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A PLAN FOR THE PROTECTION AND MAINTENANCE OF SALMON AND STEELHEAD IN THE AMERICAN RIVER, CALIFORNIA, TOGETHER WITH RECOMMENDATIONS FOR ACTION

Prepared jointly by

United States Fish and Wildlife Service
and the
California Department of Fish and Game

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PREFACE

This plan for the protection and maintenance of salmon and steelhead trout in the American River, California, is concerned with the effects of Nimbus Dam which is under construction by the Bureau of Reclamation as a part of the American River Division of the Central Valley Project. Folsom Dam, under construction by the Corps of Engineers, will also be operated by the Bureau as a part of the project. The latter dam is being constructed on the American River at a site approximately 30 miles above the confluence with the Sacramento River about 3/4 mile below the main fork of the American River. When completed, the dam will be a concrete-gravity and earthfill structure 284 feet high with an overall crest length of 21,500 feet (including auxiliary dikes). It will impound a maximum of 1,000,000 acre-feet of water and will be the main storage unit of the project division. Folsom Power Plant, under construction at the base of the main dam by the Bureau of Reclamation, will have a capacity of 198,000 k.v.a. in its three units. Nimbus Dam with a 15,000 k.v.a. power plant of two units and forming a combination re-regulating reservoir and diversion structure is under construction by the Bureau of Reclamation at a site 7 miles downstream from Folsom Dam. This concrete-gravity structure will be 76 feet high and 800 feet long when completed and will create a lake of 8,900 acre-feet.

A schematic map showing these project features is attached at the end of the report.

Of the more than 400,000 acre-feet of water to be developed by the American River Division, 272,000 acre-feet will be diverted from Nimbus Dam to service about 150,000 acres of newly irrigated lands.

The Fish and Wildlife Service has prepared a preliminary evaluation report on the Folsom Project dated June 1950 which contains additional data on the various project features mentioned above and discusses all fish and wildlife aspects of them. This Service report should be consulted for a

description of the American River area and for other, above mentioned, information. The present report considers only the effects of Nimbus Dam on anadromous fishery resources.

INTRODUCTION

The U. S. Fish and Wildlife Service and the California Department of Fish and Game have the responsibility under act of August 14, 1946 (60 stat. 1080; 16 U.S.C. 661) 79th Congress of preparing an action plan for the conservation of salmon and steelhead runs affected by the construction of Nimbus Dam on the American River. As a result of discussions between these agencies and with the Bureau of Reclamation, an investigative period of from February 1, to July 1, 1953 was originally selected to be devoted to the development of such a plan. An outline of the various items to be considered during this period was prepared and distributed to the agencies involved on February 2, 1953. As the investigation progressed it became apparent that effective salmon and steelhead salvage facilities must be in operation by the fall of 1954. To speed up preparations for handling the runs the deadline for the report on an action plan was advanced to May 15, 1953.

This report follows the outline as closely as possible. The investigation of a few of the items has not been completed because of the curtailment of the investigative period. It may be necessary to submit a supplementary report covering these points at a later date.

PART ONE

NATURAL HISTORY AND NUMBERS OF AFFECTED ANADROMOUS FISHES

Time And Size Of Adult Salmon Runs

The runs of salmon in the American River are made up entirely of one species, the king salmon (Oncorhynchus tshawytscha). Like other species of Pacific salmon, kings are completely dependent on fresh water streams for reproduction and upon the sea for growth to maturity.

King salmon enter the American River in well-defined spring and fall runs. The spring run arrives at old Folsom Dam mainly during the months of May, June and July and involves comparatively few salmon. Until recently spring salmon made use of the fish ladder at the old Folsom Dam in migrating to the deeper, cooler areas up river where they could spend the summer. Counts of these migrants (Table 1) were made at Folsom Dam in 1945, 1946 and 1947. In 1950 floods destroyed the ladder. No attempt was made to rebuild this structure since the new Folsom Dam, a complete block to migratory fish, was under construction a short distance upstream. Since 1950 spring-run salmon have been forced to remain in the pools below the old dam. Nothing is known of the size of these latter runs or of the numbers of salmon which survived high water temperatures during the summer.

The main salmon run in the American River takes place in the fall, beginning in late September, peaking in October, continuing in November and tapering off in December. Most of these fish spawn between Sacramento and Folsom Dam. A small portion of the run (Table 1) spawned upstream from Folsom Dam prior to the destruction of the fish ladder.

For three years, 1944 through 1946, the size of the fall salmon runs in

the American River was calculated by means of tagging and tag recovery programs. Each of these projects involved trapping and tagging a sample of the spawning run at a temporary weir located near the H Street Bridge at Sacramento. Subsequently, the dead spawned-out salmon, both tagged and untagged, were recovered on the spawning beds. The salmon population was estimated by assuming that the ratio between the number of tagged fish recovered to the total number tagged was the same as the ratio between the total number of dead fish recovered and total population.

Each fall since 1946, with the exception of 1947 and 1950, crews have patrolled the spawning beds of the American River counting the dead salmon and looking for tags which had been placed on fish caught and released in the ocean. From the numbers of dead salmon recovered and from observing the numbers of live fish on the riffles, it was possible to make reasonably accurate estimates of the size of the salmon runs. Table 2 shows the results of population studies made from 1944 to 1946 and the estimated runs in the following years. From these data the average annual salmon run is estimated to number 26,000 fish.

Sex Ratio

The sex ratio of the salmon in the American River is based on the dead fish recoveries. An experienced observer can tell the sex of most spawned-out salmon at a glance. Moreover, all dead salmon are cut in two with a machete to enable the observer to examine the body cavity and definitely establish the sex of the fish in case of doubt. Cutting the fish in two also prevents recounting the same individuals on later trips over the same area. A few salmon are so badly decomposed that it is impossible to determine their sex. These fish are classified as skeletons in the recovery records and are disregarded in calculating the sex ratio.

From Table 3 it would appear that the adult salmon population in the

American River is composed of only slightly more males than females. Observations made on the spawning beds, however, indicate that there was always a considerable surplus of males. Therefore, it was concluded that there was some difference in the rate of recovery between the sexes. This may be explained by the fact that males tend to wander off downstream after they complete spawning and often die in the deeper or more inaccessible places in the river. On the other hand females stay close to their nests until expiring and, consequently, are easier to locate. Furthermore, a considerable number of males (jacks) are extremely small and are apt to be overlooked.

A tagging experiment on the Stanislaus River in 1948 showed that when equal numbers of male and female salmon were tagged and released on the spawning beds only 82.2 males would be recovered for every 100 females. Some similar ratio probably holds true in most of the rivers in the Sacramento-San Joaquin system. When this ratio is applied to the American River dead salmon recovery data, we find that the population consists of 61.2 percent males and 38.8 percent females, or for practical purposes a 60-40 ratio.

Fecundity

No data are available on the fecundity of the king salmon in the American River, but it is assumed that it is no different from that of the same species in adjacent streams where egg counts have been made. Hanson, Smith and Needham (1940)[1] found the average number of eggs per female in the run at Redding on the Sacramento River was 6,790. They used the round figure of 7,000 in calculating the total number of eggs in the run. The

[1] U.S. Fish & Wildlife Service Special Scientific Report No. 10. An Investigation of Fish Salvage Problems in Relation to Shasta Dam by Harry A. Hanson, Osgood R. Smith, and Paul R. Needham, 1940.

average egg yield of female king salmon at Coleman Hatchery on Battle Creek varies from 6,000 to over 6,500. King salmon from the Tuolumne River, a stream very similar to the American, produced an average of 6,700 eggs per female in studies made in 1947. For the purposes of this report the figure of 6,500 eggs per female was assumed for the American River king salmon.

Habits Of Young Salmon

Salmon eggs which have been deposited in the gravel riffles in the American River incubate for a period of from one to three months depending on water temperatures. After hatching the fry remain in the gravel until the yolk sac is almost absorbed. The downstream migration begins as soon as the fry emerge from the gravel. The speed with which the migrants move out of the American River is influenced by fluctuations of the river, weather, and by water temperatures.

The seaward migration of young salmon was sampled by means of fyke nets for three seasons, from 1945 through 1947. Two types of nets were used in the study. A round fyke net with a five-foot diameter opening was fished in deep water and a riffle type net with a three-foot by five-foot rectangular opening was used in shallower water on a riffle. The nets were located near the Haggin Gravel Company about six miles upstream from the H Street Bridge at the edge of Sacramento. Practically all spawning takes place above this point.

Figures 1 and 2 show the duration and intensity of the downstream migration as indicated by the two fyke nets. The seaward migration starts about February 1, and continues into June. The peak of the migration occurs between April 1 and May 15. A number of variables make it impossible to compare directly the results obtained with a net one year with catches made the following year. Such factors as water fluctuations, current, amount of debris, and condition of the net change the fishing success from day to day.

Obviously, quantitative data obtained through the use of gear as inefficient and selective as a fyke net cannot be used to give an accurate estimate of the total numbers of downstream migrants passing the net site.

The rate of growth of the migrants trapped in the fyke nets is shown in Figures 3 and 4. In February and March the average total length of the migrants does not vary a great deal since the catch is dominated by large numbers of small fish which are constantly emerging from the gravel. However, from the first of April until the conclusion of the migration in June an extremely rapid growth rate is evident.

Distribution Of Adult Salmon In The American River

The numbers of salmon which spawned above and below Nimbus Dam site were estimated from the dead salmon recovery records. These figures were available for each year from 1944 through 1952 with the exception of 1947 and 1950, and are presented in Table 4. From this information it was calculated that an average of 72.5 percent of the annual salmon run spawns in the area above the Nimbus Dam site.

In obtaining the distribution of salmon above and below Nimbus from the dead salmon recovery figures some allowance had to be made for the fact that dead fish are carried downstream by the current before they become stranded. The distance some fish are washed downstream is well illustrated the first time the river is covered each year on the dead fish survey. The section of the river between Folsom and Fair Oaks is patrolled first and all dead salmon recovered are cut in two with a machete. The following day the crew covers the section of the river between Fair Oaks and the Haggin Gravel Co., some four miles downstream. Some of the dead salmon which had been cut in two the day before, in the upper section are now seen throughout the lower area. For this reason in analyzing the recovery data all the dead salmon recovered above the Fair Oaks bridge were

classified as spawning above the Nimbus Dam site and those found between Fair Oaks and Sacramento were recorded as spawning below Nimbus. Using the Fair Oaks bridge as a dividing point should make the estimate of the number of fish spawning above Nimbus a conservative figure.

In Table 5 the number of female salmon that would have been blocked at Nimbus are listed by years. This figure was obtained by multiplying the estimated total run passing Nimbus by 38.8 percent. From the table it can be seen that the number of female salmon spawning above Nimbus Dam site in recent years varied from 3,000 to almost 12,000. To obtain the number of eggs produced above Nimbus, the number of females was multiplied by 6,500. The average number of eggs deposited annually in this area was found to be 47,570,000.

Numbers Of Fish At And Below Nimbus Dam With Artificial Spawning Channel And With Stream Improvement

There is no possibility of estimating the number of salmon which could be handled in an artificial spawning channel until studies are made with a test channel. The segment of the salmon population which could be accommodated on improved spawning beds below Nimbus Dam can not be determined until after Folsom Dam is in operation.

Advisability Of Counting Adult Runs In 1953

It appears unnecessary to spend time and effort in obtaining further detailed data on the salmon run in the American River in 1953 since adequate information is already available on the time and size of the runs (Table 2). A tagging and tag recovery project to estimate the salmon population in 1953 would involve the construction of a temporary weir at the lower end of the salmon spawning area where the fish could be trapped and tagged. In addition the services of a biologist and four assistants would be required for at least four months to install and maintain the weir and to recover the dead salmon on the spawning beds. It is estimated that such a program

would cost $10,000.00. Furthermore, experienced crews will be counting the dead salmon on the spawning beds of the Central Valley rivers while searching for tagged or marked fish. The numbers of dead fish recovered in the American River will provide the basis for a reasonably accurate estimate of the size of the 1953 fall salmon run.

In the event that Nimbus Dam blocks salmon in the fall of 1953, some method, such as a fish ladder or trapping and hauling by truck will be used to get the fish past the barrier. If such is the case it would be advisable to check the number of salmon passing the dam either by counting the fish through a ladder or keeping accurate records of the number of fish hauled by truck.

Time And Size Of Adult Steelhead Runs

Little is known of the natural history of the steelhead trout (Salmo gairdnerii) in the American River. The only available material on the steelhead of this stream are the counts that were made at the fish ladder at the old Folsom Dam from 1943 through 1947. A study of Table 6 shows that some steelhead pass Folsom in every month of the year with the exception of August and September. The peak of the run, however, occurs in May and June and part of July. The largest count was made in 1946 when 1,287 steelhead passed through the ladder.

Since the destruction of the fish ladder at Folsom Dam in 1950 the steelhead runs probably have been virtually eliminated. It is necessary that these fish migrate upstream considerably past Folsom Dam to reach the small tributary streams where they spawn. There is no evidence that steelhead have ever spawned in the main stream between Sacramento and Folsom. With the main portion of the run arriving below the dam in May and June it is unlikely that these fish could have endured the high summer water temperatures in the lower river and remain to spawn the following winter.

Fortunately steelhead runs build up rapidly when conditions are favorable. Lower water temperatures and a more stable flow after the construction of Folsom and Nimbus Dams may produce an environment favorable to these fish. Yet it may be necessary to maintain the runs through artificial propagation if the area below Nimbus Dam proves unsuited for steelhead spawning.

Habits of Young Steelhead

It can be safely assumed that young steelhead in the American River migrate to sea in their second year as is the case in other streams. If any of these fish moved downstream in their first year while they are still very small they certainly would have appeared in the fyke net catches along with the young salmon. Yearling steelhead are too large and active to be trapped in a standard fyke net.

TABLE 1

Numbers of King Salmon Counted Through the Fishway of Old Folsom Dam, American River, 1944-1947

Month	1944 Spring	1944 Fall	1945 Spring	1945 Fall	1946 Spring	1946 Fall	1947 Spring	1947 Fall
Jan.					0		0	
Feb.					13		0	
March					0		0	
April					0		0	
May	198		24		0		0	
June	808		18		3		2	
July	132		0		0		1	
Aug.				0		0		
Sept.		2		0		0		
Oct.		299		547		263		
Nov.		1851		1686		152		
Dec.		50		13		6		
Totals	1138	2202	42	2246	16	421	3	

TABLE 2

Estimated Size of King Salmon Runs of the American River for the Period 1944-1952

Year	Number of Salmon
1944	30,592*
1945	38,656*
1946	38,388*
1947	---- **
1948	15,000
1949	12,000
1950	---- **
1951	22,000
1952	25,000
Average	25,948

*Calculated from tagging and tag recovery program.
**No data were collected in these years.

TABLE 3

Numbers and Sex of Dead King Salmon Recovered from the Spawning Area, American River, for the Period 1944-1952*

Year	Total Males & Females	Males**		Females	
		Number	Percent	Number	Percent
1944	1,542	799	51.8	743	48.2
1945	2,343	1,669	71.2	674	28.8
1946	6,809	3,640	53.5	3,169	46.5
1947					
1948	1,324	758	57.3	566	42.7
1949	1,947	947	48.6	1,000	51.4
1950					
1951	1,315	796	60.5	519	39.5
1952	1,014	585	57.7	429	42.3
Total	16,294	9,194	56.4	7,100	43.6

*Skeletons recovered in the surveys are omitted from this table.

**1948 Stanislaus River population study indicated that when equal numbers of tagged male and female King salmon were released on the spawning beds only 82.2 males were recovered for every 100 females.

Applying this ratio to the American River recovery figures we find 9194 males ÷ .822 = 11,184 or 61.2 percent males and 7,100 or 38.8 percent females, which for practical purposes is a 60-40 ratio.

TABLE 4

Estimated Size and Distribution of King Salmon Runs of the American River for the Period 1944-1952

Year	Estimated Total Salmon Run	Estimated Run Above Nimbus	Percent	Estimated Run Below Nimbus	Percent
1944	30,592	23,762	77.7	6,830	22.3
1945	38,656	24,815	64.2	13,841	35.8
1946	38,388	30,684	79.7	7,704	20.3
1947					
1948	15,000	12,060	80.4	2,940	19.6
1949	12,000	8,028	66.9	3,972	33.1
1950					
1951	22,000	13,684	62.2	8,316	37.8
1952	25,000	19,050	76.2	5,950	23.8
Averages	25,948	18,869	72.5	7,079	27.5

TABLE 5

Estimated Numbers of Female King Salmon Spawning Above Nimbus Dam Together with the Calculated Numbers of Eggs Deposited by Them for the Period 1944-1952

Year	No. of Salmon Above Nimbus*	No. of Female Salmon Above Nimbus	No. of Eggs**
1944	23,762	9,220	59,900,000
1945	24,815	9,628	62,600,000
1946	30,684	11,905	77,400,000
1947			
1948	12,060	4,679	30,400,000
1949	8,028	3,115	20,200,000
1950			
1951	13,684	5,309	34,500,000
1952	19,050	7,391	48,000,000
Average	18,869	7,079	47,600,000

*Calculated on the basis that 38.8 percent of the total number of salmon are females. See footnote Table 3

**Calculated on the basis of 6,500 eggs per female. The total is rounded to the nearest 100,000 eggs.

TABLE 6

Numbers of Steelhead Trout Counted Through the Fishway at Old Folsom Dam, American River, 1943-1947

MONTH	YEAR				
	1943	1944	1945	1946	1947
Jan.		47		0	12
Feb.		0		5	49
March		0		6	16
April		0		0	4
May		5	87	577	180
June		53	294	669	254
July		142	1	6	11
Aug.		0	0	0	
Sept.		0	0	0	
Oct.	62	10	3	11	
Nov.	12	12	25	0	
Dec.	14	0	2	13	
Total	88	269	412	1287	526

Figure 1.

Downstream Migration of King Salmon Fry as Determined by Catch per Hour.

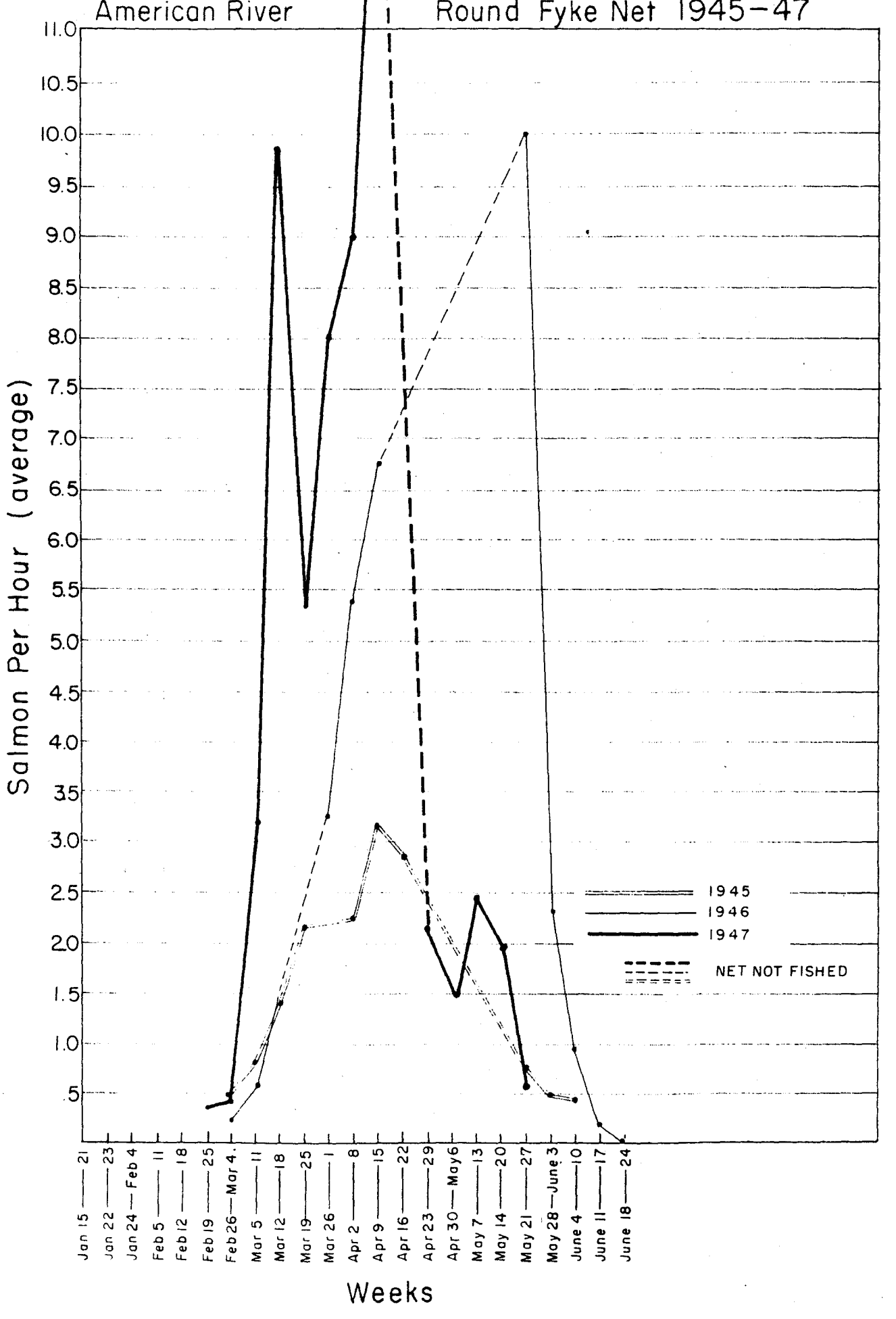


Figure 2

Downstream Migration of King Salmon Fry as Determined by Catch per Hour.

American River Riffle Fyke Net 1945-47

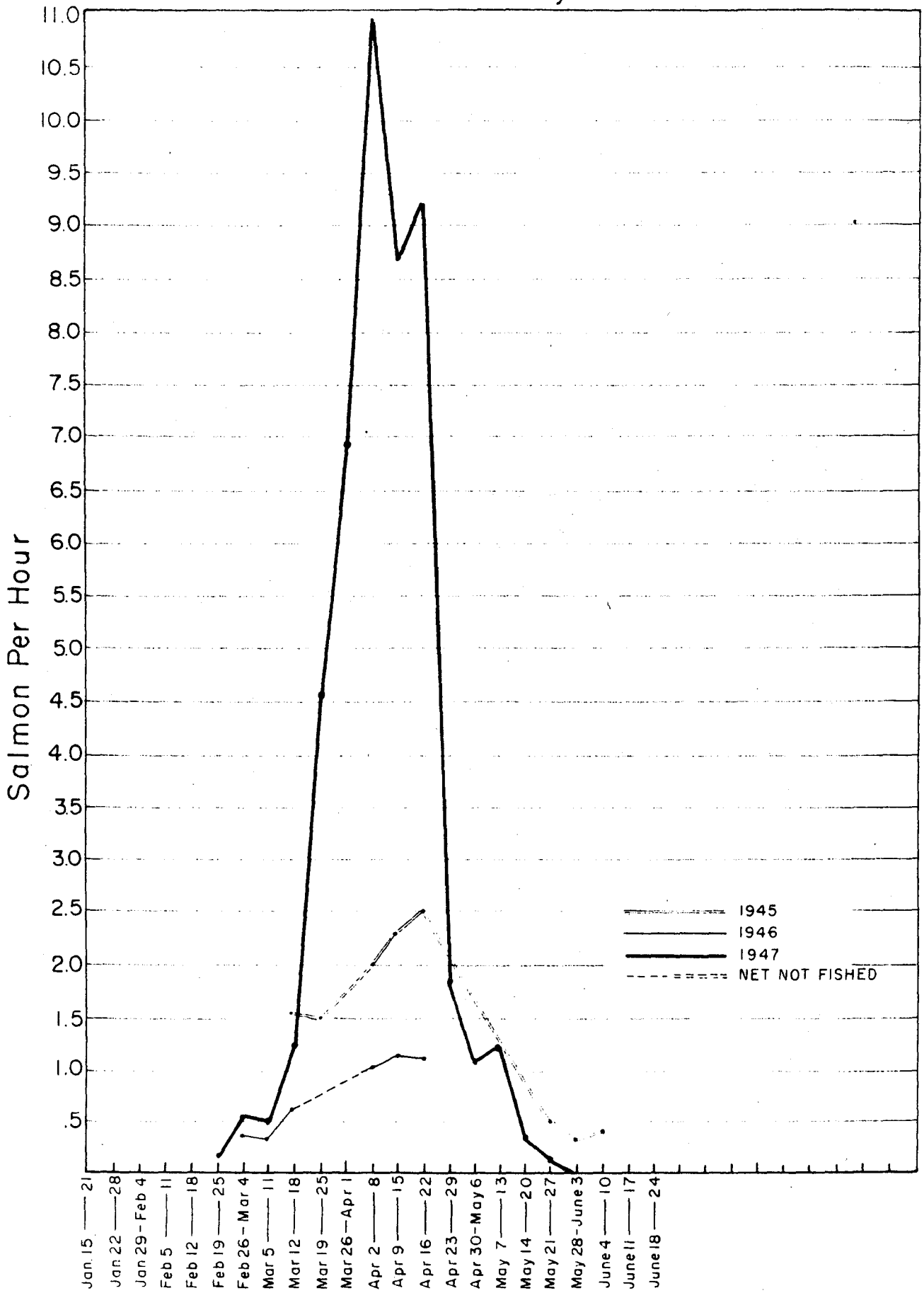
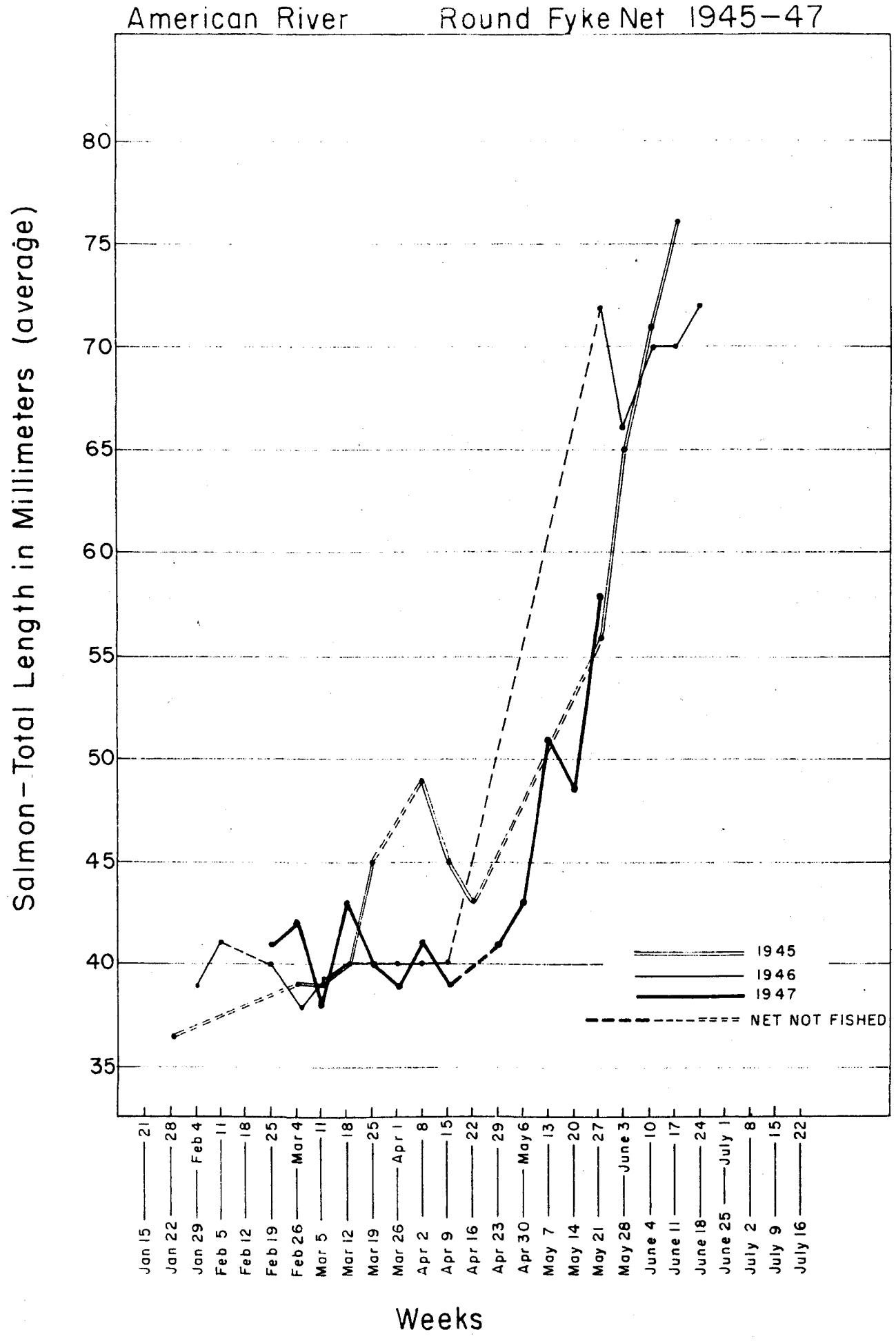


Figure 5

Average Length of Downstream Migrant King Salmon Plotted by Weeks.



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American River Riffle Fyke Net 1945–47