A PRELIMINARY REPORT

ON THE DIAMOND LAKE STUDY

MARCH 1947

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by
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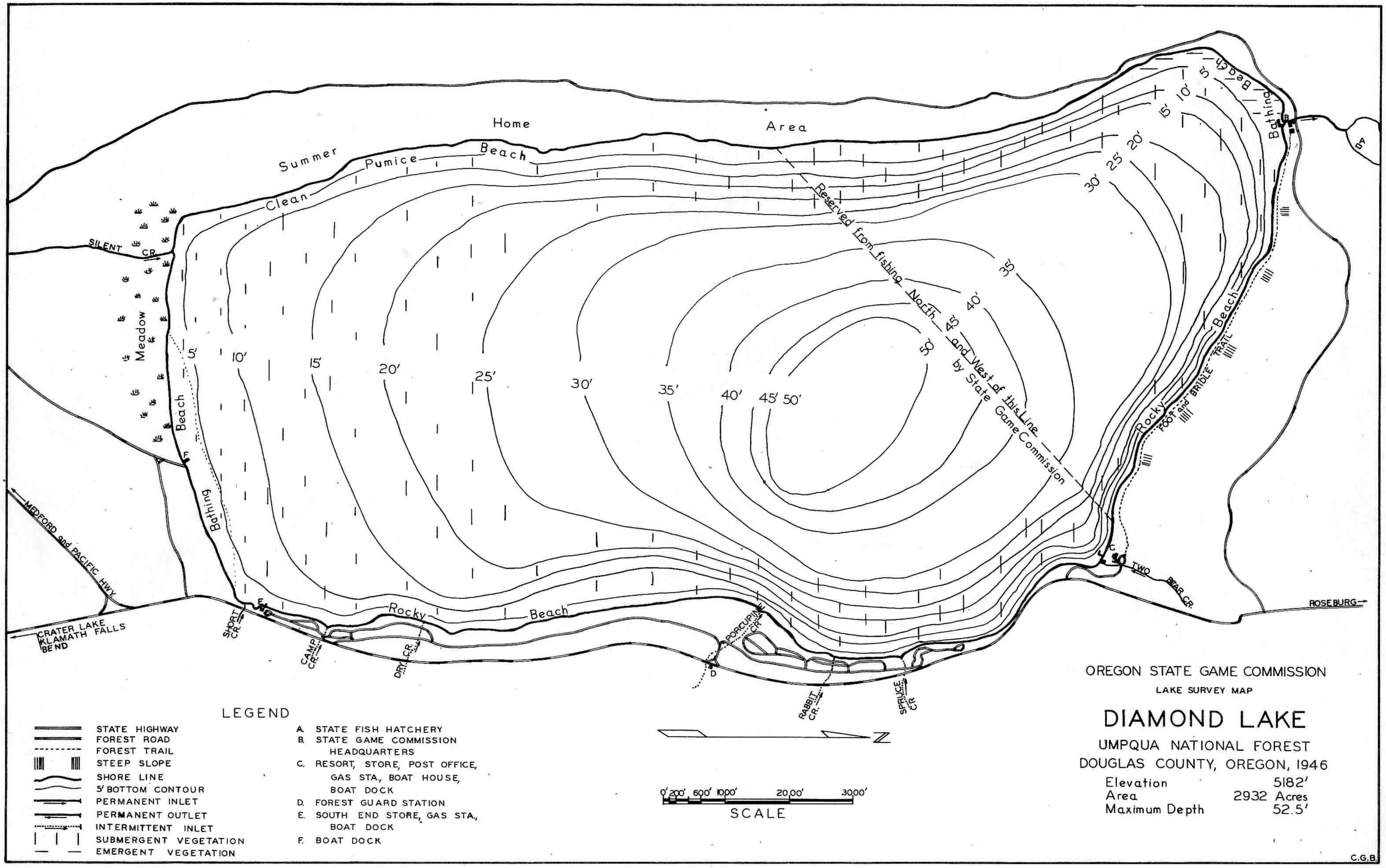

OREGON STATE GAME COMMISSION
LAKE SURVEY MAP
DIAMOND LAKE
UMPQUA NATIONAL FOREST
DOUGLAS COUNTY, OREGON, 1946
Elevation 5182'
Area 2932 Acres
Maximum Depth 52.5'
LEGEND
STATE HIGHWAY
FOREST ROAD
FOREST TRAIL
STEEP SLOPE
SHORE LINE
5' BOTTOM CONTOUR
PERMANENT INLET
PERMANENT OUTLET
INTERMITTENT INLET
SUBMERGENT VEGETATION
EMERGENT VEGETATION
A. STATE FISH HATCHERY
B. STATE GAME COMMISSION HEADQUARTERS
C. RESORT, STORE, POST OFFICE, GAS STA., BOAT HOUSE, BOAT DOCK
D. FOREST GUARD STATION
E. SOUTH END STORE, GAS STA., BOAT DOCK
F. BOAT DOCK
0' 200' 600' 1000' 2000' 3000'
SCALE
N
Summer Home Area
Clean Pumice Beach
Bathing Beach
Rocky Beach
Meadow
Reserved from fishing North and West of this Line by State Game Commission
5' 10' 15' 20' 25' 30' 35' 40' 45' 50'
SILENT CR.
SHORT CR.
CAMP CR.
DRY CR.
PORCUPINE CR.
RABBIT CR.
SPRUCE CR.
TWO BEAR CR.
FOOT and BRIDLE TRAIL
MEDFORD and PACIFIC HWY.
CRATER LAKE
KLAMATH FALLS
BEND
ROSEBURG
C.G.B.

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INTRODUCTION

In January 1946 the Oregon State Game Commission authorized a study of Diamond Lake to determine reasons for an apparent decline in the size and number of rainbow trout with the object of maintaining a maximum annual yield through proper management.

Diamond Lake is located in the eastern end of Douglas County in a region of past volcanic and glacial activity. It lies at an elevation of slightly less than one mile above sea level and covers an area of approximately 3,000 acres. The lake is oblong in shape with the long axis extending in a northwest-southeast direction. It is approximately 3½ miles long and 1½ miles wide. The lake is comparatively shallow with a maximum depth of 52½ feet. The surrounding region is mountainous and extensively forested. The shoreline is gently sloping with the exception of the abrupt rocky shore on the northeast side and a marshy flat on the extreme south end. Lying on the western slope of the Cascade range, its outlet forms the headwaters of the north branch of the Umpqua River. The lake is easily accessible by a paved road from the Dalles-California highway.

Ordinarily the lake freezes over in late December or early January, and does not open until April or early May. The annual snowfall at Crater Lake was obtained from the U. S. Weather Bureau. From incomplete records for 1920 to 1942, the maximum snowfall was 879 inches and the minimum 208 inches. The average snowfall for 14 years was 500 inches. The elevation of Diamond Lake is about 2,000 feet less than the Crater Lake station, and would therefore have a somewhat lower annual snowfall. The total snowfall for the winter of 1945 and 1946 at Diamond Lake was slightly over 21 feet.

The lake is fed by six tributaries, only three of which are permanent and only one of these is of sufficient length and volume to be considered suitable for spawning.

At present the lake contains three species of fish, rainbow trout, brown trout and the roach, Siphateles bicolor bicolor. In addition, a species of dace was collected in the outlet above the dam.

HISTORY

The exact year in which Diamond Lake was first planted with trout is uncertain, but past records indicate that it occurred about 1910. By the early twenties, excellent trout fishing was reported. According to present day standards, rather fabulous statements were made regarding the size and number of rainbow trout taken at that time. It is quite evident that six and eight-pound fish were not uncommon, and a record of one fish weighing 27½ pounds appears to be authentic. In 1941 a 21-3/4 pound fish was taken by angling. Control measures such as bag limits, legal size, season regulations and restricted areas, have been established in the course of the lake's history. A fairly constant stocking policy has been maintained since 1938 and, with the exception of 1939 and 1943, well over two million trout fry have been liberated each year.

ACKNOWLEDGEMENTS

I am indebted to Mr. Darrell C. Davenport for his cooperation in securing creel census data; to Mr. Milton O'Brien, former Diamond Lake hatchery superintendent, for biological history and cooperation in securing egg counts. I wish to thank Mr. Frank Wire, supervisor of the Oregon State Game Commission, for advice on past regulations and historical facts. I am indebted to Dr. Paul R. Needham, Director of Fisheries, for his help and guidance in collecting field data and preparing this manuscript. I also wish to thank Dr. H. S. Davis, Technical Advisor of the Oregon State

Game Commission, for his help in summarizing biological data. I should like to express my appreciation to Mr. Frank Smith and members of his lake survey crew for the physical, chemical and biological data included in this report.

PHYSICAL AND CHEMICAL CHARACTERISTICS OF DIAMOND LAKE

A Game Commission survey party made physical, chemical and biological examinations of Diamond Lake from August 9 to 19th, 1946. During this time, a contour map of the lake was made and the surface area computed. From the map it was found that the lake had an area of 2,932 acres with a maximum depth of 52½ feet.

Diamond Lake derives its water supply from six tributaries which is augmented to some extent by a heavy spring run-off. Silent and Short Creeks form the only major tributary streams. The latter, although having a considerable volume, is of practically no value as a spawning area due to its short length and extremely low temperature.

Temperatures

The maximum surface temperature recorded for Diamond Lake in the summer of 1946 was 74° F. on July 28. Early spring temperatures recorded at the outlet before the ice had gone out, were only a few degrees above freezing; however, the temperature had risen to 45° F. and 50° F. by the third week in May. Although the surface temperature rises above the optimum for trout, it remains at this temperature for a very short time and is of minor importance inasmuch as underlying temperatures remain below 70° F. throughout the summer. Thermal stratification is present only in the extreme lower portion of the lake basin, (40 to 52½ feet), where a minimum reading of 58° F. was recorded.

Oxygen

Oxygen appears to be present in sufficient quantities to support trout at all depths, with the exception of that area lying below the 45-foot contour. At this depth the dissolved oxygen was found to be 4.8 parts per million, but had diminished to 0.3 parts per million at 50 feet, which is below the level necessary to maintain trout.

p.H.

The pH readings varied from 8.5 to 6.5, or alkaline to slightly acid. Only that portion below forty feet is on the acid side.

M.O. Alkalinity

Hardness of the water represented in ppm. of Ca CO_3 is rather low in Diamond Lake. It ranged from 15.2 to 20.0 ppm. Silent and Short Creeks were slightly higher but are still considered low in hardness.

PLANTS

Four species of submergent vegetation constitute the bulk of higher aquatic plants in Diamond Lake. Two species of wide-leaf pond weed and *Anacharis canadensis* appear in varying densities and combinations from two to eighteen feet in depth. *Najas flexilis* extends from 18 feet to a depth of approximately 25 feet. It is believed that vascular aquatic plants are present in sufficient quantities to provide adequate cover for game fish.

BOTTOM ORGANISMS

The productivity of bottom organisms appears to be considerably above the average for other Oregon lakes. From 17 one-quarter square foot dredge samples collected at various depths, it was found that fish food organisms were evenly distributed throughout the lake basin. The minimum number of bottom organisms in one-quarter square foot was 8, and the maximum number, 149, with an average of 48. The weight of fish food organisms is obtained by converting the volume in cc to grams at the rate of 1 to 1. The volume per square foot varied from 0.4 cc to 6.8 cc with an average of

3.0 cc. Based on the above data, the lake has an average standing crop of about 292 pounds per acre. Since this high productivity is composed of many organisms which are available to the trout, it is logical to assume that the lake is capable of supporting a relatively large population of fish. Leeches, snails, midge-larvae, and fresh water shrimp constitute a good percentage of the bottom organisms, and are found inhabiting the submergent vegetation quite extensively. It is believed that the total productivity would be even higher had sampling included a more thorough examination and evaluation of organisms found on aquatic vegetation.

FOOD STUDIES

Cursory food studies made throughout the summer revealed that a few dominant organisms constituted the bulk of the invertebrates consumed as food. Leeches, snails, midge-larvae and scuds were found in stomachs throughout the entire season, and, with the exception of a marked increase in aquatic Diptera at the time of an emergence in June, they seemed to be taken in relatively uniform numbers. Algae, parts of higher aquatic plants, and bits of detritus were also observed to be present in a good number of the stomachs examined. Aquatic vegetation, especially algae, is quite often found in the stomach contents of rainbow trout, but it has not been proven whether it is consumed as food or taken while feeding on animal life. The roach, although quite heavily populating some areas of the lake, apparently are not utilized by rainbow trout, for at no time were they recorded from the stomachs.

EGG COUNTS

To maintain a maximum annual yield of trout in Diamond Lake, it is necessary to allow a sufficient escapement of adult fish. Certain measures have been in force for the past number of years to protect brood stock, such as closed areas, bag limits, etc. Although there has been a marked decline in the number of eggs produced at the hatchery since the early twenties, the annual egg production with few exceptions has been sufficient to stock the lake. Egg production is not only based on the number of fish but also on the size of the fish. During the spawning season of 1946, egg counts were made on a random sample of 60 adult female fish ranging in size from 352 mm. to 623 mm. in length. Total counts were made on the first nine specimens and the number compared with the estimated total number. By counting a 2-ounce sample, the error was found to be well under 5 per cent, and except for periodic checks, all further counts were calculated from a 2-ounce sample. With the exception of a few fish which produced an exceptionally large number of eggs, there appeared to be a direct correlation between the size of the fish and the number of eggs produced. A formula by Allen (1946) to determine the egg production of rainbow trout when applied to this study indicated that the present population of Diamond Lake produced fewer eggs per given size fish than those in New Zealand. The average number of eggs produced by the 60 fish examined was 2,006. If Diamond Lake is to be stocked with a prescribed number of trout fry, (1,000 per acre) each year, the annual egg take required will exceed three million. The exact loss of eggs in hatching cannot be determined in advance, but it is believed that approximately 25 per cent loss could be anticipated under present hatchery conditions. To produce three million fry, allowing for a 25 per cent loss in hatching, it would be necessary to spawn some 2,000 females of the present population. Should the spawning fish become smaller in future years, it will be necessary to allow for a greater escapement of fish. See Figure 1, a scatter diagram showing egg production of 60 female fish.

MARKED FISH

During the spawning operations of 1946, each fish handled was marked (adipose fin removed) before being returned to the lake. A total of 5.251 fish were marked in this manner. It is estimated that 251 or 4.7 per cent of marked fish were lost during the spawning period, and were not available to the anglers at the opening of the season.

NATURAL SPAWNING IN LAKE BOTTOM

Repeated observations of trout fry in the lake prior to hatchery liberation led to a controversy as to whether successful natural spawning occurred in the lake proper. In past years trout were observed to be spawning on the gravel shoal area on the northeast shore, but no effort was made to investigate the beds or check the area for small trout emerging from the gravel. It has been the common belief among fishery biologists that natural spawning of rainbow trout in a lake, without a definite flow of water either by tributary or spring, would not be successful. In the spring of 1946, an experiment was set up to simulate natural spawning and secure information pertinent to the controversy. In this experiment ripe females from the trap were stripped, the eggs fertilized and immediately transferred to a semi-protected gravel shoal area on the northeast shore. The eggs were placed in wire screen baskets containing gravel and planted in depths of one, two and three feet of water. At each depth the gravel was excavated to a depth of about six inches and the wire baskets placed in the depressions. The baskets were then covered with sufficient rock to exclude sunlight but not to the extent of eliminating water circulation. Unfortunately, control experiments were not carried out in conjunction with the lake planting, but it was found that successful natural spawning could occur, for at each depth in which eggs were planted small fish were recovered. To what extent natural spawning in past years has been successful is not known, but it could undoubtedly alter the significance of previous planting records.

OPEN AND CLOSED AREAS

Approximately one third of the lake is closed to angling at all times. In addition to this, two small areas, one at the mouth of Silent Creek and one at the mouth of Short Creek, are closed until July 15th to protect spawning fish which remain in the creeks and at the mouths of the streams for some time after the spawning season is over.

CREEL CENSUS

Creel census studies began on the opening day of the trout season, June 8th, and were terminated at the end of the season, September 30th. The distribution of the numerous camp areas, summer homes, and boat landings, made a complete census impossible with the personnel allocated for the project. However, a system was devised whereby a more or less constant check was made at the lodge boat landing and the camp areas were visited one or more times each day. Two types of creel census data were recorded. If anglers were contacted as they came off the lake, more or less complete information was obtained regarding the number of fish, time fished, method of fishing, length and weight of each fish, and the number of fish marked. If the anglers were contacted after the fish were dressed or disposed of, a verbal statement was accepted relative to the above data. It was often impossible to secure accurate information on the number of marked fish from persons not contacted before fish were dressed or eaten, as the absence of an adipose fin is not too noticeable and could be easily overlooked in handling the fish. Figure 2 on page 23 shows weekly fluctuations in the number of anglers and the number of fish.

Three types of angling were recorded in creel census data. Trolling and still fishing were the most common methods with only a small percentage using the fly. Percentages of fish taken by each method have not been calculated for this report.

ANGLERS CONTACTED

In the 1946 season 10,365 anglers were contacted and records obtained regarding their catch. These anglers took 8,965 fish which represented a total of some 44,850 man hours of fishing effort. To facilitate an estimate of the total catch for the season, complete counts were obtained for a two-day period through the cooperation of the Lake Survey Crew. On Sunday, August 18th, and Monday, August 19th, a complete check on all anglers was made. Daily fishing intensity varies considerably with a definite increase over the week end. It is believed that the data from complete checks on Sunday and Monday are comparable to other week end and midweek days, and therefore suitable for comparisons.

Although it would have been desirable to extend the complete check over a longer period, lack of personnel limited this particular phase of the investigation to two days. To obtain an estimate of the percentage of the catch recorded in the daily creel census, the data of eleven Sundays and Mondays were averaged as to the anglers and number of fish.

	Aver. for 11 Sundays	Complete Sunday	Aver. for 11 Mondays	Complete Monday
Anglers	149	321	99	202
Fish	111	157	88	113

From the above data it will be noted that considerable variations exist in regard to the number of anglers contacted in daily creel census as compared to those recorded in the complete census. This is undoubtedly due to checking some anglers two or more times in one day, whereas in the regular creel census one record was obtained for the entire day's fishing. It is believed that the fish recorded are more indicative of the true comparisons to be made, inasmuch as there were only minor fluctuations in the catch per hour over the period used in the above data. It was found that the catch for eleven Sundays was 70.7 per cent of the number recorded for the complete census on Sunday, and 78.6 per cent recorded in a similar comparison for the corresponding Monday.

From the data at hand coupled with general field observations, it is estimated that the past season's creel census was seventy per cent effective or thirty per cent of the anglers and their catch were not recorded.

Assuming that regular creel census was 70 per cent effective, the total number of anglers for the season would be 14,807. The total number of fish is calculated in the same manner; 70 per cent, 8,965, or a total of 12,807 fish. From incomplete data on 8,965 fish, 828 were marked or approximately 8.9 per cent, but many of the fish were not actually seen and information obtained from anglers regarding the number of marked fish was not complete. Accurate data were recorded on 1833 fish, and of this number 228 fish were marked. Thus, it is assumed that about 12.4 per cent of the total season's catch were marked.

TOTAL FISH

The total population of legal trout at the beginning of the season is calculated by using the proportion of marked fish to unmarked fish with a known population of marked fish at the beginning of the season. In the following calculation, it is assumed that 5,000 marked fish were available to the angler on June 8th.

$$5{,}000 \times \frac{1833}{228} = 40{,}197$$ legal fish at the beginning of the season

ESCAPEMENT

The total number of legal fish remaining in the lake at the end of the season is 27,390 or an escapement of 2.1 to 1. Escapement figures are based on the total legal population which, of course, includes fish too small to spawn. Further investigations should produce more complete data.

AVERAGE LENGTH AND WEIGHT

In calculating the average lengths and weights, the complete data on some 1800 fish were used. It was found that the average length was 402 mm. or approximately 15-3/4 inches and the average weight 1.93 lbs.

TOTAL YIELD

The total yield was approximately 24,717 lbs. or 8.4 lbs. per acre. At the beginning of the season the lake is estimated to have contained 77,580 lbs. or 26.4 lbs. of legal trout per acre.

FISH PER HOUR

The average angler fished about 4.3 hours per day. His catch per hour averaged 0.199 which is low as compared to most trout waters; however, the average in pounds per hour was 0.38 which is considerably above that recorded in most trout streams and lakes. Figure 3 indicates weekly averages of the catch per hour.

LENGTH FREQUENCIES

Figure 4 is a length-frequency chart showing the distribution of fish by numbers in 10 mm. groups. The chart shows quite clearly the relation between marked and unmarked fish. Marked fish do not appear in significant numbers until the 400 mm. group is reached, but thereafter appear to be correlated in proportionate numbers. The chart also shows a very sudden rise between the 300 and 350 mm. groups. This is believed to be due to the presence of a two year group. Some trout appear to reach legal size (10 inches) in the latter part of their second summer and are taken by the angler. The sharp decline beyond the 500 mm. group is obviously the result of an absence of large fish represented in the angler's catch. Marked fish compose about 20 per cent of the catch in fish measuring from 390 mm. to 590 mm.

AGE GROUPS

Scale samples for age determinations were collected from immature and mature fish from early spring to fall. It was found that considerable overlapping existed in most age groups. Fish collected in October after having had only one summer's growth ranged from 62 to 135 mm. in length. Although age classes cannot be correlated with the length frequency chart, certain general deductions can be made. The fish taken by the angler may be from one to seven years old, but it is believed few fish over six years old are present in the lake. Although male fish under 10 inches long appear in the spawning run, few females under 15 inches were recorded. It would appear that only a few female fish reach maturity in their third year.

The absence of large fish in this year's catch as compared to former years has been attributed to over fishing. However, it is possible that a growth factor may be responsible for the decline in the size of Diamond Lake fish. Age determinations were made from scales of two preserved specimens taken in 1924. These fish although weighing 15½ and 16½ pounds, had just completed their fourth annulus. This is phenomenal growth as compared to the present population and could possibly be attributed to some environmental or ecological change in the past twenty years. Information on newly impounded waters has shown that it is quite common to obtain large yields for a number of years after stocking, which is followed by a gradual decline in the yield with an eventual leveling off at a scale somewhat below the original production. The history of Diamond Lake may well fit into this picture with its original high production and gradual decline.

ANNULUS FORMATION

The scales from 50 fish were examined to determine the average length of fish at the time of annulus formation. The formula:

$$\frac{\text{Scale radius at year x}}{\text{Total scale radius}} = \frac{\text{Length of fish at year x}}{\text{Total length of fish}}$$

is based on the assumption that linear scale growth is in direct proportion to linear body growth.

The following table presents the average size of the fish at the time of annulus formation in Diamond Lake, as compared to other waters.

	Length of fish in inches at time of annulus formation					
Number of annuli	1	2	3	4	5	6*
Diamond Lake	2.62	7.95	11.65	15.23	18.01	20.06
Odell Lake	1.8	4.1	5.8	7.5	11.2	14.5
Fish Lake, Utah	2.9	7.5	12.4	15.4	17.6	

*The average length for six year fish may not be significant as they are based on three samples for Diamond Lake and one for Odell Lake.

Figure 5 showing rate of growth for Diamond Lake fish.

Diamond Lake trout show a good growth rate each year as compared to other waters. Their growth rate also compares favorably with an expected development based on the abundance of fish food organisms found by the lake survey party.

CONDITION FACTOR

The condition factor is actually a measurement of a fish's plumpness and is used as a means of comparing the condition of a fish in one body of water with that of another. The formula for determining the condition factor is as follows:

$$K = \frac{100 \times \text{weight of fish in grams}}{(\text{length of fish in cm.})^3}$$

where length of fish is measured from snout to fork of tail. The average condition factor of sixty-five unmarked fish was 1.37; six fish had a condition factor under 1.0, the lowest being 0.86, while 20 fish were over 1.5 with a maximum of 2.02. The condition factor for Diamond Lake fish is considered above average and would not indicate the presence of a stunted population. In 1935 Hazzard found that in Fish Lake, Utah, 20 rainbow trout had an average condition factor of 1.414.

Wales (1946) in a more recent study of a California lake found an average condition factor of 1.00 to 1.08 over a five-year period.

OTHER FISH

Brown Trout

Brown trout have been present in Diamond Lake for at least four or five years. One ten pound brown trout was taken a number of years ago but no other records were obtained until this year. Only one 13½-inch brown trout was recorded in creel census data. However, three overnight sets in October with a 125 foot 4-inch stretch mesh gill net resulted in the capture of five brown trout weighing from 1½ to 7 pounds, and 15 rainbow trout from 1½ to 3½ pounds. Approximately 30 brown trout from 7 to 13 inches were collected in Lake Creek above the falls through angling and by the use of poison. The presence of brown trout in Diamond is undoubtedly the result of an upstream migration in Lake Creek. The number of brown and rainbow trout secured in the three net sets is probably not indicative of the true ratio of the species, but it does show that brown trout are not taken easily by the angler. Past experience has shown that in certain lakes brown trout are almost impossible to take by angling and therefore are not considered as a desirable species in lake stocking. This appears to be the situation in Diamond Lake and control measures have been undertaken to eliminate or reduce the present population.

Roach

The roach, *Siphateles bicolor bicolor*, was first observed in the lake about six years ago and has obviously increased since it was first introduced. Population estimates have not been made but tremendous schools have been observed along the south and southeast shore. Preliminary spot poisoning was begun last August but was discontinued due to the presence of small trout in the shoal area. Through sampling it was found that roach were from 0.5 to 8 inches long. An attempt was made to determine the age of a few large specimens through scale readings. Although exact determinations could not be made, it would appear that roach from 6 to 8 inches are either three or four years old. Information obtained from preliminary food studies of this species would indicate that small roach are largely plankton feeders and therefore not competitive to larger trout. Larger specimens had taken immature and mature aquatic insects and were direct competitors.

Roach populations in other Oregon lakes have seriously reduced the trout populations and it is assumed that similar results can be expected in Diamond Lake if they are not controlled.

The dace, Rhinichthys osculus nubilus, collected in the outlet, is of little importance in the lake as its preferred habitat is a cold gravel rubble bottom stream and there is little possibility that it will become established in the lake.

SOURCES OF LOSS IN DIAMOND LAKE

There appears to be a tremendous loss of fish between liberation and harvesting. In 1946 returns were less than 1 per cent. This means that for every 100 fish liberated less than one legal fish is caught. Although no investigations were made to determine the extent of the various losses, observations would indicate that many factors are responsible for the low percentage of returns.

The probable sources are listed as follows:

Predation

Birds

Cormorants, observed

Ospreys, observed

Fish ducks, observed

Eagles, observed

Mammals

Mink, reported

Otter, reported

Reptiles

Garter snakes, observed

Cannibalism

Rainbow trout, to some extent

Brown trout, probably some

Diseases

Fungus infection at spawning time. Undoubtedly others but none observed.

Escapement by outlet stream

In fall, winter and spring when screens are not in operation.

Angling

Occurs in fish under 10 inches when hooked too deep or improperly handled before being returned to the water.

Winter kill

It is possible that some trout are killed by ice at the time of spring break-up. It is improbable that a loss occurs through suffocation in winter.

Senescence

It is conceivable that some fish die through natural aging.

POSSIBLE ERRORS

Certain deductions and explanations included in this report are based on the use of limited data and it is quite possible that errors have been made in determining populations, season's catch, etc. Further investigations should confirm or disprove tentative conclusions reached in this report.

An error in estimating the numbers of marked fish lost prior to the opening day of fishing season would produce an error in estimating the total population of fish.

The percentage of anglers contacted was based on a relatively small sample and could easily be in error. It is possible that marked fish were more readily taken by the angler and would therefore induce variations in catch records. It has been shown that regular creel census efficiency varies with fishing intensity; thus daily fluctuations could easily produce an error in population estimates.

DISCUSSION

The approximate yield for Diamond Lake can be more accurately determined after several season's data have been accumulated and summarized. From creel census data secured over the past season, it would appear doubtful if the lake can be restored to its former productiveness with respect to large fish made available to the angler. A body of water is similar to grazing or crop land in that it is potentially capable of producing a certain quantity of food annually. Water productivity is even more variable than land, for under certain conditions water can be practically sterile in fish production; whereas, in other areas an acre of water will produce an annual yield of fish in excess of the annual yield of beef or pork on an acre of the most fertile land.

The presence of exceptionally large game fish in a lake or stream is undoubtedly the desire of most anglers. The Muskellunge in Wisconsin, Minnesota and Ontario, will attract anglers for thousands of miles. The West Coast steelhead is likewise prized by the angler. Similarly, the Kamloops trout of Lake Pend d'Oreille, Idaho, attracts anglers from many states. The presence of exceptionally large game fish in a body of water thus creates additional problems in proper lake or stream management.

Although it would be desirable to the angler to produce bag limits of large fish, it is not biologically feasible in average waters. In 1946 Diamond Lake was considered to be quite heavily fished and if it were to be returned to its former status, as in 1942 when fish six and eight pounds were common, the resultant influx of anglers would be tremendous. The legal crop of fish in 1946 was estimated to be 8.4 pounds per acre, which was harvested by some 14,000 anglers. If the average size of the fish were to be increased from two pounds to four pounds, the lake would produce 2.1 fish per acre. At this rate the lake would yield 6,157 fish for the season or about one-half fish per angler per day. The presence of large fish would probably increase fishing intensity and reduce the catch per hour still further.

In comparing the results of the 1946 study with information of past years, it is quite obvious that there has been a reduction in the size of rainbow trout in Diamond Lake. A reduction in the number of fish still remains questionable, as no records are available on the annual catch in earlier years.

Confronted with the problem of improving the angling in Diamond Lake, it becomes necessary to evaluate the many factors involved. To improve the fishing, an increased annual yield must be effected in some manner. This means that the total number of pounds of trout in the lake must be increased either by producing fish of larger size or a greater number of fish, or a combination of the two.

A yield of 8.4 pounds per acre is somewhat below that which might be expected in a lake having such an abundance of natural food. Allowing plausible errors in estimating the total catch for the season, the yield would not be over 11 or 12 pounds. The roach, no doubt, have reduced the yield to some extent. Had each pound of trash fish been converted to rainbow trout in 1946, it is conceivable that the yield would have been increased a few pounds per acre. The physical and biological properties of Diamond Lake are such that an annual yield of 15 to 20 pounds should be expected under normal conditions. It is likely that changes in the present management policy will have to be made in order to increase the yield to these amounts. A small increase in the pounds per acre should be anticipated in reducing the roach population by spot poisoning.

A change in the stocking intensity will require a study of the present population of rainbow trout. Six and eight pound fish recorded in former years were not represented in this year's catch. The absence of large trout in the past season's catch may be the result of a change in growth rate. It is possible that a six year old fish in 1924 could have weighed 15 to 20 pounds, whereas it would have weighed only 5 or 6 pounds in 1946. The average life span for wild rainbow trout appears to be about 6 years. If this is the life span of Diamond Lake trout, it would account for the absence of large fish in this year's catch.

Fishing intensity at Diamond Lake has increased tremendously in recent years, while the number of fish stocked has been relatively constant. Intensive fishing in other waters has produced results which are very similar to those found at Diamond Lake. When the catch exceeds the annual production, there is a tendency to remove great numbers of trout as they become legal size, hence, few remain to reach maturity or attain an appreciable size. Mottley (1939) has shown that it is possible to reduce the average weight and length of trout by increasing the stocking intensity. It is interesting to note that through an increased rate of stocking, the average weight of trout was reduced from 1.5 to 1 pound in a period of 3 or 4 years.

Information secured in one season's investigation would indicate that the decline in the Diamond Lake fishing is primarily the result of either one of two factors, a reduction in the food supply over a period of years or over fishing. Supporting evidence has been found for each theoretical causative agent. Until further information is obtained, it would seem advisable to accept over fishing as the reason for the present decline. Improved angling would therefore require a higher rate of stocking. In 1946 the rate of planting was increased from 600 to 1000 fry per acre. It is suggested that this rate be continued in 1947 and subsequent years until returns are obtained on the development of adult fish. Yields in later years will show if the increased stocking rate merits continuation or needs revision. An increased stocking rate is advocated for the following reasons:

(1) From information at hand it appears to be the most practical method to compensate for over fishing.

(2) It would meet with public approval.

(3) It would not be detrimental to the lake.

(4) If the increased rate of stocking does not prove beneficial, the only loss would occur in an increased mortality of fry.

CONCLUSIONS

Present data are inadequate to form sound management policies and investigations should be continued for at least two more years to obtain a more comprehensive picture of the biological conditions and more accurately ascertain population trends.

It is suggested that under no condition should the lake be opened before the first week in June, and it is further recommended that the season be closed by the middle of September each year inasmuch as certain factors indicate over fishing. The reduced season will thus serve as a precautionary measure until more detailed information can be secured.

It is recommended that roach control be instigated at the earliest possible date in 1947 and continued until their numbers are materially reduced. It is believed that present regulations regarding closed areas should be continued. Bag limits and legal size also appear to be satisfactory biologically and acceptable to the angler.

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Scatter Diagram Of Egg Production In Relation To Length From 60 Female Trout - Diamond Lake, 1946

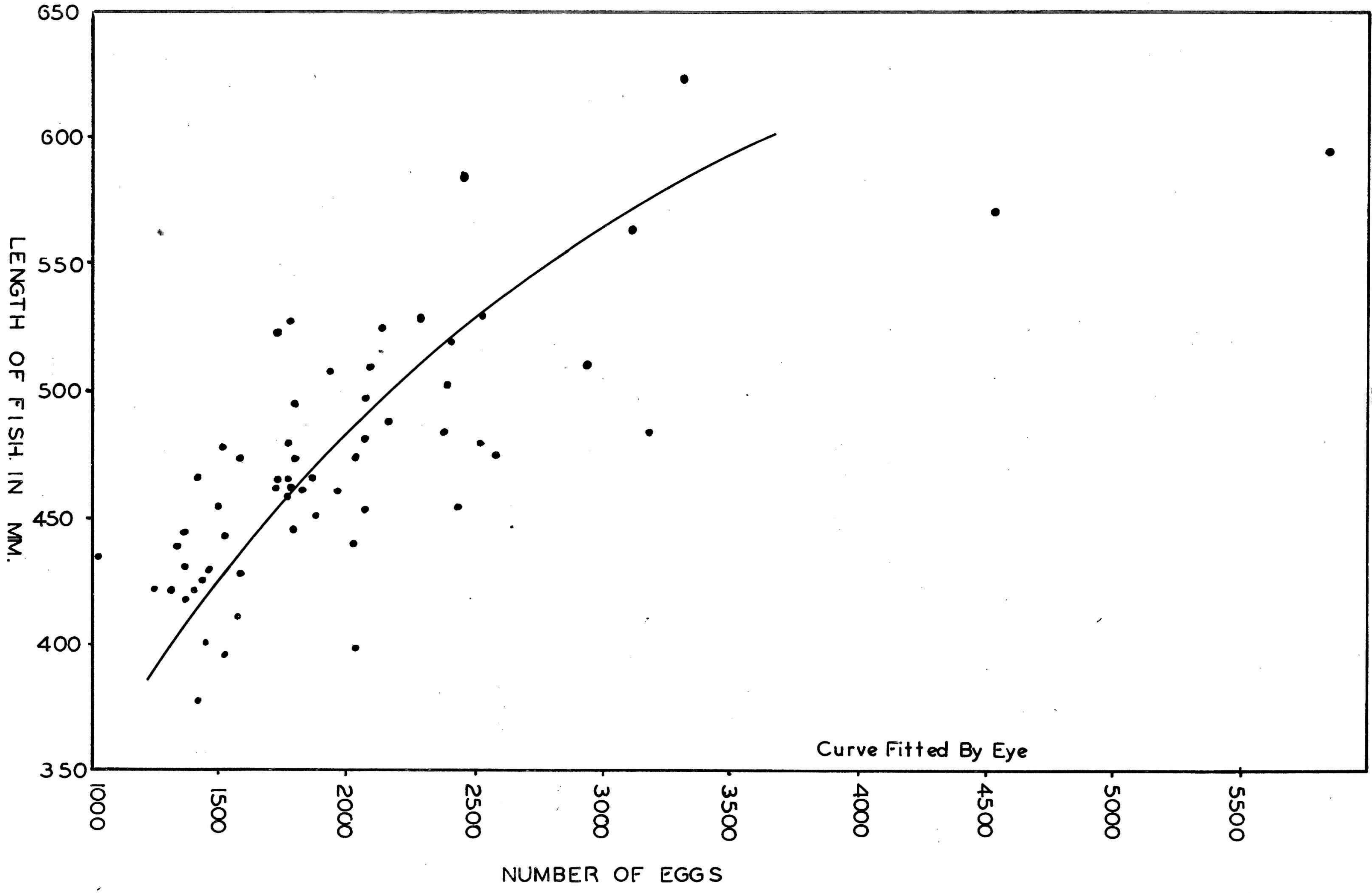


FIGURE - 2

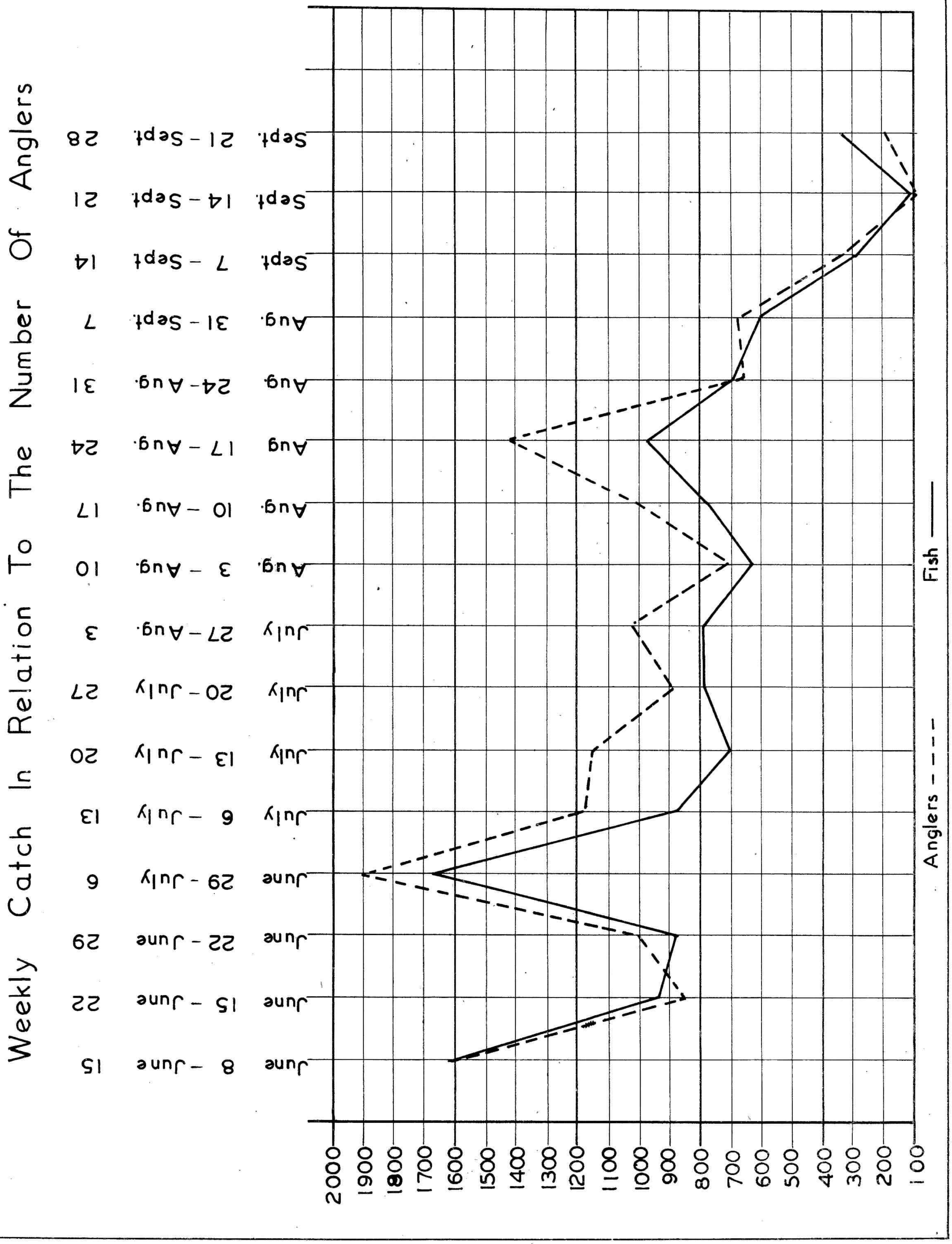

Weekly Catch In Relation To The Number Of Anglers
June 8 - June 15
June 15 - June 22
June 22 - June 29
June 29 - July 6
July 6 - July 13
July 13 - July 20
July 20 - July 27
July 27 - Aug. 3
Aug. 3 - Aug. 10
Aug. 10 - Aug. 17
Aug 17 - Aug. 24
Aug. 24 - Aug. 31
Aug. 31 - Sept. 7
Sept. 7 - Sept. 14
Sept. 14 - Sept. 21
Sept. 21 - Sept. 28
2000
1900
1800
1700
1600
1500
1400
1300
1200
1100
1000
900
800
700
600
500
400
300
200
100
Anglers - - - -
Fish ——

FIGURE - 3

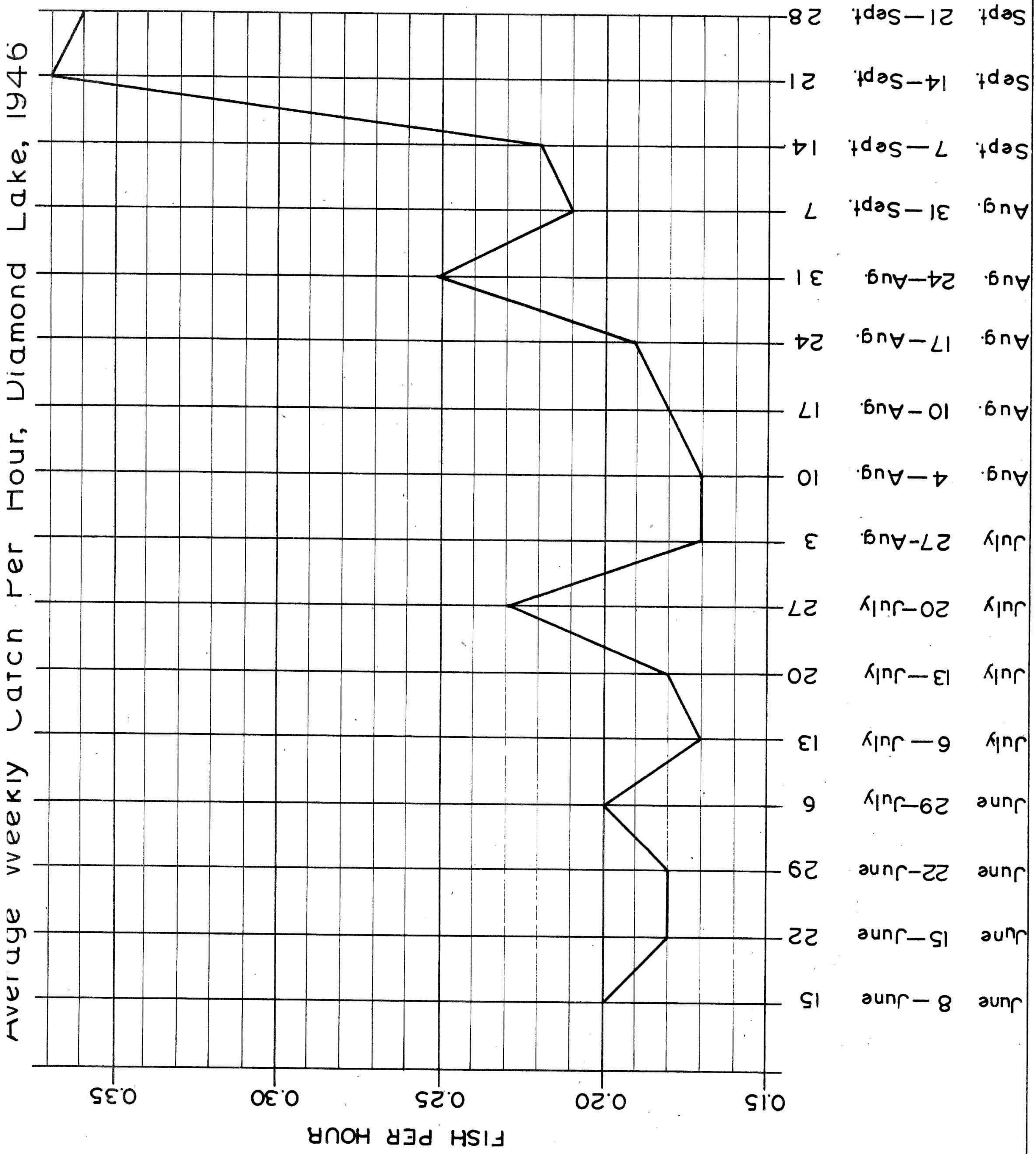
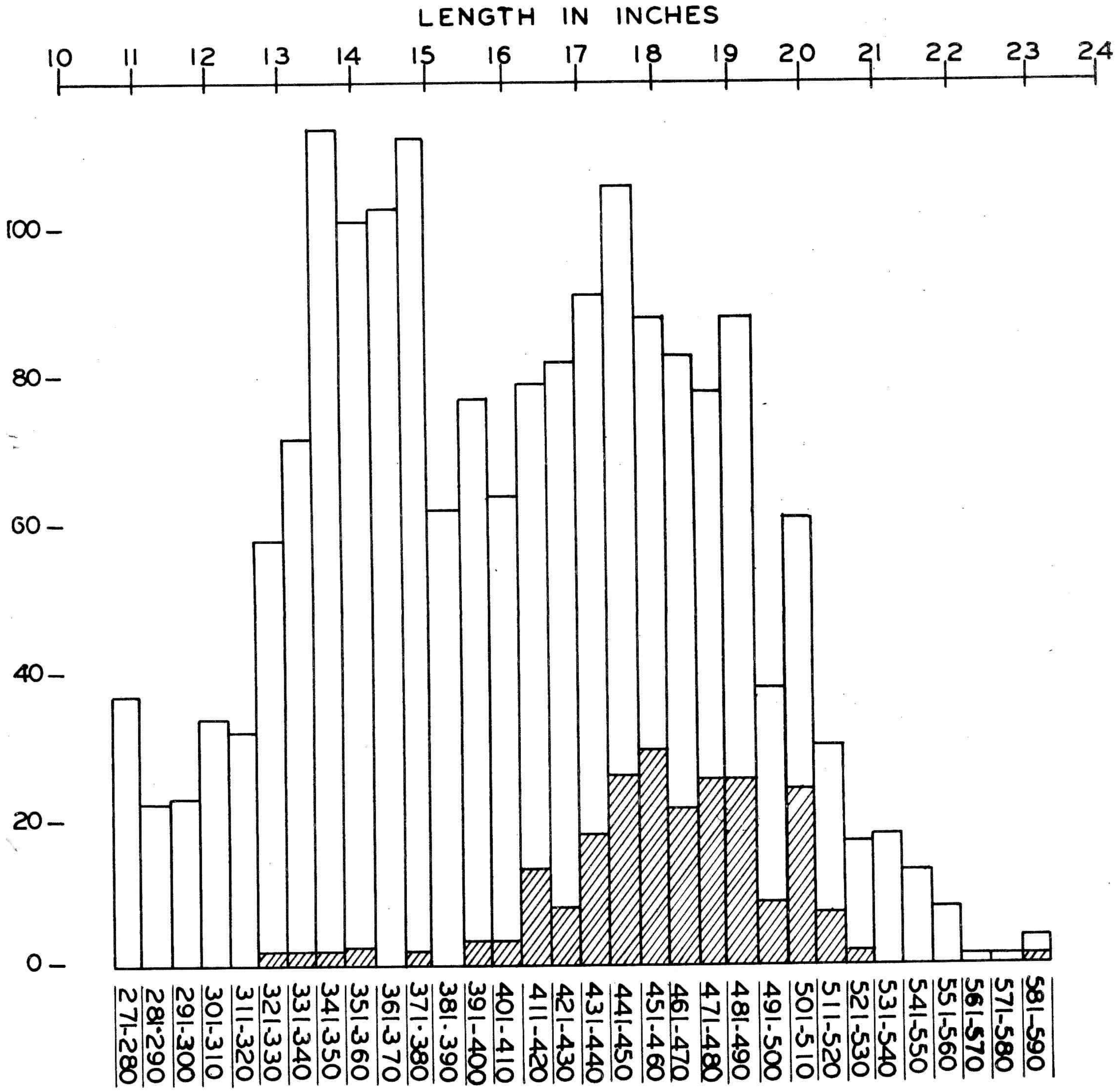

Average Weekly Catch Per Hour, Diamond Lake, 1946
FISH PER HOUR
0.15
0.20
0.25
0.30
0.35
June 8—June 15
June 15—June 22
June 22—June 29
June 29—July 6
July 6—July 13
July 13—July 20
July 20—July 27
July 27-Aug. 3
Aug. 4—Aug. 10
Aug. 10—Aug. 17
Aug. 17—Aug. 24
Aug. 24—Aug. 31
Aug. 31—Sept. 7
Sept. 7—Sept. 14
Sept. 14—Sept. 21
Sept. 21—Sept. 28

FIGURE - 4



Length Frequency Distribution Of
1800 Rainbow Trout Caught By Anglers
DIAMOND LAKE, OREGON, 1946

Unmarked Trout

Marked Trout

FIGURE - 5

c.g.b.

Age Of Fish At Time Of Annulus Formation
From 50 Diamond Lake Rainbow Trout - 1946