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INVESTIGATIONS OF THE FISHERY OF FISH LAKE, UTAH

by  
Vaughn D. Madsen

A thesis submitted in partial fulfillment of the requirements  
for the degree of  
Master of Science  
in the  
School of Forestry

Utah State Agricultural College  
1942

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Approved:

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Major Professor

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For English Department

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Dean of the School

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Chairman of Committee on Graduate Work

Utah State Agricultural College  
1942

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#### ACKNOWLEDGEMENT

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\* Cooperating agencies: U. S. Fish and Wildlife Service, Utah State Agricultural College, Utah Fish and Game Department, and American Wildlife Institute.

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## INTRODUCTION

Fish Lake, which is located in Sevier County, Utah, is considered to be one of the most productive lakes in the intermountain regions. It is visited annually by thousands of fishermen from Utah and surrounding states. In 1934, a thirteen day check made by the Utah Fish and Game Department showed that anglers caught 17,521 fish with a total weight of 13,844 pounds, and spent a sum of \$27,246.21 on expenses.

Because of the great recreational value of Fish Lake, chiefly as a fishing resort, it is desirable to find out whether or not any great change has taken place or is taking place in the fisheries of the lake, in order to draw up a suitable plan of management for the fisheries. With these objects in mind, a series of investigations were carried on at the lake in 1935, 1938, 1940 and 1941. Part of the data gathered from these investigations are used as a basis for this paper.

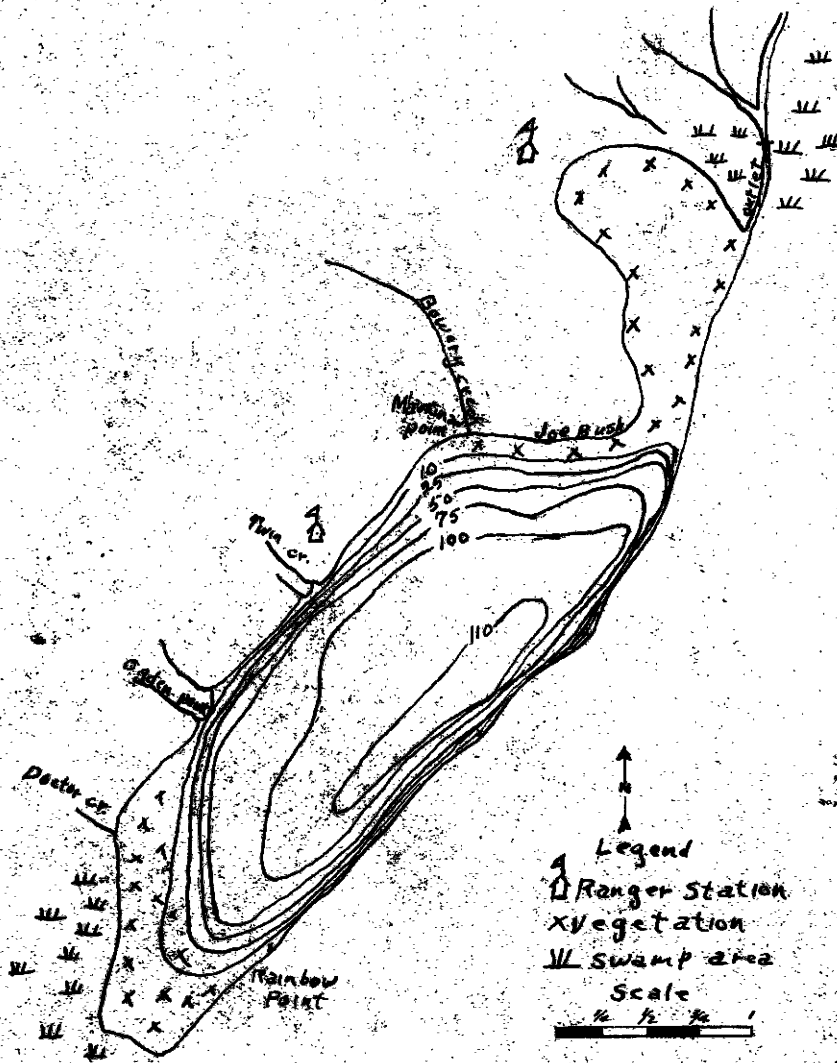
Description of the Lake. A good description of the lake is given by Hazzard (1935) as follows:

Fish Lake is at an elevation of 8800 feet and is situated in a region of past volcanic and glacial activity. It is five and one-fourth miles in length by an average of three-fourths mile wide; the area being roughly 2,500 acres. The long axis of the lake extends in a northeast-southwest direction. The precipitous, wooded, rocky shore of the southeast side is in direct contrast to the more gently sloping hills of the northwest and the marshy flats at each end.

The lake is supplied by six spring-fed streams, only one of which is of sufficient size to furnish any spawning area for trout from the lake, and in this one the area is restricted to less than one-half mile.

About seventy percent of the lake is over ninety feet deep with a maximum depth of 117 feet (Figure I). Principal shoals and

Figure 1. Contour map of Fish Lake, Utah. Soundings by A. S. Hazzard and Lee Kay. Map, M. J. Madsen. Revised from Forest Service map of 1923



weed beds are found at the ends and along the northwest side. The water is quite clear. The lake bottom is principally of mud mixed with decaying aquatic plants. Dense aquatic plant beds are found in the shallow areas.

History of the Fisheries. The lake, originally, was literally teeming with the native cutthroat trout (Salmo clarkii), according to reports given by many of the early fishermen who visited the lake. One old timer relates the story of his horses stepping on the trout and his wagon running over them when he crossed Twin Creeks during the spawning season. Other accounts are similar to this story. Native trout fishing was unexcelled.

In the year 1906, a small number of brook trout (Salvelinus fontinalis) and mackinaw trout (Christivomer namaycush) were introduced into the lake. The introduction was a success, as these two species increased and provided excellent fishing for a number of years. Of special note was the excellent shore fishing for brook trout, of which many were taken weighing several pounds. Previous to the introduction of these species, a decline in the number of native trout had taken place. At the present time there are only a few natives in the lake, and they are probably not of the original stock as it has been supplemented by plantings. Very few natives are now taken during the fishing season. About 19 the rainbow trout (Salmo gairdnerii) was introduced into the lake. It increased steadily until it now makes up more than 90 percent of the total catch.

About 1923 the Utah Lake chub (Gila atraria) was accidentally introduced into the lake. Owing to its tremendous reproductive

ability, it increased rapidly until in 1928 it had become a nuisance to the fishermen who were casting along the shore for brook trout. Several years later (about 1934), a decline in the brook trout fishing became noticeable. The decline continued, until, at the present time, the brook is of little importance in the lake fishing. A number of factors probably entered into the decline of the brook trout fishery, and these will be discussed in the appropriate section.

In 1938 control measures were applied to the chub, and continued through the summers of 1939, 1940, and 1941. All persons concerned are of the opinion that these measures have been successful in reducing the number of chubs. The chub can never be completely exterminated as many of them remain in the lake proper, and control measures can be applied only when they come into the shallow water to spawn. However, if control measures are continued the chub can be kept at such low numbers that it will not be a nuisance to the fishermen and a menace to the game fish through competition for space and food in the lake.

#### REVIEW OF LITERATURE

In 1927, Samuel F. Hilderbrand and Irving L. Towers made a report on Fish Lake, Utah, which was published in "Ecology" Volume VIII, No. 4, October, 1927. The data for the report were obtained during the summers of 1922, 1923, and 1924. Physical characteristics of the lake, and the feeding habits of the animal life found there, constitute the subject matter of the article. Forest Service rangers obtained 118 fish stomachs from guides and fishermen and later sent

them to Hilderbrand and Towers for analysis. The report lists Daphnia, midge pupae, and shrimps (Gammarus) as the most important foods eaten by the trout. The life history and ecology of many of the smaller aquatic animals are given in the report.

Dr. A. S. Hazzard made a report on Fish Lake, which was published in Volume 65, 1935, of the "transactions of the American Fisheries Society", under the title, "A Preliminary Study of an Exceptionally Productive Trout Water, Fish Lake, Utah." An account of the general, physical, chemical, and biological characteristics of the lake is given, as well as that of a study of food taken by trout in the lake. This study was made from July 21 to 31, 1933, by analysis of 39 rainbow stomachs, 17 eastern brook, and 3 mackinaw. The mackinaw trout weighed from 9 to 13 pounds and had eaten from one to three brook trout from five to ten inches in length. The most important foods taken by the rainbow trout were shrimp, higher plants, algae, and mollusks. Cladocerans, shrimp, and Diptera, were the most important food items in the diet of the brook trout.

In 1935, Dr. D. I. Rasmussen, now of the Fish and Wildlife Service, and leader of the Utah Cooperative Wildlife Research Unit, made an investigation of the fishery of Fish Lake which was concerned primarily with competition between the species of trout and the Utah chub as shown by their food habits. The data gathered during this study were worked up by Clyde R. Madsen, and presented as a Bachelors Thesis at the Utah State Agricultural College Forestry School under the title, "A Study of the Fish Foods of Fish Lake, Utah." Stomach analyses were made of the following kinds of fish:

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rainbow, brook and mackinaw trout, and the Utah chub. Forty-six rainbow stomachs were examined. Items of food in order of importance were filamentous algae, chubs, Daphnia, shrimp, shiners, and higher plants. Twenty-three brook trout stomachs were analyzed, showing the following items present in order of importance: chubs, bullheads, brook, shiners, and shrimp. Analyses of 46 mackinaw stomachs showed rainbow to be the most important food. Food other than fish made up only 6.45 percent of the total, showing the mackinaw to be pre- dominately fish eaters. Stomachs from 16 chubs were analyzed. They were found to eat Daphnia, filamentous algae, terrestrial insects, and shrimps. The main competition for food was found to be between the rainbow and the chub, as they both fed to a considerable extent on plants and insects. Competition of other species was not important. In the opinion of Madsen, the fish life of the lake is in the main dependent indirectly on the plant area of the lake.

In this study, scale readings were made on rainbow, brook, and chubs. It was found that the rainbow made the fastest growth of those computed. Scale studies of the brook seemed to indicate that the males outgrow the females, and a stopping or slowing down, of the scale growth occurred after they reached four or five years of age. The scale study showed that the chub in Fish Lake grew ten inches in seven years.

In 1938, L. E. Perry carried on an investigation of the fishery of Fish Lake. The results of this study were presented in the form of a typewritten report under the title "Investigations of the Fishery of Fish Lake, Utah, 1938." This report contained

data on a partial creel census, and food studies of the rainbow, mackinaw, and brook trout, and Utah chub.

#### HISTORY OF THIS INVESTIGATION

Data used in this study were gathered during the summers of 1935, 1938, 1940, and 1941. During the summer of 1935 the Utah State Fish and Game Department, in cooperation with the Utah State Agricultural College, made an investigation of the fishery of Fish Lake, Utah, under the direction of Dr. D. I. Rasmussen. As previously stated the investigation was concerned primarily with competition between the species of trout and the Utah chub, as shown by their food habits. The investigations were discontinued during the 1936 and 1937 seasons, but were again reopened in 1938 through a cooperative agreement between the Utah State Fish and Game Department and the Utah Cooperative Wildlife Research Unit, under the direction of Dr. D. I. Rasmussen, and the U. S. Bureau of Fisheries. During the 1938 investigations a program of control of the Utah chub was begun and has continued since. The investigation included fish food studies by analysis of stomach contents, angling success as shown by a partial creel census, and other phases some of which will not be discussed in this paper. Only the chub control program was continued in 1939, but the other phases of investigation were reopened in 1940 and 1941. The methods used during these several years were essentially the same so that comparisons can be made with confidence. Through these investigations it is hoped that a suitable management plan for the fisheries can be developed.

The resident biologist in 1938 was L. Edward Perry; in 1940 and 1941, Vaughn D. Madsen. The investigations in 1938 and since, have been under the supervision of Dr. Stillman Wright of the U. S. Fish and Wildlife Service.

#### DATA AND DISCUSSION

Food Study. The food study was carried on by analysis of the contents of fish stomachs, which were obtained during the fishing season, beginning June 15 and ending September 30. In 1935, 1938, and 1940, stomachs for study were taken from mackinaw (Christivomer namaycush), rainbow, (Salmo gairdnerii), and brook trout (Salvelinus fontinalis). In 1941 the food study of rainbow and brook trout was discontinued in order to permit more complete study of more important phases of the investigation. In 1935 and 1938, stomachs were also taken from the Utah chub. Arrangements were made with guides and other fishermen to save stomachs from trout taken. In most cases it was possible to measure and weigh the trout before the stomach was removed, but sometimes this could not be done, as the trout were cleaned before the fishermen came to shore. Owing to the fact that fishermen returned to shore at many widely separated points, it was impossible for one man to interview all of them. However, many of the same fishermen were interviewed mornings and evenings, and enough stomachs were obtained from other sources to permit the collection of various kinds of samples.

In most cases, analyses of stomach contents were made in the laboratory. The volume of the contents was measured in a graduated



cylinder by means of the common water displacement method. A separate stomach analysis sheet was kept for each stomach examined. A sample of this sheet is shown in exhibit 1.

Food items taken generally fall in one of three groups: fish, invertebrates, or plants. Material which is classed as debris is also taken occasionally. It includes rocks, sticks, and any other miscellaneous material.

Fish which were taken as food included the silverside minnow (Richardsonius balteatus hydrophlox), Utah Lake chub (Gila atraria), brook trout (Salvelinus fontinalis), rainbow trout (Salmo gairdnerii), and sculpins (Cottus). Also included in this group were unidentified trout and other fish remains too far digested to be identified, and in a few cases, fish eggs. Among the invertebrates were mollusks, insects, annelids, scuds, and cladocerans. Insects taken most often were ants and wasps (Hymenoptera), flies (Diptera), and beetles (Coleoptera), in both the adult and immature forms. Annelids were the common earthworms (Lumbricus terrestris) which were taken from the hooks of fishermen using them as bait. The scuds were the so-called fresh water shrimp (Gammarus linneaus). Cladocerans were the water fleas (Daphnia pulex). The plant group included algae and higher plants. The most common kinds of algae were Cladophora and Nostoc.

Rainbow Trout. Investigations of the food of the rainbow trout were carried on in 1935, 1938, and 1940. Reference to table 1 shows that the fish group made up a larger percentage of the food items taken than any of the other groups. This indicates that the fish item was

Exhibit 1. Type of sheet used at Fish Lake, Utah, for the purpose of recording data pertaining to stomach analysis of fish. (These sheets were hectographed).

STOMACH ANALYSIS

Species..... Lake.....Location.....  
Length.....Weight.....Sex.....  
Method caught.....Date.....Time.....  
Recorder.....

Volume.....State of digestion.....  
Intestine.....

	Organism	Number	Length	Volume	% of total
1.....					
2.....					
3.....					
4.....					
5.....					

Remarks.....  
.....

Table 1. Food of all rainbow trout, Fish Lake, Utah, 1935, 1938, 1940

Item	Food, percent by volume		
	1935	1938	1940
Fish	38.5	71.1	46.5
Invertebrates	33.9	17.6	21.5
Plants	27.6	10.3	28.1
Miscellaneous	---	0.9	2.7
Total	100.0	99.9	98.8
Number stomachs examined	46	74	92

of most importance in the rainbow diet. Although fish made up the largest percentage of any group, the invertebrates were taken most often and were therefore of considerable importance. Plants were also present to a considerable degree.

Because of possible differences in diet, the rainbow examined in 1940 were arbitrarily divided into two classes, those two pounds or more in weight, and those weighing less than two pounds. Fifteen stomachs were obtained for analysis in the larger size class, as compared to 77 in the smaller size class. Table 2 shows that fish in the larger size class tend to feed more on fish than do those in the smaller size class. Fish made up only 29.47 percent of the total volume of food taken by rainbow weighing less than two pounds as compared to 84.01 percent for those weighing more than two pounds. Plants made up the largest percentage, as a group, of either group of food items in the smaller size class of fish. This indicates that the type of food taken depends to a large extent on the size class of the rainbow.

Brook Trout. Owing to scarcity of the brook trout, stomachs for analysis were difficult to obtain. Practically all brook trout were taken along the shore, generally in the evening, by means of bait or artificial flies. Twenty-three stomachs were obtained for analysis in 1935, 18 in 1938, and 12 in 1940.

Reference to table 3 brings out several important points. In 1935, 91.2 percent of the food taken by brook trout was made up of fish. In 1938 the fish percentage had dropped to 28.0. In 1940, fish were not present in the brook stomachs analyzed. The trend

Table 2. Comparison of food of rainbow trout weighing two pounds or more, with food of rainbow trout weighing less than two pounds, Fish Lake, Utah, 1940

Item	Volume of food item cc		Percent of total volume	
	Less than 2 pounds	2 pounds or more	Less than 2 pounds	2 pounds or more
Fish	92.6	134.9	29.5	84.0
Invertebrates	90.8	12.0	28.3	7.4
Plants	123.4	11.0	38.9	6.8
Miscellaneous	10.4	2.7	3.9	1.7
Total	317.2	160.6	99.6	99.9
Number stomachs examined	77	15	77	15

Table 3. Food of brook trout, Fish Lake, Utah, 1935, 1938, 1940

Item	Food, percent by volume		
	1935	1938	1940
Fish	91.2	28.0	---
Invertebrates	8.0	64.0	81.4
Plants	0.7	5.6	7.7
Miscellaneous	---	2.5	11.0
Total	99.9	100.1	100.1
Number stomachs examined	23	18	12

during these three years is in direct contrast to the percentage of invertebrates in the diet. As will be noted, invertebrates composed only 8.04 percent of the total volume in 1935, as compared to 81.36 percent in 1940. As it is known that the brook has been constantly decreasing in size and numbers in this lake over the period of years from 1934 to the present time, this trend of diet can be directly attributed to a decrease in size of the brook trout.

Mackinaw Trout. The mackinaw in Fish Lake are of considerable importance because it is a piscivorous species, i.e., it feeds principally on other fish. Great controversy exists between the fishermen as to whether or not this species of fish should be increased by planting or done away with in Fish Lake. One group contends that the mackinaw eats too many rainbow, while the other points out that it feeds on chubs, thereby helping to destroy this undesirable fish. Since the mackinaw was first introduced into the lake in 1906, it has seemingly held its own through natural reproduction, because very few artificially propagated mackinaw have been planted here. Therefore the species will probably survive even though artificial propagation is not carried on.

During the summers of 1935, 1938, 1940, and 1941, a food study of the mackinaw was carried on by analysis of stomach contents. Table 4 shows that most of the mackinaw are caught during the early part of the fishing season. This conforms with results given for certain Canadian lakes (Fry 1939). The table also shows that only 49.3 percent of the stomachs examined contained food, a fact which, coupled with relatively small number of mackinaw taken, makes it difficult to obtain an adequate sample for analysis. Because of

Table 4. Seasonal trend in number of mackinaw trout stomachs examined and those containing food, Fish Lake, Utah, 1940 and 1941, combined.

Item	Late June	Early July	Late July	Early August	Late August	Early September	Late September	Total
Examined	66	51	47	15	14	7	11	211
Contained food	37	22	25	9	4	3	4	104



possible changes in food habits with increasing size, the mackinaw were divided into two classes; those two pounds or more in weight, and those weighing less than two pounds. The food of mackinaw is summarized in table 5. From this table, one can readily see that even with the smaller mackinaw, fish are the major item in their diet. Invertebrates are of considerable importance, and plants are taken occasionally. Summary of the food of mackinaw over two pounds in weight, in table 5 shows that as they reach this size, they feed almost entirely on other fish. In the four years listed in the table, more than 95 percent of the total diet of the larger mackinaw was made up of fish. The remainder consisted chiefly of invertebrates, with plants of little importance.

In order to show the principal fish species upon which the mackinaw feed, table 6 was drawn up. In 1935, the principal fish in the mackinaw's diet was the rainbow trout, which made up 67 percent of the total volume. Brook trout made up 16 percent, and the chub 8 percent. Figures for 1938 show a complete reversal of species taken as food, as compared to 1935. The chub replaced the rainbow, with a volume of 58 percent of the total, while the rainbow made up only 11 percent, and the brook was completely out of the picture. A second reversal took place in 1940 with the rainbow again leading. The reversal in 1938 was probably due to a great increase in the number of chubs. As they became overly abundant, competition for space resulted, thereby forcing the chubs into the

Table 5. Food of mackinaw trout, Fish Lake, Utah, 1935, 1938, 1940 and 1941

Item	Food, percent by volume, mackinaw under two pounds				Food, percent by volume, mackinaw two pounds or more			
	1935	1938	1940	1941	1935	1938	1940	1941
Fish	79.2	78.5	82.2	85.7	96.1	95.2	95.5	99.5
Invertebrates	19.5	13.6	17.7	7.8	3.6	2.4	0.6	---
Plants	1.3	3.3	---	6.5	0.3	1.4	0.5	0.3
Miscellaneous	---	4.6	---	---	---	0.8	3.4	0.2
Total	100.0	100.0	99.9	100.0	100.0	99.8	100.0	100.0
Number stomachs examined	15	25	12	9	21	54	45	38

Table 6. Species of fish taken as food by mackinaw trout weighing two pounds or more, Fish Lake, Utah

Species	Food, percent by volume			
	1935	1938	1940	1941
Rainbow	67	11	60	37
Chub	8	58	21	56
Brook	16	--	4	--
Other	9	31	15	7
Number stomachs examined	21	54	45	38

deeper water where they were available to the mackinaw. The reversal in 1940 is explained by a reduction in numbers of chubs through the control program which was begun in 1938. The high percentage of chubs in 1941 is explained by the late spawning of the chub. The chub normally spawn in June and July in the shallow water. In 1941, the lake was higher and colder than normal, resulting in the chubs remaining in the deep part of the lake where they were available to the mackinaw at the time most of the mackinaw stomachs were obtained.

Absence of brook trout in the mackinaw's diet in 1938 and 1941, and the small percentage present in 1940, is explained by scarcity of brook trout in the lake in recent years.

Table 7 shows the importance of fish in the mackinaw's diet. This table was compiled by combining the volumes of each food item for both small and large fish and using these totals as a basis for figuring the percentages in this table.

The Utah Chub. Studies of the food of the Utah chub were made in 1935 and 1938. Table 8 summarizes the food of the chub in the study made in 1935 as shown by the contents of 16 stomachs. This table shows that the chub examined, fed predominantly on invertebrates, as they made up 76.7 percent of the total volume. Daphnia made up 39.2 percent of the total, micro-crustaceans 8.3 percent, and shrimps, 12.5 percent. The remaining 16.7 percent (miscellaneous insects) in this class was composed of Sphaeridae, annelids, terrestrial insects, mayfly and midge larvae, and miscellaneous animals. The plant group made up 23.3 percent of the total; filamentous algae having the highest percentage, with 16.8 percent.

Table 7. Food of mackinaw trout of all sizes, Fish Lake, Utah

Item	Food, percent by volume			
	1935	1938	1940	1941
Fish	94.9	91.6	95.0	98.8
Invertebrates	6.3	4.4	1.3	0.4
Plants	0.2	1.6	0.5	0.6
Miscellaneous	---	1.4	3.2	0.1
Total	101.4	99.0	100.0	99.9
Number stomachs examined	36	79	57	47

Table 8. Food of chubs, Fish Lake, Utah, 1935\*

Item	Percent of total
Invertebrates	
Daphnia	39.2
Micro-crustaceans	8.3
Shrimps	12.5
Mis. insects	16.7
Plants	
Filamentous algae	16.8
Nostoc	2.4
Mis. plants	4.1
Total	100.0

\*Data presented on volumetric basis; 16 fish

In late November, 1935, a number of chubs caught in a gill net were examined. No food was present in their digestive tracts. It has been a common belief that the chub goes into a state of inactivity during the colder winter months. These empty stomachs would tend to uphold this belief to a certain extent. However, these gill net sets and other sets made in November by Dr. Stillman Wright and L. Edward Perry, show that the chubs are not entirely inactive as they would have to move around to be taken in the gill net.;

In another sample of 285 chubs taken in 1935 it was found on a rough measurement scale that 70 percent of the 285 fish in the sample contained over 75 percent microcrustaceans (mostly Daphnia) in their stomachs, 20 percent contained nothing, and 10 percent contained over 75 percent plant material.

In 1938, L. E. Perry made a study of the food of the Utah chub. The data was presented in table form and is reproduced in table 9. In this case, the study was made on a frequency basis rather than a volumetric basis. Stomachs were examined from 74 chubs. In 18 stomachs, or 24.3 percent of the total number, water fleas (Daphnia) were present. Filamentous algae was present in 51 or 68.9 percent of the total number. Comparison with the 1935 data, shows that in both cases, filamentous algae and Daphnia were highly important in the diet of the chub.

In considering food of the chub it must be remembered that chubs feed in schools and therefore all chubs in one school would tend to be feeding on the same kind of food at the same time.

Table 9. Food of chubs, Fish Lake, Utah, 1938\*

Food Item	Number stomachs containing item	Percent of total number
Invertebrates		
Scuds	5	6.7
Insects	4	5.4
Water fleas	18	24.3
Aquatic worms	1	1.3
Water mites	2	2.6
Plants		
Filamentous algae	51	68.9
Nostoc	1	1.3
Higher plants	2	2.6
Debris	10	13.5

\*Data presented on frequency basis; 74 fish.



Reference to table 2 shows that the chub is competing with the smaller rainbows, which are the size commonly taken by fishermen, for such food items as invertebrates and plants. Small size of the brook trout in the lake results in competition between the brook and chub, as they both feed on the same type of organisms. Competition between the chub and rainbow has had no serious effect on the rainbow population as far as it is known. In the case of the brook trout, its decline has probably resulted from competition with the chub for food as well as for space. Further discussion on this subject follows in the section on the brook trout fishery.

Creel Census. Beginning in 1938, and continuing in 1940 and 1941, a partial creel census was carried on. The census was made during the fishing season, beginning June 15 and ending September 30. The census is not complete as only a small percentage of the fishermen that visited the lake could be interviewed, but is probably a representative sample of the fishing.

Fishing on the lake can be divided into two general classes: trolling and shore fishing. Trolling consists of pulling a lure on the end of a line behind a boat, at a low rate of speed. This type of fishing is done with or without a guide. Shore fishing consists of casting with bait or artificial flies from the shore, or from a boat anchored near the shore. In most cases, however, artificial flies are used.

A guide accompanied shore fishing parties in only one or two instances. Therefore no separate record was kept on shore fishing with guides. An attempt was made to keep a record of under-sized fish which were caught but for various reasons was discontinued.

The census was made by recording pertinent data on the catch of each party interviewed, a party being composed of all fishermen in one boat. Trolling parties varied from one to four persons per party, while shore fishing parties included in some cases, as many as six persons per party. Results from each party were recorded on one creel census sheet. During the summers of 1938 and 1940 the creel census sheet used was of the type shown in exhibit 2. The sheet used in 1941 was modified somewhat, but consisted of essentially the same features. This sheet is shown as exhibit 3. Reference to these sheets shows that records were kept on date of fishing, location on the lake, kind of fishing, bait used, and number and species of fish caught, number of lines used and hours fished.

**SHORE FISHING.** The most popular lure used for shore fishing was artificial flies. Various kinds were used, among which some of the most popular patterns were Jock Scott, Silver Doctor, Barber Pole, Royal Coachman, and Slim Jim. The bait fishermen relied on night crawlers, minnows, or pieces of chub. Although more fish per unit of effort were taken in most cases by the fly fishermen, the largest fish were taken by bait fishermen.

The most common fish taken by shore fishermen was the rainbow trout. Brook trout were next in importance, and occasionally a native was taken. During the month of September, the mackinaw came to the shores to spawn, and a few were taken at this time of the year by shore fishermen.

A complete summary of the creel census records for shore fishing at Fish Lake in 1940 and 1941, is given in table 10. By

Exhibit 2. Type of sheet used to record creel census data at Fish Lake,  
Utah, 1938 and 1940. (These sheets were hectographed)

CREEL CENSUS

Lake or stream.....Date.....

Location.....

Fish	Legal		Undersize		Kind of Fishing (check)
	No.	Avg. length	No.	Avg. length	
Brook.....					Boat.....Trolling.....
Rainbow.....					Shore.....Cast.....
Native.....					Still.....No. of lines.....
Brown.....					Bait.....
Mackinaw.....					Worms.....Spinner.....
Chubs.....					Insects.....Artif. fly.....
					Minnows.....Plug.....

Hours fished:.....to.....A.M.....to.....P.M. Total.....

Fisherman's name.....Address.....

Exhibit 3. Type of sheet used to record creel census data at  
 Fish Lake, Utah, 1941. (These sheets were hectographed)

FISH LAKE CREEL CENSUS

Location.....Date.....

<u>Kind of Fishing</u>		<u>Bait</u>	
Trolling.....	Worms.....	Spinner.....	
	Guide.....		
Shore.....	Artificial fly....	Minnow.....	
Number of lines.....	Plug.....	Other.....	
Hours fished: .....to.....A.M.....to.....P.M. Total.....			
Weather conditions.....			
Fisherman's name.....Address.....			
.....			

Rainbow

Mackinaw

Brook

Table 10. Summary of shore fishing creel census records, Fish Lake, 1940 and 1941

Year	Parties	Fishermen	Fishermen per party	Hours fished	Hours per man	Number fish	Fish per man-hour
1940	188	539	2.9	675	1.25	1414	2.09
1941	316	924	2.9	1634	1.77	2814	1.72

comparing the number of fish taken by one man during a unit of time, returns from fishing effort expended can be readily calculated. This affords a means of comparing the returns from a given water during different periods of time, or returns from different waters during a period of time. At Fish Lake, one hour was used as the unit of time. Reference to table 10 shows that in 1940, an average of 2.09 fish were taken per man-hour of shore fishing as compared to an average of 1.72 during 1941, or a difference of 0.37 between the two years. The significance of this figure remains to be seen, as it is believed a continuation of the creel census study for several more seasons is necessary before any accurate conclusion can be drawn. Various kinds of information, which require no explanation, is given in table 10. It seems that shore fishing is gaining in popularity at this lake, and as a result, fishermen go out earlier in order to secure a good fishing spot. This might possibly explain the increase in number of man-hours spent in fishing in 1941. The census in 1941 was more intensive than in the preceding year, resulting in collection of a larger number of creel census records. However, the methods used during both years were similar so that the data are comparable.

In order to show the seasonal trend of shore fishing during 1940 and 1941, table 11 was drawn up. As can readily be seen, the catch dropped slightly from June to July, increased in August, and reached a maximum in September, for both years. The catch for each

Table 11. Shore fishing catch in fish per man-hour, Fish Lake, Utah, 1940 and 1941

Year	June	July	August	September	Weighted mean
1940	1.38	1.26	2.18	2.79	1.98
1941	1.27	1.14	1.71	2.64	1.75

month in 1940 was higher than for the corresponding month in 1941. No attempt is made at the present time to explain the difference in the catch for 1940 and 1941.

The mean was arrived at by giving June a weight of one, and the other months a weight of two, because there were only 15 fishing days in June, and 30 or 31 in the other months.

**TROLLING.** Trolling consists of pulling a lure behind a boat at a low rate of speed. When trolling for rainbow in Fish Lake, the lines are usually let out for a distance of 75 to 125 feet. Lures commonly used are daredevils, many kinds of plugs, and popgears baited with earthworms or minnows. When trolling for mackinaw it is necessary to use a copper line in order to reach them and hold them when hooked. The mackinaw are usually taken near the bottom of the lake, where they go to find the cooler water. The most popular lures for this trout are plugs, and Davis spinners baited with minnows.

Besides the rainbow and mackinaw, a few brook, and occasionally natives or salmon (Oncorhynchus keta) are taken by trolling. Chubs are rarely taken by trollers. Trolling is broken down into two divisions: those fishermen trolling with the aid of a guide and those trolling without the aid of a guide. Trolling results for the years 1938, 1940 and 1941, are summarized in table 12.

**TROLLING WITH GUIDES.** Table 12 shows, with reference to trolling with guides, that practically the same number of parties and fishermen were interviewed for each year. There was also little difference in the number of hours spent in fishing. Comparison of the number



Table 12. Summary of creel census records, for trolling, Fish Lake, 1938, 1940, 1941

Trolling with guide

Year	Parties	Fishermen	Fishermen per party	Hours fished	Hours per man	Number fish	Fish per man-hour
1938	134	307	2.3	1085	3.53	871	0.80
1940	129	305	2.4	1189	3.90	1220	1.03
1941	137	398	2.2	1186	3.98	981	0.83

Trolling without guide

1938	108	228	2.1	716	3.14	388	0.54
1940	166	382	2.3	1471	3.85	736	0.50
1941	287	664	2.3	2388	3.60	1207	0.51

All trolling

1938	242	535	2.2	1801	3.37	1259	0.70
1940	295	687	2.3	2620	3.87	1956	0.74
1941	424	962	2.3	3574	3.72	2188	0.61

of fish taken per man-hour shows that the best fishing was in 1940, with a catch of 1.03 fish per man-hour. There was little difference in the catch for 1938 and 1941. The difference in the catch might be accounted for by the fact that not all of the same guides were present on the lake during the three different years under consideration.

ALL TROLLING. A summary of all trolling, which is a combination of the results of non-guided and guided parties, is also given in table 12.

Seasonal trends of the catch per man-hour by trolling are shown in table 13. In all cases, June was the best month for trolling. The catch of non-guided trollers was more constant than that of guided trollers. The mean for all trolling was 0.74 fish per man-hour for 1938 and 1940, but dropped to 0.62 for 1941. This mean was obtained by giving June a weight of one and all other months a weight of two, because of reasons previously stated.

SPECIES COMPOSITION OF THE CATCH. The species composition of the catch reported in the Fish Lake census for 1938, 1940 and 1941 is summarized in table 14. A more intensive census was carried on in 1941 than previously, which accounts for a larger number of fish being reported. In 1938, 1246 rainbow were reported which made up 81.4 percent of the total catch. In 1940 and 1941, the rainbow made up 93.0 and 94.1 percent, respectively, of the total catch. These figures show that the rainbow is by far the most important species in the lake. The brook trout was important at one time

but makes up only a small percentage of the catch at present. Mackinaw are not taken in any great numbers, but their large size makes them an important game fish in the lake. Mackinaw weighing 15 pounds are often taken at Fish Lake, and occasionally one is caught which weighs between 20 and 30 pounds. Native trout and salmon are taken only occasionally and may be considered as negligible.

Many more fish are taken by shore fishermen (table 10), but larger fish are taken by trollers. Trolling may produce fish any time of the day, while successful shore fishing is limited to a short time in the evening.

**TROLLING WITHOUT GUIDES.** It is believed that a more reliable indication of the trolling results during the three years is given by the records of non-guided parties for several reasons. Guides often spend a full trip trolling for mackinaw only, and in all cases the same guides are not at the lake each year. In most cases, non-guided parties will not spend their full time fishing for mackinaw, but will turn to rainbow fishing if mackinaw fishing is unfavorable. During the 1941 season, only one guide remained at the lake after September 1. In 1940, four guides remained at the lake until the fishing season closed on September 30. Also in 1941, one of the best guides did not arrive at the lake until in July, thereby missing the best trolling, which was during the month of June. Another factor that might enter in, is that the guides may go for some period of time without making a fishing trip, while very few days pass without several non-guided parties doing some fishing. As shown by table 12, there was very little difference in the number of fish taken per man-hour in the three years. In 1938, a catch of 0.54 fish per man-hour was made, as compared to 0.50 for 1940, and 0.51 for 1941.

Comparison of fishing by non-guided and guided parties (table 12) shows in all cases that the guided parties were much more successful than non-guided parties. It is obvious, from this comparison, that the guides selection of the time and place to fish, and kinds and methods of handling gear is an important factor in fishing success. The guides are not allowed to fish, but can aid and instruct their parties on how and where to fish and what type of lures to use.

Status of the Fisheries. Throughout the history of the Fish Lake fisheries there has been a constant changing of fish species in the lake. These changes can be directly or indirectly attributed to man's interference. Until recent years, very little serious thought has been given to a management plan for the fisheries. In order successfully to carry out such a plan it is necessary to have an insight to the status of the fisheries. At the present time the fisheries can be divided into three main divisions: the brook trout, the rainbow, and the mackinaw fisheries.

BROOK TROUT FISHERY. Brook trout were introduced into Fish Lake in 1906. They readily adapted themselves to the lake and grew in numbers and size, resulting in excellent brook fishing. Many brook were taken that weighed several pounds. A picture of a three pound brook, taken from Fish Lake during the 1941 season, is shown in figure 2. In 1934 a serious decrease in abundance and average size was noted. A record of the brook trout egg-take (table 15) shows by the egg-take after 1935, the decline of the fisheries and finally the almost total collapse in 1941. From 1930 to 1933 the take was about five million eggs. According to W. C. Sorenson, the annual egg-take

Table 13. Catch per man-hour by trolling, Fish Lake, Utah. Seasonal trends and weighted means for 1938, 1940 and 1941

Trolling	Year	June	July	August	September	Weighted mean
With guide	1938	1.47	1.19	0.75	0.72	0.97
	1940	1.30	0.99	0.90	1.02	1.02
	1941	0.98	0.84	0.77	0.78	0.82
Without guide	1938	1.10	0.40	0.34	0.45	0.50
	1940	0.72	0.40	0.39	0.51	0.47
	1941	0.80	0.40	0.30	0.56	0.47
All	1938	1.13	0.72	0.64	0.65	0.74
	1940	0.93	0.73	0.59	0.79	0.74
	1941	0.83	0.53	0.52	0.71	0.62

Table 14. Species composition of catch reported in census, Fish Lake, 1938, 1940 and 1941

Species	Number			Percentage		
	1938	1940	1941	1938	1940	1941
Rainbow	1246	3134	4710	81.4	93.0	94.1
Brook	59	127	80	3.9	3.8	1.6
Mackinaw	226	95	201	14.7	2.8	4.0
Native	0	6	7	0.0	0.2	0.1
Salmon	0	5	4	0.0	0.1	0.1
Total	1531	3367	5002	100.0	99.9	99.9

was also about five million, for several years prior to 1930 (Wright 1941). In 1934 the take was less than two million. By 1941 the take had dropped to 88,000, indicating virtual extinction of the brook trout.

The general opinion is that the sharp drop in 1934 resulted from unseccessful competition with chubs. The chubs were accidentally introduced in the early 1920's and apparently increased every year up to 1938 when a control program was started. This program has continued to date. Although it has never been definitely proved that the chub was responsible for the decline of the brook trout, there does seem to be a cause and effect relationship between the two. Both species inhabited the inshore waters, and the decline of the brook seems to coincide with the increase of the chub. If the chub were the cause of the decline of brook trout, and other conditions remained essentially the same, decrease of the chub population through the control program should result in an increase in size and numbers of the brook. However, this has not happened. Reference to table 14 shows that in 1940 the brook composed 3.8 percent of the catch, and only 1.6 percent in 1941. The average size of the spawning fish has not increased and the egg-take is negligible. Therefore the possibility that some other factor has prevented the expected improvement may be considered.

Table 16 gives the planting record of rainbow and brook trout from 1930 to 1941. A total of 4,508,000 rainbow, as compared to 7,493,000 brook were planted during the 12 year

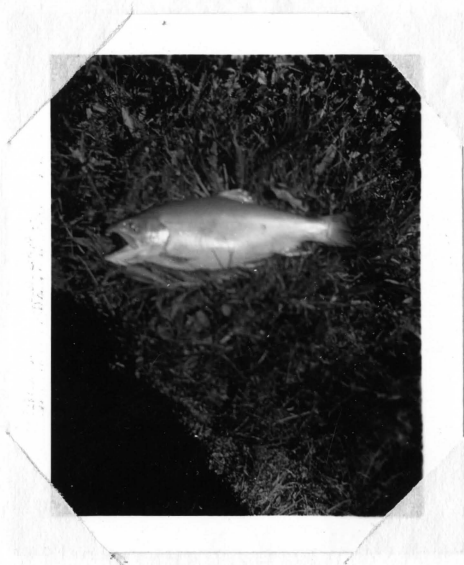


Figure 2. Three pound brook trout taken from Fish Lake, Utah, 1941



Table 15. Production of brook trout eggs, Fish Lake, 1930-41

Year	Number of eggs
1930	5,120,000
1931	5,267,000
1932	9,623,000
1933	5,825,000
1934	1,748,000
1935	2,684,000
1936	606,000
1937	545,000
1938	946,000
1939	925,000
1940	162,000
1941	88,000

Table 16. Plantings of rainbow and brook trout in thousands of fish, Fish Lake, Utah, 1930-41

Year	Rainbow			Brook			Grand Total
	Fingerlings	Fry	Total	Fingerlings	Fry	Total	
1930	73	---	73	490	--	490	563
1931	296	---	296	440	---	440	736
1932	280	---	280	560	*999	1559	1839
1933	665	---	665	546	*414	960	1625
1934	104	324	428	386	---	386	814
1935	211	36	247	256	---	256	503
1936	167	258	425	191	---	191	616
1937	322	140	462	158	335	493	955
1938	271	370	641	38	767	714	1355
1939	364	190	554	404	299	703	1257
1940	437	---	437	7	1294	1301	1738
1941							

\*Eyed eggs

period, or a yearly average of 410,000 rainbow and 681,000 brook. This would indicate an advantage for the brook because of greater numbers being planted. In order to make a fair comparison of the plantings, the figures in table 16 were converted to number of fish planted in terms of three-inch fish (Wright 1941.). This was done by use of the survival table found in the bulletin, "Instructions for conducting stream and lake surveys" (Davis 1938). The figures in table 16, as converted to three-inch fish by Dr. Wright, are reproduced in table 17. From 1930 to 1934, plantings of brook far exceeded those of rainbow. From 1935 to 1941 the reverse was true. The sharp decline in egg-take of the brook trout took place in 1934, following a period of heavy plantings, and the decline has continued through a period of heavy plantings of one-inch fish. Throughout the period, rainbow have maintained themselves in large numbers, showing that they are more successful than brook under the present conditions in the lake. Rainbow are a much more hardy species than brook, and this, along with the fact that in recent years brook fry have had to compete with rainbow fingerlings, probably explains in part, the failure of the brook fishery.

**THE RAINBOW TROUT FISHERY.** The rainbow was introduced in Fish Lake about 19 . It readily adapted itself to the lake and increased rapidly in numbers and size, until at the present time, it is the most important game fish in the lake. Reference to table 14 shows that in 1938, rainbow made up 81.3 percent of the total catch recorded in the creel census. In 1940 the rainbow made

Table 17. Plantings of rainbow and brook trout in Fish Lake, in terms of 3-inch fish, 1930-41

Year	Plantings of 3-inch trout or equivalents		
	Rainbow	Brook	Total
1930	131,000	396,000	527,000
1931	348,000	260,000	608,000
1932	206,000	610,000	816,000
1933	252,000	567,000	819,000
1934	220,000	657,000	877,000
1935	374,000	264,000	638,000
1936	324,000	273,000	600,000
1937	543,000	191,000	734,000
1938	504,000	72,000	576,000
1939	621,000	250,000	871,000
1940	694,000	139,000	833,000
1941	353,000	512,000	865,000
Total	4,573,000	4,191,000	8,764,000
Average	381,00	349,000	730,000

up 93.0 percent of the total catch, and in 1941, 94.0 percent. These figures show that Fish Lake has become essentially a rainbow lake.

According to the opinion of many persons who are intimately acquainted with the lake, the rainbow has been decreasing in size for several years, until at the present, the average rainbow runs about a pound in weight. A picture of a typical string of rainbow, taken from the lake during the 1941 season, is shown in figure 3.

Table 18 shows the production of rainbow trout eggs at Fish Lake from 1930 to 1941. Reference to this table shows a fairly constant egg-take throughout the twelve year period. If it is true that the rainbow is decreasing in size, the figures in this table would tend to substantiate the evidence in table 14, that the species is increasing in numbers in the lake. The increase in numbers would tend to offset the decrease in size, in holding the egg-take at a more or less constant number as shown in table 18.

One possible explanation for the decrease in size of the rainbow is that the lake has been over-stocked. A planting table used by students of trout lakes (Davis 1938) gives the number of three-inch trout to be planted per acre of water in depths of 50 feet or less; the number to be planted, depending on abundance of food, effectiveness of natural spawning, and fishing intensity. According to this table, 240 three-inch fish per acre, should be planted annually in a lake having the conditions found in Fish Lake; namely, an abundance of food, poor natural spawning conditions, and heavy fishing. The area of the lake less than 50 feet in



Figure 3. A typical string of rainbow trout from Fish Lake, Utah, 1941

Table 18. Production of rainbow trout eggs at Fish Lake, Utah  
1930-41

Year	Number of eggs
1930	7,106,000
1931	6,582,000
1932	7,364,000
1933	10,449,000
1934	10,796,000
1935	9,007,000
1936	9,069,000
1937	8,804,000
1938	10,248,000
1939	10,370,000
1940	7,500,000
1941	7,500,000

depth is roughly 800 acres, which would give an annual plant of 192,000 three-inch fish (240 x 800). Table 17 shows that the total annual plant in terms of three-inch fish for the past twelve years has been far in excess of this amount.

In considering the question of the number of fish to be planted there seems to be two choices: planting large numbers of trout in the lake, and consequently having large numbers of relatively small trout in the lake, or planting small numbers of trout and having fewer but larger trout.

**THE MAKINAW TROUT FISHERY.** The mackinaw is native to the Great Lakes and the region north to the arctic circle. Like the brook, it is not a true trout, but represents a group of fishes known as chars. However, the name "trout" is commonly applied to it. Its flesh contains more oil than that of other trouts, and it is an excellent food fish. The mackinaw requires cold water and an abundance of forage fishes in order to succeed in a lake.

The mackinaw was introduced into Fish Lake in 1906. It has never become important in numbers, but the large size of the species makes it attractive to anglers. It is common for fishermen to take them weighing from 5 to 20 pounds, and a few are caught which weigh between 20 and 30 pounds, in Fish Lake. Two large specimens are shown in figure 4. Their color markings resemble the brook somewhat, but they are not so highly colored as the brook. Figure 5 shows their markings. They have decreased somewhat in numbers in Fish Lake in recent years. Some controversy exists as to whether or not the mackinaw should be encouraged in this particular lake,



because of their habit of feeding on rainbow trout. That they do feed to a considerable extent on rainbow was shown by food studies of the mackinaw. In this case, as usual, there are good arguments in favor of the mackinaw as well as against it. They feed to some extent on the chub, and their value as a game fish, because of their large size, should not be overlooked. If the mackinaw is to remain in the lake, the sportsmen must accept the fact that many of the rainbow planted in the lake will become food for the mackinaw.



Figure 4. A Fish Lake guide with two well pleased fishermen. These mackinaw weighed 14 and 13 pounds, respectively



Figure 5. Picture showing markings on mackinaw trout taken from Fish Lake, Utah

## CONCLUSIONS

The information obtained from this investigation seems to justify certain conclusions which are of importance in relation to formulation of a plan of management for the fisheries.

Because of the scarcity in numbers of brook trout in the lake, the food study of this species was unimportant. Investigations of the food of the rainbow trout showed that fish made up a larger percentage of food items taken than any of the other groups. The type of food items taken by the rainbow depends to a large extent on the size of the trout. The food study of the mackinaw is considered of most importance because the mackinaw are the principal predators in the lake, feeding principally on rainbow and chub. The proportion of chub and rainbow in the food of the mackinaw has changed each year, because of difference in availability to the mackinaw.

The relative number of chub and rainbow found in the food of the mackinaw acts as an index of the control of the chub. If the chub are abundant they are forced out into the deep water where they are available to the mackinaw, and vice versa. It is the opinion of all concerned that the chub are less abundant at the present time, than they were before the control program was started.

The decline of the brook trout is believed to be a result of competition for space and food with the chub, and the fact that brook planted as fry must compete also with rainbow as fingerlings.

The mackinaw, because of its large size, attracts fishermen, but by far the largest number of fish taken are rainbow. More than

ninety percent of the total catch recorded in the creel census are rainbow. In 1941 the census showed a decline in the average catch per man-hour as compared with earlier years, but there is reason to believe that this was not due to a decrease in number of rainbow in the lake. In spite of a marked reduction in average size of spawning rainbow, the egg-take has remained at a high level, indicating an increase in the total number of rainbow. Decrease in size and increase in number is believed to be the result of over-fishing and over-planting. During the past twelve years the average annual plant of trout (brook and rainbow) has been approximately twice the proper plant as estimated for a liberal planting policy.

SUMMARY

1. Because of the great recreational value of Fish Lake, chiefly as a fishing resort, it is desirable to find out whether or not any great change has taken place or is taking place in the fisheries of the lake, in order to formulate a plan of management for the fisheries. With these objects in mind, a series of investigations were carried on at the lake in 1935, 1938, 1940 and 1941.

2. The lake was originally populated with the native or outthroat trout. A decline of this species took place previous to 1906, when brook and mackinaw trout were introduced into the lake. The introduction of these species was successful as they increased and provided excellent fishing in the lake. About 19 the rainbow was introduced into the lake. It increased steadily until it now makes up more than ninety percent of the

total catch. The Utah lake chub was accidentally introduced into the lake in the early 1920's. It increased enormously in abundance and apparently is responsible in large part for the decline of the brook trout. A program of control of the chub was started in 1938 and has continued since. The chub can never be completely eradicated but can be kept at relatively low numbers if the control program is continued.

3. A food study was carried on by analysis of the contents of fish stomachs. Fish were found to be the most important item in the diet of the rainbow. The type of food taken depended to a large extent on the size class of the rainbow. Because of the small size of most of the brook trout that are now in the lake, invertebrates are their main food item, whereas several years ago, fish were the main item, because of the large size of the brook at that time. Studies of the food of the mackinaw showed that fish were the main item in their diet. The main fish species taken as food were rainbow and chub. Studies of the food of the chub showed it to feed principally on invertebrates and plants. Competition for these food items exists between the chub and the rainbow and brook, particularly in small sizes of trout.

4. A partial creel census was carried on in 1938, 1940 and 1941. Fishing on the lake was divided into trolling and shore fishing, and trolling further divided into trolling with guides and trolling without guides. The best trolling was during the month of June, while the best shore fishing was during the month of September. In 1941 the census showed a decline in the average catch per man-hour in both trolling and shore fishing, as compared

with earlier years. The best fishing as shown by the census was in 1940. Comparison of guided and non-guided parties showed that the guided parties were much more successful than non-guided parties.

5. Introduction of brook trout in the lake was a success, as they grew in size and numbers and provided excellent shore fishing for a number of years. In 1934 a serious decrease in abundance was noted. The egg-take showed a decrease since 1935, until in 1941 a mere 88,000 eggs were taken, indicating virtual extinction of the brook fishery.

6. After their introduction, the rainbow increased in numbers, resulting in the lake becoming essentially a rainbow lake. The rainbow has been decreasing in size in recent years, but increasing in numbers, probably as a result of over-fishing and over-stocking.

7. The mackinaw was introduced into Fish Lake in 1906. It has never become important in numbers, but the large size makes it attractive to anglers. Mackinaw weighing from 5 to 20 pounds are commonly taken in Fish Lake. If the mackinaw is to remain in the lake many of the rainbow will become food for the mackinaw.

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