Ref ID 90291

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

MOKELUMNE RIVER FISH INSTALLATION
ANNUAL REPORT FOR 1965-66 SEASON

by
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SUMMARY

This is the second annual report of the Mokelumne River Fish Installation. It covers the period of operations from July 1, 1965 to June 30, 1966.

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 12 to December 12, 1965, 173 adult salmon entered the facilities. Of this number, 169 were placed in the spawning channel; 33 were females. From these, an estimated 150,883 eggs were deposited in the gravel, and 76,435 young salmon were counted out of the channel. This is an egg to outmigrant survival of 50.6 percent.

Two female salmon were artifically 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.

Thirty adult steelhead were received from January 3 to March 27, 1966. Eight females were spawned which resulted in 30,970 eggs collected. An additional 331,400 steelhead eggs were received from Nimbus Hatchery, for a total of 362,370 eggs from the 1966 brood year.

Young steelhead from the 1965 brood year were planted in the Mokelumne River, some as fingerlings and some as yearlings. From July 1, 1965 to January 30, 1966, 131,420 fingerlings were planted. Then in the spring of 1966, 84,410 yearlings were planted.

1/ Anadromous Fisheries Administrative Report No. 70-10.
Submitted June 1970

INTRODUCTION

This is the second annual report of the Mokelumne River Fish Installation and covers the period of operation from July 1, 1965 to June 30, 1966. 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 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 the loss of fall-run king salmon and steelhead trout spawning area which was inundated by the 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 (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. After a short time in the troughs, 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 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. Not enough fish have been available to operate both loops. The channel is designed to operate with a spawning flow of 60 cfs. At this flow the average depth is 1.5 feet and average velocity is 2 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.

TABLE 1-a

King Salmon Spawning Channel Annual Summaries --
Mokelumne River Fish Installation 1964-65 and 1965-66 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

TABLE 1-b

Steelhead Hatchery Annual Summaries --
Mokelumne River Fish Installation 1963-64 through 1965-66 Seasons

Season	Number Native Fish Received	Number Females Spawned	Number Eggs Taken	Number Eggs From Nimbus	Total Eggs	Number Fry Transferred To Ponds	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	310,000	163,280	92,520
1965-66	30	8	30,970	331,400	362,370	283,200	131,420	84,410

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

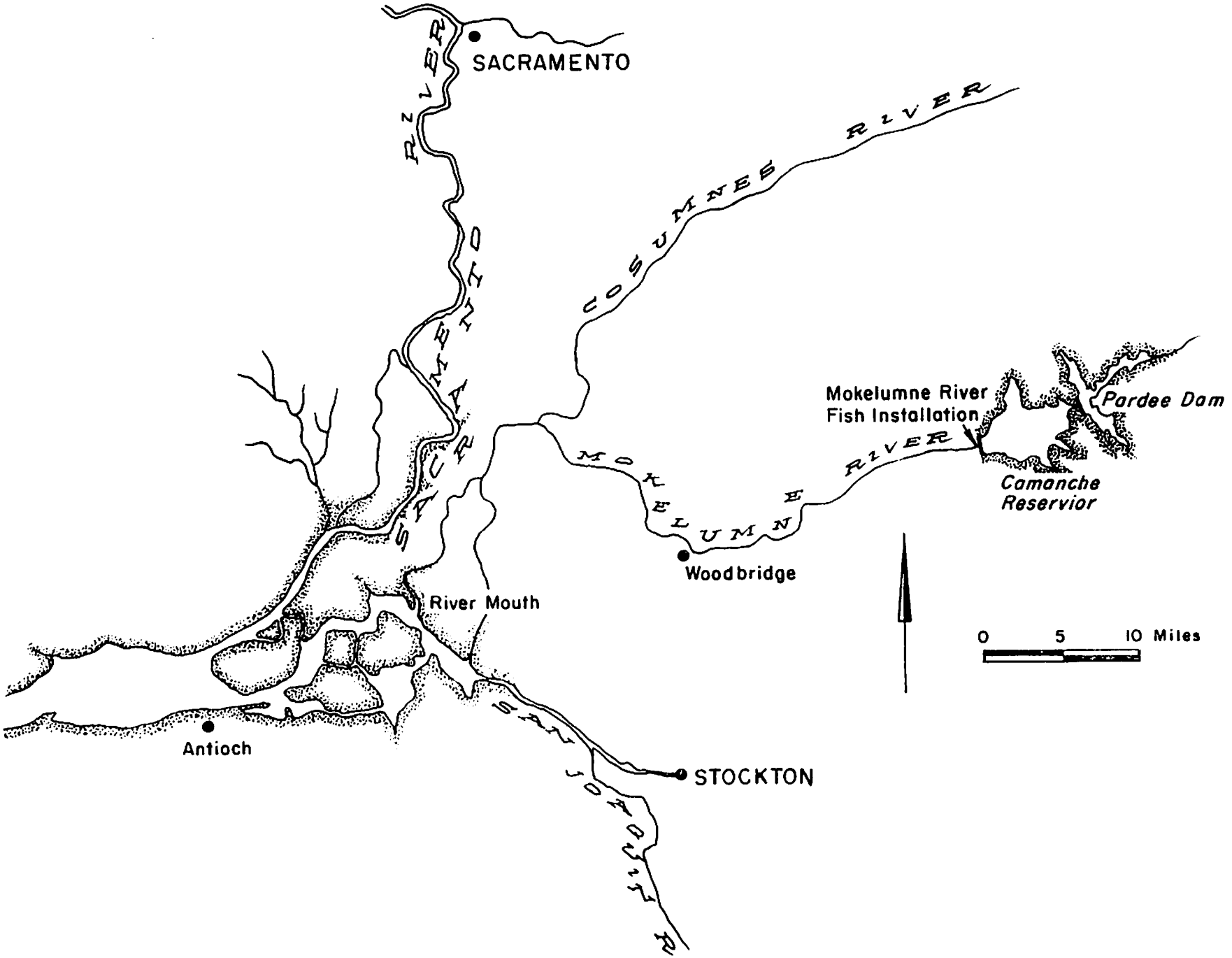

Figure 1. Map Showing Location of the Mokelumne River Fish Installation

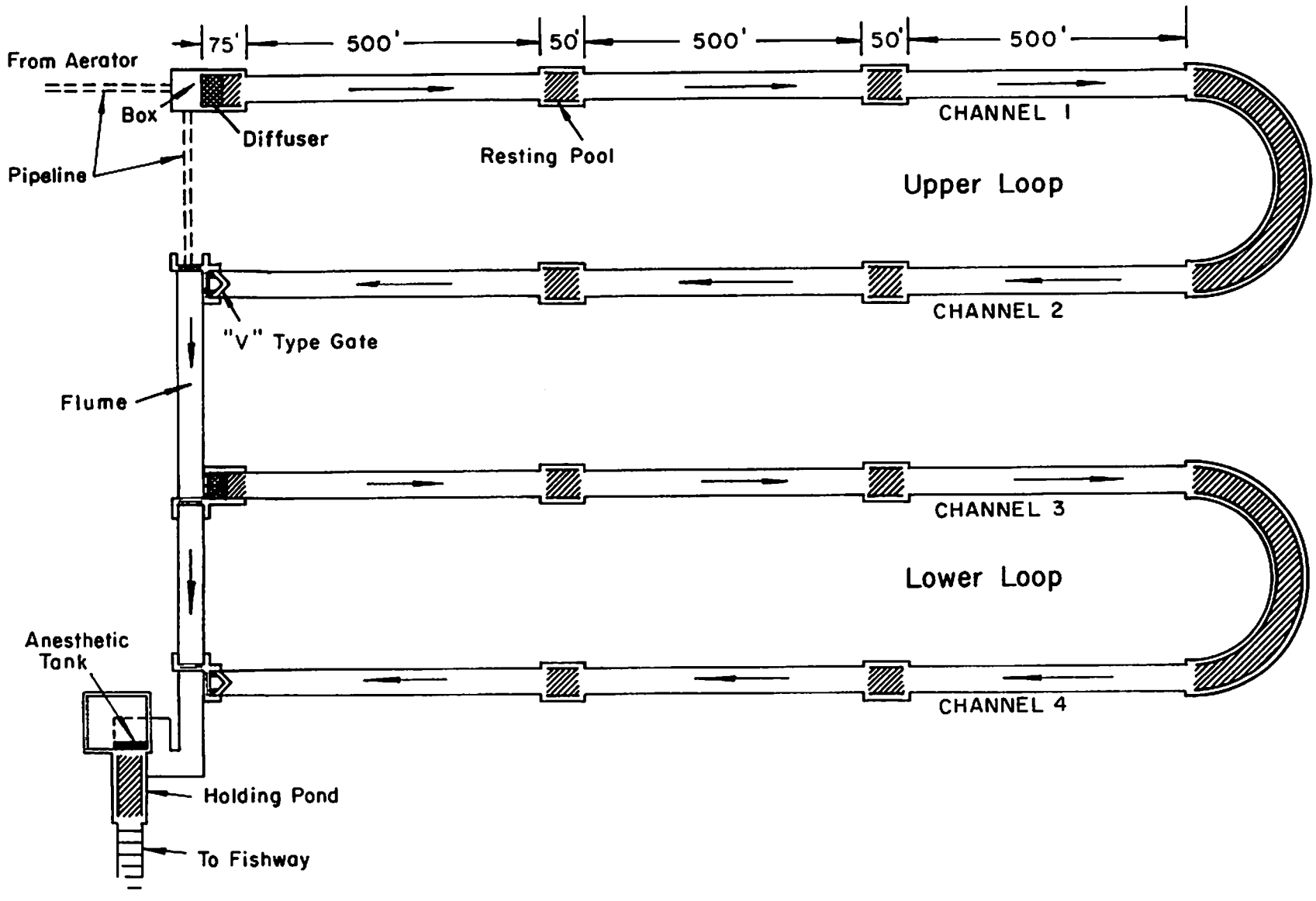

Figure 2. Diagram of the Mokelumne River Spawning Channel

An inexpensive but important change was made prior to the 1965 salmon season. A fine mesh grill was installed between the holding pond and the entrance to the flume which leads to the spawning channel. This was found to be necessary to prevent young steelhead from entering the spawning channel. During the 1964 season, this area was open for small fish to come and go as they pleased, and over 5,000 fingerling and yearling steelhead were found to be living in the channel during the period when salmon fry were emerging from the gravel. The steelhead fed heavily on the salmon, and as a result salmon production in the channel was poor.

KING SALMON MAINTENANCE PROGRAM

Spawning Season 1965 Brood Year

The spawning channel was in good condition at the start of the 1965 season, and no maintenance work was required since last season's operation. Redds from the previous spawning season were left as they were.

On October 7, 1965, a flow of 55 cfs was released into the spawning channel and maintained between 55 and 59 cfs for the remainder of the spawning season.

All of the adult salmon received at the installation came in of their own volition. The first arrived on October 12 and the last one on December 12. Of the 173 salmon which entered the installation 169 (58 males, 33 females, and 78 grilse 1/) were released into the spawning channel (Figure 3). Two males and two females were artificially spawned. The eggs from the two females were hatched in incubator trays in order to test for survival of fry in relation to high water temperatures.

The peak of adult salmon migration occurred at the Installation in the first week of November. Early arrivals were in the "green" stage of development and in good condition. The ones arriving later in the season were much darker, in a ripe condition, and with fungus spots on their bodies.

When adult salmon were first placed in the channel, they moved from the lower end to the upper end as though they were scouting out the channel. Most of them would then drop back and hold in the large holding pool in the bend at the end of channel one. This was especially true of the early arrivals which had a period of waiting before they were ready to spawn. Many of the later arrivals, most of which were ready to spawn, would select a redd site almost immediately after entering the channel. The fish seemed to make a fast adjustment to their new environment. Very little jumping was observed and generally the fish were not seen in shallow water until they were ready to spawn.

The female salmon selected almost all sections of the channel for spawning. Some superimposition occurred in a few places. Most areas selected for spawning were the same spots used the previous season. One area, a 500-foot section at the upper end of channel two, was not used this year or last year.

1/ Males under 24 inches fork length

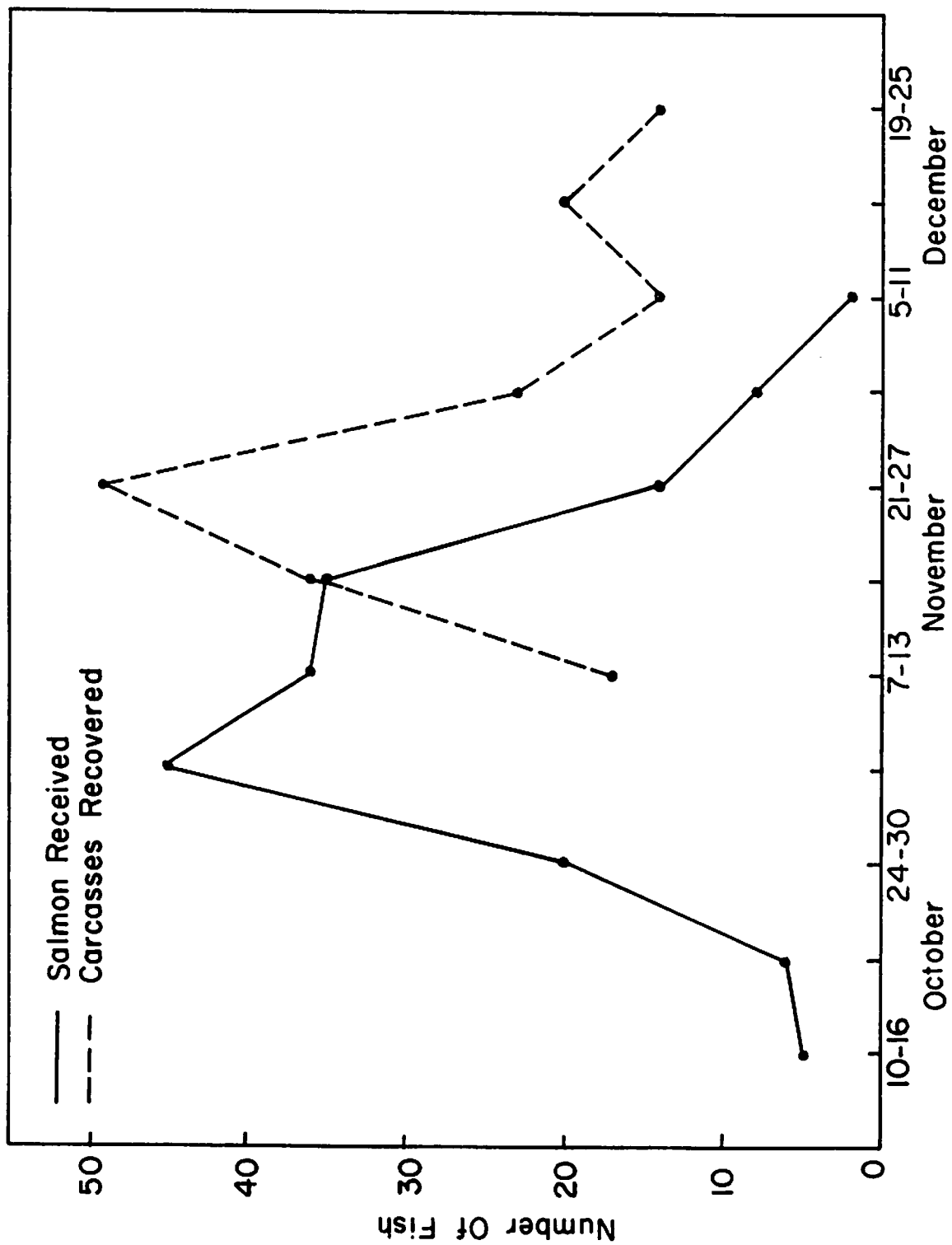

FIGURE 3 - Adult salmon received and carcasses recovered by seven-day periods: Mokelumne River spawning Channel 1965-66 season

Carcass Recovery 1965 Brood Year

Salmon carcasses were recovered from the channel on a daily basis. Carcasses were recovered from all sections but the majority were washed onto the V-gate at the lower end of channel two. Each carcass was measured and cut open in order to record gonad condition. All eggs retained in the females were counted. The peak of carcass recoveries occurred about three weeks after the peak number of fish entered the channel (Figure 3).

All of the salmon placed in the channel were recovered. Of the 33 females recovered, one died without spawning. In the other 32 combined, only 500 eggs remained. After being examined, the carcasses were disposed of in the river just below the Installation.

Estimated Egg Deposition 1965 Brood Year

The length fecundity data from 4 females sampled in the 1964 run and 2 females from the 1965 run were used as a basis to estimate the number of eggs deposited in the gravel this season. The data were applied to the least squares formula $y = a + b x$ where y = number of eggs and x = fish length in inches. The regression line which represented this sample was $y = -9884.7 + 488.6x$. Applying this equation to the 33 females which entered the channel gave a potential of 157,043 eggs (Appendix A). Subtracting the unspawned eggs (6,160) 2/ gives a total of 150,883 eggs deposited.

Downstream Migrant Production 1965 Brood Year

After the spawning had been completed the flow in the channel was reduced to 25 cfs where it remained for the duration of the downstream migration period. Enumeration of the voluntary outmigrants 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 residuals were seined from the channel at the end of the migration season.

The downstream migrant trap was installed on December 16, 1965, and the first migrants were captured the following day. The migration season continued until June 18, 1966. On June 19, the water in the channel was slowly reduced and finally shut off completely. Then on June 25, the remaining holdouts were seined from the holding pools. During the season the channel produced 76,435 fish, which is 50.6 percent of the estimated number of eggs deposited in the gravel. Of this number, 75,435 were recovered in the trap and 1,000 seined from the channel pools. The peak of migration occurred towards the latter part of May (Figure 4).

The method used to enumerate the outmigrants was to make an actual count if the number of fish was small. During periods of heavy migration, the number of fish in a 16-ounce sample was counted to obtain the number of fish per ounce. The total weight of fish trapped was then multiplied by the number per ounce to get total fish by time periods.

2/ Included eggs from one fish which died without spawning and eggs remaining in 32 other females.

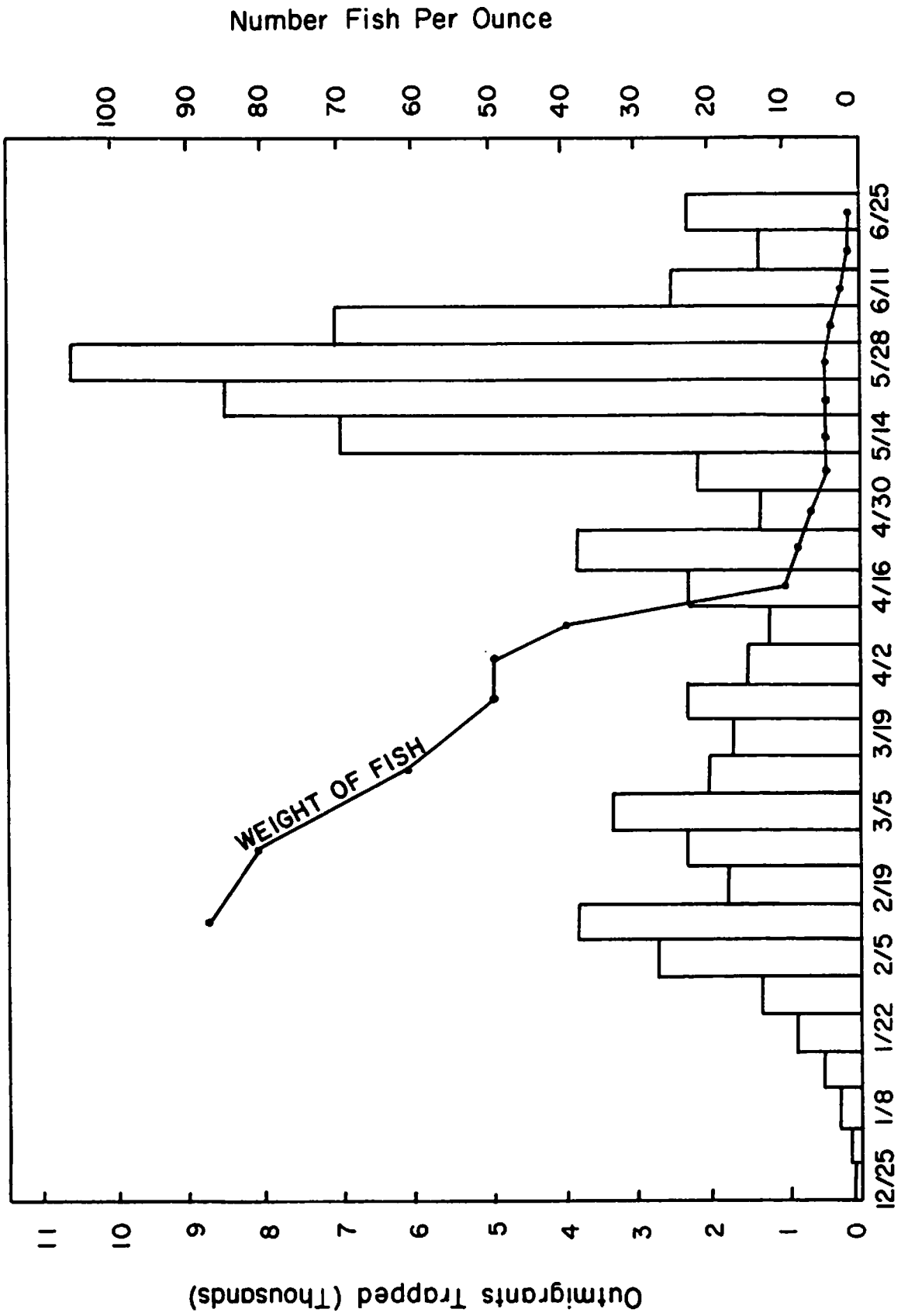

FIGURE 4 - Weight and number of King Salmon outmigrants by weekly periods at Mokelumne River Spawning Channel, 1965-66 season

Most of the early migrants were yolk sac fry. From December 17 to January 8, 400 were trapped compared to 170 buttoned up fry for the same period. The last yolk sac fry was observed on February 25. The number of sac fry counted was 715. All of these were transferred to a hatchery trough but only a very few survived.

The size of the outmigrants ranged from 85 per ounce in early February to 2.5 per ounce (40/lb) by mid-June (Figure 4).

From the start of the downstream migration period through March 15, the salmon were transferred from the spawning channel trap to the hatchery troughs. Here they were held until sufficient numbers gathered to warrant planting. There were 21,000 of these fish planted in the Mokelumne River below Woodbridge Dam. After March 15, 55,000 more fish were trapped, and hauled directly from the trap to the river below the Installation.

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 that 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 outmigration season.

Subsurface Water and Oxygen

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. In this case, 24 plastic standpipes were buried about 15 inches deep in the gravel.

Twenty-two of the standpipes were installed before the start of the 1965 spawning season in areas where no spawning had taken place last season. No spawning took place near these standpipes again this season. After completion of the 1965 spawning, the other two standpipes were placed just at the downstream end of two different redds. The apparent subsurface velocity measurements taken from these standpipes in various periods is presented in Appendix B.

At spawning flows (50 to 59 cfs) in non-redd areas (locations 1 through 18), the subsurface velocities were somewhat higher than at the incubation flows (25 cfs). However, the opposite was true at the two redd sites (locations A & B). Also, the velocity through the gravel was considerably higher in the vicinity of the two redds than in any of the non-redd areas. The change in water hydraulics after a redd is constructed appears to be responsible for this difference.

Dissolved oxygen content was determined by the standard Winkler method. A water pump was used to extract the sample from the standpipes. This worked very

well except we had no way of knowing if the sample was being contaminated by surface water. We don't believe this happened, but if too large a sample is taken from the standpipes there is a chance of picking up some surface water and we had no way of checking for this. In the future, we plan to use a "Precision Galvanic Cell Oxygen Analyzer". This method is faster, easier, and eliminates possibility of contamination.

Dissolved oxygen samples were taken in the standpipes, once at the spawning flow and again at the incubation flow. In all cases, the oxygen content of the water was the same as that of the surface water, and in no case was it less than 10 ppm.

Egg and Fry Survival at High Temperatures

Two female king salmon were artificially spawned during the early part of the spawning period when water temperatures were at their maximum, 60 to 61° F. This was done to determine survival of eggs and early fry under these conditions. Results showed that under these temperature conditions a survival of about 75 percent or higher can be expected up to almost a month after hatching (Table 2). These fish appeared to be normal with respect to size and action. As a result of experiments in more northern waters temperatures this high are often considered to be lethal. However, this stream is near the southern limit for the species and it is possible that a strain of fish has developed which can tolerate higher water temperatures. Additional tests are planned for future years.

STEELHEAD MAINTENANCE PROGRAM

Hatchery Operation - 1966 Brood Year

The first steelhead this season entered the hatchery on January 3 and the last one on March 27, 1966. During this period 30 fish were received, 20 males and 10 females. The males averaged 19.3 inches and the females 19.7 inches. Eight of the females were spawned. From these, 30,970 eggs were taken, for an average of 3,871 eggs per female. The other two females were released in the river in a "green" stage of development. An additional 331,400 eggs were supplied from Nimbus Hatchery. This supplement was necessary to guarantee at least 100,000 fish would be raised to yearling size.

Planting - 1965 Brood Year

As the steelhead from last season's egg take grew and the capacity of the rearing ponds was reached, some of the steelhead fingerlings had to be removed. From July 1, 1965 to January 30, 1966, 131,420 surplus steelhead fingerlings were planted in the Mokelumne River. In the spring of 1966, 84,410 steelhead of yearling size were planted, 57,260 of these in the river below Woodbridge Dam and the remainder in the river just below the Installation.

After this year's crop of yearlings had been planted, 283,200 young steelhead fingerlings for next season's plant were transferred to the rearing ponds.

TABLE 2

Salmon Artificially Spawned at Maximum Water Temperatures to Determine Survival of Fry -- Mokelumne River Fish Installation, November 1965

Fork Length of Female = 29 inches
Hatching Time = 30 days

Date	Water Temp.(°F) Max.	Min.	Ounces Eggs	Number per oz.	Number of Eggs	Mortality	Percent Survival
11-09	61	60	47	78	3,666	Spawned	
11-10	61	60				570	
11-22	58	56				213	
11-27	56	54				105	
12-09	50	50				Hatching	
12-24	47	47				35	
01-05	46	45				5	
						928	74.7

Note - Two ounces of Malachite Green stock solution was used twice a week until the eggs were in the advanced eyed stage. Eggs were hatched in a Heath Incubator and the swim-up fry were moved to hatchery troughs on January 5, 1966.

Fork Length of Female = 31 inches
Hatching Time = 36 days

Date	Water Temp.(°F) Max.	Min.	Ounces Eggs	Number per oz.	Number of eggs	Mortality	Percent Survival
11-17	60	60	61	81	4,941	Spawned	
11-18	59	58				358	
11-27	56	54				112	
12-09	51	51				75	
12-23	47	46				Hatching	
12-24	47	47				30	
01-20	45	43				5	
						580	88.3

Note - Two ounces of Malachite Green stock solution was used twice a week until the eggs were in the advanced eyed stage. Eggs were hatched in a Heath Incubator and the swim-up fry were moved to hatchery troughs on January 20, 1966.

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 50's and low 60's prevailed in the early part of the salmon spawning season. The temperatures dropped slowly after about November 18, and reached a low of 44° by mid-January (Appendix C).

Very little difference in temperatures occurred in any 24-hour period. In the spawning season it didn't vary more than four degrees, and during the downstream migration season the difference was no more than two degrees.

MARKING

No formal marking of salmon or steelhead was done and no mark recoveries were made in this fiscal year.

PUBLIC RELATIONS

During the 1965-66 fiscal year, an estimated 21,885 people visited the Installation. Tours of the Installation were conducted for several special interest groups.

REFERENCES

Gangmark, Harold A., and Richard G. Bakkala. 1958. Plastic standpipe for sampling streambed environment of salmon spawn. United States Department of the Interior, Fish and Wildlife Service, Special Scientific Report - Fisheries No. 261, 19 pp.

Groh, Frederick H. 1965. Annual report Mokelumne River Fish Installation fiscal year of 1964-65. California Department of Fish and Game, Inland Fisheries Administrative Report No. 65-21, 27 pp. (mineo.)

APPENDIX A

Potential number of eggs contained in 33 female salmon using the Mokelumne River Spawning Channel in 1965-66 season

Length Inches	Estimated Number of Eggs Based on Length*	Number of Fish	Potential Number of Eggs Contained In Channel Fish
25	2331	2	4662
26	2819	2	5638
27	3308	2	6616
28	3796	4	15184
29	4285	4	17140
30	4774	6	28644
31	5262	4	21048
32	5751	3	17253
33	6240	2	12480
34	6728	2	13456
35	7217	1	7217
36	7705	1	7705
		33	157,043

* $y = -9884.7 + 488.6x$

APPENDIX B

Velocity of intragravel water at various flows and locations in Mokelumne River Spawning Channel 1965-66 season

Location	Water Temp. (°F)	Surface Flow In Channel (cfs)	Velocity of Intragravel Water (feet per hour) Oct. 20	Oct. 28	Nov. 5	Dec. 6	Jan. 19	Jan. 21	Jan. 26
01	62	50	1.40						
01	45	25					1.07		
02	62	50	2.05						
02	45	25					.78		
03	62	50	1.92						
03	45	25					1.15		
04	60	59			2.14				
04	45	25					.91		
05	60	59			1.93				
05	45	25					.72		
06	60	59			2.09				
06	45	25					1.46		
07	60	59			2.42				
07	45	25					1.27		
08	60	59			1.25				
08	45	25					1.15		
09	60	59			1.28				
09	45	25					.86		
10	60	55		2.00					
10	45	25						1.53	
11	60	55		1.27					
11	45	25						.70	
12	60	55		1.69					
12	45	25						1.35	
13	62	50	2.28						
13	45	25						1.43	
14	62	50	1.90						
14	45	25						.80	
15	62	50	1.07						
15	45	25						.78	
16	60	55		1.26					
16	45	25						.83	
17	60	55		1.26					
17	45	25						.90	
18	60	55		1.43					
18	45	25						1.03	
19	62	20	1.08						
20	62	20	1.38						
A	52	64				2.32			
A	45	25							4.20
B	52	64				3.07			
B	45	25							4.14

Note - All standpipes were buried 15 inches deep in spawning channel gravel. Standpipes located at A and B were buried at the downstream edge of salmon redds.

APPENDIX C

Water Temperature Data at Mokelumne River Fish Installation 1965-66 Season

Water Temperature (°F)

Date 1965	Max.	Min.	Date	Max.	Min.	Date	Max.	Min.
Sept. 1	58	54	Oct. 10	60	58	Nov. 18	59	58
2	58	54	11	61	58	19	59	58
3	58	54	12	61	58	20	59	58
4	58	54	13	61	58	21	59	58
5	58	54	14	60	58	22	58	56
6	58	54	15	60	58	23	58	56
7	58	54	16	60	58	24	58	56
8	58	54	17	61	58	25	56	55
9	58	54	18	61	58	26	56	54
10	58	54	19	61	58	27	56	54
11	58	54	20	61	58	28	56	54
12	58	54	21	61	58	29	55	54
13	58	54	22	61	58	30	55	54
14	58	54	23	62	58			
15	58	54	24	62	58	Dec. 1	54	53
16	58	54	25	62	58	2	53	52
17	58	54	26	62	58	3	53	52
18	58	54	27	62	58	4	53	52
19	58	54	28	62	58	5	52	52
20	58	54	29	62	58	6	52	52
21	59	55	30	62	58	7	52	52
22	59	55	31	62	58	8	51	51
23	59	55				9	50	50
24	59	55	Nov. 1	62	60	10	50	50
25	58	56	2	62	60	11	50	50
26	58	54	3	62	60	12	50	50
27	56	56	4	62	60	13	50	50
28	58	54	5	62	60	14	50	50
29	58	54	6	62	60	15	50	50
30	60	56	7	62	60	16	50	48
			8	62	60	17	50	48
Oct. 1	60	56	9	61	60	18	50	48
2	60	56	10	61	60	19	49	48
3	60	56	11	61	60	20	48	47
4	60	56	12	60	60	21	48	47
5	60	56	13	60	60	22	48	47
6	60	57	14	60	59	23	47	46
7	60	58	15	60	59	24	47	47
8	60	58	16	60	60	25	48	46
9	60	58	17	60	60	26	47	46

APPENDIX C (continued)

Water Temperature (°F)

Date	Max.	Min.	Date	Max.	Min.	Date	Max.	Min.
Dec. 27	47	46	Feb. 5	46	46	Mar. 18	48	46
28	47	46	6	46	46	19	48	46
29	47	46	7	46	44	20	48	46
30	46	45	8	46	44	21	48	46
31	46	45	9	46	44	22	48	46
1966			10	46	44	23	48	46
Jan. 1	46	44	11	46	44	24	48	46
2	46	45	12	46	44	25	48	46
3	46	45	13	46	44	26	48	46
4	46	45	14	47	45	27	49	47
5	46	45	15	47	45	28	49	47
6	46	45	16	47	45	29	49	47
7	46	45	17	47	45	30	49	47
8	46	46	18	47	45	31	49	47
9	46	46	19	47	45			
10	46	45	20	47	45	Apr. 1	49	47
11	46	45	21	47	45	2	49	47
12	46	44	22	48	46	3	50	48
13	46	44	23	48	46	4	50	48
14	46	44	24	46	46	5	50	48
15	46	45	25	46	44	6	49	48
16	46	44	26	47	45	7	49	48
17	46	44	27	47	45	8	49	48
18	46	44	28	46	44	9	49	48
19	46	44				10	50	48
20	45	43	Mar. 1	46	45	11	50	48
21	46	44	2	46	44	12	50	48
22	46	44	3	46	44	13	50	48
23	46	44	4	48	46	14	50	48
24	46	44	5	48	46	15	50	48
25	46	44	6	48	46	16	50	48
26	46	44	7	48	46	17	48	48
27	46	44	8	48	46	18	48	48
28	46	44	9	48	46	19	48	48
29	47	45	10	48	46	20	48	48
30	46	45	11	48	46	21	48	48
31	46	46	12	48	46	22	49	48
			13	48	46	23	50	48
Feb. 1	46	46	14	48	46	24	50	48
2	46	44	15	48	46	25	50	49
3	46	44	16	48	46	26	49	48
4	46	46	17	48	46	27	49	48

APPENDIX C (continued)

Water Temperature (°F)

Date 1966		Max.	Min.	Date		Max.	Min.	Date		Max.	Min.
Apr.	28	49	48	May	19	51	49	June	10	52	50
	29	49	48		20	51	49		11	52	50
	30	50	48		21	51	49		12	54	50
					22	51	49		13	54	52
May	1	50	48		23	51	49		14	55	53
	2	50	48		24	51	49		15	55	53
	3	50	48		25	51	49		16	54	52
	4	50	48		26	51	49		17	54	52
	5	50	48		27	51	49		18	54	52
	6	50	48		28	51	49		19	54	52
	7	50	48		29	50	49		20	54	52
	8	50	48		30	50	49		21	54	52
	9	48	48						22	54	52
	10	48	48	June	1	50	49		23	54	52
	11	49	48		2	50	49		24	54	52
	12	50	48		3	51	49		25	55	53
	13	50	48		4	51	49		26	55	53
	14	50	48		5	52	49		27	56	54
	15	50	48		6	52	50		28	56	54
	16	50	48		7	52	50		29	56	54
	17	50	48		8	52	50		30	56	54
	18	51	49		9	52	50				