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Salmon of the Klamath River California

The Salmon and the Fishery of Klamath River
A Report on the 1930 Catch of King Salmon in Klamath River

By
JOHN O. SNYDER
Stanford University

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THE SALMON AND THE FISHERY OF KLAMATH RIVER

THE SALMON AND THE FISHERY OF KLAMATH RIVER

INTRODUCTION

The present paper is a digest of the work accomplished in a salmon investigation* conducted under the authority of the Bureau of Commercial Fisheries of the California Division of Fish and Game. Active work was begun in 1919, and is still in progress. At the outset the investigation was so planned as to contribute as directly as possible to the solution of certain questions relating to the conservation of the fishery. The work has progressed in a fairly satisfactory way in some directions as will appear, while in others the results are not so good. The information now most needed relates to the seaward migration of young salmon, and to the relative contribution of natural and artificial propagation to the population of the river.

It may seem that the matter of depletion is overstressed in this report, since its progress has been evident for years. A condition of increasing depletion was not sufficiently evident on the Klamath however, to be convincing to those most interested. In fact, opinions to the contrary were commonly held, some asserting that the "run" was not only maintaining itself but that it was gradually building up. There is very little exact information concerning fishing operations on Klamath River previous to 1912, and no really dependable statistics are available relating to the catch before that time. During the period of placer mining on the river, large numbers of salmon were speared or otherwise captured on or near their spawning beds, and if credence is given to the reports of old miners, there then appeared the first and perhaps major cause of early depletion. In 1912 three plants operated on or near the estuary and the river was heavily fished, no limit being placed on the activities of anyone. A resume of commercial fishing near the mouth or the river appears on page 88.

In the collection of statistical data relating to the ocean catch of salmon, the state authorities have not been able to separate the different species. Four occur in the state, but only two species are of commercial importance—the king salmon, or chinook, and the silver salmon or coho; hence all statistics relating to ocean fishing include both of these fishes in unknown proportions, the king salmon certainly predominating in a large measure.

Commercial fishing is now confined to the lower part of the estuary of Klamath River, partly as a matter of convenience and partly because of legal restrictions. Formerly nets were used at certain places as far up stream as Blue Creek, and occasionally beyond. Advantage was taken of slack water below the swift riffles, and much work was done at Ferry Drift and at Hollow Tree Drift. (Fig 6.) An official tide limit, above which fishing was illegal, was first fixed at the mouth of McGarvey Creek. Later it was moved down stream at the point where the highway bridge stands. Salmon are caught by means of drifting gill nets, which are laid out across the river mostly between the lowermost island

* Salmon considered in this report are of the genus *Oncorhynchus*, but principally *tschawytscha* and *kisutch*.

and a safe distance from the jaws. It is the habit of the fishermen to start the layout at a signal from the cannery whistle, usually about eight o'clock in the evening. The nets are laid from the decked stern of a large rowboat, one man at the oars and another at the net. Occasionally a skilful man manages both boat and net. Layouts are accomplished simultaneously from both sides of the river, the nets thus interdigitating across the stream. After the layout the nets drift with the current until recovered. The fisherman passes slowly from end to end of his net removing the entangled fish, evidence of which is apparent from the movements of the corks. Often the fishing is over in a short time, and in rare cases the fish become entangled so rapidly that no time is lost in bringing in both net and fish. Too often however, drift after drift is made with poor success.

Occasionally a large sturgeon runs afoul of the nets, harbor seals have been caught, while small sharks, skates, and almost any fish of small size may become entangled. The capture of some steelheads can not be avoided.

The number of fishermen varies somewhat from year to year, and also during the season, more boats operating after the migration is well on, some fishermen being perfectly willing to allow others to do the prospecting and preliminary exploring when fish may be scarce, and hidden snags not definitely located. Fishing is not usually accompanied with success when there is a bright moon overhead.

The actual fishing and the work in the cannery is to a considerable extent in the hands of Indians who are the descendants of members of the small aboriginal tribes which inhabited the region. Salmon have always furnished a great part of their food, and they have come to depend pretty largely upon the money earned during the fishing season for the few necessities of a simple life. They are skilled in the production of artistic baskets, and formerly, dugout canoes of large size and fine proportions were made by them. Some of these were beautifully carved. The lore of these people is replete with legends relating to the things about them. They were greatly restricted in their geographic outlook, but they seem to have been closely acquainted with every detail of their own land. They were essentially nature worshipers, and the fishes, reptiles, birds and mammals were adopted into intimate spiritual companionship.

The estuary of the river contributes in no small degree to the scenic beauty of the immediate region, and although it is not pertinent here, one finds it difficult to refrain from launching into an attempted description of the beauty of the entire river basin. From mouth to source the course of the stream offers a panorama of unending grandeur, and an incomparable assemblage of mountains and forests and great open spaces.

In connection with this work, invaluable aid was rendered at times by temporary assistants in the laboratory and field. Among these the following deserve particular mention: Messrs. W. L. Scofield, E. C. McGregor, C. D. Duncan, Paul Bonnot, E. C. Scofield, G. H. Clark, and R. P. Hayes. The study would have been impossible without the friendly cooperation of dealers and fishermen, and of officials of the Bureau of Fish Culture and the Bureau of Patrol. Mr. E. V. Cassell, Superintendent of the Fall Creek Hatchery aided in the marking experiments. At the mouth of the Klamath, the writer and his assistants were granted every possible courtesy by Mr. George R. Field who was in charge of the plant of the Klamath Packers Association, and later by Mrs. Field. Finally, the writer wishes to express his obligations to Mr. Norman B. Scofield, Chief of the Bureau of Commercial Fisheries of the California Division of Fish and Game, and a pioneer in salmon investigation, for constant and valuable aid in the work.

GENERAL CHARACTERISTICS OF KLAMATH RIVER SALMON

The salmon of Klamath River, which at present is of chief commercial importance is the king salmon, *Oncorhynchus tschawytscha* (Walbaum). It is a species of wide distribution, extending from the region of Monterey Bay northward to Alaska, and across to the Asiatic coast and Japan. Occasional wanderers are taken along the cost of the southern part of California.

In this State it enters the larger streams to spawn, the Sacramento, Eel, Klamath and Smith rivers having migrations of commercial importance. Individuals sometimes enter the smaller streams, and experiments in artificial propagation have demonstrated the possibility of at least temporarily establishing the species in a small creek where the water is cool and the mouth open to the sea.

It is well known that all the species of salmon are anadromous. They enter the coastal streams to spawn, migrate even to the small tributaries, lay their eggs in the gravel and then die, none returning to the sea from whence they came. The young which appear shortly afterward, remain for a time in the stream and then pass out into the ocean where they rapidly grow, and eventually approach maturity.

The actual contribution of the river to the entire salmon catch of the State is not known, nor can it be known, for the reason that the Klamath salmon migrate southward to Monterey Bay and enter the ocean catch from there, as well as from other fishing points to the northward.

A graph, figure 1, representing the entire yearly catch of the State, together with that of Klamath and Sacramento rivers, is presented. From this it will be seen that in the years immediately before and following 1918, the Sacramento contributed largely, and the Klamath rather meagerly, while lately the Klamath compares more favorably through shrinkage of the Sacramento. The fishery of the Klamath is particularly important, however, because of the possibility of maintaining it, while that of the Sacramento probably is doomed to even greater depletion than now appears, on account of commercialization of the river, the damming of its tributaries, irrigation of its valley, pollution, and the introduction of competitive species.

There are current among fishermen and dealers, statements relating to differences which may be seen between king salmon of the Klamath and Sacramento rivers. Most of the alleged differences disappear upon close comparison of examples from the two streams. There are, however, important anatomical differences as was discovered by N. B. Scofield while making a study of salmon in 1900. A detailed examination of these differences was made by E. A. McGregor at a later date.

The Klamath fish have been described by some observers as smaller, more rounded and somewhat heavier in proportion to the length, while

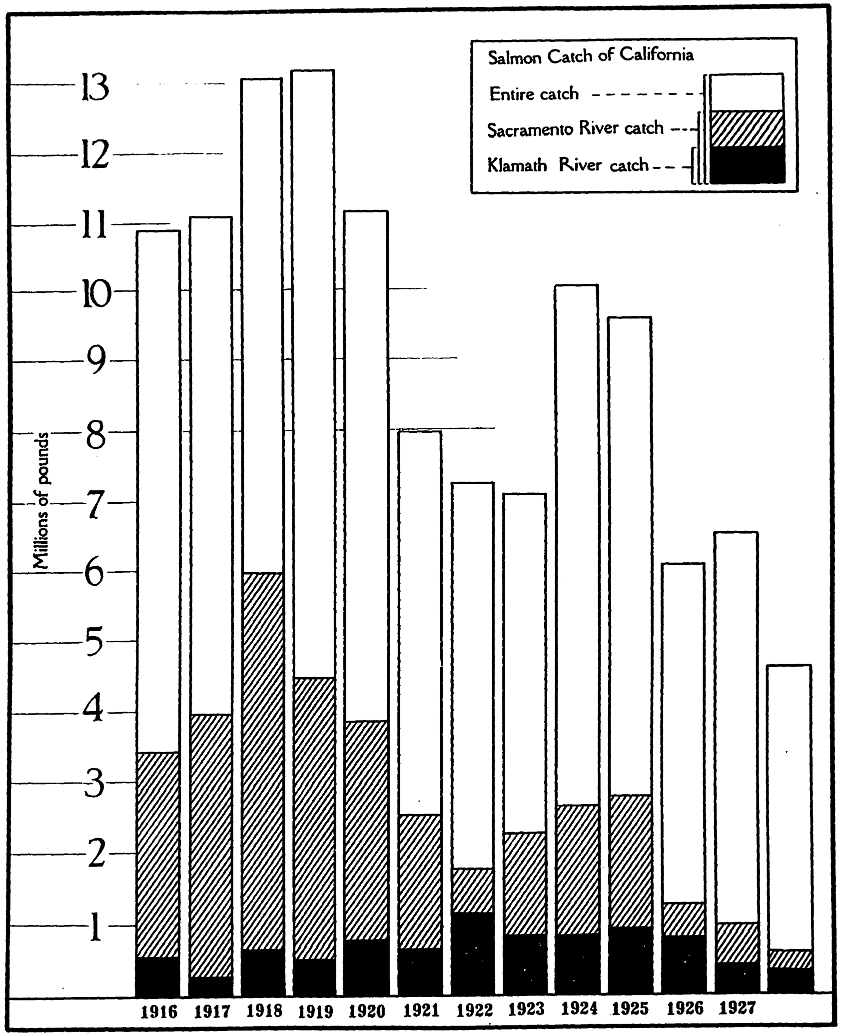

FIG. 1.

the same characteristics, except length, have been ascribed by other persons to Sacramento fish. All agree that Sacramento fish are larger, and this is well illustrated when series of fishes of the same age class are compared. For example, four-year Klamath fish are much smaller than four-year Sacramento River fish as demonstrated in table 1. (Fig. 22.)

In the matter of weight in relation to length, there appears to be very little or no difference. Tables, which after a fashion express the relations between length and weight are presented. In the preparation of these an average weight was computed for twenty examples of a given length and sex class, when as many as that number were available.

As previously stated, N. B. Scofield found that Klamath salmon differ from Sacramento River salmon in having more gill rakers on the

TABLE 1

Illustrating the Relative Lengths of Four-Year-Old Salmon from the Klamath and Sacramento Rivers, and from Monterey Bay

Length in cm.	Number of individuals in each length group		
	Monterey Bay	Sacramento River	Klamath River
	2	------	------
58	2	------	------
59	1	------	------
60	3	------	1
61	5	------	2
62	6	------	3
63	7	------	3
64	11	------	4
65	14	------	13
66	21	1	13
67	18	------	24
68	23	1	33
69	34	------	45
70	55	6	74
71	63	3	80
72	66	5	97
73	69	3	137
74	73	4	161
75	80	7	196
76	81	1	235
77	101	10	291
78	92	10	300
79	106	10	287
80	103	14	300
81	130	18	236
82	110	23	262
83	106	15	202
84	94	20	146
85	112	25	155
86	100	19	114
87	106	28	112
88	93	28	86
89	72	20	64
90	68	35	50
91	68	45	44
92	84	33	30
93	77	41	29
94	57	39	22
95	74	45	15
96	62	32	13
97	60	36	12
98	54	40	12
99	40	33	5
100	32	16	1
101	30	19	1
102	15	20	1
103	15	20	2
104	16	14	------
105	6	14	------
106	3	6	------
107	3	8	------
108	3	7	------
109	3	6	------
110	------	7	------
111	1	5	------
112	------	1	------
113	------	1	------
114	------	1	------
115	------	1	------
116	------	1	------
117	------	------	------
118	------	------	------
119	------	1	------
120	------		------
Totals	2,730	798	3,913

TABLE 2

Length-Weight Relation—Klamath River Fish

Length of fish in cm.	Average weight 20 males recorded in pounds and tenths	Average weight 20 females recorded in pounds and tenths	Extreme weights males recorded in pounds and ounces	Extreme weights females recorded in pounds and ounces
40	2.0		2-00 to 2-00	
42	2.3		2- 0 to 2- 8	
44	2.5		2- 2 to 2-14	
46	2.7		2- 6 to 3-00	
48	3.3		3- 0 to 3-12	
50	3.7		3- 4 to 4-10	
52	3.9		3- 1 to 4- 4	
54	4.4		4 -2 to 5- 0	
56	4.9		4- 0 to 8- 4	
58	5.8	6.0	5-4 to 6-14	
60	6.5	6.4	5-10 to 8-12	
62	7.0	6.8	6-10 to 10- 4	6- 1 to 7- 2
64	8.0	7.8	7- 8 to 9- 4	7- 4 to 8- 8
66	8.4	8.6	7-12 to 9- 4	8 -0 to 10- 8
68	9.4	9.0	8- 4 to 10- 2	8- 0 to 10- 0
70	10.6	10.0	10- 0 to 12- 8	9- 0 to 10-12
72	11.0	10.7	10- 0 to 12- 4	9-10 to 12- 0
74	11.6	11.4	10- 4 to 13-12	10- 0 to 12- 6
76	12.6	12.5	12- 0 to 14- 2	10-14 to 13-12
78	13.6	13.8	12- 8 to 15- 0	12- 0 to 15- 0
80	14.2	14.7	14- 0 to 16- 2	13- 0 to 17- 8
82	16.1	15.4	15- 0 to 18-10	13- 8 to 16-12
84	16.6	16.8	15- 6 to 17-14	15-12 to 18- 6
86	18.0	18.0	17- 0 to 19-14	17- 0 to 21- 8
88	18.9	19.0	17- 0 to 21- 4	16- 0 to 21- 8
90	20.8	19.7	18- 2 to 22- 4	18-12 to 23- 0
92	22.5	22.4	20- 2 to 26 -8	19-10 to 24- 4
94	24.1	23.3	22- 4 to 28- 4	20- 0 to 29- 0
96	24.9	24.2	16-14 to 28- 8	18- 0 to 27-10
98	26.8	26.9	21-14 to 30- 4	24-12 to 32- 0
100	28.8	28.5	23- 8 to 36- 0	28- 0 to 32- 0
102	29.9	31.0	27- 4 to 34-10	26-12 to 34- 0
104	31.6	31.4	27- 4 to 35- 2	26- 6 to 36-12
106	33.8	34.8	28- 8 to 37-10	34- 4 to 36- 0
108	34.9		32- 8 to 38- 6	
110	38.9		34- 8 to 43- 8	

first arch, and fewer pyloric caeca. It was later learned that a considerable difference exists in the number of eggs produced by the individual, the Klamath salmon having smaller ovaries.

At the writer's suggestion, the data obtained by field observers of the Fish and Game Commission were reported on by E. A. McGregor in California Fish and Game (Vol. 9, No. 4, pp. 134–150, 1923). McGregor not only confirmed the previously made observations of Scofield, but he also found that Sacramento River fish have fewer vertebrae. The following table 4, taken from McGregor's paper, summarizes these differences.

The distinctive characters here found would be regarded by systemists as subspecific, and they are just such differences as characterize geographic races.

No data are at hand to enable one to make a comparison between these forms and the king salmon of the rivers to the northward, nor can any statement be made at this time regarding characteristics which king salmon from Eel and Mad rivers may possess.

While it is possible to distinguish between king salmon from the Sacramento and Klamath rivers, any attempt at the present time to determine the relative number of either in an ocean catch must be regarded as premature at least, for the very simple reasons that we have

TABLE 3

Length-Weight Relation Sacramento River Fish 1919

Length of fish in cm.	Average weight 20 males recorded in pounds and tenths	Average weight 20 females recorded in pounds and tenths	Extreme weights males recorded in pounds and ounces	Extreme weights females recorded in pounds and ounces
68	9.4		8-12 to 9-14	
70	10.0		9- 4 to 10-12	
72	10.8		9-10 to 11- 6	
74	11.0	12.0	10- 2 to 12-12	11- 2 to 13- 0
76	12.0	13.0	11- 8 to 13- 2	10-12 to 14- 2
78	13.2	14.1	11-14 to 15- 0	12-10 to 16- 4
80	14.0	15.1	12- 6 to 15- 6	13-12 to 16-10
82	15.2	16.8	14-10 to 17- 6	15- 8 to 17- 2
84	16.8	17.0	15- 2 to 18-12	15-10 to 18- 8
86	18.6	18.0	16-10 to 20- 2	16- 8 to 20- 8
88	19.7	19.6	16-14 to 27-14	17-12 to 22- 8
90	20.2	20.2	18- 0 to 21- 6	15-10 to 29-10
92	21.9	21.3	20- 6 to 23-10	20- 4 to 23- 6
94	23.0	23.3	22- 6 to 26-14	21-10 to 25-12
96	24.6	24.7	22- 4 to 26-14	21- 8 to 27- 0
98	26.5	26.5	23- 0 to 28-14	23-14 to 31- 8
100	28.2	28.0	25-10 to 31- 6	24- 8 to 33- 4
102	30.1	30.0	28- 8 to 31- 8	22- 2 to 32-14
104	32.0	31.1	27- 8 to 35- 0	23-14 to 35-12
106	34.2	32.1	30- 0 to 38- 2	23- 8 to 35-10
108	36.6	34.0	31- 6 to 41- 2	25- 2 to 41- 4
110	38.3	37.0	33-12 to 44- 4	30- 6 to 44- 4
112	40.1	41.0	34-14 to 45- 0	35-14 to 48-14
114	42.0		37- 8 to 48-12	
116	44.8		40- 4 to 49- 8	
118	46.0		40- 4 to 53- 6	
120	49.0		46- 4 to 50-10	

TABLE 4

	Klamath River		Sacramento River	
	Range	Mean	Range	Mean
Number of Eggs	1,718 to 4,977	3760.0	4,795 to 11,012	7453.0
Number of caeca	93 to 193	132.2	134 to 214	176.4
Number of gill rakers	24 to 30	24.7	21 to 35	23.5
Number of vertebrae	66 to 68	67.0	62 to 65	63.8

little knowledge of the migration of salmon at sea, and we know almost nothing of any racial traits which may characterize salmon from the rivers entering the ocean to the northward of the Klamath. As information relating to the movements of salmon at sea slowly accumulates it becomes increasingly evident that their migrations are often very extensive, and hence the marine catch in any locality may contain fish which are natives of far distant streams. The notion, once common, that salmon do not in their ocean life move far from the stream in which they were hatched has been abandoned in so far as concerns California fish at least.

As occasion offered, certain anatomical characters of Klamath River salmon useful in the discrimination of species were examined. The results are here presented in tabular form.

TABLE 5

Scales

Scales in lateral series	130	131	132	133	134	135	136	137	138	139
Number of specimens	4	6	9	14	9	11	13	8	10	10

Scales

Scales in lateral series	140	141	142	143	144	145	146	147	148
Number of specimens	12	6	7	5	3	4	1	2	1

Scales

Scales before dorsal	54	55	56	57	58	59	60	61	62	63	64	65	66	67
Number of specimens	1	4	6	6	12	17	14	21	12	13	8	5	5	2

Scales

Scales above lateral line	25	26	27	28	29	30	31	32
Number of specimens	2	7	10	15	38	32	25	6

Fin Rays

Dorsal rays	10	11	12	13	Anal rays	13	14	15	16
Number of specimens	4	82	46	3	Number of specimens	2	35	81	17

Gill Rakers

Number of gill rakers	9–15	10–13	10–15	10–16	10–17	11–14	11–15	11–16	11–17	12–12
Number of specimens	2	1	5	1	2	13	14	12	1	1

Gill Rakers

Number of gill rakers	12–13	12–14	12–15	12–16	12–17	13–14	13–15	13–16	14–15
Number of specimens	1	31	21	11	5	3	6	4	1

Gill Rakers

Number of gill rakers on both sides of arch	23	24	25	26	27	28	29
Number of specimens	1	2	15	43	33	17	9

Branchiostegals

Number of branchiostegals	13	14	15	16	17	18
Number of specimens	3	11	31	55	17	3

TABLE 5—Continued

Individual Characters of 30 Klamath River Salmon

Scales before dorsal	Scales in lateral series	Scales above lateral line	Number dorsal rays	Number anal rays	Number branchi-ostegals	Number of gill rakers
62	136	28	11	14	18	11–15
59	134	29	11	14	16	12–14
55	131	30	12	15	17	11–16
55	137	29	11	14	15	11–15
57	136	29	11	15	16	12–15
58	136	31	11	16	14	11–14
59	132	29	11	14	15	10–13
61	133	28	12	15	14	13–15
56	135	31	11	15	17	13–14
60	144	30	12	15	15	13–16
59	135	29	11	15	15	12–16
66	142	29	12	15	14	12–14
59	136	26	11	14	16	11–14
54	132	26	11	15	17	12–14
65	140	29	11	14	16	12–14
60	135	29	12	15	15	12–15
60	133	31	11	14	16	13–15
61	135	29	12	15	17	12–14
60	139	29	12	15	16	12–16
61	145	29	12	16	16	12–16
61	139	30	11	16	15	12–15
64	142	29	12	15	15	13–16
61	134	29	11	14	16	12–15
60	147	28	12	15	16	12–14
62	139	29	11	15	16	12–14
60	136	29	11	15	15	13–13
61	137	29	11	15	16	12–14
58	139	29	10	15	16	12–14
55	133	29	11	14	16	12–15
66	145	28	11	13	16	12–14

TABLE 6

Silver Salmon in the Klamath River Catch

Date	Number	Weight
September 20, 1919	1,000	6,950
September 22, 1919	618	4,326
September 23, 1919	660	4,620
September 24, 1919	1,059	7,413
September 25, 1919	783	5,481
September 26, 1919	250	1,584
September 27, 1919	287	2,103
September 29, 1919	559	4,053
September 30, 1919	163	1,248
	5,379	37,788
October 1, 1919	47	376
October 2, 1919	151	1,253
October 3, 1919	111	852
October 4, 1919	82	685
October 6, 1919	679	5,100
October 7, 1919	567	4,371
October 8, 1919	800	6,138
October 9, 1919	743	5,795
October 10, 1919	183	1,430
October 13, 1919	328	2,500
October 14, 1919	239	2,031
October 15, 1919	514	4,145
October 16, 1919	361	3,067
October 17, 1919	193	1,649
October 18, 1919	197	1,662
October 20, 1919	290	2,428
October 21, 1919	148	1,237
October 22, 1919	150	1,329
	5,783	46,048
Totals	11,162	83,836

SPECIES OTHER THAN KING SALMON

Besides the king salmon, three other species enter Klamath River to spawn, namely, the silver salmon (*Oncorhynchus kisutch*), the humpback (*O. gorbuscha*) and the dog salmon (*O. keta*). The humpback and dog salmon are seldom seen and the fishermen are not familiar with them. The silver salmon occur in large numbers, the migration being later than that of the king salmon.

An occasional silver salmon is caught in the nets prior to September 6. The migration starts after that date and it is usually in full progress by the 20th of the month. No statistics of the silver salmon catch were kept prior to 1919 and no effort has been made to catch these fish since that time.

During 1919 only a few silver salmon were taken prior to the closed season which extended from September 6 to 20. On and after that date they appeared in the catch as shown in table 6.

Silver salmon are said to migrate to the headwaters of the Klamath to spawn. Nothing definite was learned about them from inquiry because most people are unable to distinguish them. In 1925, 295 silver salmon appeared at the Klamathon racks, of which 269 were males and 26 were females.

The blue-back salmon or redfish (*O. nerka*) is recorded by Jordan and Evermann (Fishes of North and Middle America, pt. 1, p. 482, 1896) as occurring in Klamath River. Nothing to substantiate the statement can be found. A fish identified by some fishermen at Requa, July 15, 1919, as a blue-back, proved to be a steelhead (*Salmo irideus*), somewhat more elongate in form than usual, very silvery on the sides and greenish blue above. The flesh was deep red. Scale counts and other characters were as follows. Scales before dorsal, 54; in lateral series, 128; above lateral line, 25; dorsal rays, 9; anal, 12; branchiostegals, 13; gill rakers, 22. Another proved to be a cutthroat steelhead (*S. clarkii*), the fine scales attracting attention. It was caught near The Jaws, July 14, 1920. It measured about 16½ inches and was silvery on the sides and pale olive on the upper part of the body. The spots were scarcely distinguishable. There was a trace of red beneath the mandible. There were 196 scales in the lateral series, 46 above the lateral line, and 86 before the dorsal.

Humpback and dog salmon are not common enough anywhere in the State to be of commercial importance; in fact, they are so rarely seen as to be unknown to any but the most observant fisherman. Both species occur as far south as Salinas River. On the other hand silver salmon are fairly common, and because of their habit of entering small streams to spawn, they are much more generally distributed than the king salmon. As king salmon become increasingly difficult to obtain within the State, more attention will be given to the protection and propagation of the silver salmon. Silver salmon seem never to have been so abundant as king salmon, but even now it is not possible to say to what extent they enter into the catch of the State.

Close attention was paid to boatloads of salmon as they appeared at the houses on Noyo Estuary near Fort Bragg, with the following results:

TABLE 7

Date	Number King Salmon	Number Silver Salmon
July 14, 1919	32	72
July 16, 1919	4	49
July 17, 1919	48	2
July 18, 1919	23	17
July 19, 1919	49	23
July 23, 1919	177	25
July 25, 1919	25	25
July 27, 1919	17	23
July 28, 1919	32	11
July 29, 1919	29	10
July 30, 1919	3	1
July 31, 1919	2	1
August 2, 1919	8	1
August 4, 1919	10	2
August 5, 1919	32	13
August 11, 1919	30	13
Totals, 1919	521	288
June 21, 1920	109	43
June 22, 1920	5	1
June 23, 1920	3	5
June 24, 1920	73	11
June 25, 1920	50	4
June 28, 1920	172	19
June 29, 1920	179	24
June 30, 1920	30	12
July 1, 1920	71	116
July 2, 1920	75	60
July 3, 1920	104	62
July 5, 1920	61	31
July 6, 1920	150	67
July 7, 1920	135	62
July 8, 1920	163	98
July 13, 1920	78	12
July 14, 1920	102	28
July 15, 1920	62	25
July 16, 1920	117	22
July 17, 1920	57	56
July 19, 1920	60	28
July 20, 1920	27	17
July 21, 1920	37	17
July 22, 1920	50	27
July 23, 1920	45	10
July 24, 1920	56	15
July 26, 1920	8	10
July 27, 1920	23	39
July 30, 1920	7	6
August 3, 1920	27	9
August 5, 1920	22	35
August 6, 1920	94	128
August 7, 1920	11	17
August 9, 1920	9	5
Totals, 1920	2,272	1,121
June 17, 1922	75	46
June 25, 1922	20	95
July 6, 1922	20	45
July 8, 1922	61	35
August 6, 1922	64	15
August 9, 1922	68	5
August 10, 1922	81	13
August 22, 1922	84	10
Totals, 1922	473	264

Reference has been made to the difficulty which one encounters in trying to assemble exact information relating to either the distribution, abundance, or extent of spawning grounds of any species of salmon, observers in general having difficulty in distinguishing species. Old male king salmon are often referred to as dog salmon, king salmon fresh from the sea are sometimes called silver salmon, and not infrequently salmon and steelheads are not distinguished.

The steelhead of the State is a sea-run trout which after living one or more years in the stream, enters the ocean, where it grows rapidly. In time it returns to the stream again, mature and ready to spawn. Steelheads usually accompany a salmon migration for the probable reason that conditions are then favorable for spawning, and not to eat salmon eggs as some assert. After spawning, the steelheads usually recover and again enter the sea, not always dying shortly after maturity as do the salmon. From an examination of 100 steelheads taken in the estuary of Klamath River it appears that these fish often spawn for the first time after having spent one year at sea. They usually enter the ocean at or near the end of the second year. Occasionally, one migrates to the sea at the age of one year, and rarely one may be found that has remained three years in the stream. One example had spawned in the second year. None had spawned before having spent a year in the sea. They usually spawn annually after the first time. The following conditions were noted:

TABLE 8

Stream	Ocean	Spawned	Age	Length
1 year	2 years	0 times	3 years	270 mm.
3 years	3 years	2 times	6 years	645 mm.
1 year	4 years	2 times	5 years	625 mm.
2 years	3 years	2 times	5 years	635 mm.
3 years	4 years	3 times	7 years	640 mm.
2 years	2 years	1 time	4 years	480 mm.
3 years	2 years	1 time	5 years	530 mm.
2 years	3 years	1 time	5 years	635 mm.
2 years	2 years	0 times	4 years	370 mm.
3 years	1 year	0 times	4 years	345 mm.

Commercial fishermen working at night in Klamath River distinguish steelheads when removing fish from the nets, by their deeper caudal peduncles and somewhat narrow tail fins, these characters being apparent to the touch. A diagram, figure 2, exhibits tracings of four species of salmon and a steelhead. The difference referred to is apparent. This together with the shorter anal base and the immaculate lining of the mouth should enable anyone to distinguish a steelhead. The lining of the mouth has much black pigment in the salmon.

THE SPRING MIGRATION—(IMMIGRATION)

Although king salmon in small numbers at least, appear to enter the Klamath at all seasons, there are apparently two more or less definite periods of migration, one occurring in the spring and the other in midsummer and early fall. Some doubt appears as to the distinctness of these migrations, the first possibly being little more than a long continued and varying start of the summer influx. However, G. R. Field and W. H. Baily, and the fishermen as well, speak of two distinct runs. Field wrote: "As the run of winter steelheads ceases, about March 30, spring Salmon begin to come. A few enter the Klamath

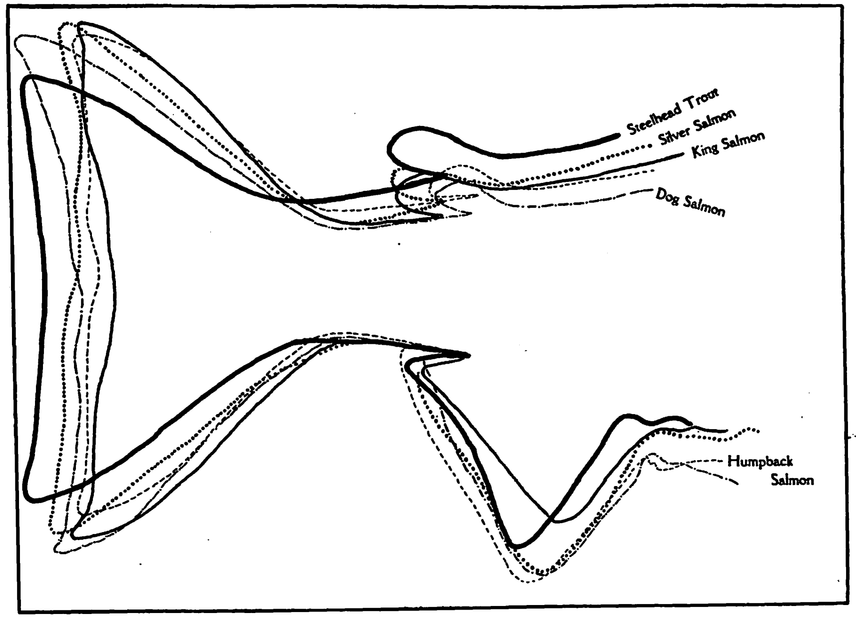

FIG. 2. Tracings of the outlines of the posterior fins and the caudal peduncles of salmon and the steelhead.

in the latter part of February, but the run really starts in March and slackens or almost entirely passes by the last of May. These fish average about 11 pounds in weight and are indistinguishable from those which come later, except that the eggs are always immature. These spring salmon may be caught in the smaller streams fed by melting snow at the headwaters of Salmon River during the month of June."

The spring migration,[1] granting that it was once very pronounced, has now come to be limited as to the number of individuals, and is of relatively little economic importance. The fish of this run begin to materially increase in numbers in the latter part of March or early in April and the migration has reached its maximum, and waned before the middle of June. The river at the time of the spring migration is apt to be in a condition of maximum flood[2] as indicated in figure 3,[3] the

[1] R. D. Hume in a paper without date, and presumably published by himself (Stanford University Library ---) says of the Klamath River: "In 1850 in this river during the running season, salmon were so plentiful, according to the reports of the early settlers, that in fording the stream it was with difficulty that they could induce their horses to make the attempt, on account of the river being alive with the finny tribe. At the present time the main run, which were the spring salmon, is practically extinct, not enough being taken to warrant the prosecution of business in any form. The river has remained in a primitive state, with the exception of the influence which mining has had, no salmon of the spring run having been taken except a few by Indians, as a reservation by the government has been maintained, until within a few years, and no fishing has been allowed on the lower river by white men; and yet the spring run has almost disappeared, and the fall run reduced to very small proportions, the pack never exceeding 6000 cases, and in 1892 the river producing only 1047 cases."

[2] The impounding of flood waters above dams may now control in a measure the violence of spring freshets, and the gradual release of this water may contribute somewhat to the minimum flow of summer.

[3] The graph was constructed from data found in Water Supply Papers, 311-313, U. S. Geological Survey.

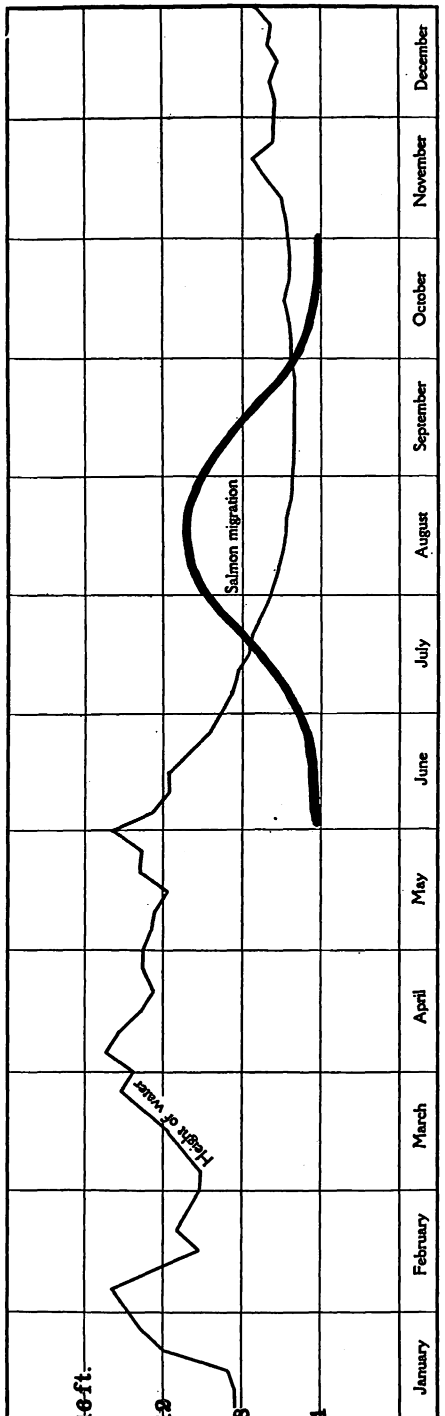

FIG. 3. The relation between height of water and the summer migration of king salmon in the Klamath River.

water bearing quantities of yellow silt and having a very low temperature. A huge yellow fan extends from the mouth outward over the surface of the ocean, occasionally reaching a width of three or more miles. Its shape and extent seemingly influenced by wind and tide, varies from day to day, now shifting far to the north or south and extending a greater or lesser distance out to sea. The line between fresh and salt water is often sharply defined by a narrow band of foam. From some distance to the north and south of the river the shore fauna shows the influence of fresh water.

The number as well as the destination of the fish which enter the river at this time is unknown. It is certain that the number is small

TABLE 9

Spring Run, Klamath River

Date	1918		1919		1920	
	Number fish	Average weight	Number fish	Average weight	Number fish	Average weight
April 16	5	13.0				
April 17	2	11.1				
April 18	6	13.1				
April 19	4	12.8			18	13.1
April 20	2	9.0			5	10.8
April 21					21	12.8
April 22	2	13.0				
April 23	2	10.0			19	13.3
April 24	9	11.2				
April 25	1	19.0				
April 26	4	11.7			23	14.4
April 27					12	16.4
April 28					18	11.2
April 29	6	10.5				
April 30	4	11.7	15	11.0	24	14.0
May 1	7	12.3	23	12.2	9	14.7
May 2	2	19.0				
May 3	2	15.5	4	11.5	6	12.0
May 4					14	13.6
May 5			20	13.3		
May 6	7	11.8				
May 7	7	9.0	54	11.5	2	12.7
May 8	1	8.0	30	12.4		
May 9			31	12.0		
May 10			36	12.1	18	14.7
May 11						
May 12			71	11.7		
May 13			20	12.1		
May 14			24	12.3	6	14.6
May 15	1	10.0	29	11.7		
May 16			57	12.4		
May 17			68	12.8	4	16.2
May 18					13	13.6
May 19			28	13.4	6	16.4
May 20	11	11.4	102	12.8	2	13.0
May 21	9	10.0	50	14.7		
May 22	1	7.0	21	12.5	9	14.3
May 23	1	13.0	40	13.3		
May 24	13	9.6	46	13.4	15	15.3
May 25						
May 26	2	11.0	8	14.4		
May 27	2	10.0	100	13.6		
May 28	10	9.2	32	12.2		
May 29	8	10.4	94	13.0		
May 30	2	10.4	27	13.0		
May 31	23	9.8				

or insignificant when compared with that of the summer run, yet many fish might easily escape notice in the silt-laden torrent with which the channel is filled. Possibly the migrating fish slowly make their way to the most distant headwaters[4] or they may spread out over a considerable area of the basin and reach maturity at the same time as those of the summer migration.

The fish of the spring run appear to be characterized by the immature condition of the gonads, and by their small stature. The ovaries when examined, April 17–25, 1920, were in all cases very small.

It is reported that spring fish do not exhibit even an approach of breeding colors, nor is the snout ever elongate as is frequently the case among fish of the late summer migration.

There is at hand very little accurate data relating to the fish of this migration. During the years 1918 to 1920, the Klamath Packers Association operated its plant in the spring, when Field preserved a record of the catch, a summary of which is presented in table 9. Fishing ceased after May in each case, the venture not proving profitable. A comparison of the average weight of these fish with that of others taken in July and August indicates that they are considerably smaller.

TABLE 10

Year	Spring		July		August	
	Number fish	Average weight	Number fish	Average weight	Number fish	Average weight
1918	1,710	9.9	312	12.4	12,140	11.9
1919	1,030	12.8	1,668	13.5	23,591	13.4
1920	242	9.8	948	14.2	46,851	14.8

From April 19 to 25, 1920, all fish to the number of 35 that were brought to the wharf were examined by the writer. The gonads of these were immature, eggs preserved in formalin measuring 3 to 3.2 mm. in diameter.

Fishermen reported that the catches were made at Hollow Tree and Ferry drifts, some distance above the mouth of the river. These fish appeared more silvery than those of the summer migration and

[4] Williamson River and the entire Klamath Lake basin are now closed to the migration of salmon and steelheads, the dam at Copco having become operative as a barrier October 25, 1917, according to H. A. Frazer of the California Oregon Power Company. During the summer of 1918, the writer, acting under the authority of the United States Bureau of Fisheries, interviewed many fishermen and old residents of the Klamath Lake region in an effort to learn something of the migration of salmon. Testimony was conflicting and the lack of ability on the part of those offering information, to distinguish between even trout and salmon was so evident, that no satisfactory opinion could be formed as to whether king salmon ever entered Williamson River and the smaller tributaries of the lake. However this may be, large numbers of salmon annually passed the point where the Copco Dam is now located.

the spots were smaller and more linear. Some scale counts resulted as follows:

TABLE 11

Lateral series	Above lateral line
136	27
140	29
141	29
136	30
147	29
145	30
136	33
133	31
139	27
133	26
139	30
135	29
143	29

Of the 35 spring fish, 29 possessed scales of the ocean nuclear type. There were five male and 21 female four-year-old fish measuring from 70 to 83.5 cm. The stream type of nucleus was represented by only six fish. Two of these were four-year-old females 76 and 80 cm. long, while there were one male and three females from 72.5 to 83 cm. long.

THE SUMMER MIGRATION—(IMMIGRATION)

The summer migration of king salmon in Klamath River begins about the first of July, mounts rapidly by the last of the month, reaches its maximum in August, declines gradually in September, and falls away almost entirely before the beginning of winter. There is no definite break between the spring and summer migrations, and it seems also that fish in small numbers continue to appear through November and even later. A spawning migration of steelheads comes with that of the king salmon, and a run of silver salmon starts early in September, and continues through October and November. The spring migration has now lost its economic importance, and seems to have almost entirely disappeared. It was formerly connected at its waning period with the summer run. The fish of the spring run enter the river during its flood height of very cold water, and pass up stream under the same conditions, while the summer migration starts as the winter and spring floods subside, most of its fishes passing upstream during a minimum flow of water, as is shown in figure 3, which was constructed from data found in Water Supply Papers, 311 to 313, United States Geological Survey.

The period of migration of the king salmon varies somewhat from year to year, both as to time of starting and duration. In 1919 it was not well begun until late in July, while some years previously, 1913, 1914 and 1915, to be more exact, fish were caught in numbers during the second week in July. (Table 12.) The progress of the migrations of 1914 and 1919 are graphically compared in figure 4.

TABLE 12

Record of the catch of king salmon in the estuary of Klamath River as kept in the office of the Klamath River Packers Association

Number of Fish Taken

Date	1913	1914	1915	1916	1917	1918	1919	1920	1921	1922	1923	1924	1925	1926
June 15		25												
June 16		19												
June 17		24												
June 18		20												
June 19		17												
June 20														
June 21			93											
June 22		39	60											
June 23	95	35	113											
June 24	64	21	98											
June 25	94	21	58											
June 26	111	32	17	11										
June 27	87	8		155	1									
June 28	33		141	53	1									
June 29		89	175	80										
June 30	112	67	116	43										
July 1	64	67	121	27		13								
July 2	74	23	95		1									
July 3	74	26	1	144	4	5								
July 4	47	6		64	2									
July 5	48		243	173	1			4						
July 6		139	108	106										
July 7	195	125	120	364			1	22						
July 8	174	72	185	32		1		1						
July 9	231	133	201		11		3	6						
July 10	207	104	85	275	14	2	2	2						
July 11	177	23		167	8	3	5							
July 12	5		375	203	6	3		4						
July 13		394	237	60	5	1		8						
July 14	231	121	363	37			2	4						
July 15	107	83	203			1	36	3						
July 16	268	60	231		6	2	12	2			258			
July 17	435	45	103	743	6	1	21	19			145			
July 18	468	5		139	7	1	1				145			
July 19	47		776	73	7		4	181			236			7
July 20		290	362	132		5		156	53		160			8
July 21	269	154	276	469			39	75	121		55		7	19
July 22	207	216	90	81		4	19	246	87				86	201
July 23	15	452	101		48		3	85	101		173		955	186
July 24	33	1,034	10	738	31	1	34	121			83		288	64
July 25	57	70		311	46	37	110		224		37		532	
July 26	165		319	291	50	32	184	178	11		161			112
July 27		2,653	299	340	57	79		164	94		442		1,507	40
July 28	697	2,332	267	361	25		223	262	51		56		1,579	37
July 29	822	966	444	178		59	333	227	136	1,514			1,120	86
July 30	714	861	1,495		31	39	195	612	70		125	397	114	77
July 31	411	2,502	242	1,333	61	20	441	582		713	17	233	129	26
August 1	560	323		104	5	46	442		931	513	3	353	1,676	
August 2	253		3,294	593	28	66	420	1,875	1,163	167	1	980		7
August 3		1,385	929	419	96	88		715	1,192	277			1,892	34
August 4	1,347	717	742	514	152		491	985	663	1,360		2,071	1,659	1,163
August 5	739	918	769	560		225	167	653	1,939	1,248		833	1,158	719
August 6	1,173	1,116	179		140	267	51	1,556	951		138	1,024	1,081	355
August 7	245	1,326	6	669	105	123	483	1,357		2,175	407	855	832	717
August 8	382	355		490	89	181	407		2,376	2,373	218	296	100	
August 9	15		1,657	682	68	412	401	642	1,008	2,662	1,282	188		1,386
August 10		1,043	554	439	151	279		2,033	990	1,645	1,109		972	115
August 11	807	1,151	792	1,213	73		1,602	1,780	2,104	1,483	539	222	288	696
August 12	1,155	2,608	1,942	844		252	439	1,264	176	754		1,120	1,603	520
August 13	1,886	2,456	494		125	115	807	1,449	1,006		984	2,817	2,774	1,557
August 14	1,504	2,363	2,491	1,560	160	190	170	2,918		4,632	9,923	2,638	913	304
August 15	1,460	2,427		784	39	300	366		2,850	690	*	1,158	402	
August 16	460		1,793	217	62	218	796	*7,420	2,741	1,646	2,959	2,269		130
August 17		4,134	2,343	268	37	373			2,638	3,703	1,666		2,065	145
August 18	2,454	424	1,279	441	163		758	*2,000	1,803	1,267	1,513	3,387	2,544	51
August 19	832	6,111	1,503	2,001		808	1,214	*2,067	1,670	1,601		809	4,135	75
August 20	830	1,891	654		189	1,628	549	*2,079	963		1,558	2,539	5,905	92
August 21	540	3,137	1,003	310	80	870	1,611	*2,112		2,937	617	1,899	*1,681	131
August 22	504	4,177		353	125	218	3,587		2,640	4,152	5,216	2,421	1,401	
August 23	704		8,705	678	67	1,211	611	*1,922	482	2,950	2,287	3,280		463
August 24		2,920	*2,832	1,879	162	487		*1,997	3,290	4,406	1,344		3,724	1,566
August 25	356	1,069	2,518	1,520	105		1,350	*1,984	1,140	1,548	1,735	3,255	2,078	3,030
August 26	218	1,034	3,087	991		995	1,875	*1,595	1,232	984		1,115	462	1,564
August 27	180	1,285	4,204		305	398	1,255	*1,230	*678		3,438	404	362	4,306
August 28	352	997	2,176	1,803	142	714	1,416	*1,572		1,524	1,270	861	1,923	1,681
August 29	220	1,004		764	126	472	1,097		*	1,334	3,243	593	1,266	
August 30	100		7,529	828	309	539	226	*2,514	*	1,382	4,309	642		578
August 31		1,187	1,852	385	181	665		*1,132	1,895	1,750	1,333		1,005	637

TABLE 12—Continued

Record of the Catch of King Salmon in the Estuary of Klamath River as Kept in the Office of the Klamath River Packers Association

Number of Fish Taken

	1913	1914	1915	1916	1917	1918	1919	1920	1921	1922	1923	1924	1925	1926
September 1	440	418	526	516	182		239	*1,565	905	1,240	*	1,185	1,353	2,037
September 2	177	853	1,797	294		1,072	493		1,108	993	*	2,380	1,410	2,744
September 3	801	509	657		300	423	267	*1,470	481		1,632	1,597	905	566
September 4	411	442	2,550	389	467	767	134	500		3,273	2,645	1,189	398	1,394
September 5	458	553	3,277	1,128	201	386	234		506	1,011	593	657	544	
September 6	192				100	578	238	776	527	1,595	2,944	204		1,146
September 20					722	374	1,402							
September 21					152	238								
September 22					86		330							
September 23						187	378							
September 24					133	49	180							
September 25					79	33	91							
September 26					193	25	66							
September 27					255	31	33							
September 28					464	36								
September 29					166		32							
September 30						133	48							
Totals	28,593	63,706	72,357	30,819	7,213	16,784	29,424	54,126	42,996	61,502	56,999	45,871	54,828	30,772

*A limit was placed on these days.

As might be presumed from what is known of the behavior of other animals, the migration does not consist of a steadily increasing flow with a similar gradual decline, but rather of a continuation of successive waves of varying size which on the whole mount higher and higher until a maximum is reached, and then die away in much the same manner as they came. Some fishermen express the opinion that these waves are caused by the varying conditions of moon and tide, but there seems to be no evidence that large schools are lingering for any great length of time in the sea near by, awaiting proper conditions for entering the river. Fishermen are not able to predict the size of the day's catch with any degree of certainty, nor are they always able to tell whether fish are plentiful in the estuary. The fish often make their presence known by "finning" as the act is called, that is, by cutting the surface with the dorsal fin or a large part of the back, a rather slow and deliberate movement, in strong contrast with the sprightly leap of the steelhead. A large catch may or may not follow a brisk exhibition of finning. It seems that fish mostly enter the river with the tide, beginning to come in numbers on low water. It is said by some fishermen that they do not come in with the night tides. Anglers appear to meet with more success on an incoming tide, but it is to be noted in this connection that the mouth of the river does not offer a large margin of safety when the tide is passing out, and anglers are not apt to venture there with their boats at that time. Many who have observed the salmon here are positive in their statements that the fish mostly enter the river with the tide, and that migration does not occur in a marked degree with the full moon tides. It is said also that fish enter the river in the daytime and that there is no marked inward movement at night. Direct occular observation at the mouth of the river is not possible because of the deep, rapid and silty water.

Usually the stomachs of the fish are entirely empty and evidence appears which suggests that the long fast of migration is already under

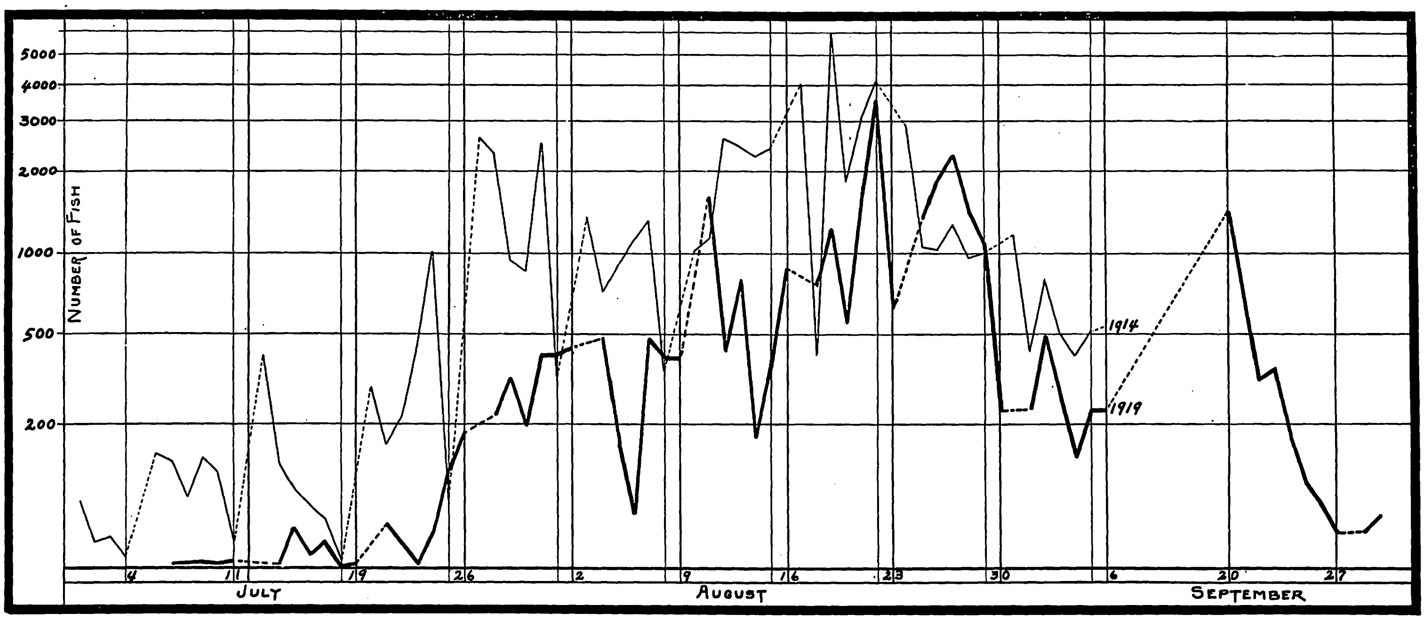

Fig. 4. Illustrating the migrations of 1914 and 1919. The dotted lines represent closed seasons.

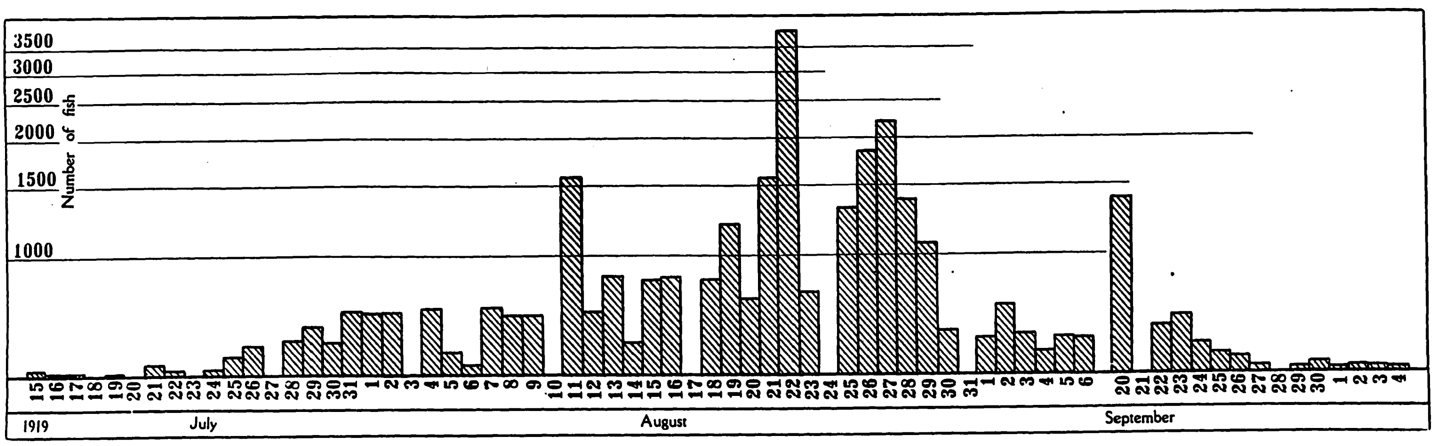

Fig. 5. The migration of 1919 as represented by the daily catch.

way. Occasional individuals have some sea food in the digestive tract and some have been seen with their stomachs full of sardines.

After entering the river, it appears that the fish are accustomed to linger in the estuary for a time at least. This seems to be established by the fact that a closed season whether long or short is generally followed at once by an unusually large catch. This is borne out by an inspection of table 12[5], and also in figure 4, where the dotted lines represent legally closed periods. It will be noted also that when fishing begins late in the season as in 1922 and 1923 the initial catch is large. In many cases two or three successive days of fishing almost clear the river. Exceptions occur, but they are not frequent. From reports it appears that fish sometimes pass quickly up the river after entering the mouth. They also linger at times in the larger pools. Nets are often successful at Ferry Drift or Hollow Tree Drift when very few fish are caught in the estuary. In migration, the fish often rest in the slower parts of the stream which extend between the rapids. They are said to select one side of the river or the other in migration, the choice presumably being made in relation to the current. All this must be taken into account in the consideration of closed periods or restricted areas as aids to conservation.

Sometimes a migratory wave of unusual size appears, suddenly taking everyone by surprise. In 1920, early in August the fish were coming in numbers and the catch was well sustained during the week ending with the 14th. On the evening of the 15th the layout began at 8.15 at the first sound of the whistle. Almost immediately fish began to strike the nets and the catch progressed so rapidly that the recall was sounded at 8.50. Some of the nets had filled so quickly that several boats were in distress from an overload and other nets had to be hauled without taking time to disengage the fish. 7420 fish were taken into the cannery at this time. From then until the end of the month the catch was limited to the capacity of the plant. At the same time the river was alive with steelheads.

The gonads of the early arrivals are comparatively immature, their size and general appearance not differing from many examples caught at sea, this condition changing with the progress of the season, some of the last fish to come being almost mature. Eggs of fish taken early in the season often measure no more than 3 mm. in diameter, while later, some measuring 7 or even slightly more may be seen. A ripe egg measures about 9 mm.

The late arrivals have in most cases acquired the external marks of mature fish, notably the highly colored skin, deeply embedded and eroded scales, the hooked jaw and enlarged teeth. The appearance of larger and older fish also characterizes the wane of the migration.

Upon entering the stream early in the season the fish are almost uniformly olive greenish above, the color somewhat lighter or darker in different individuals, and bright silver on the sides, the sheen disappearing on the lower surface. The spots of the body are elongate, in many cases almost reduced to zigzag lines each covering 4 or 5 scales and extending obliquely with the rows of scales.

[5] In these tables the catch of the previous evening is recorded as of the following day. For example, the catch of August 14th was begun August 13th at 8.15 p.m. and continued at intervals during the night of that date and the early morning of the 14th.

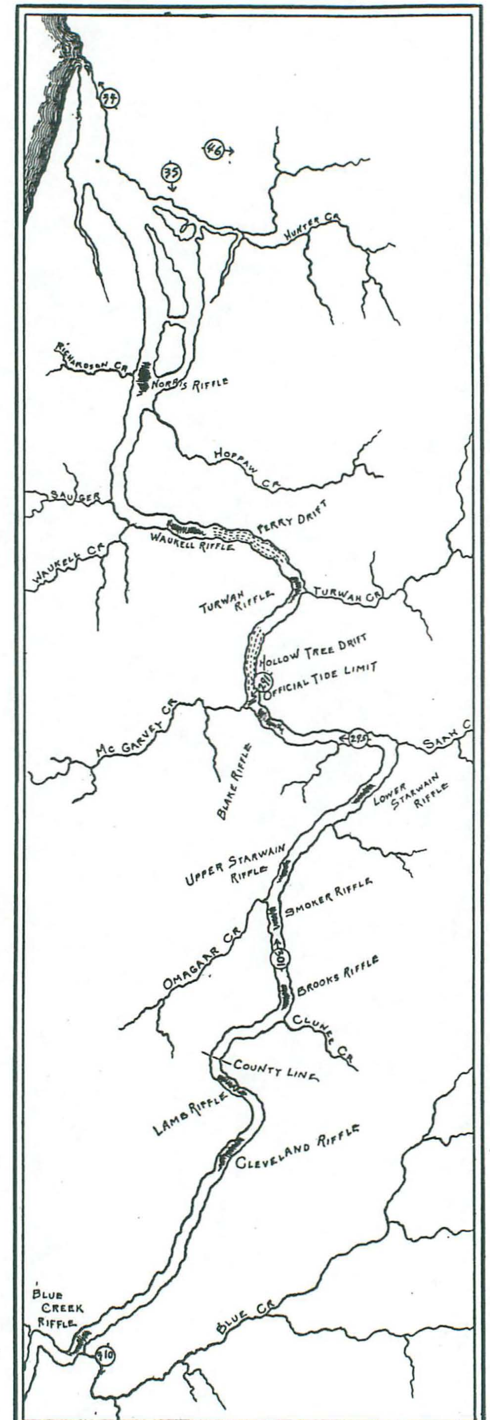

FIG. 6. Representing Klamath River between the mouth and Blue Creek and indicating the location of rapids (riffles) and fishing grounds.

The dorsal fin is profusely spotted. The caudal fin may be completely spotted or immaculate. In a series of specimens exhibiting variously spotted fins the immaculate condition is approached by a disappearance of spots first from the middle of the fin, then downward toward the lower lobe, remaining to the last on the lower edge, then dorsally toward and finally including the upper rays of the upper lobe. The spots of the caudal are round or slightly ovate, usually more elongate near or on the upper and lower edges.

Inside the mouth the tissue is blue black on the lower jaw near the teeth, on the tongue and backward along the gill arches, along inside of upper jaw, on edge of valve and on two elongate areas bordering palatine teeth. This character serves to easily distinguish between salmon and steelheads, the latter having the inside of the mouth white.

About the middle of August fishes begin to appear with traces of the nuptial colors. Some have the back and sides suffused with a brilliant bronze which is often strongly tinted with pink. Others are dark or even blackish and along with the color comes an elongation of the snout and a thickening of the skin. As the season progresses individuals with colors more nearly approaching those of the spawning period appear from time to time, while very late in the season an occasional male is seen the color of which is almost in full bloom.

When about ripe the males become very dark olive or almost black, the silver having entirely disappeared, even the ventral surface being dark, the throat and chin black. The region of the branchiostegals, the jaws and snout and the lower sides of the paired fins are black. Above and behind the anal fin the body is cherry red. Axil and covered areas anterior to branchiostegals and beneath jaws, dead white.

As the bright color stage advances the red progresses anteriorly until the whole head and body are suffused with it. The advanced color phases are not entirely coordinate with maturity, a brilliantly colored example sometimes not being so nearly ripe as one which is much less ornate.

Far up stream even late in the season individuals are occasionally seen with something of the silvery color of the sea. These are identified by the casual observer as silver salmon while the darker colored examples are spoken of as hook-bills.

No observer has had an opportunity to trace a migration up the river, and at present there is nothing to offer in this connection except what may be culled from interviews with residents or anglers and other fishermen along the stream. Information secured in this way is difficult to evaluate because of confusion resulting from an inability to distinguish species or to discriminate between members of the same species. When the observer is called upon to regard males and females, some with their silvery sheen fresh from the sea, and others dark and highly colored as they approach maturity, not to mention old males with hooked jaws, and the steelheads and silver salmon, the difficulty becomes acute. Out of a mass of reports and descriptions it appears safe to accept in the main the following extract.

In the past there were two fairly distinct runs of king salmon, noted even to the headwaters of the river and its larger tributaries. First came the spring or summer salmon, which were later followed by

the fall or snow salmon. The migration of spring salmon has everywhere been diminishing until of late years it has practically disappeared. It is reported that the spring salmon lingered near the spawning beds both in the main river and its tributaries where they at last matured, ripened and spawned with the fishes of a later run. The spring salmon, also known as "silvers" because of their bright color, were said to arrive in the region of Happy Camp in May or June, and in Shasta River in June and early July. These fish are described as being silvery in color, the scales plainly seen on the surface, and the jaws without hook or fighting teeth. These are never seen spawning. The inference is plain that before spawning they assume the characters common to spawning fish, and this at about the time that fish of the summer run appear on the spawning beds. There is said to have been no spring run into Scott River.

The fall or snow salmon sometimes called "hookbills," appeared later in the season arriving near Happy Camp late in August or early in September and continuing to come, entering such streams as Clear, Elk, Indian, China and Grider creeks where they spawned from November on, some even as late as January. Fish of this run enter Scott River and Beaver Creek at about the same time. They formerly came to Shasta River in great numbers, an old resident referring to it as the best spawning tributary of Klamath River. The demands of irrigation have changed all that and now the Shasta is said by many to contribute relatively little to the population of the main river.

The racks at Klamathon, near Hornbrook are usually in place by the latter part of July in anticipation of the early arrivals of the summer migration and they sometimes remain until late in November, most of the fish having then been entrapped. Artificial spawning begins at the racks a little after the middle of October and continues into November. Fish of the summer run, and especially after their entry into the tributaries, which may in some cases be delayed until the rains of early autumn, are often dark in color, some having a conspicuous area of cherry red on the sides. Their skin is then thick and leathery, the scales small (eroded or absorbed) and deeply embedded, and the jaws of the males greatly extended, hooked and armed with large teeth. In a word they are mature, and ready to spawn. The designation "hookbills" or "dogs" as applied to these is easily understood. In spite of the emaciated condition of some of these and their poorly flavored flesh, they were formerly sought with hook and spear and many were destroyed just before the eggs were laid.

The time of arrival of salmon in the tributaries appears to differ markedly, at least in certain cases, and their degree of maturity varies also. For example, during the week beginning October 16, 1927, a relatively small number of the fish held between the Klamathon racks were ripe. In Shasta River large numbers were actively spawning, while many spent and a few dead fish were seen. At the same time only a few fish were in Scott River, the migration having scarcely begun there. Spawning had not yet started. The volume of Scott River at the time was equal to or greater than that of the Shasta.

During the summer migration the salmon enter the river from a constantly lower temperature to a varying higher one. No careful observations on temperature and its possible relation to migration in

Klamath River has been made, but a cursory examination of conditions prevailing there leads one to suspect that an investigator with temperature control as a thesis will find ample food for thought. In passing up the stream, salmon enter tributaries which are either warmer or colder than the main channel as the case may be. Diurnal variation is great both in the main river and its tributaries. One may at times find a difference of two degrees between the water flowing along the north and south banks where the river is not more than 250 feet across, and where there are neither springs nor tributaries to affect it.

A tributary may at one time of day be colder than the river while at another time it may be warmer. Some tributaries into which salmon migrate have a flow so weak when compared with the main stream that their temperature influence may be detected only a short distance either laterally or below their mouths.

Some scattered observations on temperature may be of interest.

During the summer of 1926, from August 10 to September 15 the ocean temperature near the mouth of the river was 55° Fahrenheit, according to G. H. Clark, assistant to the Bureau of Commercial Fisheries. He reported river temperatures at the same time as follows:

TABLE 13

Date	Time	Depth of water	Bottom temperature (degrees, Fahrenheit)	Top temperature (degrees, Fahrenheit)
August 1, 1926	10.00 a.m.	8′ 6″	71.5	72.0
August 3, 1926	10.30 a.m.	8′ 8″	71.0	72.0
August 4, 1926	10.30 a.m.	9′ 6″	71.0	71.0
August 5, 1926	10.00 a.m.	8′ 2″	70.0	70.5
August 6, 1926	10.00 a.m.	8′ 6″	70.0	70.5
August 11, 1926	10.00 a.m.	8′ 1″	70.0	70.0
August 12, 1926	9.30 a.m.	2′ 8″	68.0	68.0
August 13, 1926	10.00 a.m.	1′ 6″	69.0	70.0
August 16, 1926	8.30 a.m.	3′ 6″	68.0	69.0
August 18, 1926	8.30 a.m.	4′ 0″	68.0	69.0
August 19, 1926	8.30 a.m.	4′ 6″	67.0	69.0
August 21, 1926	8.30 a.m.	4′ 0″	68.0	69.0
August 23, 1926	10.30 a.m.	5′ 2″	61.0	71.0
August 25, 1926	2.30 p.m.	7′ 3″	60.0	65.0
August 30, 1926	10.00 a.m.	5′ 0″	68.0	68.0
September 1, 1926	11.00 a.m.	5′ 0″	68.0	69.0
September 4, 1926	10.00 a.m.	5′ 10″	64.0	67.0
September 7, 1926	9.00 a.m.	5′ 2″	65.0	66.0
September 14, 1926	10.30 a.m.	5′ 0″	67.0	67.0
	10.30 p.m.	5′ 0″	66.0	66.0

At the egg taking station near Hornbrook the water temperatures during the month of July of the same year varied from 60° to 76° Fahrenheit, the daily variation being from 4° to 10°. During August it was just a little lower. In September it fell, going down to 40° at one time. In October and November it was still lower. The following summary may be of interest.

Average temperatures for ten-day periods taken twice each day at 8 a.m. and 5 p.m.:

TABLE 14

Date	Degrees, Fahrenheit (a.m.)	Degrees, Fahrenheit (p.m.)
July 1 to 10	68.1	75.0
July 11 to 20	67.2	72.6
July 21 to 30	61.9	70.7
August 1 to 10	60.0	70.4
August 11 to 20	60.0	68.6
August 21 to 30	60.2	66.6
September 1 to 10	58.6	66.2
September 11 to 20	55.0	62.6
September 21 to 30	49.6	60.0
October 1 to 10	50.6	59.2
October 11 to 20	51.4	56.9
October 21 to 30	47.6	56.8
November 1 to 10	46.6	53.7

From time to time one hears the declaration that the migration is growing later each year. This often accompanies a plea for a late extension of the legal open season. The same report also comes from Eel and Smith rivers. This belief expressed by many fishermen and other observers, is in the writer's opinion a misinterpretation of a phenomenon of depletion. Instead of the curve of migration progressively moving toward the end of the calendar year, the early part of it is being rapidly cut off. The spring run has practically disappeared and the early part of the summer migration has been greatly diminished, while increased effort has sustained the size of the catch which is now largely obtained from what was once the central region of the curve. The partial disappearance of the early fish together with the increased effort necessary to maintain the catch have contributed toward a manifestation of depletion which has been wrongly interpreted as a change in the habits of a species.

The cause of the disappearance or depletion of the early spring migration is another matter and it is doubtful if an entirely satisfactory explanation may now be offered. It is attributed by some to the closure of the river at Copco, this belief resting upon the supposition that the fish of the early part of the migration were bound for Williamson River and the upper Klamath. But depletion of the early run was well under way, if not about complete long before the erection of the dam. Mining operations, overfishing both in the river and at sea, irrigation, and other causes have been suggested.

SEX REPRESENTATION IN THE MIGRATION

During the migration of 1919 the sex of 3136 individuals was recorded. In each case the sex was determined by dissection. Of these, 1461 were found to be males, while 1675 were females. This enumeration takes almost no account of the three-year males, the so-called chubbs or grilse, which, because of their small size, easily escape the nets in numbers and when caught are not usually brought

TABLE 15

Sex Representation in the Annual Catch, Klamath River

Date	1919				1920				1921				1922				1923			
	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female
July 10					1	1														
July 11	2	3															3	2		
July 12					2	2														
July 13					3	5											2	9		
July 14	1	4			1	2											3	21	8	32
July 15	6	31			1	2														
July 16					1	1											11	44		
July 17	4	16			3	12	12	25									17	58		
July 18																	11	74		
July 19	2	1	15	55	22	47											19	56		
July 20					20	40			24	29							11	49		
July 21	5	31			10	20			47	79							5	44	74	325
July 22	2	16			40	59			18	58										
July 23		2			20	65			32	63	121	229					9	56		
July 24	5	13			25	50	137	281									21	59		
July 25	34	70							47	53							7	22		
July 26	24	26	70	158	23	46			4	4							12	53		
July 27					30	43			43	49							12	68		
July 28	16	24			34	70			20	30							8	2	69	260
July 29	71	78			35	60			40	60			23	57						
July 30	46	39			53	101			34	53	188	231					14	61		
July 31	36	44			47	107	222	427					12	53			4	13		
August 1	29	34							54	56			16	34				3	18	77
August 2	35	24	233	243	81	122			41	68			8	20						
August 3					45	74			50	50			4	36						
August 4	34	30			42	107			55	116			13	62						
August 5	14	11			72	67			49	80			13	27	89	289				
August 6	31	14			66	114			38	62	287	432								
August 7	22	48			60	127	366	611					82	186			20	60		
August 8	37	53							43	66			65	154			9	46		
August 9	1	4	139	160	44	65			39	65			202	428			22	63		
August 10					89	151			36	69			79	212			13	77		
August 11	58	67			97	186			36	64			15	35			10	40	74	286
August 12	34	40			67	119			40	60			17	33	460	1,048				
August 13	20	35			51	139	348	660	44	56	238	380					9	66		
August 14	11	4											20	44			23	77		
August 15	15	20			69	131			33	87			14	43			22	65		
August 16	14	20	152	186	86	133			35	65			15	40			17	53		
August 17					61	134			40	58			100	207			24	56	95	317
August 18	29	30			78	117			34	71			14	46						
August 19	19	36			87	118			43	55			10	50	173	430				
August 20	33	32			130	125	511	758	39	56	224	392					26	50		
August 21	30	43											73	226			13	27		
August 22	41	65							32	73			61	164			23	62		
August 23	38	36	190	242	85	129			22	28			19	30			20	65		
August 24					73	132			79	106			92	177			31	44		
August 25	34	70			87	113			60	44			111	168			16	34	129	282
August 26	29	46			89	121			53	47			14	25	370	790				
August 27					103	108			49	57	295	355					11	64		
August 28					61	89	498	692					23	61			21	54		
August 29	33	27											48	102			26	49		
August 30	21	18	117	161	60	90							56	134			27	54		
August 31					68	82			49	64			189	281			24	62	109	283
September 1	39	30			71	79			57	53			185	341						
September 2	51	36							42	57			22	53	523	972				
September 3	32	27			50	95			49	51							24	51		
September 4	66	58			31	49			51	49			24	51			26	53		
September 5	27	25							44	66	292	340	96	179			28	47		
September 6	33	21	248	197	56	84	336	479					101	174	221	404	24	36	102	187
September 20	70	58																		
September 21																				
September 22	33	21																		
September 23	5																			
September 24	12	17																		
September 25	11	9																		
September 26	14	16																		
September 27	11	13	156	134																
September 28																				
September 29	5																			
September 30	2	3																		
October 1	4	3																		
October 2	5	5																		
October 3	15	9																		
October 4	3	2	34	22																
October 5																				
October 6	4	7																		
October 7	18	20																		
October 8	4	17																		
October 9	6	9																		
October 10	13	16																		
October 11	11	5	56	74																
October 12																				
October 13																				
October 14	21	12																		
October 15	6	11																		
October 16	13	10																		
October 17	5	6																		
October 18	6	4	51	43																
Totals			1,461	1,675			2,430	3,933			1,645	2,359			1,836	3,033			678	2,049

into the cannery. Early in the season there was a relatively large proportion of females in the catch, but as the season advanced the males became more numerous. This is illustrated in table 15 where for comparison the sex enumeration for later years is also recorded. Reduced to percentages, the relative number of females appearing during successive periods of the migration is as follows:

TABLE 16

Percentage of Females in the Catch During Successive Periods of the Summer Migration

	1919	1920	1921	1922	1923
To July 19	70.5	67.5			76.4
July 20 to 26	69.3	67.2	65.4		79.0
July 27 to August 2	51.0	65.7	55.1	76.2	81.0
August 3 to 9	53.5	61.8	60.0	69.4	79.4
August 10 to 16	55.0	65.4	61.4	68.1	76.9
August 17 to 23	56.0	59.7	63.6	68.0	68.6
August 24 to 30	57.9	58.5	54.6	65.0	72.2
September 1 to 6	44.3	58.5	53.8	64.6	64.7
September 20 to 27	46.2				
September 28 to October 4	39.3				
October 5 to 11	56.9				
Total number observed	3,136	6,442	3,975	2,134	2,724

In the case of sex representation the desirability of considering numerically large samples has not escaped attention, and an illustration of what a sample of small size might present may not be out of place here. One day, August 25, 1922, to be more particular, 100 fish picked up without conscious selection resulted in finding 37 males and 63 females. Other hundreds were then examined in small pods just as they came to hand with the following results:

TABLE 17

Males	Females	Males	Females	Males	Females	Males	Females
8	17	11	14	12	13	9	16
8	17	13	12	5	20	9	16
8	17	10	15	12	13	10	15
15	10	10	15	15	10	8	17
39%	61%	44%	56%	44%	56%	36%	64%

It appears that we have no means of knowing the relative number of either sex in an entire migration, principally because the small males are allowed to pass the nets in large numbers, and further, there is no opportunity to observe the latter part of the migration when males are apparently more numerous. The results of some observations on Trinity River[6] in Hoopa Valley, extending over a short period from September 18 to 26, are suggestive. During this time 340 king salmon were caught under such circumstances as would warrant presumption that a fair sample of the migration at this time was secured. Of these, 260 were males which measured less than 64 centimeters in length, all of a size most likely to escape the nets at the mouth of the river. Of

[6] Snyder, J. O. Indian methods of fishing on Trinity River and some notes on the king salmon of that stream. California Fish and Game, vol. 10, no. 4, pp. 163–172, 1924.

TABLE 18

Average Weight of King Salmon in Klamath River as Shown by the Daily Catch for 1917-1925

Date	1917	1918	1919	1920	1921	1922	1923	1924	1925
July 17	14.9		12.4	13.6			14.4		
July 18	16.8		14.0				14.1		
July 19			12.2	14.9			15.6		
July 20	18.8			15.0	13.8		15.6		
July 21			14.1	14.7	14.0		14.3		15.7
July 22			13.6	14.7	15.0				15.0
July 23	18.2		15.7	14.6	14.1		15.0		16.6
July 24	15.1		13.1	14.7			15.5		16.5
July 25	16.1		13.2		14.5		13.6		16.0
July 26	16.0		14.7	14.1	12.2		14.3		
July 27	14.8			14.5	14.4		15.0		16.6
July 28	15.3		13.3	14.6	13.8		14.2		16.3
July 29			13.2	14.1	14.5	15.6			15.8
July 30	14.9		13.8	14.7	13.2	15.0	14.9	14.6	16.3
July 31	14.8		13.8	14.3			14.3	14.0	15.3
August 1		12.7	13.4		13.3	14.9	14.6	13.8	15.6
August 2	15.0	12.9	12.6	14.9	12.6	15.0	10.0	14.6	
August 3	14.9	12.3		14.4	12.8	15.1			15.6
August 4	15.1		13.3	14.4	12.5	14.9		13.6	15.1
August 5		11.9	12.2	13.9	13.1	14.8		13.4	14.8
August 6	14.6	12.5	12.9	14.3	12.2		14.4	13.9	15.3
August 7	14.4	12.3	12.8	14.0		15.0	14.2	13.8	16.0
August 8	15.0	12.2	12.8		14.1	15.1	14.0	12.8	16.1
August 9	13.3	12.4	12.7	14.0	12.7	14.9	14.9	13.4	
August 10	14.9	13.3		14.5	12.6	14.3	14.6		15.1
August 11	14.5		12.7	13.9	13.1	14.9	14.5	14.7	16.0
August 12		13.1	13.0	14.4	13.3	14.6		13.7	15.6
August 13	14.9	12.6	12.5	13.7	13.8		14.2	14.0	15.4
August 14	14.1	12.4	13.0	14.4		15.1	15.0	14.3	14.5
August 15	15.3	12.0	12.5		15.5	14.0		14.2	14.6
August 16	14.4	12.3	13.2	14.4	14.3	14.1	14.1	13.1	15.1
August 17	14.9	11.9			13.3	14.8	14.2		
August 18	15.9		12.6	14.4	13.4	14.6	14.9	14.5	16.0
August 19		12.0	12.6	14.9	13.5	13.2		15.1	15.7
August 20	15.3	12.2	13.0	15.3	12.8		13.9	15.1	15.4
August 21	15.1	11.8	13.5	15.8		13.6	13.6	14.6	16.6
August 22	14.8	12.0	13.8		13.9	13.8	14.1	14.3	15.8
August 23	15.0	12.1	14.1	14.9	15.3	14.6	14.3	16.0	
August 24	13.1	11.1		14.8	14.3	14.8	13.9		16.6
August 25	14.2		13.6	15.1	17.4	15.1	13.3	16.0	15.4
August 26		11.3	13.2	15.5	14.7	15.9		16.0	15.0
August 27	15.1	11.7	13.6	15.2	15.4		13.6	14.4	15.0
August 28	14.1	11.4	14.2	15.1		14.3	13.8	15.5	15.5
August 29	13.9	11.2	14.0			13.5	13.9	14.4	15.8
August 30	16.5	11.3	14.1	16.6		14.0	14.1	13.8	
August 31	15.2	11.3		15.4	15.1		14.7		16.4
September 1	15.0		14.0	16.9	14.6	14.3		14.9	16.6
September 2		11.6	14.2		15.2	14.6		16.5	16.2
September 3	16.2	11.2	15.1	14.9	16.3	15.3	14.0	16.3	16.4
September 4	16.5	12.1	15.3	14.9		15.7	15.0	17.1	16.4
September 5	18.3	12.7	16.9		16.2	15.7	15.4	18.9	15.5
September 6	17.6	12.5	14.8	16.7	15.9	16.4	15.4	16.6	
September 20	21.1	17.3	22.8						
September 21	18.0	17.9							
September 22	20.6		23.3						
September 23		19.1	22.7						
September 24	20.6	20.6	22.9						
September 25	18.3	23.5	21.8						
September 26	14.1	19.1	24.3						
September 27	18.1	21.3	22.9						
September 28	18.5	24.0							
September 29	21.1		21.7						
September 30		23.1	21.0						
October 1		23.9	24.0						
October 2		22.3	17.3						
October 3		25.1	19.0						
October 4		25.1	21.2						
October 5		24.5							
October 6			21.8						
October 7		27.0	18.6						
October 8			23.2						
October 9		24.6	26.6						
October 10		23.4	23.5						
October 11			27.0						
October 12		23.0							
October 13			25.6						
October 14			22.9						
October 15									
October 16			23.2						
October 17		24.3							
October 18			25.2						
October 19		24.2							

TABLE 19

The Increase in the Average Length of Fish as the Klamath River Season Progresses

Date	Number males	Number females	Average length males	Average length females
July 11	2	3	72.8	76.3
July 14	1	4	60.5	77.0
July 15	6	31	75.3	77.1
July 17	3	16	69.8	76.1
July 19	2	1	76.0	72.0
July 21	5	31	68.5	77.5
July 22	2	16	80.5	77.6
July 24	5	13	80.7	78.1
July 25	34	70	75.8	76.5
July 26	24	26	80.4	78.1
July 28	16	24	75.9	77.0
July 29	71	78	77.8	77.4
July 30	42	39	76.8	77.3
July 31	36	44	79.6	76.7
August 1	29	34	79.2	77.0
August 2	35	24	77.7	73.6
August 4	34	30	85.0	77.2
August 5	14	11	79.5	71.8
August 6	31	14	73.5	75.9
August 7	22	48	78.4	78.2
August 8	87	53	76.6	76.4
August 11	58	67	79.8	78.1
August 12	34	40	77.5	75.4
August 13	20	35	77.0	77.7
August 14	11	4	82.9	77.6
August 15	15	20	80.4	77.4
August 16	14	20	75.0	78.3
August 18	27	30	78.0	76.4
August 19	19	36	72.5	75.4
August 20	33	32	81.9	77.3
August 21	30	43	77.3	76.3
August 22	41	65	81.9	79.2
August 23	32	36	80.7	78.9
August 25	46	67	82.1	78.3
August 26	27	46	84.4	78.6
August 29	33	27	80.5	80.2
August 30	19	17	76.9	76.8
September 1	34	30	87.9	83.2
September 2	41	36	84.8	80.5
September 3	32	27	85.2	80.1
September 4	66	57	84.7	80.2
September 5	27	25	85.4	82.9
September 6	33	21	85.3	82.4
September 20	56	57	88.4	89.1
September 22	23	21	89.6	87.0
September 24	12	17	94.5	94.1
September 25	11	9	86.2	89.4
September 26	14	16	85.0	87.4
September 27	9	13	85.9	87.5
September 29	5	0	92.7	0.0
September 30	2	3	80.5	96.5
October 1	4	3	85.4	89.5
October 2	5	5	93.2	90.6
October 3	15	9	78.8	89.1
October 4	3	2	107.5	94.7
October 6	4	7	90.6	92.7
October 7	18	20	90.2	90.8
October 8	4	17	99.4	91.1
October 9	6	9	95.26	90.5
October 10	13	16	94.2	93.3
October 11	11	5	92.6	97.1
October 14	21	12	96.8	93.0
October 15	6	11	92.8	92.5
October 16	13	10	92.4	98.3
October 17	5	6	92.9	96.1
October 18	6	4	95.6	94.3

the remaining fish there were 47 males and 33 females, just about the proportion of each sex that one would expect to find in the catch near the mouth of Klamath River at the same time. It seems quite likely that the presence of so many small fish here is due largely to the straining process going on in the commercial fishery. It may be noted in

passing that 206 of these small fish were in the second year of growth, examples of which are difficult to find at the mouth of the river.

The racks near Hornbrook are so constructed as to prevent the passage of all salmon. A census of salmon entrapped there since 1925 is presented on page 91. Where the record is complete it will be seen that males are far in excess of females. But of these males the larger number are grilse, the small two and three-year old fish which escape the nets and do not appear in the catch at the mouth of the river. If the grilse are disregarded it will be found that the females exceed in number the males of their own size.

FISH INCREASE IN AVERAGE WEIGHT AND SIZE AS THE SEASON ADVANCES

A considerable increase in the average weight of the fish is observed as the season progresses. The increase is not always gradual from day to day, not even from week to week, but when the fish taken early or late in the season are compared, the latter are always found to average much the larger. This is well illustrated in the catch of 1919 as reported by Field (table 18) as also in the catches of the two previous years. When the fishing season is short as in 1922 for example, the difference is not so marked, while in 1923 and 1925 it scarcely appears. The whole picture might differ somewhat if a record of the small three-year fish, the so-called grilse or chubbs, which escape the nets in numbers, should enter into its composition. Not only do the fish apparently increase in weight, but there is a corresponding gain in their average length as is demonstrated in table 19, which exhibits the average measurements of a number of examples of both sexes as observed from day to day. An inspection of the data here presented should not lead to the inference that the increase in average size is due entirely to seasonal growth, for such is not the case.

An occular inspection of the catch as it lies from day to day, spread out on the floor of the receiving house, leads one to note the appearance of unusually large fish in increasing numbers as the season progresses. Most of the fish taken early in the season measure less than 90 cm. in length, an example of much larger size being noted as unusual, while late in the season such large fishes are relatively common. The recorded measurements of 3200 fish observed during the season of 1919 are tabulated as follows:

TABLE 20

Date	Number examples	Per cent measuring less than 90 cm.	Per cent measuring 90 cm. or more
July 14–20, 1919	75	98.6	1.4
July 21–27, 1919	208	92.3	7.7
July 28–August 3, 1919	483	91.3	8.7
August 4–10, 1919	302	92.7	7.3
August 11–17, 1919	315	94.3	5.7
August 18–24, 1919	432	90.3	9.7
August 25–31, 1919	355	88.6	11.4
September 1–6, 1919	433	78.9	21.1
September 20–28, 1919	284	51.8	48.2
September 29–October 5, 1919	56	48.2	51.8
October 6–12, 1919	133	37.6	62.4
October 13–19, 1919	83	27.7	72.3

Here, as frequently occurs elsewhere, the statistics of the catch fail in a measure to present a true picture of the migration. Fishermen, aware of the fact that unusually large fish appear late in the season, lay their plans accordingly and occasionally provide themselves with nets of very large mesh. The practice does not appear to have been general in the past, and is not now resorted to because of the shortened legal fishing season. A number were in use in the fall of 1919 but there was no means of determining just what effect they may have had on the average size of the fish caught. That the use of a net of large mesh may produce results different from that of a net of small mesh may be demonstrated. For example, on September 21, 1916, Stansbury and Fisher, with a net of $6\frac{3}{4}$-inch mesh caught 78 fish weighing 1180 pounds, while at the same time and place, Robinson and Madsen, with a net of $8\frac{3}{4}$-inch mesh took 54 salmon weighing 1070 pounds. The fish of the small meshed net averaged 15.13 pounds; those of the large meshed net 19.81 pounds.

The presence of large fish is by some attributed to artificial propagation, the direct result of the introduction of Sacramento salmon. If true, their appearance would date from the introduction of these fish, and hatchery experts who have had to do with propagation on the Klamath maintain that this is the case. This supposition is not sustained, however, by the reports of old residents at the mouth of the river, including Indian fishermen whose memory reaches a long way back of artificial propagation in the state. According to them these very large fish have always appeared in the fall just as they do now. Moreover they all agree in reporting that these fish mostly enter the lower tributaries to spawn. Many are said to go into Blue Creek, and for this reason the very large fish are locally referred to as "blue-creekers." These "blue-creekers" resemble the fish of Smith River in size, as well as in color, character of snout and other peculiarities associated with maturity. The Smith River fish like the "blue-creekers" enter the river late in the season, are relatively mature, and have but a short distance to migrate to their spawning beds.

Bailey, on April 17, 1920, told the writer that these large fish, the so-called blue-creekers, had always been a feature of the latter part of the migration.

A more detailed account of the progressive entry of large fish into the migration is given in table 21, where for a short period of time the percentage of fish which constitute a given length class is recorded. For example, it will be seen from a glance at the table that during the period from July 21 to 31, of the 509 fish measured, only 0.78 per cent were 90 cm. long, while from September 20 to October 18, of 569 fish, 2.99 per cent were 90 cm. long. From data contained in this table, figure 7 was constructed. This presents the percentage of individuals of any length from 55 to 110 cm. which are found in representative samples of the catch during certain periods of the season. Here a late invasion of large fish is distinctly evident. This invasion would not seem so abrupt if data covering the time from September 6 to 20 were available. An inspection of fish caught on hooks during this closed season indicated that the large fish gradually became more numerous.

TABLE 21

The Percentage of Klamath River Fish which Constitutes a Given Length Class for a Certain Period of Time

Length in cm.	July 21–31	Aug. 1-14	Aug. 15–16	Aug. 25–Sept. 6	Sept. 7–19 (closed season)	Sept. 20–Oct. 18
	1	2	3	4	5	6
40	----	----	----	----	----	----
41	----	.42	----	----	----	----
42	.19	.56	----	----	----	.17
43	----	.14	.19	----	----	.34
44	----	.14	----	.24	----	----
45	----	.84	----	.39	----	----
46	----	.42	----	.24	----	----
47	----	.42	----	.39	----	.17
48	.19	.84	.19	----	----	.17
49	----	.14	.19	.84	----	.17
50	----	.42	.39	.39	----	----
51	.25	.56	.39	.53	----	----
52	----	----	.19	.24	----	----
53	.19	.14	----	.96	----	----
54	.19	.28	----	.39	----	.34
55	.19	.28	.60	----	----	.52
56	.58	.14	----	.24	----	.71
57	.25	.14	.39	.24	----	.52
58	.25	.14	.19	.53	----	.87
59	.19	----	----	.39	----	.71
60	.19	.28	.39	.39	----	.71
61	.98	.56	.19	.24	----	.71
62	.58	.28	.60	.12	----	.34
63	.19	.84	.79	.24	----	.34
64	.98	1.13	.60	----	----	.34
65	1.32	1.55	.79	.66	----	.87
66	1.57	2.39	1.02	.53	----	.52
67	2.36	2.93	2.79	1.08	----	.17
68	2.36	2.64	3.00	1.45	----	.34
69	3.73	4.23	4.19	1.20	----	.52
70	3.30	3.63	3.79	2.53	----	.17
71	4.32	2.93	4.19	1.56	----	----
72	3.73	3.10	4.40	2.29	----	.52
73	4.52	2.93	4.19	2.89	----	.17
74	2.74	3.80	4.19	2.53	----	.17
75	4.91	3.63	3.40	2.53	----	.17
76	5.50	4.23	4.00	2.88	----	1.50
77	5.50	4.93	4.59	3.36	----	.34
78	5.30	5.64	4.59	3.61	----	.86
79	5.50	4.93	4.79	4.46	----	1.40
80	5.69	4.93	4.59	5.66	----	1.40
81	3.54	3.80	4.59	5.55	----	1.40
82	3.30	2.52	3.60	5.91	----	2.61
83	3.73	3.10	4.40	5.18	----	1.93
84	4.13	2.23	3.19	4.82	----	2.99
85	2.36	2.64	2.79	3.12	----	2.99
86	2.36	2.64	1.04	2.89	----	3.32
87	.19	1.83	2.79	3.49	----	4.00
88	1.37	2.64	2.40	2.88	----	4.00
89	1.76	1.97	2.00	3.10	----	4.38
90	.78	1.55	3.00	2.25	----	2.99
91	1.37	1.55	2.19	1.93	----	3.13
92	1.96	1.13	.19	1.08	----	4.92
93	.58	.84	.39	1.08	----	2.99
94	1.37	.75	.90	1.08	----	3.50
95	.78	.14	1.02	.96	----	4.00
96	.19	.56	.19	1.56	----	3.13
97	.19	.14	.60	1.81	----	3.13
98	.25	.42	.39	1.08	----	4.38
99	.25	.28	----	.39	----	3.85
100	.25	.42	.39	.53	----	2.61
101	----	----	.19	.24	----	2.61
102	----	.28	----	.66	----	1.58
103	.19	.28	----	.24	----	2.81
104	.19	.14	----	.39	----	1.93
105	.19	.28	----	.12	----	1.58
106	----	----	.19	.24	----	1.50
107	----	----	----	.12	----	1.58
108	----	.14	----	.12	----	.52
109	----	----	----	.24	----	.71
110	----	----	----	.12	----	1.40
111	----	----	----	----	----	.17
112	----	----	----	.12	----	.34
113	----	----	----	----	----	.71
114	----	----	----	----	----	.17
115	----	----	----	----	----	.17
116	----	----	----	.12	----	----
Number of specimens examined	509	709	507	829	----	569

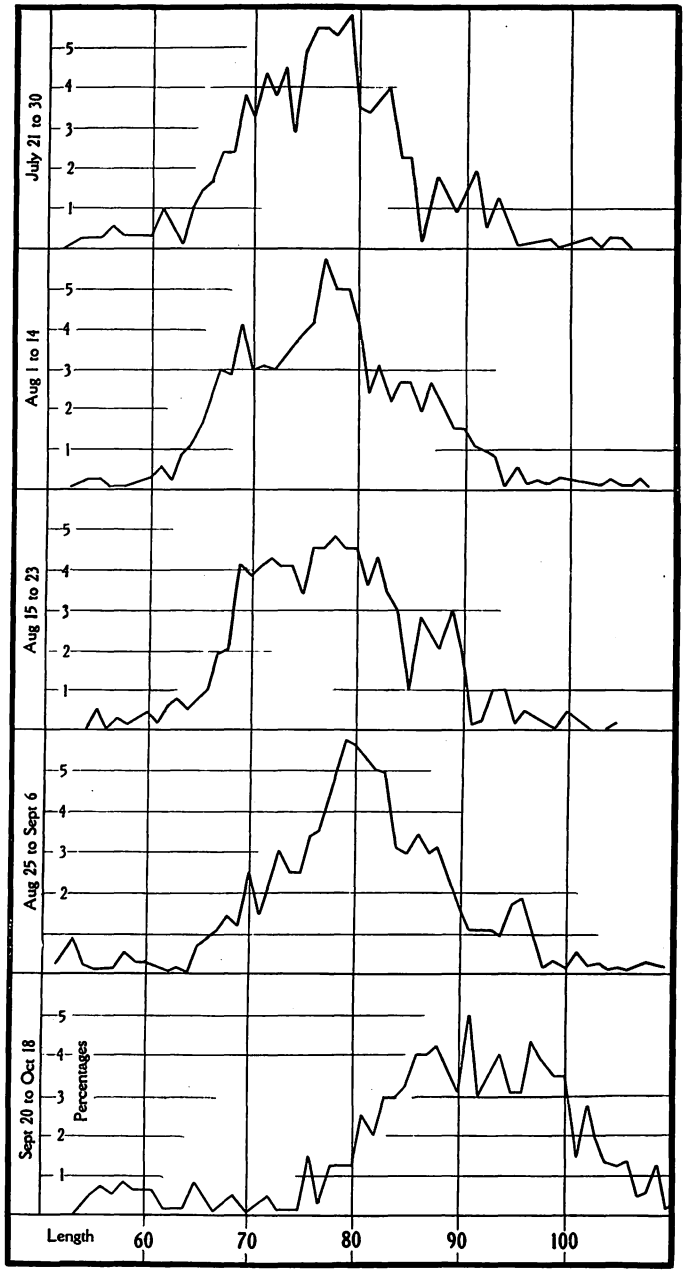

Fig. 7. Graph presenting the percentages of fishes of lengths from 55 to 100 cm., which are found in representative samples of the catch during given periods of the season.

ANGLING FOR SALMON

When the river water becomes sufficiently clear, numerous king salmon are caught by anglers in the lower part of the estuary by means of trolling or casting with a naked spinner. At times, when the river or tidal current is sufficiently strong, it is only necessary to anchor the boat and await a strike.

When hooked with light tackle in the river, the salmon is not given to leaps like the more sprightly steelhead. However, his rushes are strong and often persistent and continued. Occasionally he prefers to fight it out by sulking on the bottom, but soon a new impulse sets him going again, and he is off to resume the struggle. Trolling with heavy line and sinker has been almost entirely superseded by the use of light rods. Casting long distance with a free reel is also a favorite method.

At the height of the season there is scarcely room for the several hundred sportsmen in the restricted estuary. Small canneries have recently sprung up, and now the successful sportsman may have his fish preserved in the usual way, the can even bearing a colored label with his name.

As the fish do not eat after entering the river, the majority of them having initiated their long fast while still at sea, it is commonly supposed by fishermen that the glittering spinner arouses the fighting instinct of the salmon. However this may be, the catch of the angler's hook is much like that of the fisherman's net as regard sex representation and size of the fish. E. A. McGregor paid some attention to this during the season of 1921 and the sum total of his observations may be well represented by the following summary (table 22) of the catch of two days.

TABLE 22

Date	Troll catch				Net catch			
	Number males	Average length males	Number females	Average length females	Number males	Average length males	Number females	Average length females
August 4	20	79.0	49	79.8	34	76.1	70	76.7
August 5	11	78.7	18	76.8	49	78.5	80	77.1

Some king salmon grilse, large and small silver salmon of both sexes, and occasionally a steelhead are caught in the same way. Salmon are occasionally caught with spinners at any place along the river, but they appear to be most easily taken below an obstruction such as an irrigation dam. A resumption of placer mining on the river and resultant silt may at any time put a stop to angling for salmon or steelhead as well.

Reports are current that salmon occasionally bite baited hooks, and one such instance at least, is well authenticated. D. H. Fry, Jr., and R. S. Croker observant anglers, reported to the writer that on September 23, 1927, in a large pool in Salmon River, about 200 yards above the junction of that stream with the Klamath, a salmon was caught with steelhead roe as bait. The baited hook, intended for a steelhead, was lying on the bottom, when a strike came, which was duly followed by the landing of a small king salmon. The fish weighed 2½ pounds, and it was a mature male. The stomach was so shrunken as to be entirely functionless.

THE SEAWARD MIGRATION (EMIGRATION)

No one has as yet traced a seaward migration (emigration) of young salmon in Klamath River. One may assume that the habits of the young are similar to those of the same species in other streams as described by Rutter, N. B. Scofield, Gilbert, Chamberlain, Rich and Holmes.

An examination of scales taken from adult fish at the mouth of the river leads to the inference that young fish enter the sea at various stages of growth, from a time shortly after free swimming has been attained to a year or a little more. There appear among these scales several kinds which include not only those bearing what have been termed the stream and ocean type of nuclei, (Figs. 20 and 21) but many others of a composite form, the latter from fish which appear to have prolonged their passage down stream and lingered for a time in the estuary.[7]

Late in the summer and in the early fall, king salmon of the year may be found near the mouth of the river. They are sometimes caught with hook and line and carried away as trout. They are six or seven inches long or even larger. In color they are light yellowish green on the upper surface and silvery on the sides. Faintly traced parr marks are to be seen on the smaller ones, these always standing out in bold relief in preserved specimens. In pursuing these little salmon with net and rod, it became evident that their distribution in the estuary was general. They seemed, however, to prefer the fresh current, although they were sometimes taken in brackish water. Schools of them moved back and forth, before or following the tides. In seining, they were sometimes caught alone, but most often they were associated with such fish as adult salmon, steelheads, flatfish, suckers, sticklebacks, bullheads (*Cottus asper*), smelt, and others. Both sexes were represented, and an occasional mature male was observed. One is at a loss to account for the presence of a precocious male among down-stream migrants, unless the condition of precocity is soon to disappear in these individuals.

Examples caught early in the season (August 5) are considerably smaller than those taken later (September 15), although an infiltration of small fish seems to be constantly progressing during this time.

A photomicrograph of a scale of one of these estuary salmon, measuring 184 millimeters, is presented as figure 8. Here a well-defined

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[7] Rich, Willis H. Early history and seaward migration of chinook salmon in the Columbia and Sacramento rivers. U. S. Bureau of Fisheries, Bull., vol. 37 (Doc. 887), p. 70, 1920.

Rich, Willis H., and Holmes, Harlan B. Experiments in marking young chinook salmon on the Columbia River, 1916 to 1927. U. S. Bureau of Fisheries, Bull., vol. 44 (Doc. 1047), p. 259, 1929.

Snyder, J. O. The return of marked king salmon grilse. California Fish and Game, vol. 8, no. 2, pp. 102–107, 1922.

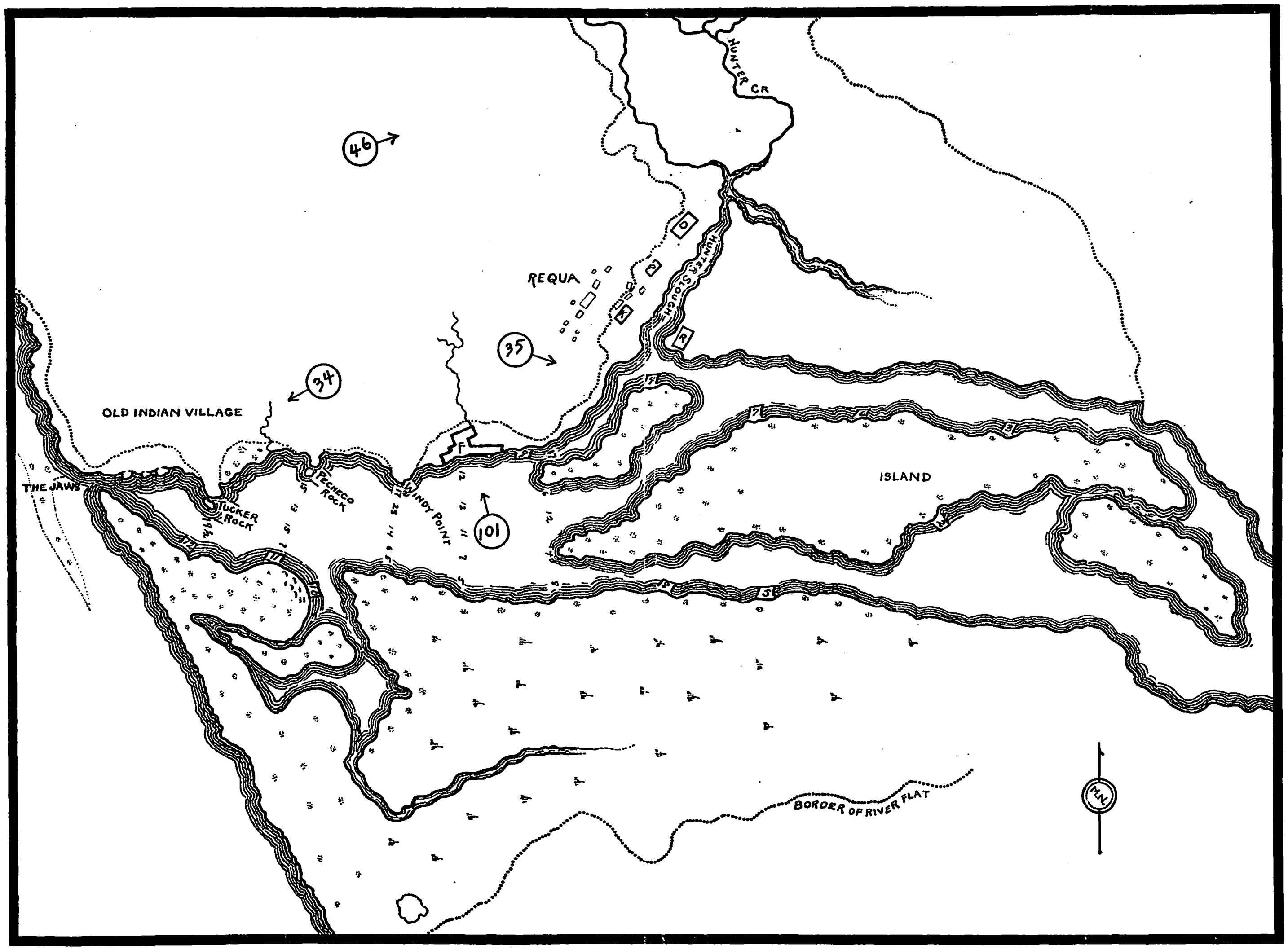

Fig. 9. Low-tide map of Klamath Estuary, 1920. River depths recorded in feet.
F. Plant of Klamath River Packers Association.
D. Del Norte Salmon Canning Company. 1912–1913.
K. Klamath River Canning Company. 1911–1913.
P. W. G. Press. (Never operated.)
R. Requa Cooperative Packing Company. 1917–1918.

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central nuclear region of more or less crowded circuli is to be distinguished from a broad outer area of widely spaced ones. The structure of this scale is typical of every one of the larger estuary fish, the size of the nuclear area remaining fairly constant, while the area lying without or bordering the nuclear part varies in width about as the fish vary in size. There is no evidence that these fish have come in from the sea. On the contrary, it is certain that they are down-stream migrants, lately arrived in the estuary where abundant food has contributed to very rapid growth. It is inferred that the nuclear area of closely apposed circuli represents the growth before reaching the estuary. This inference is supported by observations as follows:

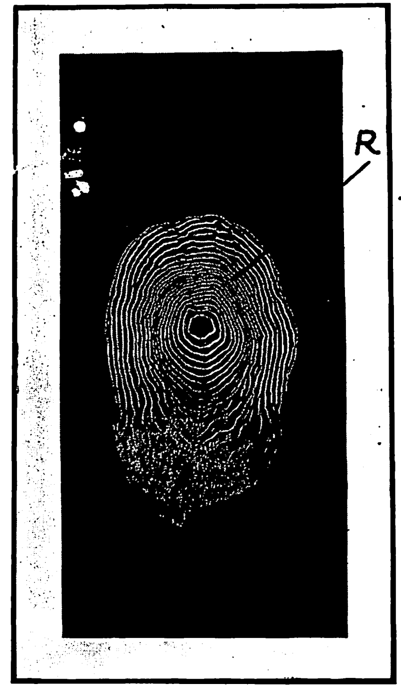

FIG. 8. Photomicrograph of a scale of a small estuary salmon, 184 mm. long.

Early in August, the 6th to be more explicit, many small fish, measuring from 80 to 118 mm., were collected from the estuary. They were then generally distributed, but they could be more easily caught on the bars of the islands and near the mouth of Hunter Creek. Scales from the smallest of these fish are represented by figure 14. It will be observed that this exactly represents a stage comparable with that of *R* in figure 8. The largest of the fish caught at this time had scales bearing two or three broad rings outside of, or beyond the region represented by the edge of this scale. These rings corresponded exactly with those of figure 8, which are outside of the point *R*. On later dates selections of fish were made, the scales of which bore every intermediate condition of growth between the extremes illustrated by the two figures. The smaller fish were darker in color than the larger, more silvery ones.

Small salmon were collected from points up stream, well above the estuary, and in all cases they bore scales like those represented by figure 14. The fishes themselves were exactly like the smallest ones found in the estuary. No fish like the larger estuary fish was seen there.

In the fall of 1920, September 18 to 26, while observations were being made on a weir which the Indians had placed in Trinity River in Hoopa Valley, young salmon measuring 56 to 75 mm. were secured. Again, on September 27, 1924, they were collected in large numbers. At this time the river was somewhat swollen and roily because of recent rains. Seining was done at two points, at the mouth of Beaver Creek, and about three miles farther up stream near the junction of the main river and the Tishtangatang. The abundance of small salmon was indicated by the presence of some four hundred in a single seine haul.

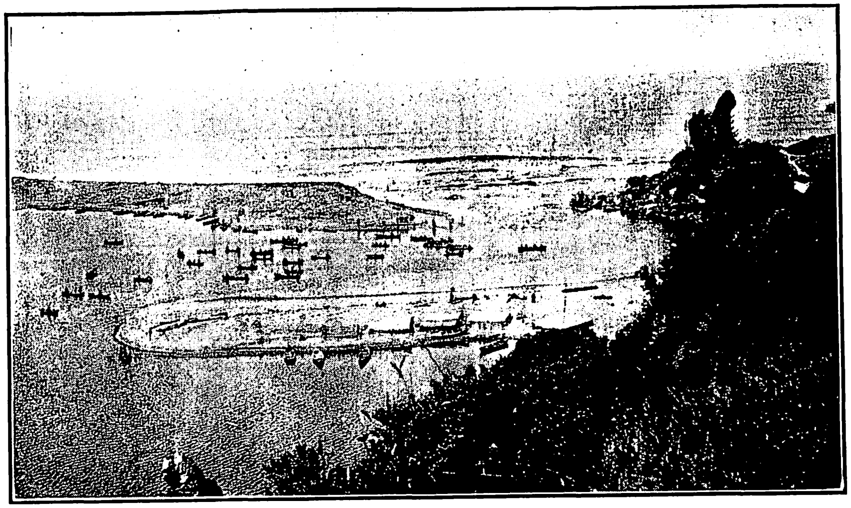

FIG. 10. Line fishing, Klamath Estuary near the Jaws; view from point 34, figure 9.

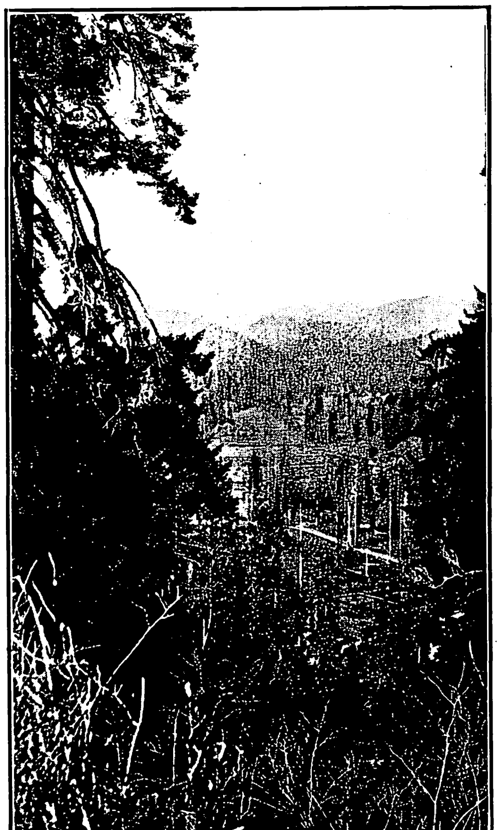

FIG. 11. Valley of Hunter Creek from point 46, figure 9.

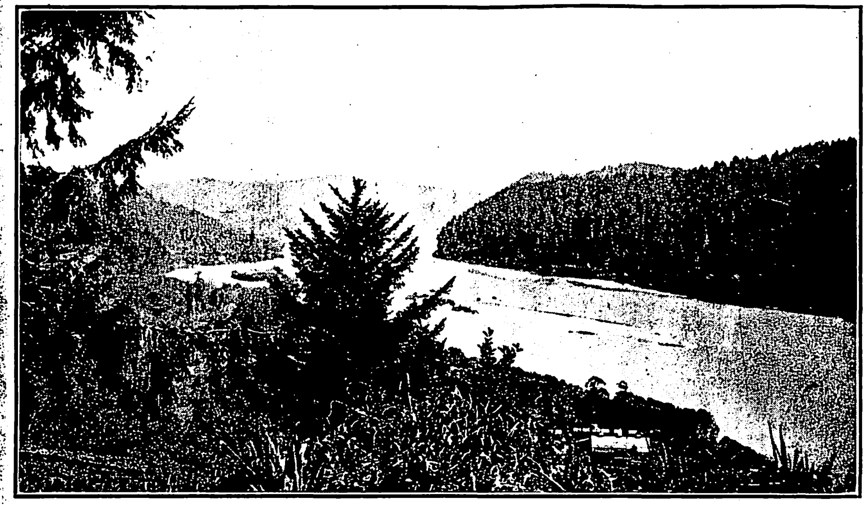

FIG. 12. View up Klamath River from point 35, figure 9.

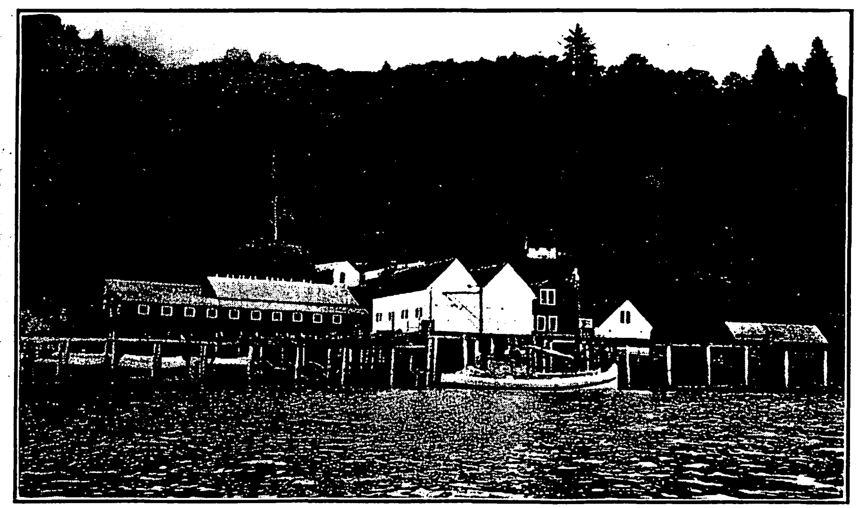

FIG. 13. Plant of the Klamath Packers Association from point 101, figure 9.

As they were plentiful at both places one might safely assume that at least the intervening three miles of river were similarly populated. It was thought that these fish were migrating down stream. They were small in size, measuring 74 to 106 mm. The scales of these were similar to that of figure 14, and the fish looked exactly like those caught in the river above the estuary and like the smallest found in the estuary.

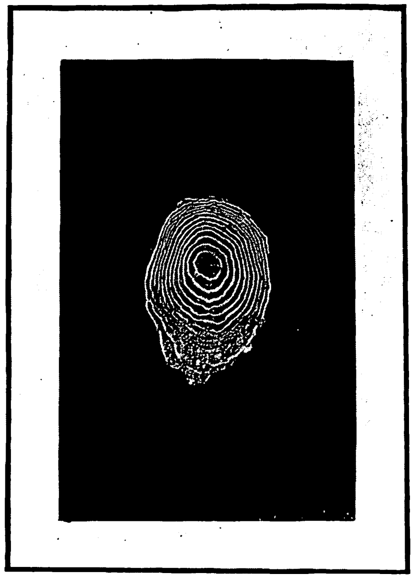

FIG. 14. Photomicrograph of a scale of a small salmon taken in the Klamath Estuary.

Similar salmon from the Sacramento basin, collected from overflow pools near Collinsville, June 22, 1922, had scales exactly like the smaller Klamath specimens, and the fish were like those of the Klamath in size and general appearance.

A pronounced check in growth may be seen at the point *R* in figure 8. The check is indicated by closely apposed, narrow circuli. Such a check is not present in many examples, the transition from stream to estuary growth being generally abrupt. Such a check has not been seen in any small specimens from either the Trinity or from the Klamath above the estuary.

All this would seem to indicate without doubt that the peculiar structure of scales, such as illustrated in figure 8, may be interpreted as representing an inner nucleus of up-stream growth, and an outer area of varying width of estuary growth. The belief that this type of structure results from environmental conditions as here observed is strengthened by the fact that the scales of fishes of the same species and of the same size as the largest estuary fish, but reared in ponds at Mt. Shasta, bore scales of homogeneous structure throughout.

It would appear from what has been discovered at and near the mouth of the river that a pronounced emigration of young salmon occurs in the late summer and early fall. The extent of this migration is not known and no more information relating to the movements of young salmon in the river is at hand.

A thorough knowledge of the migratory movements of young salmon is essential to any meritorious plan of conservation, and with this in mind observations are now being carried on in the Klamath and one of its tributaries, Shasta River.

When the scales of mature fish are carefully scrutinized, many are found which present exact duplication of the growth record of the large estuary fish. An example of such is illustrated in figure 15, a scale from a fish measuring 50 cm. and caught in the estuary September 1. Here, *R* represents the stream nucleus and from *R* to *E* is thought

to be estuary growth. If the present interpretation of growth as represented by this scale is correct, the individual from which it was taken, hatched from an egg deposited in the fall or early winter, passed down stream in time to arrive in the estuary in the following summer, remained in the estuary until growth represented by *R-E* was complete, perhaps late fall, and then migrated to the sea. A check in growth, probably the first winter check, is plainly indicated at *E*. From *E* to the margin of the scale is no doubt ocean growth. The fish was a mature male in its second year.

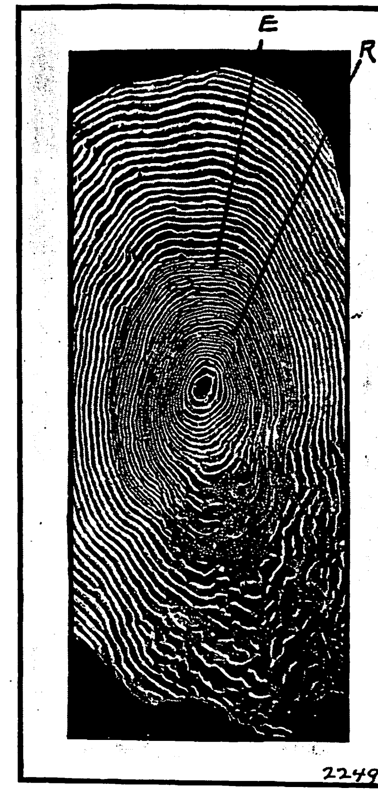

FIG. 15. Photomicrograph of a scale from a male salmon, 50. cm. long, taken in the Klamath River Estuary, September 1, 1919.

A scale from a three-year fish is represented in figure 16. This is from a male, measuring 69 cm. caught in the estuary August 11. Its age is believed to be about three years, and it is very probable that the growth from *R* to *1* was made in the estuary.

Among the returned adults in Klamath River are large numbers which bear scales of this type. Intergradations between this record of first year growth and the ocean type, *i.e.*, a very large nucleus of homogeneous structure and even growth, are so complete as to make the two indistinguishable in many cases. The writer is at present unable to state in what proportion either type is represented in the catch, and hence both are termed ocean nuclei and the fishes bearing such scales are separated from those bearing the strictly stream type of nucleus, and which are believed to have remained in the stream somewhat longer than a year.

With the tabulated data relating to both ocean and river catches there is a separate enumeration of those fish which have had a protracted life in the stream, extended presumably over a year or somewhat more, and which is indicated in the scales by the presence of the so called stream nucleus. The writer finds nothing of economic importance in this concerning California king salmon. The number of fish which bear scales with stream nuclei which appear in the ocean catch or in the stream immigration is not, in so far as we know, an index to the relative number of young fish which enter the sea either as late or early migrants. Nor has it any known bearing on the question as to whether fry should be released early or late from a hatchery. It appears to be a feature which is entirely beyond artificial control, and in some cases it is perhaps a matter of chance, as when a tributary becomes closed early in the season by a bar across its mouth, thus entrapping the young fish and delaying emigration.

On several occasions it has been reported that large numbers of young salmon are left to perish in pools of the lower courses of small tributaries as the water dries up. Upon investigation these have proved to be silver salmon. One case may serve to illustrate. On July 8, 1919, the lower course of Turwah Creek was examined. Many isolated pools containing silver salmon were found. Something over 2500 vigorous young fish were rescued from a single pool roughly measuring 10 by 25 feet, and from 3 to 18 inches deep. Seining in the stream above these pools did not reveal any examples of king salmon.

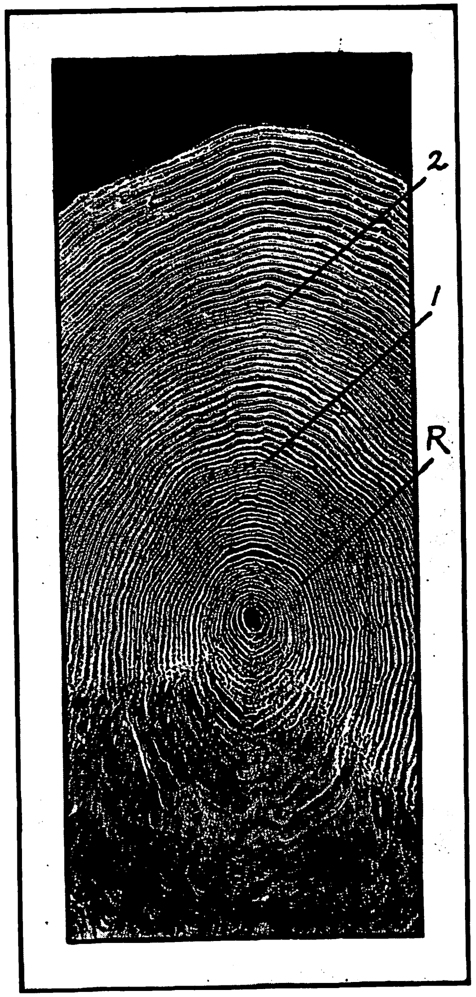

FIG. 16. Photomicrograph of a scale of a male king salmon, 69 cm. in third year, caught in Klamath Estuary, August 11.

OBSTRUCTIONS IN THE RIVER

Klamath River and its principal tributaries are fairly free from obstructions below the large dam at Copco. Projects have appeared in the recent past which if carried through would have blocked the stream to most of its migrating fish. Others will come in the future, and eventually the anadromous fish may disappear from the river.

Klamath River presents an almost continuous series of potential power sites from its source to its mouth. The development of any one of these involves the erection of a high dam which under our present limited knowledge of the habits of salmon and steelhead trout, will constitute an absolute barrier to the upward passage of the migrating adults, or the downward migration of the young. Certain articles have lately appeared in current periodicals which allege that experimental work has conclusively shown that the obstacles presented by high dams to the migration of fish may be easily overcome. These statements are misleading. No method has as yet been devised which will safely provide for the downward migrants, and the only

proposed scheme for overcoming the barrier to up stream migration of adults, which seems at all feasible, is the use of a hoist. The hoist would lift the fish from a channel or fishway at the bottom of the dam. John N. Cobb, who has experimented with the proposed hoist concludes as follows: "If the fish can be induced to enter such a fishway, they may be lifted to almost any desired height. In the majority of cases this method can be employed in getting fish over high dams, provided an experienced biologist, who is familiar with the habits of the fish sought to be lifted is called in before the work on the dam is started. This is absolutely essential as certain precautions must be taken with the bed of the river, *etc.*, before and during the construction period, in order to persuade the fish to foregather in front of the entrance to the fishway or fish hoist." The writer of the present paper sincerely hopes, however, that the experienced biologist, the dam and the fish may be assembled on some other stream in an effort to persuade the fish to foregather, for if the dam is built and the fish refuse to be persuaded, the jig is up.

In the Klamath River a condition prevails that must be constantly kept in mind in any discussion of the relation of dams and fish, namely, that the principal migrations occur during low water (Fig. 3), and when the water is in greatest demand by the power plant. At this time it will be very difficult to maintain an overflow sufficient for large fishways.

As obstructions appear in a river it becomes increasingly difficult to deal with them, and it seems that no general law or rule will apply to all. If possible, they should be dealt with individually, for each presents a set of problems of its own. A single illustration may serve to explain. On Shasta River is a power plant the chief auxiliary of which is a dam built across the river, at a point about seven miles above its junction with the Klamath. During the migration and spawning period of 1926 the dam was supplied with a functioning fishway and all the requirements of the law were apparently complied with. None the less the presence of the dam was responsible for the daily destruction of large numbers of salmon.

At the time, the dam was about 290 feet long and 7 or 8 feet high. At the left side of the river was a race some 15 or 20 feet wide, which extended 1800 feet or so to the power house. (See figs. 17, 18, and 19.) Its source was protected by a revolving screen. A fishway was placed against the right bank of the river in line with the main channel just as it should be, and an ample flow of water was passing, as was easily demonstrated by tests, fish swimming easily and rapidly up the fishway when given an opportunity. For a long distance below the dam the channel had a deeply scored bed of solid rock with numerous minor channels. One of these channels led from the fishway, while the others came from leaks in the dam and the sides of the race. Fish, in passing up stream, frequently chose the wrong way and instead of reaching the fishway were led aside to struggle up the false channels and at length throw themselves out of the shallow water alongside the race, or batter their heads against the dam. On September 20, 79 large fish, either dead or in impossible situations were seen. A few days later conditions were no better. The remedy in this particular case was both obvious and simple.

Here, also, the law relating to the spearing of fish below a dam was inoperative, for a fish 800 feet below the obstruction was just as much exposed as one 150 feet or less from it.

The Indians sometimes construct a weir on Trinity River[8] where numbers of fish are caught. The weir will not long withstand the high water following the early fall rains, and it appears that the obstruction is rendered inefficient before the migration is well on.

Klamath River has a relatively limited amount of irrigable land in its basin and consequently the problems attending a conflict between agriculture and the conservation of fisheries may not attract attention there for some time.

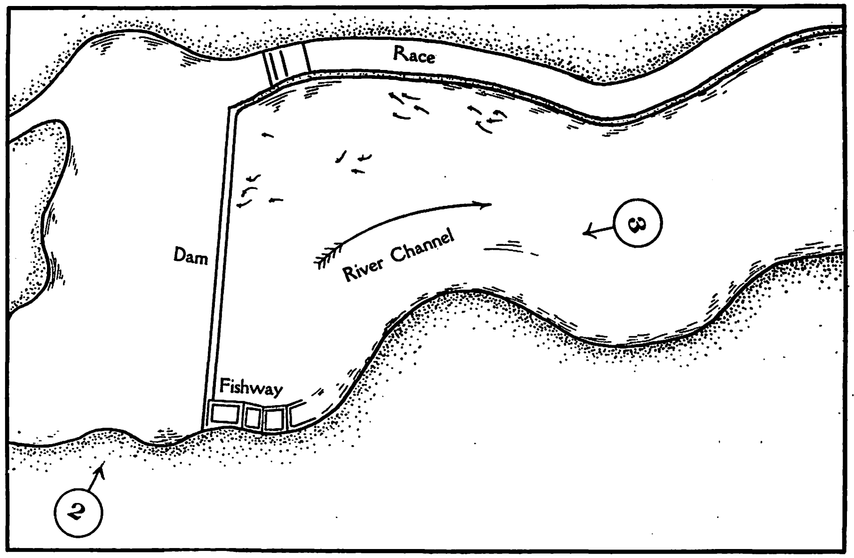

FIG. 17. Map showing dam and the affected part of Shasta River.

THE AGE AT MATURITY OF KLAMATH KING SALMON

An age determination of king salmon has been accomplished here, largely through a microscopic examination of the scales, a method long employed by investigators, and first successfully applied to the various species of Pacific salmon by Dr. Charles H. Gilbert. It is perhaps unnecessary to remark that the method appears to be reliable. In the case of Klamath River fish it has been verified by numerous comparisons with marked individuals of which the age and something of the life history were known. The relations of some details of scale structure to growth are not understood, but these need not enter into the present discussion.

Photomicrographs of two fairly typical scales are here so presented as to illustrate the manner in which the age and one or more details of the life history of the individual fish are portrayed by particulars of structure. (Figs. 20 and 21.) What are commonly known as seasonal

[8] Snyder, 1924, op. cit.

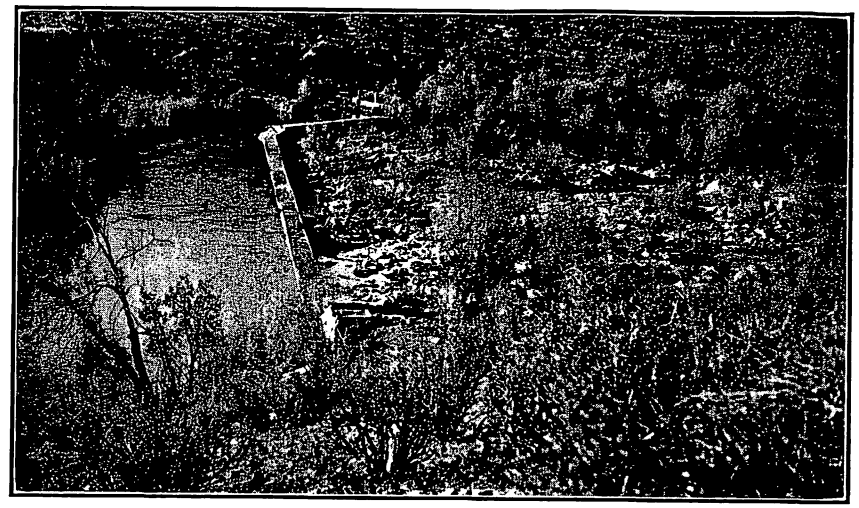

FIG. 18. Shasta River dam with fishway in the foreground and rocky streambed below. View taken from point 2 on map, figure 17.

FIG. 19. Rocky streambed with its numerous false leads fatal to migrating salmon. View from point 3 on the map, figure 17.

checks or annuli, changes in the rate of growth, are depicted at *A* and *D*. That portion of the scale included between *D* and *E* represents the growth of the third year, *i.e.*, from some time in the winter to July 28 in the case of figure 20, and August 27 of figure 21. From *A* to *D* represents the growth of the second year, while from the center of each scale to *A* is a record of the first year. Although somewhat out of place here it may be well to proceed further with an interpretation of the two figures. A marked difference appears in the areas of the two scales from the centers to *A*. One of these (fig. 20) is believed to represent ocean growth while the other (fig. 21) pictures stream growth. From ample observation it appears certain that the fish which bore the former scale entered the sea soon after being able to swim freely, while the one which possessed the latter (fig. 21), to be more particular, remained in the stream for a long time, perhaps a year or so. The parts lying within *A* in both figures, are usually termed nuclear areas, while of the two, the smaller one, representing stream growth, is generally spoken of as a "stream nucleus," and the larger as an "ocean nucleus."

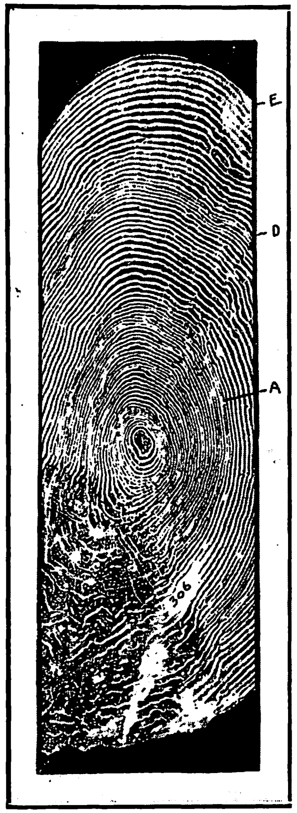

FIG. 20. Photomicrograph of a scale with the ocean type of nucleus.

Klamath River king salmon are found to mature at ages ranging from less than one year to that of six. No seven-year example has been seen. Those which mature before the age of approximately one year are of the male sex only and are usually spoken of as "precocious males." They are numerous at times among fish which are held in hatchery ponds, and they are sometimes found in the rivers, particularly in the estuaries, there mingling with otherwise normal young fish. They appear to mature at about the same time as older individuals, and as a test of the possibility of functioning in the process of spawning, C. V. Cassell, foreman in charge of the Fall Creek Hatchery, was requested to fertilize some eggs with the milt of precocious males. This he did, and the eggs developed in a perfectly normal way. One year later 3000 of the resulting fish were marked by removing the posterior half of the dorsal and the entire left ventral. These were liberated in Klamath River in 1923. Four of them were later recaptured; one in Klamath estuary and one at the Klamathon racks in 1925; one off the coast of Eureka and one at the racks in 1926. All were normal fish. There is some reason to believe that precocious yearlings, together with second-year males, and even the small three-year males, when associating with larger salmon on the spawning beds, may be mistaken for egg-eating trout.

In so far as we know, the two- and three-year males are of no commercial importance in the river catch. There is no way of determining their relative number. If taken at sea, there is no trustworthy method of always separating them from males which might mature at a greater age. In the river estuary they are not entrapped in numbers by the large meshed nets. In the upper courses of the river, as at the

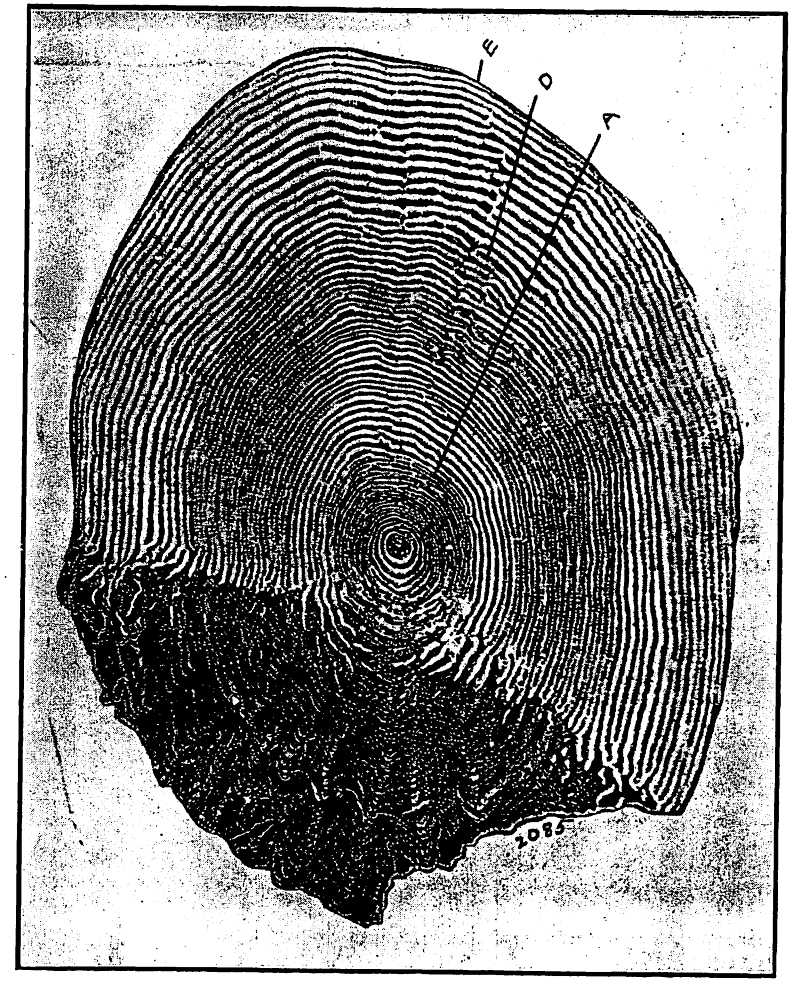

FIG. 21. Photomicrograph of a scale with the stream type of nucleus.

racks, one observes the large number which has escaped the straining process of the estuary fishery. It seems quite probable that these small fish are now reaching the spawning beds in ill-proportioned numbers, and if their propensity to mature at an early age is hereditary and transmissible in a marked degree, their involuntary selection and preservation may be a menace to the fishery of the future. However, so long as the role of precocious yearlings, and of the two- and three-year males remains unknown speculation regarding them is of little more than passing interest.

Three-year mature males appear to outnumber by far those of two years, but no reliable method of determining anything like an exact proportion of the two classes was found.

Examples of mature fish of the age of two years are not easily obtainable in the Klamath. Those which we have were nearly all caught by means of a small seine. Of 314 specimens from the estuary of the Klamath and from Trinity River, the smallest is 35 cm. in length and the largest 58. The Trinity River individuals average somewhat smaller than the others. Measurements of the series are presented in the following table:

TABLE 23

Length Measurements of Two-year Fish

Length (cm.)	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58
Klamath River, 1919	--	--	--	--	--	--	2	3	1	4	7	5	3	6	8	3	7	3	6	1	3	2	1	1
Klamath River, 1920	--	--	--	--	1	2	3	2	3	3	4	2	4	2	3	1	3	4	--	2	2	--	1	--
Trinity River, 1920	1	--	--	3	2	2	2	17	17	15	21	28	28	23	18	15	7	3	4	--	--	--	--	--
Totals	1	--	--	3	3	4	7	22	21	22	32	35	35	31	29	19	17	10	10	3	5	2	2	1

These are smaller than fish of the same class from the Sacramento, where in a series of 33 examples, the smallest is 48 cm. long, the largest 60, and the mean about 55.

All of the above are males and the scales possess the ocean type of nucleus.

When one has at hand samples of the scales of a fish of known length, it is possible, with some degree of accuracy, to compute the length or stature which the particular fish had attained at a given time in its life. This computation presumes that the growth of the scale progresses at about the same rate as that of the fish. It will be of interest to compare the computed second year stature of fish of the same class, *i.e.*, males which entered the sea at an early age but which matured at three, four or five years, with that of these small, two-year individuals.

TABLE 24

Computed Lengths at Two Years, Klamath River, 1919, Males, with the Ocean Type of Nucleus

Length (cm.)	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60
Length at 2 years of fish matured at 3	--	--	--	1	2	4	6	4	8	8	11	6	9	6	4	2	2	--	--	--	--	--
Length at 2 years of fish matured at 4	1	--	2	1	--	4	6	6	13	9	6	12	10	15	11	6	2	7	3	4	1	1
Length at 2 years of fish matured at 5	--	--	--	--	--	--	--	2	1	4	--	2	4	13	4	4	1	7	4	--	2	--
Totals	1	--	2	2	2	8	12	12	22	21	17	20	23	34	19	12	5	14	7	4	3	1

In connection with the above it is to be noted that the measurements of two-year fish were made from individuals which ceased growth in the summer or early fall, while the computed lengths were statures attained at a later date, perhaps midwinter. This may account for the comparatively smaller stature shown by the grilse. The Trinity River fish were smaller than the Klamath River examples, but the former were all

collected by means of a seine of small mesh. The computed length at two years, of fish which matured at three, compares favorably with two-year grilse from the Klamath catch. That of fish which matured at four years is somewhat greater, while that of five-year fish is considerably greater.

Fish of the third year which appear in the catch are included in three categories. The first is of males which have scales of the stream type. These are relatively small, not much larger in fact than two-year males which possess scales of the ocean type. Of this class, 40 exhibited length measurements of from 54 to 67 cm. These fish enter the catch only by accident as they are ordinarily able to pass through the meshes of the nets. The second category consists of males with scales of the ocean type. These fish have evidently spent more time in the ocean than those of the first class and the consequent advantage is reflected in the growth. They are relatively more numerous than those previously mentioned and they are also much larger, ranging in length from 51 to 81 cm., as determined from an inspection of 417 examples. The third group, consists of females which bear scales of the ocean type. These appear in numbers, a condition in the Klamath which is contrary to the observations of Gilbert[9] and Rich[10] in the Columbia. Females of this class appear also in the Sacramento River where they attain large size. Three-year fish contribute something like 11 to 16 per cent to the commercial catch in the Klamath. The three-year fish appear to increase in numbers until about the middle of August after which they grow relatively less numerous until the end of the season.

TABLE 25

Date	Year class			
	Three	Four	Five	Six
	Per cent	Per cent	Per cent	Per cent
July 11–19, 1919	9.9	86.5	3.6	----------
July 21–26, 1919	9.3	74.3	16.4	----------
July 28–August 2, 1919	14.3	62.5	22.2	----------
August 4– 9, 1919	25.8	60.2	14.0	----------
August 11–16, 1919	24.4	64.4	10.8	0.4
August 18–23, 1919	28.3	64.7	7.0	----------
August 25–30, 1919	23.7	64.8	11.5	----------
September 1– 5, 1919	10.8	73.0	15.9	0.3
September 20–27, 1919	5.5	42.7	44.6	7.2
September 30–October 4, 1919	12.2	38.7	38.7	10.4
October 6–11, 1919	2.8	41.0	43.5	12.7
October 14–18, 1919	4.8	37.5	51.5	6.2

Casual daily observation of the catch as it lies en masse on the floor of the receiving room, reveals an increase of large fish toward the end of the season. The early catches are characterized by comparative uniformity in the size of the fish which are relatively small, while the later catches are distinguished by the incursion of larger and older fish, as is elsewhere shown in detail.

The bulk of the catch consists of four-year fish. In 1919 when the fishing season extended into the late fall, 63 per cent were of the four-

[9] Gilbert, Charles H. Age at maturity of the Pacific coast salmon of the genus *Oncorhynchus*. U. S. Bureau of Fisheries, vol. 32 (Doc. 767), p. 14, 1913.
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Totals	1	--	--	3	3	4	7	22	21	22	32	35	35	31	29	19	17	10	10	3	5	2	2	1

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Length at 2 years of fish matured at 4	1	--	2	1	--	4	6	6	13	9	6	12	10	15	11	6	2	7	3	4	1	1
Length at 2 years of fish matured at 5	--	--	--	--	--	--	--	2	1	4	--	2	4	13	4	4	1	7	4	--	2	--
Totals	1	--	2	2	2	8	12	12	22	21	17	20	23	34	19	12	5	14	7	4	3	1

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[10] Rich, 1920, op. cit., p. 4.

year class. In 1920 and 1923, both shorter seasons, there were 78 and 60 per cent respectively.

Previous to the middle of September, fish of this age class make up 60 to 80 per cent of the catch, while after that date, five- and six-year examples appear in sufficient numbers to reduce the four-year fish to 35 or 45 per cent of the catch.

Four-year fish measure from 61 to 104 cm. in length, the average being somewhere near 80. Individuals smaller than 65 or larger than 95 cm. are very uncommon. Four-year Klamath fish are smaller than those of the Sacramento as is graphically shown in figure 22. Fish which early migrated to sea are on the whole larger than those which spent a year or so in the stream. The males average somewhat larger than the females.

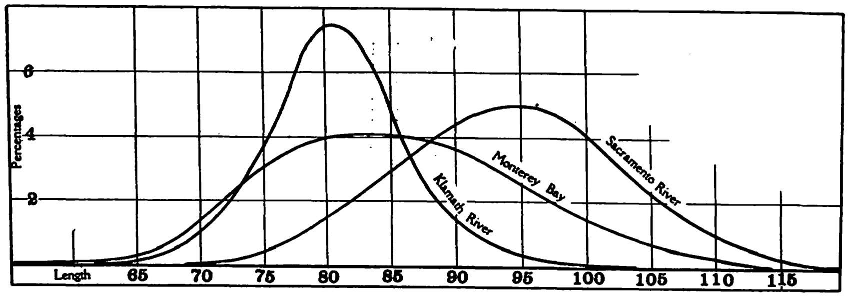

FIG. 22. The number of four-year fish of given lengths in river and ocean catches.

Numerous details relating to the four-year age class are recorded in tables 26, 27, and 28.

TABLE 26

KLAMATH RIVER 1919

Class	Type	Length in centimeters	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70
Three Year Class	Ocean Type	Males	3	3		4	1	3	5	7	8	9	11	10	13	18	18	25	15
		Females								3		3	2	4	10	8	27	18	11
		Total	3	3		4	1	3	5	10	8	12	13	14	23	26	45	43	26
	Stream Type	Males	4	1	2	3	6	2	3	1				1					
		Females																	
		Total	4	1	2	3	6	2	3	1				1					
	Total 3 year fish		7	4	2	7	7	5	8	11	8	12	13	15	23	26	45	43	26
Four Year Class	Ocean Type	Males													1	1			8
		Females												1	1	1	1	2	3
		Total												1	2	2	1	2	11
	Stream Type	Males								1	1	2	2	2	4	1	3	6	2
		Females											1	1	4	2	13	3	8
		Total								1	1	2	3	3	8	3	16	9	10
	Total 4 year fish									1	1	2	3	4	10	5	17	11	21
Five Year Class	Ocean Type	Males																	
		Femles																	
		Total																	
	Stream Type	Males																	
		Females																	
		Total																	
	Total 5 year fish																		
Six Year Class	Ocean Type	Males																	
		Femles																	
		Total																	
	Stream Type	Males																	
		Females																	
		Total																	
	Total 6 year fish																		

Class	Type	Length in centimeters	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90
Three Year Class	Ocean Type	Males	12	16	12	8	6	4	2		1		1									
		Females	8	7	9	4	2															
		Total	20	23	21	12	8	4	2		1		1									
	Stream Type	Males																				
		Females																				
		Total																				
	Total 3 year fish		20	23	21	12	8	4	2		1		1									
Four Year Class	Ocean Type	Males	2	6	4	5	8	13	9	23	16	16	26	21	22	22	17	24	30	30	22	27
		Females	13	16	25	36	39	45	59	61	72	63	68	44	54	36	26	25	19	17	18	5
		Total	15	22	29	41	47	58	68	84	88	79	94	65	76	58	43	49	49	47	40	32
	Stream Type	Males	5	5	5		3	3	4	6	4	2		1	1		2					
		Females	11	14	3	7	6	3	5	2		2		1				1	2	1		
		Total	16	19	8	7	9	6	9	8	4	4		2	1		2	1	2	1		
	Total 4 year fish		31	41	37	48	56	64	77	92	92	83	94	67	77	58	45	50	51	48	40	32
Five Year Class	Ocean Type	Males															1	2	1	1	2	7
		Femles						1				2				4		6	4	7	4	5
		Total						1				2				4	1	8	5	8	6	12
	Stream Type	Males					1	1		1	1	6	4	2	5	3	4	5	6	3	5	6
		Females		1	4	4	3	4	6	5	13	9	5	6	5	4	3	6	3	4	3	3
		Total		1	4	4	4	5	6	6	14	15	9	8	10	7	7	11	9	7	8	9
	Total 5 year fish			1	4	4	4	6	6	6	14	17	9	8	10	11	8	19	14	15	14	21
Six Year Class	Ocean Type	Males																				
		Femles																				1
		Total																				1
	Stream Type	Males																				1
		Females																			1	
		Total																			1	1
	Total 6 year fish																				1	2

Class	Type	Length in centimeters	91	92	93	94	95	96	97	98	99	100	101	102	103	104	105	106	107	108	109	110	111	112	113	114	115	Total
Three Year Class	Ocean Type	Males																										215
		Females																										116
		Total																										331
	Stream Type	Males																										23
		Females																										
		Total																										23
	Total 3 year fish																											354
Four Year Class	Ocean Type	Males	18	12	12	9	9	7	4	5	5	1				1												436
		Females	4	2	5	1	3		2	3	3	2	1		1	1												778
		Total	22	14	17	10	12	7	6	8	8	3	1		1	2												1214
	Stream Type	Males																										65
		Females																										90
		Total																										155
	Total 4 year fish		22	14	17	10	12	7	6	8	8	3	1		1	2												1369
Five Year Class	Ocean Type	Males	5	9	4	8	7	10	10	7	5	3	8	4	5	1	4	2	3	2	3	1	6				1	122
		Femles	5	5	4	3	5	9	5	8	1	2	5	3	2		1	2	1									94
		Total	10	14	8	11	12	19	15	15	6	5	13	7	7	1	5	4	4	2	3	1	6				1	216
	Stream Type	Males	5	4	4	2	3	2	3	4	1	1	1	2	2	2			3					1	1	1		95
		Females	3	4	1	2	2	1	1	1	1		3	1														111
		Total	8	8	5	4	5	3	4	5	2	1	4	3	2	2			3					1	1	1		206
	Total 5 year fish		18	22	13	15	17	22	19	20	8	6	17	10	9	3	5	4	7	2	3	1	6	1	1	1	1	422
Six Year Class	Ocean Type	Males								1					1		1	1	2	1		2					1	10
		Femles		2	1		1	1			1				1	1	1	2										12
		Total		2	1		1	1		1	1				2	1	2	3	2	1		2					1	22
	Stream Type	Males					1	1				1	1							1		1						7
		Females			1					1				1		1												5
		Total			1		1	1		1		1	1	1		1				1		1						12
	Total 6 year fish			2	2		2	2		2	1	1	1	1	2	2	2	3	2	2		3					1	34

TABLE 27

KLAMATH RIVER 1920

Class	Type	Length in centimeters	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83
Three Year Class	Ocean Type	Males	2		1			2	2		6	2	6	7	6	13	12	8	15	8	5	9	4	1	2	1						
Three Year Class	Ocean Type	Females				1		2					2	9	2	9	4	14	7	11	4	9	2	4			1					
Three Year Class	Ocean Type	Total	2		1	1		4	2		6	2	8	16	8	22	16	22	22	19	9	18	6	5	2	1	1					
Three Year Class	Stream Type	Males	3	1	3	2		2			1		1			2																
Three Year Class	Stream Type	Females																														
Three Year Class	Stream Type	Total	3	1	3	2		2			1		1			2																
Three Year Class	Total 3 year fish		5	1	4	3		6	2		7	2	9	16	8	24	16	22	22	19	9	18	6	5	2	1	1					
Four Year Class	Ocean Type	Males														1	2	2	2	5	6	5	12	13	18	19	20	17	10	24	18	27
Four Year Class	Ocean Type	Females													1	1	1	5	6	12	9	17	29	50	55	73	103	99	88	90	61	70
Four Year Class	Ocean Type	Total													1	2	3	7	8	17	15	22	41	63	73	92	123	116	98	114	79	97
Four Year Class	Stream Type	Males															1		2	4	2	1	2	7	1	2	1	3				
Four Year Class	Stream Type	Females														2		3	3	3	2	5	3	4	3	2			1			
Four Year Class	Stream Type	Total														2	1	3	5	7	4	6	5	11	4	4	1	3	1			
Four Year Class	Total 4 year fish														1	4	4	10	13	24	19	28	46	74	77	96	124	119	99	114	79	97
Five Year Class	Ocean Type	Males																							1					1	1	
Five Year Class	Ocean Type	Females																				1		1					7	1	3	2
Five Year Class	Ocean Type	Total																				1		1	1				7	2	4	2
Five Year Class	Stream Type	Males																	1			1		1		1	1	2			1	2
Five Year Class	Stream Type	Females																			1	2			1	6	6	3	9	3	4	2
Five Year Class	Stream Type	Total																	1		1	3		1	1	7	7	5	9	3	5	4
Five Year Class	Total 5 year fish																		1		1	4		2	2	7	7	5	16	5	9	6
Six Year Class	Ocean Type	Males																														
Six Year Class	Ocean Type	Femles																														
Six Year Class	Ocean Type	Total																														
Six Year Class	Stream Type	Males																														
Six Year Class	Stream Type	Females																														
Six Year Class	Stream Type	Total																														
Six Year Class	Total 6 year fish																															

Class	Type	Length in centimeters	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100	101	102	103	104	105	106	107	108	109	110	111	112	113	Total
Three Year Class	Ocean Type	Males																															112
Three Year Class	Ocean Type	Females																															81
Three Year Class	Ocean Type	Total																															193
Three Year Class	Stream Type	Males																															15
Three Year Class	Stream Type	Females																															
Three Year Class	Stream Type	Total																															15
Three Year Class	Total 3 year fish																																208
Four Year Class	Ocean Type	Males	25	19	21	20	26	28	15	20	15	7	6	7	3	5	4	4	2		1												429
Four Year Class	Ocean Type	Females	49	34	25	18	15	4	3	2	2		2	1		1																	926
Four Year Class	Ocean Type	Total	74	53	46	38	41	32	18	22	17	7	8	8	3	6	4	4	2		1												1355
Four Year Class	Stream Type	Males		1			1																										28
Four Year Class	Stream Type	Females																															31
Four Year Class	Stream Type	Total		1			1																										59
Four Year Class	Total 4 year fish		74	54	46	38	42	32	18	22	17	7	8	8	3	6	4	4	2		1												1414
Five Year Class	Ocean Type	Males	2	1	1		1	1	1		2	3		4	1	1		2		1	4	3	2	3		2	1	1	1			1	42
Five Year Class	Ocean Type	Females	5	4	6	1	4	5	4	3	4		1	2	2	1		2									2						61
Five Year Class	Ocean Type	Total	7	5	7	1	5	6	5	3	6	3	1	6	3	2		4		1	4	3	2	3		2	3	1	1			1	103
Five Year Class	Stream Type	Males	3	1	1	3	2	1		2		1			1	1		1	1				1										29
Five Year Class	Stream Type	Females	4	4	6		1	3	2																								57
Five Year Class	Stream Type	Total	7	5	7	3	3	4	2	2		1			1	1		1	1				1										86
Five Year Class	Total 5 year fish		14	10	14	4	8	10	7	5	6	4	1	6	4	3		5	1	1	4	3	3	3		2	3	1	1			1	189
Six Year Class	Ocean Type	Males																								1							1
Six Year Class	Ocean Type	Femles																															
Six Year Class	Ocean Type	Total																								1							1
Six Year Class	Stream Type	Males																	1										1		1		3
Six Year Class	Stream Type	Females								2		1				1																	4
Six Year Class	Stream Type	Total								2		1				1			1										1		1		7
Six Year Class	Total 6 year fish									2		1				1			1							1			1		1		8

TABLE 28

KLAMATH RIVER 1923

Class	Type	Length in centimeters	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84
Three Year Class	Ocean Type	Males		1	3		1	2	3	1	6	2	9	11	7	4	10	10	6	4	6	1	2	1					
Three Year Class	Ocean Type	Females				1				2	2	7	11	19	24	20	22	12	13	15	2	4	1	1					
Three Year Class	Ocean Type	Total		1	3	1	1	2	3	3	8	9	20	30	31	24	32	22	19	19	8	5	3	2					
Three Year Class	Stream Type	Males	1				1																						
Three Year Class	Stream Type	Females																											
Three Year Class	Stream Type	Total	1				1																						
Three Year Class	Total 3 year fish		1	1	3	1	2	2	3	3	8	9	20	30	31	24	32	22	19	19	8	5	3	2					
Four Year Class	Ocean Type	Males											1	1		1	1	2	3	3	3	4	7	7	9	10	10	21	10
Four Year Class	Ocean Type	Females									1			3	4	7	6	16	24	19	44	55	64	19	84	82	78	66	59
Four Year Class	Ocean Type	Total									1		1	4	4	8	7	18	27	22	47	59	71	86	93	92	88	87	69
Four Year Class	Stream Type	Males					1	1			1	3	2	2	1	1	2	4	4	2	2	2	1	1	1			2	1
Four Year Class	Stream Type	Females										1		6	6	10	11	10	12	7	6	1	3	2	1		2		
Four Year Class	Stream Type	Total					1	1			1	4	2	8	7	11	13	14	16	9	8	3	4	3	2		2	2	1
Four Year Class	Total 4 year fish						1	1			2	4	3	12	11	19	20	32	43	31	55	62	75	89	95	92	90	89	70
Five Year Class	Ocean Type	Males																						1	1		1	1	2
Five Year Class	Ocean Type	Females																	1		1	1	1		2	3	7	10	18
Five Year Class	Ocean Type	Total																	1		1	1	1	1	3	3	8	11	20
Five Year Class	Stream Type	Males																	1	1					2				2
Five Year Class	Stream Type	Females																1	2	3		2	2	3	7	2	3	4	2
Five Year Class	Stream Type	Total																1	3	4		2	2	3	9	2	3	4	4
Five Year Class	Total 5 year fish																	1	4	4	1	3	3	4	12	5	11	15	24
Six Year Class	Ocean Type	Males																											
Six Year Class	Ocean Type	Females																											
Six Year Class	Ocean Type	Total																											
Six Year Class	Stream Type	Males																								1			
Six Year Class	Stream Type	Females																						1	1	1	2	1	
Six Year Class	Stream Type	Total																						1	1	2	2	1	
Six Year Class	Total 6 year fish																							1	1	2	2	1	

Class	Type	Length in centimeters	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100	101	102	103	104	105	106	107	108	109	110	111	Total
Three Year Class	Ocean Type	Males																												90
Three Year Class	Ocean Type	Females																												156
Three Year Class	Ocean Type	Total																												246
Three Year Class	Stream Type	Males																												2
Three Year Class	Stream Type	Females																												
Three Year Class	Stream Type	Total																												2
Three Year Class	Total 3 year fish																													248
Four Year Class	Ocean Type	Males	9	17	9	8	6	7	2	10	4	10	2	4																181
Four Year Class	Ocean Type	Females	37	41	16	14	8	7	4	3	2	1		1	1															826
Four Year Class	Ocean Type	Total	46	58	25	22	14	14	6	13	6	11	2	5	1															1007
Four Year Class	Stream Type	Males		1																										35
Four Year Class	Stream Type	Females	1																											79
Four Year Class	Stream Type	Total	1	1																										114
Four Year Class	Total 4 year fish		47	59	25	22	14	14	6	13	6	11	2	5	1															1121
Five Year Class	Ocean Type	Males	1	1	1	4	3	6	1			1	3	3		3	1	1	1				1				1		1	39
Five Year Class	Ocean Type	Females	11	8	7	3	6	6	2	5	1	1	4	2			2	1												103
Five Year Class	Ocean Type	Total	12	9	8	7	9	12	3	5	1	2	7	5		3	3	2	1				1				1		1	142
Five Year Class	Stream Type	Males		1		1		1	1	1	1					1		1				1								15
Five Year Class	Stream Type	Females	7	1	4	3					1				1			1												46
Five Year Class	Stream Type	Total	4	2	4	4		1	1	1	2				1	1		2				1								61
Five Year Class	Total 5 year fish		16	11	12	11	9	13	4	6	3	2	7	5	1	4	3	4	1			1	1				1		1	203
Six Year Class	Ocean Type	Males																												
Six Year Class	Ocean Type	Females	1																											1
Six Year Class	Ocean Type	Total	1																											1
Six Year Class	Stream Type	Males		1			1		1				1																	5
Six Year Class	Stream Type	Females	2	1	1	2	1				1			1																15
Six Year Class	Stream Type	Total	2	2	1	2	2		1		1		1	1																20
Six Year Class	Total 6 year fish		3	2	1	2	2		1		1		1	1																21

TABLE 29

Summary of Klamath River Age Classes

Year class	3			4			5			6			Totals			Percentages		
Year—	1919	1920	1923	1919	1920	1923	1919	1920	1923	1919	1920	1923	1919	1920	1923	1919	1920	1923
Males	238	127	92	501	457	216	217	71	54	17	4	5	973	659	367	45	36	23
Females	116	81	156	868	957	905	205	118	149	17	4	16	1,206	1,160	1,226	55	64	77
Ocean type	331	193	246	1,214	1,355	1,007	216	103	142	22	1	1	1,783	1,652	1,396	82	91	88
Stream type	23	15	2	155	59	114	206	86	61	12	7	20	396	167	197	18	9	12
Ocean type males	215	112	90	436	429	181	122	42	15	10	1	5	783	584	291	36	32	18
Ocean type females	116	81	156	778	926	826	94	61	103	12	0	1	1,000	1,068	1,086	46	59	68
Stream type males	23	15	2	65	28	35	95	29	15	7	3	5	180	75	57	8	4	4
Stream type females	0	0	0	90	31	79	111	57	46	5	4	15	206	92	140	9	5	9
Totals	354	208	248	1,369	1,414	1,121	422	189	203	34	8	21	2,179	1,819	1,593	------	------	------
Percentages	16	11	16	63	78	70	20	10	13	1	.4	1	------	------	------	------	------	------

That the fish of an age class should appear successively larger as the season advances, due to an extended period of ocean growth, might be presumed. Such is the case as is seen in the following table 30 from a series of four-year examples, measured at intervals as they were taken during the season of 1919.

TABLE 30

Date	Average length females in cm.	Number of examples	Average length males in cm.	Number of examples
July 11–20	77.5	41	75.7	7
July 21–26	77.5	63	81.7	17
July 28–Aug. 2	77.7	122	81.2	48
August 4– 9	78.9	73	84.3	27
August 11–26	77.4	72	85.2	54
August 18–23	78.9	114	85.3	57
August 25–30	78.4	80	85.1	51
September 1– 6	79.5	123	85.1	99
September 20–25	82.9	26	86.9	25
September 26–October 1	86.8	10	85.6	10
October 2– 7	87.9	11	88.9	15
October 8–13	89.7	18	91.9	9
October 14–18	93.2	12	101.1	9

The five- and six-year fish lag behind in the migration, and they are more nearly ripe when they arrive, as is evidenced by the condition of the gonads, by the color of the body and by the development of the snout and teeth. It is presumed that these fish proceed with greater speed to the spawning grounds.

The five-year class contributes 10 or 20 per cent to the catch, the larger percentage appearing when the season is extended to late fall. They measure from 70 to 115 cm. in length. Here again those which migrated to sea early in their stream history average somewhat larger than those which lingered a year or so in the river.

The six-year fish are found only occasionally, 34 examples among 2179 fish in 1919, eight with 1819 fish in 1920, and 21 with 1593 fish in 1923. They are not to be distinguished from the five-year fish in any particular.

From the observations here recorded it will appear that a shortening of the legal fishing season from the late end will allow a relatively greater number of fish which mature at an advanced age, and are consequently larger, to escape the nets. It is believed also that it will contribute in a measure toward a compensation for the straining out of the larger fish by gill net fishing.

The results of an age analysis of catches from Klamath River and also from the Sacramento are here recorded in tabular form. These are based in all cases upon pods of fish which have been received from the fishermen, and from which no selections had been made. Considerable numbers of individuals have been examined, and it is believed that the conditions here found represent the normal for the particular periods. It is to be kept in mind, however, that these are analyses of catches, and not of migrations. They represent individuals which have been selected by the nets. They take no account of fish which are too small to be intercepted, or of those which pass while the nets are inoperative.

TABLE 31

SACRAMENTO RIVER 1919

Length in centimeters			51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100	101	102	103	104	105	106	107	108	109	110	111	112	113	114	115	116	117	118	119	120	
Two Year Class	Ocean Type	Males																	1																																																						1
		Females																																																																						
		Total																	1																																																						1
	Stream Type	Males																																																																						
		Females																																																																						
		Total																																																																						
	Total 2 year fish																		1																																																					1
Three Year Class	Ocean Type	Males	2				2	4			3	1	4	3	1		3	4	2	1	2	2	2	1	5		2	3	2	1	1								1																																				52
		Females						1		2	5	2	4	1	4	2	4	3	3	4	2	3	1				2			3		1																																									47
		Total	2				2	5		2	8	3	8	4	5	2	7	7	5	5	4	5	3	1	5		4	3	2	4	1	1							1																																				99
	Stream Type	Males																																																																						
		Females																																																																						
		Total																																																																						
	Total 3 year fish		2				2	5		2	8	3	8	4	5	2	7	7	5	5	4	5	3	1	5		4	3	2	4	1	1							1																																				99
Four Year Class	Ocean Type	Males																						1	1			1	1	1			3	6	5	1		2	2	3		1	2	3		3		2		2	2	1			1	2	2	2		1			1										52
		Females																					3	2	1	2	2	2		2	4	2	3	2	3	7	4	7	2	6	11	4	5	10	7	6	12	7	6	9	7	5	4	7	5		2	1		1		1											164
		Total																					3	3	2	2	2	3	1	3	4	2	6	8	8	8	4	9	4	9	11	5	7	13	7	9	12	9	6	11	9	6	4	7	6	2	4	3		2		1	1										216
	Stream Type	Males																					2		1					1								1											1																								6
		Females																										1		1				1					1																																		4
		Total																					2		1			1		2				1				1	1										1																								10
	Total 4 year fish																						5	3	3	2	2	4	1	5	4	2	6	9	8	8	4	10	5	9	11	5	7	13	7	9	12	9	7	11	9	6	4	7	6	2	4	3		2		1	1										226
Five Year Class	Ocean Type	Males																																												1	1		1		2			1	1			3	1		2	1	3	1		3	2	1	1	1		1	27
		Females																																							1	1	1		1	1	1	2	3	2	1	4	3	6	9	1	4	4	5			2	1										53
		Total																																							1	1	1		1	2	2	2	4	2	3	4	3	7	10	1	4	7	6		2	3	4	1		3	2	1	1	1		1	80
	Stream Type	Males																																															1	1			2							1													5
		Females																																	1			1	1	1	1	3	1		1	4	1	6	2	1		1						1		1													27
		Total																																	1			1	1	1	1	3	1		1	4	1	6	3	2		1	2					1		2													32
	Total 5 year fish																																		1			1	1	1	2	4	2		2	6	3	8	7	4	3	5	5	7	10	1	4	8	6	2	2	3	4	1		3	2	1	1	1		1	112
Six Year Class	Ocean Type	Males																																																																						
		Females																																																																						
		Total																																																																						
	Stream Type	Males																																																							1						1		1						3
		Females																																							1	1				1				2	2	1	1	1	2	1							1								15
		Total																																							1	1				1				2	2	1	1	1	2	1	1						2		1						18
	Total 6 year fish																																								1	1				1				2	2	1	1	1	2	1	1						2		1						18

TABLE 32

SACRAMENTO RIVER 1921

Length in centimeters			48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100	101	102	103	104	105	106	107	108	109	110	111	112	113	114	115	116	117	118	119	120	121	122	123	124	
Two Year Class	Ocean Type	Males	1				2	2	6	8	4	1	1	2	1																																																																28
		Females																																																																												
		Total	1				2	2	6	8	4	1	1	2	1																																																																	28
	Stream Type	Males																																																																												
		Females																																																																												
		Total																																																																												
	Total 2 year fish		1				2	2	6	8	4	1	1	2	1																																																																28
Three Year Class	Ocean Type	Males			1		1				1	2	3	2	6	3	3		3	6	2	3	4	6	4	8	2	8	5	7	5	2	5	4	2	1	2	2	1	1				1																																				106
		Females																					1	2			1			2		2	4	2	3	2	2	8	1	3	3	1		1																																				38
		Total			1		1				1	2	3	2	6	3	3		3	6	2	3	5	8	4	8	3	8	5	9	5	4	9	6	5	3	4	10	2	4	3	1		2																																				144
	Stream Type	Males						1											1			1	1																																																									4
		Females																																																																												
		Total						1											1			1	1																																																									4
	Total 3 year fish				1		1	1			1	2	3	2	6	3	3		4	6	2	4	6	8	4	8	3	8	5	9	5	4	9	6	5	3	4	10	2	4	3	1		2																																				148
Four Year Class	Ocean Type	Males																				1		1		1			1	1	3		2	3	3	5	3	4	1	6	7	3	6	4	2	5	5	1	6	4	4	4	3	6		2	3	1	3	1	4	2	2	2	3	3	3	1	1	1		1			1					129
		Females																										1					3	3	3	3	6	6	6	7	8	9	11	13	11	22	22	24	23	21	31	20	20	22	27	9	9	13	15	9	7	4	4	5	2	3	2				1									405
		Total																				1		1		1		1	1	1	3		5	6	6	8	9	10	7	13	15	12	17	17	13	27	27	25	29	25	35	24	23	38	27	11	12	14	18	10	11	6	6	7	5	6	5	1	1	1	1	1			1					534
	Stream Type	Males																										1		1								2		1							1			2				1																										9
		Females																																	2			3		2		2	2		2	1	4	1	3		1	1	2	2		1																								29
		Total																										1		1					2			5		3		2	2		2	1	5	1	3	2	1	1	2	3		1																								38
	Total 4 year fish																					1		1		1		2	1	2	3		5	6	8	8	9	15	7	16	15	14	19	17	15	28	32	26	32	27	36	25	25	31	27	12	12	14	18	10	11	6	6	7	5	6	5	1	1	1	1	1			1					572
Five Year Class	Ocean Type	Males																																				1		1			1	2	2	2	1	2	1	1		1	2		1	2	3	1	4	1	4	3	1	2	1	4	4	3	8	4	3	8	6	4	4	3	5	3	2	101
		Females																																		1									2	4	1	3	9	12	11	11	22	18	21	21	33	18	43	29	26	26	18	11	7	9	4	4	4											368
		Total																																		1		1		1			1	2	4	6	2	5	10	13	11	12	24	18	22	23	36	19	47	30	30	29	19	13	8	13	8	7	12	4	3	8	6	4	4	3	5	3	2	469
	Stream Type	Males																																						1							1					1					1	1				1	1	1				1													9
		Females																																		1		1			2		1		1			4	2	2	6	3	6	3	2	4	3	2	3		3	4	1		2																56
		Total																																		1		1		1	2		1		1		1	4	2	2	6	4	6	3	2	4	4	3	3		3	5	2	1	2			1												65
	Total 5 year fish																																			2		2		2	2		2	2	5	6	3	9	12	15	17	16	30	21	24	27	40	22	50	30	33	34	21	14	10	13	8	8	12	4	3	8	6	4	4	3	5	3	2	534
Six Year Class	Ocean Type	Males																																																							1		1				1																3
		Females																																																																													
		Total																																																							1		1				1																3
	Stream Type	Males																																																														1							1								2
		Females																																																				1		1	1					1																	4
		Total																																																				1		1	1					1	1						1								6
	Total 6 year fish																																																				1		2	1	1				2	1						1								9

TABLE 33

Summary of Sacramento River Age Classes

Year class	2		3		4		5		6		Totals		Percentages	
Year—	1919	1921	1919	1921	1919	1921	1919	1921	1919	1921	1919	1921	1919	1921
Males	1	28	52	110	58	138	32	110	3	2	146	388	32	30
Females	0	0	47	38	168	434	80	424	15	7	310	903	68	70
Ocean type	1	28	99	144	216	534	80	469	0	3	396	1,178	87	91
Stream type	0	0	0	4	10	38	32	65	18	6	60	113	13	9
Ocean type males	1	28	52	106	52	129	27	101	0	0	132	364	29	28
Ocean type females	0	0	47	38	164	405	53	368	0	3	264	814	58	63
Stream type males	0	0	0	4	6	9	5	9	3	2	14	24	3	2
Stream type females	0	0	0	0	4	29	27	56	15	4	46	89	10	7
Totals	1	28	99	148	226	572	112	534	18	9	456	1,291	------	------
Percentages	.2	2	22	12	49	44	25	41	4	.7	------	------	------	------

MARKING EXPERIMENTS

Since undertaking the study of Klamath River salmon the writer has come in contact with or initiated several marking experiments, the principal purpose of which was to determine as definitely as possible the ocean range of growing fish, and to test in some detail the parent stream theory.

Previous to this one or more carefully planned and executed experiments were undertaken by State authorities, from which no returns were secured. It was later suspected that failure was due, not to any methods used in the process, but rather to lack of an energetic attempt to secure returns. The method used in all cases was that of fin mutilation. Fishes were held in rearing ponds until of sufficient size, when the adipose together with all, or a part of some rayed fin (fig. 23) was so excised as to prevent regeneration. Returned fish have amply demonstrated the efficiency of the marking method when the

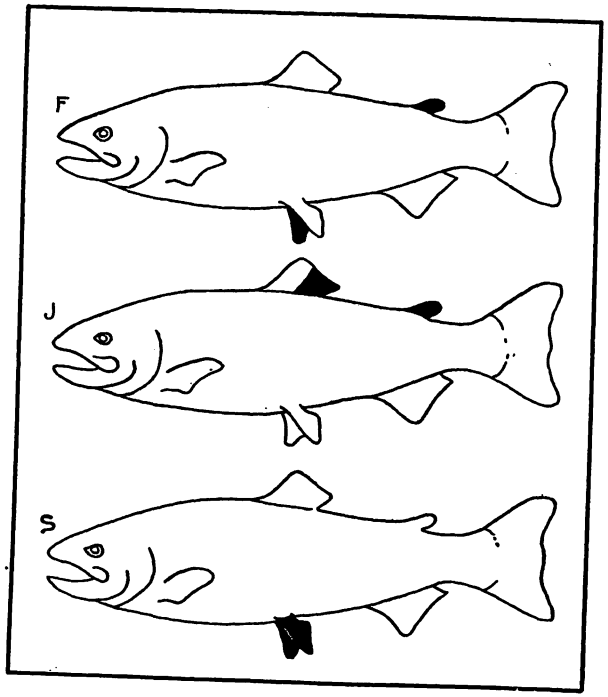

FIG. 23. Diagram showing how various lots of salmon were marked in experiments on the Klamath River.

details are in the hands of careful operators. The employment of good observers, and the cooperation of fishermen, dealers, and others have secured excellent returns from the later experiments.

Experiment in 1916.

On August 29, 1919, a king salmon measuring 43 inches, weighing 35½ pounds, and having the adipose and left ventral fins absent, was taken in the estuary of the Klamath. This was one, and the only one, recovered from 3500 marked yearlings released in the Klamath, February 15, 1916. The eggs were from Battle Creek, a tributary of the Sacramento. This merely served to show that a salmon introduced into the Klamath, although the egg which produced it was from another stream, would return to the Klamath. Also an age estimate made from a scale from the fish was in accord with its known age.

Experiment in 1918.

A later experiment[11] was somewhat more fortunate. Fry from Sacramento River eggs to the number of 18,000, and marked by removing the adipose and left ventrals, were liberated in Cold Creek, a tributary of the Sacramento on March 19, 1918. Three adults from these young fishes were secured in 1920. One was taken at Monterey, April 6; another was caught at Shelter Cove, August 17; a third entered the Sacramento and was secured near Pittsburg, September 15. From this it became apparent that Sacramento River salmon had a far more extensive ocean range than was suspected. The parent stream theory also found another fact in its support.

Experiment in 1919.

In November, 1919, 25,000 yearling king salmon, marked by the removal of the adipose and right ventral fins, were liberated in Fall Creek, Klamath River. The eggs from which these were hatched came from Mill Creek, a tributary of the Sacramento[12]. Considerable publicity was given to this experiment and a small reward was offered for data relating to captured fish. The following summary (table 34) presents the returns from this attempt.

Here, in accord with previously observed facts, the returning adult fish on their nuptial migration from the sea, entered the river into which they had been introduced, and proceeded toward the particular tributary in the waters of which they were reared. None was taken in the stream where the eggs were procured. It was also demonstrated among other things, that Klamath salmon migrate southward at least to Monterey Bay.

Experiment in 1920.

In September and October, 1920, 20,000 king salmon, hatched from eggs taken at Mill Creek, a tributary of the Sacramento, and reared in ponds at the Mt. Shasta Hatchery, were marked by removing the adipose and posterior half of the dorsal fin.[13] On April 8, 1921,

[11] Snyder, J. O. Three California marked salmon recovered. California Fish and Game, vol. 7, no. 1, pp. 1–6, 1921.

[12] Scofield, W. L. King salmon marking experiment at Klamath River, 1919. California Fish and Game, vol. 6, no. 3, p. 101, 1920.

Snyder, J. O. The return of marked king salmon grilse. California Fish and Game, vol. 8, no. 2, p. 102, 1922.

Snyder, J. O. A second report on the return of king salmon marked in 1919, in Klamath River. California Fish and Game, vol. 9, no. 1, p. 1, 1923.

Snyder, J. O. A third report on the return of king salmon marked in 1919 in Klamath River. California Fish and Game, vol. 10, no. 3, p. 110, 1924.

[13] Scofield, W. L. Sacramento River salmon marking. California Fish and Game, vol. 7, no. 2, p. 125, 1921.

TABLE No. 34

Summary of Data Relating to the Capture of Fish Marked in 1919

Locality	Number of fish	1921	Number of fish	1922	Number of fish	1923	Number of fish	1924
Monterey Bay			2	June 7–14				
Off Point Reyes			1	July 7				
Off Fort Bragg					1	June 8		
Off Cape Mendocino			1	August 5	1	July 17		
Redding Rock			4	July 21–August 3				
Klamath Estuary			1	August 14	2	August 17–31		
Klamath Racks	23	October 24–November 14	15	October 19–November 15	8	October 24 November 15	1	November 8

the surviving 15,400 were introduced into Sullaway Creek, a tributary of the Sacramento.

The first reported returns from this experimental introduction came from Battle Creek (*B* on fig. 24) a hatchery of the U. S. Bureau of Fisheries, where 7 grilse measuring from 53 to 63 cm. in length were taken. These were seen by W. E. Lupardus in charge of the station, on dates from November 4 to 21, 1922.

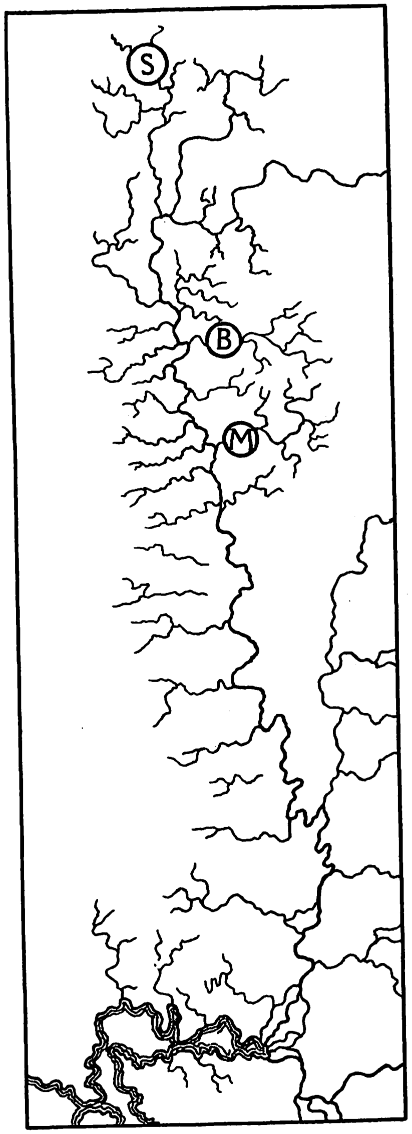

FIG. 24. Map of Sacramento River indicating where marked salmon were liberated when young and caught when mature.

Two were later taken at sea, the first on April 13, 1923, in Monterey Bay, the second July 25, near the Eureka Bar. Here again the wide sea range of Sacramento salmon was demonstrated.

In 1923, from October 27 to December 5, fish bearing the mark of this experiment entered Mill Creek and Battle Creek where they were taken by C. A. Hruby and also by Mr. Lupardus. These fish measured from 66 to 96 cm., and were representative of both sexes.

One other example was reported from Battle Creek, November 20, 1924.

A summary follows in table 35.

Here the yearlings were planted in the headwaters of the river (*S* on fig. 24), and on their return migration as adults were apparently scattered over the basin. There is no reason to presume that they entered only Mill Creek (*M* on fig. 24) and Battle Creek, but rather that these were the only places from which they were likely to be reported.

It has been recognized that the Sacramento is not a stream which is well adapted for experimental purposes. The river itself is temperamental, so to speak, responding quickly to periods of rain or drought, breaking over its banks and flooding its bottoms at times, or shrinking and dwindling when the season is dry. Irrigation projects, dams for power purposes, commerce and pollution, have also contributed to its difficulties. And with all this it is not easy to get returns from experimental work because of the varied nationality of its fishermen. At the time of the return of these fish

the river was unusually low and conditions were not what might be considered as normal. Possibly the behavior of the migrating salmon was not altogether normal.

TABLE 35

Locality of capture—	Date	Sex	Length in cm.
IN 1922, THE THIRD YEAR OF THE EXPERIMENT			
Battle Creek	Nov. 4	Male	
Battle Creek	Nov. 4	Male	
Battle Creek	Nov. 13	Male	63
Battle Creek	Nov. 18	Male	63
Battle Creek	Nov. 18	Male	53
Battle Creek	Nov. 20	Male	53
Battle Creek	Nov. 21	Male	56
IN 1923, THE FOURTH YEAR OF THE EXPERIMENT			
Monterey Bay	April 13	Male	75
Near Eureka Bar	July 25	Female	86
Mill Creek	Oct. 27	Male	66
Mill Creek	Oct. 27	Male	66
Battle Creek	Nov. 7	Female	71
Battle Creek	Nov. 9	Male	74
Mill Creek	Nov. 13	Female	89
Mill Creek	Nov. 14	Female	76
Battle Creek	Nov. 15	Female	86
Battle Creek	Nov. 16	Male	96
Battle Creek	Nov. 17	Male	84
Battle Creek	Nov. 20	Male	86
Battle Creek	Nov. 22	Female	71
Mill Creek	Dec. 4	Male	71
Mill Creek	Dec. 5	Male	71
IN 1924, THE FIFTH YEAR OF THE EXPERIMENT			
Battle Creek	Nov. 20	Female	89

For some years salmon have been reared in the hatchery at Sisson and at opportune times allowed to escape into the upper part of the Sacramento. However, no return migration has been reported to that part of the stream above the mouth of Pit River, and the question has been raised as to what became of these fish. The results of this experiment offer a provisional answer, namely, that such as return are probably scattered over the entire basin, or because of adverse conditions they are forced to enter tributaries before they are able to reach the one into which they were originally introduced. The inference that some of them returned to the tributary from which the eggs were taken because of that, is scarcely to be entertained.

Experiment in 1922 (Sacramento River).

It was desired that evidence be obtained to show whether fish hatched from Klamath eggs, and introduced into the Sacramento would return to that stream as adults. Accordingly, 15,000 yearlings from Klamath River eggs taken at the Klamathon racks and reared at Mt. Shasta, were marked by removing the adipose and both ventral fins, and introduced into the Sacramento basin from the hatchery in October, 1922. The marking of these fish was performed by E. A. McGregor.

One of these fish measuring 50 cm. was caught at Santa Cruz, May 13, 1924. The next year, 3 others were taken at Eureka, June 7, 15, and 25. Another was secured at Bodega Head, July 25. Nothing further came of this effort.

Experiment in 1922 (Klamath River).

In the fall of 1922 it was planned to initiate an experiment at Fall Creek which should demonstrate whether introduced salmon, on their return from the sea, would tend to enter the particular tributary in which they were planted. A sufficient number of yearlings was not available and the work was postponed. However, in lieu of the intended plantings, 18,500 yearlings from which the adipose and left ventral fins had been removed were released in Fall Creek in November. These fish were reared from eggs taken at the Klamathon station.

In 1924 six individuals carrying the mark of this experiment were secured in the estuary of Klamath River, August 19 to 26. They were all males measuring from 54 to 63 cm. From October 16 to November 1, 13 examples were collected at the Klamathon racks. These were males measuring 47 to 64 cm.

In 1925, 161 examples were observed. Four were caught off the coast near Eureka, May 18, June 25, July 31, and August 1; 1 near Cape Mendocino, May 30; 6 off Trinidad, June 21 to July 14; 2 near Patricks Point, June 22; 3 off Big Lagoon, July 10; 92 in Klamath estuary, July 23 to September 3; and 53 at the Klamathon racks, September 11 to November 3.

In 1926, 52 fish of this class were caught; 2 off Trinidad (no date); 1 near Eureka, August 25, and 2 more September 5; 33 in Klamath estuary, July 15 to August 28; and 14 at the racks at Klamathon, October 16 to 24.

In 1927, 1 was taken off Eureka, July 8; 2 in Klamath estuary July 27; and 1 at the same place August 6.

Some of the 1925 fish, four years old, which came into Klamath River were measured with the following results:

TABLE 36

Length in cm.	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94
Male	1	--	--	3	1	5	4	3	2	5	4	--	2	3	--	2	1	1	1	1	1	--	--	--	--
Female	2	2	2	6	11	9	10	4	5	8	5	2	6	2	1	2	--	--	2	1	--	--	--	--	1
Totals	3	2	2	9	12	14	14	7	7	13	9	2	8	5	1	4	1	1	3	2	1	--	--	--	1

When these length measurements are compared with those of a similar class, *i. e.*, four-year fish bearing scales with a stream nucleus, assembled from examples observed in previous years, 1919, 1920 and 1923, to be particular, it appears that the fish of this experiment have attained a considerably greater stature. An inspection of the following table will confirm this.

TABLE 37

Length in cm.	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88
Male	1	1	3	3	2	4	2	3	6	8	5	10	9	10	6	12	17	8	8	8	3	--	1	3	2	2	1	--	1
Female	--	--	--	--	1	1	4	4	4	12	17	24	27	18	22	17	12	8	5	2	4	--	3	--	--	1	1	2	1
Totals	1	1	3	3	3	5	6	7	10	20	22	32	36	28	28	29	29	16	13	10	7	--	4	3	2	3	2	2	2

The five-year fish which appeared in 1926 and entered the river measured from 69 to 98 cm. The sexes were about equally represented.

Experiment in 1923–1924.

An experiment was planned in 1923,[14] the purpose of which was to demonstrate whether returning fish would actually seek out and enter the particular tributary in which they were reared. It was also desired to learn something of the behavior of returning fish which had been reared in the water of one tributary and then introduced into an adjacent tributary. It is perhaps needless to remark that information of this sort is of great practical importance in artificial propagation and distribution.

The upper Klamath furnished an ideal layout for the experiment, as will be seen from an inspection of the accompanying figure 25. The division maintains a hatchery at Fall Creek, and an egg-collecting station on the main river at Klamathon. The racks at this station are so placed in the river as to trap every salmon which passes up during the fall migration, thus enabling an observer, if he so desires, to examine the fish individually. A particular fish after entering the trap may be held for a period between the racks, or it may be passed on and allowed to pursue its way up the river. About 15 miles above this trap is the great Copco dam which presents an impassible barrier to migrating fish. About 2 miles below the dam, Fall Creek enters the Klamath. This is a large, perennial stream of clear, cold water, with a high fall at a point about a mile above its mouth. The hatchery is located at the foot of the fall. The creek below the fall is small and clear enough to permit of inspection throughout its length, and salmon which enter it may be easily seen and taken if occasion warrants. Jenny Creek, a stream similar to Fall Creek, but unfortunately without barriers, enters the main river somewhat over 2 miles below the mouth of Fall Creek. Salmon are known to enter this stream, and there is no apparent reason why they should not do so at any time if so inclined. Several miles below the Klamathon racks, Shasta River enters the Klamath. It is a stream which formerly was famous for its salmon and trout.

The young salmon used for experimental purposes were selected from the large number reared at the Fall Creek hatchery. These were from eggs collected in 1922 and held in the rearing ponds until the following fall, 1923, when 75,000 of them were marked.

From 25,000, the adipose and right ventral fins were removed. (See fig. 23.) These were allowed to enter Fall Creek, October 8, where they might pass down and into the main channel of the Klamath.

Another 25,000 were marked by removing the adipose and posterior half of the dorsal. These were transported to Jenny Creek and introduced at a point about 500 feet above the mouth of the stream on October 4, 9 and 11.

A third lot of 25,000 had both ventrals removed. They were taken to Shasta River and introduced near the highway bridge, eight-tenths of a mile from the junction of that stream with the main river, October 5, 10 and 14.

[14] Snyder, John O., and Scofield, Eugene C. An experiment relating to the homing instinct of king salmon. California Fish and Game, vol. 10, no. 1, p. 9, 1924.

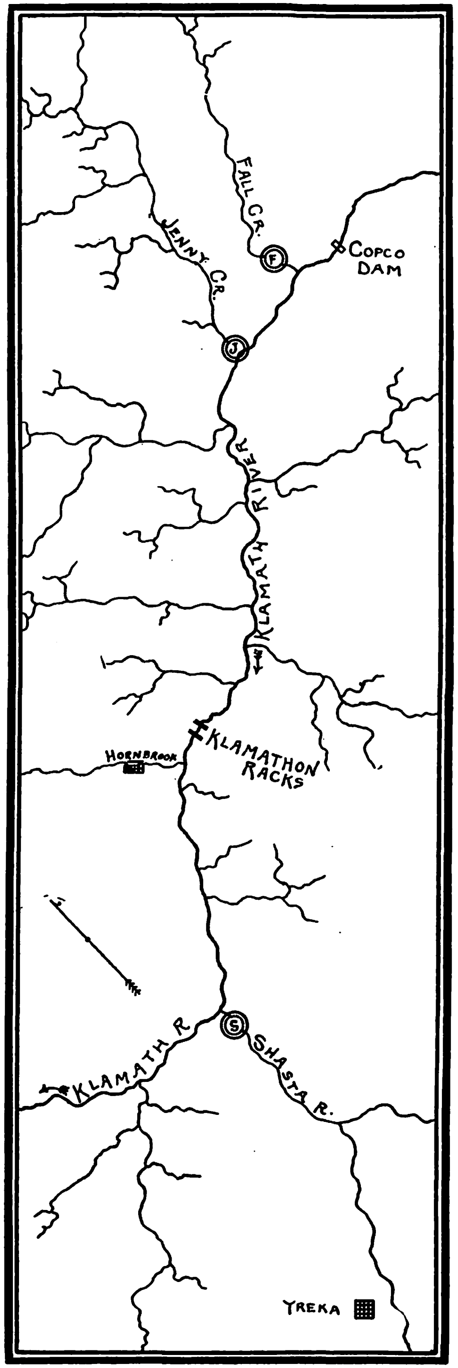

FIG. 25. Map showing location of salmon spawning and marking experiments on the Klamath River.

The first group had been hatched and reared in the waters of Fall Creek, and then allowed to enter the stream at a point which would necessitate a passage of one mile through its channel before entering the main river. The second group was given an exposure of only 500 feet to the waters of Jenny Creek. Some of them only loitered in the stream a few hours before entering the Klamath. Some of these might mingle with others of Fall Creek on their downward migration to the sea. The third lot had an exposure of nearly one mile to the water of Shasta River. It will be seen that if the adults return to the tributaries into which they were placed, all of them will pass the fishery at the mouth of the river; the Jenny Creek and Fall Creek fish will come into the racks at Klamathon; while the Shasta fish may enter this tributary, the one in which they were planted, or they may move up the main channel where they will be intercepted at the racks.

On the following year, 1924, the planting was repeated, each detail of the previous year having been observed.

The greatest care was taken throughout the work, so that no mixing of the fish would occur at the hatchery, and that no marked fish would accidentally escape into the river. Conditions were not favorable in Shasta River as the water was low at the time of both plantings, and fish could not be held at Fall Creek until later in the season when the water might be

expected to rise. It is obvious, however, that the introductions were all successful, for returns were received from them at sea, at the mouth of the Klamath and from points farther upstream as were expected.

A brief summary of the recorded captures of adult fish of this experiment follows:

TABLE 38

Fin marks	Date of capture							
	1925				1926			
	At sea	Klamath estuary	Klamathon racks	Shasta river	At sea	Klamath estuary	Klamathon racks	Shasta river
Right ventral, Fall Creek	8	8	29	0	31	81	140	0
Half dorsal, Jenny Creek	0	3	7	0	17	69	104	0
Both ventrals, Shasta River	0	2	0	1	5	6	2	2

TABLE 38—Continued

Fin marks	Date of capture								Totals
	1927				1928				
	At sea	Klamath estuary	Klamathon racks	Shasta river	At sea	Klamath estuary	Klamathon racks	Shasta river	
Right ventral, Fall Creek	36	185	21	0	9	35	0	0	583
Half dorsal, Jenny Creek	37	151	24	0	2	34	2	0	450
Both ventrals, Shasta River	8	35	5	1	2	5	2	0	76
Totals									1,109

As might have been predicted, that part of the experiment which pertained to Shasta River was not rewarded by very abundant returns. Fishes bearing its mark were not caught anywhere in large numbers. None the less, they appeared in marine catches and they came into the Klamath on their nuptial migration. The fact of particular interest is that part of them entered the Shasta, while others pursued their course up the main river until they encountered the racks at Klamathon. Apparently all of those fish which were planted in Fall and Jenny creeks and which escaped the nets in the estuary, moved up the main channel and entered the racks as if bound for the tributaries from which they had once migrated toward the sea.

On observing the split in the migration of the Shasta fish, one's curiosity is at once aroused as to how the Fall and Jenny creek fish might have behaved if not intercepted by the racks, and fortunately an answer is at hand.

In 1926, 124 fish bearing the Fall Creek mark and 85 of the Jenny Creek planting were taken out of the Klamathon trap and allowed to pass on up the river. A considerable number of these were tagged with metal bands on the upper lobe of the caudal, that they might be easily recognized in the water. This tagging was soon abandoned because of the weakened condition of many of the fish, some being unable to stem the strong current after being released. Marked fish were passed over the racks from September 26 to November 7.

Of the fish which were allowed to pass up the river, 59 were eventually recovered as follows:

34 Fall Creek fish caught in	Fall Creek
3 Fall Creek fish caught in	Bogus Creek
2 Fall Creek fish caught in	Klamath River
1 Jenny Creek fish caught in	Jenny Creek
16 Jenny Creek fish caught in	Fall Creek
1 Jenny Creek fish caught in	Bogus Creek
2 Jenny Creek fish caught in	Klamath River

The fish which came into Bogus Creek (Fig. 26) were intercepted by the traps at an egg collecting station. The single one caught in Jenny Creek was taken in an improvised trap over which others might possibly have escaped, as it was difficult to keep it free from floating leaves.

It would appear from the results of this experiment that when yearlings are introduced into, and given a sufficient exposure to the waters of a particular tributary, they tend on their return migration to seek out and enter that tributary, while under other conditions, they may scatter to a considerable extent.

Observations seem to confirm the belief that in nature a species is under a condition similar to water in a reservoir, namely a proclivity to break down its barriers and spread. The homing instinct is a barrier to dispersal in the case of the salmon, and apparently in many other species as well. For example, striped bass and shad which were introduced into the Sacramento basin, returned there in large numbers after their seaward migration, but a small scatter occurred, the species having attempted to extend their ranges both north and south of the place of introduction. It may be inferred that at least a slight dispersal accompanies the return of either artificially or naturally propagated salmon, the tendency of a few individuals to scatter or break over the natural barrier to dispersal offering the species an opportunity to extend its range.

The four-year-old marked fish which came into the nets of the estuary in 1926 and 1927, and of which measurements and sex deteminations are available are very similar to fishes of the same age and type usually taken, as will appear when the following summary is compared with tables 26, 27, and 28.

The summary, table 38, indicates that the toll of marked fish taken by the nets at the mouth of the river grew relatively greater as the fish increased in size. In 1925 when only the small three-year fish returned, the nets stopped 13, while 36 came to the Klamathon trap. In 1926 when both three- and four-year fish appeared, the nets caught 156 while 246 reached Klamathon. Nine of those taken in the nets, and 21 of those taken between the racks at Klamathon were three-year fish In the following year the nets took 371 fish, leaving only 50 to be caught at Klamathon. In 1928, when the largest fish, five- and six-year individuals entered the river, 74 were caught in the estuary, and only 4 were seen at Klamathon. As a matter of fact the number caught in the

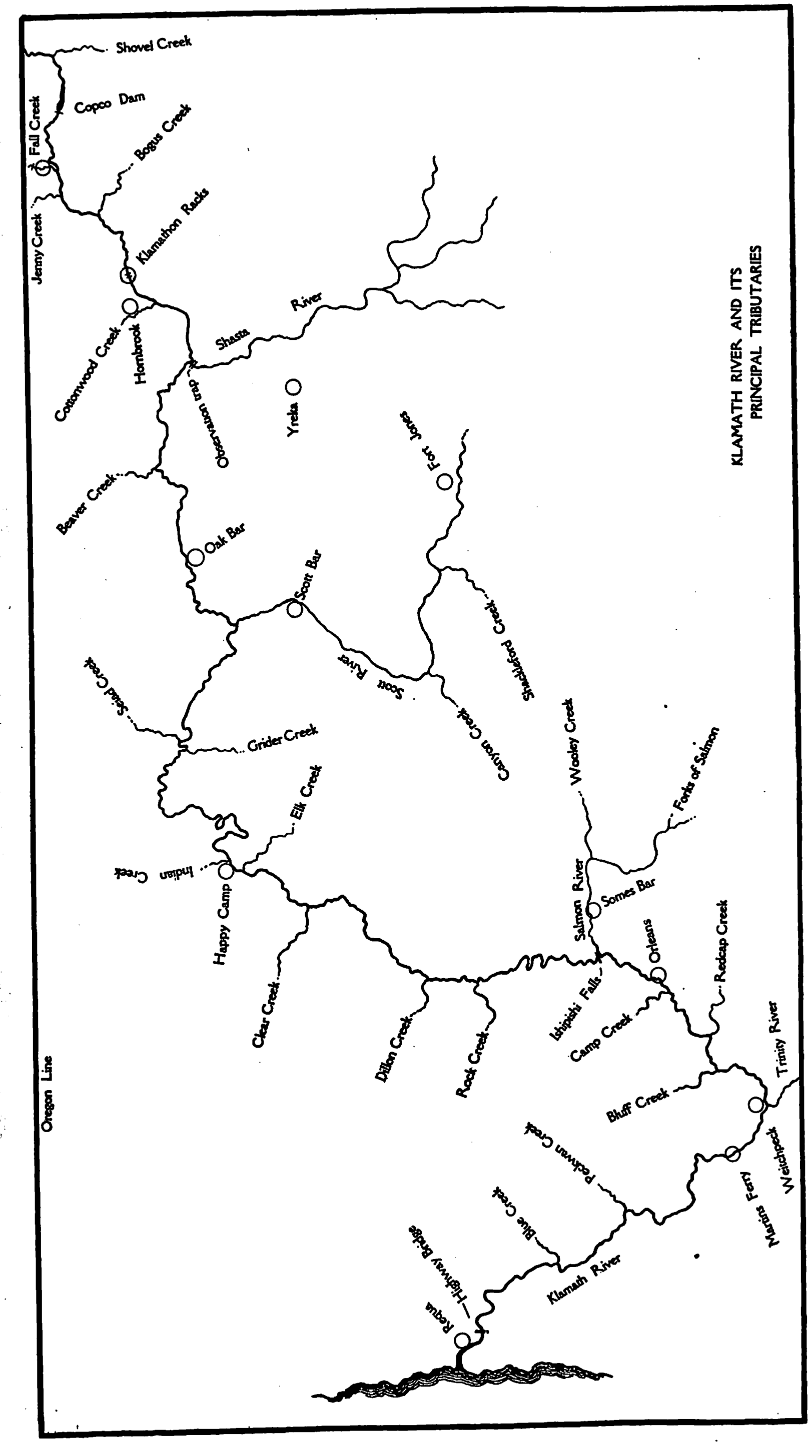

FIG. 26.

nets is considerably larger, for the returns here recorded came almost exclusively from the plant of the Klamath River Packers Association, the various dealers who ship fresh fish from the Klamath being unwilling to delay long enough to report the appearance of marked fish.

TABLE 39

Length in cm.	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83
Four-year fish of 1926—																								
Males	1	--	1	--	--	1	2	--	1	2	2	3	4	4	7	2	9	5	2	2	5	2	2	1
Females	1	--	--	--	--	2	2	1	1	6	5	8	10	15	3	10	5	6	6	2	2	1	--	--
Totals	2	--	1	--	--	3	4	1	2	8	7	11	14	19	10	12	14	11	8	4	7	3	2	1
Four-year fish of 1927—																								
Males	--	1	1	1	--	--	1	2	--	1	--	1	3	--	1	3	6	6	8	2	1	--	--	--
Females	--	--	--	--	--	--	--	1	--	•4	4	10	14	10	10	10	17	12	7	7	2	--	--	--
Totals	--	1	1	1	--	--	1	3	--	5	4	11	17	10	11	13	23	18	15	9	3	--	--	--
Total four-year fish	2	1	2	1	--	3	5	4	2	13	11	22	31	29	21	25	37	29	23	13	10	3	2	1

The results of this experiment agree with the observation made on a previous page, that the method of fishing now pursued at the mouth of the river is a deleterious straining process that permits the escape of small fish which later appear in ill-proportioned numbers on the spawning beds. The use of seines under proper regulation might avoid this.

The time of arrival of the market fish in the river was well spread over the migratory season. They appeared in varying numbers much as did the fish of the entire catch as illustrated in table 40.

The writer is convinced that nothing of importance may be determined from a comparison of the number of recorded returns with the number of marked and liberated fish. In these experiments the percentage of captured adult fish is no measure of either the success or failure of artificial propagation. The number of returns depends in a large measure upon the effort put forth in obtaining them. For example, the marine returns in the last experiment were as follows:

1925

5 marked fish near Trinidad, June 23 to July 11.
1 marked fish near Patricks Point, June 22.
2 marked fish near Eureka, July 27, 30.

1926

12 marked fish near Trinidad, June 21 to August 17.
41 marked fish near Eureka, June 21 to September 5.

1927

81 marked fish near Eureka, May 12 to July 8.

1928

13 marked fish near Eureka, July 7 to August 13.

It will be noted that not a single marked fish was reported south of Eureka. It may be stated also that a special observer was located at Eureka, and that he was responsible either directly or indirectly for the recovery of nearly all of the marked fish reported from that region.

TABLE 40

Date (1927)	July 19	July 25	July 26	July 27	July 28	July 29	July 30	August 1	August 2	August 3	August 4	August 5	August 6
Catch of Klamath River Packers Association	154	51	82	44	240	134	88	239	92	57	72	240	114
Number of marked fish	2	---	6	3	12	5	---	16	---	4	7	9	1
Fourth year fish	---	---	3	1	1	1	---	5	---	2	3	3	---
Fifth year fish	2	---	3	2	11	4	---	11	---	2	4	6	1

Date (1927)	August 8	August 9	August 10	August 11	August 12	August 13	August 15	August 16	August 17	August 18	August 19	August 20
Catch of Klamath River Packers Association	66	141	237	258	153	2,014	3,531	225	561	631	1,674	507
Number of marked fish	5	3	9	2	2	44	50	8	15	15	26	6
Fourth year fish	---	---	---	1	1	14	17	5	10	6	13	5
Fifth year fish	5	3	9	1	1	30	33	3	5	9	13	1

Date (1927)	August 22	August 23	August 24	August 25	August 26	August 27	August 29	August 30	August 31	September 1	September 2	September 3	September 5	September 6
Catch of Klamath River Packers Association	235	107	130	649	435	298	414	911	788	528	365	189	145	44
Number of marked fish	11	2	3	5	8	5	8	9	11	10	3	1	1	---
Fourth year fish	5	---	2	3	6	3	7	7	4	5	1	1	1	---
Fifth year fish	6	2	1	2	2	2	1	2	7	5	2	---	---	---

In 1927, 41 fish bearing the mark of this experiment were found in Astoria, Oregon, by Harlan B. Holmes of the United States Bureau of Fisheries. They had all been shipped there after having been purchased from a barge which was anchored in Humboldt Bay near Eureka.

It seems quite probable that the fish marked in 1923–1924 migrated just as far at sea as did those of previous experiments, but the novelty of finding a marked fish had lost its freshness, and in spite of the publicity given to the experiment, and the offer of a small reward for fin scars, the marked fish were pretty generally overlooked.

It was intended that during the season of 1926, salmon should be caught with a seine in the estuary of the river, marked with a metal tag and then liberated. It was thought that the recovery of some of these fish might furnish facts relating to the length of time they linger in the estuary, their progress and speed during the stream migration, the relative number which would come to the Klamathon racks, etc. The work was in charge of E. C. Scofield, and he expected to proceed with it as the migration progressed. One unavoidable delay followed another, however, and productive operations were not begun until August 28. From that date to September 15, 343 fish were caught, tagged and liberated. Recoveries were eventually made as follows:

TABLE 41

Date when tagged	Date of capture	Place of capture
September 13, 1926	October 3, 1926	Johnsons
September 13, 1926	October 17, 1926	Klamathon racks
September 13, 1926	October 20, 1926	Klamathon racks
September 14, 1926	September 25, 1926	Ishipishi Falls
September 14, 1926	October 5, 1926	Johnsons
September 14, 1926	October 13, 1926	Klamathon racks
September 14, 1926	October 17, 1926	Klamathon racks
September 14, 1926	October 19, 1926	Klamathon racks
September 14, 1926	October 20, 1926	Klamathon racks
September 14, 1926	October 26, 1926	Shasta River
September 14, 1926	October 30, 1926	Klamathon racks
September 15, 1926	October 20, 1926	Blue Creek
September 15, 1926	October 3, 1926	Ishipishi Falls
September 15, 1926	October 24, 1926	Shasta River
September 15, 1926	October 26, 1926	Shasta River
September 15, 1926	November 11, 1926	Camp Creek

Not enough was accomplished to warrant any generalization, yet the results indicate the possibilities of such an experiment.

OCEAN TAGGING

Attempts to tag salmon at sea were made in 1926 and 1927. The only source of supply was the trolled fish. Because of adverse conditions the project was not successful.

In 1926, 130 fish were tagged at points along the California coast from Monterey Bay to Trinidad. One of these tagged near Trinidad August 8, was recovered at Mill Creek Hatchery, Sacramento basin, November 14, 1927.

In 1927, 53 fish were tagged in Monterey Bay from April 28 to June 14. This attempt was more successful, 16 of the fish having been retaken. A summary follows:

TABLE 42

Tag number	Tagged		Recovered	
	Date	Locality	Date	Locality
IPSIF 5	May 10	Monterey Bay	Aug. 5, 1927	Monterey Bay
7	May 10	Monterey Bay	Aug. 4, 1927	Monterey Bay
11	May 11	Monterey Bay	July 23, 1927	Monterey Bay
12	May 11	Monterey Bay	Aug. 7, 1927	Off Point Reyes
13	May 11	Monterey Bay	Aug. 6, 1927	Off Point Reyes
17	May 16	Monterey Bay	July 25, 1927	Monterey Bay
19	May 16	Monterey Bay	April 27, 1928	Monterey Bay
22	May 16	Monterey Bay	Aug. 15, 1927	Off Point Reyes
27	May 25	Monterey Bay	Sept. 12, 1927	Near Rio Vista
28	May 25	Monterey Bay	July 20, 1927	Monterey Bay
33	May 27	Monterey Bay	May 22, 1928	Monterey Bay
38	June 12	Monterey Bay	Sept. 7, 1927	San Francisco Bay
USBF 50	June 14	Monterey Bay	May 26, 1928	Off Eureka
306	May 18	Monterey Bay	April 27, 1928	Monterey Bay
307	May 18	Monterey Bay	Aug. 6, 1927	Monterey Bay
308	May 19	Monterey Bay	May 25, 1927	Monterey Bay

DEPLETION

It has been said, even of late, that the salmon population of Klamath River is holding its own. That this is not the case, and that rapid depletion of the stock is not only threatened, but is actually under way, will appear.

In an attempt to discover whether the salmon population of Klamath River is being maintained or whether depletion is threatened or is actually in progress, there must be considered not only the conditions in the river itself, but attention must be directed to the fishery of the entire coast to the southward, and also to other rivers of the state where salmon are taken. As the supply from other and more accessible streams becomes reduced, the attack on the Klamath will become more vigorous. As sea fishing in Monterey Bay, where Klamath salmon along with those from other streams are caught, becomes less profitable, the center of effort will move northward and approach the river itself. A decline in the entire catch of the state, or in the region of Monterey Bay, or off the coast to the northward, or even in the Sacramento River, spells decline in the Klamath, even though superficial indications in the river do not now point in that direction.

Dependable salmon statistics for the State date from about 1918, when the catch was somewhat over 13,000,000 pounds. In the following year it was about equally large, but in 1920 a decline began, and this has continued with occasional recoveries until 1928 when about 4,400,000 pounds were taken. Figure 27 illustrates the situation.

With the general decline of the catch of the entire State, there has occurred a somewhat similar falling off in every section, whether the fish were taken at sea or in the rivers.

The condition in Monterey Bay is perhaps more serious than that of any other part of the State. Here a reported catch of over 5,000,000 pounds in 1916 has dwindled to less than 52,000 pounds in 1926. This

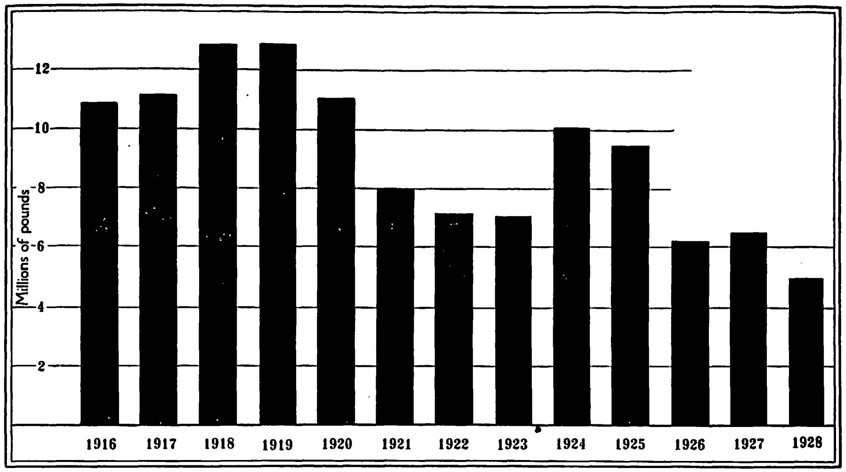

FIG. 27. The salmon catch of California expressed in millions of pounds.

depletion in the catch is not due to a restricted fishing period as will be readily seen by an examination of table 43 and figure 28, where the catch is represented by monthly periods. Here the catch of any month shows a decline through a period of years.

The rapid growth of the fishery near Fort Bragg and along the coast in the vicinity of Eureka has not only suffered a check, but also shows unmistakable evidence of serious decline. The rapid advance and the later recession of the fishery in this region is depicted in figure 29.

Attention is called to table 44, which was compiled from data furnished by the Division of Fish and Game.

During the season of 1928 it became evident that a considerably larger proportion of small fish was being brought to the markets from sea trolling than ever before. The fishermen attempted as usual to account for this in various ways, but a small sampling of the Monterey catch seemed to indicate that a large proportion of young and immature fish was being taken. Of 383 representative examples secured from June 22 to July 15, 56.9 per cent were in the second year of growth; 31.4 per cent were in the third year, 10.9 per cent in the fourth year, and 0.8 per cent in the fifth year. This was an enormous increase in the relative number of two- and three-year fish over what may be regarded as the normal of preceding years.

In 1929 a careful survey of the situation was made at Monterey from April 23 to July 29, inclusive, when samples of the catch were taken. Scales were collected, measurements and sex determinations were made of 2847 fish. Of these 17.5 per cent were in the second year of growth and 62.3 in the third year. Only 17.2 per cent were in the fourth year, 2.9 in the fifth and 0.1 of one per cent in the sixth year. It appears then that 79.8 per cent of the catch was made up of two- and three-year fish. (Fig. 30.) (Full particulars are given in table 45.)

Here is a notable departure from the normal as indicated in tables 64 and 67. It is not only evident that an unusually large number of

1925		1926		1927		
Santa Cruz	Monterey	Santa Cruz	Monterey	Santa Cruz	Monterey	
43	32,874	0	48	0	0	January
248	68,547	0	0	0	0	February
8,837	238,095	0	0	1,240	4	March
89,248	167,582	0	322	58,454	137,752	April
45,864	157,239	1,968	30,832	23,647	180,318	May
49,121	180,942	7,778	8,031	35,327	145,063	June
45,001	8,430	2,016	0	90,857	29,653	July
6,233	333	306	287	6,660	8,052	August
78	0	167	0	0	0	September
0	0	0	0	0	0	October
0	0	0	0	0	0	November
0	0	0	0	0	0	December
244,673	854,042	12,235	39,520	216,185	500,842	Totals

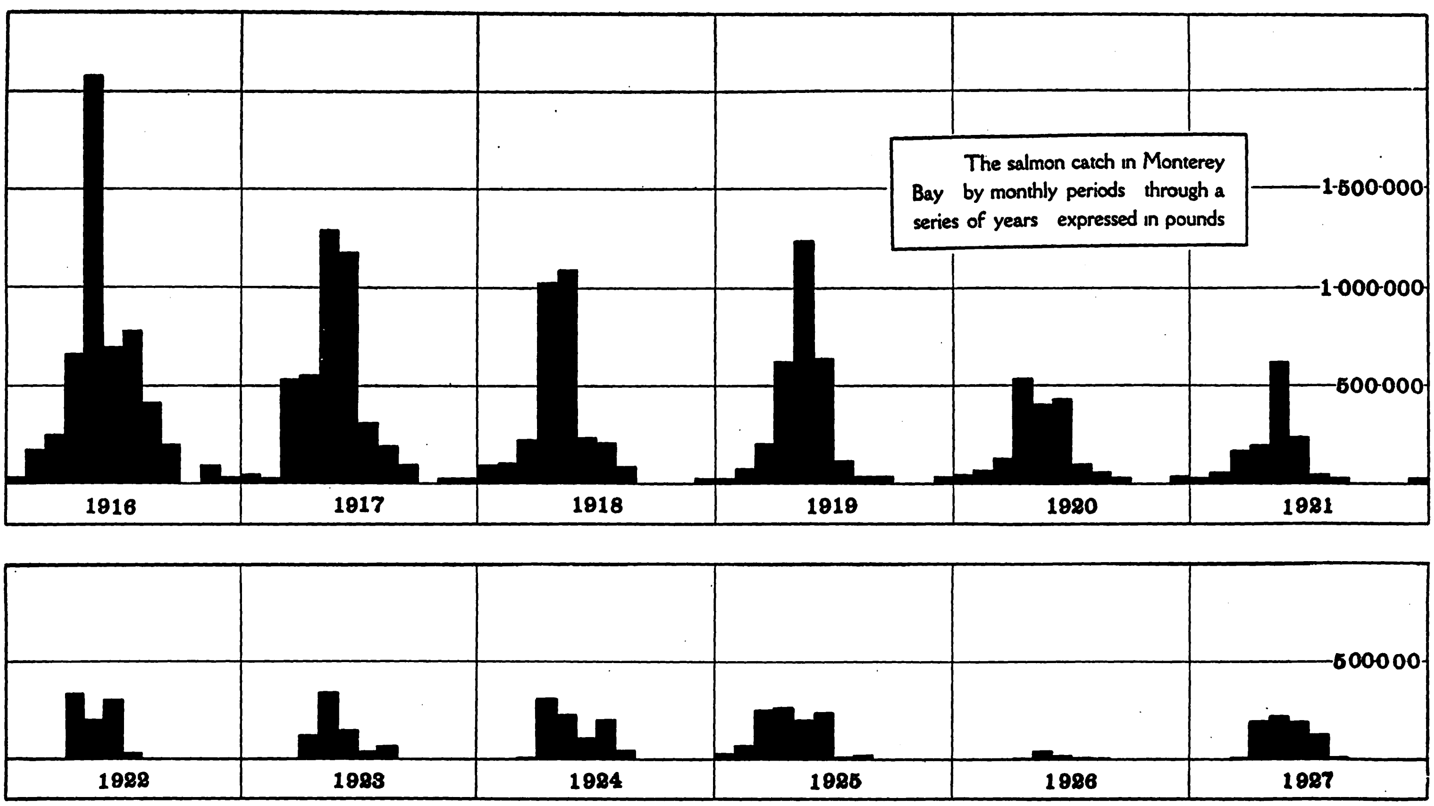
The salmon catch in Monterey Bay by monthly periods through a series of years expressed in pounds
1-500-000
1-000-000
500-000
1916
1917
1918
1919
1920
1921
500000
1922
1923
1924
1925
1926
1927

FIG. 28.

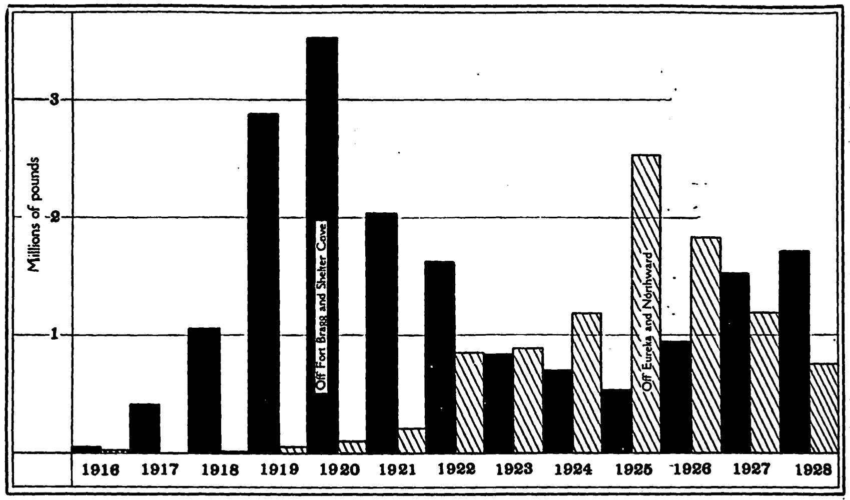

FIG. 29. Salmon catch off Fort Bragg and Shelter Cove, and off Eureka and northward, expressed in millions of pounds.

TABLE 44

Salmon Catch of California from 1916 to 1928 Expressed in Pounds

Year	Monterey	Santa Cruz	Near San Francisco	Near Ft. Bragg and Shelter Cove	Off Eureka and northward
1916	5,071,891	158,948	260,030	7,654	90,699
1917	3,608,672	270,815	1,242,913	401,450	522,742
1918	2,682,953	209,923	1,756,134	1,097,771	12,840
1919	2,316,854	499,168	1,427,137	2,899,603	50,039
1920	1,291,738	199,139	1,451,270	3,015,130	100,251
1921	860,402	383,558	937,452	2,084,080	216,179
1922	482,771	397,358	951,137	1,621,760	875,081
1923	422,000	306,336	1,283,748	812,867	880,844
1924	504,955	372,231	3,616,455	687,240	1,193,102
1925	854,042	244,673	1,270,918	582,194	2,529,691
1926	39,520	12,235	936,330	982,295	1,865,214
1927	500,842	216,185	1,488,746	1,528,898	1,186,908
1928	259,408	75,246	815,815	1,562,715	731,117

young fish were being killed, but it is also reasonable to presume that there is before us ample evidence of extreme depletion. Unless an unsound inference is being made, it would seem that the supply of old fishes is inordinately reduced, and that the Monterey Bay catch of 1929 was greatly reducing the population of young fish which should be left to mature in the near future.

Other offered explanations of the exceptional abundance of small fish in the catch, such as "these fish did not grow large as usual," "the large fish are feeding farther out," or "the abundance of young fish is the precursor of large catches next year," do not seem to be borne out by the facts.

There is no room for the presumption that a large harvest of male fish which would presumably mature as grilse was made, for it is found that sex representation in the catch of 1929 was about normal.

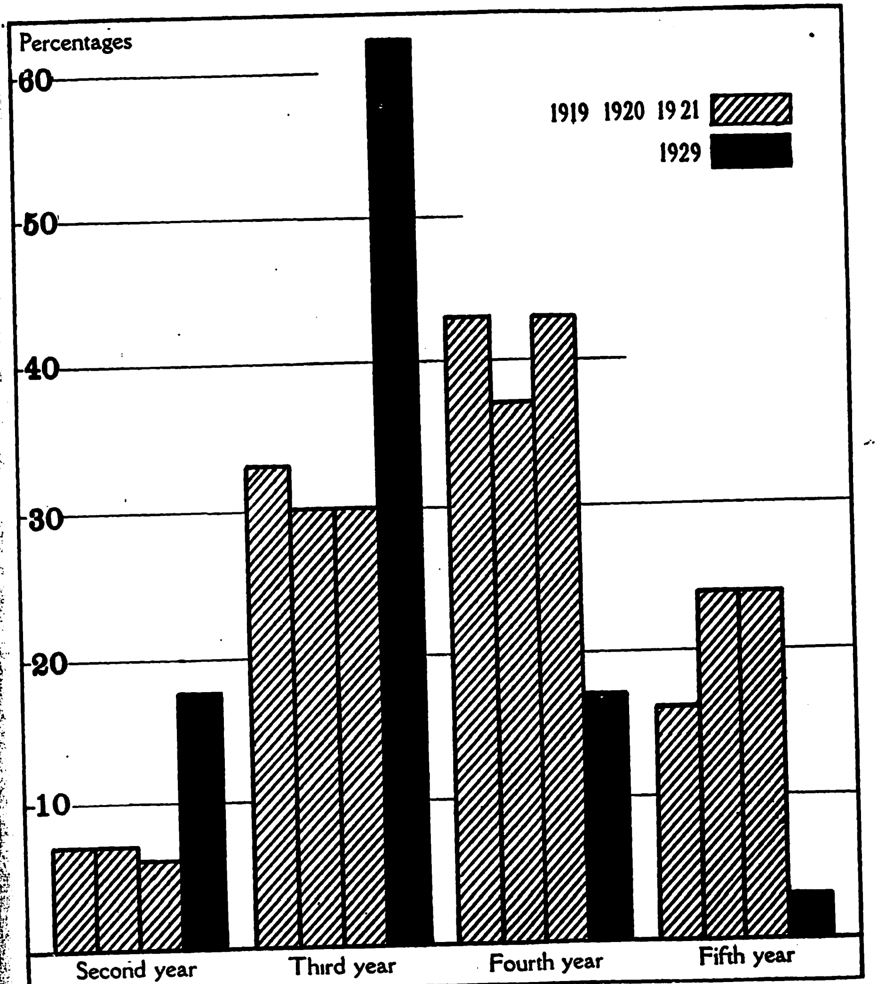

FIG. 30. Graph expressing the percentage of each year class in the Monterey catches for four years. Note the great relative increase of two- and three-year fish (black) in the season of 1929.

In the Sacramento River the catch has fallen away in an unmistakable manner as is evidenced by table 48.[15]

Depletion in the Sacramento can only affect the Klamath indirectly, in that an increased demand for fresh fish will call attention to the nearest supply. But depletion in the ocean affects the Klamath directly, for it has been definitely shown that the feeding grounds of Klamath salmon extend to Monterey Bay.

Previous to the appearance of G. R. Field in the fishing activities of Klamath River no records relating to the catch appear to have been kept. Access to his books which was generously given, revealed a continued expansion of statistics other than those relating to business

[15] Clark, G. H. Sacramento-San Joaquin salmon (*Oncorhynchus tschawytscha*) fishery of California. California Division of Fish and Game, Fish Bull., no. 17, 1929.

TABLE 45

MONTEREY BAY 1929

Length in centimeters	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60
Two Year Class, Ocean Type, Males			1	2	5	7	8	19	28	24	26	26	38	37	32	33	21	19	18	14	7	7	4		
Two Year Class, Ocean Type, Females						1	5		4	10	12	15	7	10	10	13	5	7	7	4	2	3			
Two Year Class, Ocean Type, Total			1	2	5	8	13	19	32	34	38	41	45	47	42	46	26	26	25	18	9	10	4		
Two Year Class, Stream Type, Males	1									2															
Two Year Class, Stream Type, Females										1															
Two Year Class, Stream Type, Total	1									3															
Total 2 year fish	1		1	2	5	8	13	19	32	37	38	41	45	47	42	46	26	26	25	18	9	10	4		
Three Year Class, Ocean Type, Males										2	3	1	3	5	9	8	15	14	18	19	28	34	29	37	43
Three Year Class, Ocean Type, Females										1	2		4		6		4	14	9	26	28	26	34	34	38
Three Year Class, Ocean Type, Total										3	5	1	7	5	15	8	19	28	27	45	56	60	63	71	81
Three Year Class, Stream Type, Males					1		1			2	2		1	4	7	6	8	6	8	2	3	9	12	4	4
Three Year Class, Stream Type, Females						1			1		2		1	3	3	2	5	3	4	3	5	3	2	6	2
Three Year Class, Stream Type, Total					1	1	1		1	2	4		2	7	10	8	13	9	12	5	8	12	14	10	6
Total 3 year fish					1	1	1		1	5	9	1	9	12	25	16	32	37	39	50	64	72	77	81	87
Four Year Class, Ocean Type, Males																									1
Four Year Class, Ocean Type, Females																									1
Four Year Class, Ocean Type, Total																									2
Four Year Class, Stream Type, Males																									
Four Year Class, Stream Type, Females																				1		1			2
Four Year Class, Stream Type, Total																				1		1			2
Total 4 year fish																				1		1			4
Five Year Class, Ocean Type, Males																									
Five Year Class, Ocean Type, Females																									
Five Year Class, Ocean Type, Total																									
Five Year Class, Stream Type, Males																									
Five Year Class, Stream Type, Females																									
Five Year Class, Stream Type, Total																									
Total 5 year fish																									
Six Year Class, Ocean Type, Males																									
Six Year Class, Ocean Type, Females																									
Six Year Class, Ocean Type, Total																									
Six Year Class, Stream Type, Males																									
Six Year Class, Stream Type, Females																									
Six Year Class, Stream Type, Total																									
Total 6 year fish																									

Length in centimeters	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85
Two Year Class, Ocean Type, Males				1																					
Two Year Class, Ocean Type, Females					1	1																			
Two Year Class, Ocean Type, Total				1	1	1																			
Two Year Class, Stream Type, Males																									
Two Year Class, Stream Type, Females																									
Two Year Class, Stream Type, Total																									
Total 2 year fish				1	1	1																			
Three Year Class, Ocean Type, Males	47	41	47	52	52	54	41	32	26	26	26	15	14	10	7	7	1	4	2						
Three Year Class, Ocean Type, Females	46	45	51	49	56	50	53	52	53	37	24	36	18	14	12	13	4	5	5						
Three Year Class, Ocean Type, Total	93	86	98	101	108	104	94	84	79	63	50	51	32	24	19	20	5	9	7						
Three Year Class, Stream Type, Males	2	2	1		2	2		1																	
Three Year Class, Stream Type, Females	2	3	2			6	2		1																
Three Year Class, Stream Type, Total	4	5	3		2	8	2	1	1																
Total 3 year fish	97	91	101	101	110	112	96	85	80	63	50	51	32	24	19	20	5	9	7						
Four Year Class, Ocean Type, Males		1				2	2	1	1	8	5	13	10	7	11	4	8	2	7	4	6	4	4	4	4
Four Year Class, Ocean Type, Females	1	1	1			3	3	6	3	5	7	11	6	11	7	11	6	13	3	2	5	6	5	6	4
Four Year Class, Ocean Type, Total	1	2	1			5	5	7	4	13	12	24	16	18	18	15	14	15	10	6	11	10	9	10	8
Four Year Class, Stream Type, Males				2	2	1	3		1	5	6	4	7	2	4	1	3	3	1	1	2	2	1	2	
Four Year Class, Stream Type, Females		2	1	3	3	6	6	3	4	3	6	4	10	8	6	7	3	5	2	6	1	2	2	4	
Four Year Class, Stream Type, Total		2	1	5	5	7	9	3	5	8	12	8	17	10	10	8	6	8	3	7	3	4	3	6	
Total 4 year fish	1	4	2	5	5	12	14	10	9	21	24	32	33	28	28	23	20	23	13	13	14	14	12	16	8
Five Year Class, Ocean Type, Males																									
Five Year Class, Ocean Type, Females																									
Five Year Class, Ocean Type, Total																									
Five Year Class, Stream Type, Males																						1	1	1	
Five Year Class, Stream Type, Females								1											1	1		1	2	1	1
Five Year Class, Stream Type, Total								1											1	1		2	3	2	1
Total 5 year fish								1											1	1		2	3	2	1
Six Year Class, Ocean Type, Males																									
Six Year Class, Ocean Type, Females																									
Six Year Class, Ocean Type, Total																									
Six Year Class, Stream Type, Males																									
Six Year Class, Stream Type, Females																		1							
Six Year Class, Stream Type, Total																		1							
Total 6 year fish																		1							

Length in centimeters	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100	101	102	103	104	105	106	107	108	Total
Two Year Class, Ocean Type, Males																								377
Two Year Class, Ocean Type, Females																								117
Two Year Class, Ocean Type, Total																								494
Two Year Class, Stream Type, Males																								3
Two Year Class, Stream Type, Females																								1
Two Year Class, Stream Type, Total																								4
Total 2 year fish																								498
Three Year Class, Ocean Type, Males																								772
Three Year Class, Ocean Type, Females																								849
Three Year Class, Ocean Type, Total																								1621
Three Year Class, Stream Type, Males																								90
Three Year Class, Stream Type, Females																								62
Three Year Class, Stream Type, Total																								152
Total 3 year fish																								1773
Four Year Class, Ocean Type, Males	4	6	8	6	4	5	9	5	5	3		7	4	2	3	1	2						1	184
Four Year Class, Ocean Type, Females	1	2	3	4	1		2	2			1													143
Four Year Class, Ocean Type, Total	5	8	11	10	5	5	11	7	5	3	1	7	4	2	3	1	2						1	327
Four Year Class, Stream Type, Males			1		3																			57
Four Year Class, Stream Type, Females		1	2	1																				105
Four Year Class, Stream Type, Total		1	3	1	3																			162
Total 4 year fish	5	9	14	11	8	5	11	7	5	3	1	7	4	2	3	1	2						1	489
Five Year Class, Ocean Type, Males		2		2	1		1	1	2	2	1	2	1		2		1		1		2		1	22
Five Year Class, Ocean Type, Females					3		1	2	1	1			2		1			1			1			13
Five Year Class, Ocean Type, Total		2		2	4		2	3	3	3	1	2	3		3		1	1	1		3		1	35
Five Year Class, Stream Type, Males	1		1	1	1	2	2	3	2	2	3	2						1	1					25
Five Year Class, Stream Type, Females	5	3	1	2	1				1		1	1												23
Five Year Class, Stream Type, Total	6	3	2	3	2	2	2	3	3	2	4	3						1	1					48
Total 5 year fish	6	5	2	5	6	2	4	6	6	5	5	5	3		3		1	2	2		3		1	83
Six Year Class, Ocean Type, Males																								
Six Year Class, Ocean Type, Females																								
Six Year Class, Ocean Type, Total																								
Six Year Class, Stream Type, Males										1														1
Six Year Class, Stream Type, Females						1	1																	3
Six Year Class, Stream Type, Total						1	1			1														4
Total 6 year fish						1	1			1														4

TABLE 46

Summary of Monterey Bay Age Classes, 1929

Year classes	Two	Three	Four	Five	Six	Totals	Percentages
Males	380	862	241	47	1	1,531	53.8
Females	118	911	248	36	3	1,316	46.2
Ocean type	494	1,621	327	35	------	2,477	87.0
Stream type	4	152	162	48	4	370	13.0
Ocean type males	377	772	184	22	------	1,355	47.6
Ocean type females	117	849	143	13	------	1,122	39.4
Stream type males	3	90	57	25	1	176	6.0
Stream type females	1	62	105	23	3	194	6.9
Totals	498	1,773	489	83	4	2,847	------
Percentages	17.5	62.3	17.2	2.9	.1	------	------

TABLE 47

Catch of	Percentages of	
	Males	Females
1929	53.8	46.2
1919	54.0	46.0
1920	51.0	49.0
1921	51.0	49.0

TABLE 48

Salmon Catch in Sacramento River

Date	Pounds live weight
1916	3,450,786
1917	3,795,486
1918	5,938,029
1919	4,529,222
1920	3,860,312
1921	2,511,127
1922	1,705,066
1923	2,243,945
1924	2,640,110
1925	2,778,846
1926	1,261,776
1927	917,525
1928	553,777

transactions up to 1917 when an interesting record appears, which takes separate account of the king salmon, silver salmon and even the steelheads, when the latter happen to be caught. The year 1912 is there said to have witnessed the greatest run of salmon known to white men. The pack was something over 1,384,000 pounds, and a conservative estimate of the number of fish caught amounted to 141,000. In one day 17,000 were taken. Three plants were then operating and the river was fished to the limit.

A digest of fishing activities compiled partly from Field's notes and partly from records in the State Division of Fish and Game follows:

NOTES RELATING TO THE SALMON CATCH OF KLAMATH RIVER[16]

1912. The plant of the Klamath River Packing Company began operations June 4. From June 4 to July 5, 426 cases of halves and 116 cases of one-pound cans were packed. (One case=48 cans); July 5 to 15, 550 halves; July 15 to 17, 4 halves. Number salmon caught in June, 1190; July, 12,042; no detailed data for remainder of season. Total for season, an amount equal to 13,300 cases of one-pound cans.

Three plants operated: Klamath River Packing Company, 13,300 cases of ones; Klamath River Canning Company, 10,611 cases of ones; Del Norte Salmon Canning Company, 5000 cases of ones; all king salmon. Season's pack, 28,911 cases of ones. Halves were packed, but they are reduced to ones in the above account.

1913. Three plants operated: Klamath River Packing Company, 5800 cases of ones; Klamath River Canning Company, 3400 cases of ones; Del Norte Salmon Canning Company, 3000 cases ones. Total, 12,200 cases of ones.

The Klamath River Packing Company took during June, 596 fish; July, 6242; August, 19, 276; September, 2479; total, 28,593. No detailed fall record.

1914. Klamath River Packing Association operated alone. Summer pack, 11,829 cases ones; fall, 5260 cases ones. June, 417 fish; July, 12,758; August, 47,558; September, inc. 6, 2775; total to September 6, inc., 63,508 fish; September 21 to October 1, 127,199 lbs., live weight; October 1 to 24, 233,985 lbs.; total, September 21 to October 24, 361,184 lbs., live weight. September-October includes silver salmon. The fall pack was: Kings, 508 cases of ones; silvers, 4752 cases of ones. No silver salmon before September 21.

1915. Klamath River Packing Association opened June 21, closed October 25. June, 871 fish; July, 7252; August, 55,327; September to September 5, 8807; total to date, 72,257, all king salmon; September from 20th, 74,526 lbs.; October, 146,105 lbs.; total, September-October, 220,631 lbs., both king and silver salmon. Total for year, about 1,232,229 lbs.

1916. Klamath River Packers Association, June 26 to July, 342 fish; July, 6841; August, 21,309; September 1 to 6, 2327; 30,819 king salmon. September 22 to October, 57,761 lbs.; October, 178,904 lbs.; total, 236,665 lbs. king and silver salmon. Total for year about 668,131 lbs.

1917. Two companies operated: Klamath River Packers Association as follows: June 27, 2 fish; July, 427,; August, 3284; September 1 to 6, 1250. Total, 4963. September 20 to October, 2250 fish; October, 10,300; November 1 to 26, 1638. Total, 14,188. Total fish for year, 19,151; total weight, 241,910 lbs. Forty-four boats in use.

Requa Cooperative Packing Company. No data from this source. The Fish and Game Commission reports all fish from the river as follows: 265,537 lbs. king and silver salmon; 1710 lbs. steelheads.

1918. Two companies operated: Klamath River Packers Association, April, 47 fish; May, 109; July, 312; August, 12,140; September 1 to 6, 3226; September 20 to 30, 1106; October 1 to 23, 466. Total 17,406 king salmon weighing 221,949 lbs.; from September 20 to end of season, 10,893 silver salmon and steelheads weighing 71,014 lbs. were caught.

Requa Cooperative Packing Company—no data.

There were reported from all sources, 672,345 lbs.

1919. Klamath River Packers Association opened April 30. April-May, 1030 fish; July 7, to August. 1668; August, 23,591; September 1 to 6. 1605. Total, 27,894 king salmon weighing 375,472 lbs. September 20 to October, 2560; October 1 to 30, 670. Total 3230 king and silver salmon weighing 64,023 lbs. Total fish for season, 31,124; weight, 439,495 lbs.

Total reported from river to Fish and Game Commission, 535,198 lbs., including steelheads.

1920. Klamath River Packers Association opened April 19. April-May, 247 fish; July, 2964; August, 46,851; September 1 to 6, 4311. Total, 54,373 king salmon; weight. 809,040 lbs.

Total reported to Fish and Game Commission, 872,295 lbs. salmon; 5910 lbs., steelheads.

1921. Two companies operated: Klamath River Packers Association opened July 20. July. 948 fish; August, 38,521; September 1 to 6, 3527. Total, 42,996 fish; weight. 604,877 lbs.

The Del Norte Packing Company reported 10,148 lbs.

Total from river reported to Fish and Game Commission, 614,247 lbs.

1922. Two companies: Klamath River Packers Association opened July 29. July, 2227 fish; August, 51,163; September 1 to 6, 8112. Total, 61,502 fish; weight, 903,509 lbs.

Del Norte Packing Company—no data.

Total reported from the river, 1,039,680 lbs. of salmon; 2345 lbs. steelheads.

1923. Klamath River Packers Association opened July 16. July, 2093 fish; August, 47,092; September 1 to 6, 7814. Total, 56,999 king salmon; weight, 826,134 lbs.

1924. Klamath River Packers Association opened July 30. July-August, 38,659 fish; September 1 to 6. 7212. Total. 45.871 king salmon; weight, 685,469 lbs.

Several small dealers bought fish, bringing the reported catch up to 814,572 lbs.

1925. Klamath River Packers Association. July 7 to 31, 6317 fish; August, 430,901; September 1 to 6, 4610. Total, 54,828 king salmon, weight, 867,103 lbs.

Some small dealers operated, bringing the reported catch up to 956,393.

[16] Mr. H. C. Roberts aided in the preparation of this summary of Field's notes. He also contributed observations relating to the habits of salmon in the estuary.

1926	July	August	September
Ellis	6,692	7,249	----------
Klamath River Packers Association	13,885	375,997	141,768
Paladini	2,320	25,805	19,924
Patterson Bros.	13,647	138,793	48,230
Fisher	----------	12,632	823
Womack	----------	3,949	----------
Total pounds	36,544	564,425	210,745

Total for 1926 season: 811,714 pounds.

1927	July	August	September
Horn	11,235	48,257	913
Patterson	3,957	68,044	3,693
Klamath River Packers Association	12,528	208,735	17,981
Ellis	----------	13,290	6,642
Estes	----------	2,798	857
Fisher	----------	2,325	4,163
Paul	----------	1,108	837
Total pounds	27,720	344,557	35,086

Klamath River Packers Association received 239,244 lbs. (16,843 fish) in 1927.
A total of 408,081 lbs. was reported to the State Fish and Game Commission for 1927.

A summary of the above data may be made as follows (table 49): (This table is also graphically represented by figure 31.)

TABLE 49

Year	The catch of the Klamath River Packers Association	Entire catch as reported to Division of Fish and Game
	(lbs.)	(lbs.)
1915	1,232,229	1,232,229
1916	668,131	801,150
1917	241,910	265,537
1918	292,963	672,345
1919	439,495	535,198
1920	809,040	872,295
1921	604,877	614,247
1922	903,509	1,039,580
1923	826,134	824,291
1924	685,469	814,572
1925	867,103	956,082
1926	531,650	811,714
1927	239,244	408,081
1928	164,470	308,826

An inspection of the table and graph might make it appear that depletion is not serious, but it is known that the catch of the Klamath has been maintained chiefly through increased effort. The large catch of 1915 was made with a maximum of 40 boats in service, while in 1926, 126 boats and a correspondingly large number of fishermen were engaged. The only available measure of the effort required to make the catch is the number of boats employed, and all things considered, it appears to be a fair measure. Detailed data relating to boats as furnished by Harry Roberts follows. Figure 32 represents in a graphic way the gradual increase in fishing effort.

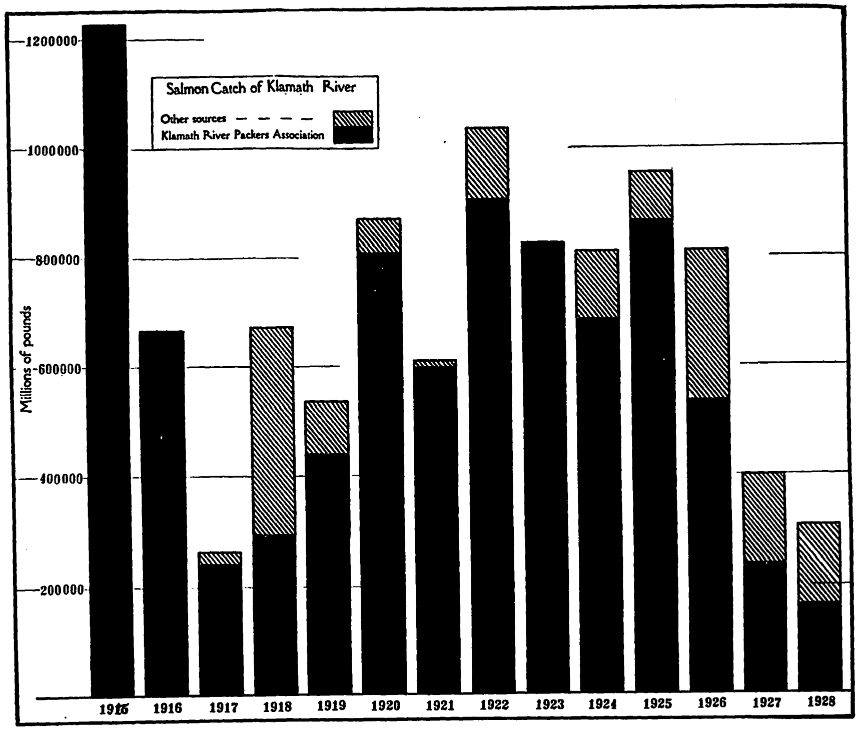

FIG. 31.

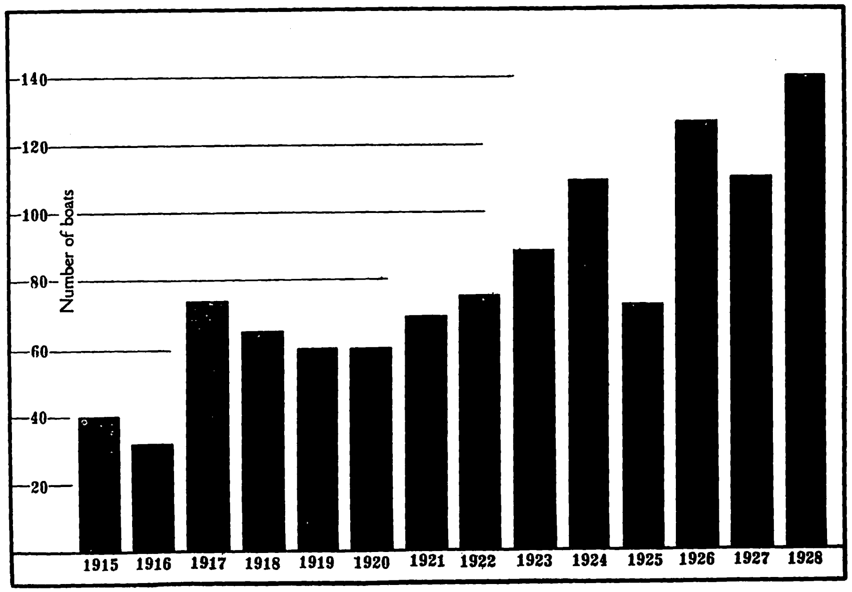

FIG. 32. Graph showing the number of boats annually employed in taking the commercial catch in Klamath River.

TABLE 50

Number of Boats in Service During the Month of August of Each Year

1915	1916	1917	1918	1919	1920	1921	1922	1923	1924	1925	1926	1927	1928
40	32	74	65	60	60	69	75	88	109	97	126	110	140

Since a greatly increased effort has not resulted in a corresponding increase of the catch, the only inference to be made is that the supply has diminished.

In 1921 the writer spent some time along the river and its main tributaries in an attempt to learn something of the migration of salmon. In interviews at that time it was constantly affirmed by people living in the region, that the supply of salmon had been greatly depleted in recent years.

The number of spawning fish taken at the racks at Klamathon have greatly decreased since 1925 as is shown by the census recorded in the following table.

TABLE 51

Summary of Klamathon Station Spawning Records

	1925	1926	1927	1928	1929	1930
KING SALMON						
Grilse	1,277	3,401	----------	----------	*1,822	924
Males of spawning age	4,202	1,250	600	540	226	260
Females spawned	4,605	3,872	1,365	1,577	950	618
Males dead on racks	184	317	----------	----------	506	260
Females dead on racks	152	302	----------	----------	527	330
Marked salmon	36	246	50	4	0	----------
Totals	10,420	9,387	----------	----------	4,031	2,392
SILVER SALMON						
Males	269	1,301	----------	----------	----------	----------
Females	26	307	----------	----------	----------	----------
Totals	295	1,608	----------	----------	----------	----------

*On December 26, 1929, E. V. Cassell wrote: "The dead females were all spent. Hundreds of undersize grilse came into Fall Creek during the fall season. These fish slipped through the one and one-half inch spacing of the upper racks at Klamathon. This is unusual."

Fishermen and others interested in the industry report that the migration is appearing later each year. This statement usually accompanies a plea for an extension of the legal season. As expressed elsewhere in this paper, it is believed by the writer that this is a phenomenon of depletion. Instead of the run appearing later in the season, the fish are becoming less numerous, and as a result the curve representing the migration is being reduced, and hence shortened. What is meant may be better illustrated than said by figure 33. Here the catches of the Klamath River Packers Association for the years 1915 and 1926 are represented by curves. A reduction of the curve of 1926 causes it to make its appearance later in the season. The September ends of both curves are lost because of the legal closure of the fishing season on September 6. It is known, however, that this end of the curve falls away very rapidly.

No trustworthy evidence is at hand which may be invoked to show that the supply of salmon is on the increase, or that the stock is being

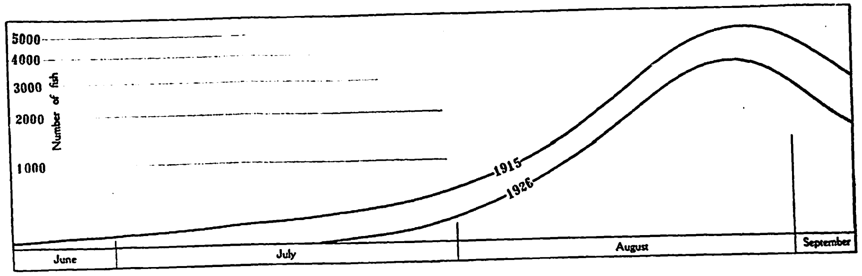

FIG. 33. Curves representing the migrations of 1915 and 1926.

maintained, while on the contrary there is ample reason to believe that the fishery will not long stand the draft that is now being levied against it.

There are indications that some efforts at protection which are now applied are not entirely effective. For example, the short closed period may be mentioned. That this is of little avail may be demonstrated by an inspection of table 12 or figure 4, where it appears that a distinctly large catch usually follows an inactive period. The closed periods accomplish little more than to allow fish to accumulate in the estuary to be taken on the following day.

Whether or not the facts here offered be accepted as an indication of depletion, it goes without question that evidence of a more exact sort should be produced. Such evidence will only come from careful observation. There is at present no certainty that all of the phenomena are known which may manifest themselves as the population of a species of salmon suffers great depletion, and hence the direction of observations which may result in the detection or measure of depletion is difficult and more or less uncertain. There is no question, however, as to the value of a yearly census of the population, when such may be secured. In addition to what we may now get from the catch at the mouth of the river and from the racks at Klamathon, there should be a careful yearly examination of certain representative spawning areas in the Klamath basin which should be made by a competent observer. Also, one or more typical streams should be barred with a rack and traps, in such a way as to furnish the conditions for taking an accurate census of each year's migration.

THE OCEAN CATCH

Until quite recently it was not thought that salmon produced by Klamath River were contributing in any substantial way to the ocean catch. Under the supposition that fish on their nuptial migration from the ocean must return to their native streams, it was presumed that during their ocean life they did not stray far from the mouth of the river of their nativity. The late George R. Field, manager of the plant of the Klamath River Packers Association, was a careful observer and by nature a naturalist. He had implicit confidence in the above presumption and frequently expressed himself as not being disturbed by ocean fishing as long as boats did not operate north of Trinidad. But before boats appeared north of that port, occasional fish came into the Klamath bearing indisputable evidence of contact with marine fishermen, in the shape of hooks, spoons and other pieces of tackle.

Recent observations[17] have amply demonstrated that ocean migrations are extensive, and any study which involves questions of river conservation or depletion, or practices relating to artificial propagation, must take into account many factors of ocean life.

In recent years the catch from the ocean has been gaining in importance when compared with that from the rivers, as expressed in the following table 52, and likewise in figure 34.

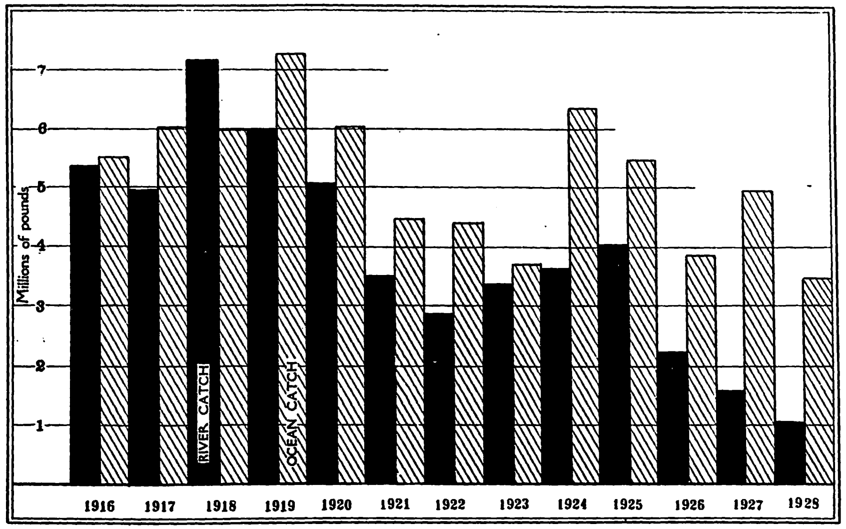

FIG. 34. The river and ocean catches of salmon in California expressed in millions of pounds.

TABLE 52

Year	Total salmon: Caught in rivers	Total salmon: Caught in ocean
1916	5,347,378	5,592,081
1917	4,974,584	6,083,991
1918	7,154,542	5,932,281
1919	5,937,296	7,208,372
1920	5,060,705	6,066,190
1921	3,501,663	4,483,100
1922	2,896,807	4,338,317
1923	3,353,336	3,736,924
1924	3,640,696	6,374,573
1925	4,044,217	5,481,536
1926	2,220,402	3,863,677
1927	1,590,329	4,921,600
1928	1,034,260	3,444,306

[17] Mottley, Charles McC. Pacific salmon migration: Report on the study of the scales of the spring salmon *Oncorhynchus tschawytscha* tagged in 1926 and 1927 off the west coast of Vancouver Island. Contributions to Canadian Biology and Fisheries, n.s., vol. 4, no. 30, pp. 471–494, 1929.

Rich, Willis H., and Holmes, Harlan B. Experiments in marking young chinook salmon on the Columbia River, 1916 to 1927. U. S. Bureau of Fisheries, Bull. (for 1928), vol. 44, doc. 1047, pp. 215–264, 1929.

Rich, Willis H., and Morton, Frederick G. Salmon-tagging experiments in Alaska, 1927 and 1928. U. S. Bureau of Fisheries, Bull. (for 1929), vol. 45, doc. 1057, pp. 1–23, 1930.

Snyder, John O. A third report on the return of king salmon in 1919 in Klamath River. California Fish and Game, vol. 10, no. 3, pp. 110–114, 1924.

Some difficulty is encountered in segregating the reports of either ocean or river caught fish, but the amounts here given are sufficiently accurate for the purpose of comparison. Discrepancies may be checked against a record of the entire catch in California for the same period.

TABLE 53

Total Catch of Salmon in California Expressed in Pounds

Year	Pounds
1916	10,939,594
1917	11,060,581
1918	13,093,188
1919	13,145,727
1920	11,133,819
1921	7,990,932
1922	7,235,124
1923	7,090,260
1924	10,015,269
1925	9,525,753
1926	6,084,079
1927	6,511,929
1928	4,478,566

The above data are expressed graphically in figure 27. In 1916 the rivers produced an amount about equal to that of the ocean, in 1917 a decided gain appeared in favor of the sea, while in 1918 the river catch was considerably the larger. From 1919 to the present, the ocean catch has remained larger and also increased in relative importance.

Fishermen and others, who have had opportunity to observe king salmon at sea, state that they move in schools. One frequently hears the sea fishermen speak of "finding the school," "striking the school," *etc.* Salmon frequently, if not always, enter the river in schools, and the school may remain in compact formation for a time while in the estuary. An observation of the catch will occasionally demonstrate this. For example, in 1922 on the evening of August 23, the Klamath River fishermen, unaware that anything unusual was about to occur laid out their nets in the customary way. The nets which were spread below Windy Point were almost at once clogged with enmeshed fish, and so many were captured in such a brief time, that a lookout, fearing that the cannery would be overtaxed blew the recall whistle. Upon assembly of the boats it was found that 4406 fish had been taken, and that practically all of them were from a small area of the river between Windy Point and Pecheco Rock. Fishermen who laid their nets elsewhere caught very few fish or none at all. Here it was apparent that a large and compact school had been intercepted.

A sample of 69 fish taken at random from the catch gave 61 examples with the ocean type of nucleus, 26 of which were in the third year, 33 in the fourth year and 2 in the fifth. Of the stream type, 3 were four-year fish, while 4 were five and 1 six. Of 200 specimens which were examined for sex, 66 were males and 134 females. It appears then that the school was made up of a rather heterogeneous assemblage, remarkable perhaps for the unusual number of three-year fish. Of these, 14 were females with the ocean type of nucleus.

Sometime ago an observation was made in connection with a marking experiment, which appears to indicate that certain fishes may remain for a considerable time, if not throughout their entire life, in the same

school.[18] The so-called homing instinct of king salmon was under study and a number of marked fish were turned loose in Klamath River at Fall Creek. When some of these fish returned as grilse in the third year it was apparent that the scales of each one bore a peculiar growth mark in the region representing the period just preceding the winter check. (See *C* and *D* in fig. 35. This mark, an anatomical peculiarity was unusual and very distinct. From experience gained in the examination of many such scales it was assumed that *D* represented the winter check in the growth of the fish. Abundant material from Monterey Bay demonstrates that this check or slowing down in the normal growth of the fish occurs in the winter or early spring, but not in all individuals at the same time. This winter check is a normal anatomical feature of practically all king salmon scales. The check *C* which appears within the other occurred at a previous time and may be spoken of as a secondary check. It represents a period in which the rapid growth of the fish was suddenly interrupted for a time, after which growth was resumed only to be again interrupted by the usual period of winter quiescence. This same secondary check appeared in the scales of marked fish of the same experiment, which were taken in the following years.

If one accepts the hypothesis that the growth of the individual is reflected by the growth of the scale, and that the growth is influenced by environment, whatever that may be, the assumption follows that all of these fish must have been in contact with the same environmental conditions for at least a short time during the second year of growth. It suggests that associations formed in the stream continued through the second year at sea, the fish remaining together, possibly in the same large school.

When the marked fish to the number of 25,000 were liberated in Klamath River, approximately 250,000 yearlings with the same life history except that they bore no distinctive fin marks, were set free with them. If any number of these remained together at sea it was to be expected that some of them would bear scales like those of the marked fish. Such was the case, as was found in the returned grilse and also in older fish. (See *C* and *D* in Fig. 35.) It was thought that unmarked individuals might be found at sea associated with the others and that they might be recognized by scale structure. Accordingly, when marked fish were discovered in a sea catch near Eureka, scales were taken from all fish in the same boat. A search among the scales of 155 individuals so taken from several boats revelead 6 which the writer is satisfied may be regarded as fishes of the 1919 liberation although they bore no fin marks. A scale of one of these is illustrated. (Figs. 36 and 37.)

Here then is evidence, meager though it may be, that salmon may remain closely associated, individuals possibly schooling together while in the ocean, and for a considerable period of their life.

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[18] Snyder, J. O. The return of marked king salmon grilse. California Fish and Game, vol. 8, no. 2, pp. 102–107, 1922.

Snyder, J. O. A second report on the return of king salmon marked in 1919, in Klamath River. California Fish and Game, vol. 9, no. 1, pp. 1–11, 1923.

Snyder, John O., and Scofield, Eugene C. An experiment relating to the homing instinct of king salmon. California Fish and Game, vol. 10, no. 1, pp. 9–17, 1924.

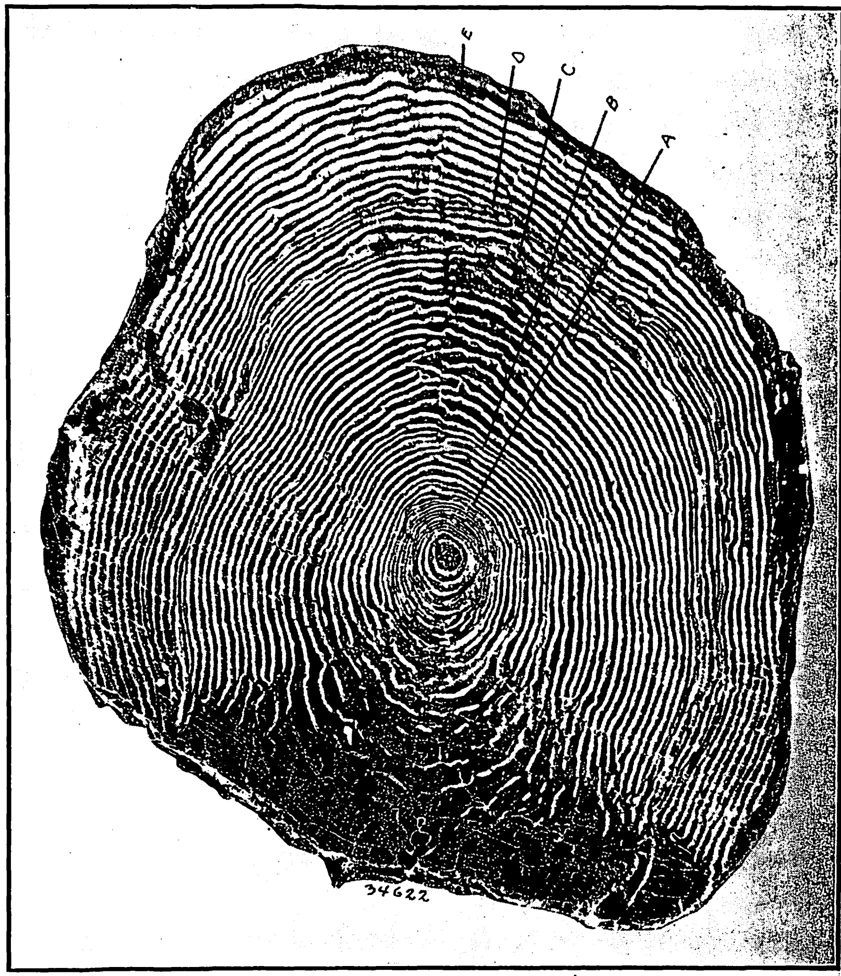

FIG. 35. Photomicrograph of a scale of a marked king salmon grilse which returned to Klamathon racks in 1921.

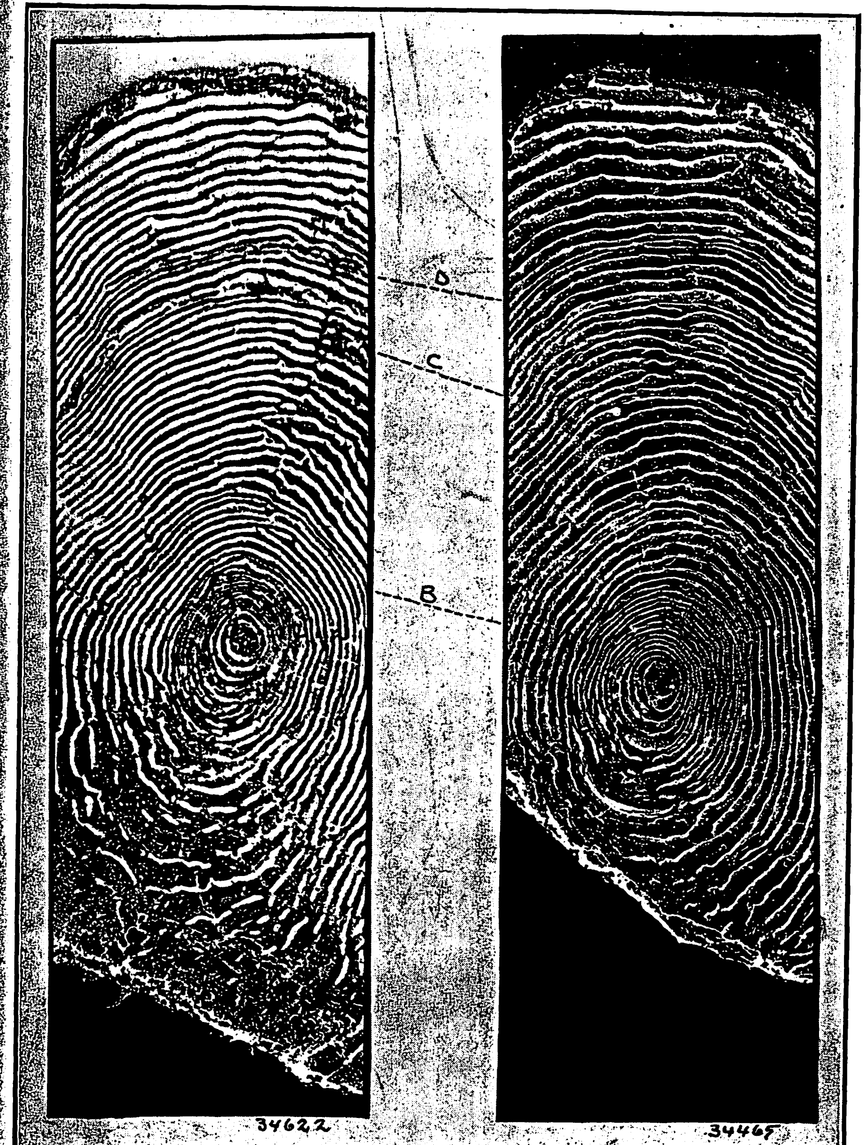

FIG. 36. Scales of marked (34622) and unmarked (34465) king salmon grilse which returned to Klamathon racks in 1921.

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FIG. 37. Photomicrograph of a scale of a salmon taken off Cape Mendocino, August 5, 1922, which shows convincing structural resemblance to scales of fish of the 1919 planting.

Ocean trolling[19] for salmon in this state originated in Monterey Bay where a fleet of small sailing craft grew in numbers, only to be replaced by larger, swifter, and more capable power boats. The explorations of the more venturesome operators of these boats extended the fishing area somewhat farther at sea, and also to the northward along the coast until now their activities reach the northern boundary of the state.

Success in the relatively shallow waters in the vicinity of Point Reyes led to fishing beyond Point Arena where a safe harbor was found in the estuary of Noyo River near Fort Bragg. About 1916, salmon from this point began to enter the market in quantity, and in two years a cannery and several mild cure plants were assisting in the care of a rapidly growing catch which reached its maximum in 1920 (fig. 29) and then began to decline. The Noyo industry extended to Shelter Cove where anchored barges took care of a part of the catch. A better picture of the activities in Noyo Estuary than appears from an examination of the statistics of the catch is presented by photographs and a sketch map made by the writer in 1920. The photographs (figs. 38, 39, and 40) were taken from points indicated on the map (fig. 41).

FIG. 38. View of Noyo Bay, from point marked *A* on map, figure 41.

As in Monterey Bay, decline began in the Fort Bragg region, and its progress was followed by a rise in the industry along the coast near Eureka where the greatest harvest was taken in 1925. Here the fishery has already been greatly overtaxed and in spite of increased effort the results rapidly diminish.

An inquiry as to whether ocean caught fish weigh less or more than those of equal length which are taken in the rivers is of interest, as some observers contend that the stream caught fish are heavier and more plump. An entirely satisfactory answer is not forthcoming however as will be seen. A direct comparison is not possible because the salmon

[19] An excellent account of the methods of ocean trolling is given by W. L. Scofield (Gear Used for Salmon Trolling in California in 1920. California Fish and Game, vol. 7, no. 1, pp. 22–38, 1921).

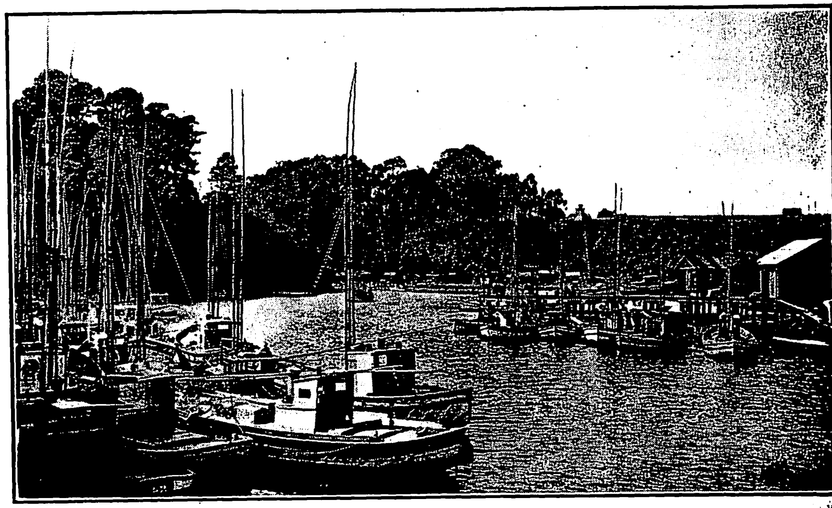

FIG. 39. Salmon boats in Noyo River, from point *B*, figure 41.

FIG. 40. Salmon boats Noyo River as seen from point *E*, figure 41.

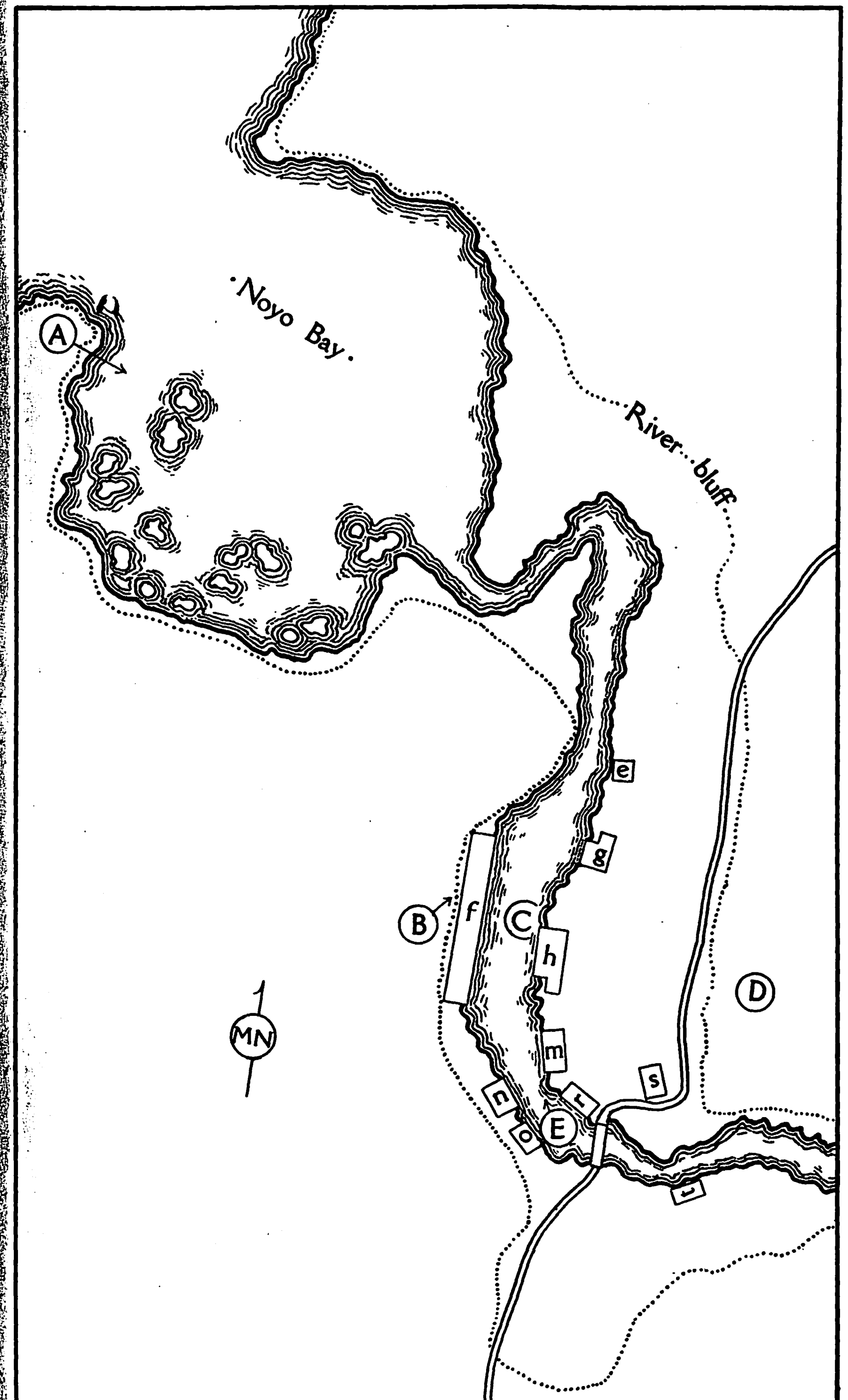

FIG. 41. Map of Noyo Bay near Fort Bragg showing the salmon fishery as of June 21, 1920; *e*, Repair shop; *f*, Noyo Fishermen's Association; *g*, Western California Fish Co.; *h*, Small and Urie; *m*, Columbia and Northern Fishing and Packing Co.; *n*, Independent Fish Co.; *o*, San Francisco [illegible]

of an ocean catch are probably from a composite mass, in so far as their stream origin is concerned and no means has as yet been discovered which will enable one to identify without question any ocean caught California salmon with the stream of its nativity.[20]

It has been shown that slight differences are to be found between the fish of Klamath and Sacramento rivers, but nothing of the kind has been determined for the inhabitants of other coastal streams. It is known from experimental evidence that fish taken in Monterey Bay may be from any salmon producing stream in the State. Possibly some Monterey Bay fish may come from rivers which enter the ocean north of the State.

However, numbers of ocean caught fish may be compared with numbers from the streams, and such a comparison is here attempted. Length-weight relations have been computed and it appears that when fish of marine origin are compared with those from the rivers, the later are slightly heavier. Tables 54 and 55, illustrating the length-weight relation of numerous salmon taken in Monterey Bay and off Fort Bragg, are here given. These may be compared with similar tables computed from river fish and presented in tables 2 and 3.

TABLE 54

Length-Weight Relation of Fish Taken in Monterey Bay. 1920

Length of fish in cm.	Average weight 20 males recorded in pounds and tenths	Average weight 20 females recorded in pounds and tenths	Extreme weights of males recorded in pounds and ounces	Extreme weights of females recorded in pounds and ounces
46	2.7	2.5	2- 0 to 3- 0	2- 4 to 2-12
48	2.9	2.9	2- 8 to 3- 8	2-12 to 3- 0
50	3.5	3.2	3- 0 to 3-12	2-12 to 3- 8
52	3.8	3.7	3- 6 to 4- 4	3- 4 to 4- 0
54	4.2	3.9	3- 8 to 4- 8	3- 4 to 4- 4
56	4.9	4.3	4- 8 to 5- 4	3- 8 to 4-12
58	5.4	5.2	5- 0 to 6- 4	4- 8 to 8-12
60	5.9	5.5	5- 4 to 6- 8	4-12 to 6- 0
62	6.5	6.1	5- 8 to 7- 0	5- 8 to 7- 0
64	7.1	7.0	6- 8 to 7- 8	5-12 to 8-12
66	7.6	7.6	6-12 to 8- 8	7- 4 to 8- 8
68	8.4	8.3	8- 0 to 9-12	6- 8 to 10- 8
70	8.9	9.4	9- 0 to 10- 8	8- 4 to 10- 8
72	10.0	9.8	9- 4 to 10-12	9- 0 to 12- 8
74	11.2	11.4	9-12 to 13- 0	10-12 to 14- 8
76	11.8	12.0	9- 0 to 13- 0	11- 8 to 14- 4
78	12.7	12.5	12- 4 to 15- 0	11-12 to 14- 4
80	13.9	13.6	9-12 to 16- 4	12- 8 to 17-12
82	14.9	14.7	13- 8 to 18- 0	11- 2 to 16- 0
84	15.4	16.0	14- 0 to 18- 4	14- 0 to 19- 4
86	16.5	16.9	14- 8 to 19-12	15- 0 to 19- 8
88	17.5	18.5	16- 4 to 19- 4	16- 0 to 24- 4
90	19.1	19.8	18- 8 to 23- 4	17- 8 to 24-12
92	20.4	20.9	18- 8 to 25- 4	19- 0 to 23- 0
94	22.4	23.0	20- 8 to 26- 8	22- 8 to 26- 4
96	23.8	24.3	21- 0 to 27-12	21-12 to 26- 8
98	24.7	27.5	21- 4 to 26-12	25- 8 to 32- 8
100	28.2	28.1	27- 0 to 31- 8	26- 4 to 31- 8
102	29.9	32.0	25- 4 to 34- 0	29-12 to 33- 8
104	32.8	33.5	29- 8 to 39- 0	30- 0 to 33-10
106	33.4	35.0	27-12 to 36- 4	34- 8 to 35- 8
108	34.4	36.0	25- 4 to 42- 4	36- 0 to 37- 0
110	36.1	37 5	35-12 to 44- 4	37- 0 to 38- 0

[20] Notable success has been attained in Washington, British America and Alaska, in tagging salmon caught at sea, and many of these have been traced to their native streams. Similar work attempted in California resulted in near failure.

TABLE 55

Length-Weight Relation of Fish Taken at Sea off Fort Bragg, 1919

Length of fish in cm.	Average weight 20 males recorded in pounds and tenths	Average weight 20 females recorded in pounds and tenths	Extreme weights males recorded in pounds and ounces	Extreme weights females recorded in pounds and ounces
58	5.0	4.5	5- 0 to 7- 0	4- 0 to 4-12
60	6.0	5.0	5- 8 to 6-10	5- 0 to 5-10
62	6.4	6.6	6- 0 to 7- 8	6- 0 to 7- 8
64	6.9	6.8	6- 0 to 8- 0	6- 2 to 7- 8
66	8.0	7.9	7-12 to 8- 8	6-12 to 8- 0
68	8.6	8.0	8- 0 to 9- 8	7- 4 to 9- 0
70	9.4	9.5	8- 4 to 10-12	9- 0 to 12- 8
72	10.5	10.2	9- 0 to 13- 0	9- 4 to 11-12
74	11.7	10.7	10- 0 to 13- 2	9- 8 to 13- 0
76	12.2	11.1	10- 8 to 13-12	9- 4 to 13- 2
78	13.1	12.9	11- 4 to 15- 8	9- 5 to 15- 4
80	14.0	13.6	12- 8 to 15- 0	12- 0 to 20- 0
82	15.5	15.4	13- 4 to 16-12	13- 4 to 20-12
84	16.0	16.3	14- 0 to 17- 8	14-12 to 18- 8
86	17.3	17.8	15-12 to 21- 0	16- 0 to 24- 8
88	18.3	18.2	16- 0 to 25- 0	16- 0 to 20- 0
90	19.8	19.4	18- 4 to 24- 0	18-10 to 23- 8
92	22.0	20.8	19- 0 to 28- 8	20- 2 to 26- 8
94	23.2	22.8	20- 8 to 26- 0	19- 2 to 27- 0
96	24.4	24.1	19- 8 to 27- 6	20- 0 to 27- 2
98	25.7	26.2	22- 8 to 28- 8	24- 0 to 28- 4
100	28.4	28.2	24- 4 to 36- 0	20- 6 to 31- 8
102	30.7	30.0	26- 8 to 35- 0	26- 4 to 33- 8
104	32.0	33.0	28- 4 to 34-12	28- 8 to 38- 8
106	33.0	35.0	22- 0 to 37- 0	31- 4 to 38- 8
108	35.2	----------	28- 8 to 40- 8	----------
110	37.3	----------	36- 8 to 46- 8	----------
112	39.3	----------	35- 0 to 47- 0	----------

Attention was called to the composite character of the ocean catch. This is well shown when measurements of large numbers of fish of a given age from different streams and from the ocean are brought together. The graph, figure 22, was constructed from a table of measurements, (table 1) consisting of 7441 individuals examined, all of the four-year class; 2730 were from Monterey Bay, 798 from Sacramento River and 3913 from the Klamath. It will be seen that the average length of Klamath fish is near 80 cm., that of Sacramento fish about 95, while the ocean fish represented by the Monterey Bay curve, fall somewhere between.

Conditions permitted of rather extended observations relating to sex occurence in the catch at Monterey during 1919, 1920, and 1921, when a total of 9539 fish was examined, 51.7 per cent of which were males. Of 2371 fish observed in 1919, 1288 or 54.3 per cent were males; of 3501 in 1920, 1765 or 50.4 per cent were males; and of 3667 in 1921, 1877 or 51.2 per cent were males. More detailed data are set forth in tables 56–58.

It appears from this that sea fishing does not discriminate in any great measure against either sex. It is evident from an inspection of the tables that a larger proportion of males comes to the market in the later part of March and the early half of April than later in the season. This is graphically shown in figure 42 which is intended to represent the seasonal distribution by weekly periods.

TABLE 56

Sex Representation, Monterey, 1919, Daily and Weekly Periods

Dates	Males		Females		Males		Females	
	Number	Average length in cm.	Number	Average length in cm.	Number	Per cent	Number	Per cent
April 23	36	73.7	34	72.6				
April 24	51	80.0	38	75.4	132	54	112	46
April 25	45	80.0	40	73.7				
April 29	28	76.9	32	77.3				
April 30	45	83.0	33	76.3	100	54	86	46
May 1	27	81.6	21	78.0				
May 4	25	79.3	11	77.3				
May 5	16	72.0	15	66.7				
May 6	17	77.0	15	63.4	153	60	102	40
May 7	41	85.8	25	74.5				
May 8	24	86.4	16	78.0				
May 10	30	78.9	20	70.7				
May 11	10	81.5	10	67.5				
May 12	14	85.5	11	81.5				
May 13	26	76.6	24	77.7	155	52	145	48
May 15	22	78.7	18	77.0				
May 16	71	84.2	74	80.9				
May 17	12	84.8	8	81.0				
May 18	32	78.0	28	83.1				
May 19	27	74.6	23	74.3				
May 21	22	80.0	18	78.5	216	56	172	44
May 22	30	89.0	24	79.6				
May 23	57	86.7	37	77.1				
May 24	48	89.6	42	81.7				
May 26	44	90.6	26	85.2				
May 27	36	80.6	29	79.1	160	62	98	38
May 28	49	92.2	29	83.1				
May 29	31	91.7	14	85.5				
June 4	11	77.3	7	82.3				
June 5	9	89.6	11	87.7	84	62	52	38
June 6	42	90.8	23	84.3				
June 7	22	89.3	11	86.0				
June 8	17	81.6	7	69.5				
June 9	15	74.8	15	70.5	70	60	46	40
June 12	16	86.8	7	78.7				
June 13	22	81.3	17	75.9				
June 16	10	74.3	15	66.1				
June 17	24	67.4	25	76.5				62
June 19	12	67.9	23	75.2	64	38	105	
June 20	10	73.8	10	72.5				
June 21	8	73.0	32	73.5				
June 22	25	63.8	30	68.5				
June 23	40	71.4	40	75.8				
June 26	7	80.7	13	72.0	100	44	125	56
June 27	23	71.4	34	75.3				
June 28	5	78.2	8	84.2				
July 11	10	90.7	10	87.0	10	50	10	50
July 21	10	69.2	6	73.5				
July 22	21	62.7	15	64.0	37	59	26	41
July 23	6	72.5	5	86.2				
July 26	7	78.0	4	90.2	7	64	4	36
Totals					1,288	54	1,083	46

TABLE 57

Sex Representation, Monterey, 1920, Daily and Weekly Periods

Dates	Males		Females		Males		Females	
	Number	Average length in cm.	Number	Average length in cm.	Number	Per cent	Number	Per cent
January 29	3	71.3	2	71.0				
January 30	3	68.3	2	68.0	6	60	4	40
February 21	4	77.2	4	71.0	4	50	4	50
February 23	10	74.2	18	73.3				
February 25	19	72.6	21	73.3	57	40	86	60
February 26	22	73.1	38	70.7				
February 27	6	71.8	9	74.2				
March 3	1	75.0	3	74.5	1	25	3	75
March 8	3	74.3	1	83.5				
March 9	0	----------	1	75.0	85	47	94	53
March 11	26	77.1	43	75.3				
March 12	56	80.2	49	70.2				
March 17	10	78.3	20	72.8				
March 18	31	72.9	54	72.8	105	37	175	63
March 19	36	70.9	64	71.1				
March 20	28	70.4	37	69.5				
March 21	10	71.7	29	72.2	23	29	56	71
March 23	13	71.7	27	70.5				
April 5	48	79.3	52	78.3				
April 6	36	81.2	44	75.6				
April 7	22	81.4	61	74.6	157	42	221	58
April 8	30	85.8	40	76.4				
April 10	21	90.7	24	78.7				
April 12	81	91.9	49	86.9				
April 13	71	92.1	39	87.8	235	64	135	36
April 14	35	91.0	25	89.5				
April 16	48	94.3	22	88.1				
April 21	27	89.3	33	85.7				
April 22	31	83.9	39	81.3	110	47	125	53
April 23	30	76.4	35	78.5				
April 24	22	84.4	18	74.4				
April 26	60	90.2	44	82.8	207	62	127	38
April 27	51	95.6	29	82.4				
April 28	96	95.3	54	88.7				
May 8	57	97.2	38	90.7	57	60	38	40
May 10	50	90.7	40	86.8				
May 11	69	95.2	56	84.6				
May 13	63	94.1	41	78.9	214	58	155	42
May 14	32	98.6	18	89.2				
May 17	27	89.5	38	85.7	59	44	74	56
May 18	32	87.5	36	83.2				
June 2	32	83.6	52	79.0				
June 3	76	66.2	68	72.0	134	45	162	55
June 4	26	81.9	42	83.3				
June 14	62	70.0	43	80.4				
June 15	32	73.9	24	79.5	188	57	143	43
June 16	38	80.3	32	82.0				
June 17	56	70.3	44	80.1				
June 21	42	60.4	38	72.7				
June 22	13	75.2	16	85.6				
June 23	26	83.9	38	79.0	123	48	134	52
June 24	5	66.6	5	74.0				
June 25	20	70.2	19	80.3				
June 26	17	70.3	18	74.4				
Totals					1,765	51	1,736	49

TABLE 58

Sex Representation, Monterey, 1921, Daily and Weekly Periods

Dates	Males		Females		Males		Females	
	Number	Average length in cm.	Number	Average length in cm.	Number	Per cent	Number	Per cent
January 21	1	72.0	0	0	6	50	6	50
February 2	2	76.0	3	65.3				—
February 4	3	71.0	2	69.5				
February 7	4	74.0	6	69.5				
February 10	51	68.9	58	67.5	86	45	103	55
February 11	31	66.9	39	65.5				
March 1	6	72.8	1	82.0				
March 2	5	66.8	5	74.4	52	52	48	48
March 3	41	70.8	42	68.5				
March 11	1	96.0	0	0	23	68	11	32
March 12	22	69.3	11	68.8				
March 13	1	75.0	0	0				
March 14	19	74.3	41	74.6				
March 15	21	73.8	40	71.0	111	35	204	65
March 16	21	71.2	33	70.6				
March 17	22	69.9	32	69.9				
March 18	27	70.3	58	70.3				
March 21	27	71.6	43	72.4				
March 22	12	71.5	8	73.3				
March 23	12	82.9	8	79.2	108	47	120	53
March 24	35	77.1	34	73.6				
March 25	12	80.4	16	73.8				
March 26	10	80.6	11	79.7				
March 28	32	73.6	27	73.0				
March 29	20	87.8	23	81.6				
March 30	30	81.1	20	79.7	140	56	112	44
March 31	21	77.7	24	75.5				
April 1	33	95.0	11	86.5				
April 2	4	92.7	7	89.1				
April 5	1	91.0	2	101.0				
April 6	13	96.9	2	88.0				
April 7	3	102.0	1	85.0	27	80	7	20
April 8	1	100.0	0	0				
April 9	9	77.4	2	68.5				
April 10	2	85.5	3	62.7				
April 11	15	93.8	9	89.8				
April 12	17	98.7	3	91.0	39	65	21	35
April 13	0	0	2	95.0				
April 15	5	101.8	4	94.2				
April 19	5	97.2	3	81.3				
April 20	1	75.0	0	0	6	60	4	40
April 21	0	0	1	91.0				
April 25	6	101.2	4	90.5				
April 26	46	95.6	18	89.8				
April 27	30	98.1	20	89.9	237	58	172	42
April 28	70	95.3	60	86.5				
April 29	40	88.7	45	84.8				
April 30	45	89.8	25	82.4				
May 2	19	90.7	35	82.4				
May 3	30	91.6	24	87.6	93	55	75	45
May 4	16	99.4	4	82.2				
May 5	20	100.7	3	95.0				
May 7	8	102.3	9	88.4				
May 9	57	97.2	24	91.0				
May 10	32	97.4	13	94.2				
May 11	30	98.1	14	94.0				
May 12	53	95.8	37	89.6	272	60	179	40
May 13	64	94.5	55	87.6				
May 14	36	86.7	36	86.4				

TABLE No. 58—Continued

Sex Representation, Monterey, 1921, Daily and Weekly Periods

Dates	Males		Females		Males		Females	
	Number	Average length in cm.	Number	Average length in cm.	Number	Per cent	Number	Per cent
May 16	9	96.9	10	82.5				
May 17	3	94.7	1	85.0	200	56	159	44
May 18	23	96.6	12	86.4				
May 19	83	88.1	57	82.7				
May 20	65	90.1	60	82.9				
May 21	17	94.6	19	88.8				
May 23	22	96.8	19	86.4				
May 24	21	94.2	31	85.0				
May 25	40	92.1	32	83.5	142	54	123	46
May 26	30	94.5	5	79.6				
May 27	17	89.7	22	81.7				
May 28	12	94.5	14	93.0				
May 30	2	89.5	6	79.7	56	43	73	57
May 31	15	83.1	27	82.6				
June 1	18	76.7	18	78.8				
June 4	21	85.3	22	80.9				
June 6	26	91.0	20	84.8				
June 7	26	90.6	23	87.0	116	45	140	55
June 8	12	88.9	22	81.5				
June 9	31	81.9	32	77.1				
June 10	21	88.6	43	80.2				
June 13	13	85.4	29	72.9				
June 14	2	79.5	2	76.0	66	41	96	59
June 15	2	63.0	0	0				
June 17	13	79.3	23	76.3				
June 18	36	74.0	42	75.2				
June 21	6	70.8	12	79.3				
June 22	28	82.4	40	77.9	93	42	128	58
June 23	28	84.5	44	78.9				
June 24	17	82.3	12	81.2				
June 25	14	64.8	20	72.2				
June 27	4	79.8	9	71.3	4	30	9	49
Totals					1,877	51	1,790	49

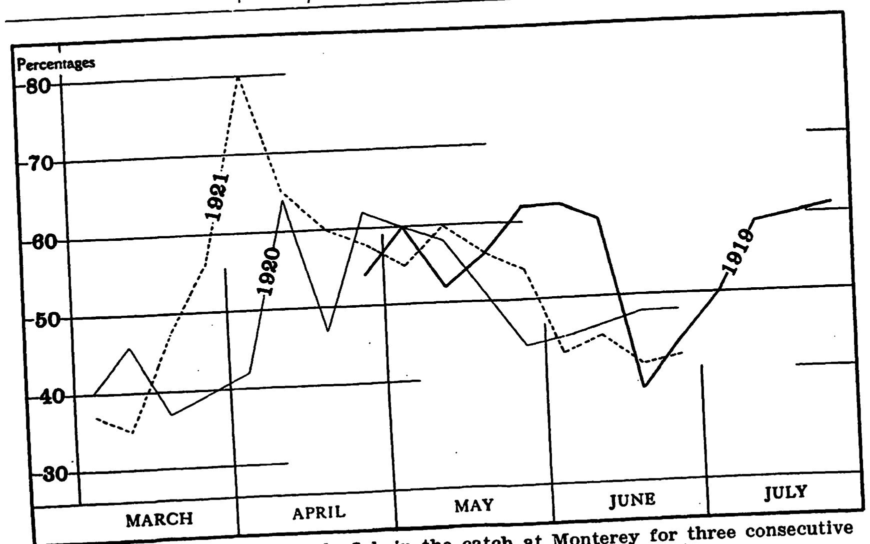

FIG. 42. Occurrence of male fish in the catch at Monterey for three consecutive years over weekly periods, and expressed in percentages.

AGE CHARACTERISTICS OF THE OCEAN CATCH

The ocean catch is made up of fish which range in age from two to six years. Although details are given in tables 61–71, a brief summary in percentages for fish examined at Monterey is offered here.

TABLE 59

Ocean Catch at Monterey

Year	Percentage of fish in each year class					Size of sample	Date of sample
	2	3	4	5	6		
1919	7	33	43	16	1	1,742	April 23 to July 26
1920	7	30	37	24	2	2,171	January 30 to June 26
1921	0.6	30	43	24	2	2,758	February 2 to June 20

As the number of fish examined at Monterey was large, and as every opportunity for obtaining a fair sample was presented, it is reasonably safe to assume that the age representation here is about normal, and any marked deviation from this assumed normal which may occur at a future time will be regarded with interest. Observers have not been able to obtain representative samples during an extended period of time at either Fort Bragg or Eureka, because of selection which often occurred before access to the fish was obtained.

The ocean catch when compared with that of the river is relatively rich in two- and three-year fish as will appear from a comparison of the following table with the previous one.

TABLE 60

Klamath River Catch

Year	Percentage of fish in each year class					Size of sample
	2	3	4	5	6	
1919	0	16	63	20	1	2,179
1920	0	11	78	10	0.4	1,819
1923	0	16	70	13	1	1,593

In the Sacramento River catch the proportion of three-year fish is somewhat greater than in that of the Klamath, the four-year fish are fewer in number, while the five- and six-year individuals are more numerous. In this connection it should be noted that the Sacramento River samples are numerically smaller than those from the Klamath, and that their time of capture extends over a shorter period.

For purposes of comparison, and as a possible check against conditions which might appear in the future, it was found necessary to make age analyses of the catches at Monterey Bay and elsewhere along the coast. At the receiving houses in Monterey the fish arrived in undisturbed boat-loads, just as caught, and it was possible at all times to secure data from a fair sample of the catch, just as at the mouth of the Klamath. At Noyo Estuary near Fort Bragg, at Shelter Cove, and

at Eureka selection was so often made from the boats before the observer came to them, that large samples covering an extended period of time could not be secured.

The samples taken at Monterey may be considered as fairly representative of the ocean catches of 1919, 1920 and 1923, and as a total they probably represent the normal proportions of the various age and other group classes of the period.

There is no knowing how these would have compared with the past, and one looks with interest to the future. Tables which record the results of these analyses are here presented.

TABLE 61

Monterey Bay, 1919

Year class	Number of examples of a given age taken during weekly periods					
	2	3	4	5	6	Totals
April 20–26	5	75	95	24	0	199
April 27–May 3	5	51	69	18	1	144
May 4–10	18	82	77	28	1	206
May 11–17	15	57	87	48	1	208
May 18–24	16	67	120	46	2	251
May 25–31	3	23	80	43	3	152
June 1– 7	1	9	59	30	3	102
June 8–14	7	27	28	11	1	74
June 15–21	13	61	36	6	0	116
June 22–28	15	82	73	25	5	200
July 6–12	3	7	6	----	----	16
July 20–26	20	24	13	6	1	64
July 27–August 2	2	1	5	1	1	10
Totals	123	566	748	286	19	1,742

TABLE 62

Proportion of Two and Three Year Fish in the Catch, Monterey Bay, 1919

	Year class			Number individuals examined	Approximate per cent of two and three year fish
	2	3	2+3		
April 20–16	5	75	80	199	40.0
April 27–May 3	5	51	56	144	39.0
May 4–10	18	82	100	206	48.5
May 11–17	15	57	72	208	34.6
May 18–24	16	67	83	251	33.0
May 25–31	3	23	26	152	17.0
June 1– 7	1	9	10	102	9.8
June 8–14	7	27	34	74	46.0
June 15–21	13	61	74	116	64.0
June 22–28	15	82	97	200	48.5
July 6–12	3	7	10	16	62.5
July 20–26	20	24	44	64	68.5
July 27–August 2	2	1	3	10	3.0
Totals	123	566	689	1,742	39.6

TABLE 63

MONTEREY BAY 1919

Length in centimeters	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59
Two Year Class, Ocean Type, Males	1	1	1	1	3	3	2	7	10	8	6	7	3	4	4	4	4	1	1	2
Two Year Class, Ocean Type, Females	1	1	1	2	1	5	3	4	4	1	3	5	1	2	2	1	1	1	1	2
Two Year Class, Ocean Type, Total	2	2	2	3	4	8	5	11	14	9	9	12	4	6	6	5	5	2	2	4
Two Year Class, Stream Type, Males					1					1					1					
Two Year Class, Stream Type, Females																				
Two Year Class, Stream Type, Total					1					1					1					
Total 2 year fish	2	2	2	3	5	8	5	11	14	10	9	12	4	6	7	5	5	2	2	4
Three Year Class, Ocean Type, Males			1					2		1	2	1	5	2	3	3	7	4	5	6
Three Year Class, Ocean Type, Females							1			1	2	1		1	1	1	5	5	8	8
Three Year Class, Ocean Type, Total			1				1	2		2	4	2	5	3	4	4	12	9	13	14
Three Year Class, Stream Type, Males						1			1	4	1		4	2	2	1	3			5
Three Year Class, Stream Type, Females							1		1	1	1	3		1	1	3	1	4	2	2
Three Year Class, Stream Type, Total						1	1		2	5	2	3	4	3	3	4	4	4	2	7
Total 3 year fish			1			1	2	2	2	7	6	5	9	6	7	8	16	13	15	21
Four Year Class, Ocean Type, Males																				
Four Year Class, Ocean Type, Females																				
Four Year Class, Ocean Type, Total																				
Four Year Class, Stream Type, Males																				
Four Year Class, Stream Type, Females																				
Four Year Class, Stream Type, Total																				
Total 4 year fish																				
Five Year Class, Ocean Type, Males																				
Five Year Class, Ocean Type, Females																				
Five Year Class, Ocean Type, Total																				
Five Year Class, Stream Type, Males																				
Five Year Class, Stream Type, Females																				
Five Year Class, Stream Type, Total																				
Total 5 year fish																				
Six Year Class, Ocean Type, Males																				
Six Year Class, Ocean Type, Females																				
Six Year Class, Ocean Type, Total																				
Six Year Class, Stream Type, Males																				
Six Year Class, Stream Type, Females																				
Six Year Class, Stream Type, Total																				
Total 6 year fish																				

Length in centimeters	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79
Two Year Class, Ocean Type, Males	1		1			1														
Two Year Class, Ocean Type, Females		1		1																
Two Year Class, Ocean Type, Total	1	1	1	1		1														
Two Year Class, Stream Type, Males																				
Two Year Class, Stream Type, Females																				
Two Year Class, Stream Type, Total																				
Total 2 year fish	1	1	1	1		1														
Three Year Class, Ocean Type, Males	16	5	14	8	9	15	15	13	12	11	10	15	8	8	11	7	6	5	3	
Three Year Class, Ocean Type, Females	8	9	10	8	13	14	21	25	16	17	15	16	15	5	10	8	9	7	5	1
Three Year Class, Ocean Type, Total	24	14	24	16	22	29	36	38	28	28	25	31	23	13	21	15	15	12	8	1
Three Year Class, Stream Type, Males	3	1	2					1		1										
Three Year Class, Stream Type, Females	2			2	1															
Three Year Class, Stream Type, Total	5	1	2	2	1			1		1										
Total 3 year fish	29	15	26	18	23	29	36	39	28	29	25	31	23	13	21	15	15	12	8	1
Four Year Class, Ocean Type, Males		2				2			1	1	1	1	1	3	3	4	7	7	6	7
Four Year Class, Ocean Type, Females					1		2	1	1	3		4	7	6	5	5	11	8	15	12
Four Year Class, Ocean Type, Total		2			1	2	2	1	2	4	1	5	8	9	8	9	18	15	21	19
Four Year Class, Stream Type, Males			1		1		1		2	1		2	3	1	2	2	2	2	3	3
Four Year Class, Stream Type, Females		1			1	1	3	3	3	1		1	2	4	4	2	2	5	3	1
Four Year Class, Stream Type, Total		1	1		2	1	4	3	5	2		3	5	5	6	4	4	7	6	4
Total 4 year fish		3	1		3	3	6	4	7	6	1	8	13	14	14	13	22	22	27	23
Five Year Class, Ocean Type, Males																				
Five Year Class, Ocean Type, Females																				
Five Year Class, Ocean Type, Total																				
Five Year Class, Stream Type, Males																1	1	2		
Five Year Class, Stream Type, Females																1	1	1	1	1
Five Year Class, Stream Type, Total																2	2	3	1	1
Total 5 year fish																2	2	3	1	1
Six Year Class, Ocean Type, Males																				
Six Year Class, Ocean Type, Females																				
Six Year Class, Ocean Type, Total																				
Six Year Class, Stream Type, Males																				
Six Year Class, Stream Type, Females																				
Six Year Class, Stream Type, Total																				
Total 6 year fish																				

Length in centimeters	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99
Two Year Class, Ocean Type, Males																				
Two Year Class, Ocean Type, Females																				
Two Year Class, Ocean Type, Total																				
Two Year Class, Stream Type, Males																				
Two Year Class, Stream Type, Females																				
Two Year Class, Stream Type, Total																				
Total 2 year fish																				
Three Year Class, Ocean Type, Males	2	1	1	1			1													
Three Year Class, Ocean Type, Females	2		1																	
Three Year Class, Ocean Type, Total	4	1	2	1			1													
Three Year Class, Stream Type, Males																				
Three Year Class, Stream Type, Females																				
Three Year Class, Stream Type, Total																				
Total 3 year fish	4	1	2	1			1													
Four Year Class, Ocean Type, Males	5	4	14	10	13	15	14	12	20	14	9	10	12	8	15	19	14	18	8	13
Four Year Class, Ocean Type, Females	17	19	22	19	16	8	19	11	11	9	12	7	4	8	7	6	5	2	3	1
Four Year Class, Ocean Type, Total	22	23	36	29	29	23	33	23	31	23	21	17	16	26	22	25	19	20	11	14
Four Year Class, Stream Type, Males		3	2	2	2		3	1	2		1			1			2			
Four Year Class, Stream Type, Females	4	2	4	4	2	2	5	1	1	1			1							
Four Year Class, Stream Type, Total	4	5	6	6	4	2	8	2	3	1	1		1	1			2			
Total 4 year fish	26	28	42	35	33	25	41	25	34	24	22	17	17	27	22	25	21	20	11	14
Five Year Class, Ocean Type, Males									1	1	1	1	4	3	6	4	5	3	4	6
Five Year Class, Ocean Type, Females					2	1	2	1	4	3	3	5	2	6	7	3	2	1	4	3
Five Year Class, Ocean Type, Total					2	1	2	1	5	4	4	6	6	9	13	7	7	4	8	9
Five Year Class, Stream Type, Males		2	3	2	1	1	6	2	1	4	4	2	1	2	2	5	3		3	2
Five Year Class, Stream Type, Females	3		5	5	1	5	1	5	3	3	3	1	1	2	2		1	2		1
Five Year Class, Stream Type, Total	3	2	8	7	2	6	7	7	4	7	7	3	2	4	4	5	4	2	3	3
Total 5 year fish	3	2	8	7	4	7	9	8	9	11	11	9	8	13	17	12	11	6	11	12
Six Year Class, Ocean Type, Males																				
Six Year Class, Ocean Type, Females														1						
Six Year Class, Ocean Type, Total														1						
Six Year Class, Stream Type, Males															1	1				1
Six Year Class, Stream Type, Females									1										2	
Six Year Class, Stream Type, Total													1		1	1			2	1
Total 6 year fish													1	1	1	1			2	1

Length in centimeters	100	101	102	103	104	105	106	107	108	109	110	111	112	113	114	115	116	117	118	119	120	121	122	123	124	Total
Two Year Class, Ocean Type, Males																										76
Two Year Class, Ocean Type, Females																										44
Two Year Class, Ocean Type, Total																										120
Two Year Class, Stream Type, Males																										3
Two Year Class, Stream Type, Females																										
Two Year Class, Stream Type, Total																										3
Total 2 year fish																										123
Three Year Class, Ocean Type, Males																										239
Three Year Class, Ocean Type, Females																										269
Three Year Class, Ocean Type, Total																										508
Three Year Class, Stream Type, Males																										32
Three Year Class, Stream Type, Females																										26
Three Year Class, Stream Type, Total																										58
Total 3 year fish																										566
Four Year Class, Ocean Type, Males	14	9	6	2	2	5	1	1		2																345
Four Year Class, Ocean Type, Females	2	1	2		1																					293
Four Year Class, Ocean Type, Total	16	10	8	2	3	5	1	1		2																638
Four Year Class, Stream Type, Males	1																									46
Four Year Class, Stream Type, Females																										64
Four Year Class, Stream Type, Total	1																									100
Total 4 year fish	17	10	8	2	3	5	1	1		2																748
Five Year Class, Ocean Type, Males	6	7	7	9	9	8	5	4	6	3	4		3	2	3	1		1								117
Five Year Class, Ocean Type, Females	1	2	2	3	2		1																			60
Five Year Class, Ocean Type, Total	7	9	9	12	11	8	6	4	6	3	4		3	2	3	1		1								177
Five Year Class, Stream Type, Males		1	3	1	1	1				1																58
Five Year Class, Stream Type, Females	1		1																							51
Five Year Class, Stream Type, Total	1	1	4	1	1	1				1																109
Total 5 year fish	8	10	13	13	12	9	6	4	6	4	4		3	2	3	1		1								286
Six Year Class, Ocean Type, Males					1			2		1															1	5
Six Year Class, Ocean Type, Females	1					1																				3
Six Year Class, Ocean Type, Total	1				1	1		2		1															1	8
Six Year Class, Stream Type, Males				1					1					1												6
Six Year Class, Stream Type, Females			1		1																					5
Six Year Class, Stream Type, Total			1	1	1				1					1												11
Total 6 year fish	1		1	1	2	1		2	1	1				1											1	19

TABLE 64

Proportion of Two and Three Year Fish in the Catch, Monterey Bay, 1919

Year	Year class 2	Year class 3	Year class 2+3	Number individuals examined	Approximate per cent of two and three year fish
January 25–31	------	6	6	7	------
February 15–21	------	6	6	9	------
February 22–28	1	81	82	120	68.3
March 1– 6	------	3	3	4	------
March 7–13	1	67	68	132	51.5
March 14–20	5	98	103	164	62.8
March 21–27	------	35	35	53	66.0
April 4–10	2	94	96	232	41.4
April 11–17	3	5	8	195	4.0
April 18–24	1	47	48	181	26.5
April 25–May 1	2	14	16	151	10.6
May 2– 8	------	2	2	58	3.5
May 9–15	2	32	34	204	16.6
May 16–22	------	21	21	102	20.6
May 30–June 5	26	27	83	186	44.6
June 13–19	63	28	91	221	45.7
June 20–26	41	45	86	152	56.5
Totals	147	641	788	2,171	26.3

ARTIFICIAL PROPAGATION IN KLAMATH RIVER

Although some experimental attempts at artificial propagation were early made near the mouth of Klamath River, and a hatchery was later established on Trinity River, active work of this sort dates from 1896, when under the direction of the United States Commission, some fry resulting from eggs taken at Battle Creek, a tributary of the Sacramento were introduced into the upper Klamath. Just why it was deemed necessary to import fish to the Klamath, or why a stream where depletion was already apparent should be further robbed does not appear. However, large numbers of Sacramento eggs were again taken in 1907, 1911, 1913, and later, something like 5,000,000 in all according to hatchery methods of enumeration, and the resulting fry liberated in the Klamath. More detailed information appears in table 72 and a digest of further hatchery operations in table 73. Since 1917 no salmon from other streams have been brought to the Klamath excepting a small number for experimental purposes. Of late years large numbers of Klamath eggs have been sent to the Mt. Shasta hatchery from where the resulting fry have been liberated in the Sacramento.

Upon the closure of the upper reaches of the Klamath by the great dam at Copco, a hatchery was established at Fall Creek (Fig. 26) and a particularly efficient trap, placed in the river near Hornbrook. This trap is sometimes spoken of as the "Klamathon Racks." Its function is to stop all migrating salmon and retain them until they are ripe enough for artificial spawning. Unless some accident occurs which would destroy the racks at a critical time, or our notion of the homing instinct of salmon is at fault, it is apparent that there is here an opportunity to demonstrate that artificial propagation may maintain the species, at least on a par with natural propagation elsewhere in the basin.

A census of all salmon entering the racks was begun in 1925 and has been continued with results as indicated in table 51. It will be seen

TABLE 65

MONTEREY BAY 1920

Class	Type	Length in Centimeters	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60
Two Year Class	Ocean Type	Males	3	2	2	4	13	14	9	10	12	5	13	9	9	5	5	1	1	1
		Females	1		2	4	2	2	4	3	5	4	2	4	2		1			
		Total	4	2	4	8	15	16	13	13	17	9	15	13	11	5	6	1	1	1
	Stream Type	Males							1											
		Females								1										
		Total							1	1										
Total 2 year fish			4	2	4	8	15	16	14	14	17	9	15	13	11	5	6	1	1	1
Three Year Class	Ocean Type	Males												2			1	1	4	2
		Females													1		1	1		2
		Total												2	1		2	2	4	4
	Stream Type	Males			1			2		2		3	3	1	1	1	4	1	4	
		Females							2		1	4	2	5	6	5	3	5	2	2
		Total			1			2	2	2	1	7	5	6	7	6	7	6	6	2
Total 3 year fish					1			2	2	2	1	7	5	8	8	6	9	8	10	6
Four Year Class	Ocean Type	Males																		
		Females																		
		Total																		
	Stream Type	Males																	1	
		Females																1		
		Total																1	1	
Total 4 year fish																		1	1	
Five Year Class	Ocean Type	Males																		
		Females																		
		Total																		
	Stream Type	Males																		
		Females																		
		Total																		
Total 5 year fish																				
Six Year Class	Ocean Type	Males																		
		Females																		
		Total																		
	Stream Type	Males																		
		Females																		
		Total																		
Total 6 year fish																				

Class	Type	Length in Centimeters	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80
Two Year Class	Ocean Type	Males				1			1													
		Females																				
		Total				1			1													
	Stream Type	Males																				
		Females																				
		Total																				
Total 2 year fish						1			1													
Three Year Class	Ocean Type	Males	1	2	2	10	9	9	11	18	11	19	15	12	15	16	14	6	10	4	7	2
		Females	3	5	10	8	9	21	26	24	23	35	30	28	27	25	16	18	12	8	8	5
		Total	4	7	12	18	18	30	37	42	34	54	45	40	42	41	30	24	22	12	15	7
	Stream Type	Males	2	1		2	1	2		1												
		Females	2	3	1	1				1												
		Total	4	4	1	3	1	2		2												
Total 3 year fish			8	11	13	21	19	32	37	44	34	54	45	40	42	41	30	24	22	12	15	7
Four Year Class	Ocean Type	Males									2	1	2	4	6	5	6	2	6	9	4	4
		Females							2		1	1	4	3	4	4	10	11	16	14	14	18
		Total							2		3	2	6	7	10	9	16	13	22	23	18	22
	Stream Type	Males		1			1		1	1			3	3	3	4	2	1	3	2	1	2
		Females					2		3	1	2	3	1	2	4	5	4	7	3	6	4	3
		Total		1			3		4	2	2	3	4	5	7	9	6	8	6	8	5	5
Total 4 year fish				1			3		6	2	5	5	10	12	17	18	22	21	28	31	23	27
Five Year Class	Ocean Type	Males																				
		Females																		1		
		Total																		1		
	Stream Type	Males																1		1		1
		Females										1			1							1
		Total										1			1			1		1		2
Total 5 year fish										1			1			1		2		2
Six Year Class	Ocean Type	Males																				
		Females																				
		Total																				
	Stream Type	Males																				
		Females																				
		Total																				
Total 6 year fish																						

Class	Type	Length in Centimeters	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100
Two Year Class	Ocean Type	Males																				
		Females																				
		Total																				
	Stream Type	Males																				
		Females																				
		Total																				
Total 2 year fish																						
Three Year Class	Ocean Type	Males		1																		
		Females	1	2			1															
		Total	1	3			1															
	Stream Type	Males																				
		Females																				
		Total																				
Total 3 year fish			1	3			1															
Four Year Class	Ocean Type	Males	8	8	14	8	11	8	14	15	11	9	9	15	13	11	14	11	8	14	9	8
		Females	13	16	14	16	20	19	22	21	26	18	12	12	16	15	7	11	9	4	4	
		Total	21	24	28	24	31	27	36	36	37	27	21	27	29	26	21	22	17	18	13	8
	Stream Type	Males	1	3	2	2			1						1	2						
		Females	2	6	7	2	6	2	5	3	2											
		Total	3	9	9	4	6	2	6	3	2				1	2						
Total 4 year fish			24	33	37	28	37	29	42	39	39	27	21	27	30	28	21	22	17	18	13	8
Five Year Class	Ocean Type	Males	1				1	1	6	7	4	6	6	7	8	10	11	9	10	8	5	11
		Females				5	5	5	3	5	9	6	8	10	13	1	10	10	6	7	3	3
		Total	1			5	6	6	9	12	13	12	14	17	21	11	21	19	16	15	8	14
	Stream Type	Males		1	1	5	1	1	4	2	2	1	1	7	11	8	10	13	9	7	8	4
		Females	1	3	1	2	6	4	9	7	6	12	7	4	10	4	2		1	2		
		Total	1	4	2	7	7	5	13	9	8	13	8	11	21	12	12	13	10	9	8	4
Total 5 year fish			2	4	2	12	13	11	22	21	21	25	22	28	42	23	33	32	26	24	16	18
Six Year Class	Ocean Type	Males																				
		Females																				
		Total																				
	Stream Type	Males										1	1	1	1	2		1	3		1	
		Females						1			1		1			2	2			1		
		Total						1			1	1	2	1	1	4	2	1	3	1	1	
Total 6 year fish								1			1	1	2	1	1	4	2	1	3	1	1	

Class	Type	Length in Centimeters	101	102	103	104	105	106	107	108	109	110	111	112	113	114	115	116	117	118	119	Total
Two Year Class	Ocean Type	Males																				120
		Females																				36
		Total																				156
	Stream Type	Males																				1
		Females																				1
		Total																				2
Total 2 year fish																						158
Three Year Class	Ocean Type	Males																				204
		Females																				350
		Total																				554
	Stream Type	Males																				32
		Females																				45
		Total																				77
Total 3 year fish																						631
Four Year Class	Ocean Type	Males	5	6	1	7	3	4	2	3	1	4		1								306
		Females	3									1										381
		Total	8	6	1	7	3	4	2	3	1	5		1								687
	Stream Type	Males																				41
		Females																				86
		Total																				127
Total 4 year fish			8	6	1	7	3	4	2	3	1	5		1								814
Five Year Class	Ocean Type	Males	8	7	11	10	11	10	10	11	11	6	3	3	1		2	1				216
		Females	2																			112
		Total	10	7	11	10	11	10	10	11	11	6	3	3	1		2	1				328
	Stream Type	Males		2	5		1	2				1										110
		Females	2																			86
		Total	2	2	5		1	2				1										196
Total 5 year fish			12	9	16	10	12	12	10	11	11	7	3	3	1		2	1				524
Six Year Class	Ocean Type	Males	1					1	1									2				5
		Females																				
		Total	1					1	1									2				5
	Stream Type	Males	3	1	1				1	3		1									1	22
		Females				1			1													10
		Total	3	1	1	1			2	3		1									1	32
Total 6 year fish			4	1	1	1		1	3	3		1						2			1	37

TABLE 66

Monterey, 1921

Year class	Number of examples of a given age taken during weekly periods					
	2	3	4	5	6	Totals
January 20–February 5		9	3			12
February 6–12	2	121	21	1		145
February 27–March 5	2	46	27	1		76
February 6–12		21	8	1		30
February 13–19	3	157	74	3	1	238
February 20–26		106	76	6		188
February 27–April 2		76	72	62	5	215
April 2– 9		4	9	14	1	28
April 10–16		5	17	36	1	59
April 17–23			6	6		12
April 24–30		15	171	86	10	282
May 1– 7		12	64	63	15	154
May 8–14		11	113	162	10	296
May 15–21		23	81	55	7	166
May 22–28		20	115	51	6	192
May 29–June 4	3	24	40	30	6	103
June 5–11	2	46	124	66	6	244
June 12–18	3	54	67	7	1	132
June 19–25	1	68	89	19	2	179
June 26–July 2		1	5	1		7
Totals	16	819	1,182	670	71	2,758

TABLE 67

The Proportion of Two and Three Year Fish in the Catch, Monterey Bay, 1921

Periods	Year class			Number of individuals examined	Approximate per cent of two and three year fish
	2	3	2+3		
January 20–February 5		9	9	12	75.0
February 6–12	2	121	123	145	84.8
February 27–March 5	2	46	48	76	63.2
March 6–12		21	21	30	70.0
March 13–19	3	157	160	238	67.2
March 20–26		106	106	188	56.3
March 27–April 2		76	76	215	35.3
April 3– 9		4	4	28	14.3
April 10–16		5	5	59	8.5
April 17–23				12	0.0
April 24–30		15	15	282	5.3
May 1– 7		12	12	154	7.7
May 8–14		11	11	296	3.7
May 15–21		23	23	166	13.8
May 22–28		20	20	192	10.4
May 29–June 4	3	24	27	103	26.2
June 5–11	2	46	48	244	19.6
June 12–18	3	54	57	132	43.2
June 19–25	1	68	69	179	38.5
June 26–July 2		1	1	7	14.3
Totals	16	819	835	2,758	30.2

TABLE 68

MONTEREY BAY 1921

Length in centimeters	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64
Two Year Class, Ocean Type, Males		1	1		1	1				2										
Two Year Class, Ocean Type, Females	1					1	1	2	2	1				1					1	
Two Year Class, Ocean Type, Total	1	1	1		1	2	1	2	2	3				1					1	
Two Year Class, Stream Type, Males																				
Two Year Class, Stream Type, Females																				
Two Year Class, Stream Type, Total																				
Total 2 year fish	1	1	1		1	2	1	2	2	3				1					1	
Three Year Class, Ocean Type, Males						6	2	3	1	2	1	2	1	2	2	10	6	9	9	13
Three Year Class, Ocean Type, Females							1	1		1		2			1	8	6	11	14	18
Three Year Class, Ocean Type, Total							3	4	1	3	1	4	1	2	3	18	12	20	23	31
Three Year Class, Stream Type, Males						1				2					1	1				1
Three Year Class, Stream Type, Females						2								1		1	3	1		1
Three Year Class, Stream Type, Total						3				2				1	1	2	3	1		2
Total 3 year fish						3	3	4	1	5	1	4	1	3	4	20	15	21	23	33
Four Year Class, Ocean Type, Males																			2	
Four Year Class, Ocean Type, Females																				
Four Year Class, Ocean Type, Total																			2	
Four Year Class, Stream Type, Males															1			1	3	2
Four Year Class, Stream Type, Females														1		1		1	1	2
Four Year Class, Stream Type, Total														1	1	1		2	4	4
Total 4 year fish														1	1	1		2	6	4
Five Year Class, Ocean Type, Males																				
Five Year Class, Ocean Type, Females																				
Five Year Class, Ocean Type, Total																				
Five Year Class, Stream Type, Males																				
Five Year Class, Stream Type, Females																				
Five Year Class, Stream Type, Total																				
Total 5 year fish																				
Six Year Class, Ocean Type, Males																				
Six Year Class, Ocean Type, Females																				
Six Year Class, Ocean Type, Total																				
Six Year Class, Stream Type, Males																				
Six Year Class, Stream Type, Females																				
Six Year Class, Stream Type, Total																				
Total 6 year fish																				

Length in centimeters	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84
Two Year Class, Ocean Type, Males																				
Two Year Class, Ocean Type, Females																				
Two Year Class, Ocean Type, Total																				
Two Year Class, Stream Type, Males																				
Two Year Class, Stream Type, Females																				
Two Year Class, Stream Type, Total																				
Total 2 year fish																				
Three Year Class, Ocean Type, Males	10	24	15	23	33	22	17	17	27	17	16	11	12	11	9	1	1	1	1	1
Three Year Class, Ocean Type, Females	25	25	33	27	33	29	29	21	32	34	24	23	17	14	22	2	1	2	1	
Three Year Class, Ocean Type, Total	35	49	48	50	66	51	46	38	59	51	40	34	29	25	31	3	2	3	2	1
Three Year Class, Stream Type, Males			1	1				1												
Three Year Class, Stream Type, Females		2				1														
Three Year Class, Stream Type, Total		2	1	1		1		1												
Total 3 year fish	35	51	49	51	66	52	46	39	59	51	40	34	29	25	31	3	2	3	2	1
Four Year Class, Ocean Type, Males			2		2	5	5	12	12	10	8	10	7	9	14	20	21	12	17	10
Four Year Class, Ocean Type, Females		1	1			11	11	13	13	11	16	11	20	20	18	25	19	31	22	26
Four Year Class, Ocean Type, Total		1	3		2	16	16	25	25	21	24	21	27	29	32	45	40	43	39	36
Four Year Class, Stream Type, Males	1	3	5	5	4	7	7	3	4	8	7	4	4	6	6	4	3	3		1
Four Year Class, Stream Type, Females	4	4	3	3	5	5	14	10	6	5	7	8	10	10	8	4	7	9	1	6
Four Year Class, Stream Type, Total	5	7	8	8	9	12	21	13	10	13	14	12	14	16	14	8	10	12	1	7
Total 4 year fish	5	8	11	8	11	28	37	38	35	34	38	33	41	45	46	53	50	55	40	43
Five Year Class, Ocean Type, Males													1		1	1			2	2
Five Year Class, Ocean Type, Females										1						1		1	1	2
Five Year Class, Ocean Type, Total										1			1		1	2		1	3	4
Five Year Class, Stream Type, Males							1								2	1	3		1	3
Five Year Class, Stream Type, Females								1	1				2	1	2	2	4	2	5	7
Five Year Class, Stream Type, Total							1	1	1				2	1	4	3	7	2	6	10
Total 5 year fish							1	1	1	1			3	1	5	5	7	3	9	14
Six Year Class, Ocean Type, Males																				
Six Year Class, Ocean Type, Females																				
Six Year Class, Ocean Type, Total																				
Six Year Class, Stream Type, Males																				
Six Year Class, Stream Type, Females																				
Six Year Class, Stream Type, Total																				
Total 6 year fish																				

Length in centimeters	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100	101	102	103	104
Two Year Class, Ocean Type, Males																				
Two Year Class, Ocean Type, Females																				
Two Year Class, Ocean Type, Total																				
Two Year Class, Stream Type, Males																				
Two Year Class, Stream Type, Females																				
Two Year Class, Stream Type, Total																				
Total 2 year fish																				
Three Year Class, Ocean Type, Males		1																		
Three Year Class, Ocean Type, Females	3	3																		
Three Year Class, Ocean Type, Total	3	4																		
Three Year Class, Stream Type, Males																				
Three Year Class, Stream Type, Females																				
Three Year Class, Stream Type, Total																				
Total 3 year fish	3	4																		
Four Year Class, Ocean Type, Males	13	20	13	18	12	11	19	9	10	18	9	28	18	24	26	13	11	16	12	5
Four Year Class, Ocean Type, Females	15	18	17	13	15	12	11	14	16	10	5	2	7	7	1	2	3			
Four Year Class, Ocean Type, Total	28	38	30	31	27	23	30	23	26	28	14	30	25	31	27	15	14	16	12	5
Four Year Class, Stream Type, Males	2	4	2	1	1							2								
Four Year Class, Stream Type, Females	3	2	1	2	2	2	2	1	1											
Four Year Class, Stream Type, Total	5	6	3	3	3	2	2	1	1			2								
Total 4 year fish	33	44	33	34	30	25	32	24	27	28	14	32	25	31	27	15	14	16	12	5
Five Year Class, Ocean Type, Males			1	3	6	2	10	7	6	13	11	18	10	12	18	21	15	32	20	22
Five Year Class, Ocean Type, Females	4	2	6	8	5	12	10	9	12	10	10	14	12	9	9	6	3	3	4	2
Five Year Class, Ocean Type, Total	4	2	7	11	11	14	20	16	18	23	21	32	22	21	27	27	18	35	24	24
Five Year Class, Stream Type, Males	2	1	2	1	4	1		4	7	5	3	10	3	5	6	7	4	3	1	4
Five Year Class, Stream Type, Females	4	4	7	6	2	6	7	6	4	6	6	2	2	1	1	2		1		
Five Year Class, Stream Type, Total	6	5	9	7	6	7	7	10	11	11	9	12	5	6	7	9	4	4	1	4
Total 5 year fish	10	7	16	18	17	21	27	26	29	34	30	44	27	27	34	36	22	39	25	28
Six Year Class, Ocean Type, Males											1	1		1	2				2	
Six Year Class, Ocean Type, Females						1		1	1	1	2	1	1		1	2				
Six Year Class, Ocean Type, Total						1		1	1	1	3	2	1	1	3	2			2	
Six Year Class, Stream Type, Males		1							1	1			1	3		2	2	1	2	5
Six Year Class, Stream Type, Females						1	1	1	1	2	1	2			1	1		2		
Six Year Class, Stream Type, Total		1				1	1	1	2	3	1	2	1	3	1	3	2	3	2	5
Total 6 year fish		1				2	1	2	3	4	4	4	2	4	4	5	2	3	4	5

Length in centimeters	105	106	107	108	109	110	111	112	113	114	115	116	117	118	119	120	
Two Year Class, Ocean Type, Males																	6
Two Year Class, Ocean Type, Females																	10
Two Year Class, Ocean Type, Total																	16
Two Year Class, Stream Type, Males																	
Two Year Class, Stream Type, Females																	
Two Year Class, Stream Type, Total																	
Total 2 year fish																	16
Three Year Class, Ocean Type, Males																	333
Three Year Class, Ocean Type, Females																	463
Three Year Class, Ocean Type, Total																	796
Three Year Class, Stream Type, Males																	9
Three Year Class, Stream Type, Females																	12
Three Year Class, Stream Type, Total																	21
Total 3 year fish																	817
Four Year Class, Ocean Type, Males	7	1															491
Four Year Class, Ocean Type, Females	1																438
Four Year Class, Ocean Type, Total	8	1															929
Four Year Class, Stream Type, Males																	104
Four Year Class, Stream Type, Females																	151
Four Year Class, Stream Type, Total																	255
Total 4 year fish	8	1															1184
Five Year Class, Ocean Type, Males	14	12	12	10	9	10	9	6	3	2	1		1			1	324
Five Year Class, Ocean Type, Females	1	2	1														160
Five Year Class, Ocean Type, Total	15	14	13	10	9	10	9	6	3	2	1		1			1	484
Five Year Class, Stream Type, Males	2	1	1	1	1		1										91
Five Year Class, Stream Type, Females																	94
Five Year Class, Stream Type, Total	2	1	1	1	1		1										185
Total 5 year fish	17	15	14	11	10	10	10	6	3	2	1		1			1	669
Six Year Class, Ocean Type, Males	2	2	1		1			2									15
Six Year Class, Ocean Type, Females																	11
Six Year Class, Ocean Type, Total	2	2	1		1			2									26
Six Year Class, Stream Type, Males	2	3	1	1	1			1	1	1	1						31
Six Year Class, Stream Type, Females				1													14
Six Year Class, Stream Type, Total	2	3	1	2	1			1	1	1	1						45
Total 6 year fish	4	5	2	2	2			3	1	1	1						71

TABLE 69

Summary of Monterey Bay Age Classes

Year	2			3			4			5			6			Totals			Percentages		
Year—	1919	1920	1921	1919	1920	1921	1919	1920	1921	1919	1920	1921	1919	1920	1921	1919	1920	1921	1919	1920	1921
Males	79	121	6	271	236	342	391	347	595	175	326	416	11	27	46	927	1,057	1,405	53.2	48.8	51
Females	44	37	10	295	395	475	357	467	589	111	198	254	8	10	25	815	1,107	1,353	46.8	51.2	49
Ocean type	120	156	16	508	554	796	638	687	929	177	328	484	8	5	26	1,451	1,730	2,251	83.2	79.9	82
Stream type	3	2	0	58	77	21	110	127	255	109	196	186	11	32	45	291	434	507	16.8	20.1	18
Ocean type males	76	120	6	239	204	333	345	306	491	117	216	324	5	5	15	782	851	1,169	44.9	39.3	42
Ocean type females	44	36	10	269	350	463	293	381	438	60	112	160	3	0	11	669	879	1,082	38.4	40.7	39
Stream type males	3	1	0	32	32	9	46	41	104	58	110	92	6	22	31	145	206	236	8.3	9.5	9
Stream type females	0	1	0	26	45	12	64	86	151	51	86	94	5	10	14	146	228	271	8.4	10.5	10
Totals	123	158	16	566	631	817	748	814	1,184	286	524	670	19	37	71	1,472	2,164	2,758	------	------	------
Percentages	7	7.3	.6	33	29.2	30	43	37.6	43	16	24.2	24	1	1.7	2	------	------	------	------	------	------

TABLE 70

FORT BRAGG 1920

Class	Type	Length in centimeters	Total
Two Year Class	Ocean Type	Males	33
		Females	21
		Total	54
	Stream Type	Males	2
		Females	1
		Total	3
	Total 2 year fish		57
Three Year Class	Ocean Type	Males	94
		Females	125
		Total	219
	Stream Type	Males	16
		Females	7
		Total	23
	Total 3 year fish		242
Four Year Class	Ocean Type	Males	227
		Females	400
		Total	627
	Stream Type	Males	16
		Females	44
		Total	60
	Total 4 year fish		687
Five Year Class	Ocean Type	Males	88
		Females	128
		Total	216
	Stream Type	Males	69
		Females	110
		Total	179
	Total 5 year fish		395
Six Year Class	Ocean Type	Males	
		Females	
		Total	
	Stream Type	Males	10
		Females	19
		Total	29
	Total 6 year fish		29

TABLE 71

Summary of Fort Bragg Age Classes, 1920

Year classes	2	3	4	5	6	Totals	Percentages
Males	35	110	243	157	10	555	39
Females	22	132	444	238	19	855	61
Ocean type	54	219	627	216	0	1,116	79
Stream type	3	23	60	179	29	294	21
Ocean type males	33	94	227	88	0	442	31
Ocean type females	21	125	400	128	0	674	48
Stream type males	2	16	16	69	10	113	8
Stream type females	1	7	44	110	19	181	13
Totals	57	242	687	395	29	1,410	--------
Percentages	4	17	48.7	28	2	--------	--------

that a rapid decline in fish of spawning age has occurred. While the number of spawning fishes was less in 1926 when compared with 1925 the number of grilse was considerably greater, possibly indicating a more intensive straining by the nets in the estuary. For some unknown reason the records for 1927 and 1928 are incomplete.

Hatchery operations on Trinity River did not meet with marked success as the following account will show.

The report of the United States Commissioner of Fish and Fisheries for 1889 to 1891 (p. 51) recites, "In view of the urgent and many requests from citizens in the regions of the Rocky Mountains and the Pacific coast to stock their waters . . . Lieut. Commander J. J. Brice, U. S. Navy . . . was directed to make a reconnaissance. Upon his recommendations the reservation at Fort Gaston, Humboldt County, California, was decided upon as offering the necessary requirements." Here then, in one of the most inaccessible parts of the state in so far as transportation was concerned, the Commission established a hatchery. Operations began by shipping salmon eggs from Baird, a station in the Sacramento basin, to Fort Gaston. Owing to difficulties encountered in securing spawning fish at Ft. Gaston, an egg-taking station was later established on Redwood Creek, and finally after several years the Fort Gaston hatchery was abandoned because of its remoteness. A summary of reported[21] hatchery activities in the region of Trinity River follows:

According to W. H. Bailey, a small hatchery was established by R. D. Hume on a stream near the mouth of Klamath River "in the nineties." Eggs were brought from Rogue River somewhere near Grant's Pass. Fish in large numbers were successfully hatched and introduced into the main river near the mouth, and also into Hunter and High Prairie creeks. Many were retained for about a year and then liberated. These were fed with canned salmon eggs, ground-up sturgeon, smelt and other fish. Adults later returned to the creeks into which they had been introduced, but no permanent run was established in either stream. None of the young salmon was ever carried up the Klamath beyond the mouth of Hunter Creek.

There is not available at present any exact information relating to the contribution of natural spawning of king salmon as compared with artificial propagation. Casual observation points to the probability that

[21] From the Reports of the U. S. Commissioner of Fisheries.

investigation of the results of natural propagation will receive more attention in the near future by those who seek fundamental facts pertaining to conservation. Incidents like the following are apt to arrest one's attention.

Shasta River, once a noted salmon stream, has of late years been regarded as of little consequence as a contributor to the population of Klamath River. Its decline, as such, has been attributed to local causes such as diversion of water for agriculture, mining, and power purposes, spearing fish on the spawning beds, and what not. When examining

TABLE 72

(The following record of artificial propagation of King Salmon in Klamath River was furnished by W. H. Shebley, of Bureau of Fish Culture)

Eggs received at Mt. Shasta during fall and winter of	Source of eggs	Date of planting	Number planted in Klamath River	
1896	Battle Creek	Mar. 8, 1897	200,000	
1896	Battle Creek	Mar. 9, 1897	300,000	
1896	Battle Creek	Mar. 10, 1897	300,000	
1896	Battle Creek	Mar. 11, 1897	300,000	
1896	Battle Creek	Mar. 12, 1897	300,000	
				1,400,000
1907	Battle Creek	Mar. 16, 1908	120,000	
1907	Battle Creek	Mar. 22, 1908	120,000	
1907	Battle Creek	Mar. 23, 1908	120,000	
1907	Battle Creek	Mar. 24, 1908	120,000	
1907	Battle Creek	April 3, 1908	120,000	
				600,000
1911	Battle Creek	April 2, 1912	350,000	
				350,000
1913	Battle Creek	April 5, 1914	330,000	
1913	Battle Creek	April 7, 1914	350,000	
1913	Battle Creek	April 16, 1914	335,000	
1913	Battle Creek	April 18, 1914	335,000	
				1,350,000
1914	Klamathon	May 2, 1915	450,000	
1914	Klamathon	May 4, 1915	200,000	
1914	Battle Creek	Oct. 13, 1915	200,000	
1914	Battle Creek	Nov. 19, 1915	30,000	
				880,000
1915	Klamathon	April 3, 1916	627,000	
1915	Klamathon	April 4, 1916	769,000	
1915	Klamathon	April 5, 1916	691,000	
1915	Klamathon	April 6, 1916	751,000	
1915	Klamathon	April 7, 1916	722,000	
1915	Klamathon	April 8, 1916	667,000	
1915	Klamathon	April 19, 1916	554,000	
1915	Klamathon	April 20, 1916	518,000	
1915	Klamathon	April 21, 1916	700,000	
1915	Klamathon	April 22, 1916	864,000	
1915	Klamathon	Nov. 2, 1916	200,000	
1915	Klamathon	Nov. 4, 1916	200,000	
1915	Klamathon	Nov. 20, 1916	150,000	
1915	Klamathon	Nov. 22, 1916	150,000	
				7,563,000
1916	Klamathon	May 17, 1917	210,000	
1916	Klamathon	May 18, 1917	218,000	
1916	Klamathon	Oct. 19, 1917	150,000	
1916	Klamathon	Oct. 22, 1917	125,000	
1916	Klamathon	Oct. 25, 1917	125,000	
1916	Klamathon	Oct. 27, 1917	100,000	
				928,000
1917	Battle Creek	April 6, 1918	75,000	
1917	Battle Creek	April 8, 1918	75,000	
1917	Battle Creek	April 10, 1918	75,000	
1917	Battle Creek	April 12, 1918	75,000	
1917	Battle Creek	Sept. 12, 1918	150,000	
1917	Battle Creek	Sept. 14, 1918	150,000	
1917	Battle Creek	Sept. 16, 1918	150,000	
1917	Battle Creek	Sept. 17, 1918	150,000	
1917	Battle Creek	Sept. 18, 1918	150,000	
				1,050,000
Total				14,121,000

TABLE 73

Record of Egg Collections on Klamath River and Tributaries

Year	King Salmon	Silver Salmon	Rainbow Trout
1916	15,872,000		1,189,000
1917	1,000,000		4,439,000
1918	277,000		1,709,000
1919	2,102,000	254,000	3,788,000
1920	4,974,000		5,600,000
1921	7,110,000		7,677,000
1922	19,178,000		9,780,000
1923	20,824,000		5,842,000
1924	5,762,000		4,941,000
1925	6,735,000	3,295,000	10,667,000
1926	18,042,000		5,838,000
1927*	11,797,000	397,000	1,765,000
1928	4,541,000		5,203,000
Totals	118,214,000	3,946,000	68,438,000

*The year 1927 was one of very high water, and every trout station on the Klamath River and its tributaries was damaged, and most of them were put out of commission for the season.

a part of the stream bed in 1926 in search for marked salmon, the writer assisted by E. C. Scofield, took occasion to make a careful estimate of the number of spawning salmon which might be actually seen between the power dam and the mouth of the stream, a distance of about 6.9 miles. The method employed was to count all individuals actually seen in such parts of the stream as could be approached, and from these counts estimate the number in inaccessible places. No account was taken of fish which might have been concealed in deep pools, nor of those carried away by spearmen. The census thus taken gave an enumeration of 7500 individuals. Any experienced observer appreciates the difficulty of seeing fish in even a small stream, and he will no doubt agree that an estimate made in this way is conservative. Grilse, small three-year males, were almost entirely absent. Spawning fish in numbers had probably passed above the dam, and it seems quite probable that the entire number of fish in the river was far in excess of the above estimate. During the same season 9387 fish by actual count entered the racks at Klamathon on the main river. From what we now know of the return migration of salmon, it is believed that the fish which entered the racks at this time owed their origin to artificial propagation, and it seems equally certain that those of Shasta River were the result of natural propagation.

The relatively small, steady flow of Shasta River during the salmon migration, together with the accessibility of the stream, would suggest it as an ideal place for a study of natural propagation.

SUMMARY

The king salmon which is indigenous to Klamath River differs in size and certain anatomical characters from that of the Sacramento River.

Two species, the king salmon and the silver salmon, are represented in sufficient numbers to be of commercial importance. The humpback and dog salmon are only occasionally seen. The redfish (*Oncorhynchus nerka*) is not found in the river.

Two definite immigrations of king salmon have been observed, a spring and a summer run. The spring run is now so depleted as to be

TABLE 74

Summary of Hatchery Activities on Trinity River

Date	Eggs received	Species	Origin	Eggs distributed	Fish distributed	Destination
1889–90	10,000	King Salmon	Baird			Trinity River
1890–91	45,000	King Salmon	Trinity River			Trinity River
1890–91	30,000	King Salmon	Redwood Creek			Redwood Creek
1891–92	150,000	King Salmon	Redwood Creek		147,600	Supply Creek (Trinity River)
1891–92	150,000	King Salmon	Redwood Creek		142,500	Redwood Creek
1891–92	21,000	Rainbow Trout	Redwood Creek			
1891–92	20,000	Brook Trout	Caledonia, New York			
1891–92	25,000	Von Behr trout	Northville, Mich.			
1892–93		Rainbow Trout	Brood fish		35,000	Local streams (Trinity)
1892–93		Von Behr Trout	Last year, Ft. Gaston		19,950	Local streams (Trinity)
1892–93		Brook Trout	Last year, Ft. Gaston		6,193	Local streams (Trinity)
1892–93	180,000	King Salmon	Redwood Creek, Trinity River		117,000	Local streams (Trinity)
1892–93	375,000	King Salmon	Redwood Creek, Trinity River		540,000	Local streams (Trinity)
1893–94	800,000	King Salmon	Redwood Creek, Trinity River		560,000	Local streams
1893–94	460,000	Rainbow Trout	Redwood Creek, Trinity River	10,000		Wytheville Station, Virginia
				100,000		Northville Station, Michigan
				50,000		Sisson, California
1893–94		Rainbow Trout	"Yearlings"		5,450	Waters of Trinity Mountain
1894–95	221,000	King Salmon	Redwood Creek		220,000	Redwood Creek, Trinity River
1894–95		Silver Salmon	Redwood Creek			
1894–95	241,800	Rainbow Trout	Redwood Creek	30,000		Japan
		and "Steelhead"		91,850		Northville Station
				100,000		Duluth Station
				25,000		St. Johnsbury Station
					1,000	Elk River
1894–95	20,800	Von Behr Trout	Brood stock, Ft. Gaston		277,500	Redwood Creek
					1,000	Yager Creek
					3,000	Streams in Marin County
1895–96	73,000	King Salmon	Redwood Creek		65,700	Adjacent streams
1895–96	795,000	Rainbow Trout	Redwood Creek		107,808	Redwood Creek
				635,000		Shipped out of state
1895–96	17,000	Von Behr Trout	Brood stock, Ft. Gaston	10,000		California Fish Commission
1895–96	87,000	Rainbow Trout	Brood stock, Ft. Gaston	30,000		Marin County Country Club
1896–97	406,000	King Salmon	Redwood Creek		405,000	Redwood Creek
1896–97	805,000	Rainbow Trout	Brood stock, Ft. Gaston		202,000	Redwood Creek
				600,000		Shipped out of state
1897–98	1,283,450	King and	Redwood Creek	710,000		Redwood Creek
		Silver Salmon	Redwood Creek	710,000		Shipped out of state
1897–98	1,451,000	Rainbow Trout	Redwood Creek		35,950	Trinity River
					Balance of rainbow trout	Redwood Creek

scarcely evident. The summer run is the only one of commercial importance.

The incoming fish show an increase in average size and weight as the season advances. This is due to both additional growth in the sea, and to the incursion of very large fish late in the season.

The time of immigration varies somewhat through a period of years, but it is not growing later as some presume.

From the results of experimental work it is safe to infer that king salmon which have been introduced into a particular tributary of a river usually seek out and enter the same tributary on their return migration, if when planted they were given a sufficient amount of exposure to its waters before they entered the main channel. The homing instinct is a barrier to dispersal. However, a small scatter may follow both natural and artificial propagation, thus constantly affording the species an opportunity to extend its range. It follows that when young salmon are introduced into a basin, they should be planted in widely separated localities if it is desired that the returning fish should distribute themselves to some extent over the basin.

The summer immigration occurs at a time of low water in the river. An emigration of young salmon also occurs, or is at least well begun, before the approach of winter floods.

Emigrating young appear in the estuary in late summer and early fall, where they linger and rapidly grow. There is evidence that at least some of these attain the maximum part of the first year's growth here. Many artificially propagated yearlings appear to tarry for a time in the estuary also.

Increasing knowledge of the habits of Klamath salmon strengthens the belief that the construction of high dams in the river will cause the extinction of the species above the dams.

Klamath salmon are found to mature at ages of from two to six years. No seven-year-old fish has been seen. Three-year females are at times fairly common in the catch. Precocious males occur during the first year of growth, and sperm from these will fertilize eggs. The ensuing young reach maturity and do not appear to differ from other adults.

Depletion of Klamath salmon is not only apparent, but it seems to be progressing at an alarming rate. There is evidence also that artificial propagation alone is not able to cope with the situation.

Gill net fishing at the mouth of the river is a deleterious straining process that permits the escape of small fish which later appear in ill-proportioned numbers on the spawning beds. If the tendency to mature early is inherited, the result may be a weakening of the entire stock in so far as it is of commercial worth.

The week-end closed period during the fishing season does not seem to accomplish its intended end.

During their ocean life, salmon migrate long distances from the mouths of their native streams.

Klamath salmon range at sea as far south as the marine habitat of the species extends. The extreme northern migration is unknown, but from what has been learned of the movements of Sacramento fish it may be inferred that Klamath salmon migrate northward also.

Ocean trolling results in the capture of immature fish in considerable numbers. Therefore, when an ocean catch is compared with that of a river, it is found to be relatively rich in two- and three-year fish.

In so far as we are able to determine, artificially propagated salmon do not differ in their habits from fish of the same species in a state of nature. Artificially propagated fish become adults which are similar in growth, stature, and other particulars to those produced in nature.

II

A REPORT ON THE 1930 CATCH OF KING SALMON IN KLAMATH RIVER

A Report on the 1930 Catch of King Salmon in Klamath River

The California Division of Fish and Game has been conducting observations on the commercial catch of king salmon (*Oncorhynchus tschawytscha* Walbaum) at the mouth of Klamath River since the season of 1919. In addition to the ordinary statistics of the catch, care has been taken through the services of trained observers, to obtain other data designed to be of value in connection with attempts at the conservation of the fishery.

Throughout each fishing season large representative samples of the daily catch have been examined in an effort to determine among other things, facts relating to the age groups of which it was composed, and as a result something like a normal representation has been reached. This has been rather laboriously set forth in another paper, but the results may be briefly summarized here as follows: Practically no two-year fish enter the catch. In fact, examples of this age were obtained in such small numbers that little was learned regarding them, and it was presumed that they were either relatively scarce, or that their small size enabled them to easily pass the nets. A few were secured in a seine net of small mesh. Three-year fish are fairly common, contributing from 11 to 15 per cent of the catch. The representation of this age group increases numerically until late in August and then rather suddenly falls away, seemingly giving place to older and larger fish. The four-year class constitutes the bulk of the catch, more precisely 63 to 78 per cent. Five-year fish are less numerous, there being from 10 to 20 per cent. There is a small scattering of six-year individuals. No seven-year fish has been seen in the Klamath. This age group representation is shown in greater detail in the appended tabulation (table 77).

During these years and those that followed until 1929, there occurred no radical departure from the general representation of the various age groups as just described, and it was accepted as probably normal. No special observer was stationed at the mouth of the Klamath during the season of 1929, but Harry C. Roberts reported that an unusually large number of small fish were caught. His letter states that these small fish appeared in such numbers as to reduce materially the average size of all fish caught. For some years he has kept a careful account of the number of fish received each day together with the weights of the same. As a result he is able to present an average weight for each season as shown in table 75.

During the fishing season of 1930, Carleton Rogers was present and examined 1872 examples so chosen as to be typical of the catch. These were carefully measured, the sex determined by dissection, and scales from each were preserved.

A study of these samples reveals a remarkable departure from what was regarded as the normal age group representation. The three-year fish appear in unusual numbers, while the proportion of four- and five-year fish is greatly reduced. To be more explicit, approximately 9 per cent of the catch are two-year fish, 49 per cent are three-year, 39

TABLE 75

Year	Number of fish	Average weight
1917	4,953	15.80
1918	15,815	12.10
1919	26,864	13.60
1920	54,397	14.69
1921	42,996	14.06
1922	61,502	14.69
1923	57,000	14.48
1924	45,876	14.94
1925	54,828	15.81
1926	30,772	17.04
1927	16,843	14.20
1928	11,534	14.26
1929	14,922	12.51
1930	32,258	11.33

per cent four-year, and but 3 per cent five-year fish. A tabulated analysis of the samples is appended. In figure 43 this very unusual condition is graphically shown.

Before inquiring as to the possible reason for this peculiar situation, it may be stated that there has been no marked departure from the characteristic stature of the age groups as determined by measurements of length. The second-year fish of this season measure 34 to 63 cm.

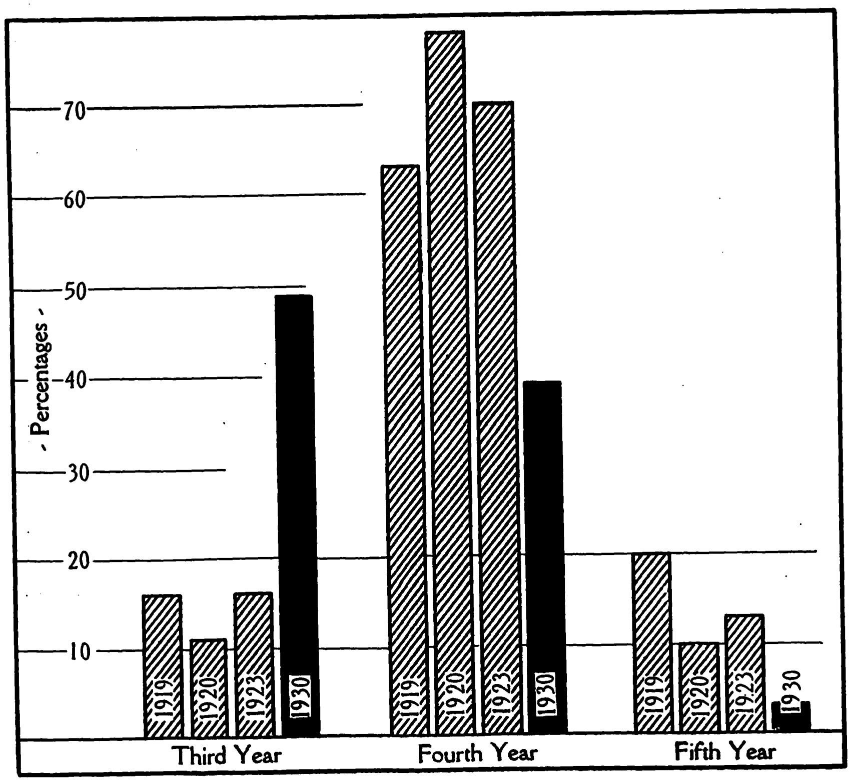

FIG. 43.

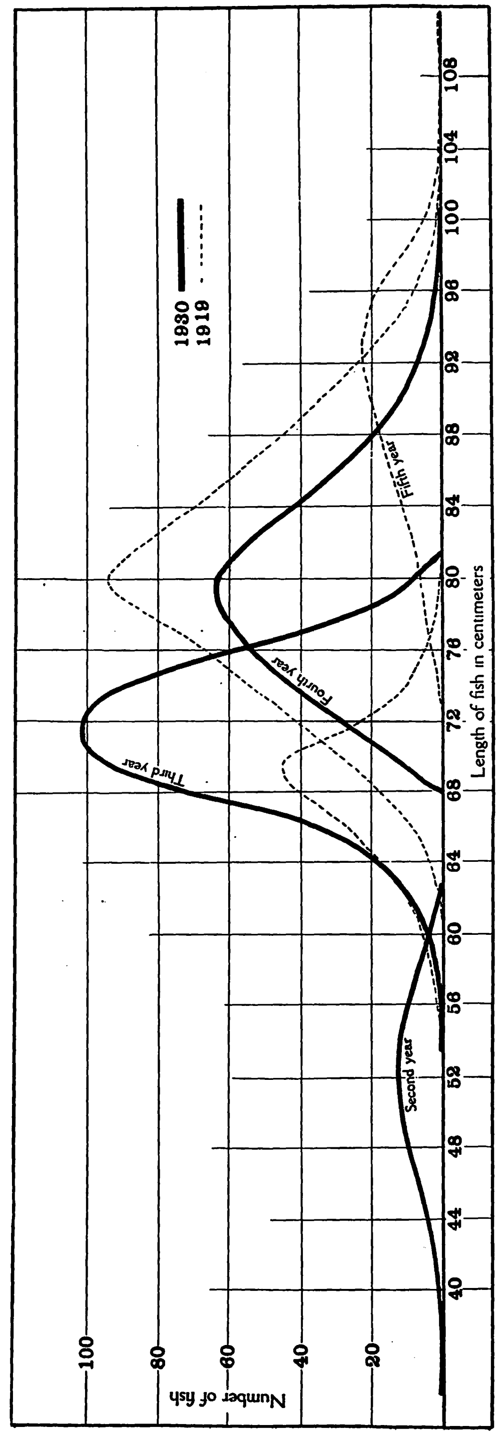

FIG. 44.

the third-year 53 to 81, and the fourth-year 68 to 101. Details are recorded in the appended table 76. A comparison of these age length determinations with similar ones of 1919 is graphically represented in figure 44. The figure also shows to what extent the second-year class has entered the picture while the fifth-year group has practically receded from it.

Assuming that no grave error has entered into these observations, the writer is able to present only four assumptions which may be seriously considered in an attempt to account for the peculiar characteristics of the Klamath River king salmon migration of 1930 as shown by the commercial catch:

1. Resulting from an increased demand, smaller fish have been accepted by the dealers, and the fishermen have employed nets of a smaller mesh in an effort to take them.
2. A swing in the pendulum of variation for which we are unable to assign a probable cause, and which will eventually right itself.
3. The presence of small fish (third-year class) is the result of a particularly successful breeding season in 1927, and as a result a phenomenal harvest of four-year fish may be expected in 1931.
4. A tendency to mature at a certain age is inherent, and consequently when selective nets deplete the older age groups, those which mature early are left to propagate in undue proportion; a possible result of depletion which in the end will be deleterious to the stock.

The first assumption may be dismissed with the statement that during the season of 1930 no methods of fishing out of the ordinary were employed; all nets were of the usual kind and size; and the dealers received fish as they came, just as in the past. As to the second and third, one guess is perhaps as good as another, but time will ultimately decide. The fourth possible cause deserves more than passing attention, for if it is actually in operation there is reason for alarm. There is at present no evidence as to whether or not a tendency to mature at an early age is a character that may be inherited and transmitted. The possibility deserves experimental test, and the work should be soon undertaken by someone who has time and funds at his disposal.

TABLE 76

KLAMATH RIVER 1930

Length in centimeters	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60
Two Year Class, Ocean Type, Males	2				2	2	2	4	2	4	5	6	7	4	15	8	2	10	13	14	9	12	13	12	11	5	2
Two Year Class, Ocean Type, Females																											
Two Year Class, Ocean Type, Total	2				2	2	2	4	2	4	5	6	7	4	15	8	2	10	13	14	9	12	13	12	11	5	2
Two Year Class, Stream Type, Males																											
Two Year Class, Stream Type, Females																											
Two Year Class, Stream Type, Total																											
Total 2 year fish	2				2	2	2	4	2	4	5	6	7	4	15	8	2	10	13	14	9	12	13	12	11	5	2
Three Year Class, Ocean Type, Males																				2				1	1	1	3
Three Year Class, Ocean Type, Females																											
Three Year Class, Ocean Type, Total																				2				1	1	1	3
Three Year Class, Stream Type, Males																				1			1	1	1	1	
Three Year Class, Stream Type, Females																											
Three Year Class, Stream Type, Total																				1			1	1	1	1	
Total 3 year fish																				3			1	2	2	2	3
Four Year Class, Ocean Type, Males																											
Four Year Class, Ocean Type, Females																											
Four Year Class, Ocean Type, Total																											
Four Year Class, Stream Type, Males																											
Four Year Class, Stream Type, Females																											
Four Year Class, Stream Type, Total																											
Total 4 year fish																											
Five Year Class, Ocean Type, Males																											
Five Year Class, Ocean Type, Females																											
Five Year Class, Ocean Type, Total																											
Five Year Class, Stream Type, Males																											
Five Year Class, Stream Type, Females																											
Five Year Class, Stream Type, Total																											
Total 5 year fish																											

Length in centimeters	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86
Two Year Class, Ocean Type, Males	1	1	2																							
Two Year Class, Ocean Type, Females																										
Two Year Class, Ocean Type, Total	1	1	2																							
Two Year Class, Stream Type, Males																										
Two Year Class, Stream Type, Females																										
Two Year Class, Stream Type, Total																										
Total 2 year fish	1	1	2																							
Three Year Class, Ocean Type, Males	4	3	3	4	5	5	11	12	17	21	30	22	33	32	41	23	27	20	14	1	2					
Three Year Class, Ocean Type, Females		5		6	7	19	11	32	64	59	86	59	67	61	33	29	18	11	6							
Three Year Class, Ocean Type, Total	4	8	3	10	12	24	22	44	81	80	116	81	100	93	74	52	45	31	20	1	2					
Three Year Class, Stream Type, Males			1		1																					
Three Year Class, Stream Type, Females																										
Three Year Class, Stream Type, Total			1		1																					
Total 3 year fish	4	8	4	10	13	24	22	44	81	80	116	81	100	93	74	52	45	31	20	1	2					
Four Year Class, Ocean Type, Males										2	5	7	4	10	18	13	20	22	28	40	24	18	18	27	9	10
Four Year Class, Ocean Type, Females								1	1	8	10	15	13	16	29	23	21	22	17	21	13	13	9	14	8	4
Four Year Class, Ocean Type, Total								1	1	10	15	22	17	26	47	36	41	44	45	61	37	31	27	41	17	14
Four Year Class, Stream Type, Males								1		2	1	3	1	4	1	1	2	3	3	3	6	4	3	2		2
Four Year Class, Stream Type, Females								3		4	5	6	7	2	3	7	7	4						1	2	1
Four Year Class, Stream Type, Total								4		6	6	9	8	6	4	8	9	7	3	3	6	4	3	3	2	3
Total 4 year fish								5	1	16	21	31	25	32	51	44	50	51	48	64	43	35	30	44	19	17
Five Year Class, Ocean Type, Males																				1						
Five Year Class, Ocean Type, Females																		1					1			1
Five Year Class, Ocean Type, Total																		1		1			1			1
Five Year Class, Stream Type, Males															1	2		1			3		1			
Five Year Class, Stream Type, Females																		1	3		1	6				
Five Year Class, Stream Type, Total															1	2		2	3		4	6	1			
Total 5 year fish															1	2		3	3	1	4	6	2			1

Length in centimeters	87	88	89	90	91	92	93	94	95	96	97	98	99	100	101	102	103	104	105	106	107	108	109	110	111	
Two Year Class, Ocean Type, Males																										170
Two Year Class, Ocean Type, Females																										
Two Year Class, Ocean Type, Total																										170
Two Year Class, Stream Type, Males																										
Two Year Class, Stream Type, Females																										
Two Year Class, Stream Type, Total																										
Total 2 year fish																										170
Three Year Class, Ocean Type, Males																										338
Three Year Class, Ocean Type, Females																										573
Three Year Class, Ocean Type, Total																										911
Three Year Class, Stream Type, Males																										7
Three Year Class, Stream Type, Females																										
Three Year Class, Stream Type, Total																										7
Total 3 year fish																										918
Four Year Class, Ocean Type, Males	11	12	6	6	5	9	8	1	3	2	3	6	1		1											349
Four Year Class, Ocean Type, Females	6	5	1	6	2		1	1	1		2		2													285
Four Year Class, Ocean Type, Total	17	17	7	12	7	9	9	2	4	2	5	6	3		1											634
Four Year Class, Stream Type, Males		2	1																							45
Four Year Class, Stream Type, Females																										52
Four Year Class, Stream Type, Total		2	1																							97
Total 4 year fish	17	19	8	12	7	9	9	2	4	2	5	6	3		1											731
Five Year Class, Ocean Type, Males											2				2		1				1	1	1	1	1	11
Five Year Class, Ocean Type, Females	1	1		1				1	1	1	1		2													12
Five Year Class, Ocean Type, Total	1	1		1				1	1	1	3		2		2		1				1	1	1	1	1	23
Five Year Class, Stream Type, Males	1		1			1		1	1									1								14
Five Year Class, Stream Type, Females	1						1							1												14
Five Year Class, Stream Type, Total	2		1			1	1	1	1					1				1								28
Total 5 year fish	3	1	1	1		1	1	2	2	1	3		2	1	2		1	1			1	1	1	1	1	51

TABLE 77

Summary of Klamath River Age Classes

Year class	2	3				4				5				6				Totals				Approximate percentages			
Year—	**1930**	1919	1920	1923	**1930**	1919	1920	1923	**1930**	1919	1920	1923	**1930**	1919	1920	1923	**1930**	1919	1920	1923	**1930**	1919	1920	1923	**1930**
lales	**170**	238	127	92	**346**	501	457	216	**394**	217	71	54	**25**	17	4	5	**0**	973	659	367	**935**	45	36	23	**50**
emales	**0**	116	81	156	**573**	868	957	905	**337**	205	118	149	**26**	17	4	16	**1**	1,206	1,160	1,226	**937**	55	64	77	**50**
cean type	**170**	331	193	246	**911**	1,214	1,355	1,007	**634**	216	103	142	**23**	22	1	1	**0**	1,783	1,652	1,396	**1,738**	82	91	88	**93**
tream type	**0**	23	15	2	**7**	155	59	114	**97**	206	86	61	**28**	12	7	20	**1**	396	167	197	**134**	18	9	12	**7**
cean type, males	**170**	215	112	90	**338**	436	429	181	**349**	122	42	15	**11**	10	1	5	**0**	783	584	291	**868**	36	32	18	**46**
cean type, females	**0**	116	81	156	**573**	778	926	826	**285**	94	61	103	**12**	12	0	1	**0**	1,000	1,068	1,086	**870**	46	59	68	**47**
ream type, males	**0**	23	15	2	**7**	65	28	35	**45**	95	29	15	**14**	7	3	5	**0**	180	75	57	**67**	8	4	4	**3.5**
ream type, females	**0**	0	0	0	**0**	90	31	79	**52**	111	57	46	**14**	5	4	15	**1**	206	92	140	**67**	9	5	9	**3.5**
Totals	**170**	354	208	248	**918**	1,369	1,414	1,121	**731**	422	189	203	**51**	34	8	21	**1**	2,179	1,819	1,593	**1,872**				
pproximate percentages	**9**	16	11	16	**49**	63	78	70	**39**	20	10	13	**3**	1	4	1									

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