IDAHO
FISH & GAME DEPARTMENT

Fisheries Division

PRIEST LAKE

FISHERIES INVESTIGATION

A SURVEY OF THE FISHERY RESOURCES OF PRIEST AND UPPER PRIEST LAKES AND THEIR TRIBUTARIES,

Completion Report on Project F-24-R, 1955-57 A Federal Aid to Fish Restoration Project

by

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with

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TABLE OF CONTENTS

PAGE

LIST OF TABLES

TABLE PAGE

LIST OF FIGURES

FIGURE		PAGE

FIGURE
PAGE

INTRODUCTION

Increasing populations in northern Idaho and northeastern Washington have added tremendously to the number of fishermen and outdoor recreationists frequenting the lakes and streams in Idaho's panhandle. A shorter work week, better roads and automobiles, and the increasing popularity of air travel have allowed anglers from distant cities to fish lakes and streams that were previously fished only by the "local people".

Priest Lake, one of three large lakes in northern Idaho, and Upper Priest Lake, which is joined to Priest Lake by a two mile thoroughfare, are two lakes which are receiving greatly increased use. The lakes, surrounded by coniferous forests and high mountains, provide many ideal sites for camping and summer cottages. The waters become warm enough in the summer for the increasingly popular sports of water skiing and swimming. Fishing, however, continues to be the main attraction.

The development of the Priest Lake country as a recreational area began as early as 1905 with a hotel located at Coolin near the south end of the lake. The first road extended as far as Coolin by 1900 and the first resorts appeared around 1915. The vast amount of valuable timber in the area also aided in the development and by the 1930's the resort business began to boom. However, the Priest lakes did not develop as a recreational area as fast as Pend Oreille and Coeur d'Alene Lakes because of poor roads. The lakes are located in the southern portion of the Selkirk Mountain Range, and are surrounded by steep topography. Many people refused to travel the rough 40-mile journey from Priest River to Priest Lake and thus the number of fishermen on Priest Lake was not as large as on the other big lakes of northern Idaho. However, any retarding effect poor roads might have had on the development of the area will be removed shortly as a paved road all the way to the lakes is scheduled for completion by the fall of 1957. The author estimates that the number of people using the recreational facilities of Priest and Upper Priest Lakes will increase greatly within the next five years. The responsibility of maintaining a suitable fishery will be greatly intensified.

Because the development of good roads did restrict to some degree the number of anglers fishing on the Priest Lakes, the pressure was relatively light when compared with that on other adjacent bodies of water. In spite of the light fishing pressure, the quality of cutthroat trout[1] fishing declined. Some claim the decline came after 1948, while others claim it has been declining since the late 1930's. At any rate, based on data collected during this investigation, only about 5,000 cutthroat a year were caught from both lakes during 1955 and 1956 and the size of the fish caught has declined from the legendary 14- to 15-inch spawner to mostly immature fish averaging approximately 11 inches in length.

Through the years, six exotic species of game fish have been introduced into Priest Lake. In 1925 the mackinaw trout was added to Priest Lake, which already contained the following native species: cutthroat, Dolly Varden,

See Appendix I for list of common and scientific names of fishes discussed.

possible three species of whitefish, squawfish, Columbia diver chub, two species of suckers, redside shiner, and others such as the dace and sculpins. The brook trout was introduced before the 1920's. While the mackinaw is found only in Priest Lake, the brook trout are concentrated mainly in the tributaries to the lake. Neither species has been found in the upper lake or its tributaries. Rainbow trout were planted in the lake one or two times but no specimens were encountered during the course of this investigation. Largemouth bass and a sunfish (probably the green sunfish) have also found their way into Priest Lake, either by planting or by migrating down from Chase Lake, which drains into the south end of Priest Lake.

Probably the most successful introduction was that of the kokanee in 1942, 1943, and 1944. This species has become the most abundant fish in the catch (approximately 100,000 fish per year; 95 percent of the total catch of game fish), and is in addition an excellent forage fish for the mackinaw and Dolly Varden. The large size now attained by the mackinaw and Dolly Varden is due largely to the great abundance of the kokanee. The once-abundant Rocky Mountain whitefish has apparently been replaced by the kokanee, although the unrestricted netting of spawners from the tributaries in years past must also have contributed to their decline.

There has been much speculation on the effects the various introductions of exotic species have had on the native species, especially the cutthroat. Because a lake has a definite carrying capacity, it cannot be expected to produce an infinite number of fish. Whether the Priest Lakes were producing their full capacity of fish before the introduction of other species is quite debatable. The author believes that the introduction of the kokanee, a pelagic, almost entirely plankton-feeding fish, filled a niche in the Priest Lake environment that was almost wholly unoccupied previously. If this is the case, the total production of fish has probably increased, both the production of kokanee and of the fish which feed upon it.

By the late 1940's the cutthroat fishing was reported to be the poorest yet experienced and more fishermen were coming to the lakes every year. Sportsmen wanted the trout fishing restored to its former high level. Although large numbers of kokanee were caught by trolling, they were not a completely suitable substitute for the cutthroat, which could be taken on flies. The sportsmen had been so indoctrinated on the value of hatchery fish they believed the planting of more and larger fish would solve their problems. However, because the planting of fish of any size is a dubious venture in a lake the size of Priest, it was decided that a study to deter-mine what factors might be limiting the cutthroat from producing large numbers of fish naturally should be undertaken.

As a result of the demands by sportsmen to improve trout fishing and also the need for facts to enable the proper management of the fishery, this investigation was initiated in May, 1955. The collection of sound biological information on the fishery resources of Priest and Upper Priest Lakes and their tributaries were the broad objectives. The investigation was divided into four phases: (l) limnological studies to obtain an idea of the general productivity of the lakes, (2) population and life history studies to obtain information on the growth rates, food habits, average size, and life cycle of each major species present, (3) stream survey to determine the condition of spawning areas, and (4) creel census, to deter-mine the total harvest for each species and other related information.

Data collected by Kemmerer et al, (1923-24) during a two-day stay at the lakes and data collected by the spawn takers during the 1940's represents the only organized attempts, previous to this investigation, toward collecting any information which might be of value in developing management plans for the fisheries.

RESULTS OF LIMNOLOGICAL STUDIES

Geology

Priest and Upper Priest Lakes occupy basins formed by glacial ice (Rhodenbaugh, 1953). Most of the pertinent geology of the Priest Lake region was included in a report issued by the U.S. Army Corps of Engineers (1952) from which the following quotations were extracted.

> "The mountains are made up of Pre-Cambrian Belt with scattered areas of Cambrian and younger rocks overlying the belt and all intruded by granites and more basic igneous rocks. The stream pattern is adjusted to the larger structural units, in fact the south-flowing river follows the bottom of the structural trench, and small tributaries entering the main river from the east and west, drain the slopes. During the Pleistocene glacial period, ice from the center of accumulation in British Columbia spread out and moved southward through this valley covering all but the highest peaks on either side of the valley. The valley is not a continuous trough such as the Purcell Trench but heads in high country in Canada. Ice moving south in the valley did not have the abundant supply such as occurred in the Purcell Trench. Because of the restricted defile for the ice to enter the head of the valley, large volumes of ice probably could not move through to the south so that ice erosion in this particular valley does not appear to have been as heavy as elsewhere."

> "Priest Lake, ..., is held in by glacial debris deposited during retreat of the ice in the preglacial river channel. It is not known whether the lake is due in part to overdeepening by ice scour."

> "The drainage changes that took place are apparently due more to deposition than to erosion. The present outlet from Priest Lake apparently is one superimposed in its present position by the aggradation of the preglacial outlet that probably left the lake near Coolin and flowed directly south. This assumption is based on the fact that the rock hills are spaced about 1 l/2 miles apart through this section, while the present outlet cuts through a rock spur at the site that extends from the right valley side."

Physiography and Morphometry

Priest and Upper Priest Lakes, situated in the Selkirk Mountains, have a coniferous forest covered watershed of approximately 600 square miles. Precipitation averages 28.95 inches annually, with December and January being the wettest months and July and August the dryest. The length of the growing season is listed as 97 days at Priest Lake as compared with 121 days at Sandpoint, Idaho (U.S. Dept. of Agriculture, 1941).

The average discharge at the outlet for the years 1951 through 1955 was 1,330 cubic feet per second. During this five-year period the flows fluctuated between a maximum of more than 7,000 c.f.s. and a minimum of less than 100 c.f.s. Peak flows of water occur in May and June.[1]

Priest Lake is 18.5 miles long and approximately 4.5 miles wide at the widest point. Upper Priest Lake is 3.2 miles long and 1 mile wide. The maximum depth recorded during the course of this study for Priest Lake was 355 feet found north of Cavanaugh Bay (Figure l). Kemmerer et al., (1923-24) reported finding a maximum depth of 369 feet in the area west of Eight Mile Island during his visit to the lake in 1911. The maximum depth found in Upper Priest Lake was 98 feet compared to 105 found by Kemmerer et al., (1923-24).

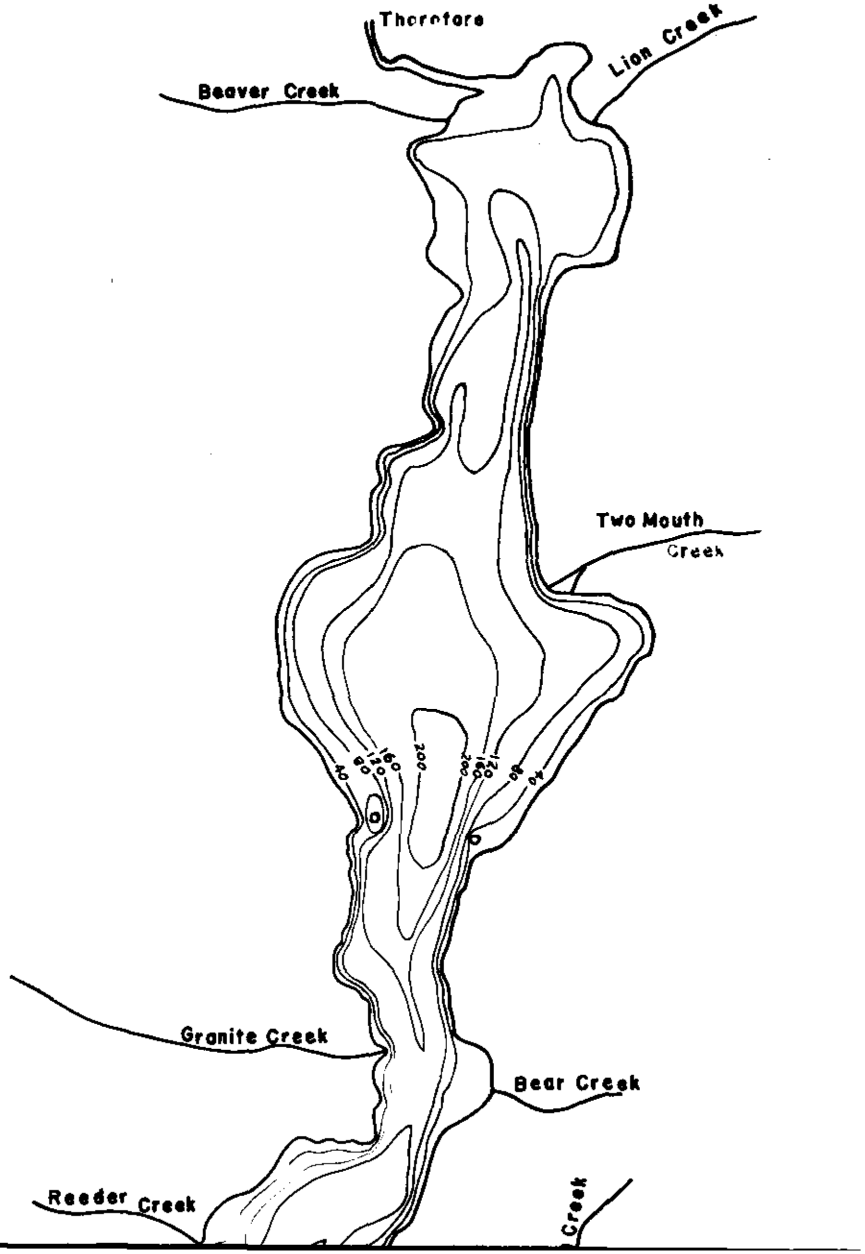
Sounding of the lakes was accomplished with a portable depth sounder which was loaned to the project by the Seattle laboratory of the Branch of Fishery Biology, U.S. Fish and Wildlife Service. Readings were taken and the time recorded while traveling a course set between two well-defined landmarks. The exact time required to travel the known distance of the line at a constant rate of speed produced the distance traveled per second, a value used to locate the approximate positions of the readings. There is some error inherent in the methods used, however, contour maps indicating shoreline slope, location of shelf areas, and general bottom depths were obtained (Figures 1 and 2).

With the exception of the south end, Bear Creek Bay, and a few smaller bays in the northern half of the lake, the Priest Lake shore-line drops to depths of 40 feet and more within a short distance of the shore. Hence the amount of littoral area and the production of *higher* aquatic plants is limited. Upper Priest Lake is very similar to Priest Lake with the south end and limited areas in the north end being the only extensive areas of littoral zone. However, Upper Priest Lake has a larger percentage of its surface area over littoral zone than does Priest Lake.

The area of the littoral zone in a lake is important, especially for a fish like the cutthroat, since a high percentage of its food is produced in such areas. Rawson (1955) illustrates the importance of morphometry in the productivity of large lakes with an inverse correlation between mean depth and the production of fish, plankton, and microscopic bottom organisms.

The location of shelf areas proved to be quite interesting and is a possible explanation for the differences in angling success for mackinaw and Dolly Varden trout from one area of the lake to another. The large shelf directly east of Kalispell Island (Figure l) is at a depth *which* approximates quite closely the depth of the bottom of the thermocline, thus producing a near optimum habitat for mackinaw and Dolly Varden in the summer time.

1Data obtained from water level and discharge records of U.S. Geological Survey, Water Resources Division, Boise, Idaho.



Thorofare
Lion Creek
Beaver Creek
Two Mouth Creek
40
80
120
160
200
200
160
120
80
40
Granite Creek
Bear Creek
Reeder Creek
Creek

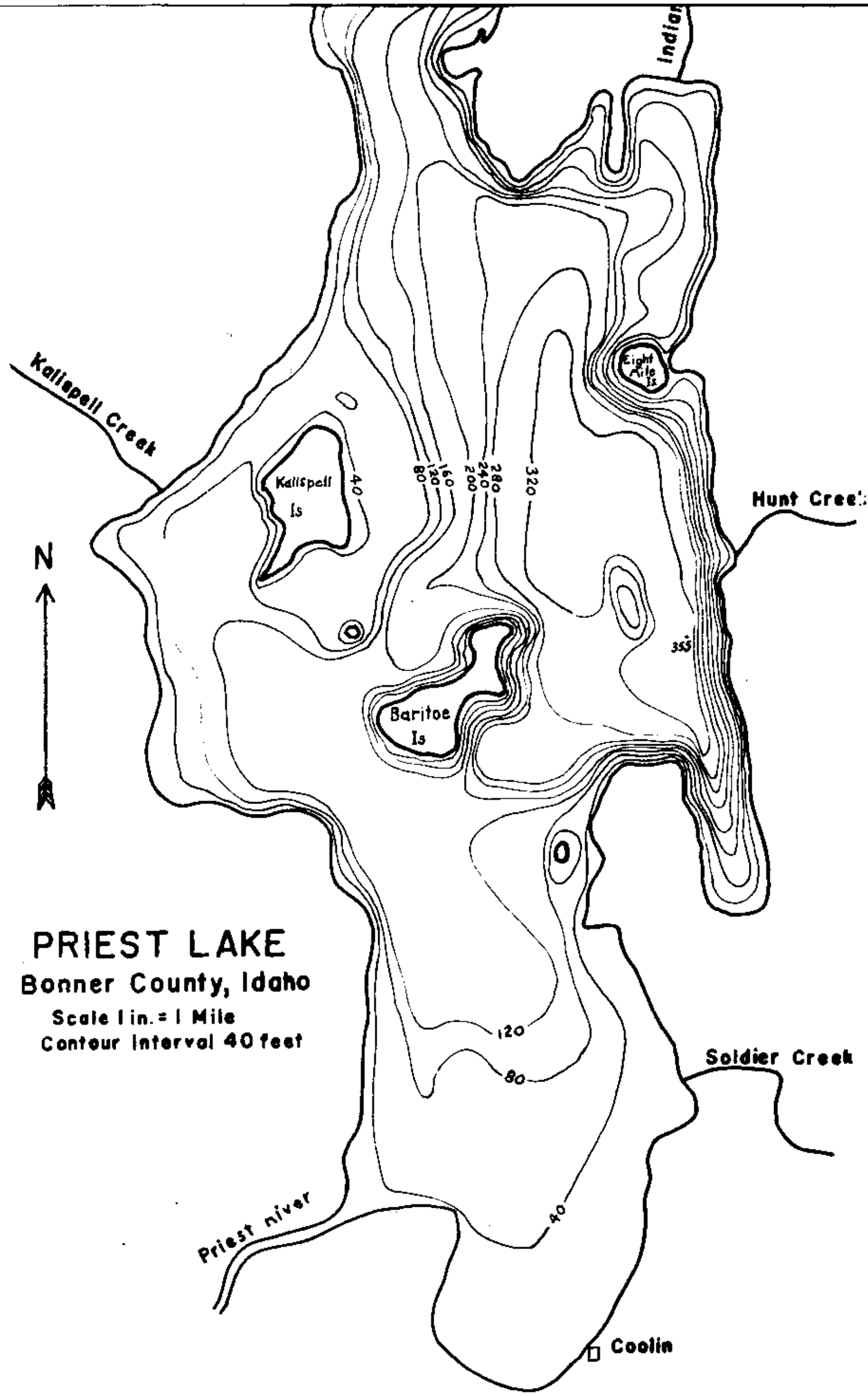


Figure 1. Map of Priest Lake showing depth contours.

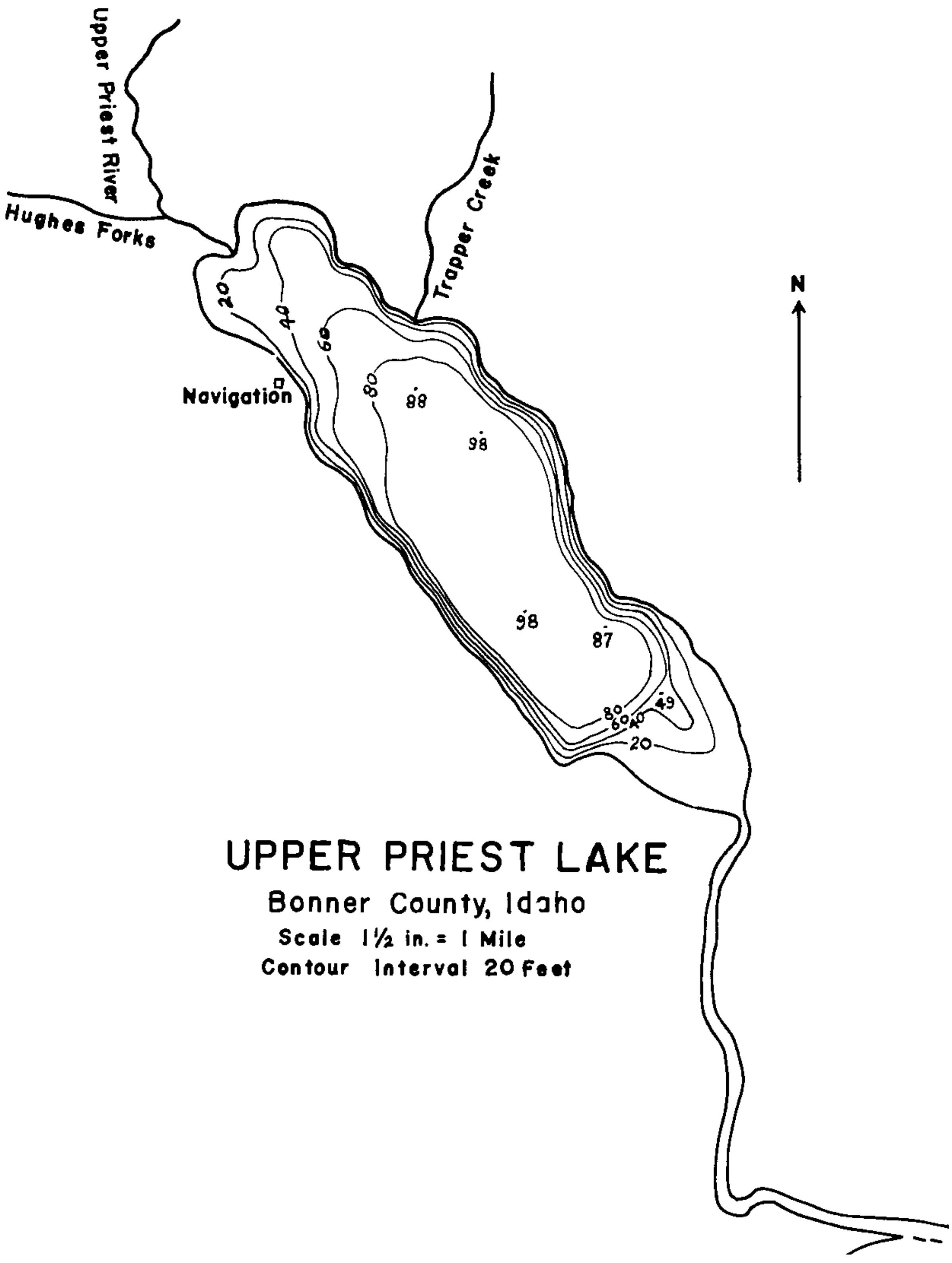


Figure 2. Map of Upper Priest Lake showing depth contours.

The bottom of Upper Priest Lake is surprisingly smooth and is shaped almost like a bathtub, while Priest Lake has a few irregularities on the lake floor such as a "submerged ridge" north of Distillery Bay and a "submerged island" north of Cavanaugh Bay.

Upper Priest Lake with a shoreline of 8 miles and an area of approximately 3 square miles has a shoreline development of only 1.3 illustrating the regular shoreline. Priest Lake on the other hand has a shoreline development of 3.0 with a shoreline of 63 miles and an area of approximately 37 square miles,

Temperatures

Temperature readings were taken biweekly during the spring, summer, and fall at five stations established on Priest Lake and at one station on Upper Priest Lake (Figure 3). The five stations on Priest Lake were more or less evenly spaced throughout the length of the lake and were located in relation to landmarks on the surrounding shores. The station in Upper Priest lake, designated as station No. 6, was located near the center of the lake.

Temperature readings were obtained with a Foxboro resistance thermometer in most instances but a reversing thermometer had to be used occasionally due to breakdown of the resistance thermometer. Temperature readings from the various stations have been plotted and are presented in Figure 4. The readings from stations No. 2 and No. 4 were not plotted in the figures because they were nearly identical with the readings of adjacent stations.

An ice covering is not uncommon on Priest Lake and usually lasts from January to the latter part of April. The ice cover on Priest Lake in 1956 broke up near the middle of April and by May 15, surface temperatures were as high as 54° F. in some areas of Priest Lake and 44° F. in Upper Priest Lake, A thermocline was present at station No. 1, near the outlet, on May 31, but cold weather and winds during the next two weeks cooled and mixed the water so that a thermocline was not evident when the next readings were taken. A permanent thermocline was established in Priest Lake at stations No. 3 and No. 5 by the middle of July. A thermocline was also established in Upper Priest Lake by the middle of July but was much shallower in depth than the one in Priest Lake.

By August 1, the top of the thermocline (at all stations except No. 5) was found between the depths of 15 to 30 feet and at temperatures of 670 to 69° F. The bottom of the thermocline was found at depths between 40 to 50 feet and at temperatures of 46° to 52° F. Temperatures at station No. 5 were quite different from those found at other stations due to a prevailing south wind. The effects of this wind are reduced at other stations due to "windbreaks" in the form of hills and irregular shoreline. These "wind- breaks" are not present to hinder the wind in mixing and warming the - - waters at station No. 5, therefore, the waters at this station warm faster in warm weather and stratification takes place earlier. The effect of the wind in mixing is clearly illustrated by the greater depth of the epilimnion at station No. 5 as compared with other stations.

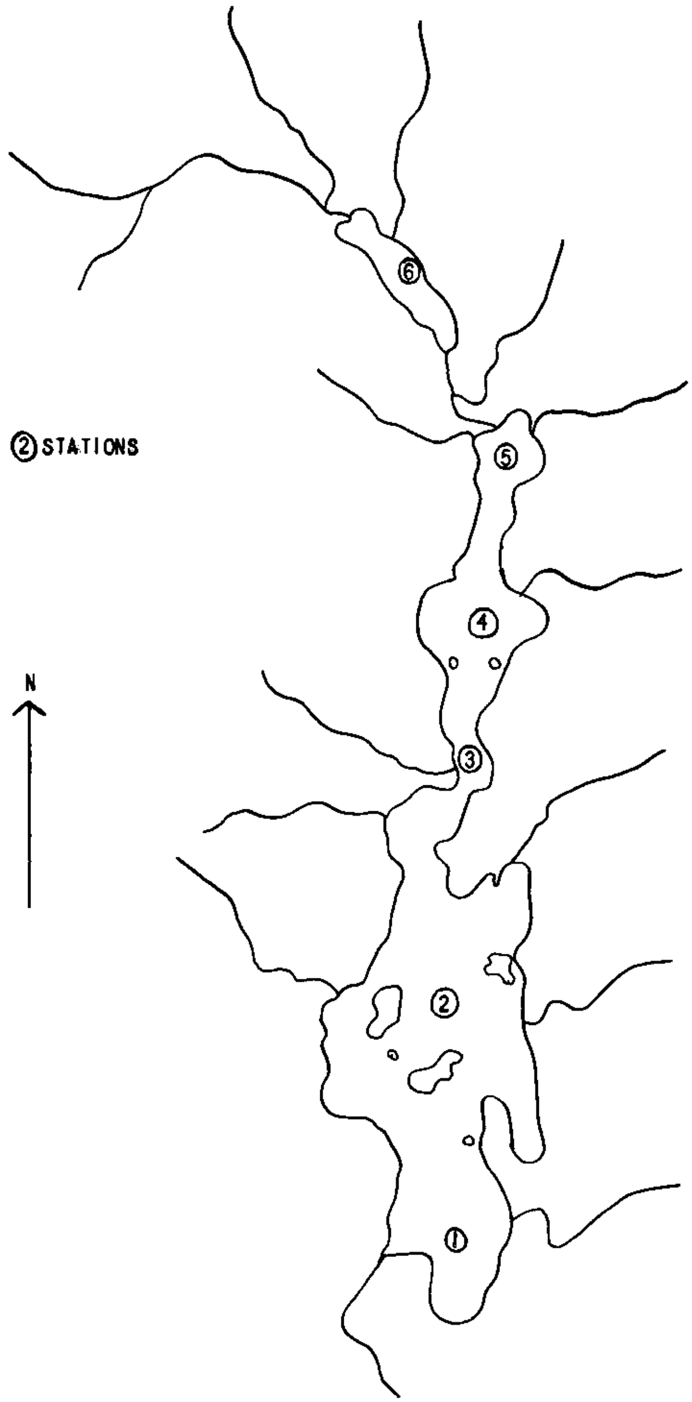


Figure 3. Map of Priest and Upper Priest Lakes showing location of plankton and temperature sampling stations.

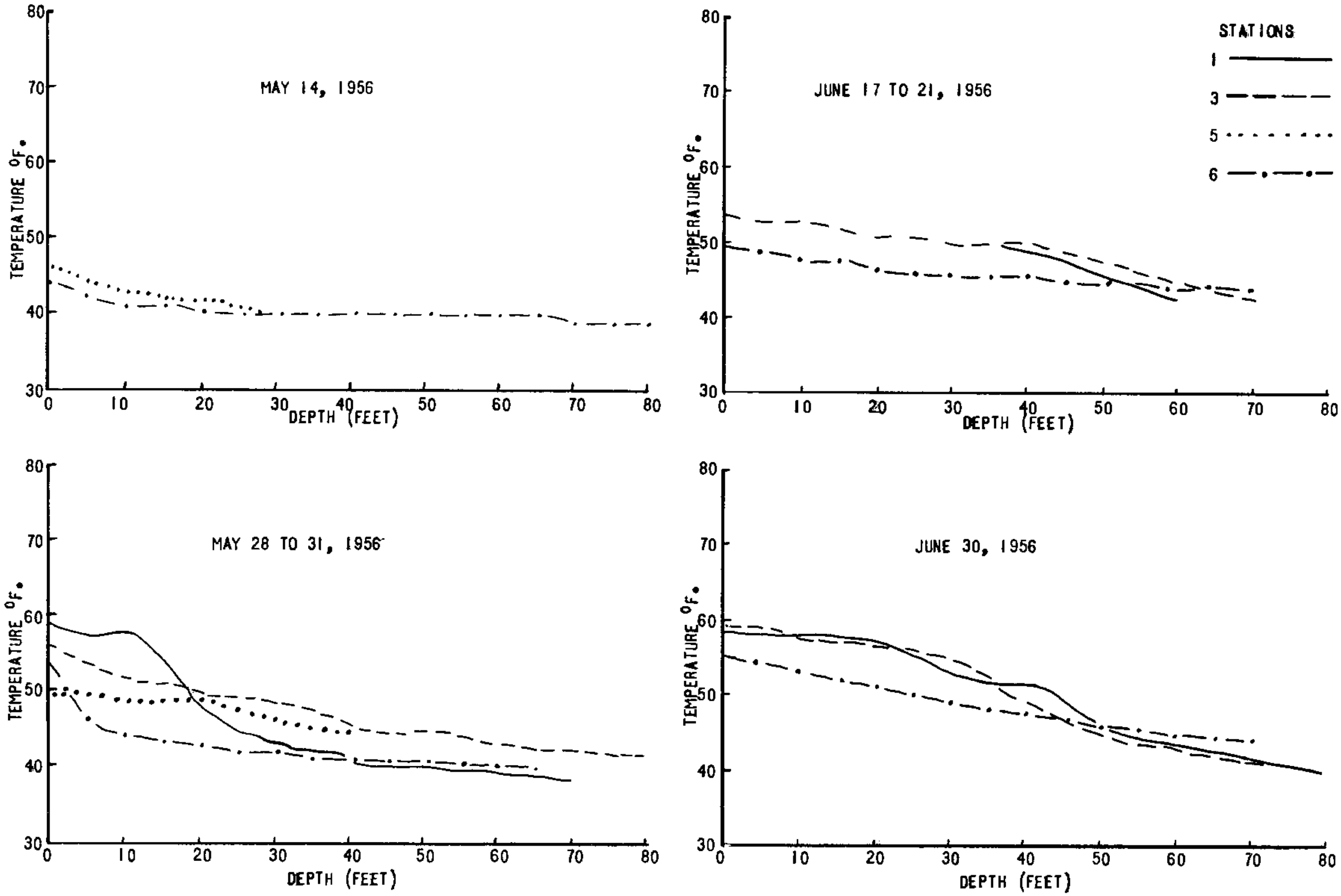


Figure 4. Temperature patterns in Priest and Upper Priest Lakes for 1956.

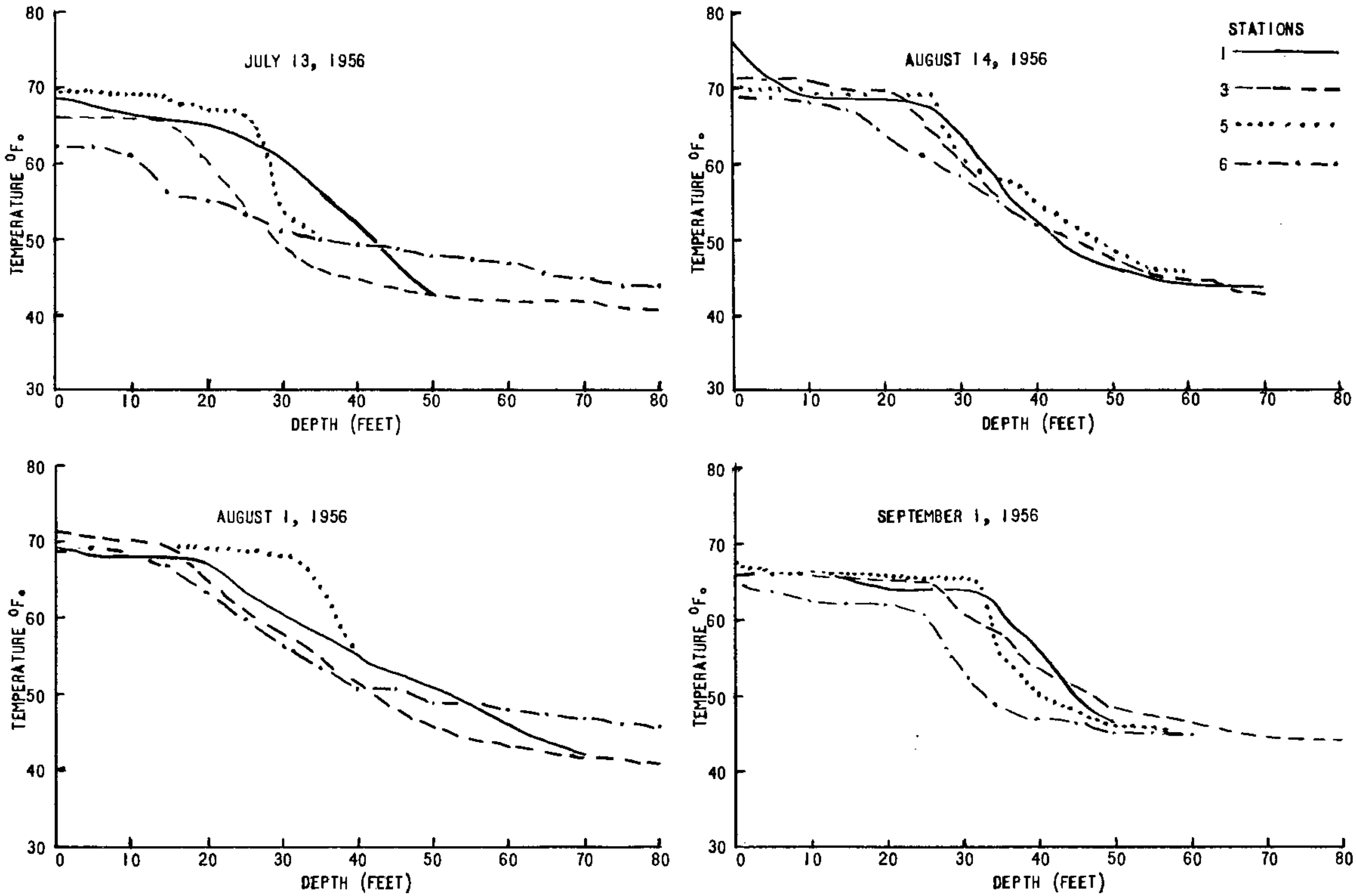


Figure 4 continued.

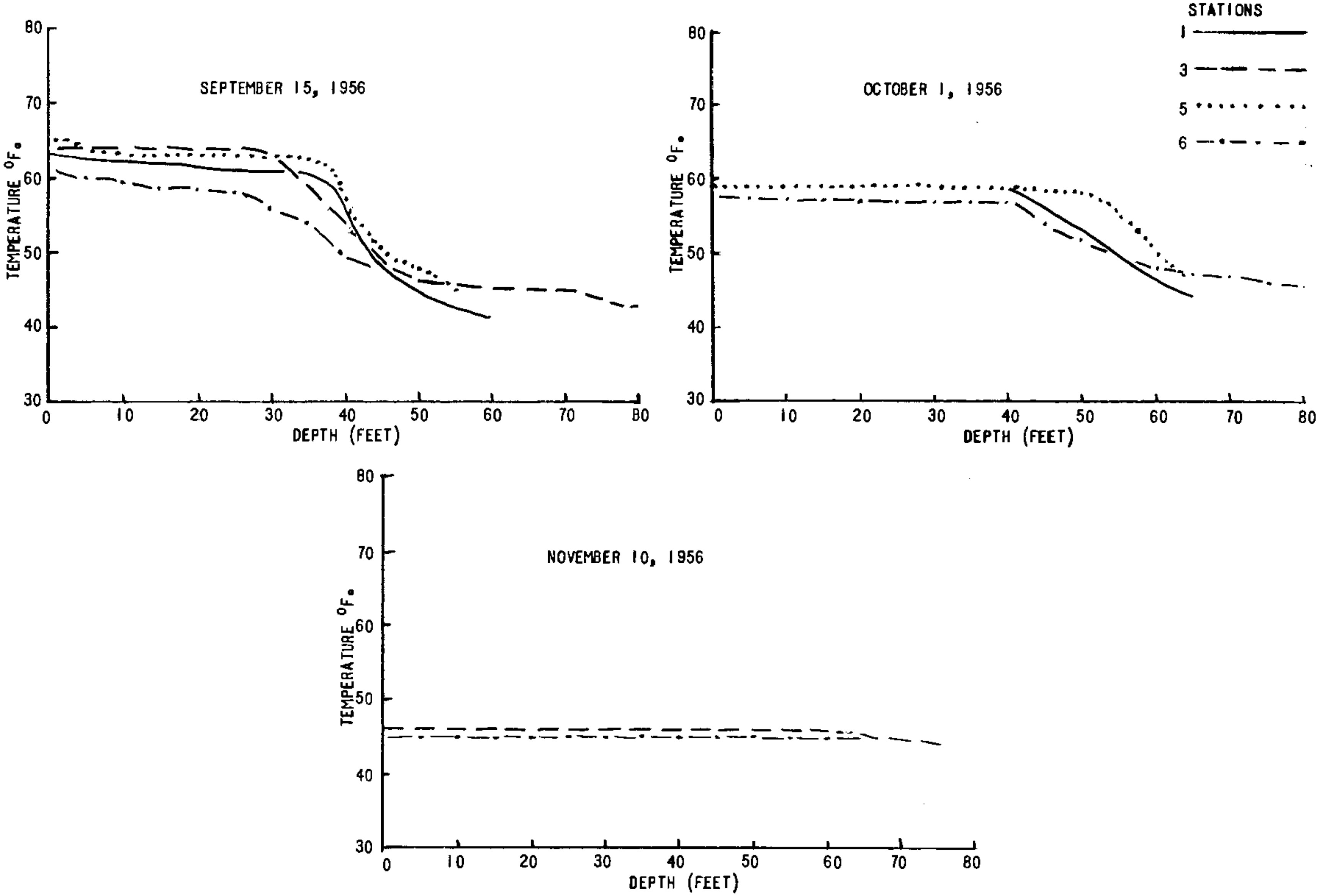


Figure 4 continued.

In September the top of the thermocline had shifted to depths between 30 to 40 feet and at temperatures of 60° to 63° F. (except station No. 6). The bottom of the thermocline was found between 45 to 55 feet and at temperatures near 45° F. Thermal stratification was still evident on October l, 1956, but by November 10, there was a nearly isothermal condition for the upper 65 to 75 feet of water at a temperature of approximately 45° F.

It is interesting to note that temperatures in Upper Priest Lake were consistently lower than the temperatures in Priest Lake. The maximum observed surface temperature in Upper Priest Lake was 69° F. compared with 76° F. in Priest Lake. A maximum-minimum thermometer set one foot below the surface near station No. 3 revealed that the temperature of the surface waters had a daily variation of 3° to 5° F. during the summer on sunny days.

The water temperatures of tributary streams varied considerably throughout the summer season with the low being near 400 F. and a high of more than 70° F. on some streams. A maximum-minimum thermometer placed in Granite Creek near the mouth recorded maximum temperatures from 60° to 70° F. and minimum temperatures between 50° to 55° F. for the month of August. By the end of September the maximum temperatures were near 50° F. and the minimum temperatures varied between 40° and 45° F. Daily variation between the maximum and minimum temperatures was as much as 10° F. on some days. Streams such as Reeder Creek, Kalispell Creek, Lamb Creek, and the Priest River frequently attained temperatures of 70° F. or more near their mouths. In contrast, the maximum temperatures of streams such as Upper Priest River, Trapper Creek, and Hunt Creek seldom exceeded 55° F.

There appears to be a definite relationship between the maximum temperatures of the streams and development of eggs and fry and growth rate in tributaries of Priest and Upper Priest Lakes.

A knowledge of the temperature patterns in Priest Lake is essential in order to help understand the problems encountered in attempting to manage the fish resources. Water temperatures in the epilimnion become too warm for optimum trout, char, and salmon habitat in late summer. Accordingly, cutthroat, Dolly Varden, mackinaw, and kokanee seek the cooler waters of the thermocline during the latter part of July, all of August, and the first part of September. On the basis of gill net set catches during the spring, summer, and fall of 1956, it appears that in general Dolly Varden and mackinaw trout preferred the lower portions of the thermocline while cutthroat and kokanee were more abundant in the upper portions. Foerster and Ricker (1941) in studies at Cultus Lake also found that cutthroat moved to cooler water in summer but did not inhabit the greater depths where chars were found to be most abundant. Kokanee, however, appeared to move freely through-out the thermocline as some specimens were collected at depths of 55 feet, the bottom of the thermocline.

Chemical Analysis of Water

As was the case when Kemmerer visited the lake in 1911 (Kemmerer et al., 1923-24), dissolved oxygen was found to be abundant at all depths (Table 1). The amount of dissolved oxygen in Priest Lake compares closely with that found in Pend Oreille Lake by Stross (1954).

The total alkalinity or total hardness of Priest Lake (approximately 23 p.p. m.) appeared to be considerably lower than that found in Pend Oreille Lake (mean during investigation equal to 72 p.p.m. at surface) by Stross (1954). Kemmerer et al., (1923-24) found the methyl orange alkalinity in Upper Priest Lake to be 39. 5 p.p.m. Northcote and Larkin (1956) found total dissolved solids (T.D.S.) had the best correlation with productivity, however, they cautioned against using the T.D.S. alone to estimate productivity. Priest and Upper Priest Lakes have relatively low amounts of T.D.S. when compared with some of the lakes in southeastern Idaho, which run up to as much as 300 p.p.m. The pH was very close to neutral.

Table 1. Dissolved oxygen, methyl orange alkalinity, and pH determinations for the waters of Priest Lake, August 10, 1956.

Depth	Temperature degrees F.	O_2 p.p.m.	pH	M.O. alkalinity p.p.m.
10	71	11.0	7.0	24
35	56	11.9	7.2	22
75	43	12.1	7.2	23

Plankton

Because the kokanee diet is composed almost entirely of plankton, an attempt was made to determine the dominant forms of zooplankton and their relative abundance throughout the kokanee growing season. Plankton samples were collected with a closing type Wisconsin plankton net at each of 6 stations (Figure 3) biweekly beginning June I, 1956. At each station a vertical haul was made through the: (l) epilimnion, (2) "thermocline", and (3) hypolimnion. The thermocline for this phase of the study was defined as the depths where change in temperature was the greatest, even though many times the change per foot was smaller than that used to define a thermocline. The "thermocline" was always found between the depths of 15 to 70 feet.

Cladocera and Copepoda are the orders represented in kokanee stomachs, therefore, only plankters representing these orders were enumerated in the analysis. Diaptomus 2E. and Cyclops E. were the two genera representing the order Copepoda. Bosmina coregoni and Daphnia longispina represented the order Cladocera.

With few exceptions the density of plankters in the epilimnion exceeded the densities present in either the thermocline or the hypolimnion

(Figure 5). However, during the latter part of July and August the differences in abundance were negligible.

There appeared to be 2 maxima in plankton densities in the epilimnion, the first coming near the end of June and the second between August 15, and September 15. The magnitude of these pulses varied between stations with the first being the dominant pulse at some stations and the second being the dominant pulse at others. Variation in the densities between stations was large at certain times in the year but total numbers for the entire season appears to be approximately equal for all the stations. No difference could be found in plankton numbers between Priest Lake and Upper Priest Lake.

Diaptomus was the plankter collected most frequently at stations 3 to 6 inclusive and made up the majority of the plankton in the pulses for these stations, with the exception of station No. 6 where Daphnia was the most abundant form in the second pulse (Figure 6). Cyclops and Bosmina were the most abundant forms collected at station No. 1 while Cyclops, Bosmina, and Diaptomus appeared to be represented in equal numbers at station No. 2. Bosmina and Daphnia have been combined in Figure 6 due to an error in identification at the initial counting. However, Daphnia did not become abundant at any of the stations until after July, thus the early pulses (June and July) at all of the stations were composed of Bosmina.

There appears to be a trend in the number of Diaptomus present from one end of the lakes to the other. Diaptomus numbers are high in Upper Priest Lake and in the north end of Priest Lake, but gradually diminish until they are sparse in the south end of the lake (Figure 6).

Plankton densities in Priest Lake appear to be slightly lower than those found in Pend Oreille Lake (Stross, 1954). However, because there is the possibility of a relatively large amount of error in the plankton estimates, comparisons must be very general.

Bottom Fauna

Bottom samples were collected with an Ekman dredge which sampled an area of 36 square inches. All samples were washed through a fine mesh screen (#40) which recovered the macroscopic organisms.

The Ekman dredge, according to Welch (1948), is designed primarily for use on loose silt and muck bottoms. In order to obtain samples from the shallow shoal areas it was necessary to use the dredge on sand and small gravel bottoms. The dredge was less efficient on these sand and gravel bottoms and therefore the number of organisms estimated would tend to be lower than the actual number present. Most of the bottom area below a depth of approximately 15 feet is a silt or muck bottom and would not be subject to this error. It is believed, however, that the data presented in Tables 2 and 3 can be used to help evaluate the productivity of the two lakes.

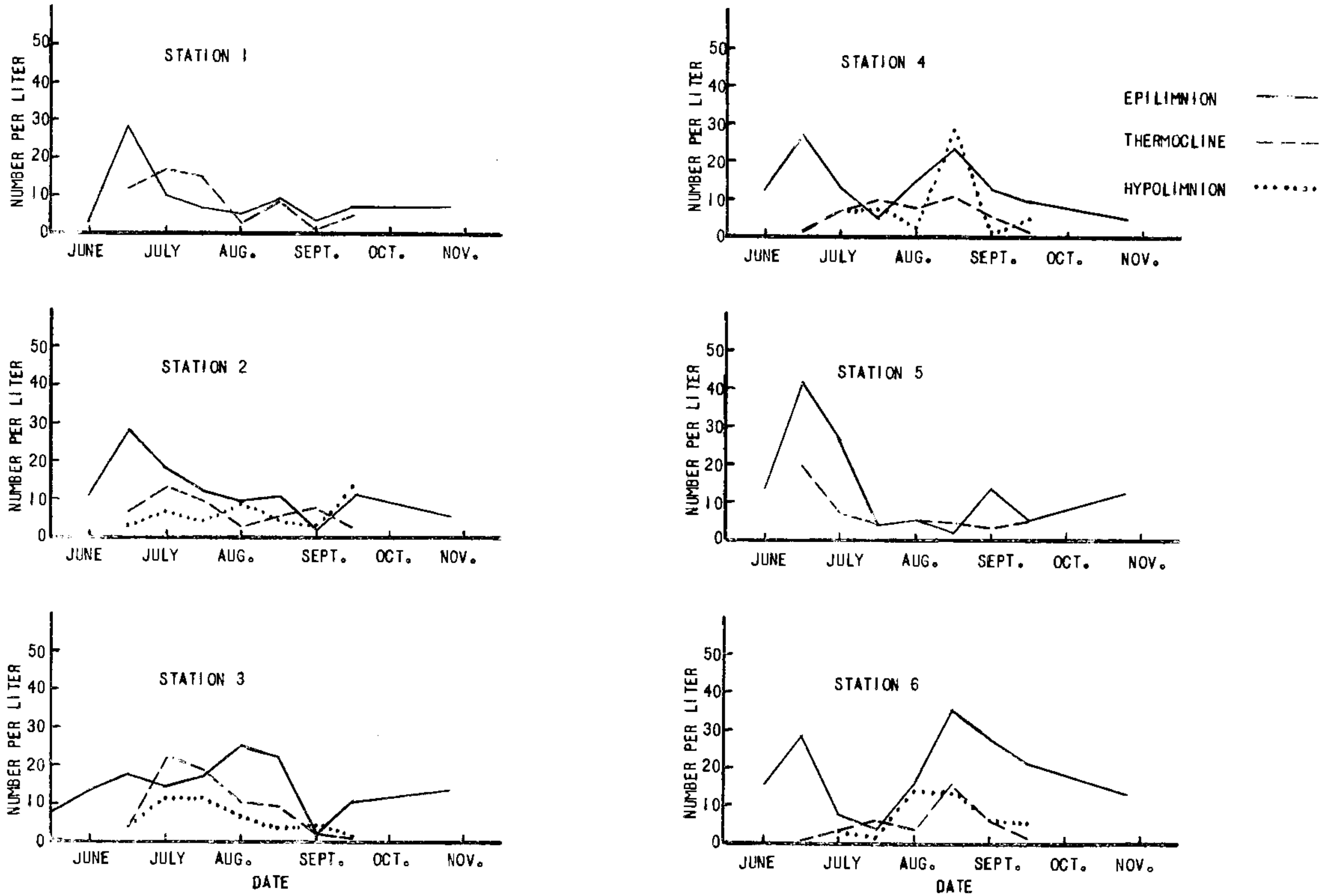


Figure 5. Total number of plankton crustacea per liter excluding nauplii in the epilimnion, thermocline, and hypolimnion of Priest and Upper Priest Lakes, 1956.

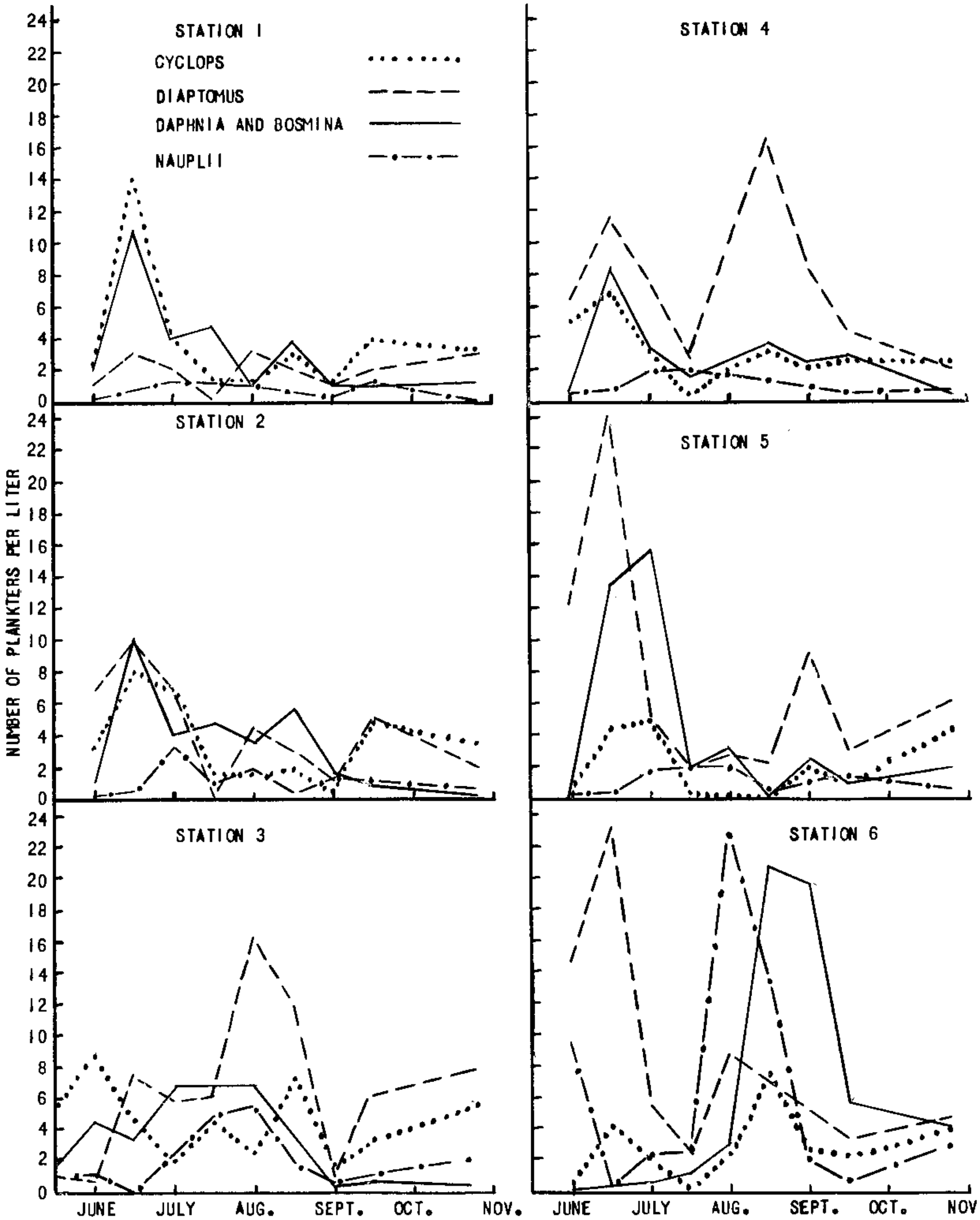


Figure 6. The number of various plankters per liter found in the epilimnion of Priest and Upper Priest Lakes from May through September, 1956.

Since this is a management study complete identification of the organisms present was not necessary. Identification in most instances was not carried beyond the order level.

Clemens, Rawson, and McHugh (1939) present a table showing the average number of organisms per square meter for seven lakes in Canada. This table is reproduced (Table 4) with Priest and Upper Priest Lakes added to illustrate the smaller number of organisms found in these two lakes.

Table 2. Number of bottom organisms per square yard in Priest Lake.

Depth (feet)	0-1	1-5	5-10	10-25	25-50	50---	All depths
Number of samples	21	24	25	5	5	12	95
Midge larvae	32	122	43	65	108	58	71
Oligochaeta	11	22	25	22	22	7	18
Amphipoda	79	22	25	14	--	--	23
Coleoptera	54	2	4	--	--	--	10
Hemiptera	36	4	2	--	--	--	7
Ephemeroptera	25	12	7	7	--	--	9
Odonata	2	4	--	--	--	--	1
Trichoptera	4	--	7	7	--	11	5
Plecoptera	11	2	--	--	--	--	2
Gastropoda	4	4	11	7	--	--	4
Pelecypoda	2	7	11	36	--	--	9
Hirudinea	4	4	2	7	--	--	3
Fish	18	--	--	--	--	--	3
All organisms	282	205	137	165	130	76	165

Table 3. Number of bottom organisms per square yard in Upper Priest Lake.

Depth (feet)	0-1	1-5	5-10	10-25	25-50	50---	All depths
Number of samples	7	6	5	3	3	3	27
Midge larvae	4	72	191	144	133	72	103
Oligochaeta	11	18	11	9	13	12	12
Amphipoda	148	--	--	--	--	--	25
Coleoptera	158	--	--	--	--	--	26
Hemiptera	130	--	--	--	--	--	22
Ephemeroptera	14	18	18	--	--	--	8
Trichoptera	4	12	11	--	--	--	5
Plecoptera	4	9	--	--	--	--	2
Pelecypoda	11	72	43	--	--	--	21
Hirudinea	4	--	--	--	--	--	1
Gastropoda	--	--	11	9	12	--	5
All organisms	488	201	285	162	157	84	230

Table 4. The density of bottom organisms in various lakes.

Lake	Area (square miles)	Mean depth (feet)	Average number organisms per square yard[1]
Priest Lake	37	75-100[2]	165
Upper Priest Lake	3	30-40[2]	230
Okanagan	370	226	304
Nipigon	4,550	180	883
Simcoe	720	49	686
Waskesiu	70	36	5,479
Paul	4	112	1,139

[1]The number of organisms per square meter was converted to number per square yard.

[2]Estimated.

Ricker (1952) reported that Clemens *et al*., (1931) found only 179 organisms per square yard in Shuswap Lake, a number which is comparable to the amount found in Priest Lake.

RESULTS OF CREEL CENSUS Introduction

During the 1955 and 1956 fishing seasons three methods were used to gather catch data. A census method similar to that used on Pend Oreille Lake (Jeppson, 1953), the data being collected as fishermen landed at the resort docks, was the first method used on Priest Lake. Since resort operators were relied upon to a great extent to collect catch data, the first method was designated as the resort owner census. Resort operators were given census forms and asked to interview fishermen as they landed at the resort docks. As explained by the author in a previous report (1956), cooperation of the resort owners varied. In most instances the resort owners were not able to interview all of the fishermen landing at their docks, especially after June, when the recreation season began to reach its peak.

Fishermen on Priest and Upper Priest Lakes may be classified as either cabin owners or non-cabin owners depending on whether they stay in private cabins or at resorts and public camp grounds. Almost every private cabin has a boat landing making it unnecessary for cabin-owner fishermen to frequent the resort docks either before or after a fishing trip. Because of this, the cabin-owner fishermen were not being censused by the resort owners and it became necessary at the end of the season to initiate the second method used. A postal card was mailed to each cabin owner requesting catch data. Later census methods revealed that the cabin-owner fishermen were harvesting a very significant portion of *the* total catch (approximately one third) and must therefore, be censused by a reliable method.

The importance of the cabin-owner catch plus the fact that fishing pressure was not great enough to warrant the placing of a hired census taker at each dock resulted in the initiation of the third and most efficient method of census in September, 1955. This method, referred to as the boat count-interview census did not require the active participation of resort owners and was designed to contact both cabin-owner and non-cabin owner fishermen. After the trial period in September, 1955, the method seemed suitable and was used throughout the 1956 season.

Methods Used and Findings

Resort Owner Census for 1955

The fishing pressure exerted by the non-cabin owners originates from the resorts and camp sites surrounding the lower one-third of Priest Lake. The area of the lake containing such resorts was divided into three sections for sampling purposes. The lake was censused on 12 randomly selected days a month for the period May 1 to August 31, 1955. This amounted to censusing two weekend days and two weekdays per section per month. The number of hours fished and the fish caught for each month the resort owner census was used is presented in Table 5.

Table 5. Fishing statistics of non-cabin owners on Priest Lake for the period May 1 to August 31, 1955.

	May	June	July	August
Number of hours fished	5,100	4,500	4,900	4,900
Number of kokanee caught	1,600	7,900	11,700	5,700
Number of trout caught	250	610	510	320

Cabin Owner Postal Card Census

There are approximately 600 cabins surrounding the lower half of Priest Lake. These cabins are found on private property and on lands leased from the U.S. Forest Service and from the State of Idaho. At the end of the 1955 season, a double postal card was mailed to 557 of the cabin owners asking for information on their fishing at Priest Lake from May 1 to August 31, 1955. Of the 557 cards mailed out, 46 percent were returned.

To determine the total cabin-owner catch for 1955, a portion of the September catch must be added to the cabin-owner census totals. Forty-one percent of the fishermen contacted in September by the boat count-interview census were cabin owners. Therefore, it is assumed that 41 percent of the effort and approximately 41 percent of the catch for September can be credited to the cottage owners. Table 6 gives the total amount of effort expended and fish caught by cabin-owner fishermen from Priest and Upper Priest Lakes during 1955.

Table 6. Total number of hours fished, kokanee caught and trout caught by cottage owners during the 1955 fishing season from Priest and Upper Priest Lakes.

	Cabin owner postal card census	41 percent of boat count-interview census	Totals
Number of hours fished	32,100	7,100	39,200
Number of kokanee caught	41,900	8,200	50,100
Number of trout caught	2,900	300	3,200
Total number of fish caught from lakes by cabin owners			53,300

Calhoun (1950) found that a return of approximately 30 percent was representative of the population sampled. In view of this finding, it is assumed that the return of 46 percent of the cards sent to Priest Lake cabin owners is representative of the 600 or more cabins at the lake. However, the reliability of the information enclosed on the postal cards is questionable, especially if a person fishes a large number of hours and catches a large number of fish throughout the season.

The use of the boat count-interview census method during the 1956 season eliminated the need of a postal card census to determine the catch of cabin-owner fishermen from the lakes. It was desirable, however, to again obtain an estimate of the harvest of fish from the tributary streams so postal cards were sent out at the end of the 1956 season, but information was requested on the catch from the streams only.

Approximately 44 percent of the cards mailed were returned. Results indicate that 21 percent of the cabins have on the average, 2.5 people who fished the streams 4.5 days each for approximately 4 hours per day. From these values it is estimated that approximately 5,400 hours were fished and resulted in a catch of approximately 1,600 cutthroat, 2,900 brook trout, and 300 Dolly Varden from the streams. These figures represent only the catch made by cabin owner fishermen. The total catch for the streams is probably twice the amount tabulated since approximately half of the fishermen contacted on the streams were non-cabin owner fishermen. The estimated catch from the streams by cabin-owner fishermen for the years 1955 and 1956 is presented in Table 7. Indian Creek, Granite Creek, and Kalispell Creek were fished most during the 1956 season.

Table 7. Number of cutthroat, brook trout, and Dolly Varden caught from tributary streams by cabin-owner fishermen during 1955 and 1956

Species	1955	1956
Cutthroat	1,300	1,600
Brook trout	4,900	2,900
Dolly Varden	100	300
Totals	6,300	4,800

The catch per hour in 1956 for fish in the stream was 0.9 as compared with 2.0 in 1955. The 1956 figure is questionable as the stream survey crew for the project fished the same streams as the sportsmen and only once did the catch per hour fall as low as 3.0 fish per hour per man. In some streams the fishing success was as high as 10.8 fish per hour per man (Table 8).

Table 8. Streams fished, fish caught, and catch per hour per man by the survey crew in the summer of 1956 at Priest and Upper Priest Lakes.

Stream fished	Date fished	Fish caught	Hours fished	Catch per hour
Trapper Creek	7-30-56	54	5	10.8
Gold Creek	7-27-56	38	6	6.2
Hughes Fork	7-26-56	12	3	4.0
	Upper end of Meadow			
	7-25-56	11	3	3.6
	Lower end of Meadow			
	7-26-56	28	8	3.5
	Creek below road			
So. Fork Granite Creek	7-21-56	24	4	6.0
Hunt Creek	6-15-56	6	2	3.0

Table 8 continued.

Stream fished	Date fished	Fish caught	Hours fished	Catch per hour
Blacktail Creek	6-23-56	16	3	5.2
Kalispell Creek	6-25-56	45	6	7.5
Soldier Creek	7-23-56	27	5	5.0
Two Mouth Creek	7-28-56	33	6	5.5
	Above Camp 11 6-13-56	34	10	3.4
Indian Creek	Below falls 6-18-56	22	6	3.7

Boat Count-Interview Census

The boat count-interview census was initiated in September, 1955, in an effort to overcome the deficiencies of the two types of census formerly used, With this type of census both cabin owner and non-cabin owner fisher-men could be contacted at the same time, thereby removing the need of a postal card census. Accuracy of the data collected was increased by shifting the responsibility of the census from the resort owners to project personnel. The use of project personnel on the census also made possible the heretofore impractical task of obtaining data for a particular area of the lakes, The amount of fishing other than from boats is negligible on Priest and Upper Priest Lakes.

The boat count-interview census is composed of two basic parts: (1) boat counts to obtain an estimate of fishing pressure, and (2) personal interviews with anglers to determine the rate of catch and species composition. The two estimates when multiplied together represent the harvest.

Boat Count. The selection of a method for making a count of the number of boats fishing on the lakes was restricted by the topography of the area, size, and shape of the lakes, and the lack of roads. The lack of roads prevented the use of an automobile, and the irregular shoreline surrounded by many ridges and mountains removed the possibility of using a central vantage point. After concluding that the efficiency of an aircraft would be impaired by the large number of overcast days, it was decided that the counts would have to be made by boat. In 1955, four hours were required to completely circle the two lakes. In 1956, a faster boat was used and the lakes could be circled in three hours. Binoculars were used to increase the efficiency of the boat counts.

The design of a sampling plan was complicated by an apparent uneven distribution of pressure throughout the fishing season, various areas of the lake, days of the week, and times of the day.

Even though data collected in 1955 (Table 5) did not support the belief that there was a significant difference in the amount of fishing pressure exerted throughout the season, the sampling plan for 1956 was designed to measure any differences that might occur. The season was stratified into 12 intervals of 14 days each as listed below:

<u>Time Interval</u>
1. May 1 - May 14
2. May 15 - May 28
3. May 29 - June 11
4. June 12 - June 25
5. June 26 - July 9
6. July 10 - July 23
7. July 24 - August 6
8. August 7 - August 20
9. August 21 - September 3
10. September 4 - September 17
11. September 18 - October 1
12. October 2 - October 15

The distribution of fishing pressure on Priest and Upper Priest Lakes appeared to be uneven. In order to determine differences in pressure between various parts of the lakes, five areas were set up (Figure 7).

The amount of fishing effort expended on weekend days was felt to be significantly different from that exerted on other days of the week. There-fore, the boat count-interview census used in 1955 was stratified by weekend days and weekdays. In 1956 the week was further stratified into three classifications: (l) Saturday and Sunday (2) Monday and Friday, and (3) Tuesday, Wednesday, and Thursday.

Differences in the amount of fishing effort expended at various times of the day are natural in most waters. Priest and Upper Priest Lakes did not appear to be an exception; therefore, the fishing day was stratified into four periods. The length of the fishing day was found to vary according to the number of hours of daylight, and to a lesser degree type of weather. Fishing very seldom occurred before daylight in the morning and after dark in the evening. As the number of daylight hours increased or decreased, correspondingly the length of the fishing day increased or decreased. In 1956, the fishing day was found to vary from 12. 5 to 16 hours as shown in Table 9.

Table 9. Length of fishing day for each interval throughout the 1956 fishing season.

Interval	Length of fishing day (hours)	Interval	Length of fishing day (hours)
1	15.0	7	15.5
2	15.5	8	15.5
3	15.5	9	15.0
4	16.0	10	14.0
5	16.0	11	13.0
6	16.0	12	12.5

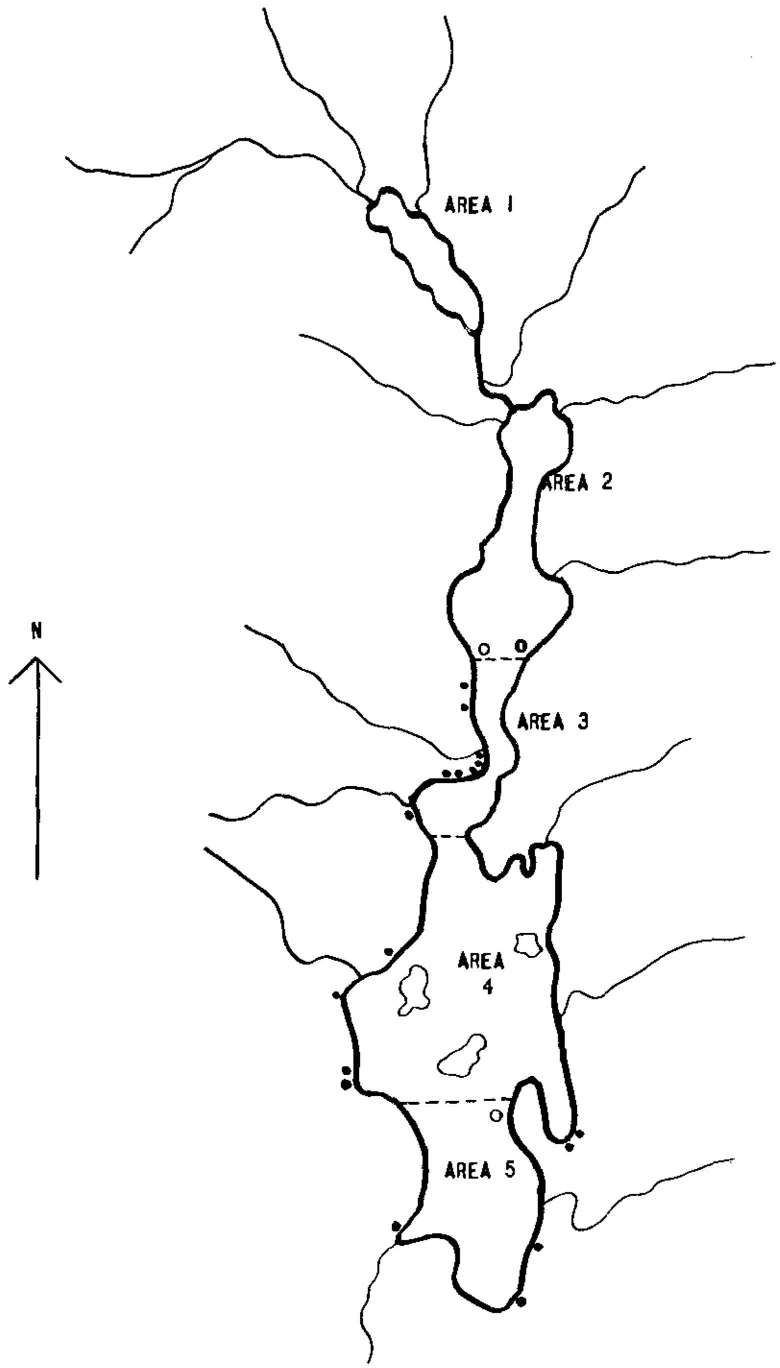


Figure 7. Map of Priest and Upper Priest Lakes showing area divisions. Dots represent location of resorts, boat liveries, or public camp grounds.

A period of three hours was used as the sampling unit in 1956 as that was the amount of time required to completely circle the two lakes. With four periods in each day, 12 hours of the fishing day could be sampled. The first period sampled the early morning fishermen, the second period the mid-morning fishermen, the third period the mid-afternoon fishermen, and the fourth period sampled the evening fishermen.

Because the length of the fishing day varied throughout the season, the beginning and/or ending of the fishing day also varied. In order to continue sampling the early morning and evening fishermen the time of the sampling periods had to be shifted as the length of the day varied. For example, if the fishing day began at 4:00 a.m. and ended at 8:00 p.m. the periods would be spaced as below with a 48 minute interval[1] at the beginning and end and between each period.

Period 1 - 4:48 a.m. to 7:48 a.m.
Period 2 - 8:36 a.m. to 11:36 a.m.
Period 3 - 12:24 p.m. to 3:24 p.m.
Period 4 - 4:12 p.m. to 7:12 p.m.

On the other hand, if the fishing day began at 6:00 a.m. and ended at 6:30 p.m., the periods would be spaced as below with only a 6 minute interval.

Period 1 - 6:06 a.m. to 9:06 a.m.
Period 2 - 9:12 a.m. to 12:12 p.m.
Period 3 - 12:18 p.m. to 3:18 p.m.
Period 4 - 3:24 p.m. to 6:24 p.m.

The boat count then, was stratified by interval of the season, day of the week, period of the day, and area of the lakes. Under ideal conditions, the number of samples to be taken in each stratum would be determined after the cost per sample unit and variability of each stratum had been analyzed. For this investigation, estimates of the variability of each stratum were not known and the cost per sampling units did not vary significantly from one stratum to the next. Therefore, it was concluded that an equal number of samples be taken in each stratum, ie. the same number of samples would be taken in Interval 1 as in Interval 5, etc.

Where it is of value to obtain an estimate of the catch for the entire season it is often desirable to proportion the number of samples in each stratum according to the relative amount of pressure that occurs in that stratum as compared to the others. However, if estimates of the relative amount of pressure occurring in each interval, day of week, period, or area are not known beforehand (as in the case of this investigation) an equal number of samples can be taken in each stratum and the results of each stratum weighted to obtain season estimates after the relative pressures are known. When the weighting is done after sampling, the advantage of using a season mean to calculate the season total is lost

1The 48 minutes is derived by dividing the difference between the length of the fishing day and the maximum number of sample hours per day, 12, by 5.

as each stratum must be treated separately and then combined to gain the season value.

It was decided that each period of each class of day of the week should be sampled once each interval, and that each area of the lake be sampled on each count. Thus in each of the 12 intervals, 12 boat counts would be made where both lakes were circled completely. For each class of day of the week, a period l, 2, 3, and 4, would be sampled. The above sampling procedure yielded a sample of 21.4 percent of the possible counts. The date a particular period of a particular class of day was to be sampled was determined in a random manner with the use of a table of random numbers (Snedecor, 1956),

Weather conditions appeared to play an important role in determining the amount of fishing pressure exerted. In an attempt to measure its effect, the weather conditions were noted each time a count was taken. Three classifications of weather were set up to simplify the analysis: (l) good (clear to partly cloudy, moderate to no wind, no precipitation, air temperature comfortable), (2) fair (overcast to partly cloudy, brisk to moderate wind, light to no precipitation, air temperature cool), and (3) poor (overcast, moderate to heavy wind, moderate to heavy precipitation, air temperature cool to cold), Obviously such an attempt at measuring weather is very subjective and dependent upon the judgement of the census clerk. However, the same person was used to make most of the counts so that the classification bias was at a minimum.

The number of boats observed during a boat count was usually a relatively small number, with large numbers of boats observed only infrequently. Consequently the number of boats per count formed a Poisson distribution (Figure 8). In order to facilitate more efficient statistical analysis a square root transformation sqrt(X + 0.5) was used (Snedecor, 1956).

A factorial arrangement of treatments was used to analyze the boat count data. The analysis is presented in Table 10. The mean squares for all second order interactions were pooled with the error mean square to reduce the possibility of accepting a false hypothesis concerning the significance of certain main effects or first order interactions. All of the interactions were non-significant while all of the main effects were found to be significant. In other words, the amount of pressure expended during some intervals was significantly different from that expended in others; more boats were fishing on Saturdays and Sundays than on other days of the week; more people fished at one time of the day than at another; certain areas of the lakes received more pressure than others; and more boats were found fishing on days with good or fair weather than on days with poor weather.

The number of boats counted during Intervals 5 and 6 (latter part of June and most of July) was significantly larger than for other intervals throughout the season (Table 11). A difference between transformed means of more than 0.2 to 0.3 was usually significant at the 95 percent level (Tukeys test; Snedecor, 1956).

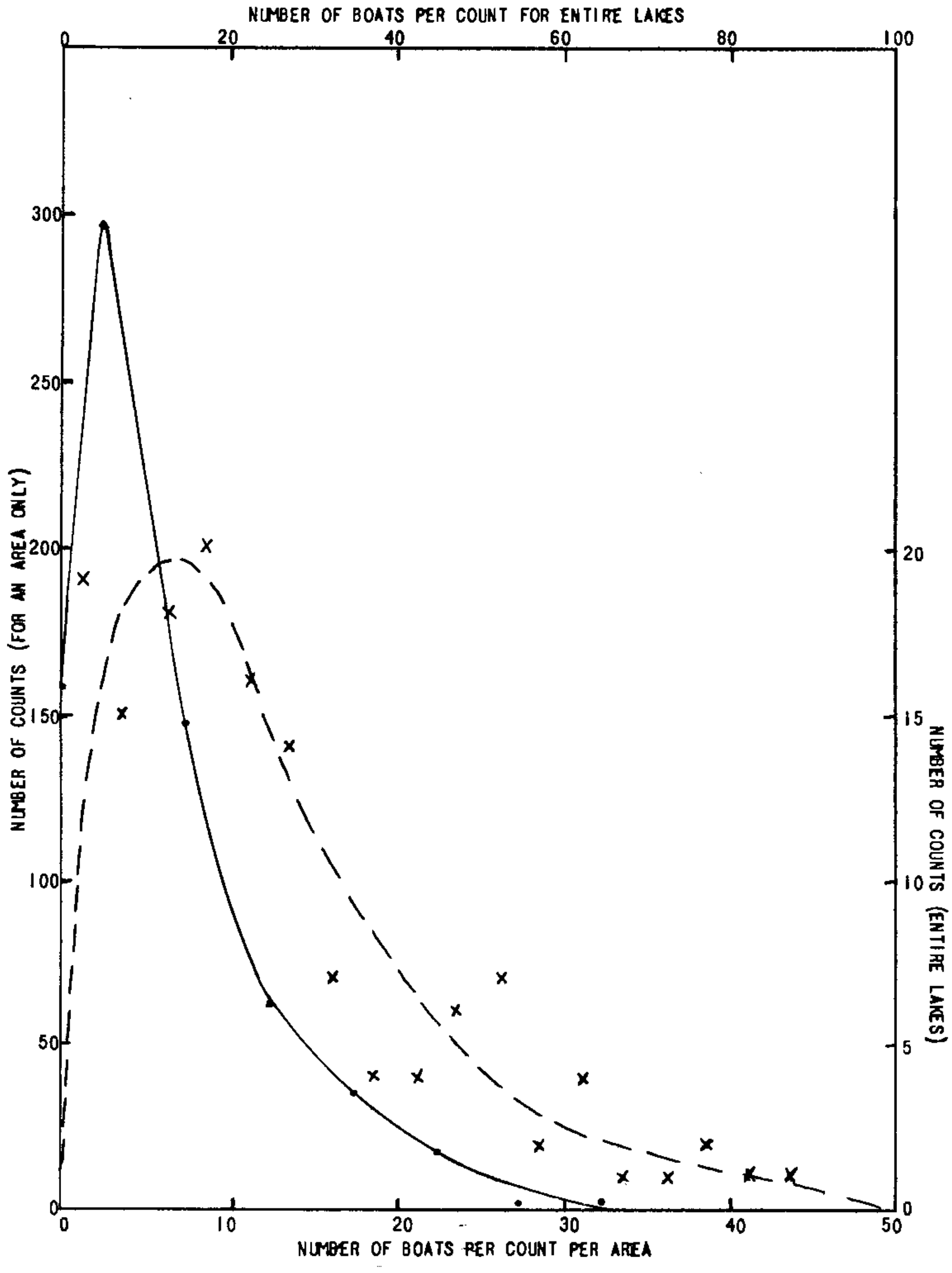


Figure 8. Distribution of counts according to the number of boats per count. The continuous line illustrates the distribution obtained when the count for each area is considered as a unit. The broken line illustrates the distribution obtained when the number of boats for all areas are combined and considered as a unit. The regression lines were fitted by inspection.

Table 10. Analysis of variance of Priest Lake boat count data for 1956.

Source of variation	Degrees of freedom	Mean square	Remarks[1]
Interval of season (I)	11	14.0	S.
Day of week (D)	2	48.7	S.
Period of day (P)	3	21.1	S.
Areas of lakes (A)	4	50.5	S.
Weather type	2	32.1	S.
I X D	22	0.7	N.S.
I X P	33	1.6	N.S.
I X A	44	1.3	N.S.
D X P	6	3.8	N.S.
D X A	8	1.1	N.S.
P X A	12	1.4	N.S.
Error	572	1.86[2]	--
Total	719	--	--

[1]S. = significant at 95 percent level, N.S. = not significant

[2]The second order interactions mean squares were pooled with the error mean square.

Table 11. Mean number of boats per count per interval given as transformed values and as retransformed values, ie. transformed mean squared minus 0.5.

Interval	Transformed mean (rounded)	Retransformed mean (rounded)
1	1.29	1.08
2	1.77	2.63
3	1.77	2.62
4	2.34	4.96
5	2.73	6.94
6	2.77	7.15
7	2.29	4.73
8	2.22	4.45
9	1.99	3.47
10	2.07	3.78
11	1.54	1.88
12	1.38	1.41

The number of boats fishing on a Saturday or Sunday was also found to be significantly larger than on other days of the week. The pressure exerted on Fridays and Mondays did not differ significantly from that on Tuesdays, Wednesdays, and Thursdays however (Table 12).

Table 12. Mean number of boats per count each weekday type given as transformed and retransformed values.

Day of week	Transformed mean (rounded)	Retransformed mean (rounded)
(1) Saturdays and Sundays	2.53	5.50
(2) Mondays and Fridays	1.79	2.72
(3) Tuesdays, Wednesdays, and Thursdays	1.71	2.43

On the average more people fished during the mid-morning (Period 2) on Priest and Upper Priest Lakes than at any other time of the day. The number of people fishing during Period 3 did not differ significantly from the number during Period 4. Period 1 received less pressure than any of the other periods (Table 13).

Table 13. Mean number of boats per count per period of the day given as transformed and retransformed values.

Period	Transformed mean (rounded)	Retransformed mean (rounded)
1	1.52	1.80
2	2.29	4.77
3	2.15	4.12
4	2.09	3.87

There were significantly more boats fishing in Area 3 than in any other area on the lakes. The number of boats counted in Area 4 did not differ significantly from that in Area 5, and likewise the number in Area 1 did not differ significantly from that of Area 2. The number counted in Areas 4 and 5 did differ significantly from those in Areas 1 and 2 however (Table 14).

Table 14. Mean number of boats per count per area given as transformed and retransformed values.

Area	Transformed mean (rounded)	Retransformed mean (rounded)
1	1.31	1.21
2	1.49	1.73
3	2.72	6.92
4	2.26	4.62
5	2.27	4.66

There was a significantly larger number of boats counted when the weather was good or fair as when the weather was classified as poor. The number counted during counts classified as good or fair weather did not differ significantly (Table 15).

Table 15. Mean number of boats per count for each class of weather given as transformed and retransformed values,

Weather class	Transformed mean (rounded)	Retransformed mean (rounded)
1 (Good)	2.16	4.18
2 (Fair)	1.97	3.37
3 (Poor)	1.22	0.99

Once the mean number of boats fishing at any one time during the various intervals, on various days of the week, during the various periods of the day in each area was determined, the number of hours fished was computed in the following manner. The mean number of boats fishing in an area, on a particular day of the week, during a particular interval was multiplied by the number of hours in the fishing day for the particular interval. This gave the mean number of boat hours fished in the area on a particular class of day in a particular interval. This mean number of boat hours per day was then multiplied by the number of days of that particular class of day in the interval to obtain the total number of boat hours fished for the area, on a particular class of day of the week for the interval. This process was repeated for each area and each class of day in each interval to obtain the total number of boat hours fished during the interval. Although there was a difference in the mean number of boats counted during various periods of the day, the total number of hours fished during each period was not computed. The amount of error introduced by neglecting to stratify by period of the day was not large enough to justify the greatly increased number of computations that would be required.

An example of the computations described in the above paragraph may serve to clarify the procedure. The mean number of boats counted in Area 1 on a Class 1 day of the week (Saturday and Sunday) during Interval 1 was l.91. This is the mean number of boats that would fish the entire length of the fishing day. The mean (l.91) is then multiplied by 15 (the number of hours in the fishing day during Interval l; Table 9), to obtain the mean number of hours fished per day, 28.7. The mean number of hours fished per day is then multiplied by 4 (the number of Class 1 days in an interval, two Saturdays and two Sundays) which gives 115; the number of boat hours fished in Area l, on Class 1 days of the week, during Interval l. The totals for each area on each class of day is then summed to obtain the total number of boat hours fished on the lakes during Interval l.

The total fishing pressure on Priest and Upper Priest Lakes during the 1956 season amounted to 53,500 boat hours.

The distribution of the pressure throughout the season was not uniform as the 1955 data had indicated. The largest amount of fishing took place during Intervals 5 and 6 (Figure 9). There was also variation between areas of the lakes in the percentage of pressure taking place during the various intervals (Figure 10).

The number of hours fished in each area of the lake was also unequal (Figure 11). Area 3, one of the smallest areas, received the largest amount of fishing pressure (36 percent). Areas 4 and 5 were nearly equal (23 and 24 percent). Area I, Upper Priest Lake, received the smallest amount of pressure (7 percent).

Saturdays and Sundays were by far the most popular fishing days. Approximately 46 percent of the total fishing pressure was exerted on the lake on these days (Figure 12). The percentage of hours fished on Class 1 days of the week as compared with those occurring on Class 2 and 3 days of the week varied throughout the season (Figure 13). During the early part of the season, nearly 60 percent of the total effort during the week was expended on Saturdays and Sundays. Shortly after the first of June the percentage dropped to approximately 40 percent and remained at that level until after the first of September. Most of the schools in Spokane, Washington, and the surrounding area have summer vacations that begin around the first of June and last until the first part of September. The increased percentage of fishing pressure occurring on Class 2 and 3 days is related to this summer vacation from school. As soon as school is out in the spring, people begin taking their vacations, and many move to their lake shore homes for the summer. As a result, there is a proportionately larger number of fishermen at the lake during the middle part of the week.

The number of boats per count observed during the various days of the week follows the same general pattern as the number of hours fished (Figures 13 and 14). Differences arise because there are six Class 3 days in each interval as compared to only four Class 1 and 2 days. Additional variation is caused by the differing number of hours in the fishing day between certain intervals.

Boat counts were made regardless of the weather conditions. It was found that on 67 percent of the counts the weather was classified as good, 21 percent fair, and 12 percent poor. Since the boat counts did sample the season, these percentages might be used to give a rough idea of the weather conditions at Priest Lake for the period May 1 to October 15. It should be stated however that a large majority of the poor weather occurred during the early and late portions of the season.

Interviews. Anglers were interviewed both while they were fishing and after they had finished. However, the lack of a central landing area, or place where anglers could concentrate made it necessary to take the majority (90 percent) of the interviews before they had finished fishing.

Interviews were taken in each of the five areas of the lakes to obtain information on the number of hours fished, fish caught, poles per boat, species of fish sought, residence, and method of fishing.

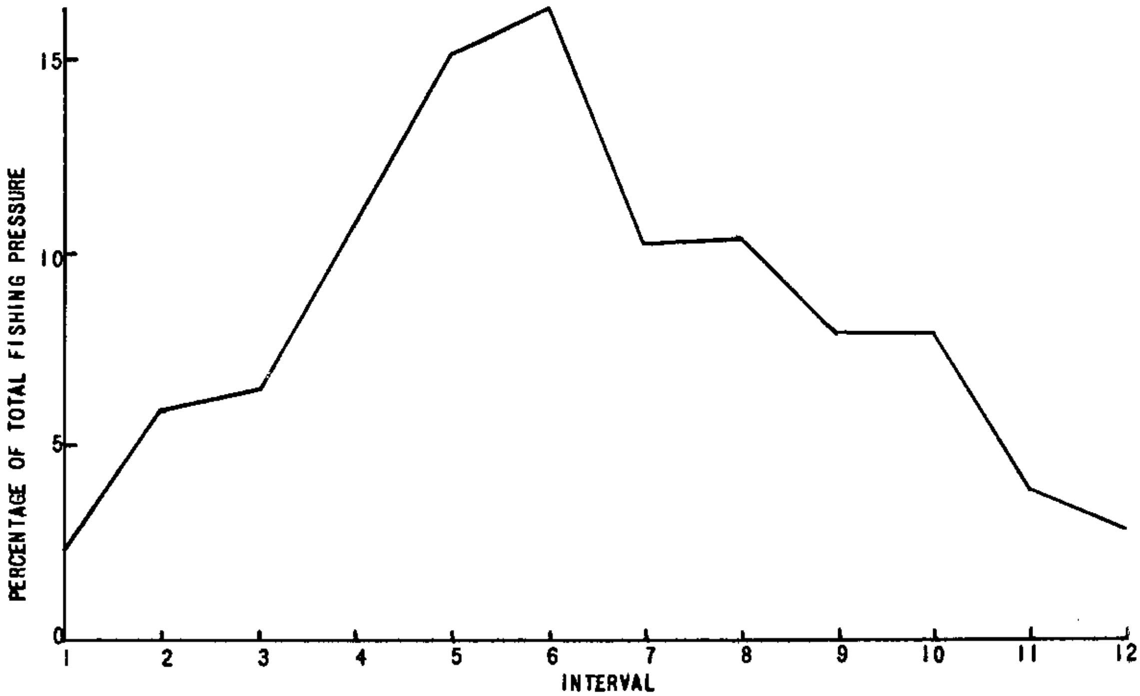


Figure 9. Percentage of total pressure expended during various intervals of 1956 season.

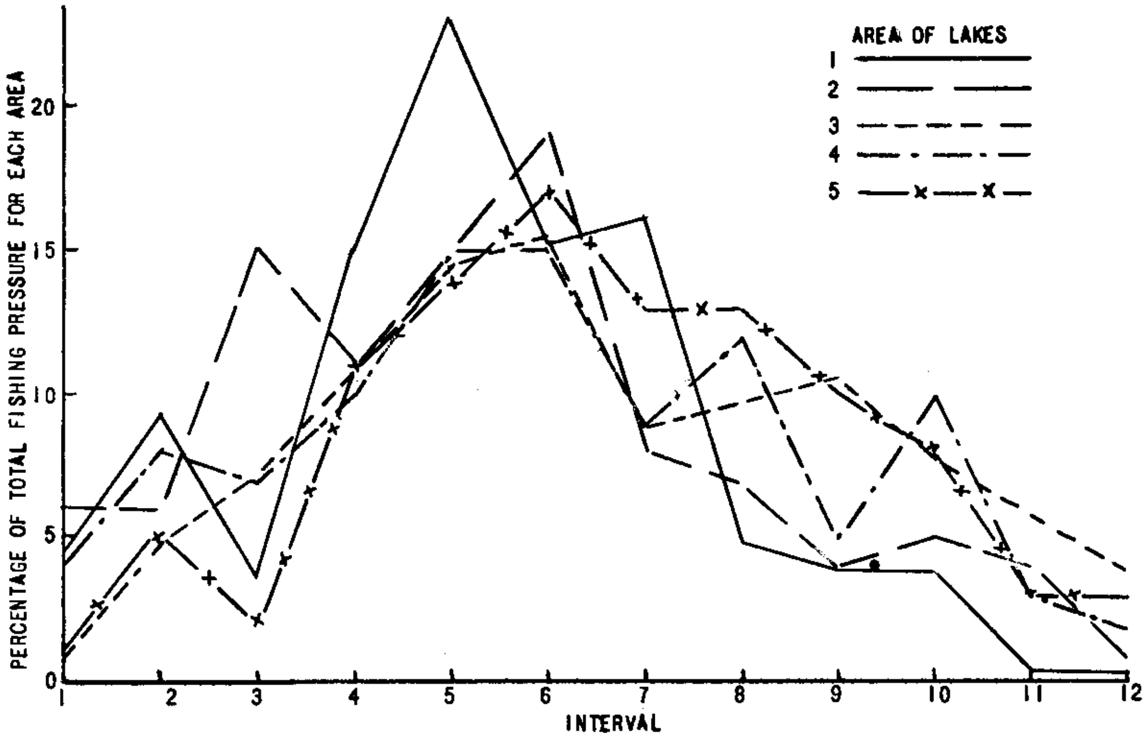


Figure 10. Percentages of total pressure for each area expended during various intervals of 1956 season.

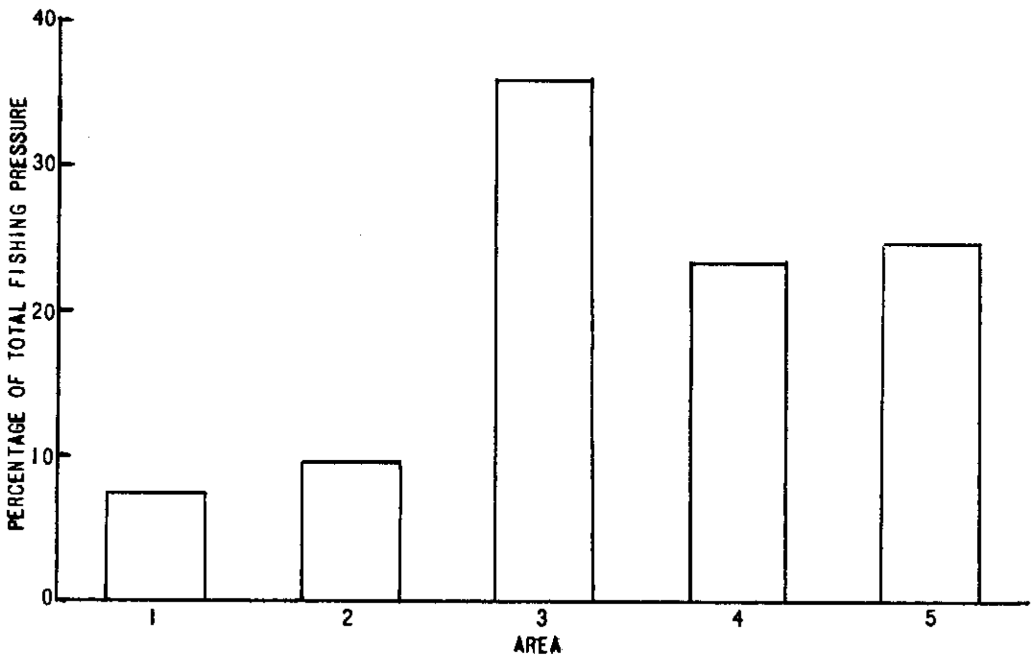


Figure 11. Percentage of total hours fished in various areas of lakes for entire 1956 season.

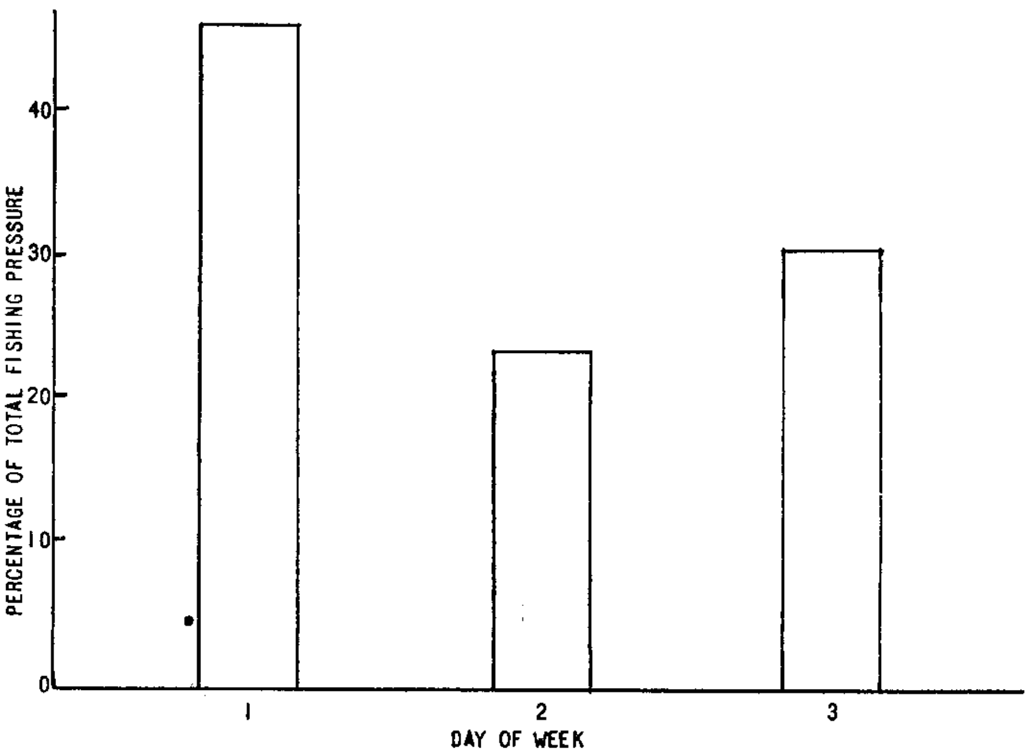


Figure 12. Percentage of total hours fished on (1) Saturdays and Sundays, (2) Mondays and Fridays, and (3) Tuesdays, Wednesdays, and Thursdays during 1956 season.

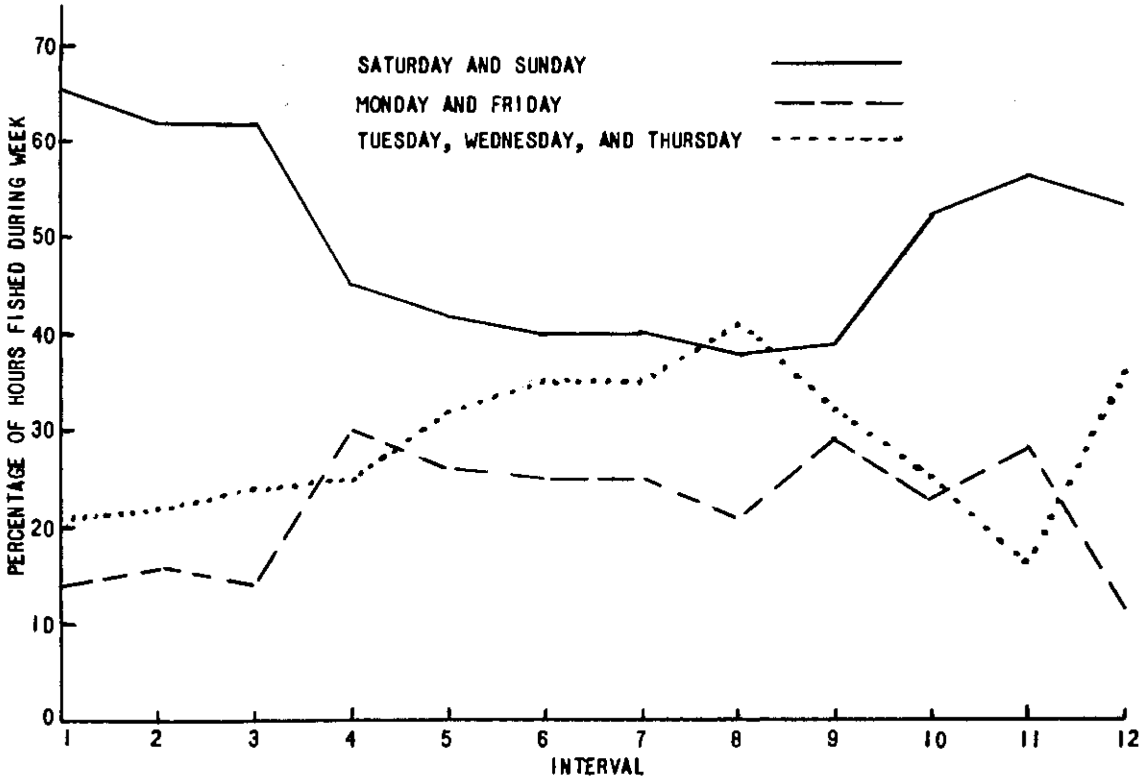


Figure 13. Percentage of hours fished during each of the three classes of week days on Priest and Upper Priest Lakes.

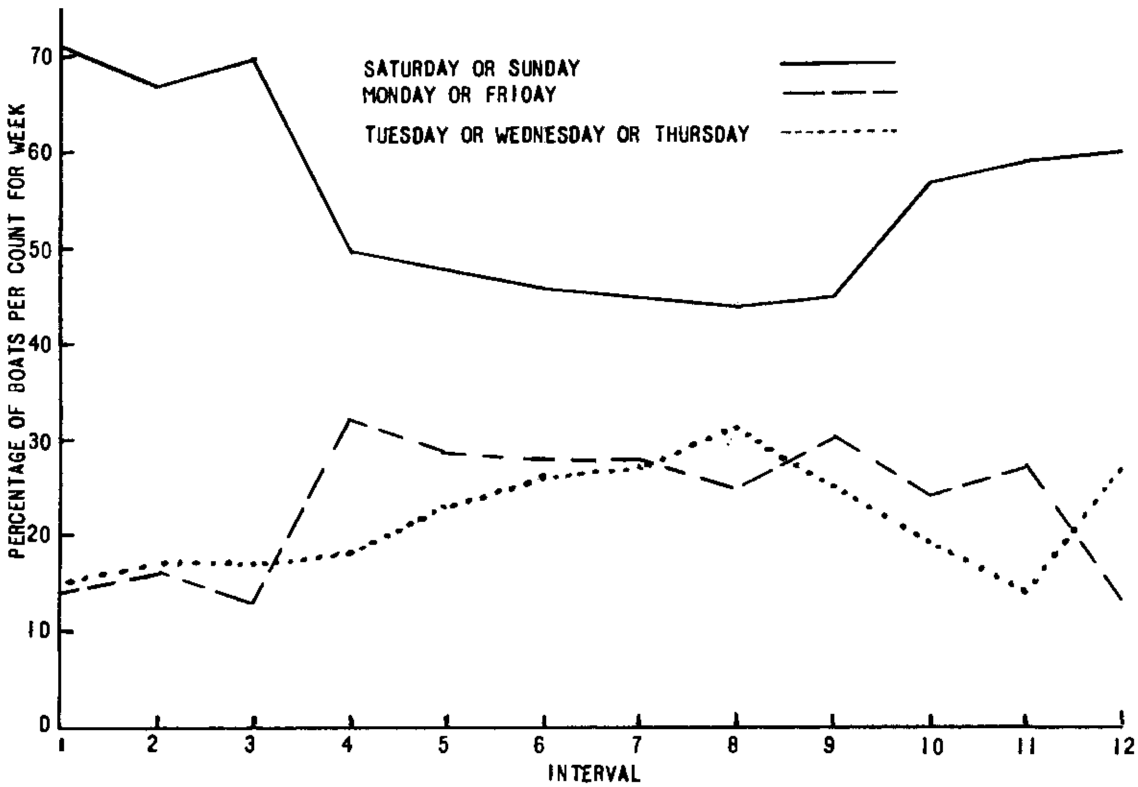


Figure 14. Percentage of the average number of boats found fishing on Priest and Upper Priest Lakes at one time.

An effort was made each time interviews were taken to contact every boat in a given area so that any bias resulting from contacting only one type of fisherman would be reduced to a minimum. Most of the interviews were taken from mid-morning through the afternoon and evening. The light fishing intensity in the early mornings and the fact that most fishermen had just begun to fish reduced the need of taking large numbers of interviews in the early morning.

From the interviews it was determined that trolling was the most popular method of fishing. Of the fishermen contacted, 95 percent were trolling, 3 percent fly fishing, and 1 percent each spinning and still fishing. All of the major game fish species in the lake can be taken on trolling gear. In fact, the cutthroat was the only game fish species taken in sizeable numbers by the other above mentioned methods.

It was impossible in most instances to determine the species of fish sought while taking a boat count, especially if trolling was the method of fishing used. It was assumed that anglers fishing for the various species of fish were interviewed in the same approximate proportions as actually took place. Therefore, by using the data collected from interviews, it was possible to determine the amount of effort expended for each of the various species in the lakes.

Upper Priest Lake differed markedly from Priest Lake in the percent effort expended to catch trout and to catch kokanee (Table 16). Kokanee fishermen expended the majority of the effort on Priest Lake, while trout fishermen spent as much time angling as did the kokanee fishermen on the upper lake. The amount of effort expended for trout and kokanee within an area also varied between areas. In Area 1 there was a relatively large amount of fishing for Dolly Varden and/or mackinaw[1]. Areas 2 and 5 in addition to Area 1 supported a large portion of the cutthroat fishing.

Table 16. The percentage of the total fishing pressure expended to catch kokanee, cutthroat, and Dolly Varden and/or mackinaw in Priest and Upper Priest Lakes and in each area of the lakes during 1956.

Lake or area	Percent of total effort	Percent of effort expended for: Kokanee	Cutthroat	Dolly Varden and/or Mackinaw
Upper Priest Lake				
Area 1	7	49	44	7
Priest Lake	93	84	7	9
Area 2	9	72	14	14
Area 3	36	89	6	5
Area 4	23	75	4	21
Area 5	25	89	9	2

[1]Since both the Dolly Varden and mackinaw inhabit the same areas of the lake and were caught on the same type gear it was not possible to differentiate between those people fishing for Dolly Varden and those fishing for mackinaw, even though a person may be fishing for only one of the species.

The relative amount of pressure expended in each area for trout and kokanee during the various intervals followed a more or less uniform pattern with the exception of Area 1 (Figure 15). Fishing for Dolly Varden and/or mackinaw and cutthroat constituted only a small portion of the total pressure exerted on Priest Lake after the middle of June (Interval 3). In Area 1, Upper Priest Lake, the amount of pressure exerted for trout and kokanee fluctuated throughout the season. Approximately one third of the total effort spent fishing for cutthroat was expended in Upper Priest Lake.

The difference in the rate of catch for cutthroat and kokanee in the upper lake as compared to Priest Lake probably is the most important factor controlling the distribution of fishing pressure. The catch per boat per hour for cutthroat in Upper Priest is l.02 compared to 0.70 for Priest Lake (Table 17). Probably of more importance, however, is the rate of catch for kokanee; 2.46 per boat per hour in Priest Lake as compared to 0.86 in the upper lake, Most kokanee fishermen naturally chose to fish in Priest Lake where the rate of success was higher even though the fish caught were slightly smaller.

Table 17. Catch per hour per boat for kokanee, cutthroat, and Dolly Varden and/or mackinaw at Priest and Upper Priest Lakes during 1956.

Lake and area	Catch per boat per hour[1] Kokanee	Cutthroat	Dolly Varden and/or Mackinaw
Upper Priest Lake	0.86	1.02	0.75
Area 1			
Priest Lake	2.46	0.70	0.36
Area 2	2.61	1.08	0.49
Area 3	2.77	0.74	0.41
Area 4	2.15	0.26	0.33
Area 5	2.14	0.66	0.09

[1]The catch per man per hour can be obtained by dividing the catch per boat per hour by the mean number of fishermen per boat (1.94 in 1956).

The rate of catch for cutthroat was noticeably higher in those areas with relatively extensive shoal areas. For example, the shallow south end of Priest Lake (Area 5) supported a higher rate of catch than Area 4, which contained little shoal area.

The rates of catch were computed as fish caught per boat per hour, The catch per man per hour can be obtained by dividing the boat catch per hour by 1.94, the average number of poles per boat. This value is applicable for kokanee, cutthroat, and Dolly Varden and/or mackinaw as the mean number of fishermen per boat was not significantly different regardless of the species of fish sought.

Statistical tests revealed that there was no significant difference in the catch per hour of those who had finished fishing and those who had

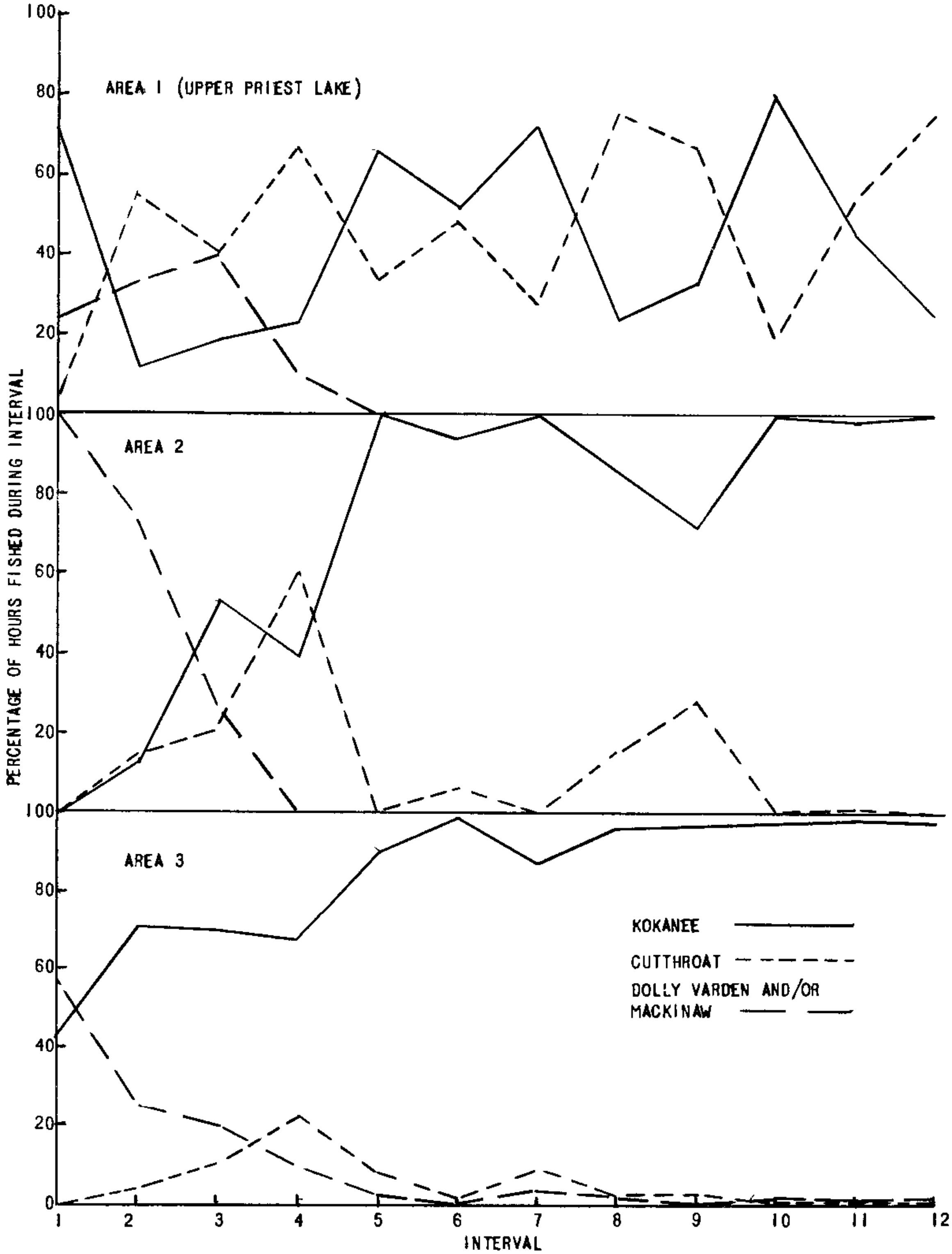


Figure 15. The relative amount of pressure expended for kokanee, cutthroat, and Dolly Varden and/or mackinaw for each time interval during the 1956 season on Priest and Upper Priest Lakes and in each area of the lakes. Expressed as percent of total hours fished during interval.

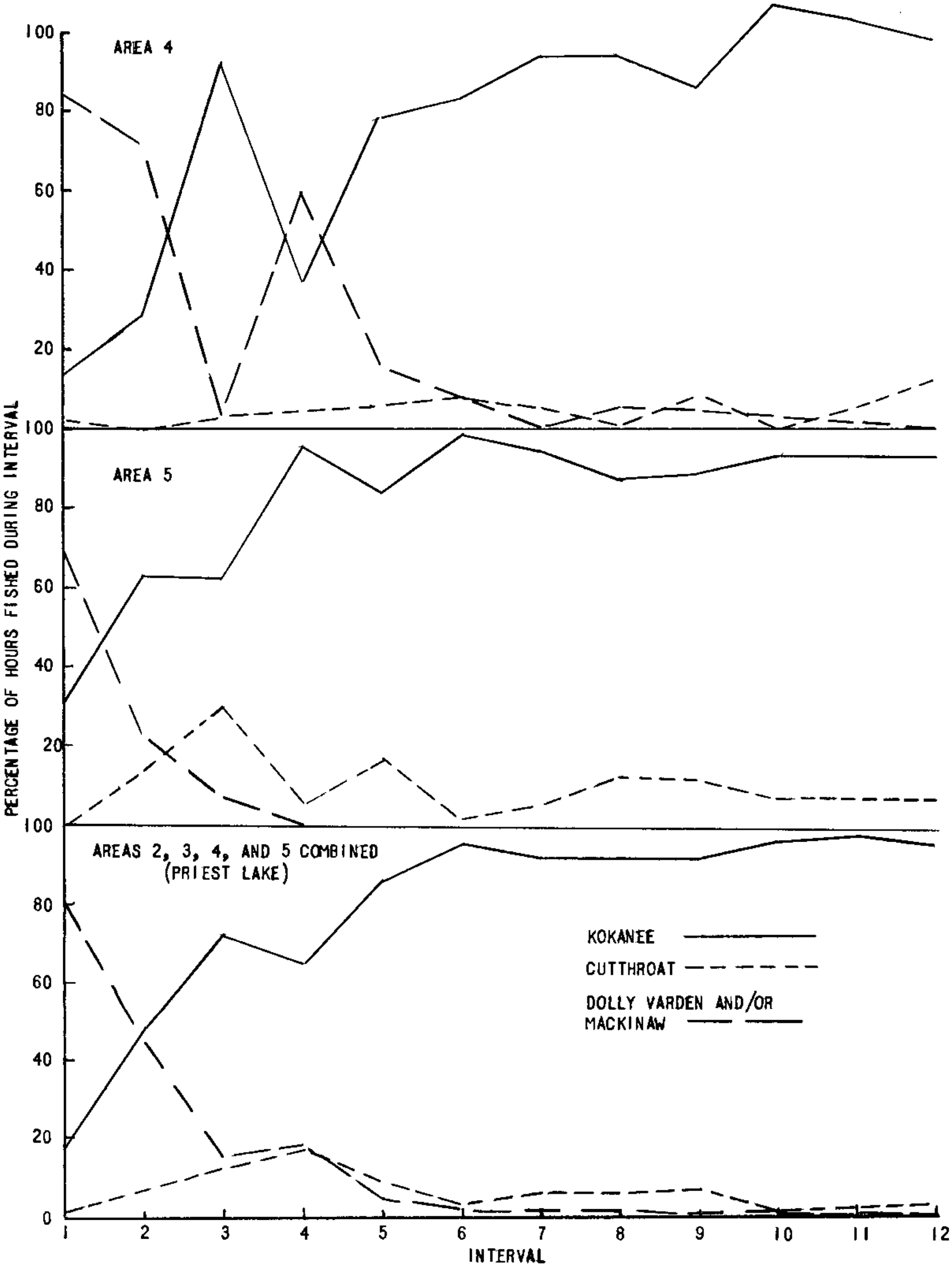


Figure 15 continued.

not. Also there was no significant difference between the catch per hour of those persons who had been fishing a short while and those who had fished for longer periods (Table 18).

Table 18. Analysis of variance of catch per hour by interval, according to the number of hours fished (group means), and by interval and hours fished.

Source of variation	Degrees of freedom	Mean square	Remarks
Interval means	11	222.9	S.[1]
Group means	21	16.2	N.S.[1]
Interval X group	165	22.3	S.
Error (discrepance)	991	4.3	
Total	1188		

[1]The mean squares for the error and interval X group interaction were pooled and the sum was used to test the group and interval means.

The rate of catch for kokanee was determined for each area during each interval (Figure 16). The rate of catch in the upper lake did vary throughout the season, however, the magnitude of variation was much smaller than that found in the areas of Priest Lake. Kokanee could be taken in Areas 4 and 5 during Interval 1 but not in Areas 2 and 3. All of the areas exhibited a decline in the rate of catch during mid-summer with peaks in the spring and fall. A very noticeable temporary decline in the rate of catch occurred during Interval 4 (middle of June) in Areas 2, 3, and 4. The catch per boat per hour during Interval 3 was as high as 4.59 in Area 2, fell to 0.64 in Interval 4, and rose to 3.33 in Interval 5. The decline did not take place in Area 5, and served to further complicate fruitless attempts to find a reason for the fluctuation.

With the exception of Area l, the rate of catch for kokanee was highest in the fall. This fact would seem to indicate that the population was not being over harvested and that there would be adequate spawning escapements.

The rate of catch for kokanee seems to have some effect on the total amount of pressure expended, however, not nearly as much as the beginning and ending of the summer vacation. There is a decline in the amount of pressure expended through the late summer that more or less follows the declining rate of success (Figure 17). However, even the high catch per hour in the fall was unable to increase the amount of pressure expended during those later intervals.

With the rate of catch and hours fished determined, the total harvest was computed. The harvest for September 1955 is listed in Table 19.

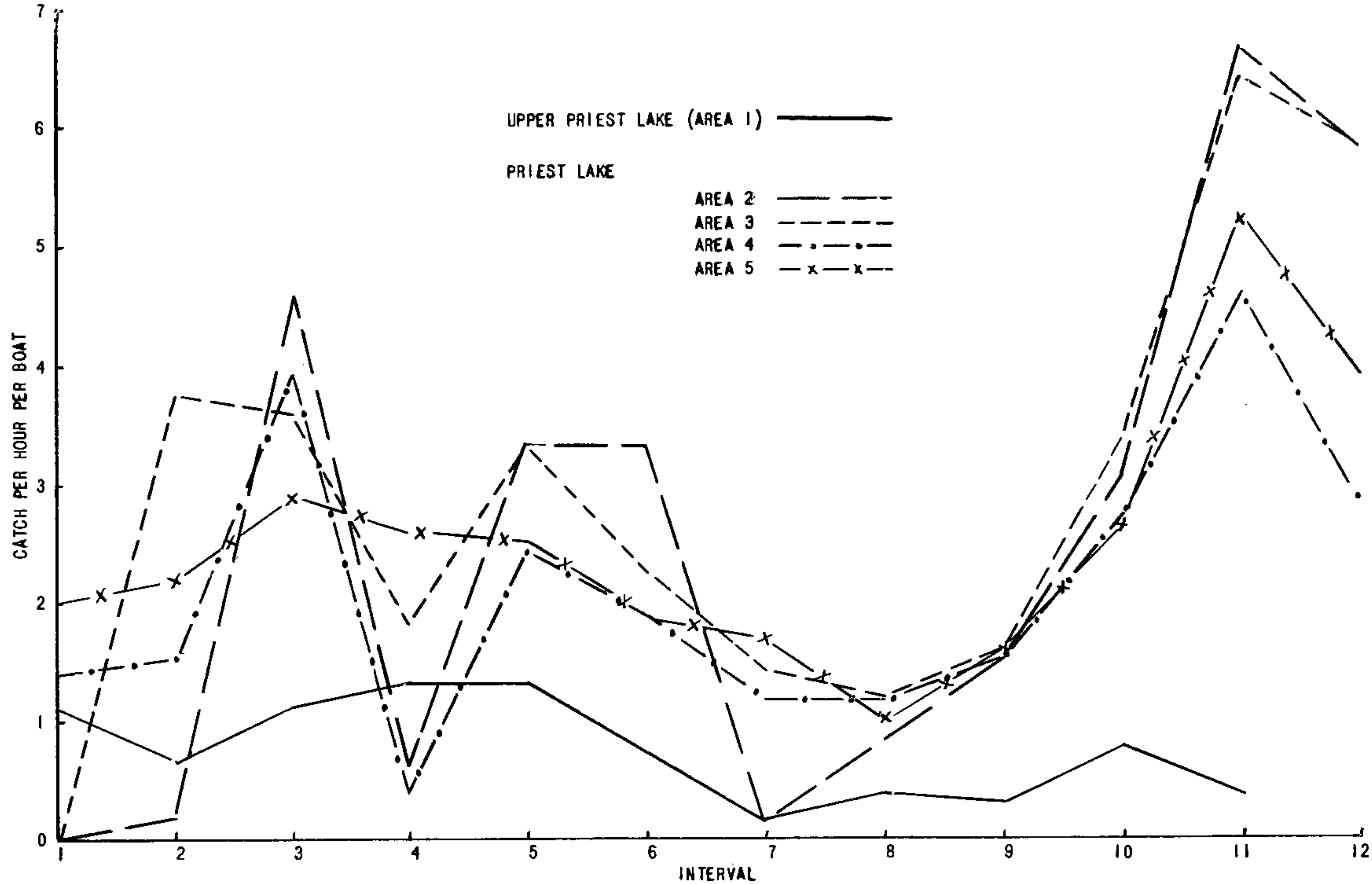


Figure 16. Catch per hour per boat for kokanee during each interval of 1956 season at Priest and Upper Priest Lakes.

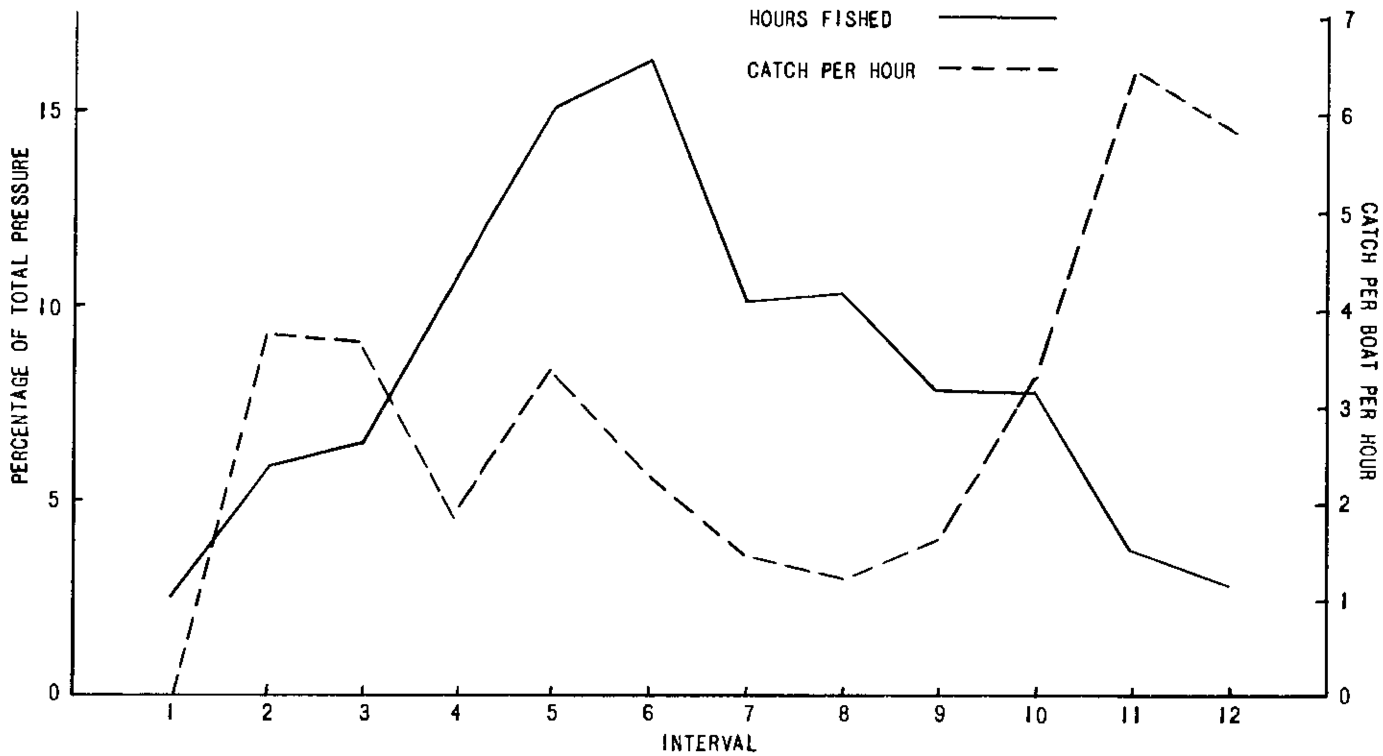


Figure 17. The relationship between the catch per hour for kokanee and the percentage of hours fished during each interval of 1956 season.

Table 19. Number of hours fished, kokanee caught, and trout caught from Priest and Upper Priest Lakes for the period September 1 to October 3, 1955.

	Priest Lake	Upper Priest Lake	Total
Number of hours fished	14,800	2,400	17,200
Number of kokanee caught	19,230	770	20,000
Number of trout caught[1]	300	300	600

[1]The term trout includes cutthroat trout, Dolly Varden trout, and mackinaw trout.

The September harvest, as determined by the boat count-interview census was then combined with the total as determined from the other methods of census to obtain the total hours fished and fish caught in 1955 (Table 20).

Table 20. Total number of hours fished, kokanee caught, and trout caught from Priest and Upper Priest Lakes for the period May 1 to October 3, 1955.

	Resort owner census	Cabin owner postal card census	Boat count interview census	Total
Number of hours fished	19,400	32,100	17,200	68,700
Number of kokanee caught	26,200	41,900	20,000	88,100
Number of trout caught	1,700	2,900	600	5,200
Total number of fish caught from lakes during 1955 census period				93,300

In 1956, approximately 103,900 man hours were spent fishing to catch an estimated 111,400 trout and kokanee. The totals for 1956 appear to be higher than for 1955 (Table 21) however the accuracy of the resort owner census used in 1955 was not as high as desired and the difference may only be apparent. The number of hours fished during the 1956 season was found to be accurate within plus or minus 4 percent of the mean at the 95 percent level. The actual number of hours fished is somewhere between 99,700 and 108,000, with 103,900 as the best estimate. The catch was estimated with an error of approximately 10 percent.

Table 21. Total number of man hours fished, kokanee caught, and trout caught from Priest and Upper Priest Lakes for 1955 and 1956.

	1955	1956
Number of hours fished	68,700	103,900
Number of kokanee caught	88,100	103,800
Number of trout caught	5,200	7,600
Total number of fish caught	93,300	111,400

Cutthroat and Dolly Varden were frequently caught while anglers were fishing for kokanee. Of the total catch of cutthroat and Dolly Varden, 22 percent and 14 percent respectively were taken in that manner. The catch of 7,600 trout from both lakes in 1956 was composed of 5,500 cutthroat, l,820 Dolly Varden, and 270 mackinaw.

The catch of cutthroat and Dolly Varden like the number of hours fished for those species was concentrated during the first half of the season (Figure 18). The catch of kokanee on the other hand was more evenly distributed through the season.

The distribution of the catch between areas of the lakes was also uneven (Figure 19). More than 45 percent of the kokanee were taken from the relatively small Area 3. Upper Priest Lake yielded nearly 35 percent of the cutthroat harvested, and Area 4 produced more than 40 percent of the Dolly Varden and mackinaw caught. Area 3 yielded more than 40 percent of the total game fish harvest while the catch from Area 1 constituted less than 5 percent. The 1956 catch from Priest and Upper Priest Lakes is presented in Table 22.

Table 22. Number of hours fished, kokanee caught, cutthroat caught, and Dolly Varden and mackinaw caught from Priest and Upper Priest Lakes during 1956.

	Priest Lake	Upper Priest Lake
Number of hours fished	96,630	7,270
Number of kokanee caught	102,360	1,620
Number of cutthroat caught	3,580	1,920
Number of Dolly Varden caught	1,590	240
Number of mackinaw caught[1]	270	---

[1]Mackinaw are not present in Upper Priest Lake.

Kokanee made up a large majority of the total catch of game fish, with cutthroat and Dolly Varden being next in line (Table 23).

Table 23. Percent effort expended for and percent of total catch of kokanee, cutthroat, and Dolly Varden and mackinaw during 1956.

Species	Percent of total effort	Percent of total catch
Kokanee	81	93
Cutthroat	10	5
Dolly Varden and mackinaw	9	2

During 1956, residents of Idaho expended approximately 23 percent of the effort and caught an equal percent of the fish. Conversely, non-residents expended 77 percent of the effort and caught 77 percent of the

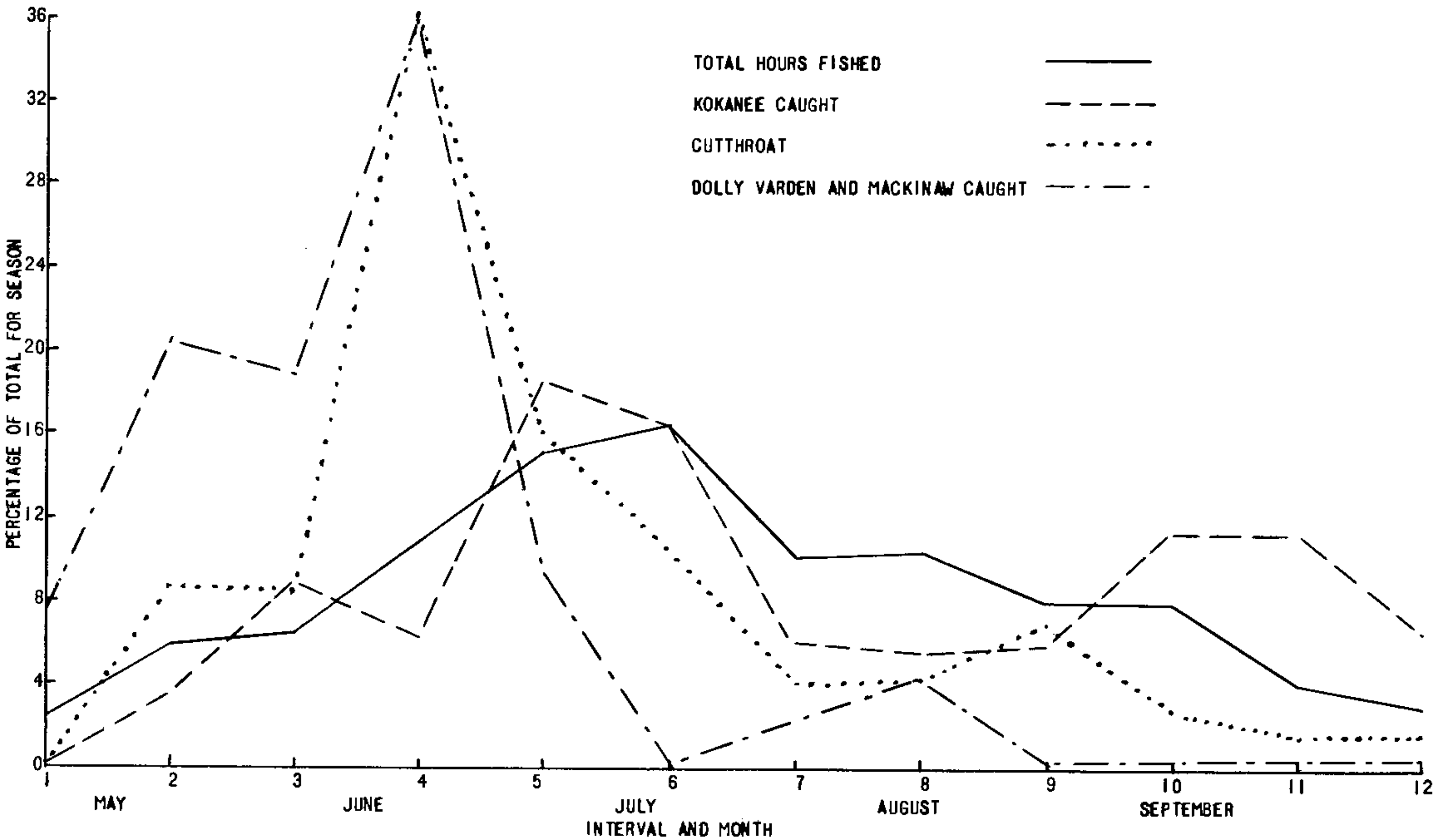


Figure 18. Percentage of the total hours expended, kokanee caught, cutthroat caught, and Dolly Varden and mackinaw caught from Priest and Upper Priest Lakes for each interval throughout census season (May 1 to October 15, 1956 inclusive).

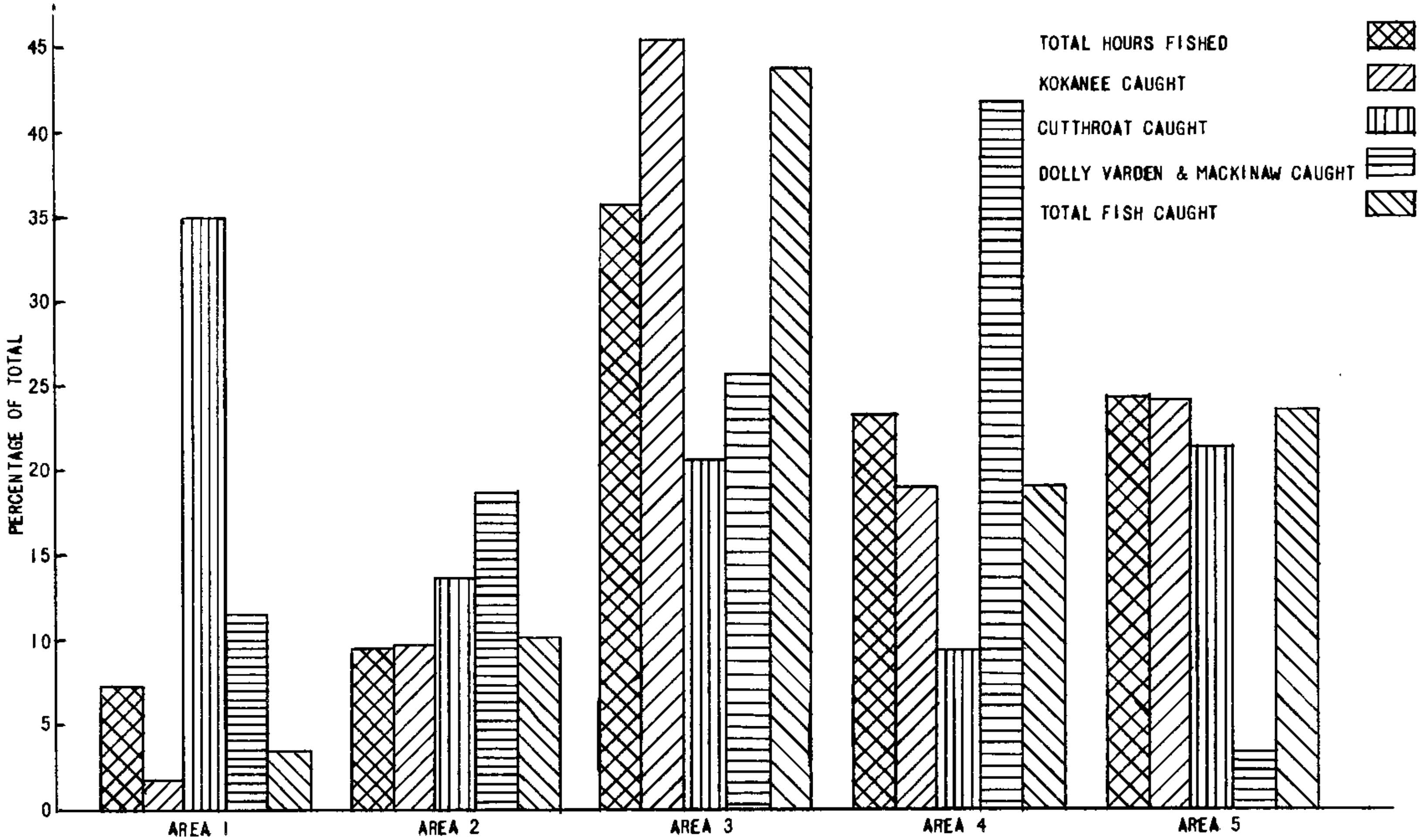


Figure 19. Percentages of total hours fished, kokanee caught, cutthroat caught, Dolly Varden and mackinaw caught, and total game fish caught from the various areas on Priest and Upper Priest Lakes for the 1956 season.

fish. The percent of resident fishermen on the lakes remained fairly constant throughout the season except for Interval 7 (Figure 20).

Of the total hours fished, anglers originating from private cabins on the lake expended 34 percent and non-cabin owner fishermen (fishermen staying at resorts or public camp grounds) fished for a total of 66 percent. The percentage of non-cabin owner fishermen as compared to cabin owner varied through the season (Figure 21). Early and late in the season, there was a larger percentage of cabin-owner fishermen, while non-cabin owner fishermen were most numerous from June through August.

Anglers seeking kokanee on Priest Lake fished on the average between three and four hours a day.

In 1956 the creel census was concluded on October 15. A small fishery for kokanee continued until approximately October 20, at which time the kokanee ceased biting. The rate of catch for Dolly Varden usually rises in November, however, very few people fish as the weather is cold and wet. Records of the fish caught and hours fished were kept by a cabin owner for the period of November 14 to 30, 1956. These records covered a group of five to seven parties who are probably above average fishermen as they have been fishing for Dolly Varden many years. In all, the group fished 227 hours and caught 54 Dolly Varden and 1 cutthroat. The resulting catch per hour per boat was 0.24 fish. It was observed that this group made up about half the number of boats fishing during November. Thus, it was estimated that an additional 200 Dolly Varden were taken during November, 1956.

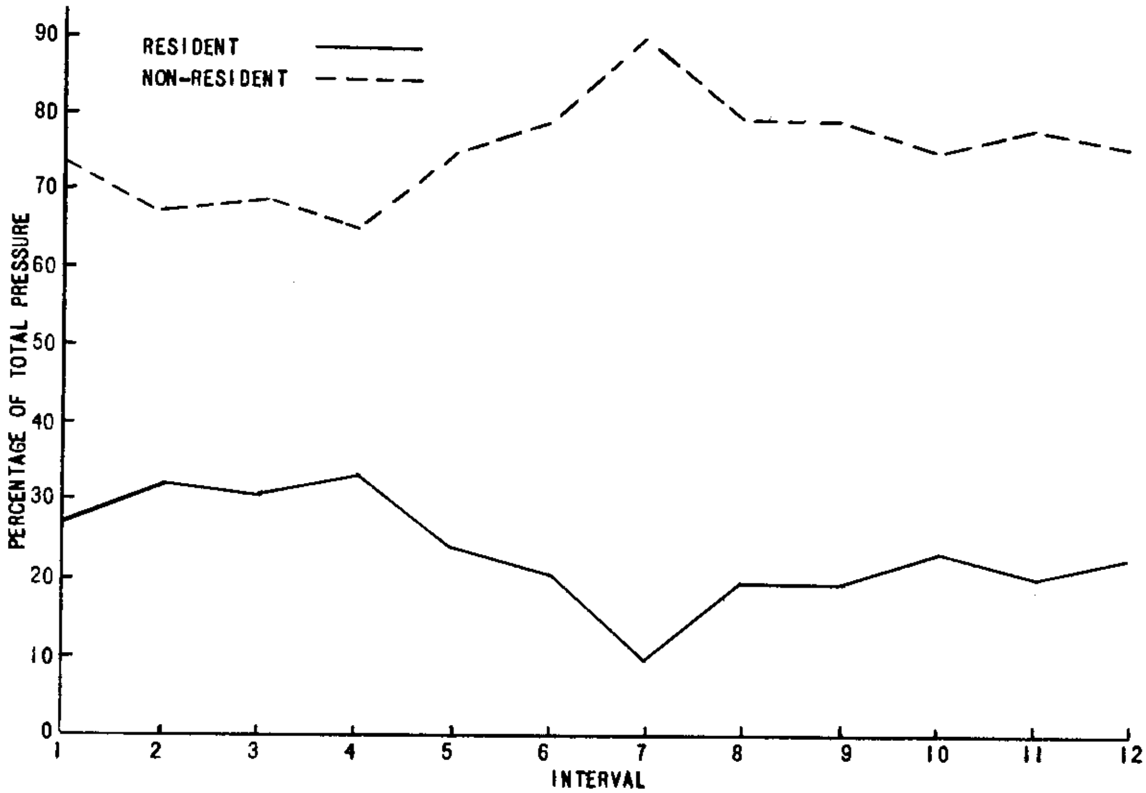


Figure 20. Percentage of total pressure expended by resident and non-resident fishermen at Priest and Upper Priest Lakes, 1956.

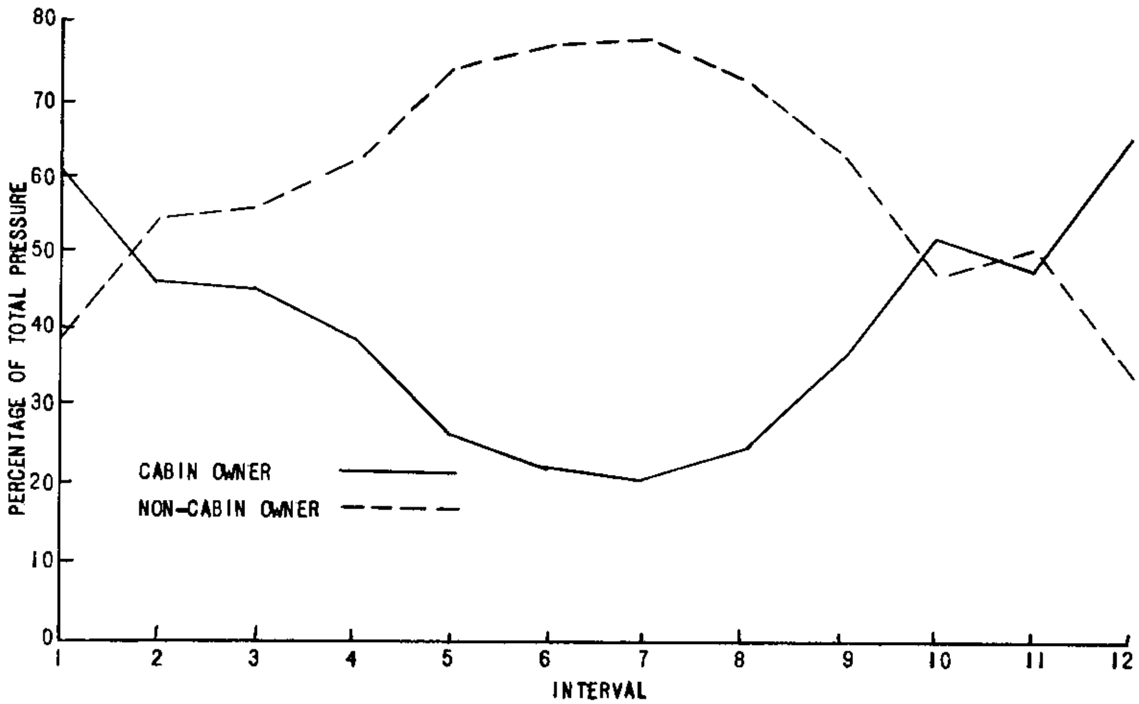


Figure 21. Percentage of total pressure expended by cabin-owner and non-cabin owner fishermen at Priest and Upper Priest Lakes, 1956.

RESULTS OF POPULATION AND LIFE HISTORY

STUDIES Methods Gill Netting

Experimental gill nets were used to determine the distribution and relative abundance of fish in Priest and Upper Priest Lakes. Sets were made on the bottom in both shallow and deep water, on the surface, and in midwater, using specially constructed floats for the two latter positions. The float consisted of 2 by it inch timbers joined together for a distance of approximately 140 feet. The float was then anchored at each end and an experimental gill net was secured to the float at five evenly spaced points with coils of rope, which were used to lower the nets to the desired depth. It was necessary for the float to be longer than the net so the net could be stretched straight in deep sets. The 2 by 4 float was fairly satisfactory in calm water but would break up in rough water when poor grades of lumber were used in its construction.

All game fish still alive when the net was lifted were released after being weighed and measured.

Collection and Analysis of Stomach Samples

Stomachs were collected from all of the major fish species in the lake in order to determine food habits and possible competition between species. All of the stomachs collected were recorded on a mimeographed form, numbered, wrapped in cheese cloth, and stored in formalin or alcohol until analysis at a later date. The analysis consisted of identifying the contents, measuring the volume of each major group, and calculating the percentage of each major group of organisms contained in the stomach.

Cutthroat, Dolly Varden, mackinaw, whitefish, and squawfish stomachs had to be collected whenever the opportunity presented itself. Kokanee stomachs were collected biweekly at the same time plankton samples were taken so as to provide a basis for comparison of food habits and food supply.

Collection and analysis of scale samples

As with the collection of stomach samples it was necessary to collect scale samples from the trout, char, and whitefish whenever the opportunity presented itself as these fish were not caught in appreciable numbers throughout the entire season.

A large number of scale samples were collected from kokanee of all age classes in the spring of the year before annulus formation and additional samples were collected throughout the season from fish which appeared to be sub-adults. These additional samples were collected in order to determine accurately the age of the smaller sized fish entering the catch.

All scale samples were taken from the left side of the fish between the dorsal fin and median line. All pertinent data for the particular specimen was recorded on the envelope containing the scale sample.

Three scales, selected for their uniform size, shape, and lack of regeneration, were cleaned and mounted on a glass slide in a glycerin--gelatin solution and projected on a ground glass screen where age was determined. In most instances the scales were read at least twice. The distance of each annulus from the focus was then recorded in order to facilitate further calculations which, when pertinent, will be described in later sections for each species.

Collection and analysis of lengths and weights

Because the average length and maturity of the fish caught can be used in some instances as a guide to population condition, an attempt was made to weigh and measure every cutthroat, Dolly Varden, and mackinaw observed in the catch during the 1956 season. Numerous lengths and weights were also taken from kokanee. Measurements of lengths of kokanee were made biweekly in an attempt to follow the yearly growth pattern. A sample of 200 to 300 lengths was usually sufficient to obtain an accurate estimate of the average length as the variation is relatively small when only fish of the same year class are combined. Kokanee in their third and fourth years of life generally did not enter the catch in large numbers, therefore, no special effort was made to obtain adequate length samples for those year classes.

All length measurements recorded were total lengths with only enough measurements of fork and standard lengths collected to compute conversion factors.

Species of Fish Cutthroat

Past History and Present Status of Fishery. Information concerning the quality of fishing on Priest and Upper Priest Lakes in years past can only be obtained from long-time residents and fishermen of the area. After weighing many of the tales and stories of cutthroat fishing in the "good old days" one must conclude that the fishing was comparatively good, especially in the spring and early summer. The rate of catch dropped off in the middle of the summer and picked up slightly again in the fall as the lake waters cooled.

Although there are some differences of opinion as to when the quality of the fishing began to deteriorate, local residents and anglers agree that a definite decline in the number of cutthroat in the lakes has taken place. In an attempt to determine if a decline had actually occurred, comparisons of rate of success, average size of fish entering catch, and maturity of fish entering the catch were made. Estimates of the total catch of cutthroat for years prior to 1955 do not exist so that a comparison of total harvest is impossible. For the same reasons, comparisons of the rate of success between years past and the present can only be made on a very general basis. Limit catches of cutthroat were reportedly commonplace back before the 1930's. At the present time limit catches (15 fish per day) are very rare occurrences. It is possible that there is an equal or larger number of fish being caught annually at present as in years past, but with the number distributed among a larger number of fishermen, thus reducing the rate of success. That the number of fishermen on the lake has increased is not questioned.

The smaller average size and larger proportion of immature cutthroat entering the catch indicates that the lake populations are not in a healthy condition. Studies at Henry's Lake in Idaho and at Yellowstone Lake indicate that the harvest of fish from a healthy population contains substantial numbers of mature adult fish capable of spawning the same year (Cope, 1953; Andriano, 1955). The various stories of fishing in the "good old days" are all woven around *the* "red belly" cutthroat spawners, thus leading to the belief that many of the fish caught in yesteryears were mature spawners 13-15 inches in length. If this were the case, the cutthroat populations in Priest and Upper Priest Lakes were in good condition at one time.

The average size cutthroat entering the creel in 1956 from Priest Lake was 11.l inches in length. In Yellowstone Lake where cutthroat mature at approximately the same length as Priest Lake fish (12-16 inches total length), the average size fish taken in 1952 was 13.3 inches (Cope, 1953). The catch from Yellowstone Lake also contained a large portion of mature fish while the catch from Priest Lake contained very few mature fish.

There was a marked difference in the size of fish taken before and after July 1 during the 1956 season (Table 21). The difference was probably due to a harvest of the larger individuals early in the season and to an influx of small (6 to 8 inches) fish from the tributaries with the spring runoff.

Table 24. Average total length (inches) of cutthroat caught from Priest and Upper Priest Lakes during the 1956 season.

Lake	Entire season catch		Before July 1		After July 1	
	Number	Mean size	Number	Mean Size	Number	Mean Size
Priest Lake	102	11.1	69	11.4	33	10.5
Upper Priest Lake	131	11.2	79	11.8	52	10.3

Observations indicating a decline in the number of spawners entering the tributaries also points to a decline in the number of cutthroat in the lakes. The number of cutthroat entering Granite Creek and Gold Creek was large enough to support spawn taking operations during the late 1930's and the 1940's. During the spring of 1947, the last year spawn was collected at Priest Lake, 1,660 spawners were caught at the Granite Creek trap, located approximately six miles up from the lake. Because the trap is located a considerable distance from the lake, the figure of I,660 fish does not represent the total run of fish into Granite Creek, It does indicate, however, that a fair sized number of fish were spawning in Granite Creek as late as 1947. During the spring of 1956 numerous attempts were made to collect spawners in Granite Creek with a hook and line. The net result being approximately a dozen fish. With the exception of one fish, all of the spawners taken were captured within two miles of the lake. No spawners were observed in the vicinity of the Granite Creek fish trap at any time during the year.

The fact that no cutthroat spawners were caught or seen near the Granite Creek trap is certainly not conclusive evidence that the numbers have declined; however, if as many as I,600 fish were migrating upstream as far as the Granite Creek trap, one would certainly expect to see or catch a few of them. The most reliable indicators of a decline in the quality of cutthroat fishing at Priest Lake are the smaller size and larger proportion of immature fish in the catch.

One factor that must be pointed out is the change in fishing habits of Priest Lake anglers brought about by change in fishing regulations. Around the 1900's there were no regulations stating when or where anglers could fish. After a time, the tributary streams were closed to protect the spawning fish, however, the closure was not too effective, as a great deal of poaching occurred. Also, anglers were still allowed to fish at the mouths of the streams, so that the spawners were subjected to a sizeable amount of fishing mortality. Restrictions on fishing continued to evolve until at the present time the streams and their mouths, for a radius of 300 feet, are closed to fishing during the spawning seasons. These changes in the areas in which anglers are allowed to fish has undoubtedly had its effect on the rate of success. There is no question but what the fishing success would be higher if people were allowed to fish where and when the spawners were concentrated.

At the present time, cutthroat rank second to the kokanee in the numbers of fish caught. During 1956, approximately 10 percent of the total effort was expended to catch cutthroat which made up approximately 5 percent of the total catch.

The cutthroat is the only game fish in Priest Lake that can be taken readily on a fly. Much of the present effort expended to take cutthroat is by fly fishermen. These anglers are the most seriously affected by the decline in cutthroat numbers.

Age and Growth. The body-scale relationship of cutthroat from Priest and Upper Priest Lakes appears to be approximately linear (Figures 22 and 23). Because juvenile cutthroat in the Priest Lake drainage stay in the streams for 2 or 3 years before migrating to the lake, it was necessary to include both lake fish and fish from the lower portions of the tributaries when computing the body-scale regression.

Upon inspection of Figures 22 and 23 it appears that the scale has a tendency to grow faster than the body after the fish attains a size of

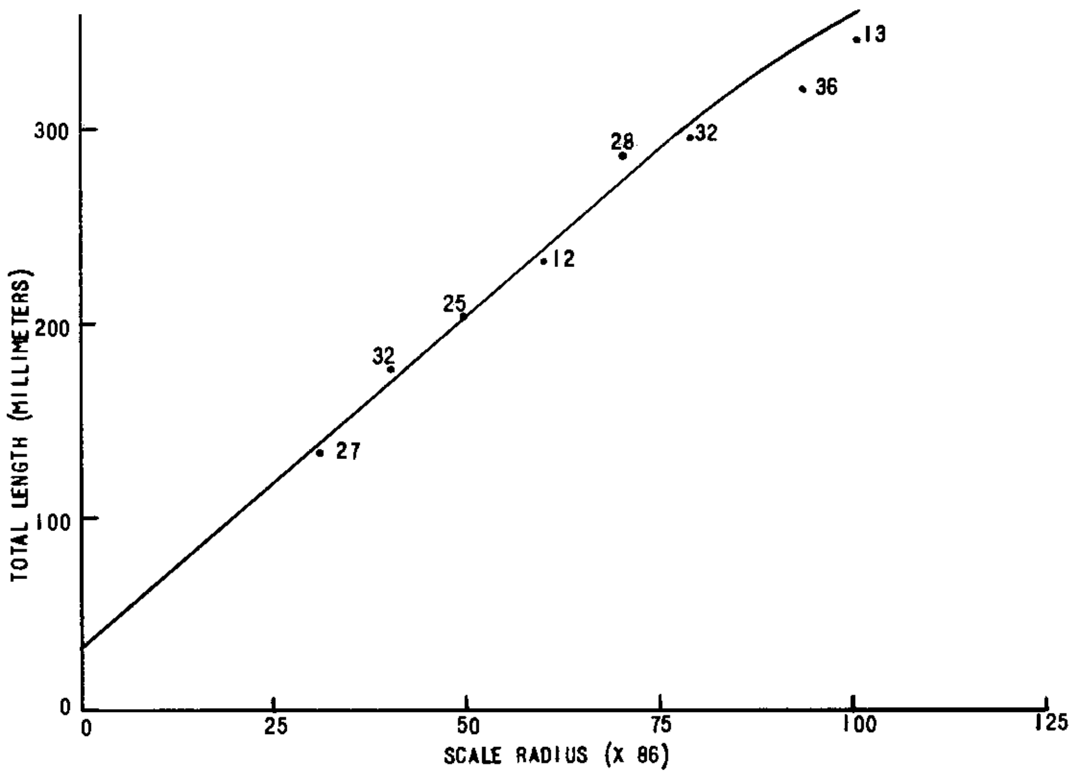


Figure 22. Body-scale relationship of cutthroat trout from Upper Priest Lake and its tributaries. Regression line fitted by inspection.

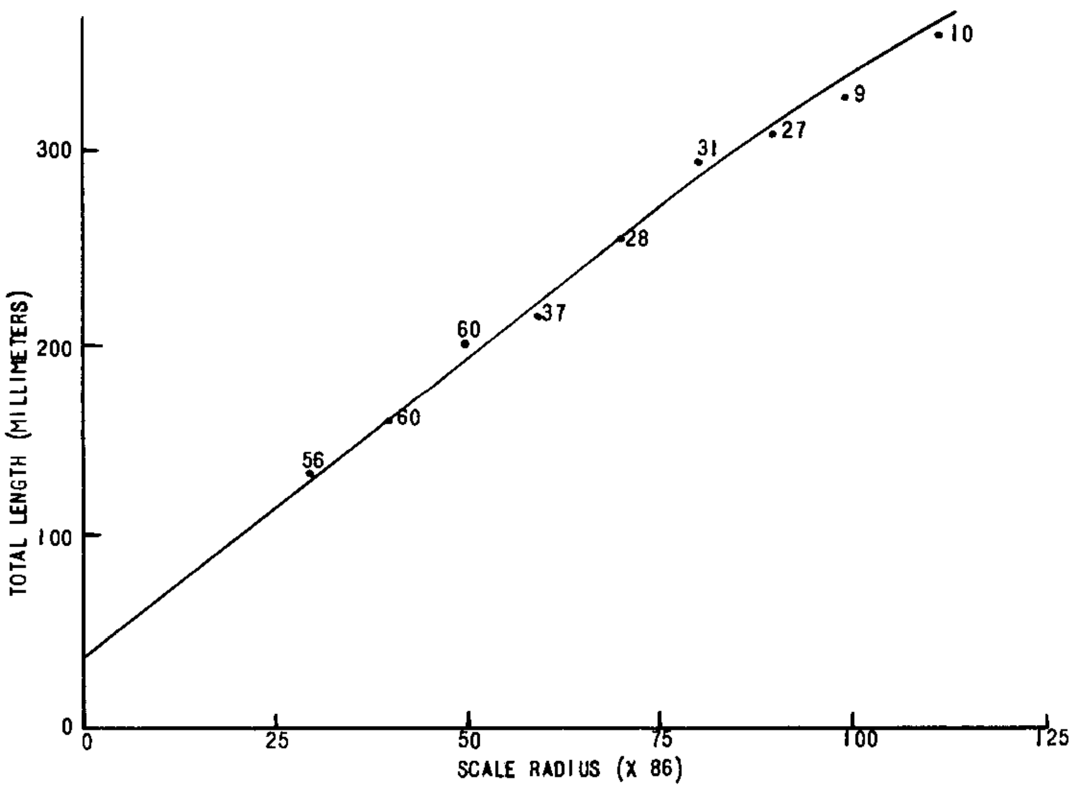


Figure 23. Body-scale relationship of cutthroat trout from Priest Lake and its tributaries. Regression line fitted by inspection.

300 millimeters or more. However, because of the small number of observations in the upper length groups this relationship cannot be accepted without some reservation.

Since the body-scale relationship might have been slightly curvilinear, it was necessary to determine whether the error obtained from calculations of body lengths based on the absolute size of the scale (regression method) would be greater than the variation obtained when based on the proportionate size of the scale. Whitney and Carlander (1956) concluded that

> "Scales from a yellow bass indicated that the variance of body lengths estimated from proportionate growth of scales were much less than those for length estimated from absolute scale size."

They also stated that

> "The use of the regression method without the correction or " normalization" of scale size may be quite satisfactory where the body-scale relationship has been adequately described and where samples are fairly large."

Because there was a large degree of variability in the size of the cutthroat scales from the Priest Lake drainage and because the samples were fairly small, especially in the larger length group, it was decided to base all calculations on the assumption that the body-scale relationship was linear. Since body lengths estimated from the proportionate size of the scale were less variable than those based on the absolute size of the scale, the following formula was used

$$La = a + \frac{SRa}{SRc}(TL - a)$$

La = computed length at annulus
TL = total length at capture
a = constant = length of fish at time of annulus formation
SRa = radius of scale at annulus
SRc = radius of scale at capture

The length of cutthroat at the time of scale formation varies with different waters. Laakso and cope (1956) found that cutthroat in Yellow-stone Lake formed scales when the fish had reached a length of between 41 to 44 millimeters. The size of Priest Lake fish at time of scale formation was not determined empirically. Since the intercept for both the Priest Lake and Upper Priest Lake body-scale regression lines approximated 35 millimeters, this value was assumed to be the length of the fish at time of scale formation. Admittedly this value may be in error. An error, however, if present, is probably quite small. With 35 millimeters as the assumed average length attained by cutthroat trout in the Priest Lake drainage at the time of scale formation, the proportion formula becomes

$$La = 35 \text{ millimeters} + \frac{SLa}{SLc}(TL - 35 \text{ millimeters})$$

Cutthroat in the Priest Lake drainage were found to spend one to four years in the streams before entering the lakes. The scales of Priest Lake and Upper Priest Lake cutthroat resemble somewhat the scales of sea run fish which spend two or three years in fresh water before migrating to the ocean (Appendix IV; Plate 8).

Once it appeared possible that cutthroat from Priest and Upper Priest Lakes might have the "unusual" trait of staying in the nursery streams for two or three years before migrating to the lake, it became necessary to form a guide for determining when a fish had entered the lake. The pattern of growth for fish which enter the lake during their first summer differs markedly from fish entering the lake after spending more than a year in the streams.

> "The rate of growth in length of Henry's Lake cutthroat trout is most rapid during its first and second years of life, declines rapidly during its third and fourth years when maturity is attained and then tapers off gradually during its fifth and sixth years of life." (Irving, 1954)

The period of most rapid growth for Priest and Upper Priest Lake cutthroat varies according to the number of years spent in the stream before entering the lake. The length increment is largest during the first year the fish spends in the lake. If the fish enters the lake at the beginning of its third year, then the third year of life is the period of most rapid growth. If the fish enters the lake at the beginning of its fourth year, then the fourth year is the most rapid period of growth (Figure 24).

In addition to the scale studies, data collected in the creel census and stream survey sections of the investigation also supported the conclusions that Priest and Upper Priest Lake cutthroat remain in the nursery streams for extended periods of time before entering the lakes. Nearly all fish taken in the streams were immature and less than three years old. Also, the smallest fish recorded in the catch from the lakes was approximately seven inches in length, the approximate length usually attained before entering the lake.

In Priest Lake, fish entering the lake after two, three, and four years in the tributaries grew in length during their first year in the lake 124, 105, and 113[1] millimeters respectively. The longer the fish stayed in the streams, the smaller the amount of growth during the first year of lake residence.

This value represents the growth increment of only one fish and therefore is not too reliable. As can be seen in Appendix III, Table 3, the average length of fish at the end of their fourth year of life (five fish) is 222 millimeters, when this value is subtracted from the length at the end of their fifth year of life, the increment is only 88 millimeters. It is felt that this smaller increment of growth more nearly represents the actual amount added during their first year in the lake after spending the first four in the streams.

Because the growth rate varied tremendously in any given year depending upon when the fish had entered the lake, it became necessary to separate the fish, for calculation of body lengths, into homogenous groups according to the number of years spent in the streams. Scales indicated that approximately the same percentages of fish were entering Priest Lake as were entering Upper Priest Lake after spending two and three years in the streams (Table 25).

Table 25. The percentages of cutthroat caught during 1956 that had entered Priest and Upper Priest Lakes after having spent one to four years in the nursery streams.

Years spent in stream before entering lake	Percent entering Priest Lake	Percent entering Upper Priest Lake
1	negligible	6
2	38	35
3	57	58
4	5	negligible

The total length attained by cutthroat in Priest and Upper Priest Lakes at various ages depends upon the number of years spent in the streams before entering the lake. Figures 25 and 26 show the lengths attained at various ages when the fish have spent from one to four years in the streams before entering the lake.

The calculated lengths and increments of growth for lake fish and stream fish are presented in table form in Appendix III.

In Table 26 are presented the average lengths of fish the same age which had migrated to the lake after differing amounts of time in the stream.

Table 26. Average length of three and four year old cutthroat in Priest and Upper Priest Lakes, one to four years in streams.

Years spent in stream	Length of three year old fish from Upper Lake (inches)	Length of four year old fish from Priest Lake (inches)
1	12.2	----
2	10.2	13.3
3	5.8	11.1
4	----	8.7

The growth rate of cutthroat differed markedly between streams (Figures 27, 28, and 29). That portion of Hughes Fork which runs through the meadow appeared to have the fastest rate of growth.

There were some questions as what portion of the scales from Priest and Upper Priest Lake cutthroat were of the retarded type. Delay in the formation of the first annulus until the fish's second winter is fairly

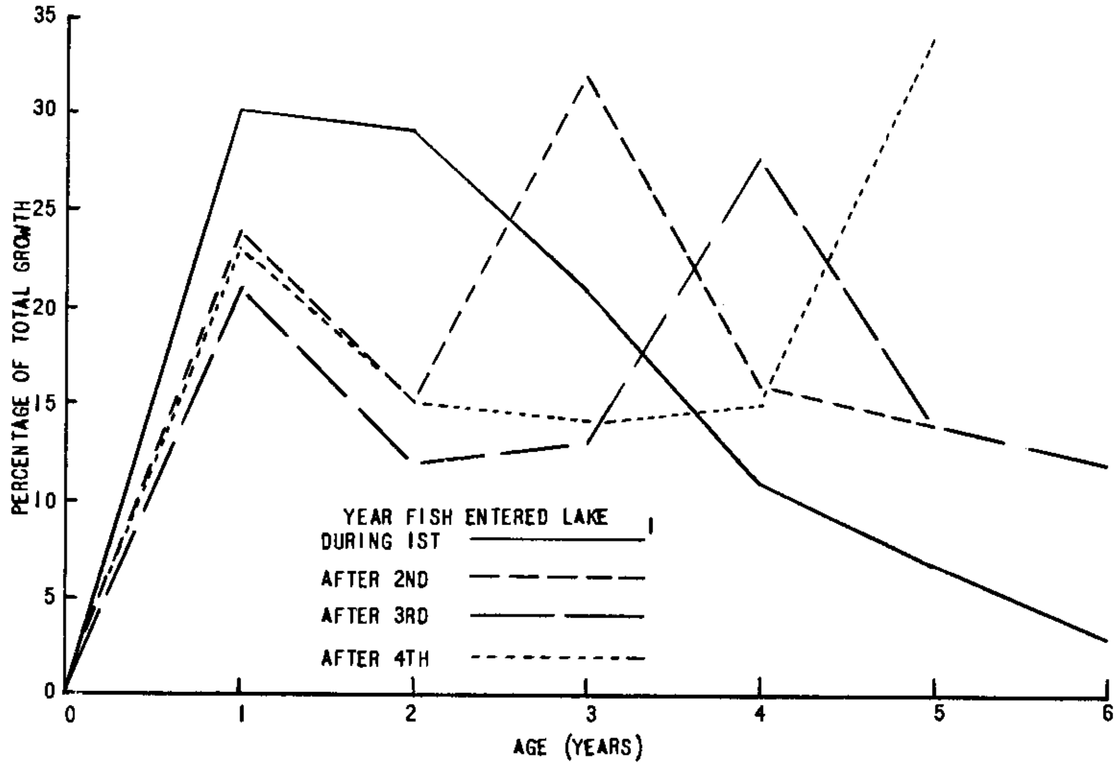


Figure 24. Percentage of growth occurring during various years of life for Priest Lake cutthroat entering the lake after spending differing amounts of time in tributary streams.

[1]Henry's Lake Cutthroat (Irving, 1954)

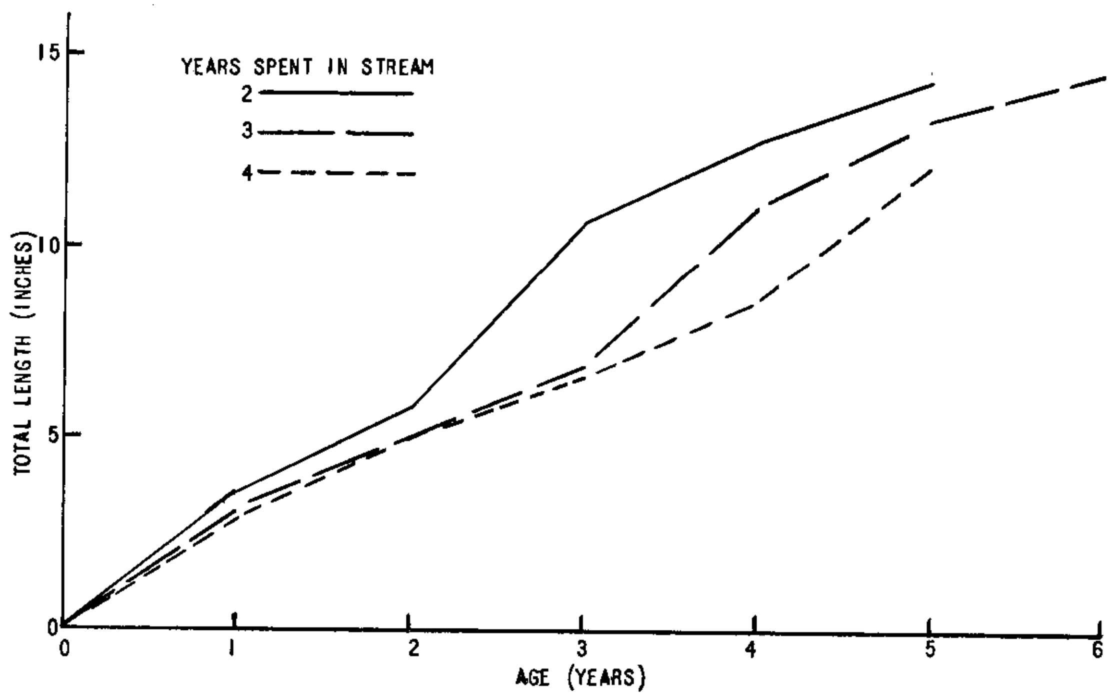


Figure 25. Length of cutthroat trout from Priest Lake at various ages after remaining in nursery streams two to four years before entering lake.

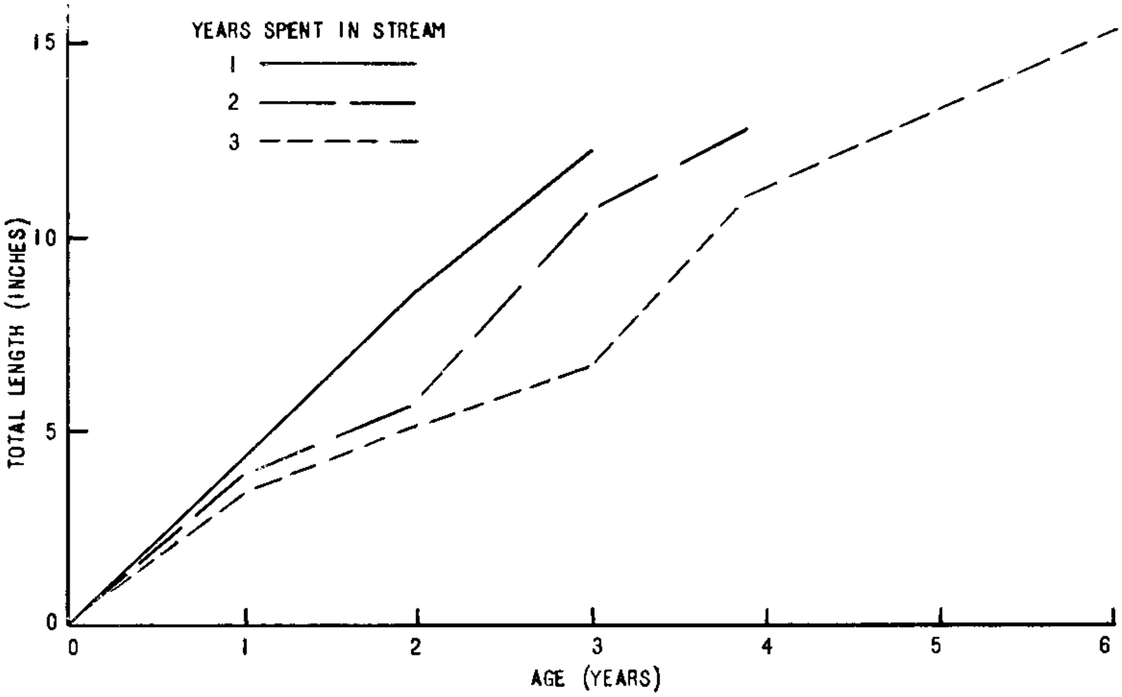


Figure 26. Length of cutthroat from Upper Priest Lake at various ages after remaining in nursery streams one to three years before entering lake.

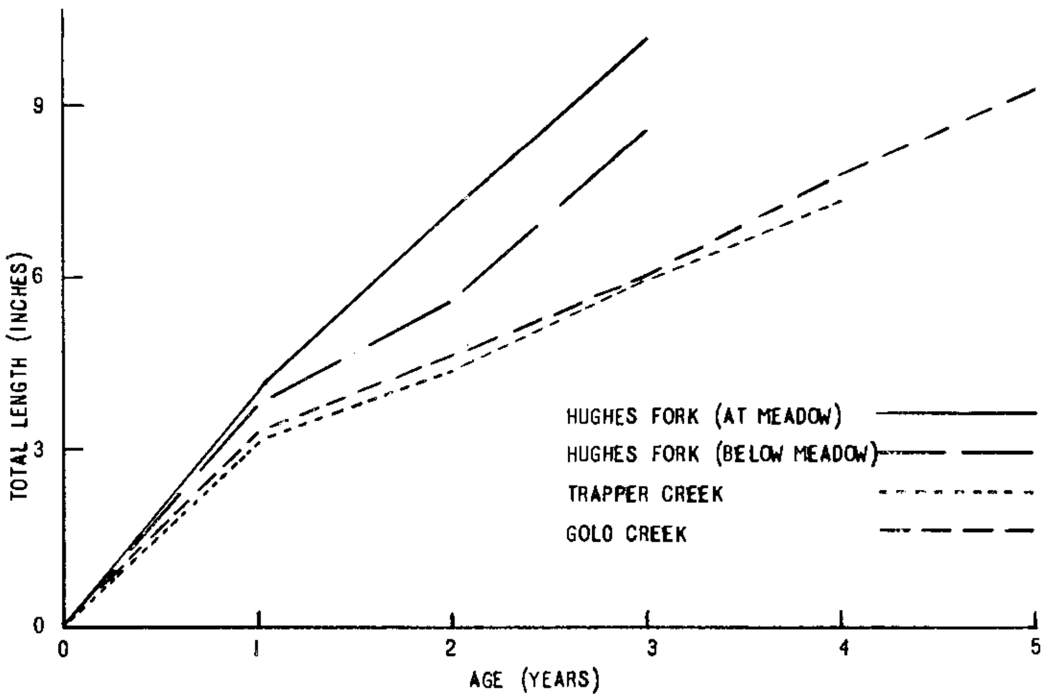


Figure 27. Age and length relationship for cutthroat from various streams entering Upper Priest Lake.

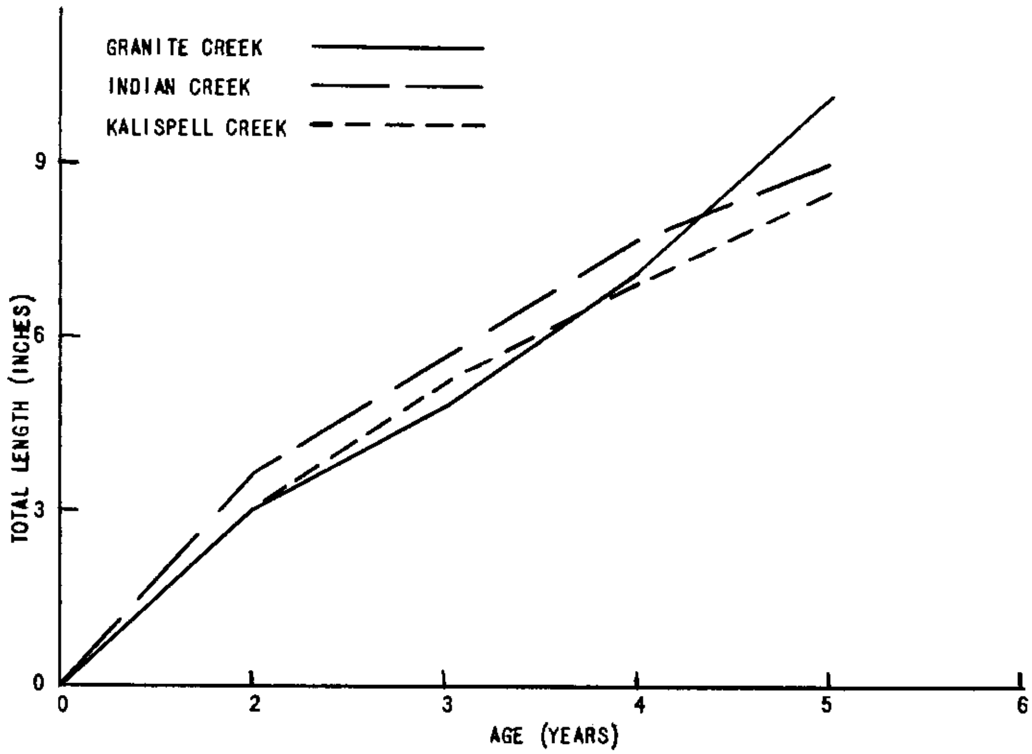


Figure 28. Age and length relationship for cutthroat from various streams entering Priest Lake.

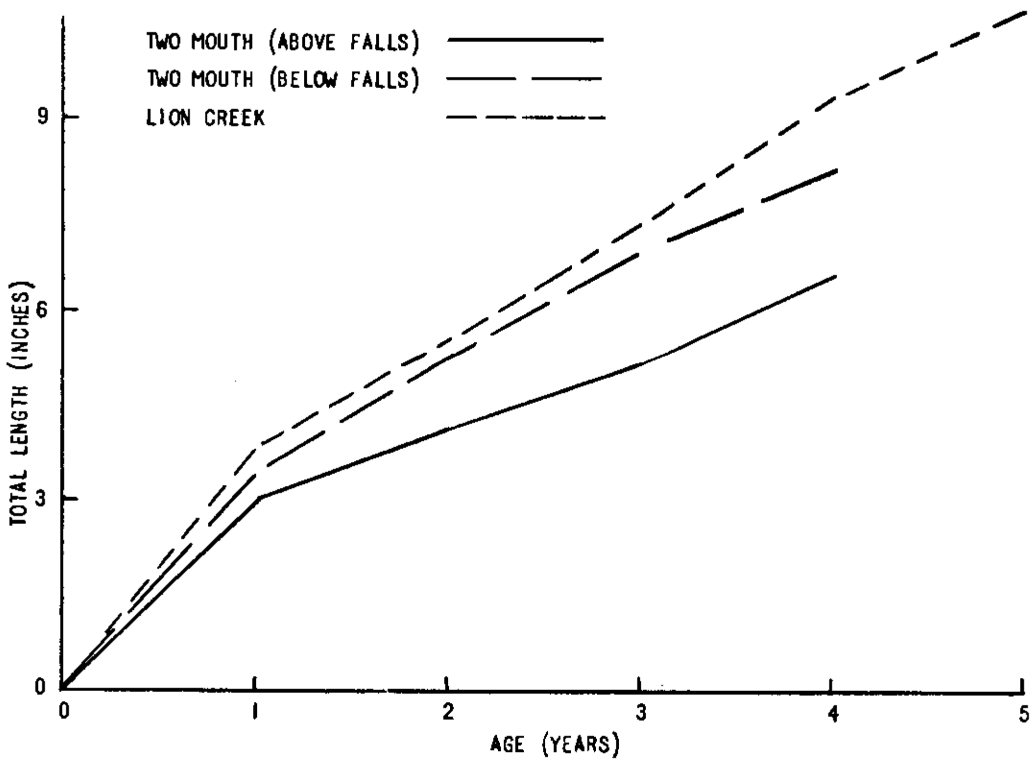


Figure 29. Age and length relationship for cutthroat from various streams entering Priest Lake.

common in some of the colder bodies of water with short growing seasons, Laakso and Cope (1956) reported that as many as half the cutthroat in some year classes in Yellowstone Lake had retarded scales. One reason for the high percent of retarded scales in the Yellowstone fish is the prolonged spawning season which lasts until the end of July. The criteria described by Laakso and Cope for distinguishing a retarded from a normal scale was not applicable to the Priest Lake fish because of the large variation in the amount of growth exhibited in the different streams. Although there are undoubtedly some fish with retarded scales in the Priest Lake Drainage, the number appeared to be insignificant. The fact that the spawning season for lake fish is generally over before July l, and the fact that stream temperatures remain high enough to sustain good growth through the month of September, leads to the belief that most of the cutthroat resulting from lake resident spawners have formed a sufficient number of circuli to facilitate annulus formation during their first winter.

The length-weight relationship of Priest Lake cutthroat is presented in Figure 30.

Reproductive Habits and Requirements. The cutthroat spawning season in Priest Lake apparently begins in April and generally ends by the middle of June. Cutthroat spawning in Upper Priest Lake appears to lag behind the Priest Lake spawning by about two or three weeks. Fish caught in the tributaries to Priest Lake after June 15 were all spent fish, while most of the fish caught between June 15 to July 1 in the Upper Priest Lake tributaries (especially Hughes Fork) were still gravid. Granite Creek spawn taking records for 1916 and 1917 indicate that nearly all of the fish had ripened and had been stripped by June 15.

Henry's Lake cutthroat also have a relatively short spawning season, usually beginning in late March or early April, reaching a peak shortly after breakup of the ice cover in mid-May, and then declining rapidly until by June 1 very few fish are entering the streams (Irving, 1954)6 According to Laakso and Cope (1956), "Cutthroat trout in Yellowstone Lake ascend spawning streams from May to late July," thus exhibiting a prolonged spawning season. Yellowstone cutthroat fry emerge from the gravel from late June to early September.

In Priest Lake the time required for eggs to hatch and fry to develop sufficiently to emerge from the gravel varies with the different tributaries because of temperature differences. In some tributaries the maximum water temperature never exceeds 55° F. while in others temperatures of 70° F. are common. Field observations indicate that most of the fry emerged by August 15. The resident populations of cutthroat which exist in many streams make it impossible to determine which fry are the result of spawners from the lake and which are the result of stream residents.

Cutthroat in Priest and Upper Priest Lakes matured at five years of age predominantly, with some fish also maturing at three, four, and six years of age. The stream's resident populations matured mostly at four years of age, with some fish maturing at three and five years of age, In Henry's Lake, male cutthroat matured as young as two years of age,

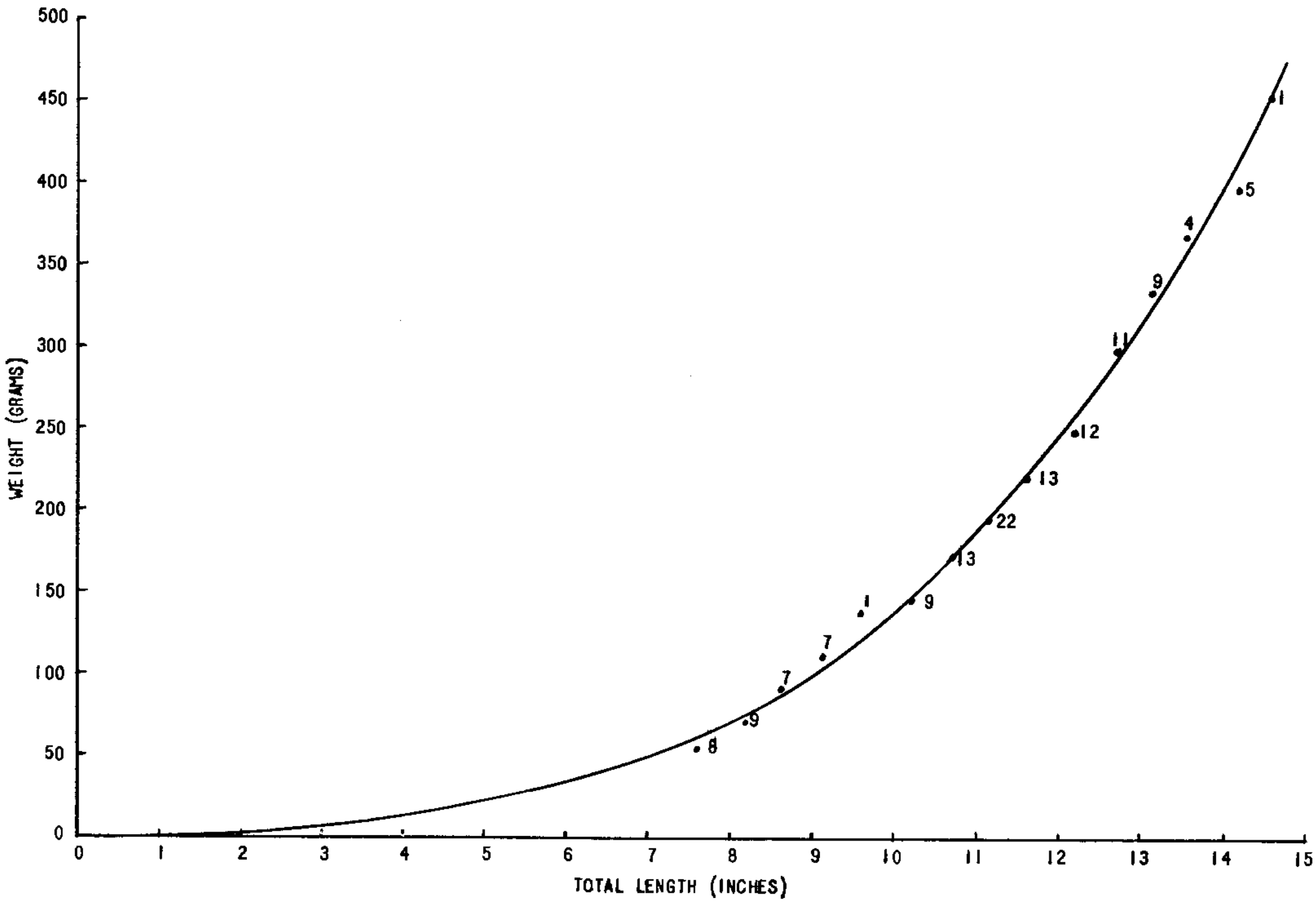


Figure 30. Length-weight relationship of cutthroat trout in Priest Lake, 1956. Regression line fitted by inspection.

however, females *did* not mature until their third year of life. The large majority of the spawning populations was composed of three and four year old fish (Andriano, 1955). In Yellowstone Lake, age class IV fish make up the biggest group of spawners.[1]

The sex ratio of spawning cutthroat from Priest Lake has been noted because of the apparently much larger number of females than males. During the years spawn was collected, spawn takers noted a shortage of males, as in 1947, when 1,410 females and 250 males were captured at the Granite Creek trap. The sex ratio of lake fish in the sport catch was also unbalanced as males made up 43 percent and females 57 percent of the catch from Upper Priest Lake while the Priest Lake catch was composed of 36 percent males and 64 percent females. Although the number of observations of fish in the sport catch is relatively small, the figures do indicate that an unbalanced sex ratio still exists.

The sex ratio of resident stream fish populations appears to be just the opposite of the lake fish. Small (6 to 10 inch) mature male cutthroat far outnumbered the mature stream resident females taken while on the stream survey. A possible explanation for the larger number of stream resident males may be found in the unusual life cycle of the lake fish. Age and growth studies supported by observations made during stream surveys revealed that the most of the cutthroat spawned from lake fish stay in the stream from one to four years before entering the lake; the large majority staying two or three years. Because male cutthroat often mature a year earlier than females it is concluded that many of the male fish mature in their third year of life and therefore remain in the tributaries to participate in spawning activities while the immature males and females migrate to the lake.

The growth rate of fish in the lake is much faster than that found in the streams, and consequently, males which have matured in the streams may reach a size of only 6 to 10 inches, while males maturing in the lake are usually 12 to 16 inches in length. The smaller number of males collected at the fish traps might then be explained as follows. The spaces between pickets of the trap were of such a size that only the larger fish would be barred from movement upstream. Thus the small stream matured males could pass between the pickets and consequently would not be captured. Only the large males from the lake would be captured in the fish trap. This being the case, there would be both the large males from the lakes and the smaller males from the streams present to service the female spawner.

It may be possible then, that a shortage of males does not exist under natural conditions.

Cutthroat require well aerated gravel beds for spawning. The more than 20 tributaries entering Priest and Upper Priest Lakes provide ample spawning area. The natural falls and numerous log jams present on some tributaries are the only major factors capable of retarding the successful spawning of cutthroat in the Priest Lake Drainage.

1-Personal correspondence to author from Dr. Oliver B. Cope. Chief, Rocky Mountain Investigation, Logan, Utah.

Food Habits. The diet of cutthroat in Priest and Upper Priest Lakes and their tributaries is composed chiefly of insects. The most striking observation was the complete absence of fish in the cutthroat diet, especially since the lake contains a great variety and abundance of forage fish.

The food habits of cutthroat while in the streams varies depending on the form that is most abundant at the particular time (Tables 27 and 28). The diet of lake resident cutthroat illustrates their shoal dwelling habits, with the order Coleoptera being the dominant form (Tables 29 and 30). Plankters (Leptodora mainly) are taken only infrequently. The large percentages of hymenoptera taken are the result of a tremendous hatch of flying ants which takes place each spring.

Table 27. Stomach contents of 10 cutthroat taken from Granite Creek, 1956.

Organism	Occurrence	Amount milliliters	Average amount milliliters	Percent volume
Trichoptera	9	30.8	3.42	71.0
Coleoptera	6	1.9	0.32	4.4
Diptera	4	0.3	0.08	0.7
Orthoptera	1	0.3	0.30	0.7
Plecoptera	7	4.7	0.67	10.8
Unidentified insects	6	4.8	0.80	11.1
Annelida	1	0.1	0.10	0.2
Fish eggs	2	0.4	0.20	0.9
Plant	2	0.1	0.05	0.2

Table 28. Stomach contents of 7 cutthroat taken from Beaver Creek, 1956.

Organism	Occurrence	Amount milliliters	Average amount milliliters	Percent volume
Trichoptera	5	2.1	0.42	21.4
Coleoptera	4	0.7	0.18	7.1
Plecoptera	2	0.9	0.45	9.2
Ephemenoptera	6	1.1	0.18	11.2
Hymenoptera	5	4.7	0.94	48.0
Hemiptera	1	0.2	0.20	2.0
Unidentified insects	1	0.1	0.10	1.0
Empty	1			

Table 29. Stomach contents of 29 cutthroat trout caught from Priest Lake, 1956.

Organism	Occurrence	Amount milliliters	Average amount milliliters	Percent volume
Trichoptera	1	0.1	0.10	0.2
Coleoptera	19	37.1	1.95	65.0
Diptera	11	4.3	0.39	7.5
Hymenoptera	15	7.2	0.48	12.6
Orthoptera	2	1.0	0.50	0.2
Lepidoptera	1	tr	--	--
Hemiptera	3	0.2	0.07	0.3
Ephemeroptera	3	0.4	0.13	0.7
Unidentified insects	4	3.5	0.85	6.1
Arachnoidea	5	0.7	0.14	1.2
Annelida	1	1.3	1.30	2.3
Plankters (Leptodora)	1	0.2	0.20	0.3
Fish eggs	1	tr	--	--
Unidentified plant	3	1.3	0.43	2.3
Empty	1	--	--	--

Table 30. Stomach contents of 24 cutthroat trout caught in Upper Priest Lake, 1956.

Organism	Occurrence	Amount milliliters	Average amount milliliters	Percent volume
Coleoptera	17	33.3	1.96	52.0
Hymenoptera	14	24.8	1.77	38.7
Hemiptera	5	0.4	0.08	0.6
Diptera	6	1.2	0.20	2.0
Odonata	1	0.3	0.30	0.5
Ephemeroptera	1	0.1	0.10	0.1
Orthoptera	2	1.2	0.60	2.0
Unidentified insects	3	2.3	0.77	4.0
Plankton	1	tr	tr	--
Unidentified plant	3	0.5	0.17	0.7

Factors Contributing to the Decline of the Cutthroat. Probably no single factor alone is responsible for the decline in the size of the cutthroat trout populations in Priest and Upper Priest Lakes. A combination of many factors and circumstances have led to the low numbers present. Before any steps can be taken to attempt to restore cutthroat fishing to its previously high quality, all of the possible causative factors must be evaluated to determine which factors have had the most effect. It must be determined if the factors causing the decline might be altered in order to effect an increase in production.

Of the many factors which could have contributed to the decline of the cutthroat, spawn taking is the most widely publicized. Sportsmen believe this to be one of the chief causes of the decline. Certainly if the taking of spawn and subsequent reduction in the numbers of fry produced for the lakes through mortality and shipment of eggs to other areas has had an effect on the numbers of cutthroat in the lakes it must be considered as detrimental. During the years spawn was collected at Granite Creek, approximately 30 percent of the eggs taken were consigned to waters other than those of the Priest Lake drainage. Even though many thousands of fry and fingerlings have been stocked in the drainage since the last year of spawn taking these fish may not have been able to replace the losses resulting from the spawn taking operations. During some years, sportsmen reported that the care of spawners at the fish trap was poor and resulted in the death of many stripped fish. Contrary to popular belief however, this mortality had little effect on the number of spawners in subsequent years as only a very small percent of the cutthroat in the Priest Lakes live to spawn a second time. A large mortality of cutthroat at the fish trap any one year would, however, reduce to some extent the number of fish available to the fishery that same year.

Another condition contributing to the decline of the cutthroat, probably more so than spawn taking was the unrestricted and often times illegal fishing that took place on the tributaries and at the mouths of the tributaries. At one time, fishing was permitted on the spawning streams and at their mouths. Even after laws were enacted making it illegal to fish in these areas, a large amount of poaching occurred, making the laws ineffective. Probably the worst effect of fishing on the spawning streams and at their mouths was the fact that spawners were generally taken before they had a chance to deposit their eggs. In this respect not only was the spawner lost but also the potential progeny.

The author believes that intraspecific and interspecific competition was and still is a factor contributing to the decline.[1] The most successful trout producing lakes are bodies of water with a very limited number of species of fish present. Before the introduction of exotic species, cutthroat in Priest and Upper Priest Lakes had to compete with a number of native fish, including the Dolly Varden, white fish, squawfish, Columbia River chub, and suckers. It is not known for sure if the redside shiner was a native or introduced species. Between 1900 and 1944, six additional game fish have been introduced with varying success. The bass and sunfish are abundant only in the shallow weedy shoals and bays. The rainbow has apparently not survived in any numbers in the Priest Lakes. Two chars, the mackinaw and brook trout, have been introduced with relative success. The kokanee, first introduced in 1942, 1943, and 1944, has prospered very well in the lake,

[1]Competition for food and space is difficult, if possible, to verify in the field. Usually, the assumption that competition within or between species is present is based not upon proof of competition but upon such circumstances as similar food habits or such correlations as the decline of a native species after the introduction of another species. The discussions of competition presented in this paper are based upon similar situations, correlations, and what appears to the author to be logical thinking.

Competition between cutthroat produced for the lake fishery and the other species takes place in both the streams and the lakes. Because juvenile cutthroat remain in the streams for two or three years before migrating to the lake, probably the most significant amount of competition takes place in the streams. Whether or not Priest and Upper Priest Lake cutthroat have always remained in the streams for extended periods of time before migrating to the lake is quite debatable. It is doubtful any changes in the environment have occurred of sufficient magnitude to bring about such a change in the life history of the species, so it has been assumed that the fish have always spent an unusually long time in the streams. This tendency of Priest and Upper Priest Lake cutthroat to stay in the streams for extended periods of time has been termed unusual, as cutthroat from both Yellowstone' and Henry's Lakes (Irving, 1954) enter the lake predominantly during their first year of life. It is felt by the author that this °unusual" behavior may have a pronounced effect on the total production of cutthroat trout.

The amount of competition between a species and its environment may be expressed by the annual mortality rate. Miller (1953) reported that streams in Alberta, Canada, and California, apparently quite similar to those in the Priest Lake drainage, had an average annual mortality rate of 60 percent. **A** section of Silver Creek, a stream in the Clearwater River drainage of Idaho was poisoned in 1956 and the annual mortality rate appeared to be about 75 percent for all year classes.2 This high natural mortality in the streams probably plays an important part in determining the number of fish ultimately recruited to the lake fishery.

The annual mortality rate present in streams tributary to Priest and Upper Priest Lakes probably has not changed significantly in the last 50 years. The productive potential of the stream is probably much the same today as it was around the turn of the century. Before the brook trout became abundant, cutthroat and a few Dolly Varden were the only game fish inhabiting the stream. Nearly all of the productive capacity was utilized by cutthroat. After the brook trout, which has become a stream resident in Priest Lake tributaries, became abundant, the productive capacity of the stream was necessarily divided between the brook trout and the cutthroat. The number of Dolly Varden in the streams is relatively small, so they will not be considered in this discussion. After making the assumption that the annual mortality rate of fish in Priest Lake tributary streams is approximately 60 percent, it is possible to show how the production of cutthroat in the streams could be reduced by introduction of the brook trout.

Let us suppose that a section of stream can support a population of l, 000 fish of mixed age classes. Before the introduction of brook trout, all of these l,000 fish would have been cutthroat. If these l,000 cutthroat were to spend three years in the stream before entering

'Personal correspondence to the author from Dr. Oliver B. Cope, Chief, Rocky Mountain Investigations, Logan, Utah.

[2]Unpublished data, Roger Bachmann, University of Idaho, 66

the lake, we find, that, with an annual mortality of 60 percent, 144 fish would be alive to enter the lake at the end of three years. Brook trout in some streams have become at least as abundant as cutthroat; therefore, this would mean that half of the l,000, or 500 of the fish in the section of stream would be brook trout. The other 500 would be cutthroat. The survival at the end of three years would still be only 144 fish, and half of those surviving would be brook trout. Consequently, the number of cutthroat available to migrate into the lake would be reduced by half, 72 fish instead of the 144. This is a very simple explanation of the relationship that probably exists between the cutthroat and brook trout in Priest Lake tributary streams.

It is also believed by the author that the annual mortality rate in the streams exceeds that present in the lakes so that the total production of cutthroat is reduced merely because the fish remain in the stream for more than a year, The production of cutthroat would increase even though the mortality rates in the lakes and streams were equal if the fish would enter the lakes earlier in life and take advantage of the much faster growth rate present in the lakes.

Once the cutthroat enters the lake, the Rocky Mountain whitefish appears to be its chief competitor. Both species inhabit the shoal areas of the lake at approximately the same depths. Food habits are quite similar, but the whitefish feed on plankton to a greater degree than do cutthroat. Competition between cutthroat and kokanee does not appear to be great. The food habits of the two species are quite different. Competition for space, an unmeasureable factor, seems to be the only possible grounds for suspecting that the introduction of the kokanee has had a detrimental effect on the production of cutthroat. Vernon (1956) states that the kokanee can become an intense competitor with trout, especially in small lakes. Vernon cites examples of where production of trout has decreased after the introduction of kokanee and then increased after the lake was poisoned and restocked with trout. The evidence presented seems to indicate that in small lakes where trout seldom attain lengths of 16 inches the kokanee is not suitable as a forage fish and may actually have an adverse effect on trout production.

Both the Dolly Varden and mackinaw are capable of preying on the cutthroat. However, the reduction in production by this means is believed to be quite small. It is possible that a larger proportion of fish than that found are migrating to the lake during their first and second years of life, however, because of their small size mortality through predation may be extremely high.

Competition with the cutthroat by non-game species is chiefly for food and space. Because the non-game species also inhabit shoal areas and eat much the same food as the cutthroat, the competition here could be quite significant. However, it must be pointed out that the amount of competition between cutthroat and non-game species is probably no greater than it was when cutthroat fishing was "good".

In summary, it appears that the greatest reduction in the production of cutthroat has been brought about in the streams through the introduction of brook trout. To what extent brook trout prey upon cutthroat fry and fingerling in the Priest Lake tributaries is unknown. McCrimmon (1954) is cited as one of the many investigators to find brook trout an important predator on small fish and it is probable that brook trout do cause a significant mortality to cutthroat *through* predation. If the "unusual trait" of staying in the streams for an extended period before entering the lake has developed within the last two or three decades or so, this could be an important factor contributing to the decline. However, if this unusual trait has been the normal occurrence since before the turn of the century, it would still contribute to the decline by producing a population with a low productive potential.

Once a fishery began at Priest and Upper Priest Lakes another form of mortality started to take its toll of cutthroat numbers. Fishing is merely a form of predation imposed on a population by man. Natural mortality takes a certain percentage of the fish population each year. If a fishery is added an additional percentage of the population is taken. When the only mortality present is that occurring from natural phenomena the population will be stabilized at a certain level of production. The increased mortality caused by a fishery can be compensated for in many instances by increased efficiency of production and/or of survival of young (Ricker, 1946). However, if the level of exploitation by the fishery is greater than can be compensated for by increased efficiency of production and/or survival of young, then the population decreases.

In a self sustaining trout population, the older, larger individuals are generally the first to be noticeably reduced. The total catch may remain the same. The average size and age of individuals in the catch however, will decrease. Obviously there is an optimum level of exploitation at which the fishery could sustain itself, the catch per hour remain at a satisfactory level, and the individual fish remain at a satisfactory size. In some fish populations the optimum level of exploitation may be so low as to allow only a very limited fishery if any at all.

It is thought that the Priest Lakes cutthroat populations, because of their low productive potential are of this type. The efficiency of production and survival of young in the Priest and Upper Priest Lakes cutthroat populations were probably near the maximum possible before a fishery was added. The large number of competing species present, the fact that the juvenile fish do stay in the streams for extended periods of time combine to make for an abnormally high natural mortality. When the mortality from the fishery was added to the natural mortality already acting upon the cutthroat, the population was able to increase efficiency of production and survival of young very little and thus a decline in the numbers of fish followed the increased pressure from the fishery. The yield of fish to the fishery can be increased by removing or reducing those factors causing the natural mortality, and by increasing the productive capacity of the body of water.

Data collected and observations made during the stream survey indicate that the amount of spawning area present in the more than 20 streams entering Priest and Upper Priest Lakes is ample to support large spawning populations. Obstacles such as falls, beaver dams, and log jams have a detrimental effect on the spawning efforts of the cutthroat, but to what extent is unknown. Poor logging practices, especially on the streams entering the east side of the lakes have undoubtedly had a detrimental effect on the production of cutthroat. Logging has been allowed down to the stream edge and many jams capable of at least retarding the spawning migration have resulted,

An Evaluation of Fish Stocking: Past, Present, and Future. Before it is possible to consider what measures might be taken to attempt to reverse the downward trend in cutthroat numbers, it is necessary to evaluate the fish stocking practices and the results that have been and might be obtained. Although the value of artificial propagation of fish has probably been oversold, the stocking of hatchery fish is an important part of the management program for many waters. However, it is question-able if the present fish stocking practices for Priest and Upper Priest Lakes are benefitting the cutthroat fishery.

In addition to the exotic species introduced, large numbers of cutthroat have been planted in Priest Lake since before 1938. Cutthroat are a very difficult fish to raise under artificial conditions and consequently nearly all of the cutthroat planted in the Priest Lake drainage have been fry. In 1956, however, over 100,000 cutthroat were planted in Priest Lake after being held at the hatchery for 16 months. These hold-over fish were still only three to four inches in length when planted, illustrating the exceedingly poor growth of cutthroat in a hatchery.

The small size of cutthroat when planted has been one of the factors contributing to the low survival of hatchery plants. For the last decade, between 400,000 and 800,000 cutthroat have been planted annually in Priest and Upper Priest Lakes and their tributaries. The harvest of cutthroat in 1955 and 1956 was approximately 5,000 fish a year. Had the entire harvest of cutthroat resulted from plants, the percentage return would only have been in the neig hborhood of 1 percent per year. In reality, it is very likely that only a small percent, if any, of the 5,000 fish harvested annually resulted from the hatchery plants. Miller (1955) found that the survival of hatchery cutthroat of all sizes, when superimposed on a resident stream population, was negligible over the first winter. With only one exception, tributaries to Priest and Upper Priest Lakes all contain populations of fish. These populations may be resident cutthroat and brook trout or they may be cutthroat which have not yet migrated to the lake. In either case, these populations of fish would have the same effect on any fish introduced from the outside. If the survival over winter of two year and older fish superimposed on resident populations in Alberta streams is neglible (Miller, 195h, 1955), then surely the survival of two or three month old fish planted in the Priest Lake drainage streams can be no better, if as good. One might suspect that the survival of cutthroat planted in the lakes may be better than that in the streams, however, less than 3 percent of the 1956 cutthroat harvest had scales which indicated they had spent less than two years in the streams before entering the lakes. And it is possible that the few fish which did have scales indicating they had entered the lake during their first or second years may have resulted from natural reproduction. Predacious fish are certainly present in sufficient numbers to make the planting of small fish in the lakes a questionable venture. Since the survival of planted fish has been assumed, and probably is negligible in the streams, cutthroat resulting from natural reproduction appear to support the fisheries in Priest and Upper Priest Lakes.

Barring any major changes in the numbers and distribution of fish present in the lakes and tributaries, future plants of small cutthroat will contribute little or nothing to the lake fisheries. The only possible value derived may be from the public relations standpoint.

Possible Remedial Measures. Many sportsmen believe the cutthroat fishery could be restored to its original quality or nearly so by plants of large hatchery fish. In order for such a fish planting program to be successful, tremendous numbers of fish would have to be planted in a lake the size of Priest, and the fishing pressure would have to be much greater than that now present. Fish Lake (2,500 acres) in Southern Utah provides a good example of the returns that might be expected from fish planted in the Priest Lakes. Neuhold (1956) reported that approximately 272,000 fishermen hours were expended at Fish Lake during the 1955 season. This amounts to a pressure of approximately 109 fishermen hours per acre. Priest Lake fishermen expended approximately 107,000 hours in 1956, or about 4 hours per acre. This pressure per unit of area for the Priest Lakes is somewhat inflated for trout, as only 19 percent of the total effort was expended for trout. The fact that some trout are taken while fishing for kokanee does compensate somewhat however. Nevertheless, it is evident that the pressure per unit of area on Fish Lake, Utah, is more than 27 times as heavy as for the Priest Lakes. Even with the large amount of pressure expended at Fish Lake, the return to the creel of 9 inch planted fish was less than 50 percent. The return of legal size fish planted in Pend Oreille Lake, which had a pressure of approximately 6 hours per acre in 1954 appears to be less than 5 percent.[1] The return to the creel of legal sized fish could not be expected to be any larger in the Priest Lakes than in Pend Oreille Lake as the environments of the two lakes are very similar.

It appears then, that even large sized hatchery fish will contribute very little toward increasing the harvest of cutthroat trout in the Priest Lakes.

Because Priest Lake contains adequate amounts of natural spawning area, the ideal method of restoring the cutthroat fishery to a high level of quality would be to increase natural production by removing the limiting factors. Situations such as the increased competition in the streams due to the successful introduction of the brook trout, the unusual behavior of staying in the streams for an extended length of time before migrating to the lakes, and the retarding effect of the log jams, falls, and beaver dams on the migrations of cutthroat up and down the streams, are all factors that are limiting the production of the cutthroat. In order to reduce the competition in the streams, the brook trout would have to be removed, probably by chemical treatment. But if this method were used to remove the brook trout, then the cutthroat and Dolly Varden in the streams would also be killed.

[1]Personal memo to the author from Charles Whitt, Fisheries Biologist, Idaho Fish & Game Dept. Route l, Athol, Idaho.

Inducing the cutthroat to enter the lake during their first year of life is probably the hardest problem to solve. If the fish stay in the stream for extended periods because of some genetic factor, the problem may be impossible to solve. Steelhead remain in freshwater until they reach a length of 5 to 10 inches before migrating and the factor or combination of factors causing the cutthroat to remain in the streams may be very similar to those that cause the steelhead to remain in the stream for extended periods before migrating. If the fish originating from lake spawners are induced to remain in the stream by the presence of non-migrating, resident stream fish, then the removal of all resident populations may solve the problem.

Removal of the log jams, falls, and beaver dams is not out of the realm of possibility and may assist in forcing the cutthroat to enter the lake at an earlier date by removing much of the cover and resting area.

If the preceding corrective measures did not result in an increased production of cutthroat it may be desirable to introduce a species which might take full advantage of the abundant spawning areas in the tributaries and forage fish populations. The introduction of the kamloops, for example, would only be an attempt to obtain a fish that would take advantage of the spawning areas in the tributaries and then take advantage of the faster growth rate present in the lakes by migrating to the lakes in their first year of life. The fact that hybrids resulting from cutthroat and rainbow crosses are generally believed to be less fertile than the pure strains should also be taken into consideration.

Restricting the harvest of fish in order to facilitate a greater survival to maturity would require reducing the daily bag limit to not more than three fish in order to be effective. And it is possible that an increased number of spawners would not increase the number of fish in the lakes since the larger portion of the natural mortality takes place in the streams rather than in the lakes,

Dolly Varden Trout

The Dolly Varden, indigenous to most waters of the Northwest, is a popular game fish in Priest and Upper Priest Lakes because of its large size. Specimens up to 25 pounds have been taken from the lakes in recent years. The harvest in 1956 was approximately l,800 fish, taken mostly in the spring and fall.

Reproduction. The Dolly Varden usually spawns during the month of September in tributaries to Priest and Upper Priest Lakes. The migration of fish to the spawning grounds apparently begins as early as May, since many large adult fish were observed in the streams at the same time the cutthroat spawners were migrating upstream. The Dolly Varden may mature as early as their fourth year of life in the Priest Lakes, however, the majority mature at five and six years of age, Most of the spawning fish observed were over 20 inches in length although a number of smaller fish (12 to 18 inches, designated as "jacks") were found to follow the adults upstream. These smaller fish (usually males) rarely participated in the spawning activities as they were repeatedly driven away by the larger males. - -

Age and Growth. The body-scale relationship of Priest and Upper Priest Lake Dolly Varden is not linear. The relationship was found to be best described by a third degree polynomial (Figure 31). Scales do not appear until the fish is 40 to 45 millimeters long, a length usually attained by August of the first year. As with the cutthroat, the Dolly Varden in Priest and Upper Priest Lakes apparently spend two or three years in the streams before migrating to the lakes. The scales of the Dolly Varden exhibit the stream type development during the early years, with the first two or three annuli close together indicating stream residence and the next annulus widely separated indicating lake residence (Appendix IV, Plate 8). It might be suspected that the fish migrate to the lake during their first year, and the change in growth rate is due only to a change of diet, from one composed mainly of insects to one composed chiefly of fish. This theory is weakened, however, by the fact that scales collected from small immature Dolly Varden in the streams exhibit the same growth rate as the lake fish during the first two or three years of life. Also, immature Dolly Varden under three years of age are numerous in many streams, while mature spawners from the lakes are the only fish older than three years found in the streams. Once the fish enter the lake the growth is fairly rapid (Figure 32, and Appendix III, Tables 24 and 25).

The longevity of Dolly Varden in Priest and Upper Priest Lakes appears to be about 10 years, with fish that age usually attaining lengths of more than 30 inches and weights above 15 pounds.

The growth rate of Dolly Varden in Priest Lake differs somewhat from that of the fish in the upper lake (Figure 32) with one possible explanation being a difference in the food habits, as noted below.

The length-weight relationship of Dolly Varden (Figure 33) is very similar to that of the mackinaw (Figure 34). The gain in weight is very rapid after the fish reach a length of 20 to 25 inches.

Food Habits. The diet of both Priest and Upper Priest Lake Dolly Varden is composed chiefly of fish (Tables 31 and 32). Dolly Varden in Priest Lake rely mainly on kokanee while fish in the upper lake consume kokanee and whitefish in approximately equal amounts. This difference is probably a function of forage fish density rather than a difference in preference. Kokanee appear to be less abundant in Upper Priest Lake than in Priest, while the whitefish is apparently more abundant in the upper lake than in Priest Lake. It is thought that because the kokanee is not so abundant in the upper lake, this condition might explain in part the slower growth of Dolly Varden in Upper Priest Lake.

Before the kokanee were introduced into Priest Lake, whitefish were probably the main food eaten by Dolly Varden. Fishermen claim that before the kokanee was introduced, a 4 to 6 pound Dolly Varden was about as large as were caught. Now, weights of 20 to 25 pounds are not uncommon and are

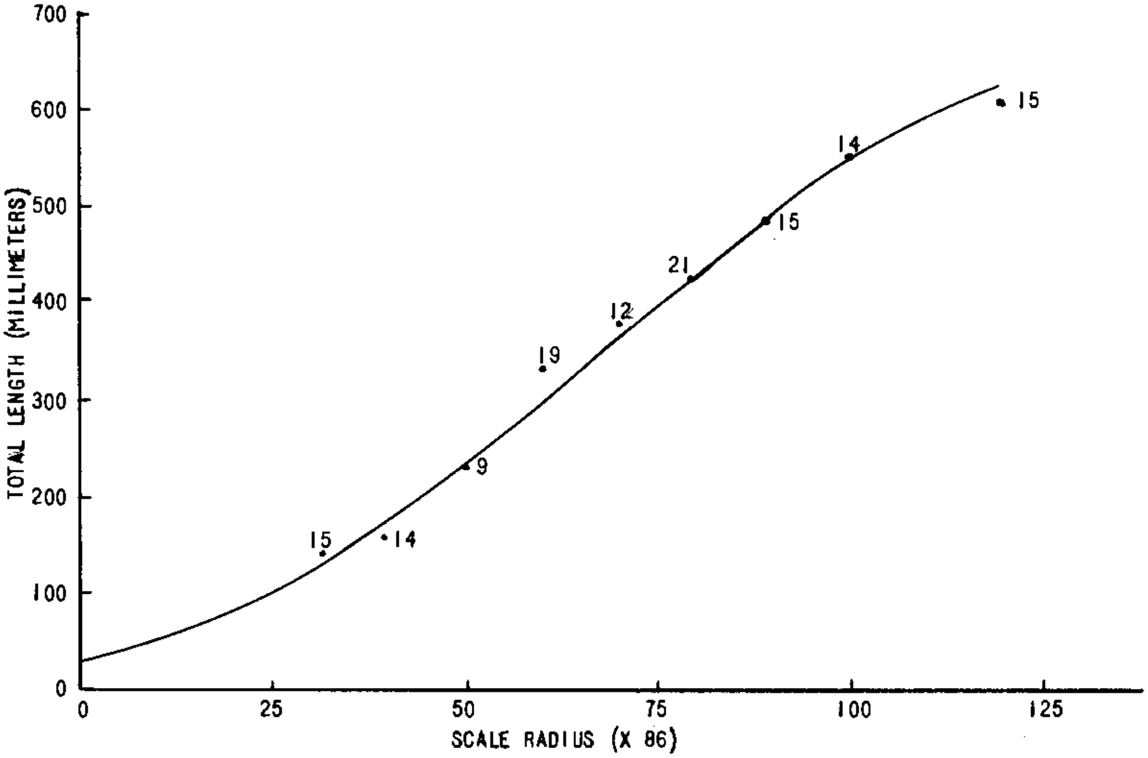


Figure 31. Body scale relationship of Dolly Varden in Priest and Upper Priest Lakes. Regression line best described by formula $L = 38 + (0.74) R + (0.0762) R^2 + (-0.000324) R^3$ derived by selected points method of fitting third degree parabolic curves.

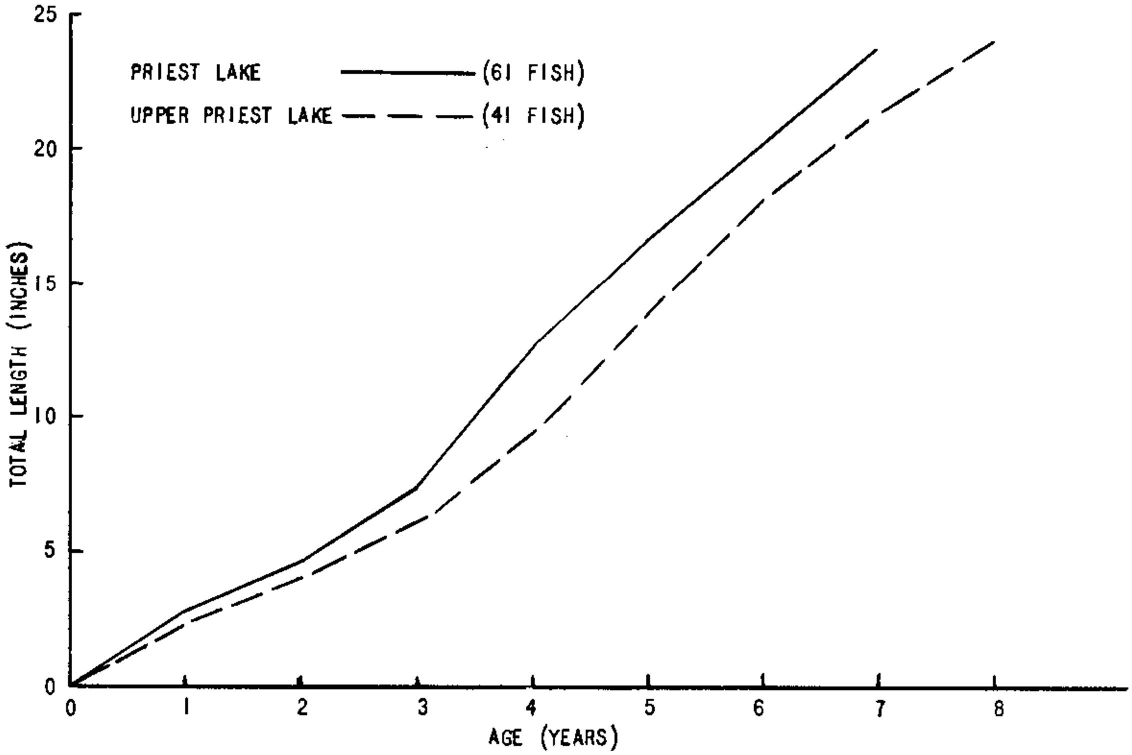


Figure 32. Age and length relationship of Dolly Varden from Priest and Upper Priest Lakes, 1956.

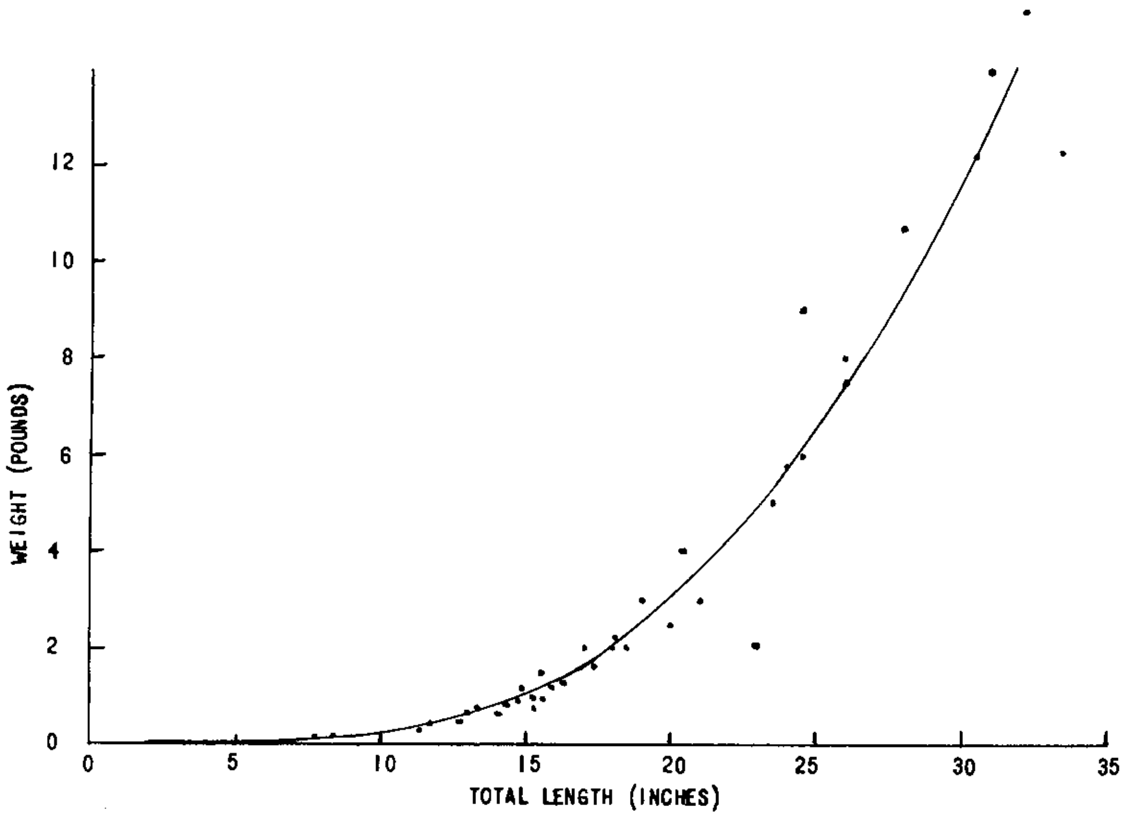


Figure 33. Length-weight relationship of Dolly Varden from Priest and Upper Priest Lakes, 1956. Regression line fitted by inspection.

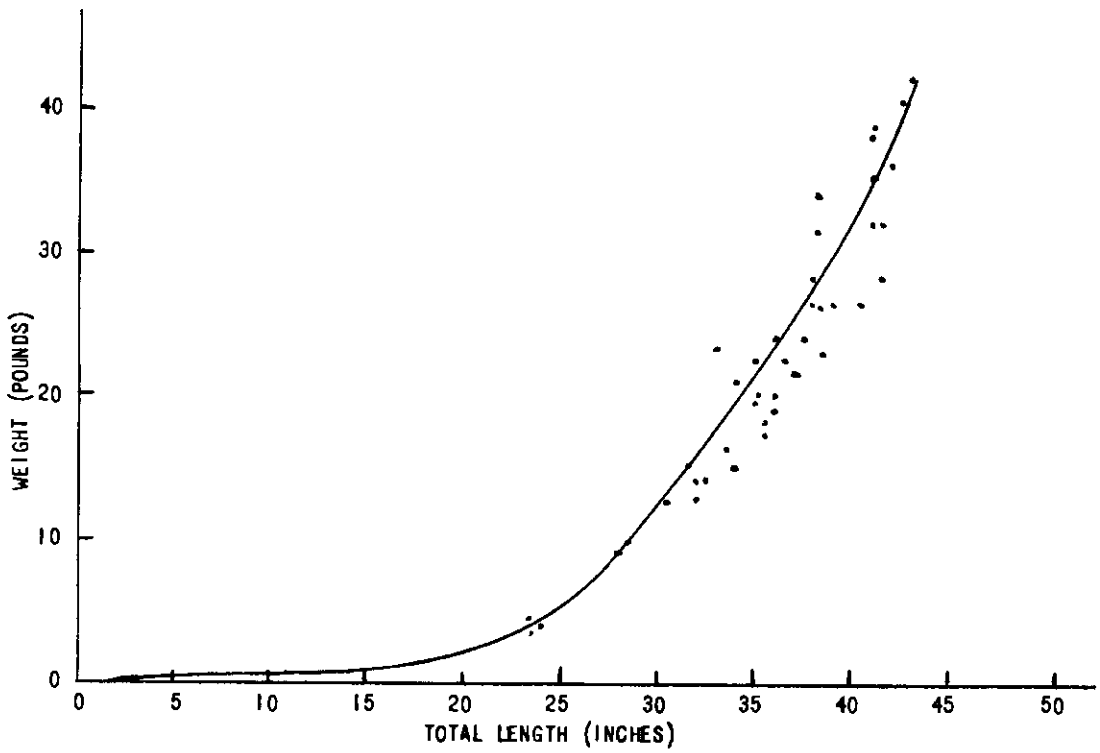


Figure 34. Length-weight relationship of mackinaw from Priest Lake. Fish collected 1952 and 1956. Regression line fitted by inspection.

without question the result of the abundance and excellence of kokanee as a forage fish. As with other species in the lake, the amount of feeding during the winter months is negligible.

Table 31. Stomach contents of 27 Dolly Varden caught from Priest Lake during 1956.

Organism	Occurrence	Amount milliliters	Average amount	Percent volume
Coleoptera	1	0.9	0.9	0.5
Hymenoptera	1	0.2	0.2	0.1
Kokanee	5	113.5	22.7	60.3
Whitefish	2	22.7	11.4	12.1
Unidentified fish remains	8	51.0	6.4	27.1
Empty	12	--	--	--

Table 32. Stomach contents of 14 Dolly Varden caught from Upper Priest Lake during 1956.

Organism	Occurrence	Amount milliliters	Average amount	Percent volume
Kokanee	5	73.0	14.6	42.7
Whitefish	3	93.0	31.0	54.4
Unidentified fish remains	2	5.0	2.5	2.9
Empty	4	--	--	--

Competition and Predation. The food habits of the Dolly Varden and cutthroat are similar while the fish are in the streams and may indicate competition. The mackinaw and Dolly Varden in the lake may compete for food since their food habits are also very similar. The species of fish eaten most by the Dolly Varden are those occupying the same ecological habitat. During the spring and fall, water temperatures at the surface are suitable for trout as well as non-game species so that the Dolly Varden may prey on any of the species in the lake at that time. During the summer, surface temperatures are too warm for the Dolly Varden and they must feed on the fish inhabiting the thermocline (cutthroat, kokanee, and whitefish mainly). The kokanee is consumed in the largest numbers because of its abundance and schooling behavior.

Depth Distribution. Gill net sets during August and September revealed that the Dolly Varden were occupying the lower portion of the thermocline at depths of 40 to 60 feet where the temperature was 45 to 55° F. During the spring and fall, when the surface temperatures are below or near 550 F. the Dolly Varden are near the surface and more easily taken by anglers.

Parasites. The large number of tapeworm infestations in most of the Dolly Varden is worthy of note as some appear to be heavy enough to impair the efficiency of the fish's physiological activity (Northcote, 1957).

Mackinaw (Lake) Trout

Mackinaw or lake trout were first introduced into Priest Lake in 1925. They contributed very little to the total catch of game fish until 1952 when anglers "accidently" found that the large fish were present. The mackinaw were "discovered" when they were taken during a Dolly Varden fishing derby. Once the fish were found the news spread rapidly and about 350 fish, weighing approximately 8,500 pounds were taken in 1952. The largest fish taken to date weighed 52 pounds. During the 1956 season approximately 270 mackinaw were harvested during the spring.

Age and Growth. Mackinaw in Priest Lake attain ages up to at least 10 years. The rate of growth is relatively slow during the first three years but increases rapidly once the fish are large enough to take full advantage of the forage fish present in the lake. In Table 33 are presented the interpretations of 55 scale samples taken from fish collected in 1952, 1955, and 1956.

Table 33. Interpretations of scales from 55 mackinaw ranging in length from 7.5 to 43.0 inches, from collections made in 1952, 1955, and 1956.

Year of life	Approximate range in length (inches)	Approximate range in weight (pounds)
1st	up to 4.0	less than 1.0
2nd	4.0 - 7.0	less than 1.0
3rd	7.0 - 10.0	less than 1.0
4th	10.0 - 16.0	0.5 - 1.0
5th	16.0 - 21.0	1.0 - 4.0
6th	21.0 - 30.0	4.0 - 14.0
7th	30.0 - 35.0	14.0 - 22.0
8th	33.0 - 39.0	18.0 - 26.0
9th	36.0 - 42.0	25.0 - 36.0
10th	42.0 - 44.0	36.0 - 42.0

The length-weight relationship of mackinaw (Figure 34) illustrates the rapid gain in weight accomplished by the fish in Priest Lake once they reach a length of approximately 25 inches.

Food Habits. The successful introduction of the kokanee is probably the most important factor contributing to the large size attained by the mackinaw in Priest Lake. Prior to the introduction of the kokanee in 1942, the mackinaw, like the Dolly Varden, possibly did not attain a very large size. The mackinaw begin feeding on fish by the time they have reached a length of 7 inches. Kokanee make up the main part of the diet of the larger fish while the smaller fish were found to feed quite extensively on the non-game fish found in the shoal areas during the summer months. The large number of kokanee, their schooling habits, and their preference for the cooler waters in the thermocline make them ideal forage fish for the mackinaw.

It is interesting to speculate on the number of kokanee that must be consumed by the larger mackinaw in order to gain the 5 to 10 pounds of weight added some seasons. If the conversion ratio of 6 pounds of fish eaten to produce 1 pound of flesh is used, it is evident a fish must consume approximately 42 pounds of fish to gain 7 pounds in weight. In Priest Lake, 10 inch kokanee run about 3.3 fish to the pound. If the mackinaw were to consume only fish 10 inches long, they would have to capture 139 fish. However, because they also feed on smaller individuals the number of fish consumed is probably 3 to 10 times that number each season.

Depth Distribution. The harvest of mackinaw is closely related to their vertical distribution in the water which is in turn regulated by the water temperature. Most of the mackinaw are harvested in the spring when the lake is homothermous from top to bottom. This species which prefers waters with temperatures near or below 55° F. is found near the surface during the spring of the year and is more readily available to the fishermen. As the lake waters begin to warm the mackinaw seek the deeper waters with their cooler temperatures and become less available to the fishermen. A notable exception is the fact that small mackinaw (7.0 to 9.0 inches) were taken with gill nets in the shoal areas during mid-summer. Gill net sets during August and September indicated that the large fish are located between 40 to 60 feet of depth at temperatures 45 to 55° F.

The large shelf, located east of Kalispell Island, (Figure I) at a depth of approximately 55 feet was found to be ideal habitat for the mackinaw and is one possible explanation as to why most of the mackinaw taken from Priest Lake are taken from around the island. Mackinaw were also taken from the deeper waters of the thermocline in Area 3 with gill nets, indicating that the fish are also found in areas other than just around Kalispell Island.

Brook Trout

The brook trout is not native to the Priest Lake drainage. Although the exact date of planting is unknown, Fish and Game Department records indicate that brook trout may have been planted in Bear Creek as early as 1916. At any rate, brook trout are now present in nearly every tributary to Priest Lake. No specimens were collected from Upper Priest Lake or its tributaries, however, it will only be a matter of time until they find their way to the upper lake.

Although brook trout are caught from Priest Lake, the bulk of the population is found in the tributaries as stream residents. It is estimated that somewhere between 2,500 and 5,000 brook trout are harvested from the tributary streams each year.

Age and Growth. The growth of brook trout differs with the various streams. In general, fish 3.5 to 5.5, 5.5 to 8.0, and 8.0 to 10.0 inches in length are in their second, third, and fourth years of life respectively. The fish mature at 5 to 8 inches during their third and fourth years of life.

Food Habits. The stomachs collected from brook trout indicate that their diet is composed chiefly of insects and some fish. Brook trout in the streams probably eat fewer fish than those in the lake.

Competition. Before introduction of the brook trout, cutthroat were the only species of trout in any number in the tributaries. Nearly all of the fish produced in the streams were cutthroat. After the introduction of brook trout the productive capacity of the streams had to be shared by both the cutthroat and the brook trout. Competition is mainly for food and space. However, it is felt that the brook trout do prey upon small cutthroat to an unknown extent. As the brook trout became established in the streams entering Priest Lake, the number of cutthroat produced was probably reduced proportionately. Some streams such as Reeder Creek and Lamb Creek are not suitable for production of cutthroat but brook trout can survive and reproduce in these waters and thus a previously unoccupied environment was filled. Other streams which once produced only cutthroat, now produce both cutthroat and brook trout but only in the same numbers that cutthroat were once produced. The net effect has been a reduction in the number of cutthroat produced.

Since very few brook trout enter the lake, fishing for this species is restricted to the tributaries. Although a few thousand fish are harvested each year from the streams, this does not outweigh the decreased production of cutthroat brought about by competition between the two species. Because many of *the* cutthroat in the streams eventually migrate to the lake and are recruited to the lake fishery, a decrease in the number of cutthroat produced in the streams is undesirable.

Kokanee

The kokanee, which now comprises more than 90 percent of the number of game fish harvested from Priest Lake, was successfully introduced in 1942, 1943, and 1944. Since there are no records indicating kokanee were planted in Upper Priest Lake, it is assumed that the population in the upper lake originated from fish migrating through the thoroughfare connecting the two lakes.

There has been much speculation on the origin and the reasons why the kokanee does not migrate to the ocean as does its anadromous counter-part, the sockeye salmon. Ricker (1940) postulates that the kokanee might differ genetically from the anadromous form. Foerster (1947) in an experiment to develop sea-run sockeye from kokanee found that, the kokanee, when released in a stream leading to the ocean, would go to the sea and return as do the normal sockeye. He concluded

> "That of the two distinctive differences between the sockeye and the kokanee - size and habit - the former cannot be hereditary and probably is environmental. For habit, the difference is less clear, but environment would seem to be a strongly-influencing factor."

In the relatively short period of 14 years, the kokanee has become the most abundant fish in the Priest Lake sport catch (Figure 35). The harvest of game fish from Upper Priest Lake is composed of approximately equal portions of trout and kokanee. The popularity of the fish arises from its excellent eating qualities, the tremendous numbers of fish produced for the fishery (creel limit 50 per day), and its value as a forage fish for the larger trout.

Age and Growth. Numerous authors have described the kokanee as a typically four year cycle fish, Ricker (1938a) found kokanee to mature in their third and fourth years of life in Cultus Lake. Clemens et al., (1939) found the kokanee to mature at four years of age in Okanogan Lake. Curtis and Fraser (1948) found all kokanee so far observed in California had matured at the end of their third year. Jeppson (1955) quoted Willis Rich, who concluded that the kokanee in Pend Oreille Lake were a four-year cycle fish. Thus it is easily understood where the sportsmen frequenting the Priest Lakes derived their belief that the kokanee there were a four-year cycle fish.

Measurements of distance to the anterior edge on the scale and total length of 255 fish were grouped according to body length to obtain the body-scale relationship of Priest Lake kokanee as shown in Figure 36. Although Whitney and Carlander (1956) suggest that grouping the data according to scale radius is the best procedure for determining the body-scale relationship, this method did not prove to be applicable for the Priest Lake kokanee. The length of fish varied considerably for any given size scale so that it was necessary to group according to body length.

As can be seen in Figure 36 the body-scale relationship appears to be curvilinear, especially at the upper end of the regression line. It is the opinion of the author that this curvature is caused by the scales of older fish, particularly mature fish, being eroded away at the edge. In actuality then, it is assumed that the body length of the larger fish does not grow at a progressively faster rate than the scale. Dunlop (1924) in studies on the scales of sockeye salmon found that "while the growth of the scale corresponds in a general way with the growth of the fish, the ratio is far from exact." This statement appears to apply also to the kokanee in Priest Lake.

With the body-scale relationship assumed to be a straight line, the back calculation of body lengths at various ages was based on the proportional size of the scale. The large variability in scale size for a particular body length of kokanee furth facilitated the decision to use the proportional size of the scale. The following formula was used for back calculation of body lengths of kokanee in the Priest Lakes.

$$La = 30 \text{ millimeters} + \frac{SRa}{SRc} (TLc - 30 \text{ millimeters})$$

where:

La = body length at the annulus
TL = total length of fish at capture
SRa = scale radius at the annulus
SRc = scale radius at capture

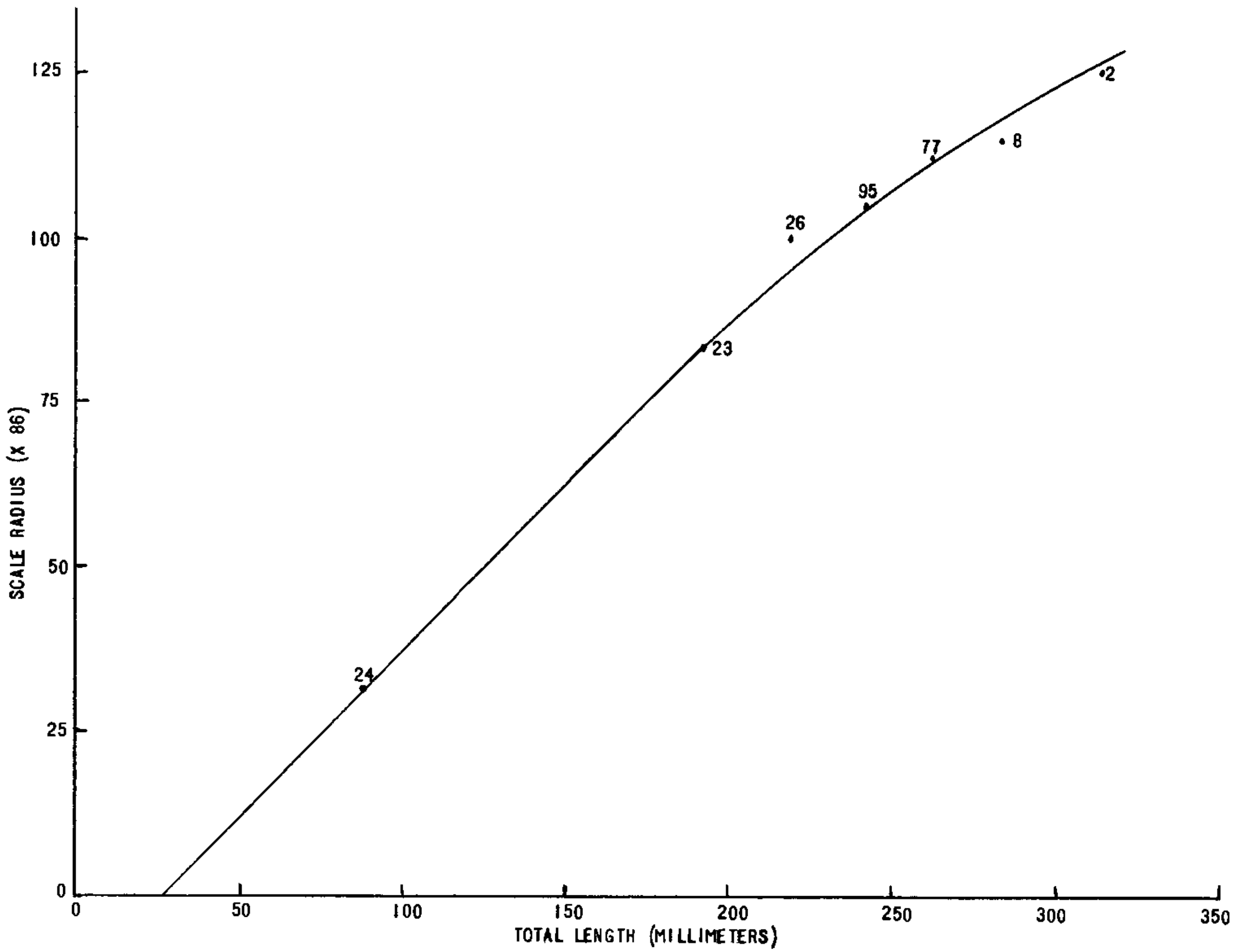


Figure 36. Body-scale relationship of Priest Lake kokanee. Regression line fitted by inspection.

The value, 30 millimeters, used in the above formula represents the average length of the fish at the time of scale formation. This value, not determined empirically, was chosen for the following reasons: (l) most salmonids form scales after reaching this length, (2) the regression line intercept approximates this value, and (3) a better estimate was not available.

After preliminary studies of scale samples collected in 1955 it became evident that knowledge concerning the time of annulus formation would be needed to facilitate the correct interpretation of the patterns present on the scales. Scale samples collected from older kokanee appeared to have either added a full year's growth by July or none at all. Thus, in 1956, lengths, weights, and scale samples were collected at semi-monthly intervals beginning in May. Examination of these scale samples revealed that the time of annulus formation varied with the age of the fish. Kokanee in their second and third years of life were found to form an annulus usually in June, while fish in their fourth, fifth, and sixth years of life would not form an annulus until July. In a few cases it appeared that no circuli were laid down during the last year of life. In Appendix IV a series of photographs of scales from fish in age classes II, III, and IV are presented to show the scale growth and annulus formation throughout the growing season.

The conclusions reached concerning the time of annulus formation appeared to be confirmed by the seasonal growth rates of the various age groups (Figure 37 and Table 34). Fish in their third year of life seemed to grow at a slightly faster rate in the spring and early summer than did the older age classes. Also the rate of growth for fish in their fourth, fifth, and sixth years increased noticeably after August l. Reasons for these differences in the rate of growth will be discussed later.

Sampling restrictions limited the determination of age composition to the sport catch and spawning populations. From scale and length measurements it was determined that age classes II, III, IV, and V were represented in the 1956 harvest. Age class IV, or fish in their fifth year of life, was the most abundant age class in the Priest Lake harvest followed by age classes II and III (Table 35). Fish in their sixth year of life made up less than 3 percent of the total harvest. The 1955 harvest also consisted predominantly of fish in their fifth year of life. The 1956 harvest from Upper Priest Lake consisted of nearly equal percentages of age classes II (26 percent), III (28 percent), IV (23 percent), and V (21 percent) (Figure 38)• Age class VI made up the remaining 2 percent.

Length frequency graphs (Figure 39) were constructed to check the validity of the scale interpretations, however, only the sample collected on October 1, 1956, appeared to be large enough to show the presence of three distinct year classes in the catch. The larger mode in the figure includes both age class IV and V as there was very little difference in length between the two.

To determine the growth in length of the kokanee only those scales collected in the spring were used to back calculate lengths at various

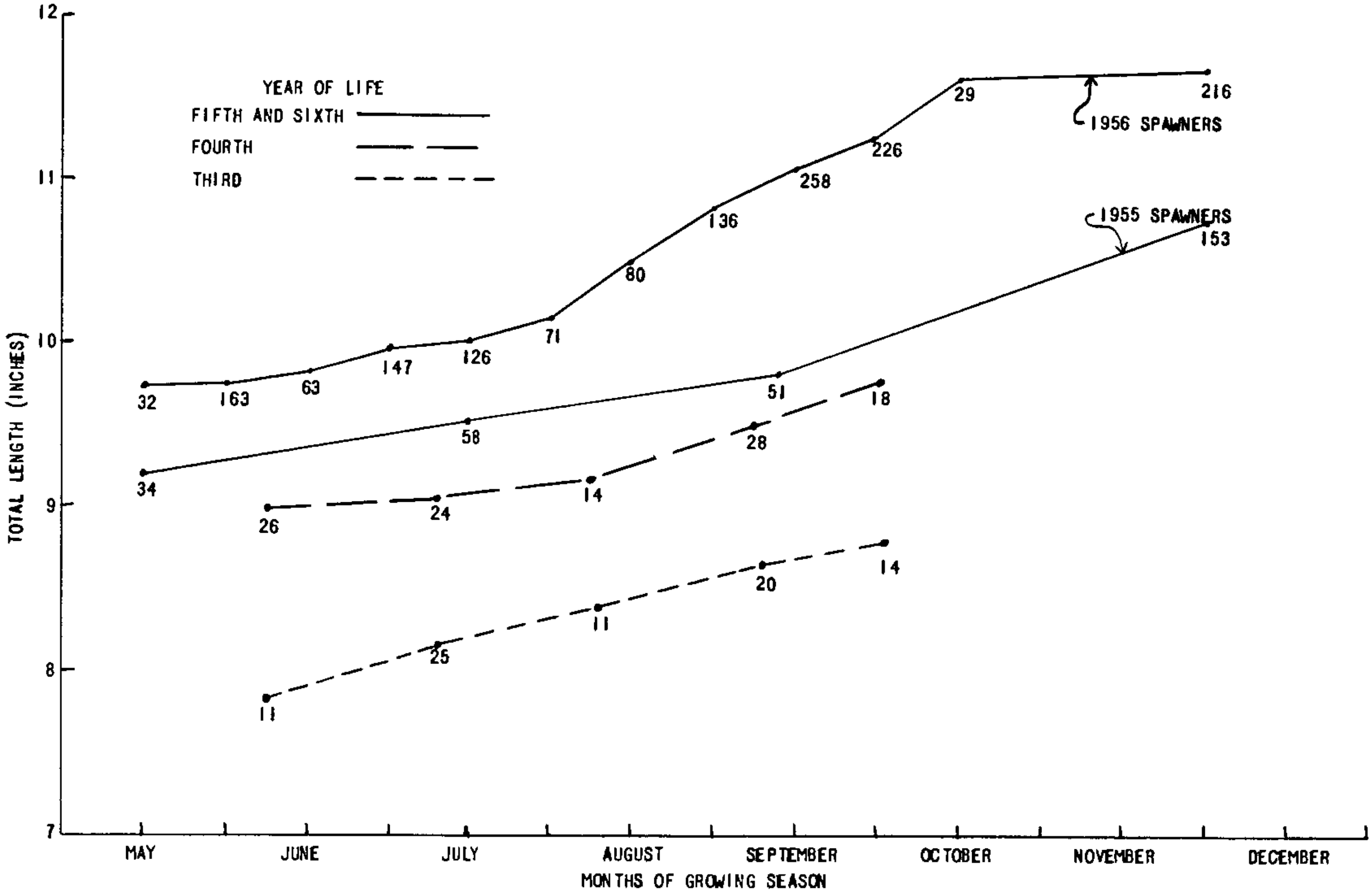


Figure 37. Annual growth of kokanee in Priest Lake by months throughout the 1956 growing season.

Table 34. Lengths and weights of Priest Lake kokanee sampled from the sport catch at various dates throughout the growing season.

Date collected[1]	1955					1956				
	Lengths (inches)			Weights (grams)		Lengths (inches)			Weights (grams)	
	Sex[2]	Number	Mean	Number	Mean	Sex	Number	Mean	Number	Mean
May 15	C	34	9.2	--	--	C	32	9.7	--	---
June 1	C	--	---	--	--	C	163	9.7	66	122
June 15	C	--	---	--	--	C	63	9.8	58	129
July 1	C	--	---	--	--	C	147	9.9	26	137
July 15	C	58	9.5	58	115	C	126	10.0	48	141
Aug. 1	C	--	---	--	--	C	71	10.1	69	151
Aug. 15	C	--	---	--	--	C	80	10.5	53	172
Sept. 1	C	--	---	--	--	C	136	10.8	90	180
Sept. 15	C	51	9.8	51	135	M	101	11.1	82	208
						F	37	10.8	28	194
Oct. 1	M	--	---	--	--	M	140	11.4	140	218
	F	--	---	--	--	F	86	11.1	86	209
Oct. 15	M	--	---	--	--	M	19	11.7	--	---
	F	--	---	--	--	F	10	11.4	--	---
Dec. 1	M	85	10.9	85	186	M	132	11.8	108	219
	F	68	10.6	68	150	F	84	11.4	63	182

[1] The samples for 1955 were grouped by month, therefore, the values reported for May 15, etc. represent all of the lengths recorded during May, etc.

[2] C = Sexes combined
M = Males
F = Females

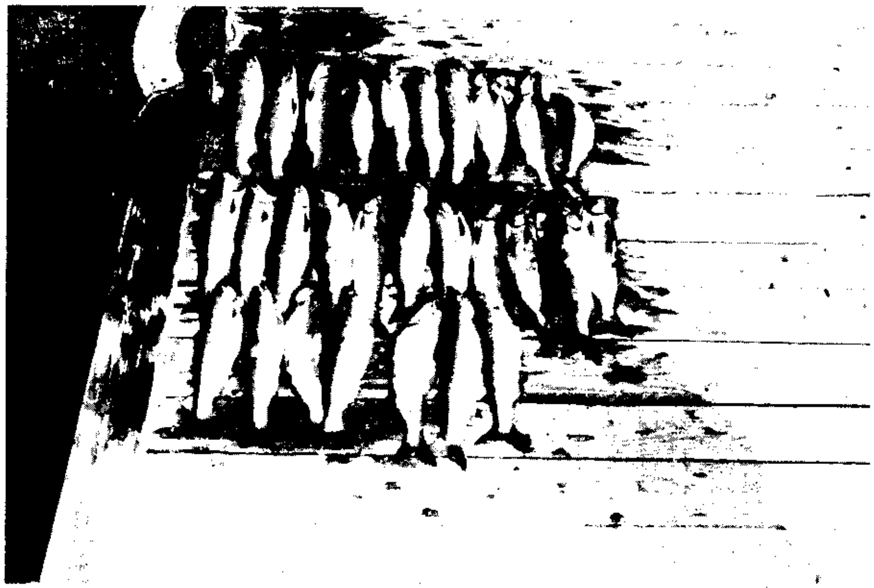


Figure 35. A catch of kokanee from Priest Lake in 1956.

Figure 38. Age class II, III, and IV kokanee taken from Upper Priest Lake, 1956.

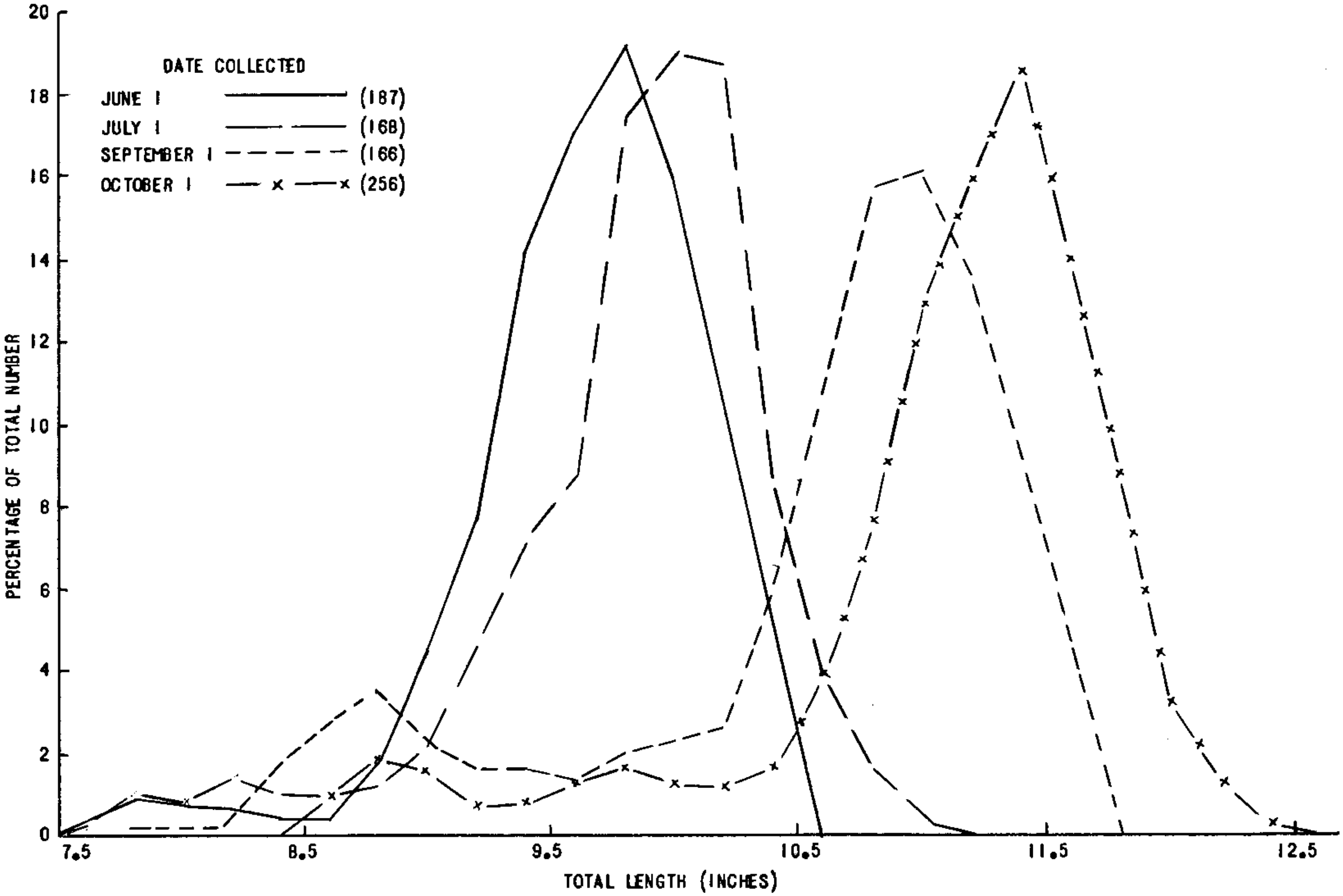


Figure 39. Length-frequency of Priest Lake kokanee at various dates throughout the 1956 growing season. Running average by three's.

ages. Also, by using scales collected in the spring before new growth appeared on the scales, there was little question concerning the position of the latest annulus laid down.

Table 35. Age composition of catch of kokanee from Priest Lake, 1956. Expressed as percentage of total in sample.

Date sample collected[1]	Number of fish	Age class II	Age class III	Age class IV[2]
May 15	33	0	3	97
June 1	188	3	10	87
June 15	73	7	7	86
July 1	168	5	7	88
July 15	155	10	8	82
August 1	80	3	9	88
August 15	95	9	6	85
September 1	162	8	8	84
September 15	281	13	6	91
October 1	256	5	6	85
October 15	29	0	7	93
Mean for season		6	8	86

[1]All samples were collected within a two or three day period around the date listed.

[2]The percentages for this group also includes the few age class V fish (estimated to be less than 2 or 3 percent of total).

All lengths given in tables and graphs will be total body lengths measured according to Lagler (1952). The following conversion factors (Table 36) are offered so that standard and fork lengths may be used if desired.

Table 36. Conversion factors for Priest Lake kokanee based on 95 fish with total lengths ranging from 210 to 285 millimeters. Sexes combined.

Standard length to total length	=	1.202
Standard length to fork length	=	1.100
Total length to standard length	=	0.832
Total length to fork length	=	0.915
Fork length to total length	=	1.093
Fork length to standard length	=	0.909

Under normal conditions, it appears that a single age class composes a high percentage of the annual harvest. Because of this fact, it was desirable to analyze the growth rates and increments of length of year classes separately rather than combine all of the age classes as is the usual procedure in age and growth studies. By analyzing each year class separately, it is possible to detect differences in growth rates during various years of life.

The mean calculated total lengths and increments of length for the various age classes are presented in tabular form in Appendix III, Tables 26 and 27. A graphic presentation is found in Figures 40 and 41.

Kokanee in both Priest and Upper Priest Lakes usually attain a length of at least 3 inches during their first year and a length of 7 to 8 inches by the end of their second year. Jeppson (1955) indicates that kokanee in Pend Oreille Lake grow at approximately these same rates during their first and second years of life. The difference in size between Upper Priest Lake fish and those from Priest and Pend Oreille Lakes is the result of differing growth rates during the third, fourth, and fifth years of life. Upper Priest Lake fish usually add nearly 3 inches to their total length during their third year of life while Priest Lake fish add only 1 to 2 inches.

Growth of kokanee during their maturing year of life was measured in 1955 and 1956 (Table 34). Fish which spawned in 1955 grew approximately I.6 inches in total length during their last year of life, compared with the 1956 spawners which grew I.9 inches during their last year of life. Female spawners were lighter in weight and shorter in length than male fish in both years (Table 34 and Figure 42). Male kokanee appeared to lose only a small amount of weight during spawning while female fish exhibited a very noticeable loss.

Growth of maturing fish during the 1956 season followed a pattern that seems to be typical of older fish; only 20 percent of the growth in length had taken place by the time approximately one half of the growing season had elapsed (Figure 42). Factors influencing the growth rate of kokanee will be discussed in a later section.

The length-weight relationship of Priest Lake kokanee is defined with the regression line in Figure 43.

Reproduction. Priest and Upper Priest Lake kokanee spawn in the late fall and early winter, usually beginning in November and ending by the last of December. Pend Oreille fish spawn at approximately this same time. Ricker (1938) found kokanee in Cultus Lake to spawn in August and September as do kokanee in some southern Idaho lakes.

The age at maturity seems to be quite variable with some populations maturing predominantly at the end of their third year of life while others do not mature until the end of their fifth year of life. Some populations also contain significant numbers of age class V spawning fish. In 1955 and *1956* age class IV, or fish completing their fifth year of life, was the dominant age class in the spawning runs in Priest Lake, Whether Priest Lake kokanee have always been a five year cycle fish is debatable. The factors causing the fish to mature at five years instead of the "normal" four years are unknown.

In Priest Lake a large majority of the kokanee spawning occurs in seep areas (Figure 44) on the gravel bottomed shoal areas of the lake, with the remainder taking place in the tributary streams. Shoal areas containing suitable spawning areas appear to be adequate in both Priest and Upper Priest Lakes (Figures 45 and 46).

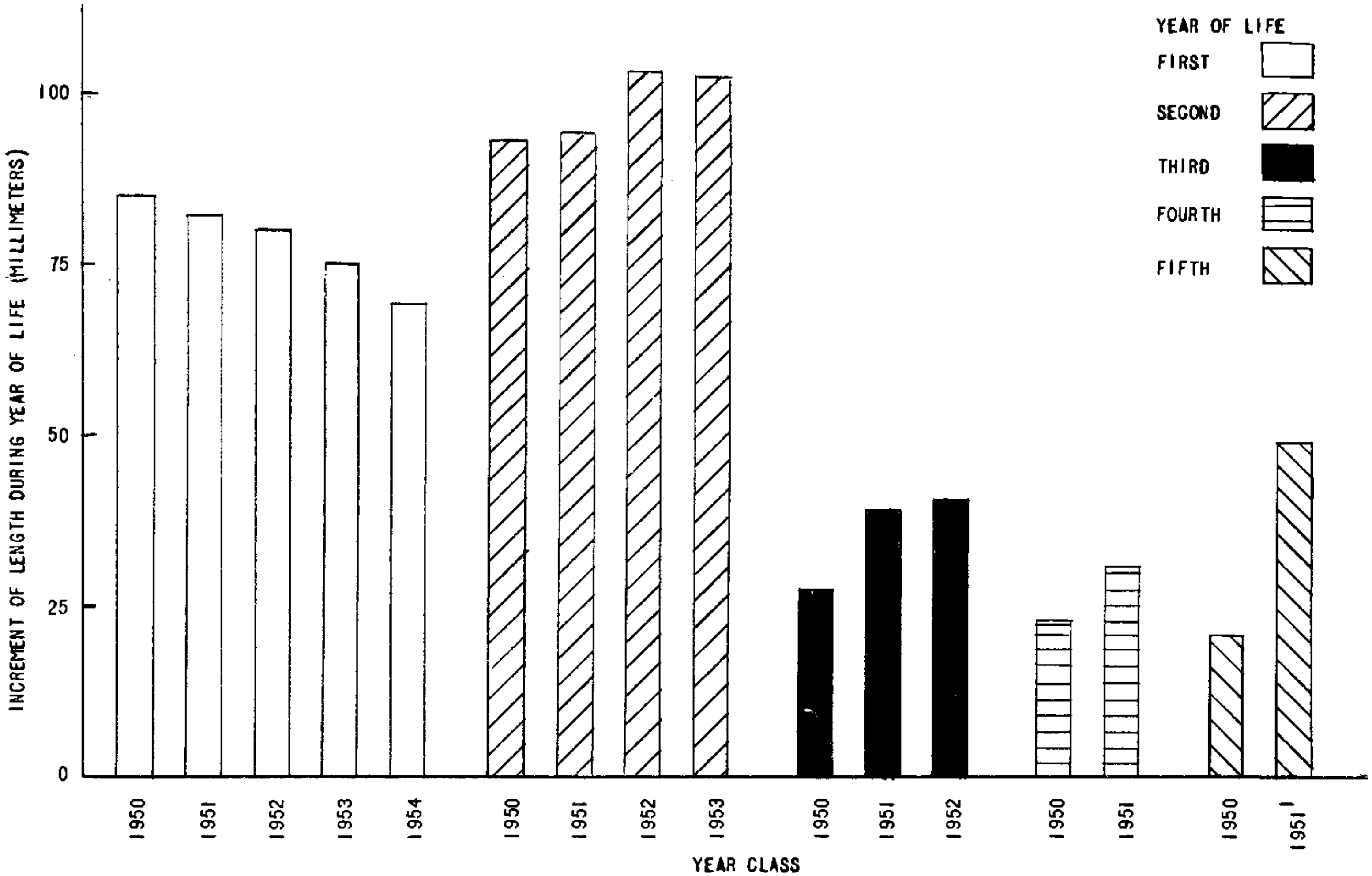


Figure 40. Growth in length of Priest Lake kokanee during various years of life.

[1]Actual measured growth during 1956 growing season.

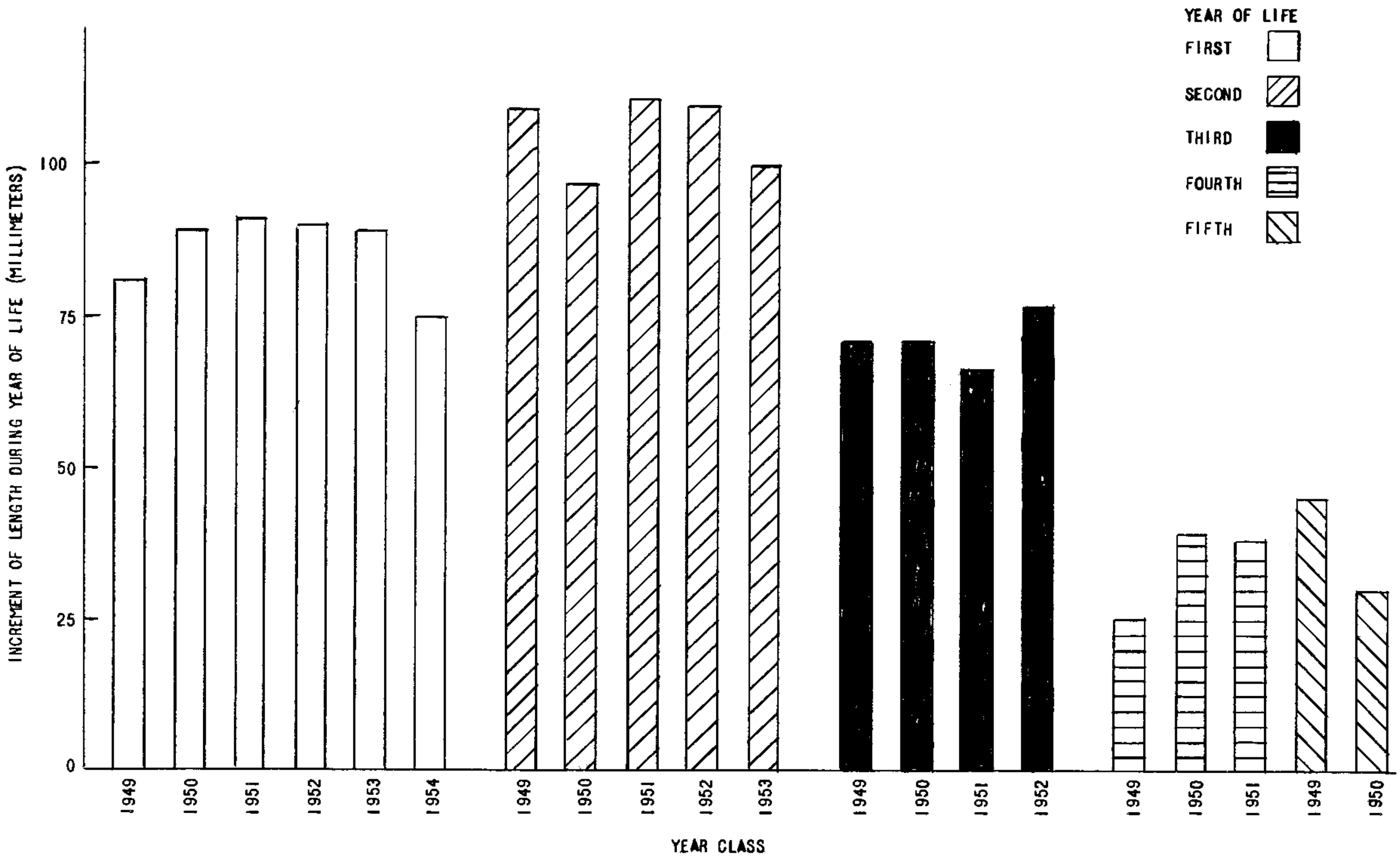


Figure 41. Growth in length of Upper Priest Lake kokanee during various years of life.

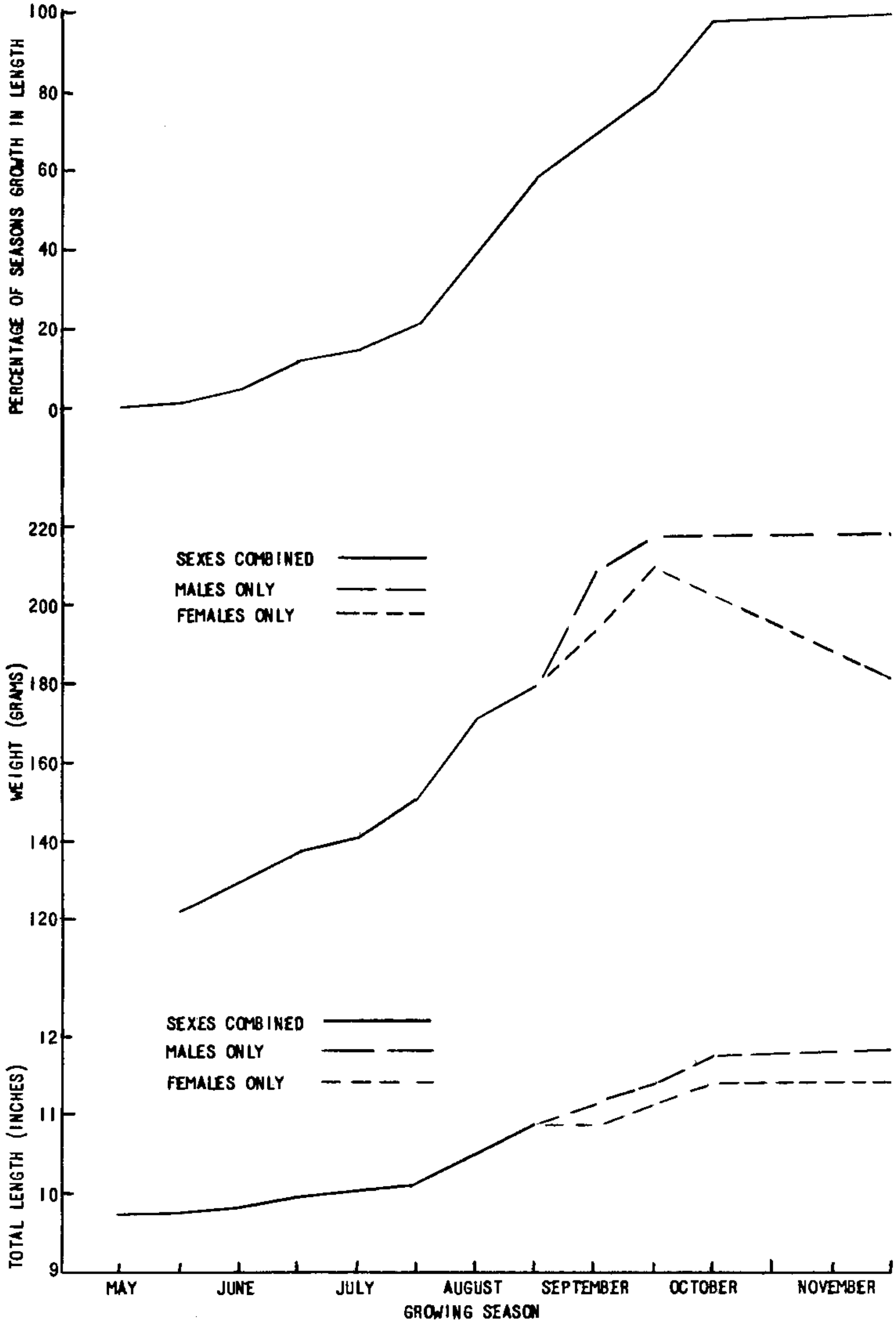


Figure 42. Growth in length and weight of kokanee in their fifth year of life from Priest Lake, 1956.

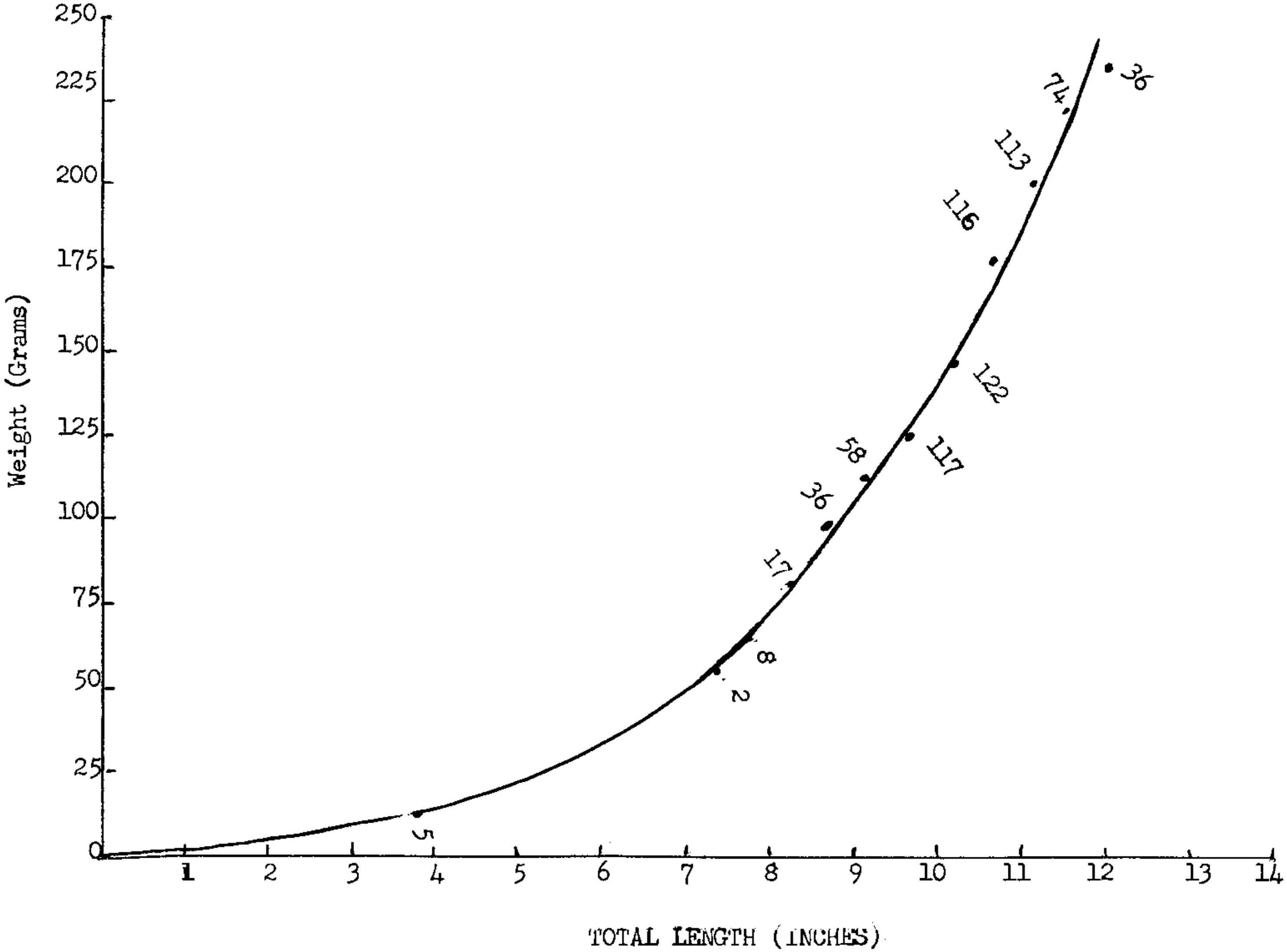


Figure 43. Length-weight relationship of kokanee from Priest Lake, 1956. Regression line fitted by inspection.

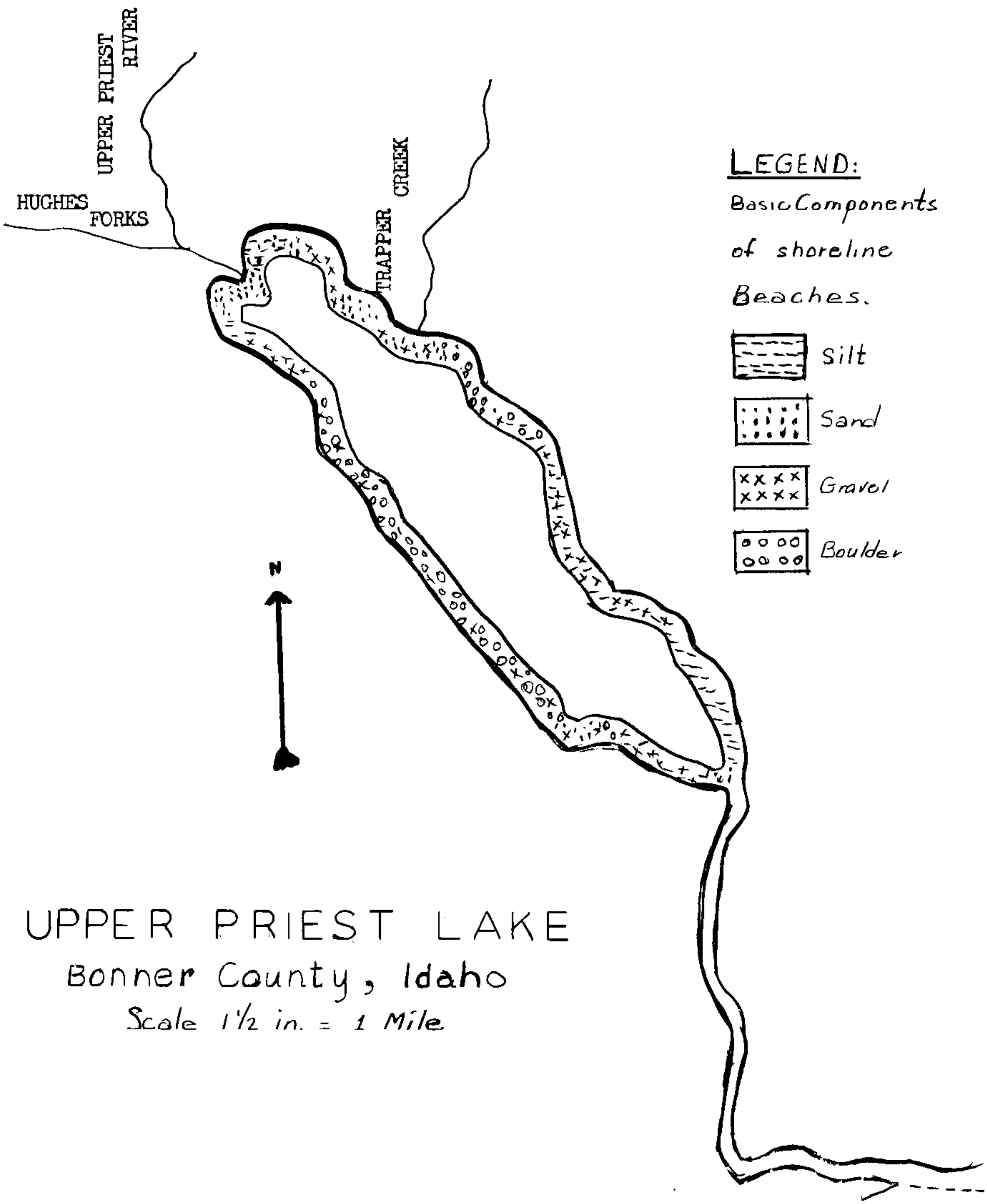


Figure 46. Map of Upper Priest Lake showing the composition of shoreline beaches down to a depth of 10 to 15 feet.

Because of the large amount of shoal area spawning that occurs in Priest Lake, drawdown of the lake water levels during incubation of eggs and emergence of fry can reduce the success of reproductive efforts (Figure 47). At present there is a structure located at the outlet to

Priest Lake that is capable of causing a drawdown of as much as three-feet (Figures 48 and 49). Before construction of the present outlet control structure, a drawdown of more than one tenth foot after December l, occurred six times in 21 years. Since contruction in 1951 there has been a drawdown of varying magnitude every year. Although some eggs and fry are lost when even a very slight drawdown occurs, it appears that with the possible exception of 1951, the operation of the outlet dam has had very little detrimental effect on the kokanee fishery. Most of the losses incurred would result from frozen eggs and fry left out of the water. Kimsey (1951) pointed out that eggs and fry frozen for extended periods of time exhibited losses up to 90 percent.

The harvest of kokanee in 1956 from Priest Lake during September and October was made up of approximately 65 percent males and 35 percent females. Samples taken on the spawning beds December l, 1956, were composed of 56 percent males and 44 percent females. There seems to be a tendency for males to be more abundant on the spawning grounds early in the season and females to be more abundant during the latter part of the season.

Spent female kokanee which had-survived after spawning were taken infrequently in the sport catch. These spent fish were usually longer than the fish just maturing for the next spawning season but were much thinner and in poorer condition. One 15 inch male which had spawned and survived was observed from the Upper Priest Lake. This male had the same appearance of the mature male kokanee at time of spawning but was some–what darker in color.

Ten kokanee averaging 11.2 inches total length had a mean of 428 eggs per female in 1956.

Food Habits. Kokanee in Priest Lake feed almost entirely upon plankton crustacea. An occasional midge larvae and some flying ants during the spring are other items appearing in the diet, however, they constitute only a very small percent of the total food consumed.

Leptodora, Bosmina, Daphnia, Cyclops, and Diaptomus were the plankters constituting the bulk of the diet. Cyclops, Bosmina, and Diaptomus were most abundant in the diet in the spring and early summer, while Daphnia and Leptodora were the most abundant forms after August 1 (Table 37)-Stross (1954) found the same type of occurrence in kokanee stomachs collected from Pend Oreille Lake,

The food consumption of Pend Oreille Lake kokanee was four times greater in May than in April and twenty times greater by late July (Stross, 1954). The increase of food consumption coincides with increasing temperature and the increasing abundance of Daphnia.

Daphnia constitutes only a small portion of the total number of plankton crustacea present, even in late summer when it reaches its

Figure 44. Seep area near mouth of Granite Creek. Note how water seepage keeps area ice free.

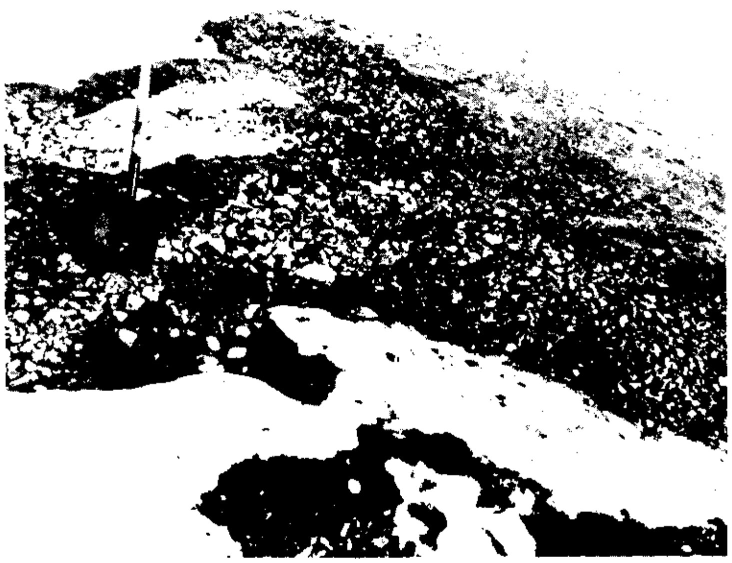


Figure 47. Kokanee nest exposed after drawdown containing dead eggs. Even though located in seep area the eggs were killed.

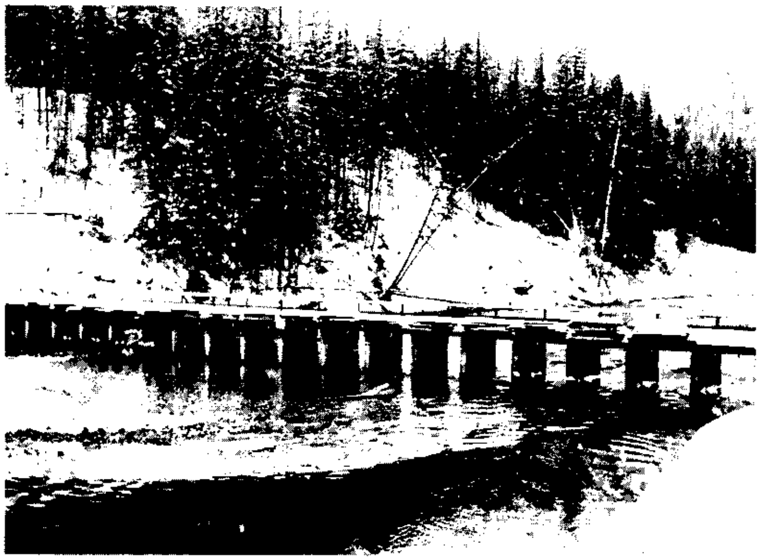


Figure 48. Present outlet control structure during low water level in winter.

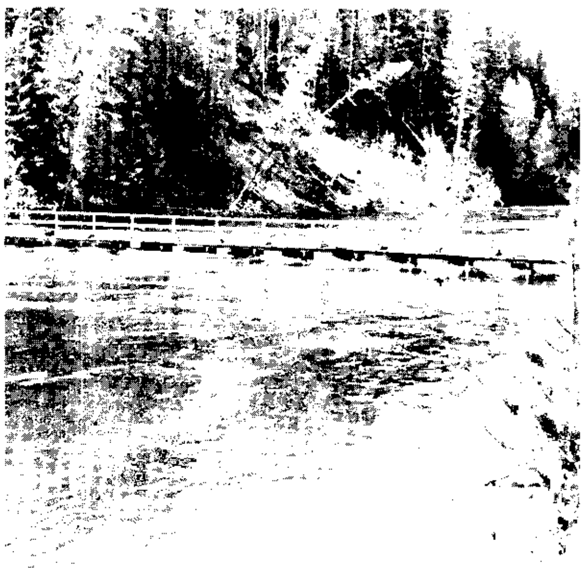


Figure 49. Present outlet control structure during high water level in spring.

Table 37. Percentage abundance of various plankters found in stomachs of kokanee taken from Priest Lake, 1956.

Date collected	Area of lake	Number of fish	Percentage of various plankters in stomach: Bosmina	Daphnia	Cyclops	Diaptomus	Leptodora	Other
6/17/56	5	10	18	tr	41	41	--	--
6/18/56	1	2	--	--	100	--	--	--
6/30/56	5	9	tr	65	12	23	tr	--
7/15/56	1	10	tr	81	5	14	tr	--
7/17/56	2	10	tr	55	4	29	9	3
8/1/56	3	8	tr	78	--	tr	22	--
8/17/56	2	3	tr	89	1	--	10	--
8/17/56	3	4	tr	86	--	1	13	--
8/18/56	3	7	tr	85	1	tr	14	--
9/6/56	3	9	tr	99	--	tr	1	--
10/1/56	3	11	tr	95	tr	5	tr	--
10/15/56	3	10	tr	97	--	tr	3	--

peak density (Figure 50). However, this form constituted a major portion of the food consumed throughout the season. Stross stated that factors causing the actual or apparent preference for Daphnia might be: (1) conspicuousness because of larger size and hopping habit in swimming, or (2) a greater natural abundance than that recorded. Ricker (1937) found sockeye in Cultus Lake to eat much the same type of food and stated that relative abundance of the various organisms seemed to be important although size was too. Selection of various plankters by kokanee while feeding was further demonstrated by the extreme variations in qualitative composition found in stomachs taken from fish collected from the same local area. Ricker and Stross also encountered the same situation at Cultus and Pend Oreille Lakes.

The growth rate of kokanee in Priest Lake, especially the older age classes, increases markedly after August 1 (Figure 51). This increase is probably due mainly to the increase in abundance of Daphnia that takes place at this time. As can be seen in Figure 51, kokanee in their third year of life, unlike the older fish, did not respond to the increased density of Daphnia. As explained by Ricker (1937) the smaller sockeye utilized Cyclops and Bosmina more than the larger fish. Since the principal food of sockeye and kokanee are the same (Ricker, 1940) the fact that smaller fish feed more on the smaller plankton forms may be an explanation.

Discussion of factors affecting the production, size, harvest, and mortality rate of kokanee. In the following discussion reference is made frequently to work done with the anadromous sockeye salmon. Although the sockeye and kokanee life cycles are not identical throughout life, the first two and in some instances three years are very similar. It is because of this similarity in food habits, environmental requirements, and movements during lake residence that reference is made to the sockeye.

The sockeye salmon migrates from its nursery lake after a period of residence, making possible the trapping and enumeration of the population. Kokanee in many instances do not at any time during their life leave the lake. Many kokanee are hatched in the shoal areas and spawn in the shoal areas, thus eliminating the most practical method of capturing and enumerating the population. For this reason, a study of the kokanee production in large lakes must be accomplished through indirect methods such as catch per unit of effort, growth rates, growth increments, and total lengths.

Actual management of a kokanee population is hard to achieve because of the lack of control over the factors controlling the population. Even the regulation of the harvest is ineffective in many cases as the creel limits and seasons do not regulate the number of fish taken.

It is common belief that the catch and spawning escapements of kokanee are composed chiefly of one age class. In many lakes in certain years this is the case. However, there is evidence that points to changes from year to year in the relative abundance of the various age classes represented in the catch and spawning escapements. For example, the catch of kokanee from Upper Priest Lake in 1955 was composed predominantly

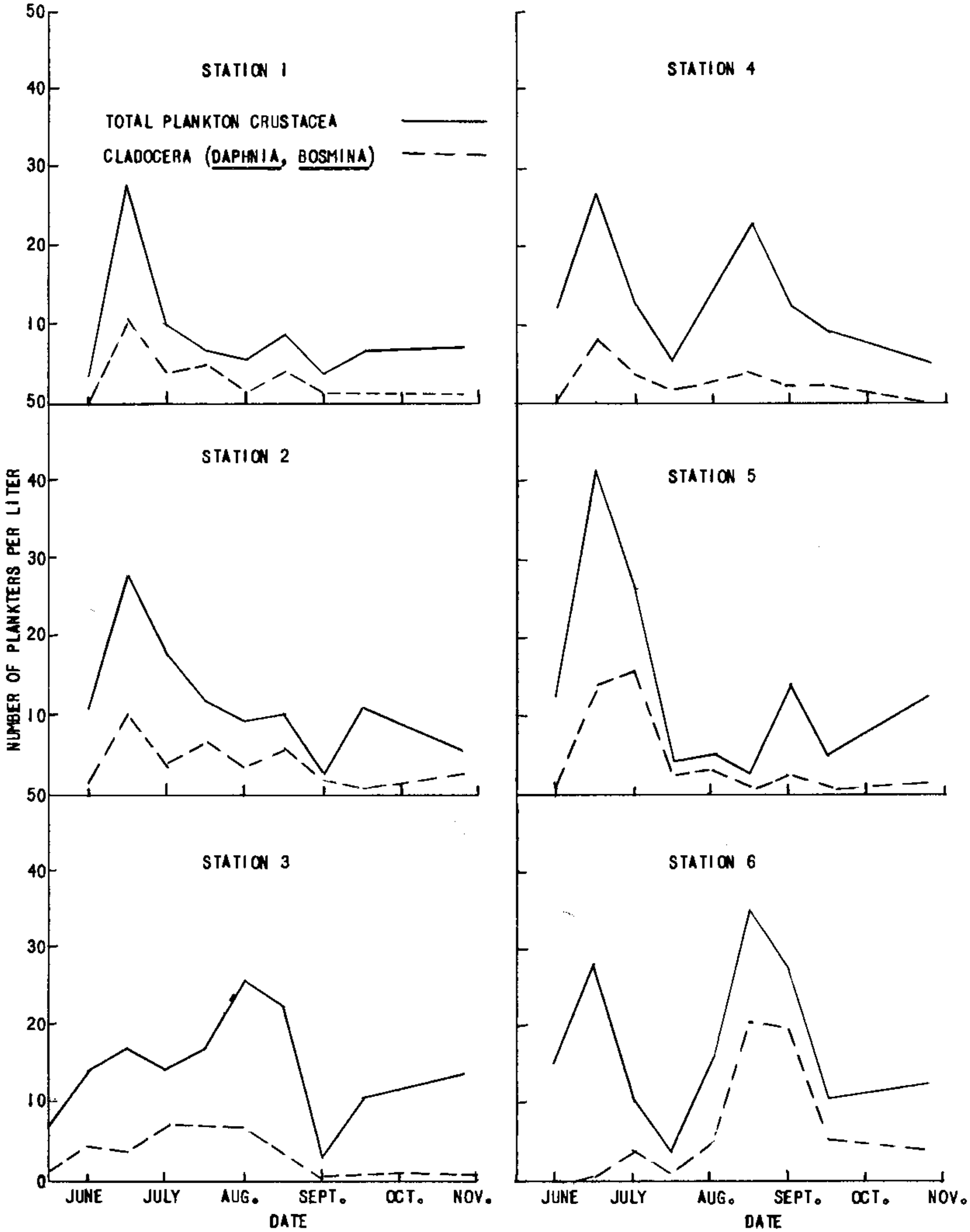


Figure 50. The total number of plankton crustacea per liter as compared to the number of cladocera (Daphnia and Bosmina) recorded in Priest and Upper Priest Lakes, 1956.

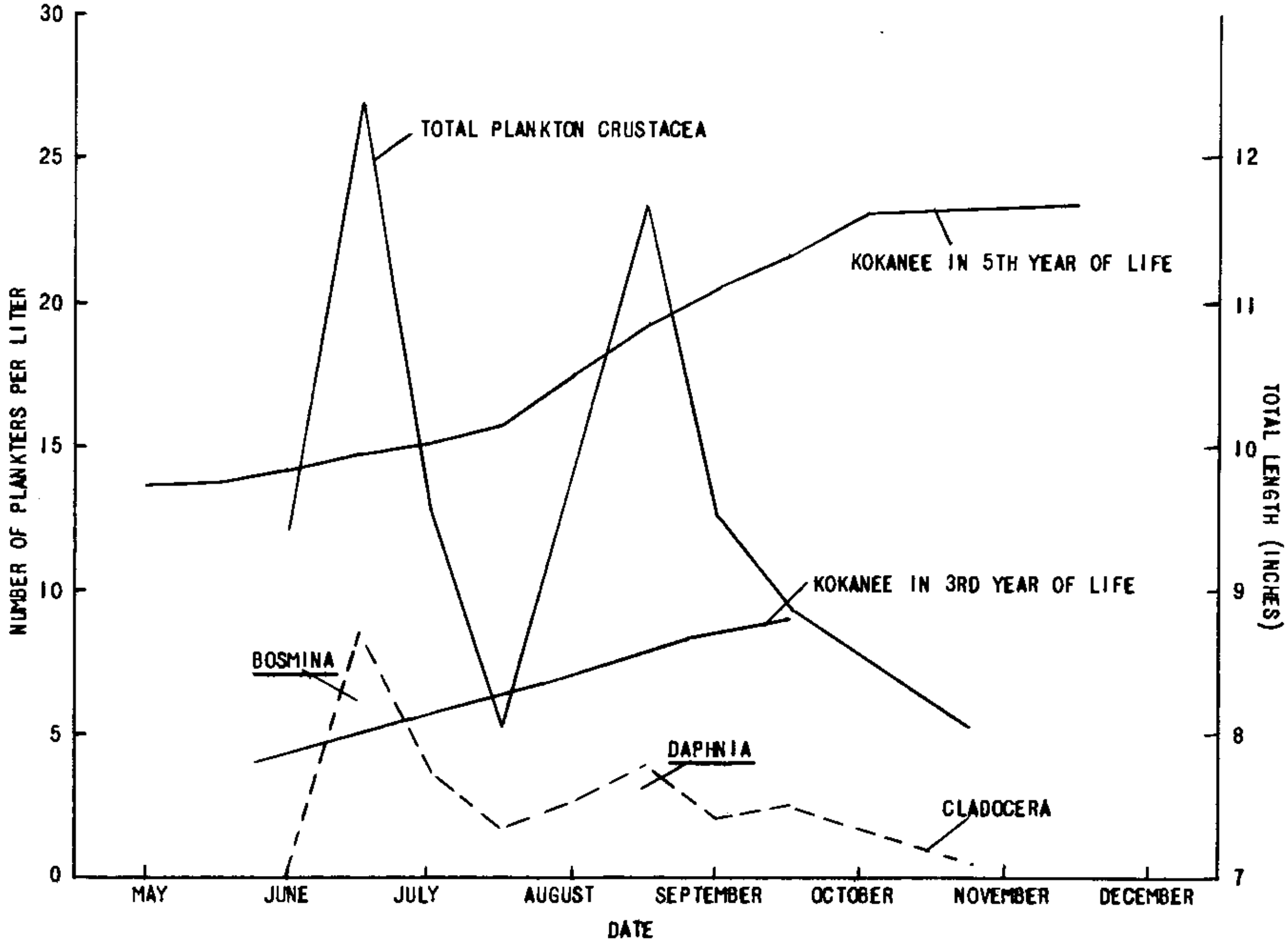


Figure 51. Growth of kokanee in relation to the plankton numbers found at Station 4 on Priest Lake, 1956.

of fish in their fifth year of life. In 1956 the composition of the catch had changed so that age classes II, III, IV, and V were represented in almost equal proportions. In contrast, the Priest Lake catch and spawning escapements in both 1955 and 1956 were composed chiefly of fish in their fifth year of life. Pend Oreille Lake kokanee may have changed in the last decade. Studies of collections made in 1951 revealed a harvest of predominantly age class III fish. Collections made and analyzed in 1956 indicate that age class IV fish were the most abundant fish in the catch. This shift in age class composition also occurs in the catch of anadromous sockeye. The run ascending the Smith River in British Columbia is given as an example. In 1952, 52 fish made up 91 percent of the catch and 42 fish 8 percent.[1] In 1953, 52 fish made up only 10 percent of the catch with 42 fish making up 89 percent (Foskett, 1953, 1954).

These shifts in age class composition are a desirable condition in kokanee populations as they prevent violent fluctuations in the population numbers from year to year. The shifts do complicate the study of the population and its trends however.

Production rates have not been computed for kokanee populations, however, some of the rates computed for sockeye salmon during their fresh water residence are probably applicable and can be used to obtain an idea of the mortality that takes place during various stages of the kokanee life cycle. Neave and Foerster (1955) found that losses to sockeye occurring from spawning, incubation, fry, emergence, and passage from the hatching area to the lake amounted to approximately 90 percent of the eggs available for deposition. Losses occurring to fry during the first year in the nursery lakes amounted to approximately 85 percent of the fish entering. A value of 1.42 percent of the eggs deposited was determined as the production value of sockeye to the smolt or migrating stage. Once the sockeyes leave the lake the mortality rates are not comparable with those of the kokanee although they may be of the same general magnitude. Foerster (1945) reports that the survival value of 0.2 percent from eggs to adults was found for sockeye in both Karluk and Cultus Lakes. Production values for kokanee would seem to be somewhat higher because of their lake residence throughout life; however, no conclusion can be reached at this time.

It appears that fish predators account for most if not all of the kokanee that die in the Priest Lakes. Ricker and Foerster (1948) indicate that this may be the case with sockeye in Cultus Lake. As explained by Ricker (1952) the number of kokanee eaten by predators in the Priest Lakes is proportional to the abundance of predators and to the abundance of the kokanee. Ricker further explains that this type of predation can occur for long periods of time and the prey species may compose large portions of the predators annual ration.

The occurrence of disease and parasitism in the Priest Lakes' kokanee appears to be very slight and is probably not a direct cause of mortality.

e subscript number indicates *the* year the fish migrated to the ocean. For example, a 52 fish migrated to the ocean in its second year of life and matured in its fifth year, For the kokanee, intraspecific competition for food, space, and spawning site is probably greater than interspecific competition. Although intraspecific competition probably does not result directly in a fish's death, it does appear to affect the fish's food consumption and growth rate. Foerster (19144) found a statistically significant inverse correlation between the size of the lake population of sockeye and the size of the migrants. In Priest and Upper Priest Lakes there have been significant differences in the growth rate from one year to another. It is possible for these differences to be due to changing productivity in the lake, however, changes in fish population densities are a much better explanation. A study of the relationships between population density and size of fish is complicated by the large number of age classes present and their schooling habits. The effect one age class has on another is not known. Food habits of all the age classes are almost identical. There appears to be a difference in the schooling behaviors of the various age classes. Age class I fish were observed in relatively compact schools, while the fact that adult fish could be caught almost anywhere in the lake indicates a very loose schooling, if any at all in the older age classes.

The differences in growth rate due to differences in density can be illustrated by comparing kokanee from Priest and Upper Priest Lakes (Figures 52 and 53). The catch of kokanee per hour in Upper Priest Lake is much lower than that for Priest Lake, indicating a lower density in the upper lake. The growth increments for the first two years are similar. The large difference is found in the growth during the third year of life. Statistical significance tests indicate that a difference of five or more millimeters is sufficient to be significant at the 95 percent level. Therefore, not only are many of the differences in growth increments between years of life significant but so are many of the differences within various years of life. As can be seen in Figures 40 and 41, there are differences between year classes in the increment of growth attained during a particular year of life. Most differences of five millimeters or more are statistically significant. Assuming that the productivity of the lakes were to remain relatively constant, these differences could be due to differences in population densities.

Changes in the average size of spawning fish also indicates changes in population density. The spawners in 1956 were nearly an inch longer than the 1955 spawners and it has been reported that the 1955 spawners were larger than the 1954 fish. Age and growth studies indicate that the spawners in 1957 should be larger than the 1956 fish. Should such a trend continue, a decline in the catch per unit of effort should appear, assuming that the differences in size are due to density and that the catch per unit of effort is a valid measure of density.

At present there appears to be two factors capable of causing significant changes in population density: (l) lake drawdown after spawning and (2) spawn taking activities (Figures 54, 55, and 56). The year of worst drawdown occurred in 1951. With a five year cycle fish the 1956 harvest would be affected if the drawdown caused any significant losses. Both the rate of catch and harvest were at least as good as for 1955, indicating the losses were not large enough to

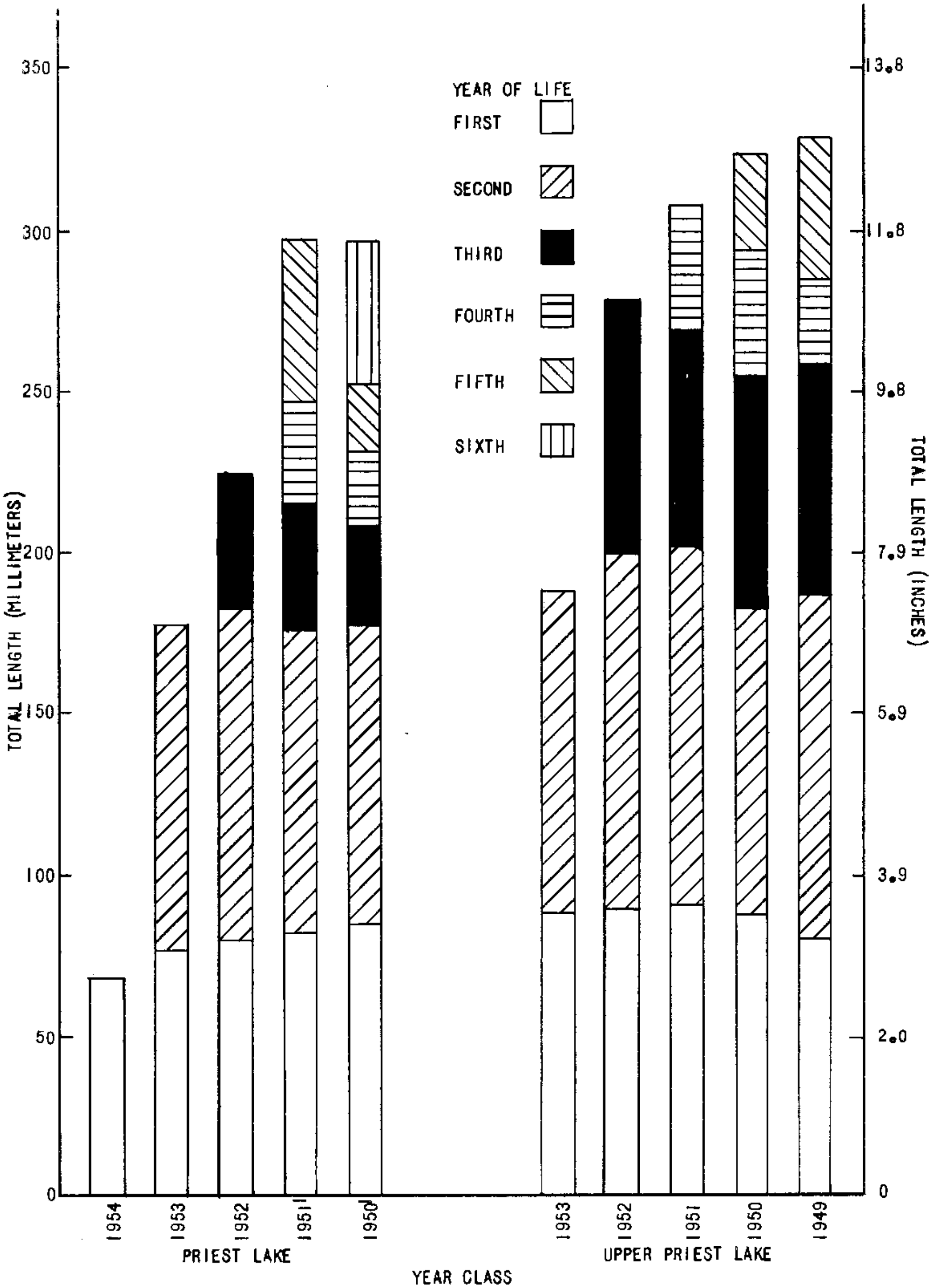


Figure 53. Growth of various year classes of Priest and Upper Priest Lake kokanee.

[1]Increments during the last year of life are from measurements of empirical lengths.

Figure 52. Relative sizes of age class IV kokanee from Priest Lake (smaller fish) and Upper Priest Lake (larger fish), 1956.

Figure 54. Seining mature kokanee from shoal areas of Priest Lake for spawn taking purposes.

Figure 55. Capturing the seined kokanee that will be stripped of their reproductive products.

Figure 56. Mature kokanee illustrating the marked change in body form and coloration that occurs in males.

affect the harvest. However, approximately 50,000 kokanee were planted in the lake in 1951 so that the real effect of the drawdown may not be known.

Kokanee spawn has been taken only for the last three years; therefore, the effect, if any, on the population numbers is unknown. Because the average size of fish in the catch and spawning escapement was progressively larger each year since 1954, and it appears that the fish caught in 1957 will be still larger, changes in the population density or productivity of the lake or both must be occurring.

The 1956 spawning escapement contained a few age class V fish in addition to the age class IV fish. These age class V fish were not significantly different in size from the age class IV spawners and led to the conclusion that those fish that did not mature at the end of their fifth year in 1955 were the smaller individuals in the year class. The average length of spawners in 1955 was approximately 0.8 of an inch longer than fish of the same age that did not spawn (Figure 57). This observation would lead one to believe that the size of fish might have some influence on its time of maturation. On the other hand, the fact that Upper Priest Lake kokanee are 2 to 4 inches longer than the Priest Lake fish at spawning, even though the same age, tends to indicate that size has little influence on the maturing of kokanee.

During the course of the investigation it was felt that there might be differences in the size of kokanee from various areas of the lake. Johnson (1956) found that young sockeye were not distributed evenly throughout the lakes he studied. Because of this uneven distribution he felt that the fish were not fully utilizing the food resources present and thus there may have been a significant effect on their size. Samples were taken in each of the four areas of Priest Lake (Figure 7) and statistical tests performed. Even though differences of approximately 0.2 of an inch would have been significant at the 95 percent level, age class IV fish caught in different areas of Priest Lake did not differ significantly in average size (Table 38).

In an attempt to determine what factors might cause the changes in catch per hour that occur during the season, values for surface water temperatures and for plankters per liter were plotted against the catch per hour (Figure 58). It appears that plankton density in the epilimnion has little effect on the rate of catch. Temperature of the surface waters on the other hand exhibits an inverse relationship. As the water reaches its peak temperatures the rate of catch declines to its lowest point. As the waters cool in the fall, the rate of catch increases. In the spring and fall kokanee are caught next to the surface. Fishermen have little difficulty finding the right depth to fish. As the water temperature becomes warmer than that desired by the kokanee they seek deeper waters. Accordingly, the fishermen, to be successful, must also seek deeper waters. Many times the author and others were able to catch fish in the middle of the summer at a rate comparable to that found in the spring and fall by fishing at a depth of 30 to 40 feet (top of the thermocline). Because it was possible to catch kokanee at a fast rate in mid-summer, it was concluded that the decreased rate of catch was due in part at least to fishermen not knowing at what depth to fish. Although many anglers

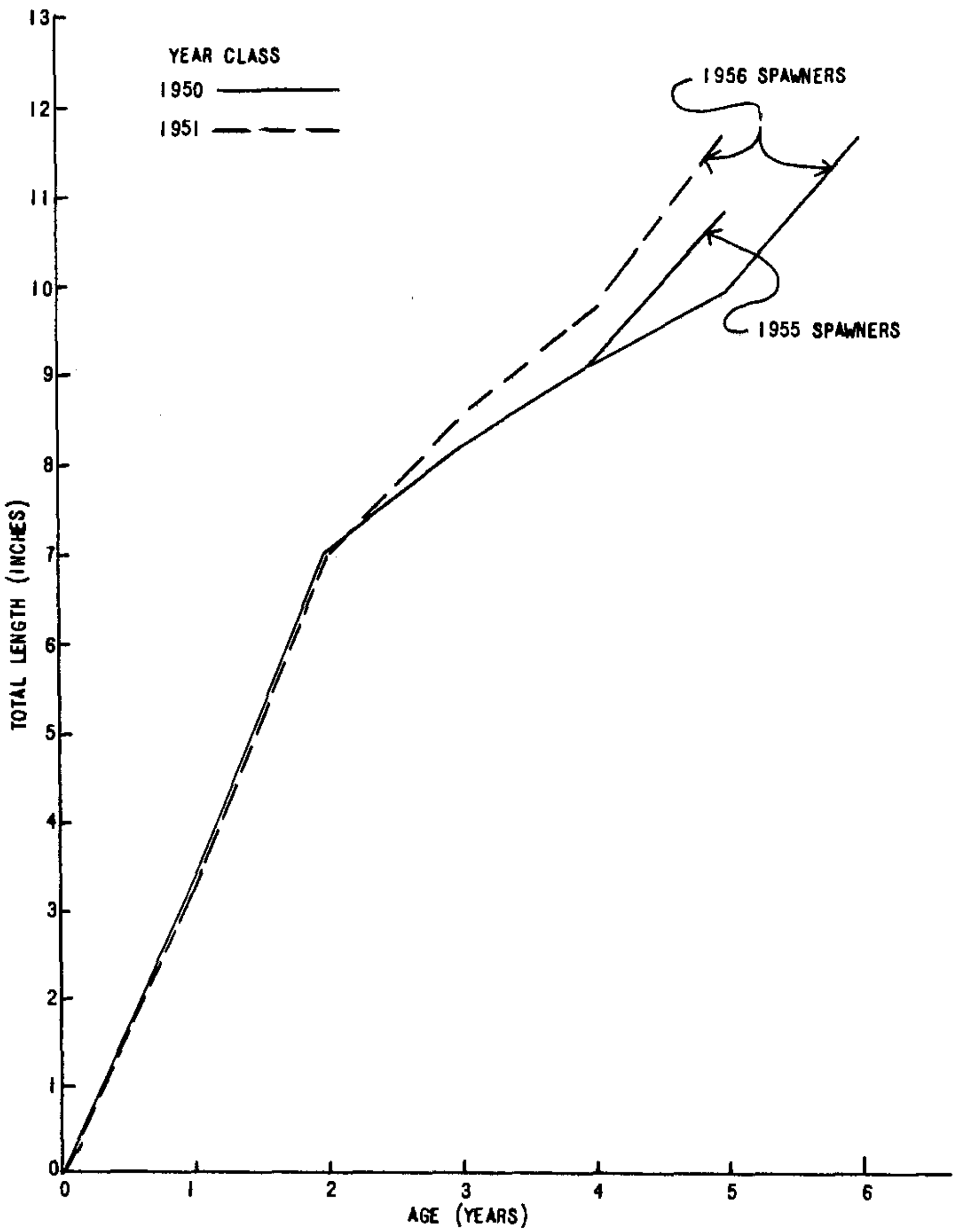


Figure 57. Age and growth of 1955 and 1956 spawning fish in Priest Lake.

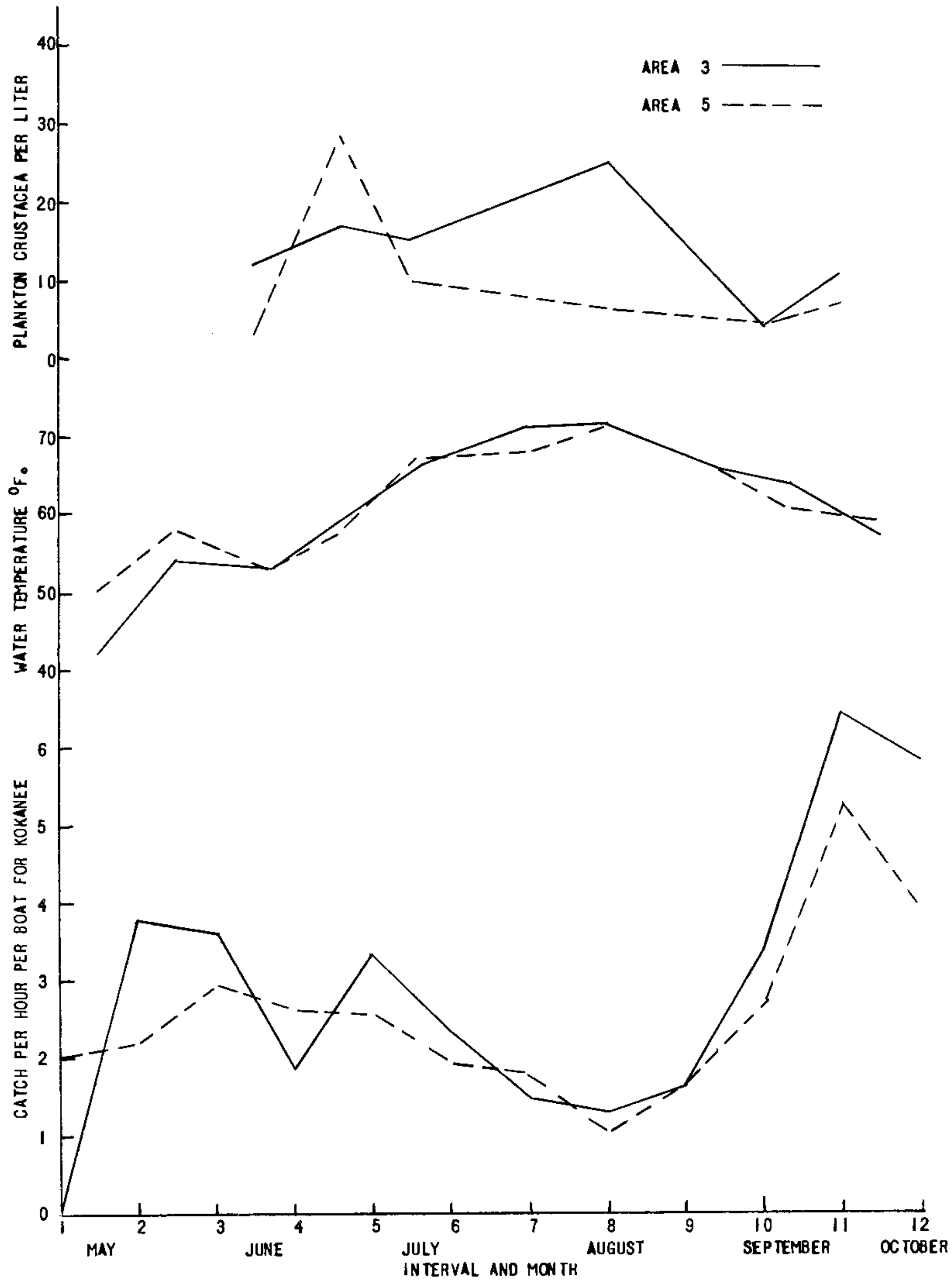


Figure 58. Water temperatures in the epilimnion, and plankton crustacea per liter in epilimnion in relation to catch per hour per boat for kokanee, in Priest Lake.

Table 38. Mean weights and total lengths of kokanee collected from the four areas of Priest Lake in 1956.

Date[1] collected	Area[2]	Sex[3]	Length (inches) Number	Length (inches) Mean	Weight (grams) Number	Weight (grams) Mean
May 15	all	C	32	9.72	--	--
June 1	5	C	20	9.84	20	124.1
	2[4]	C	66	9.74	--	--
	2[5]	C	38	9.70	9	121.1
	3	C	39	9.73	37	120.6
	all	C	163	9.73	66	121.8
June 15	3	C	20	9.82	15	127.6
	5	C	43	9.80	43	130.1
	all	C	63	9.81	58	129.4
July 1	3	C	80	9.92	26	136.8
	5	C	67	9.99	--	--
	all	C	147	9.95	26	136.8
July 15	2	C	81	10.01	22	148.4
	3	C	14	10.09	14	132.6
	4	C	31	10.00	12	137.8
	all	C	126	10.01	48	141.2
August 1	3	C	57	10.10	55	148.8
	5	C	14	10.23	14	159.4
	all	C	71	10.13	69	151.0
August 15	3	C	49	10.54	34	169.4
	4	C	14	10.46	9	180.4
	5	C	17	10.44	10	171.8
	all	C	80	10.50	53	171.7
September 1	3	C	74	10.87	69	179.3
	4	C	32	10.83	--	--
	5	C	30	10.74	21	181.4
	all	C	136	10.83	90	179.8

[1]All samples were collected within a two or three day period of the date listed.

[2]See Figure 7.

[3]C = sexes combined, F = females, M = males.

[4]Lion Bay.

[5]Twin Islands.

Table 38 continued.

Date collected	Area	Sex	Length (inches) Number	Length (inches) Mean	Weight (grams) Number	Weight (grams) Mean
September 15	2	C	67	11.13	14	206.4
	3	C	53	11.13	10	206.7
	4	M	51	11.14	50	209.2
		F	22	10.81	20	192.9
	5	M	50	11.09	32	207.0
		F	15	10.91	8	196.0
	all	C	258	11.08	134	205.0
October 1	3	M	140	11.37	140	217.6
		F	86	11.09	86	209.4
		C	226	11.26	226	214.5
October 15	3	M	19	11.73	--	--
		F	10	11.37	--	--
		C	29	11.61	--	--
December 1	3	M	132	11.80	108	218.5
		F	84	11.42	63	181.7
		C	216	11.65	171	204.9

had a fair idea of the best depth at which to fish, their success was poor because they were not fishing at the depth they had thought they were.

It might be noted that commercial fishermen attempted to handline on Priest Lake during 1956. However, they were not able to catch fish at a faster rate than the sport fishermen.

Rocky Mountain Whitefish

Although there are thought to be three species of whitefish in Priest Lake, the Rocky Mountain whitefish was the only species encountered during this investigation. Gill net set catches indicate that whitefish are present in fair numbers (Appendix II) in Priest and Upper Priest Lakes, however very little effort is expended to catch them and therefore the harvest is almost nil.

The food habits of the Rocky Mountain whitefish are varied, with plankton crustacea and insects making up the major portions of the volume (Table 39). A comparison of whitefish and kokanee food habits reveals the possibility of sharp competition for food. Whitefish stomachs collected in December were found to contain kokanee eggs, indicating that predation is present but it is not believed to be significant.

Table 39. Stomach contents of 15 whitefish caught from Priest Lake during 1956.

Organism	Occurrence	Amount milliliters	Average amount milliliters	Percent volume
Hymenoptera	1	0.2	0.2	8
Hemiptera	1	0.1	0.1	4
Plecoptera	1	0.2	0.2	8
Tricoptera	1	0.1	0.1	4
Unidentified insects	1	0.5	0.5	21
Daphnia	7	1.4	0.2	55
Leptodora	1	tr	tr	-
Empty	4			

Growth rates of kokanee and whitefish are somewhat similar as both species are fall spawners and juveniles of both fish reach a length of 3 to 4 inches by the end of the first year. Growth after the first year is variable, but in general, the growth of the whitefish is similar to that of the kokanee.

Before the introduction of the kokanee, whitefish were considered very abundant and dipping with nets was allowed on the spawning streams. The whitefish numbers have declined markedly in recent years and it appears that competition with the kokanee for food, space, and possibly even spawning area have been the major causative factors.

The Rocky Mountain whitefish in Priest Lake appears to inhabit much the same areas of the lake as do the kokanee during the first year. It was not uncommon to find yearling whitefish and yearling kokanee in the same predator stomach, an occurrence that might indicate that the two fish school together during the first year. Older whitefish tend to stay close to shore and do not school in the open water like the kokanee.

Whitefish make up a large portion of the diet of Dolly Varden in Upper Priest Lake and a significant portion of the diet of Dolly Varden in Priest Lake (Tables 31 and 32). The difference in the percentage volume of whitefish consumed in the two lakes probably reflects the differences in levels of abundance of the kokanee between the two lakes. Priest Lake has a higher density of kokanee than Upper Priest Lake and a higher percentage of kokanee found in the predator stomachs. Upper Priest Lake has a lower density of kokanee and apparently a higher density of whitefish than Priest Lake.

The decline of the whitefish cannot be looked upon with much alarm or regret, as the harvest was limited mostly to the netting of the fish out of the streams at spawning time. The kokanee must certainly be considered the more valuable of the two species. Because the whitefish is also a competitor with the cutthroat for food and space it appears advantageous to have their numbers reduced.

Largemouth Bass and Sunfish

The largemouth bass and one or two species of sunfish are present in Priest Lake, but contribute very little to the total fishery of the lake. Although fair sized bass (up to 5 to 6 pounds) are relatively common in the south end of Priest Lake and other weedy shoal areas, only a small amount of effort by local residents is expended to catch them. The abundance of forage fish in the shoal areas provides ample feed for the bass but the amount of growth is limited by a relatively short growing season. Fish in their fifth year of life were found to be approximately 13 inches in length. Because the bass is highly piscivorous it is possible that they do take some trout; however, the bulk of their diet seems to consist of non-game species.

Neither bass nor sunfish were collected from Upper Priest Lake during the course of this investigation. If they are present in the upper lake their numbers are very small.

Non-Game Fish

The squawfish, Columbia River chub, sucker, and redside shiner are the most abundant non-game fish collected in the lake. They are an important factor in lake production because they compete with and sometimes prey upon the game fish species of the lakes.

The squawfish is the most notorious non-game fish present and receives its reputation from its fish-eating habits. Ricker (1911), Chapman and Quistorff (1938), and Taft and Murphy (1941) all reported fish as an important part of the squawfish diet. Squawfish in Priest Lake eat fish, but apparently only to a limited extent (Table 40). Ricker (1941) found sockeye salmon fry to be the most important food of squawfish more than 100 millimeters long, except from May to September, during which period the squawfish in the shoal areas eat coarse fish (shiners and sticklebacks), terrestrial insects, and plankton. Ricker points out that the number of sockeye consumed per individual squawfish is lower than that of salmonid predators, but because of the large number of squawfish, their effects on reducing the sockeye production were quite significant. In fact, after reducing the number of squawfish (more than 200 millimeters in length) and Dolly Varden to approximately one tenth their original abundance, the mean survival rate of sockeye was increased 3 1/3 times over conditions present prior to predator control (Foerster and Ricker, 1941).

As shown in Table 40, squawfish in Priest Lake, like those in Cultus Lake, feed a great deal upon insects from June through September. No stomachs taken from squawfish in Priest Lake contained recognizable fish or fish remains. However, a few squawfish stomachs examined from Upper Priest Lake did contain small fish (thought to be shiners), and large (12 to 16 inches) squawfish were captured occasionally as they attempted to swallow 7 to 8 inch whitefish caught in the gill nets.

Table 40. Stomach contents of 35 squawfish collected from Priest Lake during 1956.

Organism	Occurrence	Amount milliliters	Average amount milliliters	Percent volume
Unidentified insects	7	1.6	0.23	36
Ephemeroptera	2	0.1	0.05	2
Coleoptera	1	0.3	0.3	7
Crustacea (plankters)	1	0.1	0.1	2
Plant	10	2.4	0.24	53
Empty	24			

Ricker (1938b) found that the growth period of young squawfish in Cultus Lake was limited probably by temperature to June through September. The temperatures in Priest Lake and Upper Priest Lake are also low enough to restrict growth of most species to the period of May through September. Accordingly the amount of food consumed is low from October to May and indicates that the predatory habits of the squawfish may be very limited in Priest and Upper Priest Lakes.

Competition for food and space seem to be the most important relationships between squawfish and the game fish species. Ricker (1938) came to the conclusion that young squawfish and young sockeye salmon feed on much the same food,(plankton Entomostraca) but that their different habitats during the feeding periods the former inshore, the latter in open water, keep them isolated and prevent competition. The same situation occurs in Priest and Upper Priest Lakes except that schools of young kokanee were observed occasionally to feed close to shores thus creating the opportunity for some competition. The competition between trout (and other shoal dwelling species) and squawfish for both food and space would seem to be more acute than between squawfish and kokanee. The food habits of cutthroat, squawfish, and whitefish are quite similar and a reduction in the number of squawfish along with the other shoal dwelling species (shiners, peanose, suckers) might increase the production of cutthroat.

The value of minnows in lakes has been questioned by numerous authors. including Larkin and Smith (1954), Vernon (1956), and Burdick and Cooper (1956). The redside shiner, if not already present, was introduced into many lakes as a forage fish for the trout. The results, in general, were the opposite of that intended, as a decrease in the production of trout usually took place. Burdick and Cooper found that good growth was possible without the presence of shiners in the diet, even though trout were found to feed on them to some extent. The shiners were probably endemic to Priest Lake so that the competition for food that takes place between the shiners and small trout was present when the cutthroat population was in fairly good condition. Cutthroat in Priest Lake derive little benefit from the shiners as they do not appear to eat fish, at least only rarely. The Dolly Varden and mackinaw, especially the smaller individuals, may feed on the shiners to a large extent.

The peanose and sucker also compete with the trout species for food and probably space, thereby helping to reduce the production of game fish in the lakes. The diet of the peanose is mostly insects.

Effective control of the squawfish and other rough fish populations is probably economically impossible in a lake the size of Priest Lake. Attempts to reduce the number of suckers in Pyramid Lake, Alberta, (320 acres) were made with no improvement in the survival of rainbow trout (Rawson and Elsey, 1950). Foerster and Ricker (1941) were successful in reducing the number of squawfish and Dolly Varden in Cultus Lake (1,550 acres) through gill netting and trapping, however, the much larger size of Priest Lake (approximately 24, 000 acres) would probably make such an operation economically unfeasable. A problem is also encountered in trying to remove only the undesirable species and not the game fish. The gill nets are not selective. However, this problem could be partially eliminated if netting were limited to the time of year when surface waters are too warm for trout species.

SUMMARY

1. In 1955, a survey of the fishery resources of Priest and Upper Priest Lakes and their tributaries was initiated. The main purpose of the study was to determine the factor or factors causing the decline in the cutthroat numbers in the lake. In addition, information on the other major species of fish present was also obtained.

2. Priest and Upper Priest Lakes, situated in the Selkirk mountain range, have a coniferous forest covered watershed of approximately 600 square miles. The northern tip of the upper lake is 15 miles south of the United States and Canadian border. Priest Lake is 18,5 miles long and 4.5 miles wide with a surface area of about 24,000 acres. Upper Priest Lake is 3.2 miles long and 1 mile wide with a surface area of about I,900 acres. The maximum recorded depth in Priest Lake was 355 feet and 98 feet in the upper lake.

3. A permanent thermocline was established in most areas of Priest and Upper Priest Lakes by the middle of July. During the late summer, the epilimnion extended to depths of approximately 35 feet and the thermocline to depths of 45 to 55 feet. The lakes were nearly homothermous by the middle of November. The surface temperatures of Upper Priest Lake were constantly lower than those found in Priest Lake,

4. Dissolved oxygen was abundant at all depths. The total alkalinity or total hardness in Priest Lake was approximately 23 p,p.m,

5. The dominant forms of zooplankton collected were <u>Diaptomus</u> sp., <u>Cyclop</u> sue., and <u>Bosmina</u> sue. present in measurable number throughout the summer and fall, and <u>Daphnia</u> sp.. which did not become numerous until late July.

6. Spawning area for cutthroat and Dolly Varden was adequate in the streams tributary to the lakes. Natural falls, beaver dams, and log jams are numerous on many streams.

7. The estimated catch of fish from Priest and Upper Priest Lakes amounted to 93,300 in 1955 and 111,400 in 1956. Approximately 68 800 hours were fished in 1955 and 103,900 in 1956. of the hours fished in 1956, 81 percent were expended to catch kokanee, 10 percent cutthroat, and 9 percent Dolly Varden and mackinaw. Of the total catch in 1956, kokanee constituted 93 percent (103,800), cutthroat 5 percent (5,500), and Dolly Varden and mackinaw 2 percent (2,100).

8. Resident fishermen expended 23 percent of the effort compared with 77 percent exerted by non-residents. Approximately 34 percent of the hours fished were expended by fishermen staying in private cabins and the remaining 66 percent by anglers staying at resorts or public camp grounds.

9. The average rate of catch for the 1956 season for kokanee in Priest Lake was 2.46 fish per boat per hour. In the upper lake the rate was 0.86 fish per boat per hour. The average rate of catch for cutthroat in the upper lake was l.02 compared with 0.70 in Priest Lake.

10. The average size cutthroat caught from Priest and Upper Priest Lakes in 1956 were 11.l and 11.2 inches total length respectively.

11. The body-scale relationship of the cutthroat appeared to be approximately linear.

12. Juvenile cutthroat spawned from fish migrating from the lakes were found to spend an extended period of time in the streams before migrating to the lakes. Of the fish collected from Priest Lake in 1956, 38 percent spent two years in the streams before migrating, 57 percent three years, and 5 percent four years. For the upper lake, 6 percent migrated after their first years, 35 percent after their second, and 58 percent after their third.

13. The spawning season of cutthroat trout in Priest and Upper Priest Lakes begins in April and generally ends by July l. Upper Priest Lake fish appear to have a slightly later season than the Priest Lake fish. Cutthroat in the Priest Lakes mature predominantly during their fifth year of life. Some males may mature during their third year of life, while some fish may not mature until their sixth year. Only a very small number of fish ever spawn a second time.

14. The food of the cutthroat is mainly insects with some plankton. Fish are noticeably absent from the diet.

15. In streams where brook trout have become abundant the competition for food and space between brook trout and cutthroat is apparently very intense. There is some competition present in the lakes, however, it appears to be much less than in the streams.

16. An average of nearly 500,000 cutthroat per year, mostly fry, have been planted in the Priest Lake drainage for at least the last 10 years. The return to the creel of these plants was less than 1 percent if only the planted fish appeared in the creel, as the annual catch in 1955 and 1956 was approximately 5,000 cutthroat.

17. The Dolly Varden, a stream spawner, also remains in the stream for extended periods of time before entering the lakes. Once the fish enter the lakes growth is very good, with some fish attaining weights up to 25 pounds, Most fish appear to spawn for the first time during their fifth or sixth year of life. Kokanee are the major item in its diet in Priest Lake.

18. The mackinaw attains a very large size in Priest Lake (as much as 52 pounds) due mainly to the abundant kokanee which serve as an excellent forage fish.

19. The catch and spawning escapements of kokanee from Priest Lake during 1955 and 1956 were composed mainly of fish in their fifth year of life, The population in Upper Priest Lake varied, however fish in the fifth and sixth years of life were present.

20. The kokanee in Upper Priest Lake mature at the same age as the Priest Lake fish, however, they averaged about 3 inches longer in length. Growth of kokanee during the first and second years of life is nearly equal in the two lakes, but fish in the upper lake continue to grow at a fast rate during their third year of life while fish in Priest Lake grow at a slower rate.

21. The average length of spawning fish in Priest Lake has been increasing each year since 1954 and age and growth studies indicate that the fish in 1957 should be still larger.

22. Kokanee in Priest and Upper Priest Lakes spawn in November and December. In Priest Lake most of the spawning appears to take place on the gravel shoal areas of the lake.

23. *Daphnia* sue. constituted a major portion of the diet of the kokanee, even though it constituted only a small percentage of the total number of zooplankton present in the lake.

24. The squawfish, contrary to popular belief, apparently does not prey on any of the game fish species to any significant degree.

CONCLUSIONS

Priest Lake has a relatively low productive potential. The amounts of total dissolved solids are smaller and the plankton production appears to be less than that found in Pend Oreille Lake. However, since the number of cutthroat migrating to the lakes is greatly reduced because the juveniles remain in the streams for two to three years, it is believed that the lakes can support a larger population of cutthroat trout. This belief is strengthened by the fact that once they enter the lake growth is very rapid.

In order to increase the production of trout in the Priest Lakes the factors that are causing what appear to be abnormally high mortality rates must be removed or altered. Inducing the cutthroat to migrate to the lakes during their first year of life would increase production greatly. Assuming that there is competition between the brook trout and the cutthroat, the removal of the brook trout from those streams used for spawning by cutthroat from the lake would also increase production of cutthroat. Elimination of barriers such as falls, beaver dams, and log jams would also increase production. A reduction in the creel limit to three fish per man per day would probably insure survival of more fish to spawning age; however, an increase in production would not take place until the mortality rate of fish in the tributary streams is reduced. To obtain the maximum production possible all of these measures would have to be applied successfully.

Should conditions continue as they are, the cutthroat fishing will not get better and will probably continue to decline. The planting of hatchery fish will not support a good cutthroat fishery.

The kokanee fishery has become the most valuable fishery at Priest Lake. The population appears to be in good condition at the present time and able to support greater pressures than were present in 1955 or 1956. However, if the assumption that the size of the fish is related to population density is correct, there must have been a decrease in the number of fish produced sometime during the last five years as the average size of fish in the catch and spawning escapements has increased each year since 1954. Fish in their fifth year of life taken in 1957 will be still larger. Should the trend toward large fish continue, a point of population size will be reached that cannot support a harvest as large as that taken in 1955 and 1956. The reduction in numbers may have taken place in a year class that has not yet appeared in the fishery. Since food habits of the kokanee are almost identical regardless of age, it is possible for a decreased production in the number of young of the year to produce an increase in the amount of growth of all the older fish.

It may be that spawn taking operations and drawdown of the lake levels after spawning are having a more significant effect on the population than was formerly thought possible. On the other hand, the changes in population density that must be taking place may be due to a "natural cycle".

The Dolly Varden and mackinaw have, without question, benefitted from the successful introduction of the kokanee. Both species may be increasing in abundance. The present fishing pressures do not appear sufficient to harm the populations.

RECOMMENDATIONS

Since hatchery reared trout can never be stocked in large enough numbers to create good fishing in Priest Lake, a program designed to develop the potential natural production capacity of the lakes and streams should be undertaken. A project should be developed to return the streams solely to cutthroat production. Experiments should be conducted to determine if the Priest Lake cutthroat can be induced to enter the lakes earlier in life, preferably during their first year. If not, other strains of cutthroat or possibly other species of trout should be introduced in an attempt to obtain a fish which can utilize the full production potential present. The chances of creating a good cutthroat fishery through natural production, especially for a lake such as Priest with its abundant spawning area, are much better and less expensive if successful than through artificial methods.

Meanwhile, the kokanee, which produced better than 90 percent of the harvest in 1955 and 1956 should not be taken for granted. Even though a fish such as the kokanee is difficult to manage in a lake as large as Priest, the full effects of lake level drawdowns and spawn taking operations on production should be evaluated. Additional life history data should be collected to determine shifts, if any, of age class composition in the catch and/or spawning escapements. Information on the rate of catch should also be collected in order to determine if the harvest is holding up.

The majority of the cutthroat caught by anglers from the tributary streams appeared to be fish which would have eventually entered the lake. At first glance it would appear that fishing should be closed on all tributaries supporting cutthroat populations. However, in addition to the cutthroat taken, equal or larger numbers of brook trout are also harvested from many of the streams, thus helping to reduce the competition between the two species. If the streams are treated to remove the competition from brook trout then it appears that those tributaries supporting spawning runs from the lakes should be closed. Even though many of the streams contain resident populations in the upper reaches that should be harvested, the problem of enforcing a partial closure on a stream may force the sacrifice of the resident population harvest.

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APPENDIX I

CHECK LIST OF FISHES DISCUSSED

Common Name	Scientific Name
Cutthroat	Salmo clarkii
Dolly Varden (char)	Salvelinus mamay
Mackinaw (lake trout)	Salvelinus mamay cush
Brook trout	Salvelinus fontivalis
Kokanee (silver, blueback)	Oncorhynchus nerka kennerlyi
Rocky Mountain whitefish	Coregonus williamsoni
Columbia large scaled sucker	Catostomus macrocheilus
Columbia small scaled sucker	Catostomus columbianus
Columbia squawfish	Ptychocheilus oregonensis
Redside shiner	Richardsonius balteatus
Columbia River chub (peanose)	Mylocheilus caurinus
Largemouth bass	Micropterus salmoides
Green sunfish	Lepomis cyanellus
Sockeye salmon	Oncorhynchus nerka nerka

APPENDIX II

GILL NET SET RECORDS

Table 1. Number and percentage of total fish caught in experimental gill nets set at surface and in shoal areas of Upper Priest Lake during May and June, 1956. The nets were fished for a total of 482 net hours.[1]

Species	Number caught	Percent of total
Columbia River chub	75	63
Mountain whitefish	14	12
Dolly Varden	10	8
Cutthroat	8	7
Squawfish	7	6
Kokanee	4	3
Sucker (Catostomus)	1	1

Table 2. Number of fish caught in experimental gill nets set on the bottom in 30 to 60 feet of water at north end of Upper Priest Lake. Nets were fished 78 net hours from September 9 through 13, 1956.

Species	Number caught	Percent of total
Squawfish	27	39
Dolly Varden	18	26
Mountain whitefish	14	20
Columbia River chub	7	10
Sucker (Catostomus)	2	3
Cutthroat	1	1
Kokanee	1	1

Table 3. Number of fish caught in experimental gill nets set at surface and in shoal areas of Priest Lake in Bear Creek Bay and vicinity. Nets were fished 790 net hours from May 5 to June 24, 1956. Surface water temperatures did not exceed 55° to 57° F.

Species	Number caught	Percent of total
Columbia River chub	60	43
Squawfish	59	42
Mountain whitefish	9	6
Dolly Varden	8	6
Cutthroat trout	2	1
Brook trout	2	1
Mackinaw	1	less than 1
Kokanee	1	less than 1

Table 4. Number of fish caught in experimental gill nets set on the bottom in the thermocline of Priest Lake. Nets were fished 220 net hours from July 17 to September 17, 1956. Surface water temperatures 60° F. and above.

Species	Number caught	Percent of total
Squawfish	29	28
Mountain whitefish	24	23
Dolly Varden	21	21
Mackinaw	10	10
Kokanee	8	8
Sucker (Catostomus)	5	5
Columbia River chub	3	3
Cutthroat trout	2	2

Table 5. Number of fish caught in experimental gill nets set at surface and in shoal areas of Priest Lake during months of July and August. Nets were set 113 net hours.

Species	Number caught	Percent of total
Squawfish	64	52
Columbia River chub	34	27
Sucker (Catostomus)	19	15
Mackinaw[1]	4	3
Mountain whitefish	2	2
Largemouth bass	1	1

[1]These mackinaw were small fish (7 to 9 inches in length) and were feeding on small non-game fish.

Table 6. Number of fish caught in experimental gill nets set on the shelf directly east of Kalispell Island at a depth of 50 to 55 feet. Nets were set for 31 net hours during September, 1956.

Species	Number caught	Percent of total
Kokanee	8	40
Mackinaw	5	25
Dolly Varden	3	15
Squawfish	3	15
Sucker (Catostomus)	1	5

APPENDIX III

AGE AND CALCULATED LENGTH TABLES

Table 1. Mean calculated lengths and increments of length of cutthroat that entered Priest Lake after spending two years in stream. Collected 1956.

Age class	Total length at capture Inches	Total length at capture Millimeters	Number of fish	Calculated length at end of year of life (millimeters) 1	2	3	4	5
II	7.3	185	1	85	144			
III	11.4	290	17	90	145	276		
IV	13.3	338	10	95	155	274	333	
V	14.7	374	6	78	140	252	314	366
Grand average and total			34	89	147	271	326	366
Increments of growth				89	58	124	60	52
Equivalent total length in inches				3.5	5.8	10.7	12.8	14.4
Number of fish				34	34	33	16	6

Table 2. Mean calculated lengths and increments of length of cutthroat that entered Priest Lake after spending three years in stream. Collected 1956.

Age class	Total length at capture Inches	Total length at capture Millimeters	Number of fish	Calculated length at end of year of life (millimeters) 1	2	3	4	5	6
III	9.3	235	9	81	128	174			
IV	11.6	294	32	79	122	173	280		
V	13.8	351	8	83	141	194	292	345	
VI	14.8	376	2	86	124	169	270	327	371
Grand average and total			51	80	126	176	281	341	371
Increments of growth				80	46	50	105	54	44
Equivalent total length in inches				3.1	5.0	6.9	11.1	13.4	14.6
Number of fish				51	51	51	42	10	2

Table 3. Mean calculated lengths and increments of length of cutthroat that entered Priest Lake after spending four years in stream. Collected 1956.

Age class	Total length at capture Inches	Total length at capture Millimeters	Number of fish	Calculated length at end of year of life (millimeters) 1	2	3	4	5
IV	10.1	256	4	78	129	176	229	
V	13.0	330	1	75	116	157	197	310
Grand average and total			5	77	127	172	222	310
Increments of growth				77	49	46	50	113
Equivalent total length in inches				3.0	5.0	6.8	8.7	12.2
Number of fish				5	5	5	5	1

Table 4. Mean calculated lengths and increments of lengths of cutthroat that entered Upper Priest Lake after spending one year in stream. Collected 1956.

Age class	Total length at capture: Inches	Total length at capture: Millimeters	Number of fish	Calculated length at end of year of life (millimeters): 1	2	3
II	9.9	251	3	111	232	
III	12.5	317	3	100	214	309
Grand average and total			6	106	223	309
Increments of growth				106	117	95
Equivalent total length in inches				4.2	8.8	12.2
Number of fish				6	6	3

Table 5. Mean calculated lengths and increments of lengths of cutthroat that entered Upper Priest Lake after spending two years in stream. Collected 1956.

Age class	Total length at capture: Inches	Total length at capture: Millimeters	Number of fish	Calculated length at end of year of life (millimeters): 1	2	3	4
II	7.5	191	2	106	164		
III	11.1	283	16	97	147	279	
IV	13.0	331	17	99	147	269	326
Grand average and total			35	99	148	274	326
Increments of growth				99	49	127	57
Equivalent total length in inches				3.9	5.8	10.8	12.8
Number of fish				35	35	33	17

Table 6. Mean calculated lengths and increments of lengths of cutthroat that entered Upper Priest Lake after spending three years in stream. Collected 1956.

Age class	Total length at capture: Inches	Total length at capture: Millimeters	Number of fish	Calculated length at end of year of life (millimeters): 1	2	3	4	5	6
III	8.1	205	6	90	138	186			
IV	11.5	291	30	87	126	169	281		
V	13.5	343	13	90	129	172	277	334	
VI	15.4	390	2	95	137	183	295	368	390
Grand average and total			51	88	129	172	280	338	390
Increments of growth				88	39	44	110	59	22
Equivalent total length in inches				3.5	5.1	6.8	11.0	13.3	15.4
Number of fish				51	51	51	45	15	2

Table 7. Mean calculated lengths and increments of length of cutthroat collected from Kalispell Creek, near the mouth, in 1956.

Age class	Total length at capture: Inches	Total length at capture: Millimeters	Number of fish	Calculated length at end of year of life (millimeters): 1	2	3	4
II	4.2	106	2	71	106		
III	7.1	180	30	79	138	177	
IV	8.5	215	21	77	130	176	215
Grand average and total			53	78	134	177	215
Increments of growth				78	56	42	39
Equivalent total length in inches				3.1	5.3	7.0	8.5
Number of fish				53	53	51	21

Table 8. Mean calculated lengths and increments of length of cutthroat collected from Indian Creek in 1956.

Age class	Total length at capture: Inches	Total length at capture: Millimeters	Number of fish	Calculated length at end of year of life (millimeters): 1	2	3	4
II	5.2	131	2	92	130		
III	8.0	204	6	94	153	203	
IV	9.0	229	1	71	101	139	229
Grand average and total			9	91	142	194	229
Increments of growth				91	51	48	90
Equivalent total length in inches				3.6	5.6	7.6	9.0
Number of fish				9	9	7	1

Table 9. Mean calculated lengths and increments of length of cutthroat collected from Soldier Creek in 1956.

Age class	Total length at capture: Inches	Total length at capture: Millimeters	Number of fish	Calculated length at end of year of life (millimeters): 1	2	3
II	6.1	154	9	81	121	
III	7.8	197	2	84	122	162
Grand average and total			11	81	122	162
Increments of growth				81	40	40
Equivalent total length in inches				3.2	4.8	6.4
Number of fish				11	11	2

Table 10. Mean calculated lengths and increments of length of cutthroat collected from Lion Creek in 1956.

Age class	Total length at capture: Inches	Total length at capture: Millimeters	Number of fish	Calculated length at end of year of life (millimeters): 1	2	3	4	5
I	5.0	127	1	89				
II	6.7	170	5	101	152			
III	7.6	192	10	95	141	188		
IV	8.5	216	1	79	116	169	204	
V	10.8	274	1	112	159	206	265	274
Grand average and total			18	96	144	188	235	274
Increments of growth				96	45	44	47	39
Equivalent total length in inches				3.8	5.7	7.4	9.3	10.8
Number of fish				18	17	12	2	1

Table 11. Mean calculated lengths and increments of length of cutthroat collected from Two Mouth Creek above Camp 11 during 1956.

Age class	Total length at capture: Inches	Total length at capture: Millimeters	Number of fish	Calculated length at end of year of life (millimeters): 1	2	3	4
II	4.0	102	7	70	98		
III	5.5	140	10	76	109	134	
IV	6.9	174	4	82	120	148	171
Grand average and total			21	75	107	138	171
Increments of growth				75	32	26	23
Equivalent total length in inches				3.0	4.2	4.5	6.7
Number of fish				21	21	14	4

Table 12. Mean calculated lengths and increments of length of cutthroat collected from Two Mouth Creek below Camp 11 during 1956.

Age class	Total length at capture: Inches	Total length at capture: Millimeters	Number of fish	Calculated length at end of year of life (millimeters): 1	2	3	4
I	4.0	102	3	78			
III	7.4	187	9	94	148	187	
IV	8.3	210	10	85	132	172	210
Grand average and total			22	88	139	179	210
Increments of growth				88	51	40	31
Equivalent total length in inches				3.5	5.5	7.0	8.3
Number of fish				22	19	19	10

Table 13. Mean calculated lengths and increments of length of cutthroat collected from Kalispell Creek near the Washington-Idaho border during 1956.

Age class	Total length at capture		Number of fish	Calculated length at end of year of life (millimeters)		
	Inches	Millimeters		1	2	3
III	5.7	146	5	63	102	137
Grand average and total			5	63	102	137
Increments of growth				63	39	35
Equivalent total length in inches				2.5	4.0	5.4
Number of fish				5	5	5

Table 14. Mean calculated lengths and increments of length of cutthroat collected from Hunt Creek below falls during 1956.

Age class	Total length at capture		Number of fish	Calculated length at end of year of life (millimeters)			
	Inches	Millimeters		1	2	3	4
III	6.0	153	5	96	126	151	
IV	6.9	175	1	82	108	138	165
Grand average and total			6	93	123	149	165
Increments of growth				93	29	26	27
Equivalent total length in inches				3.7	4.8	5.9	6.5
Number of fish				5	5	5	1

Table 15. Mean calculated lengths and increments of length of cutthroat collected from the South Fork of Granite Creek during 1956.

Age class	Total length at capture		Number of fish	Calculated length at end of year of life (millimeters)	
	Inches	Millimeters		1	2
I	4.0	102	2	79	
II	6.1	156	9	86	128
Grand average and total			11	84	128
Increments of growth				84	42
Equivalent total length in inches				3.3	5.0
Number of fish				11	9

Table 16. Mean calculated lengths and increments of length of cutthroat collected from Blacktail Creek during 1956.

Age class	Total length at capture		Number of fish	Calculated length at end of year of life (millimeters)			
	Inches	Millimeters		1	2	3	4
II	4.8	123	3	81	117		
III	5.8	148	8	85	118	147	
IV	6.9	176	4	89	124	151	174
Grand average and total			15	85	119	149	174
Increments of growth				85	34	28	23
Equivalent total length in inches				3.3	4.7	5.9	6.9
Number of fish				15	15	12	4

Table 17. Mean calculated lengths and increments of length of cutthroat collected from Beaver Creek during 1956.

Age class	Total length at capture		Number of fish	Calculated length at end of year of life (millimeters)			
	Inches	Millimeters		1	2	3	4
I	4.0	102	1	85			
II	5.0	127	4	79	117		
III	6.1	155	4	82	119	155	
IV	7.7	195	9	90	125	154	189
Grand average and total			18	86	122	154	189
Increments of growth				86	36	31	35
Equivalent total length in inches				3.4	4.8	6.1	7.4
Number of fish				18	17	13	9

Table 18. Mean calculated lengths and increments of length of cutthroat collected from Granite Creek during 1956.

Age class	Total length at capture		Number of fish	Calculated length at end of year of life (millimeters)			
	Inches	Millimeters		1	2	3	4
I	4.8	122	1	79			
II	4.9	124	3	68	112		
III	7.8	198	8	80	122	181	
IV	10.6	269	1	86	146	203	258
Grand average and total			13	78	122	183	258
Increments of growth				78	44	59	55
Equivalent total length in inches				3.1	4.8	7.2	10.2
Number of fish				13	12	9	1

Table 19. Mean calculated lengths and increments of length of cutthroat collected from Hughes Fork below Hughes Meadow road during 1956.

Age class	Total length at capture: Inches	Total length at capture: Millimeters	Number of fish	Calculated length at end of year of life (millimeters): 1	2	3
I		112	1	85		
III		221	6	98	143	220
Grand average and total			7	96	143	220
Increments of growth				96	45	77
Equivalent total length in inches				3.9	5.6	8.7
Number of fish				7	6	6

Table 20. Mean calculated lengths and increments of length of cutthroat collected from Hughes Fork in the Hughes Meadow during 1956.

Age class	Total length at capture: Inches	Total length at capture: Millimeters	Number of fish	Calculated length at end of year of life (millimeters): 1	2	3
I	6.0	153	9	104		
II	8.3	212	7	104	183	
III	10.7	272	11	103	182	258
Grand average and total			27	104	182	258
Increments of growth				104	79	76
Equivalent total length in inches				4.1	7.2	10.2
Number of fish				27	18	11

Table 21. Mean calculated lengths and increments of length of cutthroat collected from Trapper Creek below falls during 1956.

Age class	Total length at capture: Inches	Total length at capture: Millimeters	Number of fish	Calculated length at end of year of life (millimeters): 1	2	3	4
I	3.5	89	2	74			
II	4.7	119	13	75	101		
III	6.6	168	18	87	117	150	
IV	7.9	200	9	80	116	155	187
Grand average and total			42	81	112	152	187
Increments of growth				81	30	35	32
Equivalent total length in inches				3.2	4.4	6.0	7.4
Number of fish				42	40	27	9

Table 22. Mean calculated lengths and increments of length of cutthroat collected from Gold Creek during 1956.

Age class	Total length at capture: Inches	Total length at capture: Millimeters	Number of fish	Calculated length at end of year of life (millimeters): 1	2	3	4	5
II	5.9	151	4	87	119			
III	7.1	180	7	85	123	158		
IV	8.9	226	4	76	119	151	198	
V	10.5	267	1	--	102	148	200	235
Grand average and total			16	85	119	155	198	235
Increments of growth				85	38	34	48	35
Equivalent total length in inches				3.3	4.7	6.1	7.8	9.3
Number of fish				16	16	12	5	1

Table 23. Mean calculated lengths and increments of length of Dolly Varden collected from streams entering Priest Lake during 1956.

Age class	Total length at capture: Inches	Total length at capture: Millimeters	Number of fish	Calculated length at end of year of life (millimeters): 1	2	3
II	4.6	118	7	68	107	
III	6.2	158	18	66	101	142
Grand average and total			25	66	103	142
Increments of growth				66	36	41
Equivalent total length in inches				2.6	4.1	5.6
Number of fish				25	25	18

Table 24. Mean calculated lengths and increments of length of Dolly Varden collected from Priest Lake during 1956.

Age class	Total length at capture: Inches	Total length at capture: Millimeters	Number of fish	Calculated length at end of year of life (millimeters): 1	2	3	4	5	6	7
III	10.1	257	9	69	120	191				
IV	14.3	363	15	72	117	191	342			
V	18.1	459	24	70	115	187	306	435		
VI	22.6	573	9	64	105	160	283	402	507	
VII	27.5	698	4	72	112	162	289	409	532	604
Grand average and total			61	70	114	183	311	424	515	604
Increments of growth				70	45	68	130	126	111	72
Equivalent total length in inches				2.8	4.5	7.2	12.2	16.7	20.3	23.8
Number of fish				61	61	61	52	37	13	4

Table 25. Mean calculated lengths and increments of length of Dolly Varden collected from Upper Priest Lake during 1956.

Age class	Total length at capture: Inches	Total length at capture: Millimeters	Number of fish	Calculated length at end of year of life (millimeters): 1	2	3	4	5	6	7	8
III	7.1	181	5	70	108	164					
IV	12.5	317	14	63	96	149	232				
V	15.6	395	7	65	101	142	238	339			
VI	22.3	566	8	71	108	179	274	388	504		
VII	26.3	668	5	67	106	149	226	314	417	561	
VIII	28.8	731	2	65	102	143	204	316	412	511	613
Grand average and total			41	66	102	154	240	349	462	546	613
Increments of growth				66	36	53	86	104	109	131	102
Equivalent total length in inches				2.6	4.0	6.1	9.4	14.1	18.2	21.5	24.1
Number of fish				41	41	41	36	22	15	7	2

Table 26. Mean calculated total lengths and increments of length of kokanee collected from Priest Lake.

Year class		Number of fish	Calculated length at end of year of life (millimeters): 1	2	3	4	5
1954	Mean	24	69				
	Increments of growth		69				
	Equivalent total length in inches		2.7				
	Growing year		1955				
1953	Mean	23	75	177			
	Increments of growth		75	102			
	Equivalent total length in inches		3.0	7.0			
	Growing years		1954	1955			
1952	Mean	47	80	183	224		
	Increments of growth		80	103	41		
	Equivalent total length in inches		3.1	7.2	8.8		
	Growing years		1953	1954	1955		
1951	Mean	58	82	176	216	246	
	Increments of growth		82	94	40	30	
	Equivalent total length in inches		3.2	7.0	8.5	9.7	
	Growing years		1952	1953	1954	1955	
1950	Mean	53	85	178	208	231	252
	Increments of growth		85	93	30	23	21
	Equivalent total length in inches		3.3	7.0	8.2	9.1	9.9
	Growing years		1951	1952	1953	1954	1955

Table 27. Mean calculated total lengths and increments of length of kokanee collected from Upper Priest Lake.

Year class		Number of fish	Calculated length at end of year of life (millimeters) 1	2	3	4	5
1954	Mean	2	75				
	Increments of growth		75				
	Equivalent total length in inches		3.0				
	Growing year		1955				
1953	Mean	23	89	189			
	Increments of growth		89	100			
	Equivalent total length in inches		3.5	7.4			
	Growing years		1954	1955			
1952	Mean	20	90	200	277		
	Increments of growth		90	110	77		
	Equivalent total length in inches		3.5	7.9	10.9		
	Growing years		1953	1954	1955		
1951	Mean	18	91	202	269	307	
	Increments of growth		91	111	67	38	
	Equivalent total length in inches		3.6	8.0	10.6	12.1	
	Growing years		1952	1953	1954	1955	
1950	Mean	23	89	183	254	293	323
	Increments of growth		89	94	71	39	30
	Equivalent total length in inches		3.5	7.2	10.0	11.5	12.7
	Growing years		1951	1952	1953	1954	1955
1949	Mean	10	81	188	259	284	329
	Increments of growth		81	107	71	25	45
	Equivalent total length in inches		3.2	7.4	10.2	11.2	13.0
	Growing years		1950	1951	1952	1953	1954

APPENDIX IV

PHOTOGRAPHS OF SCALES

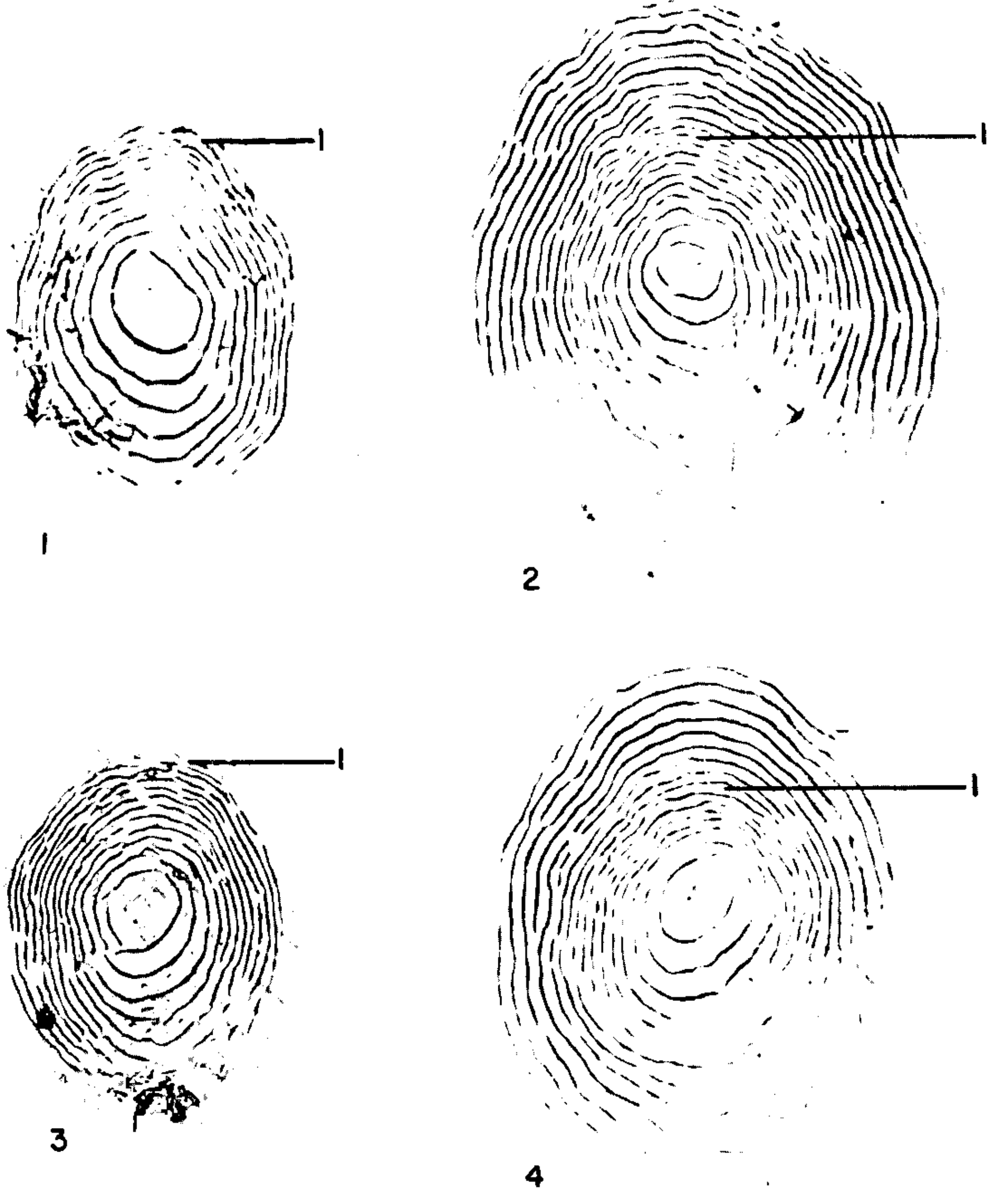


Plate 1. Scales from age class I kokanee. (1) 2.8 inch fish collected May 28, 1956 from Upper Priest Lake; (2) 4.6 inch fish collected September 11 from Upper Priest Lake; (3) 3.2 inch fish collected May 17 from Priest Lake; (4) 3.6 inch fish collected July 10 from Priest Lake.

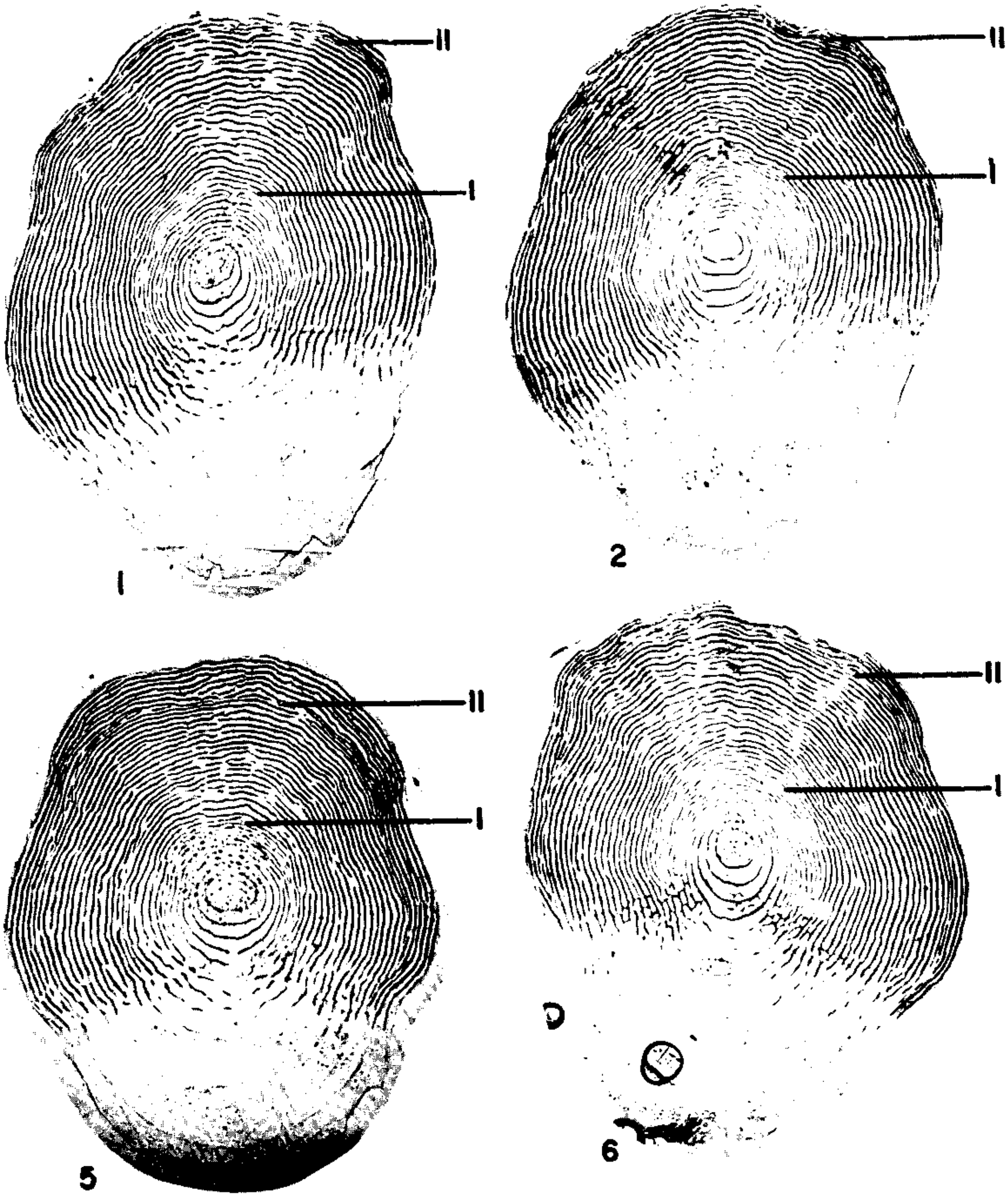


Plate 2. Scales from age class II kokanee collected from Priest Lake throughout the 1956 growing season. Note the scale development through the season. (1) 7.6 inch fish collected May 25; (2) 7.8 inch fish collected May 30; (3) 7.4 inch fish collected June 17; (4) 8.0 inch fish collected June 30; (5) 7.8 inch fish collected July 15; (6) 8.6

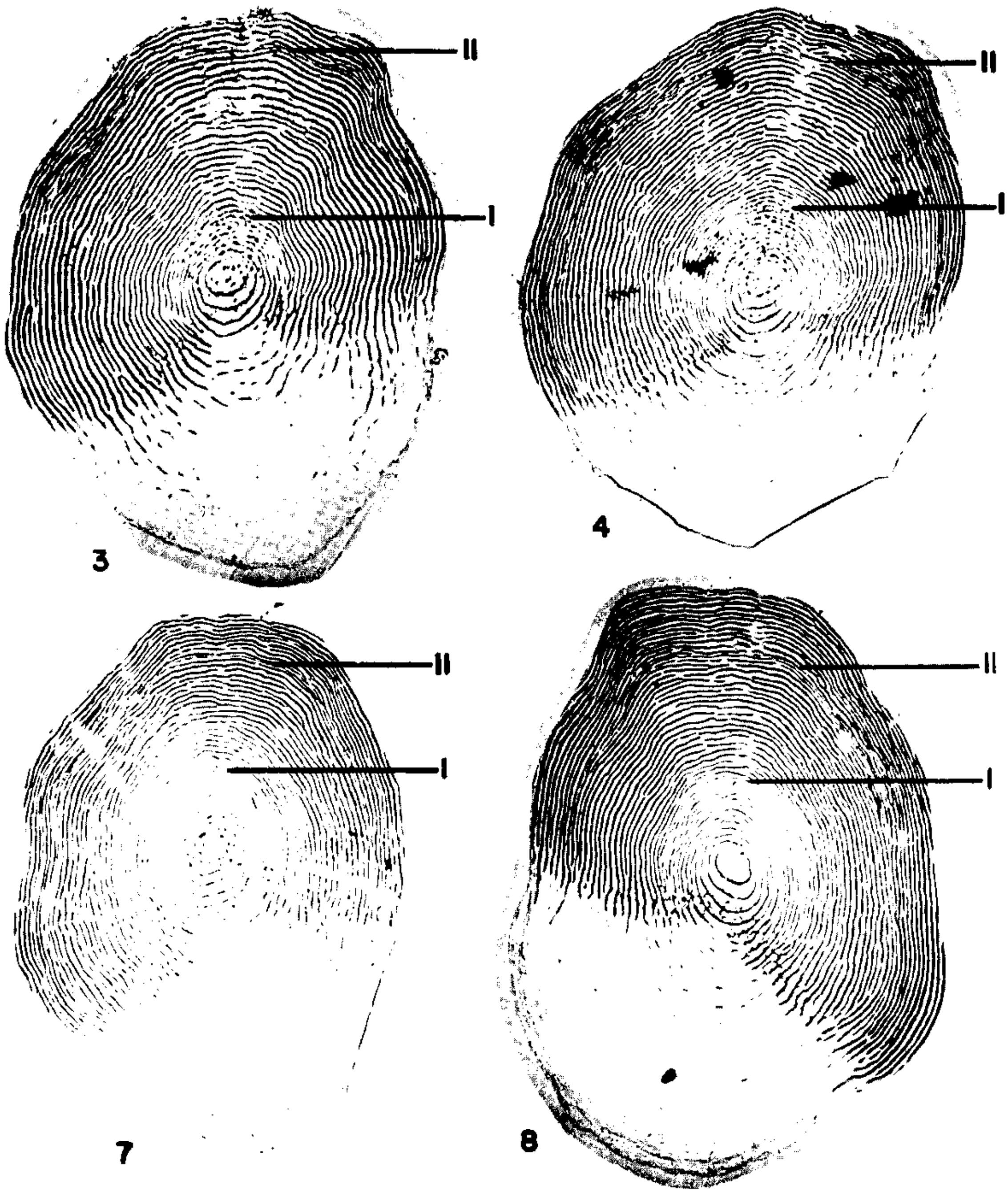


Plate 2 continued. inch fish collected August 4; (7) 8.6 inch fish collected August 16; (8) 8.8 inch fish collected September 30. These scales are felt to be representative of age class II kokanee and illustrate the early annulus formation (near the first of June) and the variation in scale growth between individual fish.

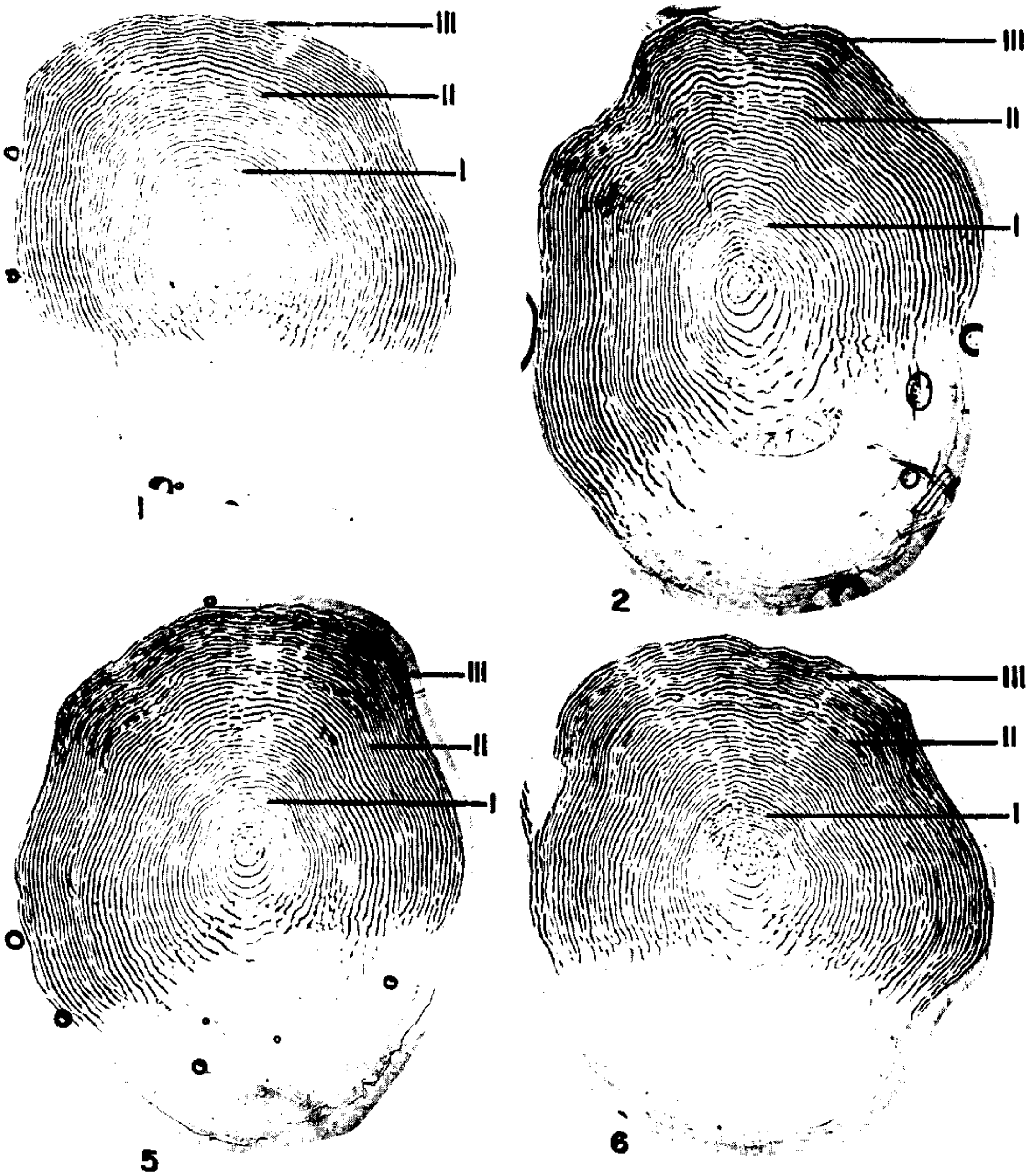


Plate 3. Scales from age class III kokanee collected from Priest Lake throughout the 1956 growing season. (1) 8.6 inch fish collected May 17; (2) 8.6 inch fish collected June 1; (3) 8.7 inch fish collected June 17; (4) 8.9 inch fish collected July 15; (5) 9.2 inch fish collected August 15; (6) 9.5 inch fish collected September 1; (7) 9.9 inch fish

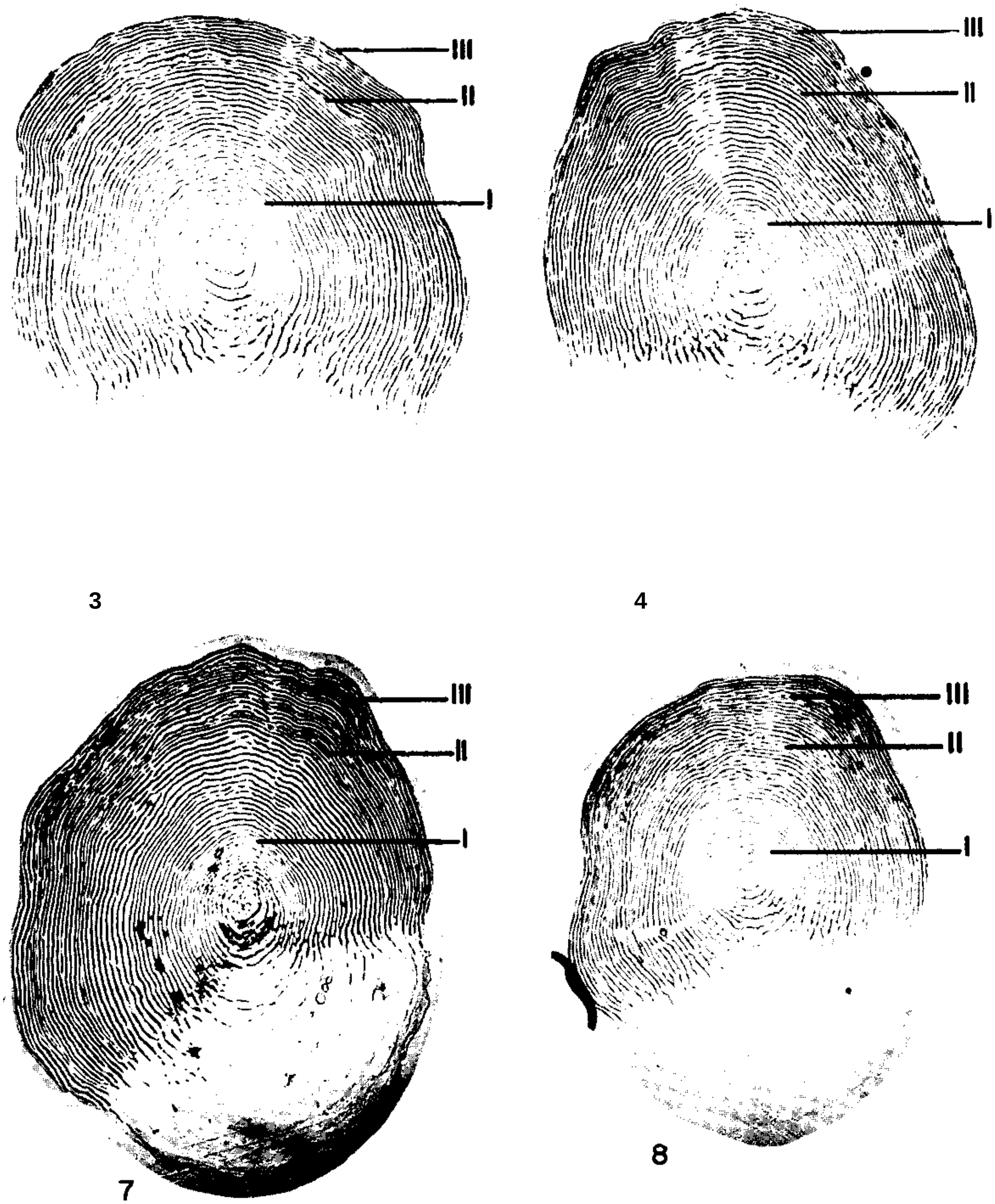


Plate 3 continued, collected September 13; (8) 9.3 inch fish collected September 30, These scales illustrate that the annulus is usually formed the latter part of June or early July on age class III kokanee, Usually three to four weeks later than for age class I and II fish,

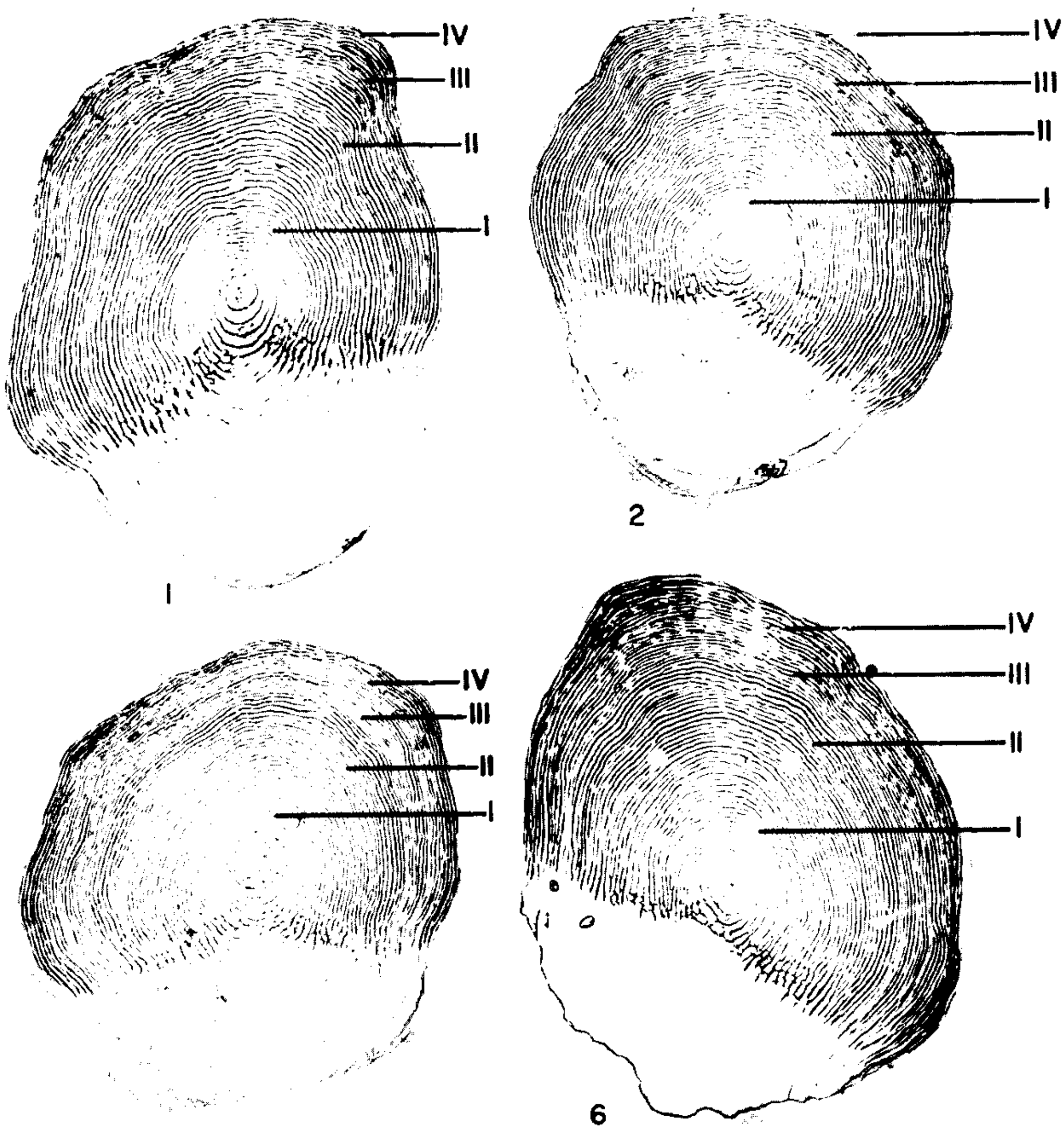


Plate 4. Scales from age class IV kokanee collected from Priest Lake throughout the 1956 growing season. (1) 9.7 inch fish collected May 16; (2) 10.0 inch fish collected May 30; (3) 9.5 inch fish collected June 17; (4) 10.0 inch fish collected June 30; (5) 10.4 inch fish collected July 17; (6) 10.5 inch fish collected August 4; (7) 10.5

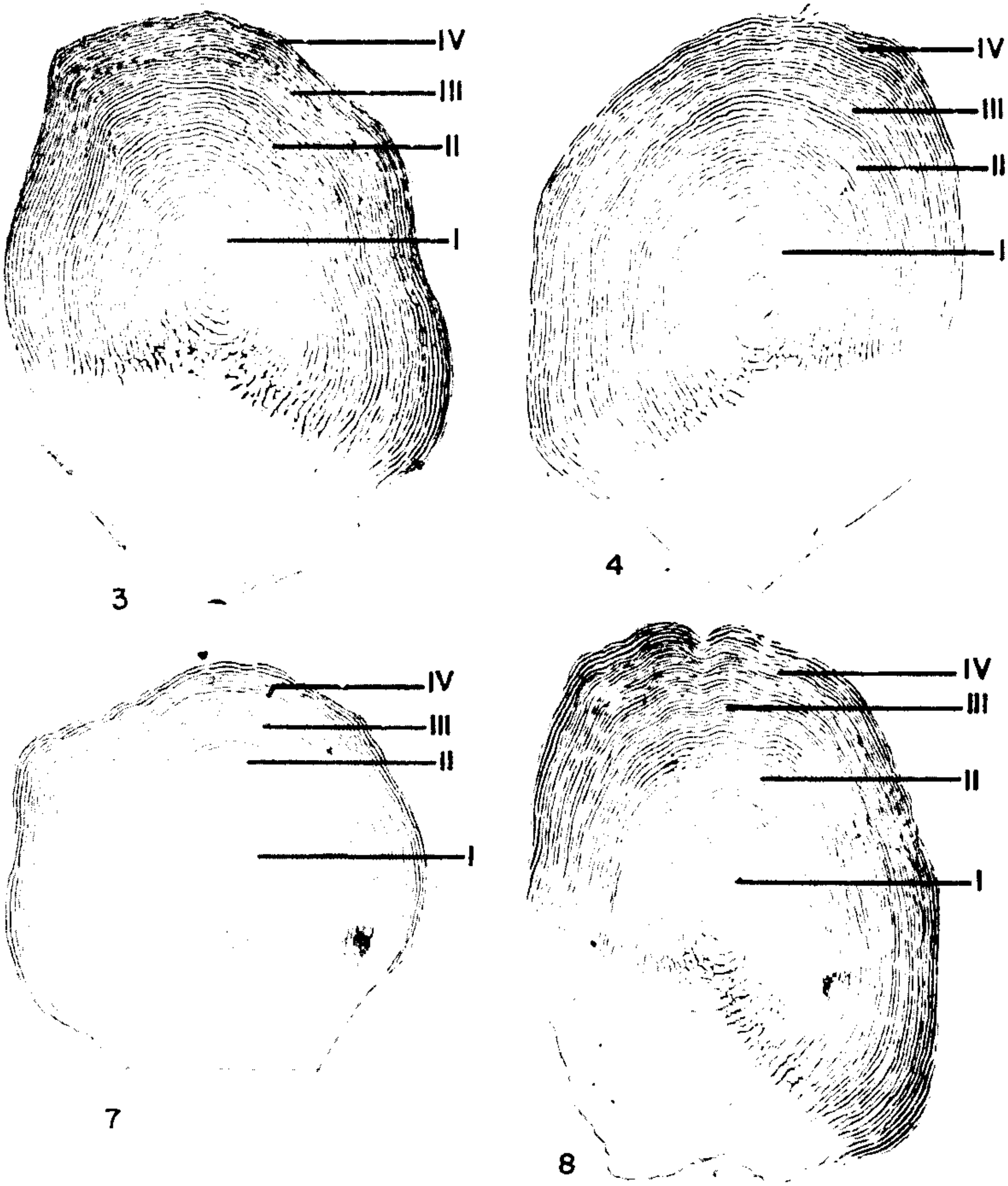


Plate 4 continued. inch fish collected September 16; (8) 10.1 inch fish collected September 30. These illustrations indicate that the annulus formation for age class IV fish is also later than for age class I and II kokanee. Annulus formation appeared to take place sometime after the middle of June.

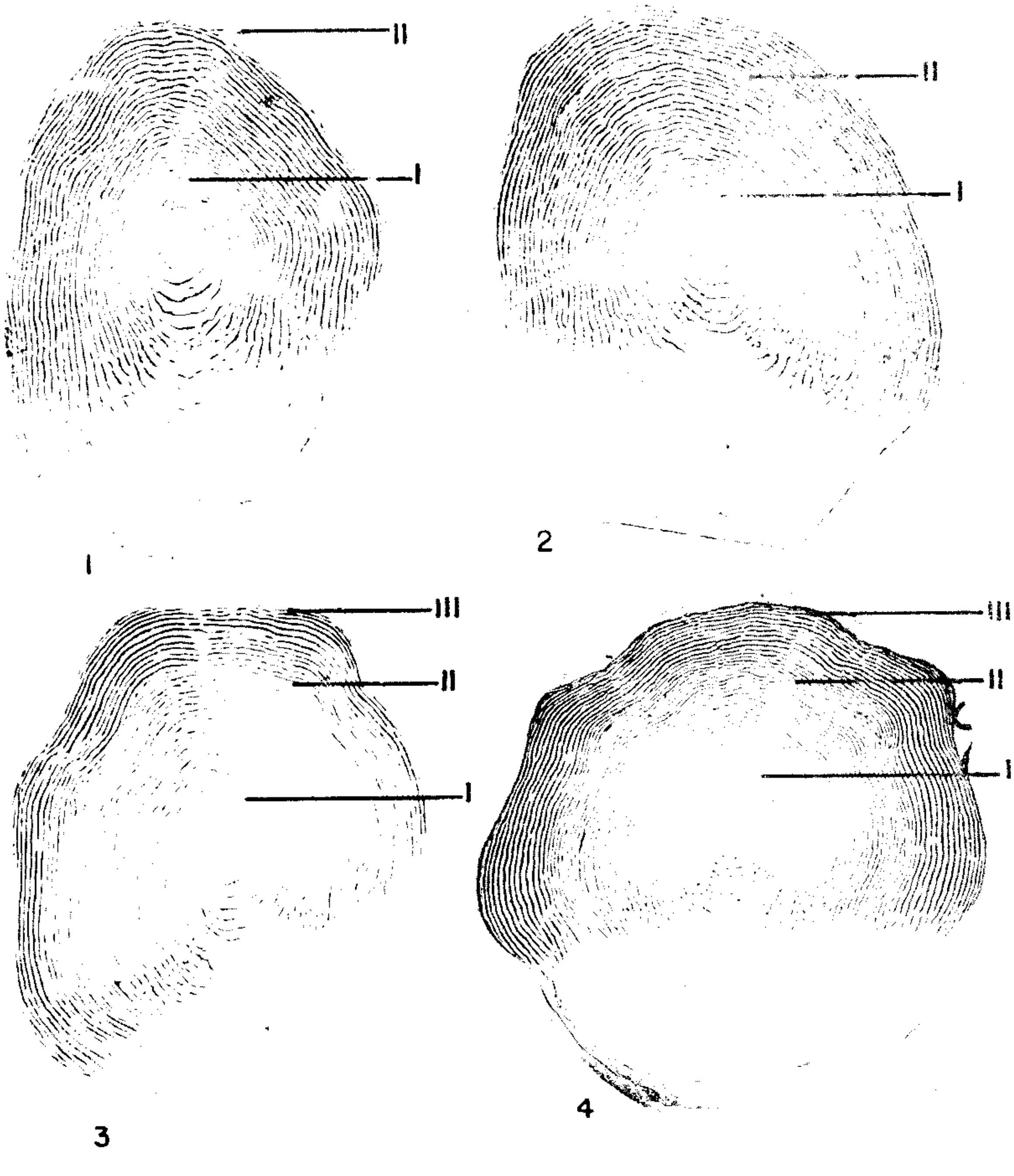


Plate 5. Scales from age class II and III kokanee collected from Upper Priest Lake in 1956. (1) 7.2 inch fish collected May 25; (2) 8.6 inch fish collected September 8; (3) 9.7 inch fish collected June 27; (4) 11.4 inch fish collected June 27. Scales (3) and (4) illustrate the fact that there may be a large amount of variation in size of fish that are the same age.

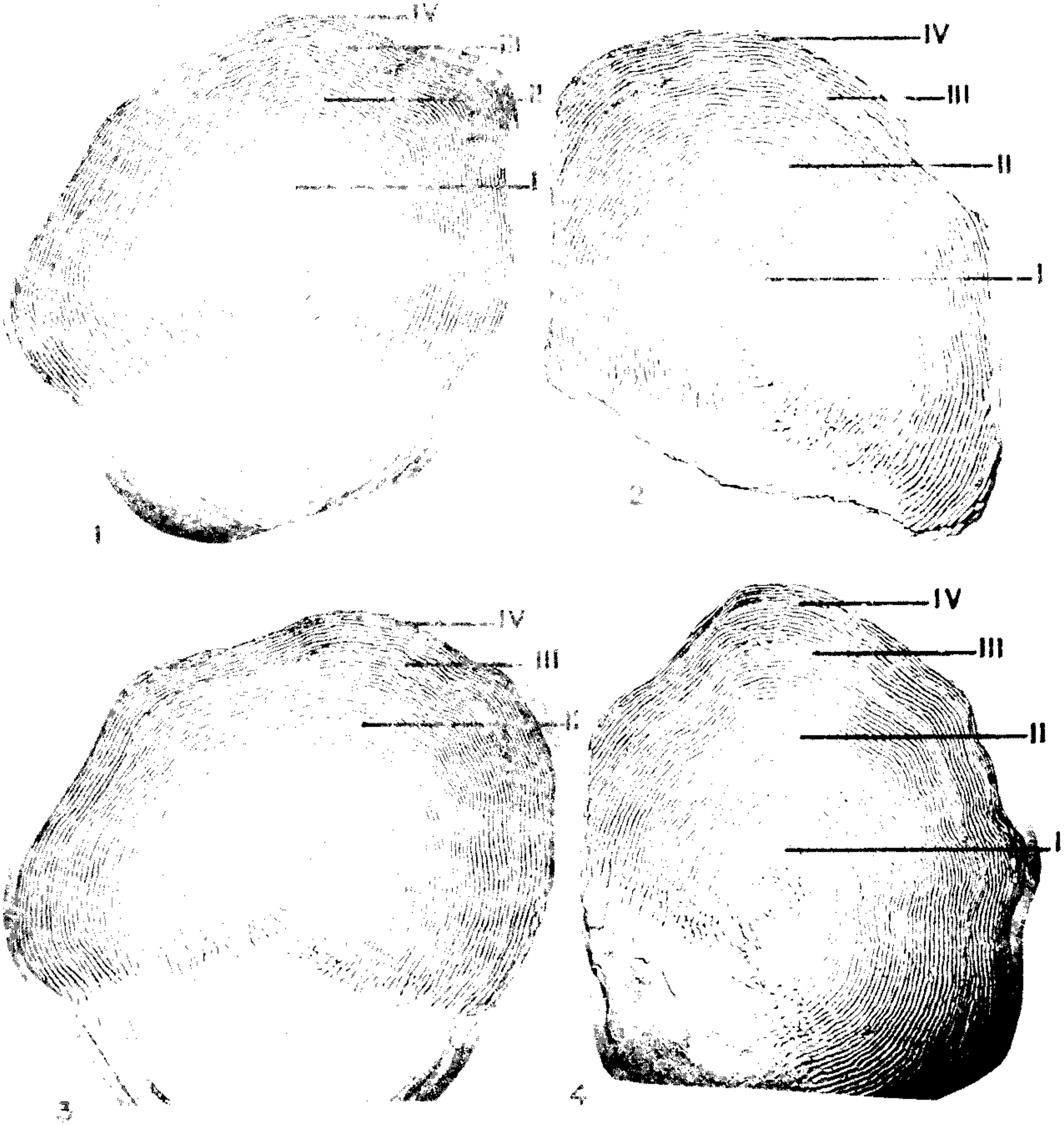


Plate 6. Scales from age class IV kokanee collected from Upper Priest lake in 1956. (1) 12.1 inch fish collected June 9; (2) 13.1 inch mature male collected September 8. Note the small amount of growth evident during the last year of life; (3) 12.6 inch fish collected July 15. Note the annulus recently formed; (4) 13.1 inch mature female collected September 8. Note the larger amount of growth evident during last year of life and the smaller amount of scale erosion on the scale from the female as compared to that of the male.

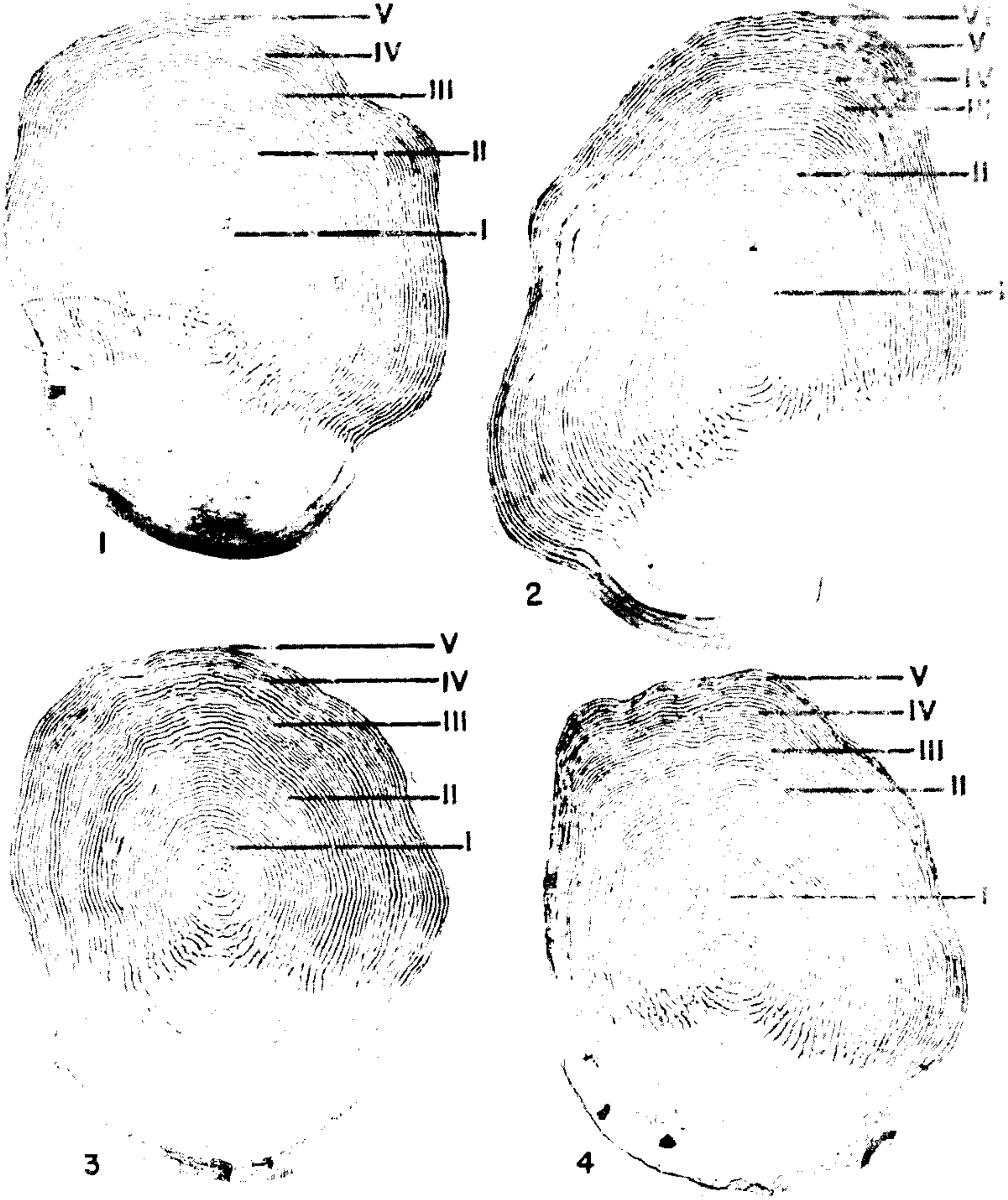


Plate 7. Scales from age class V and VI kokanee. (1) 12.7 inch fish collected June 22 from Upper Priest Lake; (2) 12.9 inch fish collected June 27 from Upper Priest Lake; (3) 9.4 inch fish collected May 19 from Priest Lake; (4) 10.9 inch female collected June 30 from Priest Lake. This female had spawned in 1955 and survived.

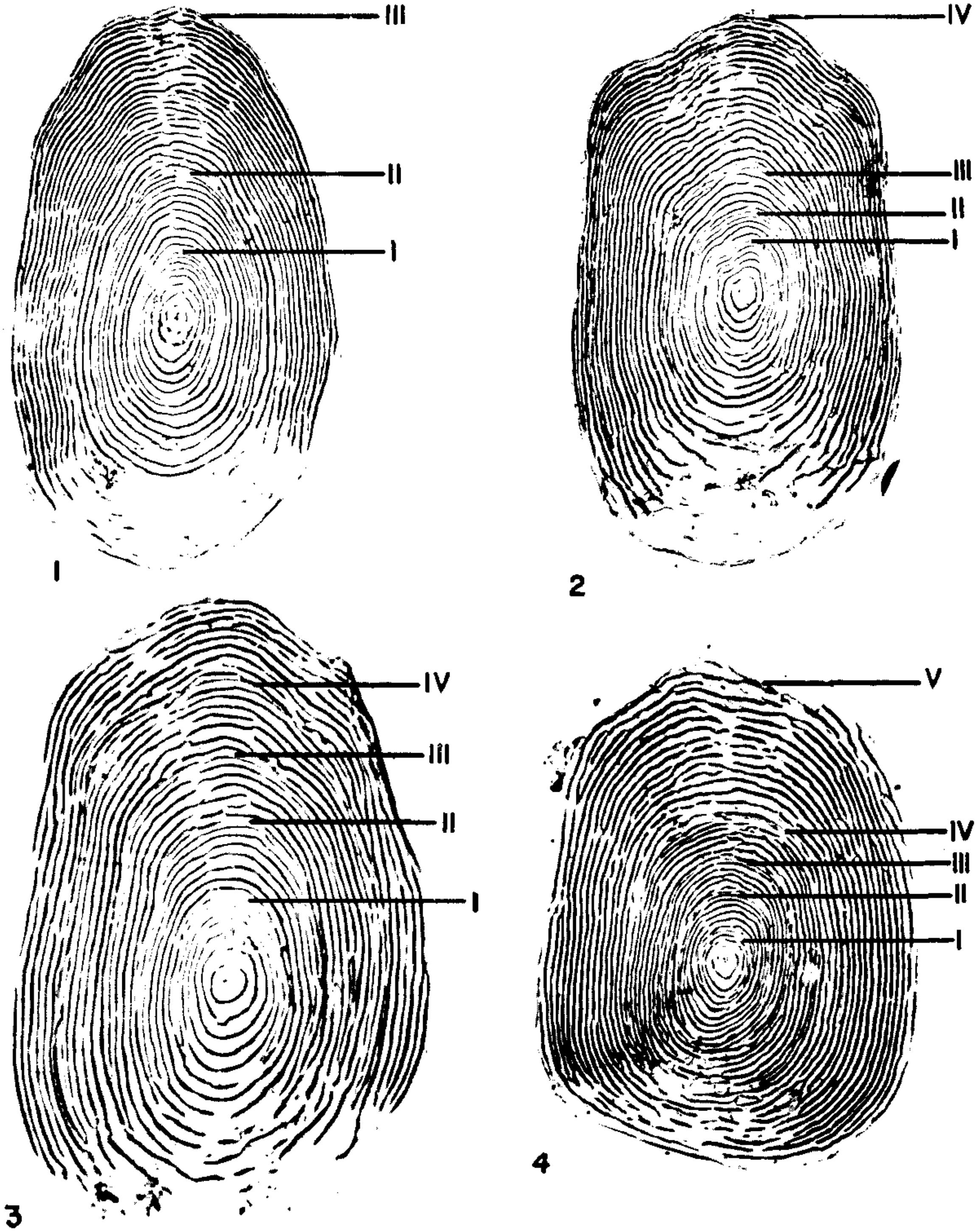


Plate 8. (1) 10.6 inch cutthroat collected June 17 from Priest Lake. This fish had spent two years in a stream before entering lake. (2) 11.9 inch cutthroat collected October 6 from Upper Priest Lake. This fish had spent three years in stream before entering lake. (3) 10.6 inch cutthroat collected from Priest Lake September 1. This fish had apparently spent four years in stream and was completing its first year in the lake. (4) 14.6 inch Dolly Varden collected from Priest Lake. This fish had spent four year in stream before entering lake.

APPENDIX V

RESULTS OF STREAM SURVEY

RESULTS OF STREAM SURVEY

A survey of all streams suitable for spawning purposes in the Priest and Upper Priest Lake drainages was undertaken to gather additional information that would help determine what factor or combination of factors have caused a decline in the catch of cutthroat trout from Priest and Upper Priest Lakes,

At the outset of the survey an attempt was made to determine the number of square yards of spawning area present in each stream. It soon became evident that not only would this approach consume a great deal of time, but the results would be questionable because of the subjective nature in which " suitable" spawning gravel is chosen. In order to detect anything other than very major changes in the amount of suitable are present, detailed maps, drawn to scale, would have to be made.

Although it appeared, after preliminary trips to major tributaries, that the availability of sufficient, suitable spawning area would not be a limiting factor, it was still desirable to continue the stream survey in order to: (l) attempt to determine which streams have spawning populations that migrate from the lakes, (2) determine periods of migration, (3) collect data for life history studies, and (4) obtain general information on the condition of spawning facilities.

In most instances the presence of cutthroat spawners in a stream was determined by catching them with a fishing rod, since high water during the spawning season reduced the visibility into the water. Dolly Varden trout were quite easily observed in the fall because of their large size and the smaller flow of water at that time of the year. Collection of fish from the tributaries for life history studies was accomplished with fishing poles, a tool which proved to be invaluable.

Kray-Meekin downstream traps (Figure l) were placed in three streams in an attempt to collect downstream migrants. A small Dolly Varden (3.5 inches) and cutthroat (4.8 inches) were the only game fish collected in the traps. The sparse number of fish collected in the traps may have been due to: (l) improper operation of the trap during high water, a period when the majority of the migration probably takes place, and/or (2) a low number of migrants passing the traps. The spring runoff was nearly over by the time the traps were put into operation and even then they were placed in water with velocities less than that required for maximum efficiency.

All of the major streams in the drainage contain log jams that affect in varying degrees the movement of fish, amount of cover, and productivity of the streams. In an effort to determine what effects these jams have on productivity, a number of bottom samples were collected and the analyzed data is presented in Appendix VI.

Upper Priest River. The Upper Priest River has its headwaters in Canada and empties into the north end of Upper Priest Lake. Summer flow is estimated between 50 to 6o cubic feet per second (Table l), with temperatures ranging from near freezing in the winter to a high of 55° to 60° F. in the summer. The stream gradient is relatively moderate , (Table 2).

The river is a meandering, deep stream flowing through a flood plain for the first 2 miles. This lower section of river contains very little spawning area and is inhabited by large numbers of suckers in the summer. Upstream from the flood plain the river enters a steep sided canyon extending to the Canadian border near which is the Upper Priest Falls (Figure 2), definitely a barrier to upstream migration. **A** few Dolly Varden travel the 16 miles from the lake to the falls, but it appears that the majority of Dolly Varden and cutthroat spawn within 12 miles of the lake. The 4 mile stretch of stream immediately below the falls contains very little spawning area and is characterized by many small falls and a stream bottom of large boulders and bed rock. That portion of the river located between the flood plain and the four mile section below the falls is interspersed with gravel-riffle, silt-sand, and boulder-bedrock bottom types.

The number of cutthroat and Dolly Varden trout observed in the river was considered very low when compared with the number found in other streams.

Log jams are quite numerous in the river and may have deleterious effects on fish migration. The dams do not completely block migration as evidenced by the fish found beyond them. Log jams do form the only good cover for fish in much of the river and it is under these jams that the majority of fish are found.

Although poaching does not appear to be widespread throughout the drainage, a long-poled gaff hook found on a log jam under which were some large Dolly Varden is evidence that it does take place.

In summary, the Upper Priest River does contain spawning area in sizeable amounts; however, the number of spawning fish using the river appeared to be relatively small.

Gold Creek. Gold Creek, for purposes of this study, is defined as a tributary to Hughes Fork, which in turn is a tributary to the Upper Priest River. This designation agrees with that found on the new (1955) Forest Service maps of the Kaniksu National Forest.

Spawning area in Gold Creek is limited because of its steep gradient (approximately 300 feet per mile). There are a number of log barriers and falls which appeared to be effective blocks to fish migration in all but high water.

Numerous small cutthroat and a few small Dolly Varden were found in the creek. Mature male cutthroat 7 to 10 inches long were captured and later scale studies revealed them to be in their fourth and fifth years of life, indicating that they had spent their entire life in the stream.

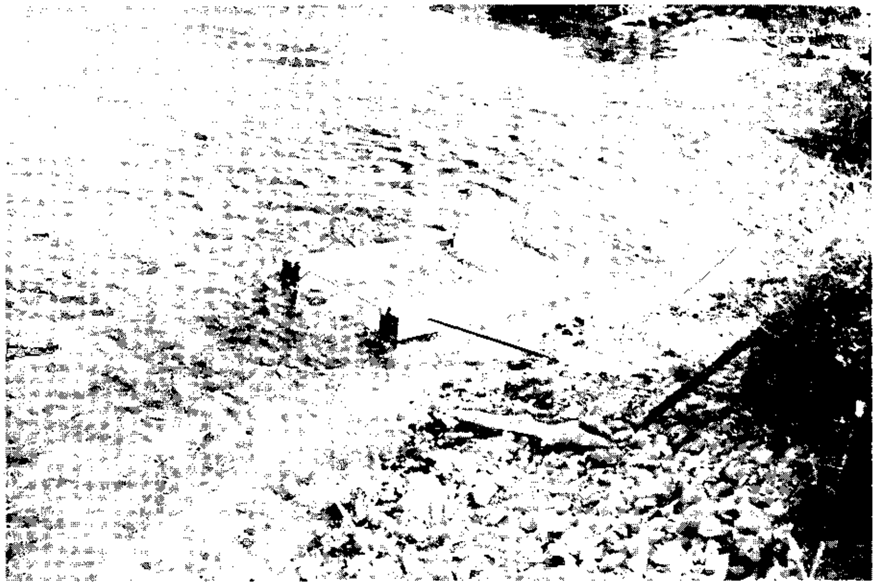


Figure 1. Kray-Meekin downstream trap.

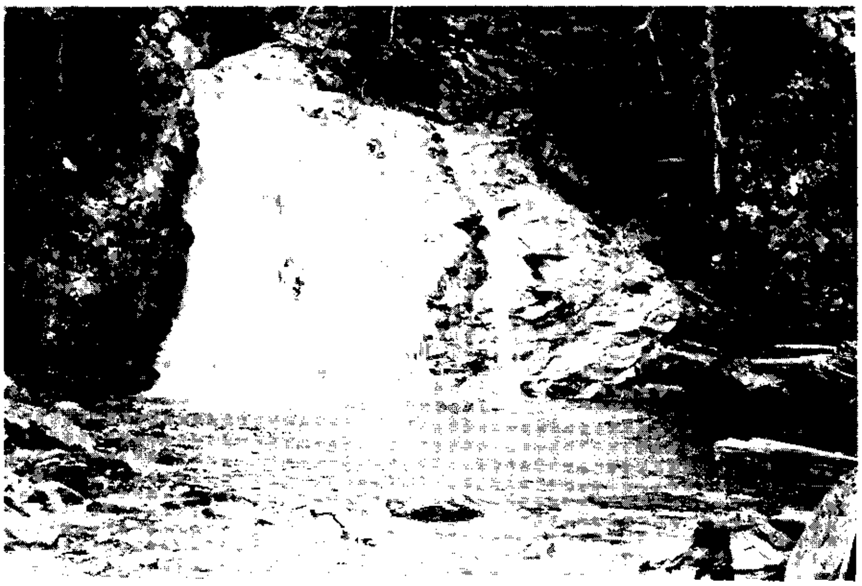


Figure 2. Upper Priest Falls, located on the Upper Priest River approximately 15 miles from the upper lake.

Because of the limited amount of spawning area, the number of fish contributed to the lake fishery by this stream is considered to be relatively small.

Hughes Fork. Hughes Fork, with a summer water flow of 15 to 25 cubic feet per second, is a tributary to the Upper Priest River, entering approximately one mile up from the lake.

Hughes Fork contains a large amount of spawning area, with the largest portion located above the mouth of Gold Creek, and extending through Hughes Meadow. The gradient of the creek is relatively low (Table 2) and growth rate in certain portions of the stream are very good when compared with the growth rate in other streams.

The number of cutthroat spawners entering Hughes Fork appears to be larger than the number entering any other upper lake tributaries.

Between 1934 and 1938 a hatchery and fish trap were constructed on Hughes Fork near the mouth of Gold Creek to "... take eggs from Gold Creek and hatch them for distribution in tributary streams of Priest Lake" (17th Biennial Report, 1939 and 1940). Records contained in the biennial reports show that between 300,000 and 700,000 cutthroat were planted from the Gold Creek hatchery each year from 1939 to 1942. Spawntaking operations ceased after 1942 (at least no records available) and have not been resumed.

Typical resident cutthroat trout populations are found in the streams above Hughes meadow. These fish mature at 6 to 7 inches in length and an age of 3 to 4 years.

Table I. Estimated summer flow of tributaries to Priest and Upper Priest Lakes.

Stream	Cubic feet per second	Stream	Cubic feet per second
Upper Priest River	50-60	Blacktail Creek	1-5
Hughes Fork	15-25	South Fork (Granite)	15-25
Gold Creek	10-15	North Fork (Granite)	15-25
Trapper Creek	10-20	Kalispell Creek	20-30
Caribou Creek	15-25	Indian Creek	20-30
Lion Creek	15-25	Tango Creek	1-5
Beaver Creek	10-15	Reeder Creek	5-10
Two Mouth Creek	15-25	Soldier Creek	15-25
Bear Creek	1-5	Hunt Creek	10-15
Granite Creek	40-50		

Growth of fish in Hughes Fork varies considerably (Figure 3). Fish in the central and northern portion of the meadow do not grow much faster than the resident populations, while fish living in a slough, emptying into the south end of the meadow, attain a length of 10 inches by the end of their third year.

Although Hughes Fork has numerous log jams, fish are able to migrate to the meadow. Log jams and, during peak runoff, the rapids (Figure 4) located about 4 miles below the meadow seem to slow down the migration as abnormally large concentrations of spawners were observed in the pools below these obstacles.

Hughes Fork probably contributes the majority of the fish to *the* upper lake cutthroat fishery.

Table 2. Approximate gradients of the major streams in the Priest and Upper Priest Lake drainages.

Stream	Distance measured from mouth (miles)	Difference of elevation (feet)	Feet/mile gradient
Upper Priest River	16	1100	70
Hughes Fork	8	800	100
Gold Creek	3	900	300
Trapper Creek	2.5	600	240
Caribou Creek	7	2200	310
Beaver Creek	4	1600	400
Lion Creek	4	1600	400
Two Mouth Creek	4	1500	375
Granite Creek and North Fork	16	1000	60
Blacktail	2	400	200
South Fork	5	1100	220
Reeder Creek	5	400	80
Kalispell Creek	11	1000	90
Soldier Creek	5	1200	240
Indian Creek	4	1400	350
Hunt Creek	1	600	600
Priest River	11	---	11

Trapper Creek, Trapper Creek, having a summer flow of approximately 10 to 20 cubic feet per second, enters the east side of Upper Priest Lake. Fish are able to migrate up the creek for a distance of approximately 3 miles before coming to a 15-foot falls (Figure 5) Fish were extremely abundant in the stream and may be mainly a resident population. Mature fish 8 inches in length were in their fifth year of life.

A series of rapids and small falls in a steep gorge 1 mile from the mouth appeared at first to be impassable, but the presence of large Dolly Varden spawners and reports of people catching cutthroat spawners in the meadow above dispelled this belief. However, it may be that the falls and rapids effectively block a large portion of the spawning run.

The number of fish contributed to the lake fishery from Trapper Creek is unknown and probably depends to a large extent upon the number of fish that are able to get past the rapids and falls to the comparatively good spawning beds in the meadow above the gorge.

Figure 3. Catch of cutthroat from Hughes Fork illustrating the many different sizes of fish found in the stream. The large fish on left is a Dolly Varden.

Figure 4. Rapids on Hughes Fork during spring runoff.

Thoroughfare River. The Thoroughfare is a 2 mile stretch of channel that connects Priest and Upper Priest Lakes. The only spawning that takes place in the Thoroughfare is that of suckers and squawfish. Migration of trout species through the Thoroughfare is restricted to the spring and fall as the summer temperatures of the surface waters of Upper Priest Lake, the source of the water for the Thoroughfare, are higher than that preferred by trout.

Caribou Creek. Caribou Creek enters the Thoroughfare about midway between Priest and Upper Priest Lakes. The lower one half mile of stream has a very slight gradient and virtually no spawning area for trout. Above the first one half mile, the next 2.5 miles of stream becomes quite swift with large areas of apparently suitable spawning gravel (Figure 6). The stream has a few log jams but none were considered serious threats to migration. In fact, the stream above about 3 miles from the mouth is well scoured with large boulders making up most of the bottom type (Figure 7).

Portions of the Caribou Creek drainage were logged from 1926 to 1929 and the logs were floated down the creek. A splash dam (Figure 8) located about 5 miles upstream was used for two years to flush the logs down the creek and natural flow was used the remaining years. At the present time practically all of the spawning area in Caribou Creek is found below the splash dam. Previous to logging the same situation probably existed because of the very steep gradient (Table 2) of the upper portion of the creek. During the period of logging, it is possible that the spawning run in this creek could have been seriously reduced. Driving logs down the creek could kill both adult spawners and juveniles (eggs and fry) located in the spawning beds.

Trout are very scarce in Caribou Creek at the present time. Three trips were made to the creek and only two small immature fish were observed. Local residents recall seeing large numbers of cutthroat spawners concentrated below the splash dam, thus indicating there was probably a good size run in the creek at one time. If the planting of fry in tributaries to the lake must continue, creeks such as this with very low densities of fish should be the streams stocked so that competition with "native" fish will not reduce survival to a negligible amount.

Caribou Creek at the present time appears to contribute very little to the lake fisheries.

Lion Creek. Lion Creek, entering the north end of Priest Lake, has a relatively steep gradient and as might be expected, a number of falls and rapids (Figures 9 and 10), most of which occur within the first mile of stream. Logging operations near the mouth have resulted in numerous log jams which appear capable of blocking migration.

Above the falls where the creek gradient is not quite as high, cutthroat are abundant and spawning area is available in sufficient amounts to support a fair sized spawning run. Mature cutthroat 7 to 10 inches long were collected from the stream, indicating that some fish never leave the stream.

Figure 5. Falls located approximately 3 miles upstream from mouth on Trapper Creek.

Figure 6. Section of Caribou Creek that is typical of the long stretches of riffle area containing little if any pool area.

Figure 7. Upper portion of Caribou Creek illustrating the large boulder type bottom.

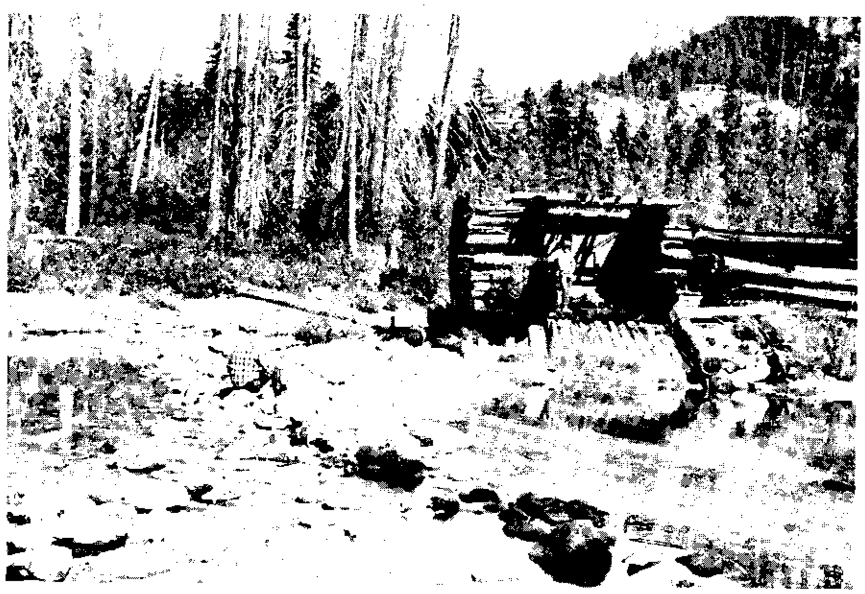


Figure 8. Splash dam used to flush logs down Caribou Creek.

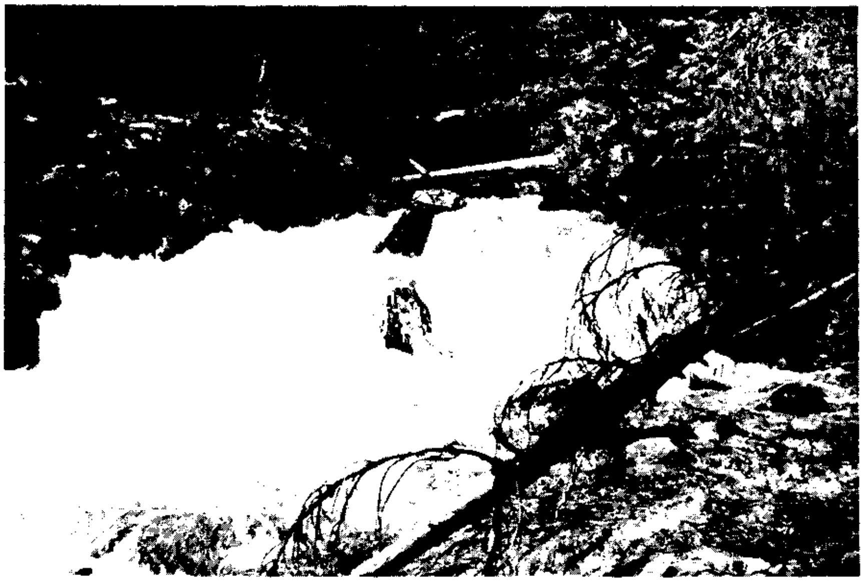


Figure 9. Falls one mile up from mouth on Lion Creek.

Figure 10. Falls one mile up from Mouth on Lion Creek.

It is believed that Lion Creek presently contributes very little to the Priest Lake cutthroat fishery.

Beaver Creek. Beaver Creek, entering Priest Lake opposite Lion Creek, also has a relatively high gradient, however, Beaver Creek differs from Lion Creek by not having any large natural falls and rapids. Log jams and beaver dams are numerous but are passable to migrating fish during high water since large (14 to 15 inches) cutthroat spawners were collected in the headwaters (4 miles from the mouth). It is interesting to note that both lake fish and resident stream fish were spawning in the same areas throughout the creek.

Beaver Creek contains fairly large percentages of spawning gravel (as high as 25 percent of the bottom type in some sections) and does contribute to the lake fishery, although the number is unknown.

Tango Creek. Tango Creek is mentioned only in reference to the planting of fry. This small creek is choked with logs, brush, and high falls making migration of fish upstream or downstream very difficult if not impossible. It is recommended that no fish be planted in this creek because they will not contribute to the lake fishery and will not provide a suitable stream fishery.

Two Mouth Creek. Like other streams entering the east side of Priest Lake, Two Mouth Creek has a high gradient (Table 2). Spawning area is patchy in distribution, with large boulders making up a large portion of the bottom type,

Cutthroat, brook, and Dolly Varden trout are present in the stream, with cutthroat appearing to be the most abundant.

Logging operations, when allowed next to the stream channel, have left the stream clogged with logs and debris. Falls, located approximately 5 miles from the mouth, are probably effective in preventing further migration of fish upstream. Cutthroat spawners from the lake and numerous small cutthroat, some of which were mature resident fish, were caught below these falls.

This stream contributes some fish to the Priest Lake cutthroat fishery but the number is believed to be small.

Bear Creek. Bear Creek enters into the east side of Priest Lake opposite Granite Creek. Spawning area is very limited and brook trout are the only fish present.

Granite Creek. Granite Creek is probably the best tributary for spawning which enters Priest Lake. Minimum flows are more than adequate and the stream is free of serious obstacles for a distance of approximately 16 miles. The gradient is low (Table 2) and allows for quite extensive gravel areas suitable for spawning.

In years past the number of cutthroat spawners ascending Granite Creek was considered ample to support spawn taking operations. From

Figure 11. Granite Creek fish trap, used for experimental purposes in fall of 1955.

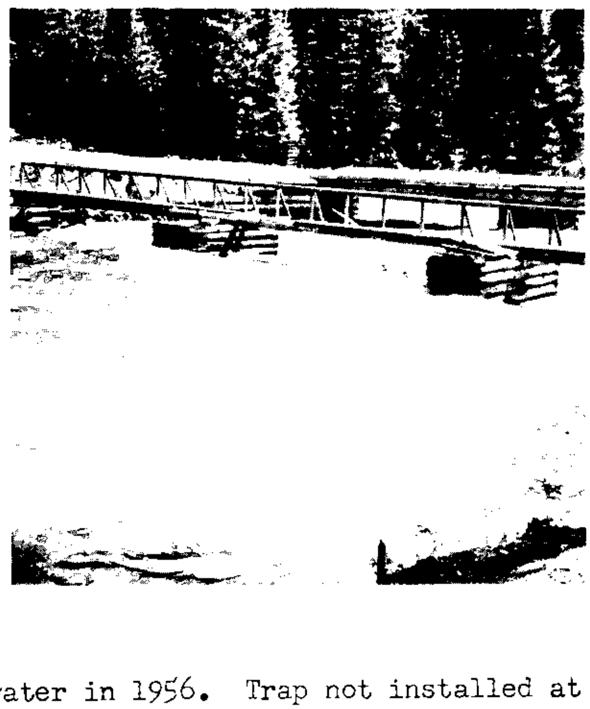


Figure 12. High water in 1956. Trap not installed at this time.

the years 1939 to 1947 a fish trap (Figures 11 and 12) was in operation six years, during which time nearly 5 million eggs were taken.

In 1947, I,660 fish were caught in the Granite Creek fish trap. Because the trap is located approximately 6 miles from the mouth, this figure does not represent the total run, however, it does indicate that fish in appreciable numbers were still ascending the creek to spawn. The local game warden reported catching cutthroat spawners near the fish trap without too much difficulty as late as 1951 and 1952. In 1956, numerous attempts were made to collect spawners in the upper reaches of Granite Creek with little success. Only one spawner was collected further than 3 miles upstream from the mouth.

Cutthroat, Dolly Varden, and brook trout were numerous in the main stem of Granite Creek and very abundant in the tributaries. Many of the fish in the tributaries appeared to be resident fish.

Granite Creek and its tributaries probably contribute a larger number of cutthroat to the lake fishery than any other creek.

South Fork of Granite Creek. The South Fork and North Fork come together to form Granite Creek approximately 9 miles from the mouth. The South Fork has a large amount of suitable gravel near the forks but the bottom type changes between 1 to 2 miles upstream from the forks to large rocks and boulders type yielding very little suitable spawning area.

Small fish are *very* abundant with cutthroat more abundant near the forks and brook trout more abundant in the headwaters.

North Fork of Granite Creek. The North Fork contains large areas of good spawning gravel interspersed with bottoms of silt, sand, and bedrock. Small fish are plentiful with cutthroat being the dominant species.

Blacktail Creek. Blacktail Creek, entering Granite Creek at the fish trap, has some accessable spawning area near the mouth. The upper reaches (2 miles from the mouth) contain typical resident populations, with the fish maturing at 5 to 7 inches in length.

Kalispell Creek. A fire in 1926 burned large portions of the Kalispell Creek watershed, and is probably the cause of the large amount of siltation that has taken place on the spawning beds in the upper reaches of the creek. Sand and silt have covered most of the spawning beds above the main road (approximately 4 miles upstream from the mouth) leaving a 3 mile stretch immediately up from the mouth as the only portion of the stream capable of supporting a spawning run. A few brook trout and Dolly Varden and large numbers of small (up to 9 inches and all immature) cutthroat were found in this 3 mile stretch up from the mouth. The upper reaches of the creek support resident populations of brook and cutthroat and probably does not contribute to the lake fishery.

Some cutthroat spawners from the lake were found to be present in the lower 3 miles, and judging from the number of small fish present near the mouth, this creek could contribute relatively large numbers of the fish to the lake fishery.

Indian Creek. Indian Creek like other creeks entering the east side of the lake has been altered somewhat by logging operations. The gradient is relatively high (Table 2) and log jams and falls are present but not considered as serious threats to migration. A flume used to transport logs to the lake usurped substantial volumes of water from the creek in the summer, however, this is no longer a problem as logging has ceased for the present on this drainage and the development of roads and better trucks have provided new means of transportation.

Spawning area although not abundant, is present in fair amounts in the lower reaches and could support some spawners. Small cutthroat were quite abundant with some being obvious mature resident fish, while others appeared to be fish that might enter the lake.

Soldier Creek. Soldier Creek, except for that portion located in the meadow approximately one mile from the mouth, is a fast flowing stream (Table 2) with numerous log jams and small falls. Logging operations along the stream banks have produced many log jams (Figures 13 and 14) that certainly appeared to be impassable, but a large Dolly Varden caught in the headwaters (5 miles from the mouth) provided evidence that some fish can and do get through. The stream supports a large population of brook trout, mostly in the lower reaches, with Dolly Varden and cutthroat being present in large numbers in the upper reaches. Spawning area is present but not abundant, and appears as small patches between large boulders and rocks. This creek probably contributes little to the lake cutthroat fishery.

Hunt Creek. Hunt Creek with an impassable falls one mile from the mouth is of little importance for cutthroat spawning. Gravel beds are present in the portion of the stream accessable to lake spawners but the small resident cutthroat present are probably the only fish to use them.

Cougar Creek. Cougar Creek is presently listed in the fish planting catalog and should be removed. Most of the fish planted are probably unable to reach the lake due to continuous falls near the mouth. The upper reaches contain a resident population of cutthroat.

Lamb Creek. Lamb Creek enters the Priest River on the upstream side of the present outlet dam. The creek is a typical brook trout stream and is of little value for cutthroat spawning.

Priest River. The Priest River after leaving the lake has a low gradient Table 2) and fairly extensive gravel beds that appear suitable for spawning.

Reports by local residents indicate that at one time the Priest River was an important spawning area for cutthroat spawners from the lake. Anglers reported very good fishing in the spring of the year

Figure 13. Log jam on Soldier Creek.

Figure 14. Log jam on Soldier Creek.

with a decline after the spring runoff. This period of good fishing would coincide with the time cutthroat spawners would be in the river attempting to spawn.

The present dam located at the outlet does not restrict movement of cutthroat spawners into the river as the boards are not installed until lake in June after the spring runoff. However, fish attempting to migrate back to the lake after the boards are installed are unable to get past the dam.

APPENDIX VI

STUDY OF EFFECTS OF LOG JAM ON INSECT PRODUCTION

THE EFFECT OF LOG JAMS ON INSECT PRODUCTION IN MOUNTAIN STREAMS WITH AN EFFORT TOWARD EVALUATING SUCH STRUCTURES

Introduction. This report deals with the influence exerted by a log jam on the productivity of mountain streams. Because beaver dams and log jams are usually found in similar areas it is worthwhile to review the results of studies dealing with beaver-trout relationships. Many papers have been written on beaver-trout relationships with results varying with the locality and situation. Rupp (1954) found in Maine that the dams built by the beaver were serious obstacles to trout movement, but that productivity was increased due to an increase in water surface. He did find that production was lower foot for foot in the pool formed behind the dam than in the stream channel. Rasmussen (1940) found that the dams offered some resistance to fish migration and that the production of microfauna was increased so there was no decrease in insect productivity.

It is the general conclusion that beaver dams are beneficial in cool steep mountain streams with little pool area and often times detrimental in slow moving warmer streams.

It was felt that the general conclusions stated concerning the effect of beaver dams on stream production might not apply to log jams because of their structural differences. Therefore, this study was undertaken to evaluate the effects of log jams on trout stream production.

Description of Study Area. Priest Lake has a number of tributary streams, all of which contain log jams in some shape or form. Granite Creek, which empties into the lake near the middle was chosen as the study stream. Granite Creek typifies many of the streams in the area being of average gradient, rock and gravel bottom, and generally well shaded by the surrounding coniferous forest.

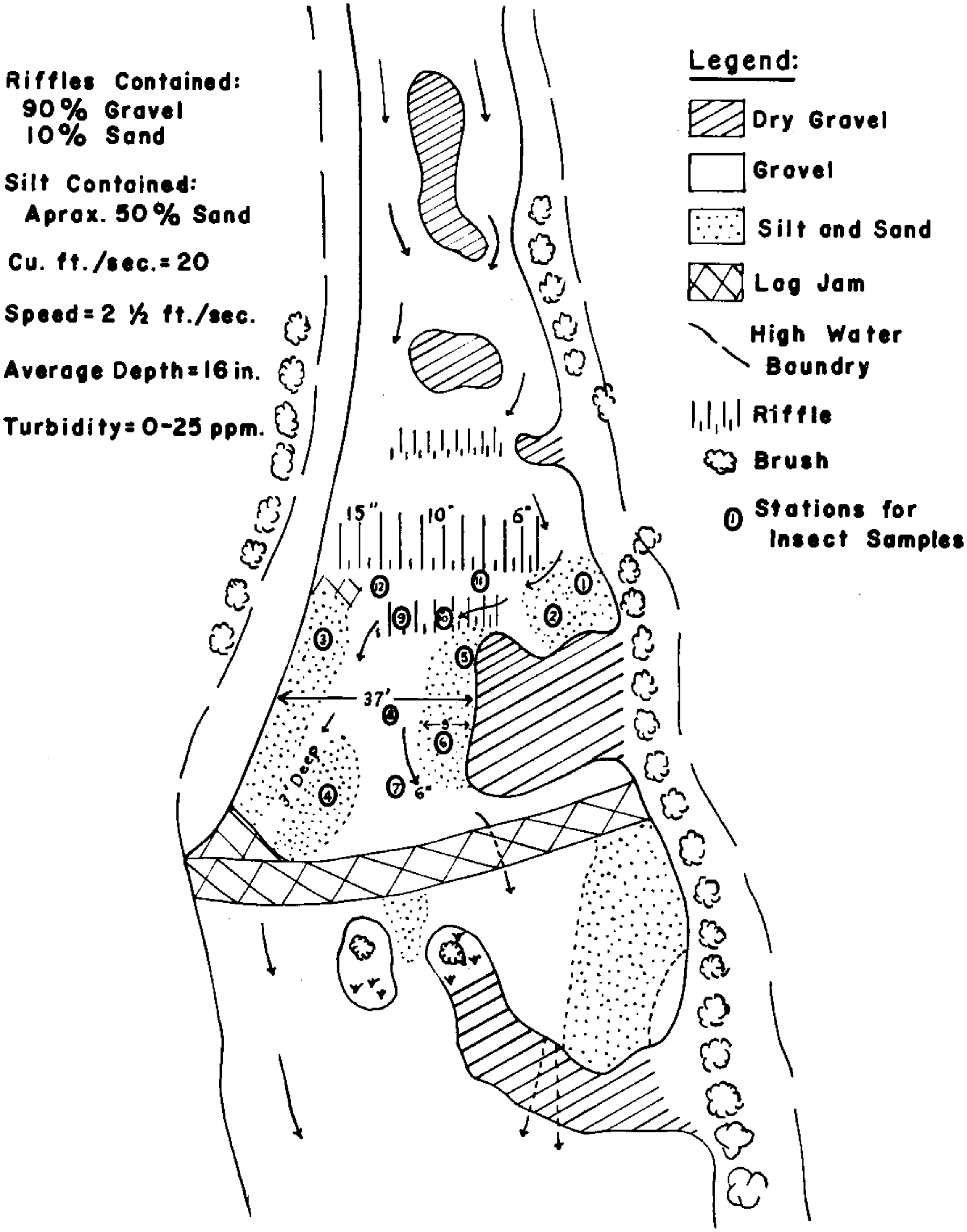
The log jam pictured in the diagram on the following page was considered to be a typical log jam for that size stream. The dam extended completely across the stream channel and is never submerged under water. During the spring runoff a large pool is formed allowing for deposition of sediment carried by the stream. After high water the level drops until the area covered by the pool is only slightly larger than the normal stream channel.

Procedure. A total of 12 bottom samples were taken with a square foot bottom sampler. Six of the samples were taken in a silt-sand bottom type and the remaining six were taken in a gravel-riffle bottom type. The samples were taken in water 6-12 inches deep.

Temperature. Temperature was taken with a maximum-minimum thermometer and found to vary between approximately 63 and 52° F. during August, which is the peak temperature period.

Oxygen. Although no water samples were taken to determine the oxygen content, it is *very* doubtful that there is a deficiency because of the nature of the stream.

GRANITE CREEK



Flow. There is a great variation between maximum and minimum flow in these streams as would be expected of an area with deep snow cover. The flow in Granite Creek was approximately 20 cubic feet per second at the time the samples were taken.

Results of Bottom Samples. The number and volume of insects collected in the bottom samples is given in Table 1.

Table 1. The number and volume of insects collected from bottom samples taken in silt-sand bottom type (six samples) and gravel-riffle bottom type (six samples) located in a pool behind a log jam.

	Silt-sand		Gravel-riffle	
Organism	Number	Volume (milliliters)	Number	Volume (milliliters)
Arachnoidea	1	tr.	--	--
Coleoptera	3	0.1	1	tr.
Deptera	4	0.2	5	0.3
Ephemeroptera	1	tr.	42	0.6
Hemiptera	1	tr.	--	--
Trichoptera	-	--	11	0.7
Plecoptera	-	--	3	0.1
Fish (sculpin)	1	0.2	1	0.1
Total	11	0.6 approx.	63	1.8 approx.
Mean per sample	1.9	0.1	10.5	0.3

Before discussing the findings presented in Table 1 it must be pointed out that this data comes from a relatively few samples and the chance for sampling error is great. The variability of stream bottom insects has been pointed out by numerous authors who caution against the use of a small number of samples in quantitative work.

With this variability in mind the quantitative analysis of this data has been limited to a superficial comparison of the mean numbers and volumes.

Examination of the data will show that the variation in this particular set of samples is not too great and also that without question there is a significant difference between these particular means.

The qualitative analysis of the data reveals a difference between the two bottom types that is possibly more striking than the quantitative analysis.

Ephemeroptera, Tricoptera, and Plecoptera make up a vast majority of the insects found in the gravel-riffle samples. Representatives of these orders are not present in the silt-sand samples with the exception of a lone mayfly nymph. This great difference in species composition between the two habitat types is without doubt due to a change in habitat conditions in the form of siltation and formation of slack water areas.

This qualitative analysis coupled with the reserved quantitative analysis points to an unmistakable difference in insect numbers in the two bottom types.

Having established that there is a decreased production of insects in the silted areas of the pool caused by the jam, it must next be determined if the total insect production has been decreased.

In most studies conducted on beaver-trout relations it was found that even though the productivity was less foot for foot in the pool the total production was greater because of the greatly enlarged area covered by water. Because the structure of a log jam does not completely block the flow of water, as does a beaver dam, the amount of pool area formed is decidedly less. Also, portions of the original gravel-riffle bottom types are silted over. The normal area covered by the jam pool is only slightly larger than the natural channel so that the increase in water area does not compensate for the lowered productivity per unit of space.

The fact that a pool is formed is of some consequence. In extremely cold streams such pools are beneficial because they warm the water so that the fish are able to more efficiently utilize the food present. In streams where it is desirable to establish a resident population of fish, such a pool may be desirable. Although the insect productivity is decreased in such areas, the formation of a resting and hiding place for the fish more than compensates for the decrease, especially in streams such as those in the Priest Lake Drainage.

If the free migration of fish up and down the streams is the desired end, then both the pool and the jam are undesirable. The jam acts as a physical barrier to migration while the pool may be an indirect delay to migration by providing a suitable but unwanted habitat.

Conclusion. Through the analysis of the bottom samples it is concluded that there is a decrease in insect production in a pool caused by a log jam. The decrease is brought about by a change in the environment (from gravel-riffle bottom type to sand-silt bottom type) which in turn changes the species composition and numbers.

The increase in area covered by water is not large enough to compensate for the lowered productivity.

The relative value of a log jam and its pool must be determined after. it is known what effect it will have on the type of fish population desired, resident or migratory.

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