DEPARTMENT OF COMMERCE
BUREAU OF FISHERIES

A BIOLOGICAL SURVEY OF STREAMS AND LAKES IN THE KLAMATH AND SHASTA NATIONAL FORESTS OF CALIFORNIA

by

A. C. Taft, Assistant Aquatic Biologist

and

Leo Shapovalov, Temporary Biologist

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INTRODUCTION

Purposes of the Survey

In line with similar work carried on in National Forests throughout the country by the U. S. Bureau of Fisheries during the summer of 1934, a stream and lake survey party conducted an investigation of the Klamath watershed in California. The object of the survey was to gather a useful description of the fishing waters of the Klamath drainage basin. The information secured in this work and the data derived from these descriptions will assist in the conservation of the fishes present, the maintenance and improvement of fishing conditions, and the eventual development of rational stocking and improvement programs.

The Klamath party was similar in its organization and in the scope of its work to two other California parties, which surveyed streams and lakes in the Sierra and the Mono and Inyo National Forests, in the Sierra Nevada mountain range. All three parties were under the direction of Dr. P. R. Needham, associate aquatic biologist of the U. S. Bureau of Fisheries and director of the field work of the California Trout Investigations. The work of these and other parties in the United States was made possible by an appropriation from the Public Works Administration to the U. S. Bureau of Fisheries for stream surveys and improvements.

Personnel

Survey work in the Klamath watershed was under the direction of A. C. Taft, assistant aquatic biologist, and fits into the steelhead studies being carried on cooperatively in California by the U. S. Bureau of Fisheries and the California Division of Fish and Game.

The personnel of the Klamath party consisted of Leo Shapovalov, leader of the party, and Kelshaw Bonham, Peter Doudoroff, and Mitchell Hanavan, scientific assistants. All of these men were university-trained biologists, in a position to carry on fisheries work. In addition to their routine stream survey duties, these assistants carried on the following work: Mr. Bonham took an excellent series of photographs for the party and also mapped and measured many of the lakes; Mr. Doudoroff analyzed the stomach contents of ninety-five trout caught in various lakes; Mr. Hanavan secured the chemical data for the party. Jack Trainor, cook and camp assistant, rounded out the personnel of the party.

Five months were spent in the field by this party, from May 1st to September 30th. Weather conditions limited the time spent in stream survey work to this period.

Equipment

Each party was furnished with the necessary scientific equipment to carry on biological, physical, and chemical investigations of both streams and lakes. Camping equipment, with the exception of personal goods and sleeping bags, was likewise supplied. The men and equipment were transported from one field camp to another by means of two Ford V-8 half-ton trucks.

The field equipment was designed and constructed to carry the chemical glassware and other delicate scientific instruments without breakage on the pack trips made to the more remote sections of the region.

Acknowledgments

Grateful acknowledgment is here made of the valuable aid and information given by various groups and individuals. Thanks are due to many members of the U. S. Forest Service who gave generously of their time, especially Tom Jones, Supervisor of the Klamath Forest; Fred Johnson, of the Shasta National Forest; District Ranger Dick Williams for arranging the pack trip to the Boulder Lakes; Al Crebbin of the Regional Office, District Ranger John Williams, and his assistant Clyde Hill, for their general valuable assistance on a pack trip into the Marble Mts. and for their information concerning, and measurements of, certain lakes in the region; and George Scriven, packer on the Marble Mts. trip.

Space does not permit individual acknowledgment to all members of the California Division of Fish and Game who gave their time, and mention is made only of the assistance rendered by Wardens W. J. Harp, Brice Hammack, and T. F. Miller. General acknowledgment is made to the various packers and sportsmen on the Klamath who gave valuable information concerning local fishing conditions.

METHODS

Taking and Recording of Data

Each survey party member was supplied with a metal notebook cover which contained printed blanks for both streams and lakes. Samples of these blanks are attached to this report.

In addition to their routine work, surveyors were on the lookout for possible stream improvement, for indications of natural spawning and its effectiveness, for possible locations for rearing or holding ponds, and other pertinent information concerning local conditions.

The individual methods and apparatus applied to all these and other phases of the work are described briefly as each part of the survey work is taken up in the report.

Stream Data

The smaller streams were generally considered as a unit, while the larger streams were split up into sections, each section being treated as if it were an individual stream. One to three stations were established on each stream or section of stream. When accessibility, time, and importance of the stream warranted it, upper, middle, and lower readings (stations) were taken. In the smaller streams generally only a lower reading was taken, near the mouth of the stream. A lower reading is probably the most important one in the Klamath streams in which a run of migratory, spawning trout and salmon takes place annually.

The amount of data taken at a station also depended somewhat upon the importance of the stream. Quantitative studies of the fish food present, chemical data, and seine hauls were taken only in the larger streams.

Irrigation and mining diversions and dams, the great importance of which in the Klamath watershed is discussed elsewhere in the report, were thoroughly investigated. When diversions were noted or known of they were followed to their intakes from the streams, measurements made upon the amount of water being diverted and upon the dam, notes taken on the presence or absence of a fish screen and a fish ladder, their dimensions and effectiveness, and on any fish present in the diversion.

Lake Data

All of the lakes were considered as single units. One or more stations were taken in the open water of the lake. There, as in the streams, the amount of information varied with the importance of the lake. In the more important lakes soundings were made, temperatures taken at various depths, and quantitative dredge hauls of the food organisms taken.

Location of Streams and Lakes

Throughout this report streams have been located according to the range, township, and section in which their mouths occur. In the case of streams split up into sections, the lower ends of the sections have been located in the same manner. Lakes have been located by the range, township, and section in which their outlets occur.

Whenever several streams and lakes are listed in this report they are arranged with reference to the main stream in the list. First the main stream is considered, or its lowermost section if it is split up into sections, then its first tributary proceeding upstream, then any tributaries of that stream, again proceeding upstream, then the next tributary of the main stream, and so on.

When one section of the main stream and all its tributaries have been listed the next section of the stream and its tributaries are taken up.

NATIONAL FOREST AREA SURVEYED

Geographic Location

All of the streams and lakes surveyed by the party lie within the California portion of the drainage basin of the Klamath River and its tributaries. Next to the Sacramento-San Joaquin, the Klamath is the largest and most important of California's rivers. It has its origin in the high table-lands east of the Cascade mountains in south-central Oregon. After expanding to form the Klamath Lakes (in Oregon) it cuts its way through the mountainous region of northern California to enter the Pacific Ocean almost midway between the mouths of the Columbia and Sacramento Rivers.

In California the Klamath watershed embraces portions of Siskiyou, Humboldt, Trinity, and Del Norte Counties. It includes all of the Klamath National Forest and portions of the Shasta and Trinity national forests, as well as some state, Indian Reservation, and privately owned land. Due to lack of time, no survey work was done during the past summer in the Trinity National Forest. The portion of the Klamath watershed lying in the latter forest is confined to a part of the drainage basin of the Trinity River, the Klamath's largest tributary.

Physiography and General Description of Watershed

In speaking of the "Klamath watershed" reference will be made in this report only to that portion of the drainage basin lying in California.

The Klamath watershed in general is a mountainous area, well-wooded with both conifers and deciduous trees and subject to considerable rainfall during the wet winter season. This is especially true of those areas lying within national forest boundaries, whose streams for countless years have been fine trout and salmon waters.

The upper parts of the Klamath watershed receive considerable snowfall, which diminishes and is replaced by rain as one proceeds toward the coast.

Most of the privately owned land is located in the Shasta and Scott valleys. It is largely agricultural or ranch land in fairly open, flat country with less rainfall than the rest of the drainage basin.

Practically all of the irrigable land in these two valleys is now utilized and as a result of the extensive diversion of water fish life has suffered more adverse affects than in any other parts of the watershed. With the exception of these two valleys, the entire area surveyed lies within the transition or boreal zones.

The extreme lower portion of the Klamath also lies outside national forest boundaries. It, however, lies in the Coast Redwood belt and is subject to heavy precipitation.

THE STREAMS

General Character of the Streams

The streams of the Klamath watershed, like most California streams, are subject to considerable natural fluctuation, due to the existence of a wet winter season and a dry summer season each year. During the past summer the streams as a rule were lower than they had been during the past decade, so they were seen under circumstances most adverse to fish life.

The streams rise with the beginning of the rainy period, which is usually in September or October. They start dropping gradually in the spring and reach their lowest points in August or sometimes September. The streams of the upper part of the watershed are subject to greater fluctuation than those near the coast. The latter streams, even those with small drainage basins, have a large and more constant volume.

Unfavorable conditions due to natural low water are greatly accentuated by the operation of diversions for mining, irrigation, power, and domestic use. Mining and irrigation ditches are the most common and create the greatest problem.

Fortunately the larger mining diversions are operated mostly during the winter, when the damage to fish life is probably less than during the summer months. Furthermore, the mining ditches usually flow back into the stream with but little loss of water and permit some of the fish in them to reach the stream, except in those cases in which the water passes through the nozzle of a "giant" in a hydraulic mine.

The irrigation ditches,unlike those for mining, are operated mostly during the spring and summer, when either the young steelhead and salmon and the surviving adult steelhead are on their downstream migration to the ocean, or the remaining fish are struggling for existence in the drying streams.

The Klamath River proper presents a problem in fluctuation all its own. Dams and power plants are located at Copco, California, some 200 miles above the mouth of the Klamath, and also above in Oregon.

These plants let through amounts of water which vary with the "load" being carried. Under present conditions this causes sudden and irregular fluctuations of the river. At times these fluctuations come daily while at other times the amount of water let through is varied only after several successive days of high or low water.

The section of the Klamath River immediately below Copco Dam is the one in which the rise and fall of the river is the greatest and most abrupt. There the water may drop or rise several feet in the space of twenty minutes. Millions of young fish are planted each year in Fall Creek, which enters the Klamath in this section, and work down into the main river. There they are sometimes caught unawares by the quickly dropping river and left stranded along its shores.

Great damage, too, is done by the fluctuation to the invertebrate life; i.e., to the potential fish food. On May 26th numbers of roving bottom organisms such as the young of mayflies and stoneflies were found dead in areas exposed by low water.

The regulation of the water to a steady flow by the construction of an equalizing dam below the Copco power plant would (1) widen the zone of production of bottom fish food, which at present is limited to the area covered by low water from Copco, (2) eliminate the stranding of young fish and of roving bottom organisms which serve as food for fish, (3) save some of the salmon spawning grounds and provide new areas for salmon spawning, and (4) eliminate a source of real danger to fishermen in the stream.

For a fuller account of diversions and other barriers to fish see Table 10 and the accompanying discussion on pages 44-46.

Most of the smaller tributaries are short and precipitous, varying from 3 to 20 miles in length and having an average gradient from mouth to source of about 500 ft. per mile. In general they are plentifully supplied with both pools and riffles and in their lower courses have many gravel beds suitable for spawning. Many of them have falls which are high enough to prevent the passage of spawning fish to the upper reaches. The location and height offalls has been given in Table 10. These streams are particularly well fitted for the production of large numbers of small fish and most of them become too shallow to support larger fish during the dry summer months.

Temperatures

Water temperature is generally the most important single factor in limiting the distribution of different kinds of trout. Rainbow trout have been found to live successfully in temperatures not exceeding 80°F. This temperature is not necessarily the death point for rainbow trout, but rather the upward limit for optimum conditions.

The highest temperature recorded in the Klamath River during the past summer was 78°F., 100 feet below Indian Creek, on July 30. The greatest temperature obtained in the Trinity River was 74°, the greatest in the Salmon 74° (77.5° in North Fork Salmon River and 78.5° in South Fork Salmon River), the highest in the Scott 72°, and the highest in the Shasta 73°, although in this stream the temperature probably goes much higher in the section near the mouth. The temperatures of the tributaries of these rivers were practically always lower than those of the main streams.

Thus on the single basis of temperature relations practically none of the streams examined this summer can be considered unsuitable for rainbow-steelhead trout, although some of the streams are too warm for eastern brook trout, which thrive best in waters which do not attain a temperature of over 75°F.

It must be noted that most streams with surface temperatures exceeding the "lethal limit" for trout have colder pools, which are places of retreat for trout during hot days.

Chemical Conditions

The purpose of the chemical studies was to determine the suitability of the various waters for fish and for fish food organisms and also to correlate some of the chemical data with certain physical data such as elevations, time of day, water temperatures, etc., and with the richness of the streams in bottom foods.

Partial or full chemical data were secured at a number of points on the Klamath, Trinity, Salmon, Scott, and Shasta rivers and their tributaries. When conditions warranted it and if possible, "full" chemical data (oxygen, methyl orange alkalinity, phenopthalein alkalinity, and hydrogen ion (pH) concentration) were secured.

All chemical determinations were made in the field with portable equipment devised for the purpose. At the start of the work the pH outfit had not yet arrived and consequently pH readings could not be taken until June 20th. In September only the pH was taken in several small streams at which little could be gained in the extra time required to take oxygen and alkalinity readings.

The variations occurring within the limits of the data obtained have little significance insofar as an interpretation of any given stream based on a single reading is concerned. This is shown by the fact that at the same station on the Klamath River (0.1 mile below Beaver Creek) four samples taken within the space of four days varied as follows: Oxygen from 8.1 to 9.9 p.p.m.; methyl orange alkalinity from 70 to 104; phenophthalein alkalinity from 0 to 30; and the pH from 7.6 to 8.1. The range for the entire series of Klamath River samples (nineteen) was only: Oxygen 8.0 to 10.4; m.o. alkalinity 63 to 104; phn. alkalinity 0 to 30; and pH 7.6 to 8.6.

With such a range of chemical readings it seems unwise to attempt to correlate any of the readings with the bottom foods present <u>in any given stream</u>.

A range in readings in a single stream takes place because oxygen, alkalinities, and the pH are all dependent upon such factors as the time of day when the reading was taken, the amount of sunlight, whether it has rained recently or not, and the number of plants present at a particular spot. Because of this maze of factors only a very large series of complete chemical samples with complete accompanying data can give us anything like a true picture of any fair-sized stream.

What we can say from our readings is that in the Klamath watershed as a whole the oxygen and alkalinity of the water are quite favorable to fish life and fish foods.

Dissolved Oxygen

This was reported in parts per million (p.p.m.). Stream samples were taken at the surface with a Kemmerer water sampler.

Providing excessive temperatures do not occur, it is only in streams chemically polluted (by pulp and paper waste, dairy and municipal sewage, etc.) that oxygen is liable to be deficient and the stream rendered unfit for game fish. In unpolluted streams the water by flowing over rocks and other natural obstructions frees itself of carbon dioxide (deadly to fish if present in sufficient quantities and coupled with low O_2) and provides itself with oxygen (necessary to fish in certain quantities). Since there is practically no pollution of the above-mentioned type in the Klamath watershed oxygen values were uniformly good. The highest value obtained was 11.9 p.p.m., at Big Spring one mile below the source, undoubtedly due in large part to the oxygenation of the water by the abundance of aquatic plants present.

Alkalinity

This was reported as methyl orange alkalinity and phenophthalein alkalinity in parts per million of calcium carbonate (p.p.m. of Ca CO_3).

In general, high alkalinity readings are indicative of streams rich in bottom fish foods. In the Klamath watershed these alkalinities show water favorable to fish life and fish foods and these indications are borne out by the general bottom food observations and collections.

The greatest m. o. alkalinity was 262, taken in the Shasta River near its mouth; the greatest phn. alkalinity 30, taken in the Klamath River 0.1 mile below Beaver Creek. High m. o. alkalinity is generally indicative of limestone, shale, or marble terrain.

Hydrogen Ion Concentration (pH)

This was determined colorimetrically against La Motte standards.

All of the streams (and lakes) in the Klamath watershed which were tested were alkaline in character. pH readings in the streams varied from 7.2 in Shovel Creek to 8.6 at several points in the Klamath River.

Food Supply

No serious food deficiency was found in practically any of the streams surveyed.

Bottom Foods

The bulk of the food of the trout in any stream is usually the food produced by the stream bottom, although in some instances over half of the food has been found to come from the land. Bottom organisms consist of various molluscs and crustaceans, and the immature stages of insects (e.g., mayflies, trueflies, stoneflies, and caddisflies).

The composition of the stream bottom has been found to bear an important relationship to the amount of food produced by the stream. Gravel and rubble bottoms are among the most productive types. Practically all of the Klamath watershed streams have bottoms with a goodly portion of rubble and gravel. This, together with their chemical nature and oxygen conditions, which, as we have seen previously in this report, are favorable to fish foods, may well account for their ample supply of bottom foods.

For the purpose of getting some idea of the relative quantity of bottom foods produced by the different streams a number of bottom samples were taken (see Tables 1, 2, and 3). These food samples were taken with an apparatus which covered just one square foot of the stream bottom with an attached fine-meshed net into which the food organisms from that square foot could be washed and later counted.

Of course, the bottom of any given stream is not the same throughout its course and is therefore not covered by a uniform population of bottom organisms. And so we are not warranted in comparing any one stream with any other stream on the basis of single samples or even several samples.

Probably the most important factors in determining the amount and kind of bottom food to be found in a given spot are type of bottom, velocity of current, and depth. Temperature of water, the time of the year, and elevation are all factors that affect the stream as a whole. Of course, it was impossible to get seasonal studies on any stream, so that a true comparison of the streams or a true picture of any one stream cannot be obtained. All we can get is a picture of the "standing crop" in the stream at the particular spot at which the sample was taken, or at most of similar spots in that stream. The determination of the relative richness in bottom foods is a difficult problem in sampling which was made more difficult by the small number of samples it was possible to take.

Table I - Data on stations at which quantitative foods samples were taken from streams in the Klamath watershed. 1934.

No.	Name of Stream	Station	Date	Elev. in ft.	Width in ft.	Depth in in.	Temp. °F. Air	Temp. °F. Water	Type of * Bottom	Mining Pollution
1	Klamath River	100 yds. below Turwar Cr.	8/21	5	200**	24**	60	73	Rubble 80	None
2	" "	1/3 mi. above Klamath Glen	8/22	9	200	12	65	73	Rubble 80	None
3	" "	" " " " "	"	"	"	"	"	"	" "	"
4	" "	1/4 mi. below Capell Cr.	8/15	100	100	24	82	72	Rubble 60	None
5	" "	1/2 mi. above Pine Creek	8/14	145	140	20	74	76	Rubble 55	None
6	" "	300 ft. above Weitchpec bridge	8/14	175	180	18	76	73	Rubble 80	None
7	" "	1/2 mi. below Red Cap Cr.	8/7	270	150	18	61	69	Rubble 50	Light
8	" "	1/2 mi. above Pearch Cr.	8/7	370	150	15	74	71	Rubble 40	Light
9	" "	1/3 mi. below Ishapish Falls	8/6	460	90	20	78	71	Boulders 50	None
10	" "	1/4 mi. below Stanshaw Cr.	8/6	615	130	12	85	74	Rubble 40	Light
11	" "	100 yds. below Tea Cr.	7/31	670	110	18	83	75	Gravel 50	Light
12	" "	2.2 mi. above Dillon Cr.	7/31	750	50	30	88	74	Rubble 35	Light
13	" "	50 ft. above Wingate Cr.	7/31	940	60	24	76	77	Bedrock 50	Light
14	" "	300 yds. above Elk Cr.	7/30	1040	100	12	82	78	Rubble 35	Light
15	" "	At Gordon's Ferry	7/3	1120	140	24	85	74	Rubble 60	Light
16	" "	0.8 mi. above Ft. Goff Cr.	7/30	1308	60	24	72	71	Rubble 50	Light
17	" "	At Seiad highway bridge	7/30	1375	80	24	85	76	Rubble 35	Light
18	" "	100 yds. above O'Neil Cr.	7/30	1425	90	10	91	76	Rubble 30	Light
19	" "	0.8 mi. above Hamburg P. O.	7/30	1520	160	6	84	74	Rubble 35	Moderate
20	" "	500 ft. above Scott R.	8/2	1530	120	24	65	61	Rubble 35	None
21	" "	0.1 mi. below Beaver Cr.	6/4	1735	90	12	67	64	Rubble 30	Light
22	" "	1/2 mi. below Camp Lowe	5/30	2060	100	10	63	65	Rubble 40	None
23	" "	At Fall Cr. bridge	5/30	2320	80	5	65	63	Boulders 50	None
	Salmon System									
24	Salmon River	20 ft. above Monte Cr.	8/24	550	50	12	75	74	Rubble 30	Moderate
25	" "	800 ft. below Horn Cr.	8/27	1175	45	10	73	70	Rubble 60	Moderate
26	N.Fk.Salmon R.	1/4 mi. above Fks.of Salmon	8/29	1200	40	6	75	71	Rubble 45	Moderate
27	" " " "	900 ft.above Little N. Fork	8/29	1975	30	4	88	77	Rubble 50	Moderate
28	Nordheimer Cr.	1/3 mi. above mouth	8/28	1100	14	4	86	69	Rubble 25	None

(Continued on following page)

Table 1 - Continued

No.	Name of Stream	Station	Date	Elev. in ft.	Width in ft.	Depth in in.	Temp. °F. Air	Temp. °F. Water	Type of * Bottom	Mining Pollution
	Scott System									
29	Scott River	100 yds. above mouth	6/29	1550	28	18	77	62	Rubble 80	Heavy
30	S.Fk.Scott R.	1/10 mi. above Boulder Cr.	6/25	3300	15	24	60	56	Rubble 50	Moderate
31	E.Fk.Scott R.	200 ft. above Mule Cr.	6/15	3300	20	5.5	79	71	Rubble 40	Heavy
32	" " " "	" " " " "	"	"	"	"	"	"	" "	"
33	" " " "	" " " " "	"	"	"	"	"	"	" "	"
34	" " " "	100 ft. above Grouse Cr.Rd.bridge	6/15	3500	16	4.5	78	67	Rubble [illegible]	None
35	" " " "	" " " " " "	"	"	"	"	"	"	" "	"
36	" " " "	" " " " " "		"	"	"	"	"	" "	"
	Shasta System									
37	Shasta River	At Copco Diversion Dam	5/23	2400	27	7	75	70	Rubble 30	None
	Klamath Tributaries									
38	Hunter Cr.	At bridge on Requa Road	8/20	5	10	3	57	53	Gravel 65	None
39	Bluff Cr.	300 ft.above highway	8/11	300	60	12	63	59	Rubble 35	None
40	Dillon Cr.	1/3 mile above mouth	8/2	850	22	8	76	66	Rubble 60	Light
41	Swillup Cr.	100 ft. above mouth	7/31	800	8	6	84	63	Rubble 35	None
42	Clear Cr.	600 ft. below S. Fork	8/2	1000	30	9	70	67	Rubble 30	None
43	Elk Cr.	100 ft. below McKee Dam	7/3	1050	30	12	80	69	Rubble 30	None
44	Indian Cr.	0.7 mile above mouth	7/6	1080	40	8	70	64	Rubble 60	Moderate
45	Grider Cr.	1/2 mi. above mouth	7/2	1400	15	6	81	63	Rubble 40	None
46	Beaver Cr.	1/4 mi. above mouth	5/16	1900	27	9	62	55	Rubble 40	Moderate
47	" "	At mouth Dutch Cr.	5/16	2300	40	8	67	56	Rubble 50	Moderate
48	" "	25 ft. below West Fork	5/17	2700	21	13	69	54	Rubble 40	Moderate

* Refers to dominant type and percentage of that type found at station where sample was taken. Samples themselves were usually taken in rubble and gravel riffles in moderate to swift water.

** All widths and depths at stations on the main Klamath River were taken when the flow was shut down at the Copco Power Plant and vary greatly from widths and depths at high water from Copco. See p. 64 of text for discussion.

Table 2 - Quantitative collections of bottom food organisms from streams in the Klamath watershed, 1934. Numbers based on samples from 1 sq. ft. areas.*

No.**	Caddisfly larvae and pupae	Mayfly nymphs	Truefly larvae and pupae	Stonefly nymphs	Aquatic beetles	Dragonfly and Damselfly nymphs	Aquatic moth larvae and pupae	Freshwater shrimps	Snails	Limpets	Clams
Klamath River											
1	1	25	120								
2	6	12	125						225		
3	20	16	40						130		
4	35	15	100								
5	215	225	123			2			x		
6	150	95	2000	2	25				2	6	
7	47	49	84		18	2	1		1	x	
8	115	75	150	5	10	6			x		x
9	24	120	36		4	1			x	x	
10	42	20	35	7	5	4	3		x	3	
11	9	28	22	1		4	x		x	x	
12	30	52	53		1	1	21			x	
13	17	170	70	3	1	1	1				
14	9	54	7			5	17		4		
15	12	24	30		2	4	6		6	30	
16	640	290	490	2	60	10	60				
17	135	85	100	8	14	4	82		15	17	x
18	87	46	34	13	23	x	4		x	x	
19	49	52	150	1	3	1	22		16	5	
20	24	80	x			1	x	x	24	13	
21	290	155	180	x	144	3	24	24	6	x	
22	220	220	30	x	25		25	x	5000	x	x
23	330	50	95	x	1		38	12	30	3	17
Salmon System											
24	8	13	8	9					8		
25	200	115	230	20	19	1					
26	331	102	119	52	47		20				
27	200	50	50	25	30						
28	50	110	180	40	8						
Scott System											
29	72	22	16	5	4				x	x	
30	7	39	35		4						

(Continued on following page)

Table 2 - Continued

** No.	Caddisfly larvae and pupae	Mayfly nymphs	Truefly larvae and pupae	Stonefly nymphs	Aquatic beetles	Dragonfly and Damselfly nymphs	Aquatic moth larvae and pupae	Freshwater Shrimps	Snails	Limpets	Clams
31	3	20	1	3	10						
32	1	23	2	3	6						
33	3	17		3	12						
34	15	45	65	10	5						
35	50	140	95	20	30						
36	15	100	110	10	35						
Shasta System											
37	34	x	15	15		x		5	95		x
Klamath Tributaries											
38	25	40	365	5				5			
39	157	79	98	33	40						
40	11	39	40	27	15		2		4		
41	25	21	4	9							
42	52	85	80	18	15				x		
43	11	24	23	6	20				3		
44	3	12	12	8	4				26		
45	96	90	30	14	8				4		
46	10	45	5	5	25				x		
47	x	25	10	5	x						
48	13	113	x	32							
Av.	82	69	120	9	14	1	7	1	73	2	+

Av. no. organisms per sq. ft. for all samples = 380

* Organisms seen but not taken in samples are indicated by an x.

** Numbers accompanying food counts correspond to station numbers in the field data table, Table 1 .

Table 3 - Summary of 48 quantitative collections of bottom food organisms in the Klamath watershed, 1934.

Organisms	Total No. Taken	Per cent by number
Caddisfly larvae and pupae	3,949	21.6
Mayfly nymphs	3,327	18.2
Truefly larvae and pupae	5,747	31.5
Stonefly nymphs	417	2.3
Aquatic beetles	678	3.7
Dragonfly and damselfly nymphs	50	.3
Aquatic moth larvae and pupae	346	1.9
Freshwater shrimps	41	.2
Snails	3,599	19.7
Limpets	84	.5
Clams	17	.1
	18,255	-

Limitations of the apparatus make it possible to take samples only on certain types of bottom and in limited depths and as a result it is difficult to obtain a similarity in these conditions from stream to stream or even within the same stream.

As has been noted previously in the report, large areas of the Klamath River are subjected to daily fluctuation in water level because of water power development at Copco, in California, and at Klamath Falls, in Oregon. This fluctuation limits the pro duction of aquatic fish food to the lowest stage of the water. Nevertheless, the Klamath River may with reasonable assurance be said to have a richer fauna both in numbers and weight of organisms per unit area and in diversity of kinds of organisms than any of the other streams examined. The next richest streams seem to be its large tributaries: the Trinity, Salmon, Scott, and Shasta rivers, especially in those portions in which there is little silt from mining. Then come the smaller tributaries of these rivers and of the Klamath, with the larger tributaries, when unpolluted by mining, generally richer than the smaller tributaries. It may be reasoned that this is so because the larger streams of the general characterof smaller streams will offer a wider choice of environment and will thus provide a foothold for more kinds of organisms.

The richest all-round sample secured in the Klamath River was taken 0.8 mile above Ft. Goff Creek. This sample was first in number of caddisflies (640), first in the number of mayflies (290), second in trueflies (490), sixth in stoneflies (2), second in aquatic beetles (60), first in dragonflies and damselflies (10), and second in aquatic lepidoptera, but contained no scuds ("freshwater shrimps"), snails, limpets, or clams.

As far as the smaller streams of the Klamath watershed are concerned, silt caused by mining is as important a factor as any, if not the most important factor, in determining the amount of bottom food present. With no mining silt present, the factors mentioned heretofore play dominant roles. That mining silt is detrimental to bottom food organisms is borne out by the following tests. On the afternoon of June 15th two stations were selected on the East Fork of Scott River, one a short distance above Grouse Creek, which carries considerable mining silt into the East Fork, and one below Grouse Creek. With the exception of Grouse Creek no tributaries enter the East Fork between these stations, the stream has essentially the same character, and the land bordering the stream between these two stations is uncultivated. Thus, it seems that the only factor to change the stream between the two stations would be the entrance of the silt at Grouse Creek.

The riffles on which the quantitative samples were taken at the two stations were picked to resemble each other. Three quantitative samples were taken at each station.

As shown by the following table there was a marked decrease in all the main groups of food organisms. This table shows the numbers of trout food organisms per square foot collected in the areas polluted and not polluted by mining silt.

June 15, 1934 P.M.	Above Mining No.1	No.2	No.3	Total	Av. per sq. ft.	Below Mining No.1	No.2	No.3	Total	Av. per sq. ft.
Mayflies	45	140	100	285	95	20	23	17	60	20
Trueflies	65	95	110	270	90	1	2	--	3	1
Caddisflies	15	50	15	80	27	3	1	3	7	2
Beetles	5	30	35	70	23	10	6	12	28	9
Stoneflies	10	20	10	40	13	3	3	3	9	3
Crayfish	-	1	2	3	1	2	-	2	4	1

Observations in other streams seem to bear out these tests. In Merrill Creek, a tributary of the Salmon River, the bottom of the lower portion of the stream is composed largely of coarse mining silt. This silt was productive of almost no food except snails.

Whenever a series of quantitative bottom samples was taken in one stream or in a series of similar streams during the summer, the average number of food organisms in the one square foot samples was always less in mined areas than in non-mined areas.

Food from the land

The amount of drift, or terrestrial food, cannot be accounted for directly. This item is sometimes of considerable importance, especially in shaded streams, typical of the Klamath watershed.

Plankton

Plankton organisms are the very small, free-swimming or suspended plants and animals occurring in water. In most of the streams these minute organisms are of comparatively little value to fish as direct food, but in the Klamath River they occur in such vast quantities at certain times of the year that they probably play a considerable part in the economy of the fish through supplying food for the organisms upon which they feed.

Fishes Present

Apparently every natural condition favorable to the support of a large fish population prevails in the Klamath watershed and originally its streams are reported to have fairly swarmed with fishes. The number of species is remarkably small, however, and several of those present consist of anadromous forms (marine fishes running up rivers to spawn) such as the sturgeon, salmon, and trout, together with others able to withstand salt water, as the cottoids and stickleback.

It is a well-known fact that the Columbia, Klamath, and Sacramento basins have each a distinctive fluvial fish fauna, consisting in many cases of characteristic species and genera. Only one stream, the Rogue, contains a Klamath form (excluding anadromous species and those able to withstand salt water). North of the Rogue the fluvial species are representatives of the Columbia fauna, while south of the Klamath they belong with the Sacramento.

The fishes occurring in the Klamath watershed (in California), including introduced forms, are given in the following list. Both scientific and common names are given, also other local common names, and pertinent comments on the life histories of these fishes. The strictly fluvial fishes (those not able to withstand salt water) are the following:

Family CATOSTOMIDAE (Suckers and buffalo fishes)

The Klamath river system, like most of the river systems of the western United States, possesses two kinds of suckers of the Catostomus group, a fine-scaled species and a coarse-scaled species. In the Klamath the coarse-scaled sucker appears to be a rare form.

1. Catostomus rimiculus. Klamath Fine-scaled Sucker.
2. Catostomus snyderi. Klamath Coarse-scaled Sucker.

Family CYPRINIDAE (Minnows, chubs, carp, etc.)

3. Apocope klamathensis. Klamath Black Minnow.
4. Siphateles bicolor. Klamath Lake Chub.
5. Tigoma bicolor. Klamath Lake Minnow.

Family AMEIURIDAE (Horned pouts and channel cats)

6. Ameiurus nebulosus. Square-tail catfish.
   Introduced into California in 1874. Common in Lake Dwinnell Reservoir and in the Shasta River from the reservoir to the mouth, and in mining dredge holes along the Klamath River. Unauthorized names: Bullhead, Sacramento cat, yellow cat, horned pout.

Family CENTRARCHIDAE (Black basses and sunfishes)

7. Helioperca incisor. Bluegill sunfish.
   Introduced into California about 1890. Common in Lake Dwinnell Reservoir, in the Shasta River from the reservoir to the mouth, and in mining dredge holes along the Klamath River.

Forms able to withstand salt water are the following:

Family COTTIDAE (Sculpins)

8. Cottus asper. Prickly bullhead.

9. Cottus klamathensis. Klamath bullhead.
This species, although probably able to withstand salt water, has so far been taken in the Klamath watershed only in its upper reaches.

Family GASTEROSTEIDAE (Sticklebacks)

10. Gasterosteus aculeatus. Common stickleback.

Anadromous forms are the following:

Family PETROMYZONIDAE (Lampreys)

11. Entosphenus tridentatus. Three-toothed Lamprey.
The lamprey is not a true fish and hence is not closely related to the true eel, although it is often called "eel" or "lamprey eel." The true eel is a fish but does not occur in California.
The lamprey may be distinguished from a true fish in that it has no jaws, the mouth being a sucking disc, no paired fins, and has seven external gill openings on each side close behind the head instead of the single gill opening of a true bony fish.

Lampreys ascend streams even as far as the headwaters for spawning purposes. Like Pacific salmon, after spawning once they die. The young are known as ammocoetes and are blind and toothless, living like worms in the dirt of the stream bottoms. After about the end of the third year of this stage, the lampreys metamorphose into the adult form and descend to salt water, from which they ascend rivers to spawn. Occasionally they become landlocked in lakes.

The Brook Lamprey, Lampetra, may also occur in the Klamath River.

Family ACIPENSERIDAE (Sturgeons)

12. Acipenser acutirostris. Green sturgeon.
13. Acipenser transmontanus. White sturgeon.
The range of this species is from Monterey to Alaska. The White Sturgeon was once abundant, but is now quite rare.

Family SALMONIDAE (Salmon and trout)

Several popular misconceptions exist concerning certain members of this family. One is that some of the Pacific salmon spawn several times. The steelhead, which are true trout, may spawn several times but all of the salmon (Oncorhynchus) die after their first spawning.

Another misconception is that the large, hook-nosed salmon called "dog salmon" by local residents form a distinct species of salmon. They are simply large males whose snouts have become hooked and elongated during the spawning season. This phenomenon takes place to a greater or less extent in all the species of salmon and to some extent in the steelhead trout. There is a species of salmon known as Dog Salmon (Oncorhynchus keta) but it occurs comparatively infrequently in California.

The "steelhead" is a trout that has come from the sea and entered a river to spawn. It is not a distinct species of trout, but a sea migrant of the particular species inhabiting the stream, and in California it may be either a cut-throat steelhead or a rainbow steelhead. In the Klamath most of the steelhead are of the rainbow type.

The young of the steelhead live in fresh water for from one to three years as rainbow or cut-throat trout and then migrate to the ocean, although some individuals appear to remain in the stream throughout their lifetime.

The brown trout and the eastern brook trout have been planted mostly in the lakes of the Klamath watershed and do not act as anadromous forms. However, they are species which are able to withstand salt water and in their native habitat do enter the ocean and later run up the streams to spawn (in Nova Scotia, England, etc.) and so are here placed in the list of anadromous forms.

14. Oncorhynchus kisutch. Silver Salmon.
    Unauthorized names: jack salmon, silversides, coho salmon.
15. Oncorhynchus tschawytscha. King Salmon.
    Unauthorized names: chinook salmon, quinnat salmon, Sacramento River salmon, Columbia River salmon, spring salmon.
16. Salmo clarki. Coast Cut-throat trout.
17. Salmo irideus. Coast rainbow trout.
18. Salmo fario + Salmo trutta levensis. Brown trout.
    Introduced into California, where all representatives are hybrids between the European brown trout and the Loch Leven trout. This crossing accounts for the large variation in the color pattern and spotting.
    Unauthorized names: German brown trout, European brown trout.
19. Salvelinus fontinalis. Eastern brook trout. Introduced into California.

Fishing Intensity and Accessibility

In the streams of the Klamath watershed the fishing is almost exclusively for three species of fishes: Rainbow-steelhead trout, King salmon, and Silver salmon.

During the spring and early summer both artificial fly and bait fishing is carried on for the young steelhead and to some extent for young silver salmon. Then there is somewhat of a lull in fishing, followed by considerable sport trolling in the estuary of the Klamath for both kinds of salmon and for steelhead, in the late summer and during the autumn.

As the runs of salmon and steelhead proceed up the river and branch out into its tributaries on their spawning migration, great numbers of people come long distances to fish for them. In the sport fishing, the steelhead are caught on artificial flies, salmon eggs, and spinners, while the salmon are caught mostly on spinners, although an occasional silver salmon is taken with an artificial fly.

In addition to the sport fishing considerable netting and trapping is carried on by the large Indian population of the Klamath. Many salmon and steelhead are caught by means of various devices, such as gill nets, stationary traps in the rivers, and homemade, long-handled dip nets. Many fish are also speared on the riffles. Many of the fish caught by the Indians are smoked for winter use.

Besides, not a little illegal spearing and netting is done by the white population of the Klamath.

Most of the important streams of the Klamath are accessible at least by trail somewhere along their courses. Many of the streams have been opened up to fishing through new roads and trails built only during the past few years by the U. S. Forest Service with CCC labor.

Although a number of streams are available by road or trail the fishing is not as heavy as in some other portions of California for the reason that the Klamath system is rather far removed from large centers of population. The nearest California city with a population as great as 20,000 is Sacramento, approximately 300 miles away.

With the new road built during the past summer, only the lower portion of the Klamath River from Klamath Glen to Pecwan Creek is not paralleled by road. Automobile roads parallel the Trinity, Salmon, Scott, and Shasta rivers. Roads also run up Redcap, Indian, Elk, Seiad, Mill, Shackleford, French, Horse, Beaver, and Cottonwood creeks. Many of these roads are quite new and there is every reason to believe that very soon the intensity of the fishing is going to increase, especially along these new roads, but also in the Klamath watershed generally. It is true that most of the new roads are being built along the ridges between creeks rather than in the canyons of the creeks, thus not opening up the streams as much as they might otherwise. Every preparation must be made to meet the demands on the fishing that will take place.

THE LAKES

General Character of the Lakes

Most of the lakes in the Klamath watershed are small, natural lakes. Of the forty-seven lakes seen, only five are over twenty acres in extent. Only two are entirely artificial. These are Copco Lake, formed by damming up a portion of the Klamath River, and Lake Dwinnell Reservoir, created by damming up a portion of the Shasta River. They are also by far the largest