State of California
The Resources Agency
Department of Fish and Game
Region 2 and Inland Fisheries

MOKELUMNE RIVER FISH INSTALLATION
ANNUAL REPORT FOR 1967-68 SEASON

by

Philo F. Jewett

SUMMARY

This is the fourth annual report of the Mokelumne River Fish Installation. It covers the period of operations from July 16, 1967 to June 30, 1968.

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

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

From October 18 to December 21, 1967, 250 adult salmon entered the facilities. Of this number, 200 were placed in the spawning channel; 93 were females. From these, an estimated 487,220 eggs were deposited in the gravel, and 177,542 young salmon were counted out of the channel. This is an egg-to-outmigrant survival of 36.4 percent.

Four female salmon were artificially spawned and their eggs reared at the hatchery to determine egg survival at the high temperatures which occurred at the Installation early in the spawning season.

A total of 103 adult steelhead were received from October 31, 1967, to March 9, 1968. Thirteen females were spawned, which resulted in 34,869 eggs collected. An additional 331,200 steelhead eggs were received from Nimbus Hatchery, for a total of 366,069 eggs from the 1968 brood year.

All of the young steelhead from the 1967 brood year were planted in the Mokelumne River as yearlings. From November 24, 1967, to April 11, 1968, 82,203 yearlings were planted.

1/ Anadromous Fisheries Administrative Report No. 70-18.
Submitted October 1970

INTRODUCTION

This is the fourth annual report of the Mokelumne River Fish Installation and covers the period of operations from July 16, 1967, to June 30, 1968. 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 1-a and 1-b.

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 40 miles southeast of Sacramento (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 loss of fall-run king salmon and steelhead trout spawning area which was inundated by the dam. The California Department of Fish and Game is responsible for operating the Installation; East Bay Municipal Utility District paid construction costs and also pays annual operating and maintenance costs.

DESCRIPTION OF INSTALLATION

A detailed description was given in the first annual report (1964-65 season). A summary of the operation is as follows:

The Installation is made up of two parts: (1) a spawning channel for natural spawning 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 an anesthetic tank to be sorted and counted. From there, steelhead are placed in a holding tank, salmon are released to the spawning channel, and any unwanted fish are returned to the river.

The steelhead are held until they are ready for artificial spawning. After they are 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. About April 15, they are moved outside to rearing ponds. The fish are raised for about one year and then released into the Mokelumne River. The hatchery and pond facilities have a capacity for rearing a maximum of 100,000 fish to yearling size.

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. The upper loop, which is 3,400 feet long is the only one which has been used since the channel was first operated

in the fall of 1964, because not enough fish have been available to operate both loops. The channel is designed to operate with a spawning flow of 69 cfs. At this flow the average depth is 1.5 feet, and average velocity is two feet per second.

After the fry emerge from the gravel, they are allowed to move out at will. A migrant trap is installed at the end of the channel section for enumeration purposes.

KING SALMON MAINTENANCE PROGRAM

Spawning Season 1967 Brood Year

Some modifications were made in the spawning gravel before the start of the 1967 spawning season. Last season we found that salmon could be encouraged to spawn on gravel berms, so this season 22 berms were constructed at equal intervals throughout the full length of the upper loop. All berms were one foot higher in elevation than the bottom, and varied in size from four to 15 feet wide and 10 to 20 feet long.

On October 5, 1967, a flow of 64 cfs was released into the spawning channel and maintained at this level for remainder of the spawning season.

The first salmon arrived at the Installation on October 18 and the last one on December 21, and all salmon received this season came in of their own volition. A total of 250 salmon entered the Installation. Of this number, 200 (95 males, 93 females and 12 grilse[2/]) were released into the spawning channel; four females and four males were artificially spawned in the hatchery; the remaining fish were surplus males (mostly grilse) which were released back into the river.

Carcass Recovery 1967 Brood Year

Dead salmon were removed from the channel each day. All carcasses were measured and cut open for examination. Condition of the gonads was recorded and the eggs retained in the females were counted. Of 93 females recovered, a total of 2,966 eggs remained in the body cavities. This was an average of 32 eggs per female, with a range of 0 to 1,359. None of the females died without spawning at least some of their eggs. Carcass recoveries peaked on November 27.

Estimated Egg Deposition 1967 Brood Year

Length-fecundity data from 18 females sampled in the 1966 run were used as a basis to estimate the number of eggs deposited in the gravel. Data were fitted to the linear model $y = a + b x$ by the least squares method.

2/ Males under 24 inches fork length.

In the equation 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 93 females that spawned in the channel and gave an estimated potential of 490,186 eggs (Appendix A). Subtracting the unspawned eggs (2,966) gives a total of 487,220 eggs deposited.

Downstream Migrant Production 1967 Brood Year

After spawning had been completed the flow in the channel was reduced to 25 cfs where it remained for duration of the downstream migration period. Enumeration of voluntary out-migrants was accomplished by screening the entire flow with an incline plane trap installed in the flume section at the end of the second channel. The trap was installed on December 28, 1967, and the first migrants were captured on January 3, 1968. The water to the channel was shut off on June 21 and the remaining fish were seined out on June 22. The migration from the channel fluctuated considerably during the season (Figure 3). The channel produced 177,542 fish which is 36.4 percent of the estimated number of eggs deposited in the gravel. Of this number, 167,456 were recovered from the trap, and 10,086 were seined from the pools.

Two methods were used to enumerate 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 in the period of heavy migration.

Weight samples of out-migrants were taken weekly. The size of the out-migrants ranged from 83 per ounce in early February to about five per ounce (80/lb.) by end of May (Figure 3).

Predators

Potential predators of young salmon in the channel were black bass, sunfish, rainbow trout (young steelhead and resident trout) and sculpin. These fish entered the channel primarily through the water supply system from Camanche Reservoir. This season predators occurred in such small numbers they were considered to be of no significance in affecting total production. An occasional predator was captured in the migrant trap and a few were captured in the channel when it was seined at the end of the out-migration season.

Subsurface Water

Subsurface apparent velocity in the spawning channel was measured by using the method described by Gangmark and Bakkala (1958). Briefly, it entails the use of plastic standpipes buried in the gravel. A salt solution is added to the standpipe water and a conductivity bridge measures the rate at which the water is being diluted.

Twenty-four standpipes were installed before the start of the 1967 spawning season. They were buried about 15 inches deep in series of three across the channel near locations 400, 800, 1,200, 1,600, 1,900, 2,200, 2,600, and 3,000 feet from the upper diffuser.

Results show that the average of subsurface velocities was somewhat lower at the spawning flow of 64 cfs than at the incubation flow of 25 cfs. The velocity of water through the gravel appears to be a factor of water depth over the gravel (Appendix B).

Egg and Fry Survival at High Temperatures

Four female king salmon were artificially spawned and their eggs hatched in incubator trays. This was done during the early part of the spawning period when water temperatures were at a maximum (61 to 62 F). The purpose was to determine survival of eggs and fry under these temperature conditions.

Many of the eggs from these fish were in various stages of maturity from too green to overripe. This condition is believed to be caused by water temperatures which were in the low 60s for an extended period before spawning. The water temperature did not drop below 60 F until 16 days after the first of these fish was spawned.

With these temperature conditions over 67 percent of the eggs hatched, but only about 28 percent survived from time the eggs were taken to planting time five months later (Table 2). Heaviest mortality occurred in the late fry stage.

STEELHEAD MAINTENANCE PROGRAM

Hatchery Operation - 1968 Brood Year

A total of 103 steelhead (60♂ and 43♀) entered the hatchery trap from October 31, 1967 to March 9, 1968. From December 5, 1967, through January 27, 1968, no steelhead entered the trap. Prior to December 5, all steelhead entering the Installation were marked and returned to the river because they were too "green" to hold. After January 27, all steelhead received were held for spawning.

Thirteen females were spawned this season. From these, 34,869 eggs were taken for an average of 2,682 eggs per female. An additional 331,200 eggs were supplied from Nimbus Hatchery. This supplement was necessary to guarantee at least 100,000 fish would be raised to yearling size.

Planting - 1967 Brood Year

In April of 1967, 83,700 fingerling steelhead were transferred from the hatchery troughs to the rearing ponds. A total of 82,200 were raised to "yearling size" and planted in the Mokelumne River in three periods as follows:

(1) November 24, 1967 - 9,900 at 15/lb. planted near the Installation,
(2) February 7, 1968 - 18,428 at 8.5/lb. planted one-half mile below Camanche Dam, and
(3) April 11, 1968 - 53,785 at 6.2/lb. planted seven miles below Camanche Dam.

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 in the high 50s and low 60s prevailed in the early part of the salmon spawning season as they have since completion of Camanche Dam. The temperatures dropped slowly after about November 28, and reached a low of 48 F by early January (Appendix C).

There was only a very little temperature difference in any 24-hour period. In the spawning season it did not vary more than two degrees, and during the downstream migration season the difference was no more than one degree (Appendix C).

On May 15, 1968, the high-level outlet at Camanche Dam was put into operation. This was the first year this outlet had been used. The purpose of the outlet is to release warm water from the lake and retain cooler water for release in the spawning season.

MARKING

A total of 31,759 salmon fingerlings were fin clipped, 19,039 RV early migrants and 12,720 LV late migrants. A total of 14 marked salmon were recovered; five LM and nine RM.

There were no steelhead marked or marked steelhead recovered.

PUBLIC RELATIONS

During the 1967-68 fiscal year, an estimated 13,600 people visited the Installation. Tours of the Installation were conducted for several special interest groups.

REFERENCES

Gangmark, Harold A., and Richard G. Bakkala. 1968. Plastic standpipe for sampling streambed environment of salmon spawn. U. S. Dept. Int., Fish and Wildlife Service, Spec. Sci. Rept. Fisheries 261, 19 p.

Groh, Frederick H. 1965. Annual report Mokelumne River Fish Installation fiscal year of 1964-65. Calif. Dept. Fish and Game, Inland Fish. Admin. Rept. 65-21, 27 p. (mimeo).

Groh, Frederick H. and Robert Menchen. 1970. Annual report Mokelumne River Fish Installation fiscal year of 1965-66. Calif. Dept. Fish and Game, Anad. Fish. Admin. Rept. 70-10.

Jewett, Philo F. and Robert Menchen. 1970. Annual report Mokelumne River Fish Installation fiscal year of 1966-67. Calif. Dept. Fish and Game, Anad. Fish. Admin. Rept. 70-12.

APPENDIX A

Potential Number of Eggs Contained in 93 Female Salmon
Using the Mokelumne River Spawning Channel in 1967-1968 Season

Length Inches	Estimated number of eggs per fish Based on length*	Number of fish	Potential Number of eggs contained in channel fish
21	2,371	2	4,742
22	2,722	1	2,722
23	3,072	2	6,144
24	3,422	1	3,422
25	3,773	3	11,319
26	4,123	2	8,246
27	4,473	4	17,892
28	4,823	14	67,522
29	5,173	16	82,768
30	5,523	23	127,029
31	5,873	6	35,238
32	6,223	12	74,676
33	6,573	2	13,146
34	6,924	3	20,772
35	7,274	2	14,548
		93	490,186

* $y = -4983.99 + 350.24x$

APPENDIX B

Velocity of Intra-gravel Water at Various Flows and Locations in the Mokelumne River Spawning Channel, 1967-68 Season

Station Number	Velocity of Intra-gravel Water (Feet per Hour)	
	October 16 Surface Flow 64 cfs	April 2 Surface Flow 25 cfs
01	1.00	1.23
02	1.27	1.77
03	1.14	1.12
04	1.64	2.10
05	1.10	.97
06	1.23	--
07	1.10	1.26
08	1.26	1.61
09	.88	1.06
10	1.61	1.78
11	1.32	2.03
12	1.41	1.67
13	1.10	1.09
14	1.01	1.34
15	1.03	.73
16	1.49	3.22
17	1.94	2.37
18	1.46	2.59
19	1.80	3.15
20	1.14	.88
21	1.22	1.24
22	1.52	1.66
23	1.85	1.28
24	1.71	1.60

APPENDIX C

Water Temperature Data at
Mokelumne River Fish Installation 1967-68

Water Temperature (°F)

Date 1967	Max.	Min.	Date	Max.	Min.	Date	Max.	Min.
July 1	58	56	Aug. 10	57	56	Sept. 18	59	58
2	58	56	11	57	56	19	59	58
3	58	56	12	57	56	20	60	58
4	58	56	13	57	57	21	59	58
5	58	56	14	58	57	22	59	58
6	58	56	15	57	57	23	59	58
7	58	56	16	57	57	24	59	58
8	58	56	17	57	57	25	59	59
9	57	56	18	58	57	26	60	59
10	58	54	19	57	57	27	59	58
11	56	54	20	57	57	28	59	58
12	58	56	21	58	57	29	58	58
13	58	56	22	58	57	30	58	58
14	58	56	23	58	57			
15	58	56	24	58	57	Oct. 1	58	58
16	55	54	25	58	57	2	57	58
17	55	54	26	58	57	3	59	58
18	55	54	27	58	58	4	58	57
19	54	54	28	58	58	5	58	57
20	55	55	29	58	58	6	58	58
21	55	55	30	58	58	7	58	58
22	55	54	31	58	57	8	59	58
23	55	55				9	59	58
24	55	55	Sept. 1	58	57	10	59	58
25	55	55	2	58	57	11	59	58
26	55	55	3	58	58	12	59	59
27	55	55	4	58	58	13	59	59
28	55	55	5	58	58	14	59	59
29	55	55	6	59	58	15	60	59
30	55	55	7	58	58	16	60	59
31	55	55	8	58	58	17	60	59
			9	58	58	18	60	59
Aug. 1	55	55	10	58	58	19	60	59
2	55	55	11	59	58	20	60	60
3	56	56	12	59	58	21	60	60
4	56	56	13	59	58	22	60	60
5	56	56	14	59	58	23	60	60
6	57	56	15	59	58	24	60	60
7	57	56	16	59	58	25	60	60
8	57	56	17	59	58	26	60	60
9	57	56						

APPENDIX C (continued)

Water Temperature (°F)

Date	Max.	Min.
Oct. 27	60	60
28	60	60
29	60	60
30	61	60
31	61	61
Nov. 1	61	61
2	61	60
3	61	60
4	60	60
5	61	61
6	61	61
7	61	61
8	61	61
9	61	61
10	61	61
11	61	61
12	61	61
13	62	61
14	62	62
15	62	61
16	61	61
17	61	61
18	61	61
19	61	60
20	61	60
21	61	60
22	61	60
23	60	60
24	60	60
25	60	60
26	60	59
27	59	59
28	60	60
29	59	59
30	58	58
Dec. 1	58	58
2	58	58
3	58	57
4	57	57
5	57	57
6	57	56
Dec. 7	56	56
8	56	56
9	56	56
10	56	56
11	56	56
12	56	55
13	55	55
14	55	54
15	54	53
16	54	53
17	53	52
18	52	52
19	52	52
20	52	51
21	51	51
22	51	51
23	51	50
24	50	50
25	50	50
26	50	50
27	50	50
28	50	50
29	50	50
30	50	50
31	50	50
1968		
Jan. 1	50	49
2	50	50
3	50	50
4	50	50
5	50	50
6	50	50
7	48	48
8	48	48
9	48	48
10	48	48
11	48	48
12	48	48
13	48	48
14	48	48
15	48	48
16	48	48
17	48	48
Jan. 18	48	48
19	48	48
20	48	48
21	48	48
22	48	48
23	48	48
24	48	48
25	48	48
26	48	48
27	48	48
28	48	48
29	48	48
30	48	48
31	48	48
Feb. 1	48	48
2	48	48
3	48	48
4	48	48
5	48	48
6	48	48
7	48	48
8	48	48
9	48	48
10	48	48
11	48	48
12	48	48
13	48	48
14	48	48
15	48	48
16	48	48
17	48	48
18	48	48
19	48	48
20	48	48
21	48	48
22	48	48
23	48	48
24	48	48
25	48	48
26	48	48
27	48	48
28	48	48
29	48	48

APPENDIX C (continued)

Water Temperature (°F)

Date	Max.	Min.	Date	Max.	Min.	Date	Max.	Min.
Mar. 1	49	48	April 13	50	50	May 26	52	51
2	48	48	14	50	50	27	52	51
3	49	49	15	50	50	28	52	51
4	49	49	16	50	50	29	52	51
5	49	49	17	50	50	30	52	51
6	49	49	18	50	50	31	52	51
7	49	49	19	51	50			
8	49	49	20	50	50	June 1	52	51
9	49	49	21	50	50	2	52	51
10	49	49	22	50	50	3	52	51
11	49	49	23	50	50	4	52	51
12	49	49	24	50	50	5	52	51
13	50	49	25	50	50	6	52	51
14	49	49	26	50	50	7	52	51
15	49	49	27	50	50	8	52	51
16	49	49	28	50	50	9	52	51
17	50	50	29	51	50	10	52	51
18	50	50	30	51	50	11	52	51
19	50	50				12	52	51
20	50	50	May 1	51	50	13	52	51
21	50	50	2	51	50	14	52	51
22	50	50	3	51	50	15	52	51
23	50	50	4	51	50	16	52	52
24	50	50	5	51	51	17	52	52
25	50	50	6	52	51	18	52	52
26	50	50	7	52	51	19	52	52
27	50	50	8	52	51	20	52	52
28	50	50	9	52	51	21	52	52
29	50	50	10	52	51	22	52	52
30	50	50	11	52	51	23	53	52
31	50	50	12	52	51	24	53	52
			13	51	50	25	53	52
April 1	50	50	14	51	50	26	53	52
2	50	50	15	51	50	27	53	52
3	50	49	16	51	50	28	53	52
4	49	48	17	51	50	29	53	52
5	49	48	18	51	50	30	53	52
6	48	48	19	52	51			
7	50	50	20	52	51			
8	50	50	21	52	51			
9	50	50	22	52	51			
10	50	50	23	52	51			
11	50	50	24	52	51			
12	50	50	25	52	51			

TABLE 1-a

King Salmon Spawning Channel Annual Summaries
Mokelumne River Fish Installation 1964-65 through 1967-68 Seasons

Season	Number of Females Released In Channel	Potential Number of Eggs	Number Female Prespawning Mortality	Estimated Egg Deposition	Estimated Number of Outmigrants	Estimated Percent Production	
						Of Potential Eggs	Of Eggs Deposited
1964-65	178	947,100	3	927,300	73,540	07.8	07.9
1965-66	33	157,043	1	150,883	76,435	48.7	50.6
1966-67	85	399,758	4	387,562	76,796	19.2	19.8
1967-68	93	490,186	0	487,220	177,542	36.2	36.4

TABLE 1-b

Steelhead Hatchery Annual Summaries --
Mokelumne River Fish Installation 1963-64 through 1967-68 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

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

TABLE 2

Salmon Artificially Spawned at Maximum Water Temperatures to Determine Survival of Fry -- Mokelumne River Fish Installation, 1967-68 Season

Date	Water Temp. (°F) Max.	Min.	Ounces Eggs	Number per oz.	Number of eggs	Cumulative Mortality to Date	Percent Survival
Fork length of female = 28 inches Start of hatching = 25 days							
11-09 Spawned	61	61	53	95	5,035	0	
12-11 Hatched	57	57				1,634	67.5
02-23 Planted	50	50				3,409	32.3
Fork length of female = 31 inches Start of hatching = 36 days							
11-14 Spawned	62	62	42	113	4,746	0	
12-20 Hatched	52	51				782	83.5
04-23 Planted	50	50				3,389	28.6
Fork length of female = 26 inches Start of hatching = 36 days							
11-14 Spawned	62	62	32	143	4,576	0	
12-20 Hatched	52	51				1,284	71.9
02-23 Planted	50	50				3,199	30.1
Fork length of female = 32 inches Start of hatching = 36 days							
11-14 Spawned	62	62	47	98	4,606	0	
12-20 Hatched	52	51				435	90.6
04-23 Planted	50	50				3,207	30.4

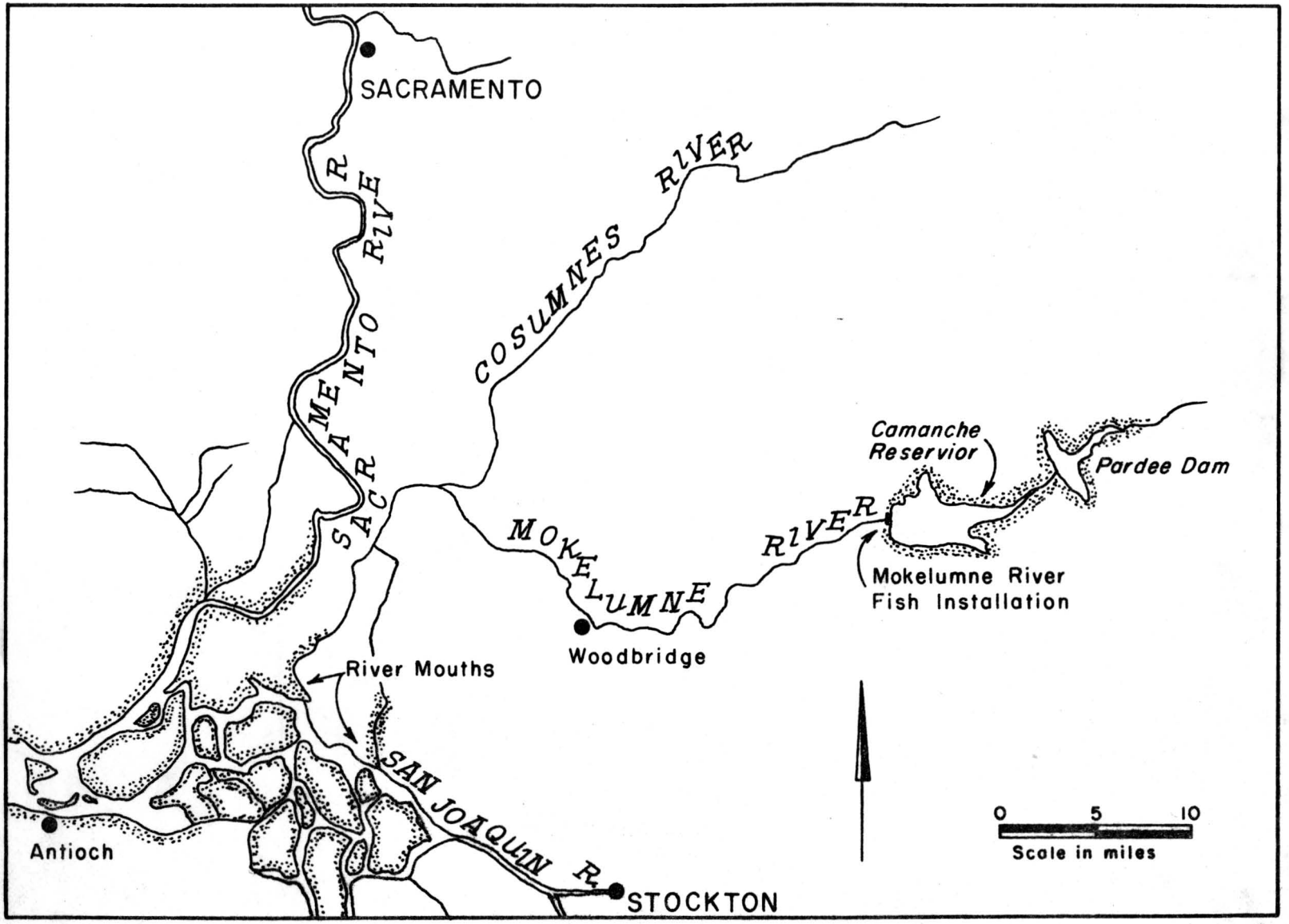

Figure 1. Map showing location of the Mokelumne River Fish Installation.

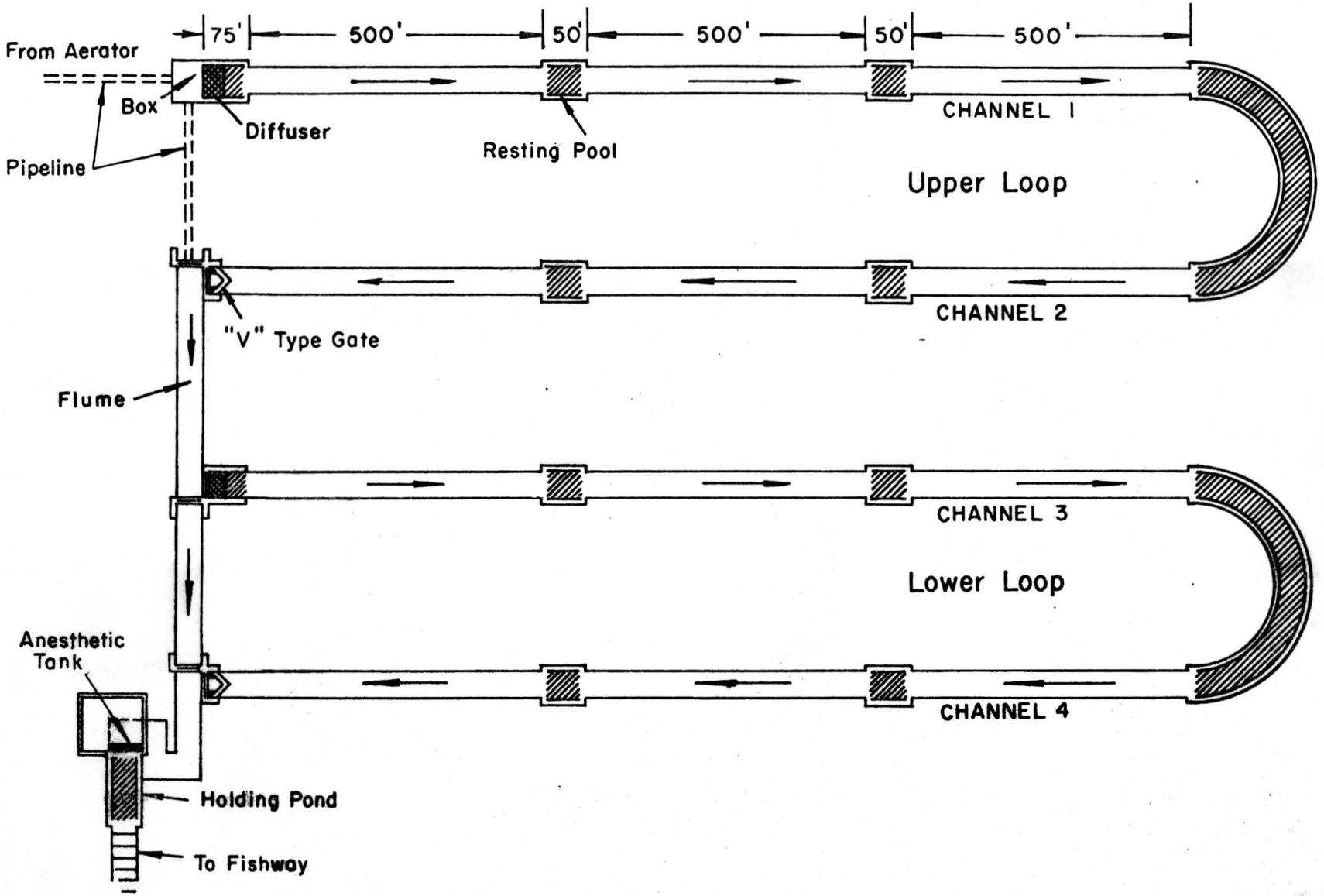

Figure 2. Diagram of the Mokelumne River Spawning Channel

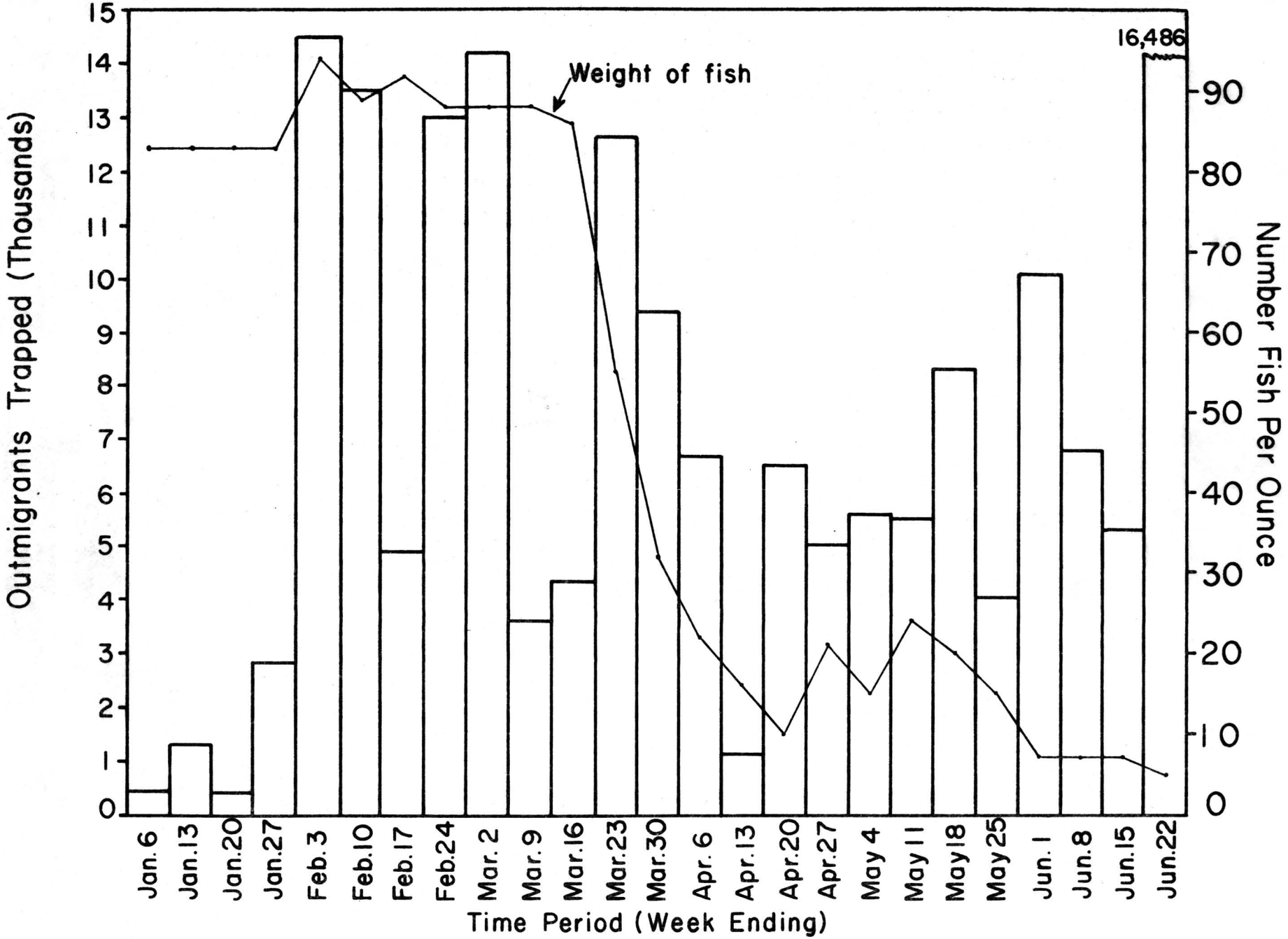

Figure 3. Weight and number of king salmon outmigrants by weekly periods at Mokelumne River Spawning Channel, 1967-68 season.