	0.02	0.12		5	0.01	0.06
	25	0.02	0.15		6	0.01	0.06
	26	0.02	0.13		7	0.01	0.06
	27	0.02	0.13		8	0.01	0.06
	28	0.02	0.14		9	0.01	0.06
	29	0.02	0.14		10	0.01	0.06
	30	0.02	0.14		11	0.01	0.06
	31	0.02	0.14		12	0.01	0.05
Feb.	1	< 0.01	0.14		13	0.01	0.05
	2	< 0.01	0.14		14	0.01	0.05
	3	0.01	0.14		15	0.01	0.05
	4	0.01	0.07		16	0.01	0.05
	5	< 0.01	0.11		17	0.01	0.05
	6	< 0.01	0.10		18	0.01	0.04
	7	< 0.01	0.11		19	0.01	0.05
	8	< 0.01	0.13		20	0.01	0.06
	9	< 0.01	0.12		21	0.01	0.06
	10	< 0.01	0.13		22	0.01	0.06

APPENDIX C (Continued)

Date		Copper ppm	Zinc ppm	Date		Copper ppm	Zinc ppm
1971							
Mar.	23	0.01	0.06	May	1	<0.01	0.08
	24	0.01	0.06		2	<0.01	0.10
	25	0.01	0.06		3	<0.01	0.08
	26	0.01	0.07		4	<0.01	0.09
	27	0.01	0.07		5	<0.01	0.09
	28	0.01	0.06		6	<0.01	0.09
	29	0.01	0.06		7	<0.01	0.08
	30	0.01	0.06		8	<0.01	0.09
	31	0.01	0.06		9	<0.01	0.09
Apr.	1	<0.01	0.07		10	<0.01	0.10
	2	<0.01	0.08		11	<0.01	0.09
	3	<0.01	0.08		12	<0.01	0.09
	4	<0.01	0.08		13	<0.01	0.09
	5	<0.01	0.08		14	<0.01	0.10
	6	<0.01	0.08		15	<0.01	0.09
	7	<0.01	0.08		16	<0.01	0.09
	8	<0.01	0.08		17	<0.01	0.09
	9	<0.01	0.06		18	<0.01	0.08
	10	<0.01	0.06		19	<0.01	0.08
	11	<0.01	0.08		20	<0.01	0.09
	12	<0.01	0.09		21	<0.01	0.08
	13	<0.01	0.10		22	<0.01	0.08
	14	<0.01	0.08		23	<0.01	0.08
	15	<0.01	0.09		24	<0.01	0.08
	16	<0.01	0.08		25	<0.01	0.08
	17	<0.01	0.08		26	<0.01	0.08
	18	<0.01	0.08		27	<0.01	0.07
	19	<0.01	0.08		28	<0.01	0.09
	20	<0.01	0.08		29	<0.01	0.08
	21	<0.01	0.08		30	<0.01	0.08
	22	<0.01	0.07		31	<0.01	0.08
	23	<0.01	0.07	June	1	<0.01	0.08
	24	<0.01	0.07		2	<0.01	0.08
	25	<0.01	0.07		3	<0.01	0.08
	26	<0.01	0.09		4	<0.01	0.08
	27	<0.01	0.08		5	<0.01	0.08
	28	<0.01	0.09		6	<0.01	0.08
	29	<0.01	0.09		7	<0.01	0.08
	30	<0.01	0.08		8	<0.01	0.08

APPENDIX C (Continued)

Date	Copper ppm	Zinc ppm
June 9	<0.01	0.07
10	<0.01	0.07
11	<0.01	0.07
12	<0.01	0.08
13	<0.01	0.08
14	<0.01	0.08
15	<0.01	0.08
16	<0.01	0.08
17	<0.01	0.07
18	<0.01	0.07
19	<0.01	0.08
20	<0.01	0.07
21	<0.01	0.06
22	<0.01	0.07
23	<0.01	0.07
24	<0.01	0.07
25	0.13	3.1
26	0.01	0.07
27	0.01	0.07
28	0.01	0.08
29	0.01	0.06
30	0.01	0.07