THE SPAWNING EFFICIENCY OF KING SALMON (ONCORHYNCHUS TSHAWYTSCHA) IN FALL CREEK, SISKIYOU COUNTY. 1954-55 INVESTIGATIONS[1]

MILLARD COOTS
Inland Fisheries Branch
California Department of Fish and Game

INTRODUCTION

The purpose of this study has been to estimate the spawning efficiencies of various numbers of adult king salmon (Oncorhynchus tshawytscha) which have been permitted to enter and spawn in Fall Creek. For five consecutive seasons limited numbers of adult king salmon were admitted into the creek. A portion of the resultant offspring were counted near the mouth of the stream and an estimate made of the total hatch for each season. 1950 through 1954, the following numbers of pairs of adult fish were allowed to enter Fall Creek: 750, 500, 300, 300, and 150, respectively.

ACKNOWLEDGMENTS

Alan Taft, formerly Chief of the Bureau of Fish Conservation, suggested that this study be undertaken. The investigation began under the supervision of Joseph H. Wales. During the 1954-55 study the adult fish were counted upstream by Robert Wills of the Mt. Shasta Hatchery. Clyde Peck counted the downstream migrants. Their help, interest, and cooperation is gratefully acknowledged.

DESCRIPTION OF FALL CREEK

Fall Creek is a relatively small tributary of the Klamath River. It is the first stream to enter the Klamath River below the California-Oregon Power Company's (Copco) dams, which are the upstream limits of migration for anadromous fishes. Fall Creek is located approximately 185 stream miles from the ocean. It is a spring-fed stream and the minimum flow is rarely less than 30 cubic feet per second. The drainage area is only about eight square miles and flooding and high water conditions generally are of short duration, usually occurring only during periods of heavy precipitation.

A small powerhouse, slightly over one mile upstream from the mouth, blocks further upstream movement of fishes. The section of stream between the mouth and the powerhouse is approximately 1.15 miles in length. It is of rather steep gradient, the mean drop being one foot for every 32 feet of stream. Numerous small falls and cascades are present.

In addition to king salmon, silver salmon (O. kisutch), both resident and anadromous steelhead rainbow trout, Klamath small-scaled suckers (Catostomus rimiculus), and Klamath sculpins (Cottus klamathensis) have been noted in Fall Creek. On November 23, 1951, a dead brown trout (S. trutta) was recovered. The Pacific lamprey (Entosphenus tridentatus) also enters the stream.

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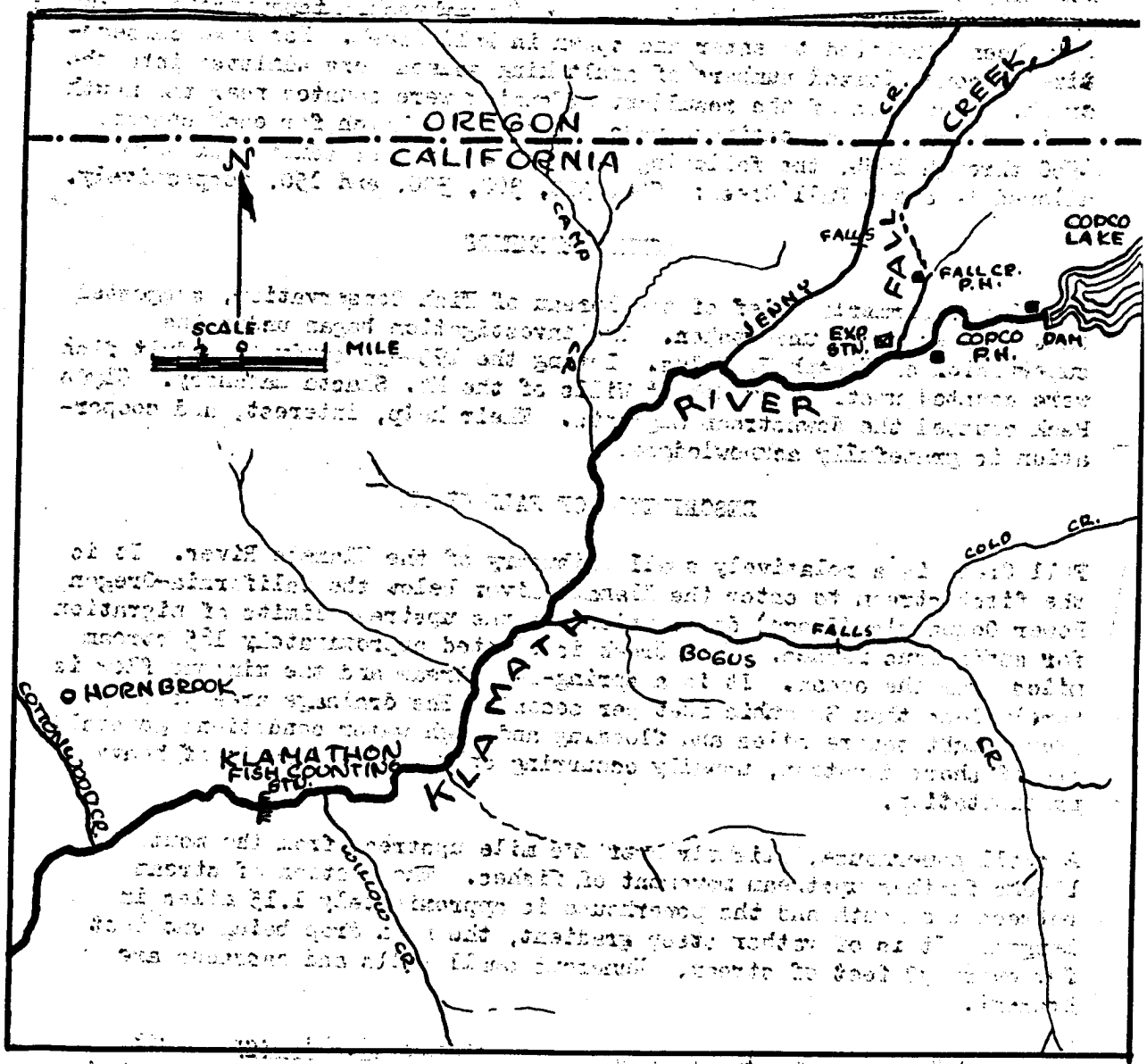

FIGURE 1. Map of the upper Klamath River.

TABLE 1

Physical Characteristics of Fall Creek

Elevation	2,317 feet - 2,509 feet
Length of stream	1.15 miles (mouth to powerhouse)
Volume of flow	32 c.f.s. - 298 c.f.s.
Average width	14 feet
Area of spawning gravel	18,800 square feet (approximate)
Gradient	1 foot - 32 feet
Mean velocity of flow	3.2 feet per second
Temperature of water	46.5 degrees F., (39 degrees - 52 degrees F.) in 1950-51

METHODS

One hundred fifty pairs of adult king salmon were allowed to enter Fall Creek during the fall of 1954. The count of spawners was accomplished by means of a fish rack and an adjoining fish trap situated near the mouth of the stream. After the 150 pairs of salmon were released upstream, the remaining fish* that entered Fall Creek were stripped, the fertilized eggs taken to the Mt. Shasta Hatchery, and the resultant fingerlings stocked in the Klamath River the following spring.

*see p [redacted]

The numbers of downstream migrants were estimated by trapping and counting a portion of the run and computing the total from it. A wooden flume was built in the stream channel near the mouth. A diversion from the flume entered a perforated plate fish screen of the type described by Wales, Murphey, and Handley (1950). Seaward migrants entered the bypass on the fish screen and were trapped and counted. Daily records were kept of the flow in the creek and of the diversion by means of water stage recorders. The estimated number of downstream migrant fry and fingerlings resulting from the previous spawning run was based on the assumption that the number of fish entering the diversion from the creek was proportional to the fraction of the flow being diverted. As has been done in the past, lots of a few hundred salmon fingerlings were given a temporary mark by the removal of a caudal fin lobe. These fish were liberated at a point just above the flume in the creek. Table 3 presents the results of these tests. Chi-square computations of the results substantiated this assumption.

The first seaward migrant salmon were recovered from the trap on January 3, 1955. Daily recoveries gradually increased and reached their peak on February 16, when an estimated 11,750 fingerlings moved out of the creek and into the Klamath River. Subsequent to that date the migration diminished until March 23, when the last fingerlings were trapped. During the month of January the bulk of the trap recoveries were yolk sac fry.

SPAWNING EFFICIENCY

The term spawning efficiency is defined as the percentage of fry resulting from the total number of eggs contained in all of the females of the spawning run. Based on egg counts from 58 females examined during 1950-52, the average number of eggs per female was 3,753. This number was used in computing the spawning efficiencies of the various runs of adult fish.

DISCUSSION

Table 4 indicates that the spawning efficiency in each of the five years varied considerably. There are variable factors, all uncontrolled and of unknown magnitude, which could adversely affect spawning efficiency. The only controlled factor was the number of adult fish that were allowed to enter the creek. Observations of spawning activity during 1950 and 1951 indicated considerable superimposition and dislodging of previously deposited eggs due to multiple use of the available spawning gravels by adult king salmon. Obviously, too many fish were allowed to enter the stream to spawn.

TABLE 2

Adult King Salmon Released Into Fall Creek, 1954 Daily

Date	Males	Females
September 20	1	1
21	-	-
22	2	1
23	-	-
24	1	1
25	-	-
26	1	1
27	1	-
28	1	1
29	1	1
30	2	2
October 1	-	-
2	8	8
3	12	12
4	14	13
5	29	27
6	23	29
7	15	22
8	18	23
9	7	5
10	14	3
Totals	150	150

TABLE 3

1955 Tests of the Validity of the Proportional Diversion Method of Migrant Count

Date	Number king salmon marked	Percentage of flow diverted	Number of marked king salmon recovered	Number of marked king salmon expected	Chi-square	Approximate probability
Feb. 4-5	223	4.51	10	10.1	.001	0.98
10-12	300	4.51	14	13.5	.019	0.89
21-23	300	4.48	13	13.4	.013	0.91

TABLE 4

Seaward Migration of King Salmon From Fall Creek

Adults*

Pairs of spawners released in Fall Creek	1950-51 750	1951-52 500	1952-53 300	1953-54 300	1954-55 150
Seaward migration period	12/27 to 4/4	12/24 to 4/8	1/5 to 4/3	12/31 to 3/25	1/3 to 3/23
Number of migrants trapped	10,419	9,774	5,550	16,950	6,509
Computed number of migrants	174,867	196,313	102,280	357,678	142,443
Percentage of eggs in the spawning run which resulted in downstream migrants	6.8	10.0	9.0	31.8	25.3

Juveniles

1/2

*Adults migration into Fall creek is monitored up to the desired # of fish; after which up stream migration is prevented - see p 4 - 1st paragraph.

Total # of chinook counted @ Fall Creek on p 11

High water and flooding conditions could have had an adverse effect on the resultant hatch by disruption of the redds. There were several such instances, especially during the first three years of the experiments. The 1953-54 and 1954-55 seasons were comparatively free of fluctuations of considerable magnitude. Damage and loss by silting appeared to be negligible. However, the shifting of the comparatively shallow gravelly areas during flooding conditions could cause a high loss of eggs.

Predation on king salmon fry and fingerlings by juvenile steelhead is an unknown and probably an important factor. Young seaward migrant salmon have been recovered from the stomachs of juvenile steelhead collected from Fall Creek. Freshwater sculpins did not seem to be serious predators. The stomachs of 41 Klamath sculpins were examined during the course of this investigation and only three eyed salmon eggs were observed.

Very few fish-eating birds have been noted along Fall Creek during the period of seaward migration. The Western Belted Kingfisher (Ceryle alcyon), Dipper (Cinclus mexicanus unicolor), and Great Blue Heron (Ardea herodias) have been observed in the vicinity.

One factor, a natural phenomenon, which likely impairs king salmon spawning efficiency is the subsequent utilization of king salmon redds by silver salmon and steelhead. Due to the limited available spawning areas, the same areas are generally utilized by all three species. A small run of silver salmon spawns in Fall Creek during November and December. A run of adult steelhead enters the creek during October and November, reaching its peak in February and continuing on until July. Silver salmon and steelhead fry emerge from the gravel in February, 40 to 60 days following the first king salmon emergence.

Parasites, such as the hemoflagellate, Cryptobia borreli, leeches, Pisciocola salmositica, and the Pacific lamprey, have been noted on Fall Creek salmon. Their general effects are probably harmful but details are not known.

The operation of the facilities for trapping and counting the seaward migrants proved highly satisfactorily. Where similar conditions are encountered the proportional diversion method of migrant count eliminates the necessity of attempting to trap and count all of the downstream migrants when such information is needed.

The Fall Creek Hatchery was deactivated in 1948. No king salmon fingerlings have been stocked in Fall Creek since then. A comparison between the escapement past the Klamathon Fish Counting Station and the number of adult fish entering Fall Creek indicates a strong correlation for the period 1950-56 (Table 6). Such a correlation is possible since many of the salmon stopped at Copco Dam, one mile above Fall Creek, drop back and enter Fall Creek to spawn.

It is not known whether the past controls on the numbers of adult fish allowed to spawn in Fall Creek have had any noticeable effects on the magnitude of subsequent spawning runs into the creek. For example, the majority of marked king salmon returning as adults, resulting from the

TABLE 5

1955 Daily Seaward Migration of King Salmon From Fall Creek

Date	Number of king salmon in trap	Percentage of flow diverted	Computed number of migrants
an. 2-3	2(2)*	4.57	44
3-6	3(3)	4.44	67
6-7	2(2)	4.35	46
7-8	1(1)	4.50	22
7-10	2(2)	4.57	44
10-12	1(1)	4.63	22
12-13	4(4)	4.62	87
13-14	5(5)	4.60	109
14-16	10(10)	4.65	215
16-17	5(5)	4.50	111
17-18	11(11)	4.57	241
18-19	3(3)	4.57	66
19-20	13(13)	4.50	289
20-21	14(14)	4.57	307
21-22	7(7)	4.52	152
22-25	60(60)	4.78	1,254
25-26	37(37)	4.65	796
26-27	27(7)	4.50	599
27-28	30(8)	4.50	666
28-29	45(5)	4.50	999
29-30	30(3)	4.61	651
30-31	37(7)	4.58	807
an.31-Feb.1	67(17)	4.43	1,508
1-2	38(3)	4.52	851
2-3	30(6)	4.63	648
3-4	33	4.57	723
4-5	62(1)	4.57	1,358
5-6	89	4.63	1,922
6-7	147	4.63	3,175
7-8	221	4.52	4,834
8-9	283	4.46	6,339
9-10	307	4.50	6,815
10-11	201	4.50	4,462
11-12	284	4.56	6,228
Feb.12-13	499	4.63	10,778
13-14	376	4.63	8,122
14-15	481	4.63	10,390
15-16	544	4.63	11,750
16-17	411	4.63	8,878
17-18	178	4.63	3,845
13-19	204	4.50	4,529
19-20	234	4.48	5,218
20-21	251	4.51	5,572
21-22	263	4.51	5,839
22-23	174	4.49	3,880
23-24	156	4.49	3,479
24-25	154	4.51	3,419
25-26	97	4.67	2,076
26-27	54	4.70	1,150
27-28	44	4.64	950
Feb.28-Mar.1	58	4.55	1,276
1-2	41	4.55	902
2-3	32	4.55	704
3-4	26	4.55	572
4-5	17	4.55	374
5-6	16	4.55	352
6-7	12	4.55	264
7-8	12	4.55	264
8-9	11	4.55	242
9-10	16	4.55	352
10-11	15	4.55	330
11-12	12	4.55	264
12-14	2	4.55	44
14-16	1	4.55	22
16-18	3	4.55	66
18-21	2	4.65	43
21-23	2	4.65	43
Total	6,509		142,446

*Numbers in parentheses are yolk sac fry and are included in the daily recoveries.

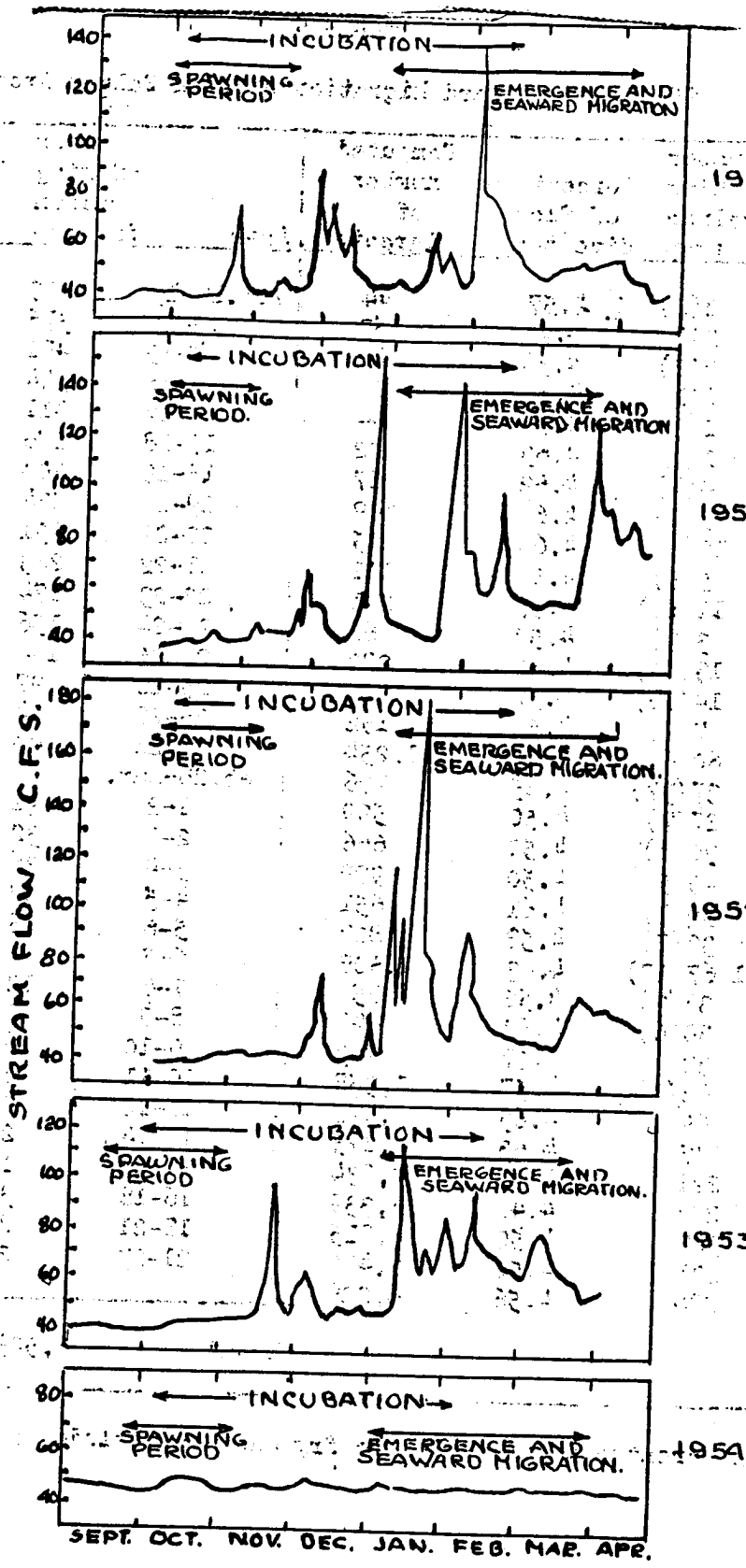

FIGURE 2. Stream flows in Fall Creek. 1950-51 through 1954-55.

TABLE 6

King Salmon Counts at Klamathon and Fall Creek

Adults

Year	Klamathon count	Fall Creek count	Percentage of Klamathon count entering Fall Creek	
1950	21,584	2,325	10.8	
1951	17,857	2,147	12.0	
1952	6,591	1,600	25.8	
1953	6,257	1,315	21.0	r = 0.882
1954	2,037	466	22.9	
1955	14,946	2,496	16.7	
1956	6,770	1,162	17.2	
Average	10,863	1,644	15.1	

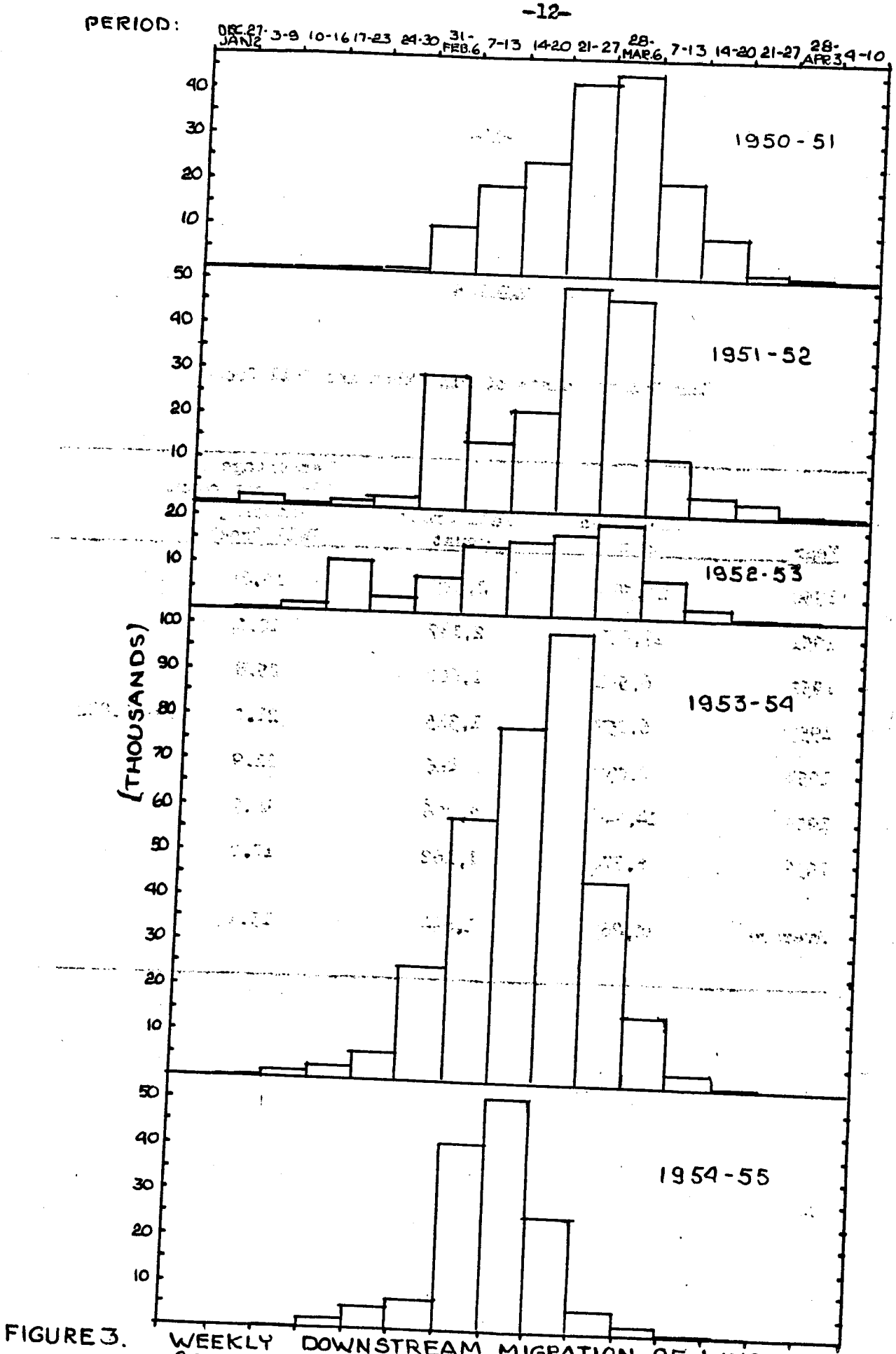

FIGURE 3. WEEKLY DOWNSTREAM MIGRATION OF KING SALMON FROM FALL CREEK.

release of marked hatchery fingerlings into the Klamath River in 1952, were recovered at Fall Creek. These fingerlings were placed in the Klamath River approximately 25 stream miles below Fall Creek.

While gathering data on the salmon and steelhead sports fishery in the Klamath River estuary during the fall of 1951, Gibbs and Kimsey (1955) took weights and lengths from 232 freshly caught king salmon. The majority of the fish, 145 males and 87 females, were measured during August and September. Likewise, during October, 1951, weights and lengths were taken from 93 king salmon, 58 males and 35 females, as they entered Fall Creek to spawn. The weights and lengths of both sexes in both samples were very similar. Figure 4 graphically portrays the comparison between these two groups of specimens. Fall Creek is approximately 180 stream miles above the Klamath River estuary and 2,500 feet higher in elevation. Assuming that the destination of the fish measured at the estuary was Fall Creek, the average loss in weight, while making this journey, would be about 13 percent. Were the sex products removed prior to weighing, the differences in weight comparisons would obviously be larger.

RECOMMENDATIONS

...e Fall Creek studies, admittedly of an exploratory nature, seem to indicate that 150 pairs of adult king salmon should be allowed to spawn in the creek. Although the 1953-54 tests with 300 pairs of adults resulted in both a greater hatch and spawning efficiency, the 1952-53 tests with the same number of fish resulted in a smaller hatch and spawning efficiency. Floods probably contributed to the low figures of the 1952-53 tests. Multiple utilization and superimposition by spawning salmon in the available spawning gravels should be reduced to a minimum with the release of 150 pairs of fish. One hundred fifty pairs of adults were allowed to spawn in the creek in 1955 and 1956.

SUMMARY

The spawning efficiency of king salmon in Fall Creek, a tributary of the Klamath River in Siskiyou County, was measured during five seasons, 1950-51 through 1954-55. In these years the following numbers of pairs of spawners were allowed to enter the stream: 750, 500, 300, 300, and 150, respectively. Estimates of the total egg production of these fish were based on sampling. The numbers of downstream migrant fingerlings resulting from each of these spawning runs were computed by trapping the migrants in a known fraction of stream flow. The percentages of potential eggs resulting in migrants leaving Fall Creek in the years sampled were: 6.8, 10.0, 9.0, 31.8, and 25.3, respectively. Some of the factors affecting spawning efficiency are discussed.

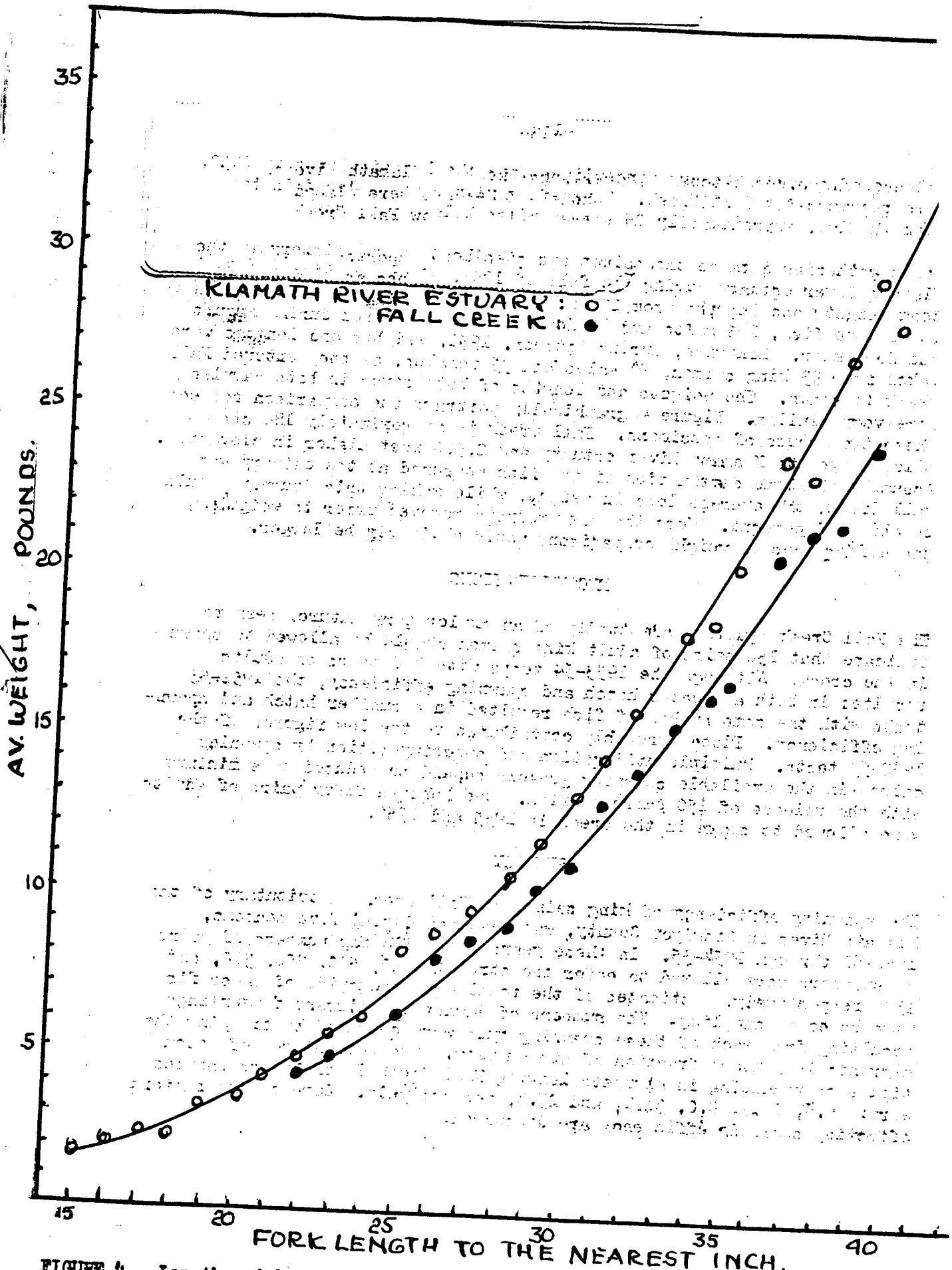

FIGURE 4. Length-weight relationships of king salmon from the Klamath River estuary and Fall Creek.

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