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KING SALMON SPAWNING STOCKS OF THE
CALIFORNIA CENTRAL VALLEY, 1940-1959¹DONALD H. FRY, JR.
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INTRODUCTION

This paper lists the best available counts and estimates of the king salmon *Oncorhynchus tshawytscha* (Walbaum) spawning runs of the Sacramento-San Joaquin River system from 1940 to 1959.

The first serious effort to determine the size of salmon runs in the Central Valley came as a result of the proposed construction of Shasta Dam. Part of the information needed to evaluate the effects of this proposed project on the fisheries was a count of the salmon which would be blocked. The first count was made in 1937, and every year since then a count or estimate has been made in one or more Central Valley streams. Estimates of the total fall run in all Central Valley streams did not start until much later. Almost all the counts given in the accompanying tables were made by the California Department of Fish and Game or the U. S. Fish and Wildlife Service. The only exceptions are the 1940-41 counts in the Sacramento River which were made by the U. S. Bureau of Reclamation.

Many counts and estimates were incomplete because counting had to be done at places where high water made it possible for fish to pass by uncounted, because fish counting weirs could not be kept fish tight, and because of the difficulty in seeing enough fish to make a satisfactory estimate possible in some of the larger streams. In addition, most of the earlier counts were made by men who had done little or no work with salmon. These men learned as they worked, but at first they did not fully appreciate how many salmon will go through a small hole in a counting weir, or how small a percent of the fish can actually be seen even in a stream where visibility seems excellent. This inevitably led to estimates which were too low—sometimes ridiculously low. In general the larger the stream the worse the difficulties of this type. For such reasons, during the 1940's, some of the estimates on the tributary streams and all of the totals on the main stem of the Sacramento were probably much too low. By way of contrast: On the tributaries the actual counts (other than incomplete counts) are reasonably accurate whenever and wherever listed, but are minimal rather than maximal.

Counting of salmon is relatively simple *only* where the entire spawning run can be forced to pass through a counting gate such as can be

¹ Submitted for publication May, 1960. Map by Clifton Corson.

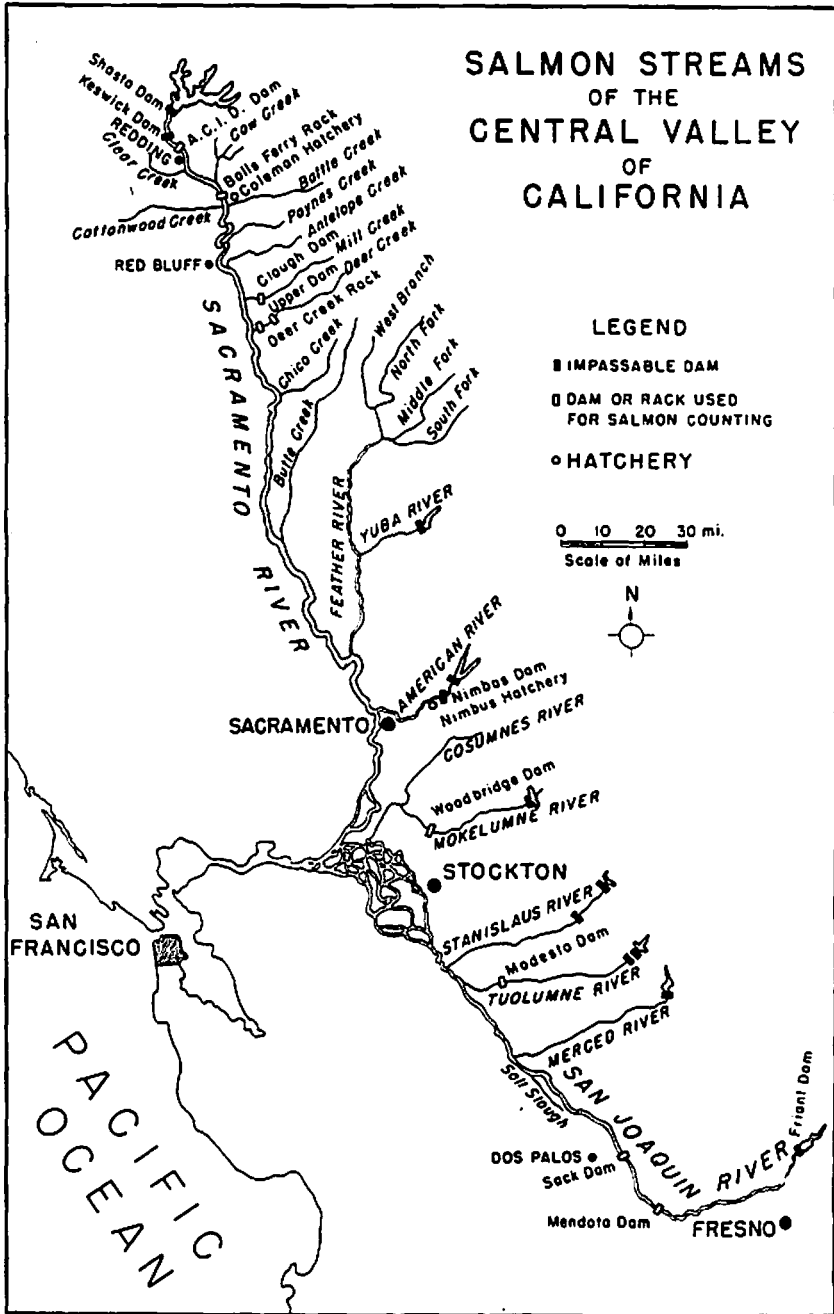


FIGURE 1. Salmon streams of the Central Valley. Only those streams and counting stations mentioned in the text are shown here. Dams with fishways are shown if mentioned in the text.

placed in a fishway over an otherwise impassable barrier. In the Central Valley no major run can be counted this easily.

For want of better places, much counting has been done at dams which have spawning area below them. Such counts are incomplete and must be supplemented with an estimate of the fish spawning downstream from the dam if a true idea of the entire spawning run is to be obtained. Often no satisfactory estimate could be made.

A good many of the earlier counts were made by the use of fish counting weirs or racks. These are structures which strain the water of the stream while, in theory, permitting the fish to go upstream only through counting gates. The more expensive ones used parallel lengths of pipe set close enough together to block the salmon, somewhat cheaper ones were wooden, and the cheapest of all were constructed of wire mesh. None proved satisfactory. Floods topped them or scoured holes underneath them, or the fish found or made small openings which they used in preference to the counting gates. One counter at such a place gave up trying to mend all the holes, closed down his counting gate, and counted the fish through the opening they seemed to like best.

Some of the runs have been calculated by the use of tag and recovery methods. For this type of study fish should be caught and tagged near the downstream end of a spawning area, then released and allowed to spawn naturally. After the fish have spawned and died the ratio of tagged to untagged fish is determined. To use a simplified example: If 500 tagged fish have been released in the stream and one out of ten spawned-out carcasses is tagged, it is assumed that the run is approximately 5,000 fish. This method has worked quite satisfactorily on the American and Stanislaus Rivers. It has proven much less satisfactory on the main stem of the Sacramento,² but nonetheless it has been the best available source of information on the main stream for several years.

The tag and recovery method has proven quite valuable as a method of training personnel to estimate the size of the run in a stream. After a man has learned from a tagging experiment about what proportion of the fish he can expect to see under certain conditions, he is then much better able to estimate the size of a run in a stream where no tagging has been done. Most of the Department of Fish and Game estimates were made by counting spawned-out carcasses and estimating the percent which the crew could be expected to find.

Another method of estimating involves aerial redd (nest) counts. There are difficulties such as those caused by many fish spawning so close together that the nests cannot be separated, but in streams where the bottom can be clearly seen the method should have good possibilities. Unfortunately, it has not yet been possible to check aerial redd counts against a fish ladder count.

Occasionally more than one estimate has appeared for a single stream for one year. One reason for this was that the Department of

² There are several reasons why tag and recovery methods have not yet been made satisfactory on the main stem of the Sacramento. Probably the most important has been the difficulty of recovering adequate numbers of spawned-out tagged carcasses in the main stem because of deep and murky water; the tagging site was only a few miles above the mouth of the Feather and was too far downstream; and the cylindrical wire traps used for catching the fish selected much too high a proportion of small salmon.

Fish and Game and the U.S. Fish and Wildlife Service sometimes made separate estimates. Both organizations have revised some estimates. In general the writer has used the Fish and Game estimate or the revised estimate when the above choices presented themselves. With some of the older material it was not possible to determine which was the revision. In such instances earlier and later runs and those in neighboring streams were considered and the more plausible figure used.

SALMON RUNS

In the Central Valley the king salmon is the only native salmon of any importance² but there are three basically different runs of kings

Fall Run

Fall run fish enter the streams in the fall or winter and usually spawn within a few weeks of their arrival at the spawning grounds. More than 80 percent of the Central Valley salmon are of this type. Many streams have only a fall run. There is considerable variation in the timing of the runs in the different valley streams. Fall run salmon bound for the main stem of the Sacramento start through the delta in numbers in late August, reach peak numbers in late September, and a few are still going upstream in January. In general the Sacramento tributary runs start somewhat later; the bulk of the fish enter the tributaries in October, but as in the main stem a few are still going upstream in January. In some of the San Joaquin tributaries a lack of water may delay the run until December.

Spring Run

Spring run salmon enter the streams in the spring, spend the summer in the deeper holes, and spawn in the fall. They can survive only where there are relatively low summer temperatures.

On some streams, dams and diversions have greatly reduced the summer flow; this in turn has resulted in high summer temperatures and has almost or entirely eliminated the spring run without seriously damaging the fall run. The fall run enters these same streams after the temperature has dropped and the flow increased. The Tuolumne and Stanislaus Rivers are examples.

In general the spring run starts through the Sacramento-San Joaquin Delta in March, peaks there in May, and drops off rapidly in June. The fish go upstream rather slowly and are available to fishermen all summer in the upper Sacramento.

In the Central Valley spring run salmon are less numerous than those of the fall run. Counts and estimates are given in Table 4. In the early 1940's the most important spring run was probably that of the San Joaquin River. The run in this stream was eliminated by the drying up of the river below Sack Dam, near Dos Palos, after Friant Dam went into full operation.

² Silver salmon (*Oncorhynchus kisutch*) have been introduced into the Sacramento system (but not into the San Joaquin). They seem to be doing well. Kokanee (*O. nerka kennerlyi*) have been planted above Shasta Dam and are abundant in the lake. Besides these introduced forms the Sacramento system has vestigial runs of pink (*O. gorbuscha*) and chum (*O. keta*) salmon. A few stray sockeye (*O. nerka nerka*) have been taken.

The Sacramento River now has the largest spring run. For the past few seasons no effort has been made to estimate the size of this run; to do so would be a major undertaking.

The spring runs listed are not complete. As with fall run fish, there are some very small runs, often in hard-to-reach places, which could not be checked without a larger staff.

Winter Run

Winter run fish are the least known and probably the least abundant of the Central Valley king salmon runs. True winter run fish enter the river in the winter and spawn early the following summer. The great majority spawns in the main stem of the Sacramento; small numbers enter some of the tributaries north of the Feather River. No estimates of their numbers have been made. In addition to the winter run fish there are some very late fall run fish which enter most of the Central Valley salmon streams in the winter and spawn almost immediately. In compiling the tables no attempt was made to separate the winter run or late fall run fish from those of the main fall run.

SALMON STREAMS

Comments on the individual streams of the Central Valley are given below; they are arranged from north to south.

Sacramento River

The Sacramento River is the largest and best salmon stream of the Central Valley. It is now blocked by Keswick Dam, but the spawning area that is still available is large and of good quality.

From 1937 through 1942 counts were made at the Anderson Cottonwood Irrigation District Dam at Redding. This is a low dam with removable flashboards which are seldom left in place during the entire run of salmon. There is a fishway past the dam. The 1937 count at this place was made by the California Division of Fish and Game. From 1938 through 1941 the counts were made by the U. S. Bureau of Reclamation, and in 1942 by the U. S. Fish and Wildlife Service.

The 1937-39 counts are not included in Table 1. They were 8,000 in 1937, 14,000 in 1938 and 22,000 in 1939. The 1939 count includes 6,000 spring run fish; the earlier counts were started after the spring run had passed. The count of 1939 is the only one of the six made at this point which appears to be complete, even for the fall run. It should be kept in mind that this counting station was upstream from almost all of the spawning area that is available to salmon today. The incomplete counts here range from 7,000 to 45,000.

From 1943 through 1945 counts on the main stream of the Sacramento were made at the Balls Ferry Rack which was three miles upstream from the mouth of Battle Creek. The rack was constructed for the purpose of counting fish, trapping them, and forcing part of the population to spawn downstream from the rack if there appeared to be danger of overcrowding in the area between Balls Ferry and Keswick Dam. The counts at Balls Ferry are incomplete. Many fish passed this rack uncounted during flood periods and many others found holes under it. Some salmon were trapped at Balls Ferry and transferred

to Coleman Hatchery. These fish are included only in the Balls Ferry count. It should be kept in mind that the counts made at Balls Ferry do not include the very substantial part of the run that spawns downstream from that point.

Balls Ferry Rack has not been used since 1945. From 1946 through 1956 the U. S. Fish and Wildlife Service made estimates of the fall and spring runs of the main stem of the Sacramento. Their estimates of the spring run are given in Table 4 for the entire period. Their estimates of the fall run are given only through 1949 (Table 1). From 1950 through 1959 the fall run estimates shown are those of the Department of Fish and Game.

The Fish and Wildlife Service estimates through 1952 were from ground level spawning area surveys. Aerial redd counts were started in January 1954 to check the estimate of the 1953 fall run and were used in making the surveys of the spring and fall runs of 1954, 1955, and 1956. These three surveys gave results which were 33 percent, 67 percent, and 46 percent of the Department of Fish and Game figures for the fall run in the same three years. The Department of Fish and Game used a tag and recovery method from 1950 through 1955 and has used spawning bed surveys since then. In six out of seven years when both organizations made estimates of the fall run, those of the Fish and Wildlife Service were lower; 1951 was the exception. A study to determine the reasons for the differences in the results obtained by the two organizations was planned but was not put into effect. Due to a lack of funds the Fish and Wildlife man in the area was transferred to another state.

Keswick Dam

Keswick Dam is located a few miles above Redding on the main stem of the Sacramento. It is a re-regulating dam used to smooth out the flow below Shasta Dam. No fish can pass Keswick Dam. Fish trapping facilities were installed there when the dam was built. The counts listed are of salmon actually trapped at Keswick. Most of them are hauled to Coleman Hatchery. In earlier years part of them were trucked to Deer Creek, and more recently some have been taken to Clear Creek.

The Keswick fish were divided into spring run and fall run; August 31st was arbitrarily selected as the last day of the spring run in this part of the river.

Because of a lack of spawning area between Redding and Keswick, the fish ladder at the A.C.I.D. Dam has been kept closed most of the time, and efforts have been made to limit the fish going past this point to a number which could be satisfactorily handled at Coleman Hatchery.

From 1937 through 1943 the counts covered only a part of the Sacramento River. Since 1944 counts plus estimates have included the entire river. Through 1949 the totals obtained (40,000 to 75,000 fish) are regarded as being too low. From 1950 through 1959 the totals have ranged from 408,000 in 1953 down to a disastrous low of 68,000 in 1957.

The spring run of parts of the Sacramento River was counted from 1939 through 1945. Spring run estimates of the entire river did not start until 1946. The last one was made in 1956. During these 11 years the estimates ranged from 5,000 in 1951 to 27,000 in 1946.

Battle Creek

Battle Creek is a salmon stream with good spawning areas and adequate water flows in its lower reaches. Starting a short distance above Coleman Hatchery, much of the stream is badly degraded by low flows resulting from power diversion.

Estimates of the spring and fall runs spawning naturally in Battle Creek were made by the U. S. Fish and Wildlife Service from 1946 through 1956. Starting in 1955 the California Department of Fish and Game has made estimates of the fall run.

Hatcheries

Two hatcheries have operated on Battle Creek. The old Battle Creek Hatchery operated through 1945. The newer and larger Coleman Hatchery has operated since 1943. The Battle Creek Hatchery took fall run fish from the natural run of Battle Creek. From 1943 through 1946 small numbers of spring run fish were trapped at Coleman Hatchery. In no instance did the number taken exceed 500. During this period Coleman Hatchery was obtaining a majority of its fish from Keswick Dam and from the Balls Ferry Racks. Not until 1946 did the Coleman Hatchery start taking fall run fish from Battle Creek. Since that time it has taken them every year.

The total run (hatchery take plus natural spawners) has averaged 15,000 fall run salmon per year since 1946, and has ranged from a low of 3,000 in 1948 to 30,000 in 1959. We cannot know how many fall run fish would be spawning in this stream if no hatchery were there.

The spring run is much smaller. In seven of the 11 years of record, the estimate was about 2,000 fish. In the other years runs were lower; in 1948 and 1949 they were below 500.

Mill Creek

For its size Mill Creek is a good salmon stream, but the fish are sometimes handicapped by low flows resulting from irrigation diversions.

From 1947 through 1952 the U.S. Fish and Wildlife Service estimated the number of fall spawners in Mill Creek from spawning area surveys. Since that time similar estimates have been made by the Department of Fish and Game.

From 1947 through 1953 the U.S. Fish and Wildlife service made estimates of the spring run in Mill Creek. Since that time a counting station has been set up at Clough Dam, and all fish passing over the dam have been counted by the Department of Fish and Game. Usually the bulk of the fall run spawns below Clough Dam; for all practical purposes the entire spring run goes upstream past the dam.

Since 1947 the fall run of Mill Creek has ranged from a high of 16,000 in 1952 to a low of 1,000 in 1956 and 1959. The spring run was about 3,000 in 1947, 1953, and 1955, and was down to less than 500 in 1951.

Deer Creek

Deer Creek is about five miles from Mill Creek, is about the same size, and suffers from the same fundamental trouble of low flows caused by irrigation diversions.

When plans were being made for the handling of Sacramento salmon blocked by the construction of Shasta and Keswick Dams, Deer Creek was selected as a place where spring run fish from Keswick could be transferred and allowed to spawn naturally. In order to determine the size of the natural run into Deer Creek, the U.S. Fish and Wildlife Service constructed a weir and set up a counting station at which spring run counts were made from 1941 through 1948. After that time the counting station was abandoned, and from 1949 through 1956 estimates were made of the Deer Creek run. Apparently the natural spring run was not increased by the addition of transfers from Keswick. No weir counts were made of the fall run. The U.S. Fish and Wildlife Service estimated the size of the fall run from 1947 through 1953. The fall run estimates during the next three years were joint ventures involving both Federal and State men. Since that time estimates of the fall run (but not the spring run) have been made by the Department of Fish and Game.

Since 1947 the largest fall run was 12,000 fish in 1952, and there were five years when the run dropped below 500. The highest spring run on record was 4,000 in 1946; in 1940 it was below 500.

Chico Creek

The fall run of Chico Creek was estimated as 50 fish in 1957, and the spring run as 1,000 in 1958 and 200 in 1959. It appears that no other estimates have been made. The 1957 fall run was included under "Miscellaneous Small Streams." An additional 15 miles of spawning area was opened on Chico Creek during the summer of 1958 by the removal of a barrier.

Butte Creek

Butte Creek, unlike the majority of the small streams of the northern Sacramento Valley, has a spring run but almost no fall run. There are numerous removable dams on Butte Creek which are left in place so late that the fall run has little chance to get past them. Some of these diversions are for duck clubs. Fishways have improved conditions somewhat, but the fall run has not built up.

The spring run has ranged from 3,000 fish in 1956 down to less than 500 in 1953 and 1959.

Miscellaneous Small Tributaries of the Upper Sacramento River

Included under this heading are Antelope Creek, Clear Creek, Cottonwood Creek, Cow Creek, Paynes Creek, and about a dozen other streams which may have fall runs when the fall rains are early and heavy. Some of the streams have spring runs. The fall runs were estimated by the U.S. Fish and Wildlife Service from 1947 through 1953, by a joint venture through 1956, and since that time by the Department of Fish and Game. The survey of these minor streams is more complete now than it was in former years.

Since 1947 the largest fall run in all of these streams combined was 13,000 fish in 1953. It was down to 1,000 in 1948 and 1949. The spring run totals in the only three years of record were under 500 fish twice, and once (1956) reached 1,000 fish.

Feather River

The Feather River is the largest tributary of the Sacramento below Shasta Dam. Dams and diversions have worsened conditions for the salmon—especially the spring run. In spite of this the Feather is still a good salmon stream. There are runs which spawn in the main stream, the North Fork, the West Branch of the North Fork, the Middle Fork, and the South Fork. The majority of the fish enter in the fall; the largest part of this run spawns in the main stream. The majority of the spring run fish spawn in the Middle Fork, with a few in the North Fork, South Fork, and West Branch.

The U.S. Fish and Wildlife Service made an estimate of the spring and fall runs in 1946. The men who did the work were not experienced at making estimates on the spawning grounds, and after considering their counts of spawning and dead fish it is the belief of the department that this estimate represents only a small part of the fish that entered the Feather that year. Since 1953 the Department of Fish and Game has estimated the size of the fall run from spawning area surveys. In 1958 and 1959 this was supplemented with aerial redd counts. The spring run was also estimated in 1958 and 1959.

The highest fall run was 86,000 in 1955. The low year was 1957 with 10,000 fish. Estimates of the spring run have ranged from 4,000 in 1959 down to 1,000 in 1955 and 1957.

Yuba River

For many years the Yuba River was seriously handicapped by a diversion dam below which there was often very little water and over which there was no functional fish ladder. Upstream migrants could pass only during very high flows. There are now two good fish ladders, one at each end of this dam, but the water problem still remains.

The fall runs in the Yuba have been estimated by the Department of Fish and Game since 1953. They ranged from a high of 10,000 in 1959 to a low of 1,000 in 1957.

The Yuba is known to have had a spring run but no estimate of its size has been made. This run has virtually disappeared.

American River

The American River formerly had a partial block at the old Folsom power dam over which there was a fishway. More recently it has been totally blocked by a dam at Nimbus. Spawning grounds below Folsom were quite extensive, but the new Nimbus Dam has cut off the grounds which were formerly used by over two-thirds of the fish. The new Folsom Dam has created some temperature problems which adversely affect the Nimbus salmon hatchery and the salmon spawning naturally in the River below.

Counts were made by the Department of Fish and Game of the runs into the American River in 1941 and 1942, but due to early floods these counts were so incomplete that they have not been included in the tables. Tagging experiments were conducted from 1943 through 1946. The 1943 experiment was not completed and results were not included in the tables. From 1948 on, estimates of the size of the American River run have been made by the department. The one exception was in 1950 when an early flood made an estimate impossible. Since 1955

fish taken at the recently constructed Nimbus Hatchery are also included in the tables. At least through 1951 there was a small spring run in the American, but at spawning time these fish became so mixed with those of the much larger fall run that it was impossible to separate them. The highest total run recorded on the American River was 39,000 in 1945. The lowest was 6,000 in 1956.

Cosumnes River

Parts of the Cosumnes River often have little or no flowing water until late fall or winter. Nature is responsible for most of this difficulty, but man contributes.

This stream has a late fall run and no spring run. A partial count was made by the Department of Fish and Game in 1941. Estimates were made by the department in 1953, and during each year since then. The highest estimate was 5,000 in 1954. The lowest was below 500 in 1959.

Mokelumne River

The Mokelumne River salmon runs have been greatly reduced by man's activities. Below Woodbridge Dam there is often too little water for the passage of salmon; for many years the dam itself was a serious fish block; industrial and mining pollution have, at times, been very serious. The stream has a fall run, but the spring run appears to be practically extinct.

All counts were made by the Department of Fish and Game, and all were made at Woodbridge Dam, which is located below all spawning areas. Partial counts were made in 1940, 1941, and 1942; complete counts in most of the following years. Woodbridge Dam has removable flashboards, but a good count can be made there in most seasons.

In both 1941 and 1942, incomplete counts gave 12,000 fish. In no other year have the counts—complete or incomplete—approached this figure. In 1948 and 1956, less than 500 fish passed Woodbridge Dam.

Stanislaus River

The Stanislaus River is a good fall run stream for its size but has almost no remaining spring run. A diversion dam (Goodwin Dam) blocks all salmon, and summer flows below it are low and warm. In the fall and winter, its waters are used for power generation and fluctuate violently.

All counts and estimates were made by the Department of Fish and Game. In 1940 and 1941 the counts were made at lightly constructed weirs and were not complete. Successful tag and recovery experiments were conducted in 1947 and 1948. Estimates were made during most of the following years. The highest estimate was 35,000 in 1953; the lowest (except for incomplete counts) was 4,000 in 1951, 1957, and 1959.

Tuolumne River

In some years the Tuolumne River has had fall runs which were larger than those of any Central Valley stream except the Sacramento. It has almost no spring run because its summer flows are low and warm, and fish cannot get past the La Grange Dam. Like the Stanislaus, the Tuolumne is used for power generation after the irrigation season is over, but its flows are larger and more stable.

Counts were made by the Department of Fish and Game at the Modesto Dam fish ladder in 1940, 1941, 1942, and 1944. The 1941 count was incomplete. In the other years, the dam was left in and counting continued until the run had dwindled away to almost nothing, then the flashboards were removed for safety reasons. The U.S. Fish and Wildlife Service made a count at the same place in 1946. This dam was condemned, and since 1947 it has been necessary to rely on estimates, all of which were made by the Department of Fish and Game. The biggest run of record was 130,000 in 1944; the smallest was 3,000 in 1951.

Merced River

Due to irrigation diversions, the Merced River is at present a marginal salmon stream. There is a lack of water at critical times of the year.

This stream has a poor fall run and poor spring run. No numerical estimate has been made of the spring run. All fall run counts and estimates were made by the Department of Fish and Game. Incomplete counts were made in 1940 and 1941. Estimates have been made every year since 1953. Since 1953 the highest estimate has been 4,000 fish in 1954. In all other years it has been below 500.

San Joaquin River

In the period under discussion this stream at first had an excellent spring run and a small fall run. Diversion of the San Joaquin at Friant Dam resulted in the drying up of the stream below the Sack Dam and in the virtually complete loss of both the spring and fall runs since 1949. All counts were made by the Department of Fish and Game, and all except those of 1948 and 1950 were made at the Mendota Dam which is well below all spawning areas. In 1948 about 2,000 salmon were trucked to a canal which led them around the dry area below the Sack Dam. The count was made as the fish left the truck. The 1950 count was made at a temporary fish ladder on Salt Slough. The ladder was built to lead salmon from the slough into a canal from which they could re-enter the river above the dry section of streambed. Only 36 fish used the ladder.

For all practical purposes, there has been no run since 1948. The highest run of record was 56,000 in 1945.

EXPLANATION OF TABLES

Counts

Few of the counts made in the Central Valley are truly complete because they were made at counting weirs which were not entirely fish tight, at low dams which some of the fish could jump uncounted, or at removable dams which had to be taken down before the run was entirely over. When it is believed that the great majority of the fish were counted, the figures used in the accompanying tables are referred to as a "count." The counts (and incomplete counts) do not include any fish which spawned downstream from the counting station.

TABLE I
Fall Run—King Salmon Spawning Stocks Upper Sacramento Valley, 1940-1959
(in thousands of fish)

Year	Sacramento River			Battle Creek			Mill Creek			Deer Creek	Misc. small tribs.	Total Upper Sacto. Valley
	Below Keswick Dam	Trapped at Keswick Dam	Total	Natural spawners	Hatchery	Total	Below Clough Dam	Above Clough Dam	Total			
1940.....	29 ^a	--	29	--	4 ^d							
41.....	30 ^a	--	30	--	3 ^d							
42.....	4 ^a	--	4	--	3 ^d							
43.....	35 ^b	1 ^e	36	--	2 ^d							
44.....	73 ^b plus ^{e*}	--	73	--	3 ^d							
1945.....	52 ^b plus ^{e*}	-- ^e	52	--	3 ^d							
46.....	40 ^{e*}	9 ^e	49	10 ^e	7 ^d	17						
47.....	75 ^{e*}	--	75	7 ^e	9 ^d	16	--	--	6	4 ^e	6 ^e	
48.....	40 ^{e*}	-- ^e	40	1 ^e	2 ^d	3	--	--	4	1 ^e	1 ^e	
49.....	50 ^{e*}	--	50	2 ^e	5 ^d	7	--	--	2	--	1 ^e	
1950.....	110 ^f	1 ^e	111	--	4 ^d	4	--	--	2	--	2 ^e	
51.....	70 ^f	3 ^e	73	4 ^e	10 ^d	14	--	--	9	3 ^e	4 ^e	
52.....	260 ^f	7 ^e	267	4 ^e	11 ^d	15	12 ^g	4 ^h	16	12 ^e	3 ^e	
53.....	400 ^f	8 ^e	408	4 ^e	12 ^d	16	6 ^e	4 ^b	10	4 ^e	13 ^e	
54.....	270 ^f	6 ^e	276	4 ^e	8 ^d	12	4 ^e	3 ^b	7	3 ^e	12 ^e	
1955.....	225 ^f	6 ^e	231	16 ^e	10 ^d	26	1 ^e	2 ^b	3	-- ^e	4 ^e	
56.....	91 ^e	3 ^e	91	14 ^e	7 ^d	21	-- ^e	-- ^b	1	-- ^e	8 ^e	
57.....	60 ^e	8 ^e	68	2 ^e	3 ^d	5	4 ^e	1 ^b	5	2 ^e	3 ^e	
58.....	120 ^e	8 ^e	128	14 ^e	15 ^d	29	3 ^e	1 ^b	4	1 ^e	8 ^e	
59.....	260 ^e	7 ^e	267	19 ^e	11 ^d	30	1 ^e	-- ^b	1	-- ^e	6 ^e	

NOTES:— Signifies 500 fish or less.

^a Incomplete counts made at Anderson Cottonwood Irrigation District Dam at Redding by U. S. Bureau of Reclamation in 1940-41, and by U. S. Fish & Wildlife Service in 1942. Most Sacramento salmon spawn below this point.

^b Incomplete counts made at Balls Ferry counting rack by the U. S. Fish & Wildlife Service. Includes fish transferred from Balls Ferry to Coleman Hatchery. A large part of the run spawns below Balls Ferry.

^c Count by U. S. Fish & Wildlife Service.

^d Battle Creek fish taken at old Battle Creek Hatchery, 1940-1945, and at Coleman Hatchery 1946-1959.

^e Estimate by U. S. Fish & Wildlife Service based on spawning area surveys and/or aerial red counts.

^f Calculation by California Department of Fish and Game based on tag recoveries.

^g Estimate by California Department of Fish and Game based on spawning area surveys.

^h Count by California Department of Fish and Game.

ⁱ The Department believes these estimates are too low.

TABLE 2
 Fall Run—King Salmon Spawning Stocks Lower Sacramento Valley, 1940-1959
 (in thousands of fish)

Year	Feather River and tributaries	Yuba River	American River			Total Lower Sacramento Valley	Total Sacramento Valley (upper and lower)
			Natural spawners	Nimlous Hatchery	Total		
1910.....							
41.....							
42.....							
43.....							
44.....	--	--	31 ^{1, 2}	--	31		
1915.....							
46.....	11 ³ plus ⁴ *	--	39 ^{1, 2}	--	39		
47.....		--	38 ^{1, 2}	--	38		
48.....	--	--	15 ⁵	--	15		
49.....	--	--	12 ⁵	--	12		
1950.....	Early flood. No complete counts or estimates possible from Feather River south.						
51.....	--	--	22 ⁵	--	22		
52.....	--	--	25 ⁵	--	25		
53.....	28 ⁵	0 ⁵	28 ⁵	--	28	62	513
54.....	68 ⁵	5 ⁵	29 ⁵	--	29	102	412
1955.....	86 ⁵	2 ⁵	9 ⁵	8 ⁵	17	105	369
56.....	18 ⁵	5 ⁵	4 ⁵	2 ⁵	6	29	153
57.....	10 ⁵	1 ⁵	7 ⁵	1 ⁵	8	19	102
58.....	32 ⁵	8 ⁵	17 ⁵	10 ⁵	27	67	237
59.....	76 ⁵	10 ^{5, 6}	18 ⁵	13 ⁵	31	117	421

NOTES: ⁵ Count by U. S. Fish & Wildlife Service.

⁶ Estimate by U. S. Fish & Wildlife Service based on spawning area surveys and/or aerial redd counts.

¹ Calculation by California Department of Fish and Game based on tag recoveries.

² Estimate by California Department of Fish and Game based on spawning area surveys (supplemented by aerial redd counts on the Feather River in 1958 and 1959).

³ Count by California Department of Fish and Game.

⁴ Includes a small but unknown proportion of spring run fish.

⁵ This published estimate is regarded as unrealistically low. The data on which it was based would make a total of 50,000 far more probable.

⁶ Includes 3,500 fish which died unspawned when part of the river dried up.

TABLE 3

Fall Run—King Salmon Spawning Stocks San Joaquin Valley Streams, 1940-1959
(Including the Cosumnes and Mokelumne Rivers)
(in thousands of fish)

Year	Cosumnes River	Mokelumne River Woodbridge Dam	Stanislaus River	Toolumne River	Merced River	Total San Joaquin Valley	Grand Total Central Valley
1940.....	--	5 ^d	3 ^d	122 ^b	1 ^d	131	
41.....	1 ^d	12 ^d	1 ^d	27 ^d	1 ^d	42	
42.....	--	12 ^d	--	41 ^b			
43.....							
44.....	--	--	--	130 ^b			
1945.....	--	6 ^b					
46.....	--	--	--	61 ^c			
47.....	--	--	13 ^f	50 ^e			
48.....	--	1 ^b	15 ^f	40 ^e			
49.....	--	1 ^b	8 ^e	30 ^e			
1950.....	Early flood. No complete counts or estimates possible.						
51.....	--	2 ^b	4 ^e	3 ^e			
52.....		2 ^b	10 ^e	10 ^e			
53.....	2 ^e	2 ^b	35 ^e	45 ^e		81	597
54.....	5 ^e	4 ^b	22 ^e	40 ^e	4 ^e	75	487
1955.....	2 ^e	2 ^b	7 ^e	20 ^e	-- ^e	31	400
56.....	1 ^e	1 ^b	5 ^e	6 ^e	-- ^e	12	165
57.....	1 ^e	2 ^b	4 ^e	8 ^e	-- ^e	15	117
58.....	1 ^e	7 ^b	6 ^e	32 ^e	-- ^e	46	283
59.....	-- ^e	2 ^b	4 ^e	46 ^e	-- ^e	52	473

NOTES: -- Signifies 500 fish or less.

^c Count by U. S. Fish & Wildlife Service.

^f Estimate by California Department of Fish and Game based on tag recoveries.

^e Estimate by California Department of Fish and Game based on spawning area surveys.

^b Count by California Department of Fish and Game.

^d Incomplete count by California Department of Fish and Game.

TABLE 4

Spring Run—King Salmon Spawning Stocks Sacramento-San Joaquin Valley, 1940-1959
(in thousands of fish)

Year	Sacramento River			Battle Creek			Mill Creek	Deer Creek	Chico Creek	Butte Creek	Feather River	Misc. small tribs.	San Joaquin River
	Below Keswick	Keswick Dam	Total	Coleman Hatchery	Natural spawners	Total							
1940	--	--	*11	--	--	--	--	- k	--	--	--	--	--
41	--	--	*15	--	--	--	--	1 k	--	--	--	--	--
42	--	--	*3	--	--	--	--	1 k	--	--	--	--	--
43	--	6 ^a	6	-- ^c	--	--	--	1 k	--	--	--	--	35 ^a
44	10 ^b	2 ^a	12	-- ^c	--	--	--	3 k	--	--	--	--	5 ^b
1945	3 ^b	1 ^c	4	-- ^c	--	--	--	3 k	--	--	--	--	56 ^b
46	26 ^a	1 ^c	27	-- ^c	2 ^a	2	--	4 k	--	--	2 ^a	--	30 ^b
47	25 ^a	--	25	--	1 ^a	1	3 ^a	3 k	--	--	--	--	6 ^b
48	9 ^a	--	9	--	-- ^c	--	2 ^a	2 k plus ^a	--	--	--	--	2 ^b
49	7 ^a	--	7	--	-- ^c	--	1 ^a	1 ^a	--	--	--	--	--
1950	18 ^a	--	18	--	1 ^a	1	2 ^a	2 ^a	--	--	--	--	--
51	5 ^a	--	5	--	2 ^a	2	2 ^a	2 ^a	--	--	--	--	--
52	7 ^a	--	7	--	2 ^a	2	2 ^a	2 ^a	--	--	--	--	--
53	8 ^a	--	8	--	2 ^a	2	3 ^a	2 ^a	--	--	--	--	--
54	9 ^a	--	9	--	2 ^a	2	2 ^b	2 ^a	--	--	3 ^a	-- ^c	--
1955	17 ^a	--	17	--	2 ^a	2	3 ^b	3 ^a	--	--	1 ^a	-- ^c	--
56	7 ^a	--	7	--	2 ^a	2	2 ^b	3 ^a	--	3 ^a	2 ^a	1 ^a	--
57	--	--	--	--	--	--	1 ^b	--	--	2 ^a	1 ^a	--	--
58	--	--	--	--	--	--	2 ^b	--	1 ^a	1 ^a	3 ^{a, m}	--	--
59	--	--	--	--	--	--	2 ^b	--	-- ^k	-- ^a	4 ^{a, m}	--	--

NOTES: - Signifies 500 fish or less.

^a Incomplete counts made at Anderson Cottonwood Irrigation District Dam at Redding by U. S. Bureau of Reclamation in 1940-41, and by the U. S. Fish & Wildlife Service in 1942.

^b Incomplete counts made at Balls Ferry counting rack by the U. S. Fish & Wildlife Service. Includes fish transferred from Balls Ferry to Coleman Hatchery.

^c Count by U. S. Fish & Wildlife Service.

^a Estimate by U. S. Fish & Wildlife Service based on spawning area surveys and/or aerial redd counts.

^b Estimate by California Department of Fish and Game based on spawning area surveys and/or aerial redd counts.

^b Count by California Department of Fish and Game.

^k Incomplete count by U. S. Fish & Wildlife Service made at counting racks on Deer Creek (1940 count at upper Deer Creek diversion dam).

^m This may include some fall run fish.

Incomplete Counts

In many instances the proportion of the run which got past the counting station unrecorded was known or suspected to be quite large. Such figures are referred to as "incomplete counts."

Fish Taken at a Hatchery or a Trapping Station

These figures refer only to salmon actually taken by the hatchery crew. At times some of these fish were transferred to another stream. The counts of such fish are included with those of the stream where they were caught, *not* where they were released.

Calculations Based on Tag Recoveries

The accuracy of this method of population estimation depends on many factors. On the American and Stanislaus Rivers the results were satisfactory. On the Sacramento there were many difficulties and the figures obtained are only rough approximations.

Estimates from Spawning Bed Surveys

These estimates are made by counting spawning salmon and/or spawned out carcasses, and basing the estimate of the size of the run on these figures. Inexperienced men have shown a tendency to make estimates that are far too low.

Estimates from Aerial Redd Counts

An airplane is flown over the stream, the salmon nests are counted or estimated, and an estimate of the run is based on this figure. Various complicating factors make the method less simple and reliable than it might seem.

SUMMARY

The fish counts of Central Valley salmon were started in 1937 as a result of the plans to build Shasta Dam. Enumeration has been by the California Department of Fish and Game, the U. S. Fish and Wildlife Service, and (less extensively) by the U. S. Bureau of Reclamation. Methods used have included fish ladder counts, fish weir counts, estimates of spawners, tag and recovery calculations, and (more recently) redd counts from the air. Many counts have been incomplete because counting weirs could not be kept fish-tight or were washed out by floods. In the early years most help was relatively inexperienced and gave estimates which were too low. Tag and recovery calculations gave satisfactory results on the American and Stanislaus rivers, but results on the upper Sacramento River have been much less satisfactory. Aerial redd counts seem to have possibilities but have not yet been standardized against fish ladder counts.

Because of a lack of manpower the earlier counts covered only limited areas; not until 1953 was an estimate made which covered the fall run of the entire Central Valley. Counts of the much smaller spring run have never covered the entire valley.

The king salmon is the only salmon of any importance in the Central Valley. Some silver salmon have recently been introduced in the Sacramento River, and some kokanee above Shasta Dam. King salmon are of three types: Fall run which enter in the fall or winter and spawn soon

after arrival; spring run which enter in the spring but do not spawn until fall; and winter run which enter in the late winter and spawn in early summer. Fall run fish are the most numerous and are found in most of the salmon streams. Spring run fish are kept separate in the counts; they are found in fewer streams and are much less numerous in total. Winter run fish are the least numerous and are confined to the upper Sacramento Valley. They are included with the fall run fish. The largest spring run may have been that of the San Joaquin River; it has been eliminated by the total diversion of the river since construction of Friant Dam and its attendant canal systems.

The largest fall run has been that of the Sacramento River which since 1953 has been estimated to have runs as high as 408,000 (1953) and as low as 68,000 (1957). In the same period, the entire Central Valley has ranged from 597,000 (1953) down to 117,000 (1957).

The spring run of the San Joaquin was 56,000 in 1945 but has been at or near zero since 1948. A complete estimate of the Sacramento spring run was first made in 1946 and last made in 1956. During that period it has varied from 26,000 (1946) down to 5,000 (1951).

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