AN ABSTRACT OF THE THESIS OF

GARVAN PAT BUCARIA for the M. S.
(Name of student) (Degree)

in FISHERIES presented on April 26, 1968
(Major) (Date)

Title: GROWTH OF JUVENILE SOCKEYE SALMON, ONCORHYNCHUS NERKA (WALBAUM), IN AUKE LAKE, ALASKA

Abstract approved: Redacted for Privacy
R. E. Dimick

The fresh-water growth and biology of sockeye salmon (Oncorhynchus nerka) were investigated during the summer and fall of 1963 and 1964 at Auke Lake, Alaska. Approximately 3, 527 adult salmon spawned at all locations in 1963 and 2, 831 in 1964. These fish represented 55 and 52 per cent respectively of all sockeye counted into the lake during the two years. One lake spawning site was located, while others might have existed in deep water off Lake Creek or in zones of inflowing waters. Most female spawners had spent three years in the ocean, while males were nearly equally divided between two and three years at sea.

Estimates of fry entering Auke Lake from Lake Creek were 134, 666 in 1963 and 118, 129 in 1964. The average fork length of fry entering Auke Lake in 1964 was 29.9 mm.

Approximately 62,389 smolts left the lake during 1964. Most fingerlings in their second and third year left the lake by May 20, followed by age I fingerlings through early June. Growth of age I smolts was evident during the spring before these fish left the lake. By June 8, yearling smolts averaged 67.3 mm.

Lake resident populations were collected in 1964 through the use of a roundhaul seine. Four age groups (ages 0, I, II and III) of juvenile sockeye were present in Auke Lake through May 23. Thereafter, age II and III fish were not encountered. Populations of age I fingerlings also declined after this date, while age 0 fish increased greatly in numbers through early August, then declined thereafter. Large average catches in August were the result of chance captures of aggregations of age 0 fish.

Age 0 and I sockeye grew more rapidly and larger in 1964 than for the same period during 1963. No significant difference in growth was detected between different regions of the lake for age 0 and I fish in 1964. By October, 1964, age 0 fish averaged 56.1 mm in fork length, weighed 1.38 gm and had a mean coefficient of condition of 0.78. For the final collecting period, age I fish averaged 71.5 mm in fork length, weighed 2.99 gm and $\overline{K}$ was 0.81.

Copepods, cladocerans and dipterous insects made up the majority of food organisms utilized by all categories of lake resident sockeye. From May through June, age I and older sockeye consumed

Daphnia in greatest numbers, shifted to *Cyclops* through August, then returned to heavy use of Cladocera. Diptera appeared consistently in stomachs through August and made up the majority of food in October. Age 0 sockeye made heavy use of copepods through early August then switched to Cladocera. Diptera were encountered in age 0 stomachs only during October. Intraspecific competition was suggested between age 0 and I sockeye during mid-summer when both groups fed heavily upon copepods.

Growth of Juvenile Sockeye Salmon, *Oncorhynchus nerka* (Walbaum), in Auke Lake, Alaska

by

Garvan Pat Bucaria

A THESIS

submitted to

Oregon State University

in partial fulfillment of
the requirements for the
degree of

MASTER OF SCIENCE

June 1968

APPROVED:

Redacted for Privacy

Professor of Fisheries

in charge of major

Redacted for Privacy

Head, Department of Fisheries and Wildlife

Redacted for Privacy

Dean of Graduate School

Date thesis is presented April 20, 1968

Typed by Carolyn Irving for Garvan Pat Bucaria

ACKNOWLEDGMENTS

This investigation was made possible through the facilities provided by the U. S. Fish and Wildlife Service, Biological Laboratory, Auke Bay, Alaska.

Sincere appreciation is expressed to Dr. David T. Hoopes, who offered suggestions and aided in the laboratory and field research.

I appreciate the assistance of laboratory personnel, especially Elmer Landingham for help with some of the illustrations and for providing his time and aircraft for aerial photographs.

Grateful acknowledgment is given to Professor Roland E. Dimick, Department of Fisheries and Wildlife, Oregon State University, for his constructive criticisms and encouragement during preparation of this thesis.

Thanks are due John C. Mason for his helpful comments during perliminary stages in the writing of the results of this investigation.

Special thanks are extended to my wife, Jeanene for her assistance in editing and proofreading the manuscript.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF TABLES (continued)

LIST OF FIGURES

GROWTH OF JUVENILE SOCKEYE SALMON, <u>ONCORHYNCHUS</u> <u>NERKA</u> (WALBAUM), AUKE LAKE, ALASKA

INTRODUCTION

This thesis presents the results of a preliminary study of juvenile sockeye salmon, <u>Oncorhynchus</u> <u>nerka</u> (Walbaum), in a small southeastern Alaska lake, Auke Lake, during the summers of 1963 and 1964. Most previous freshwater sockeye investigations have concerned large lakes, often parts of interconnected lake systems. Foerster (1925, 1938, 1944) studied the food and food supply, predator-prey relations, mortality at different life stages and effects of population density on size of young sockeye in Cultus Lake, British Columbia. Ricker (1937) also reported on studies of the food and food supply of juvenile sockeye in Cultus Lake. Foerster and Ricker (1941) related reduction of predaceous fish to survival of young sockeye in Cultus Lake. Burgner (1962a) investigated smolt abundance, growth and survival in Wood River Lakes, Bristol Bay, Alaska. Studies of the freshwater biology of sockeye in Kamchatka (U. S. S. R.) were reported by Krogius and Krokhin (1956). These studies concerned large salmon stocks of major economic importance.

The paucity of information regarding the fishery resources deriving from lakes in the southeastern region of Alaska prompted the U. S. Bureau of Commercial Fisheries to initiate a long term study on Auke Lake, near the Fish and Wildlife Service Biological Laboratory on Auke Bay. The initial program involved determination of the age composition and numbers of returning adult sockeye, the downstream fry immigration into the lake and the smolt emigration from the lake. Physical and chemical data were collected and analyzed by laboratory personnel during the investigation. Fry, smolt and adult sockeye studies were started in the spring of 1963 and supplemented by examining juvenile lake resident sockeye in the late summer of 1963 and throughout the summer and fall of 1964.

Most of the emphasis of the study in 1964 was directed to growth and food aspects of the lake resident age groups. Also, counts were made to ascertain the number of adult sockeye that produced the 1963 age class and to learn of the spawning success of those adults in terms of resultant fry. Smolt outmigrants from the lake were aged and numbers estimated as well.

THE STUDY AREA

Auke Lake is located approximately 4.7 miles (7.5 kilometers) north of Juneau, Alaska, at 53° $23'$ North latitude, 134° $37'$ West longitude. It is contained in a unibasinal depression of glacial origin (Figure 1). It is approximately 114 acres (46 hectares) in surface area and lies at an elevation of approximately 65 feet (20 meters) above sea level. The morphometric data shown in Table 1 were supplied by Dr. D. T. Hoopes (1964), supervisor, Auke Lake Investigations.

Table 1. Morphometric features of Auke Lake

Maximum length	1,103 Meters
Maximum width	600 Meters
Mean width	418 Meters
Maximum depth	34 Meters
Mean depth	19 Meters
Elevation above sea level	20 Meters
Length of shoreline	3,395 Meters
Volume	8,840,100 Cubic meters
Mean depth/maximum depth	0.55
Direction of major axis	NNE-SSW
Surface area	46 Hectares
Shoreline development	1.4
Volume development	1.6
Drainage area	2.3 Square kilometers

Lake Creek is the major tributary, but two other smaller streams, Lake Two Creek and Northeast Bay Creek, also flow into the lake. A small seep enters the lake at the southeast end. Auke Creek, the outlet stream, flows 340 meters to Auke Bay, cutting through a narrow ridge before entering tidewater.

Vegetation

The drainage system is heavily forested except where trees have been cleared for roads and dwellings (Figure 1). Beck (1964) has provided information concerning cover composition for the watershed. Western hemlock, *Tsuga heterophylla*, (Raf.) Sarg., makes up about 80 per cent of the overstory; the remaining 20 per cent is dominated by Sitka spruce, *Picea sitchensis*, (Bong.) Carr., which occurs adjacent to the stream courses. Lodgepole pine, *Pinus contorta*, Loud. and Alaska cedar, *Chamaecyparis nootkatensis* (D. Don) Spach, are represented by scattered trees in muskeg areas. Red alder, *Alnus oregona*, Nutt. is found immediately near the streams. The ground cover consists of dogwood, *Cornus canadensis*, L.; rusty menziesia, *Menziesia sp.* and a variety of mosses and lichens.

The shore line is bordered by a narrow band of emergent vegetation consisting mainly of horsetail, *Equisetum sp.*, and yellow water lily, *Nuphar polysepalum*, Engelm. Aquatic vegetation

Figure 1. Aerial photograph of Auke Lake and vicinity.

becomes sparce along most of the steep eastern shore.

Climate

Despite its northerly latitude, southeastern Alaska has a humid mesothermal climate characterized by mild temperatures. The Aleutian (Subarctic) Current affects this coastal region and the mountain relief acts as a barrier, retaining the marine influence and inducing heavy rainfall. Seasonal temperature variations are minor and extreme weather conditions are local and usually of short duration.

Extensive weather records for the Auke Lake vicinity are available as are local weather data from the Juneau Airport, 2.5 miles southeast of Auke Lake (U. S. Weather Bureau 1948-1964). Warmest months are generally June and July, while coolest temperatures are recorded in December and January. The average yearly temperature for 17 years was 39.9°F. (4.4°C.). During this period, extremes in temperature ranged from 84°F. (28.9°C.) in July, 1956, to -19.8°F. (-28.8°C.) in December, 1949. Average yearly rainfall for the same period was 54 in. (137.2 cm.) and ranged from a high of 68.1 in. (173 cm.) in 1961 to a low of 37.4 in. (96 cm.) in 1951.

Fish Fauna

Sockeye salmon, *O. nerka* (Walbaum), are the most numerous of the Pacific salmon in Auke Lake and were observed to spawn in the two tributaries, Lake Creek and Lake Two Creek, and in a restricted area in the southeast end of the lake. Coho salmon, *O. kisutch* (Walbaum), use each of the tributaries and the outlet stream. Pink salmon, *O. gorbuscha* (Walbaum), spawn intertidally in Auke Creek and also use the area upstream near the lake; a few spawn in Lake Creek, the major tributary. Small numbers of chum salmon, *O. keta* (Walbaum), have been observed to spawn only below the lake in Auke Creek and in the intertidal reaches of the stream. Of these species, only the young of coho and sockeye salmon remain in the lake during early life stages. Juvenile sockeye are represented by age groups 0, I, II and III.

Other fishes found in the system include the coastal cutthroat trout, *Salmo clarki* Richardson; Dolly Varden, *Salvelinus malma* (Walbaum); threespine stickleback, *Gasterosteus aculeatus* Linnaeus; the coastrange sculpin, *Cottus aleuticus* Gilbert and the prickly sculpin, *C. asper* Richardson

METHODS

Adult Enumeration

During 1963, most adult sockeye entering Auke Lake were counted as they passed a weir located at the Glacier Highway culvert. The 1964 escapement counts were made at a weir positioned approximately 120 feet below the culvert. During both years, samples were taken for measurement of sizes of migrating adults (mid-eye to fork of tail) and scales were collected.

Spawning ground surveys were made to enumerate adult spawners utilizing tributaries and littoral regions of the lake. To facilitate stream counts, numbered markers were placed at 100 yard intervals from the mouth of Lake Creek upstream 1,500 yards to impassable falls. Periodic surveys were made in each 100 yard section at intervals of three to seven days. Numbers of living and dead adults were recorded separately for each section. This procedure permitted a comparison of spawning ground densities in the stream between different years and minimized counting errors. Spawning ground counts were made only occasionally on Lake Two Creek, since relatively few fish used this stream. The extent of lake spawning along the shoreline area was estimated in 1963 using snorkel gear. Counts of lake spawning fish were made from a skiff in 1964.

Fry Population Estimates

The numbers of fry leaving Lake Creek in 1963 and 1964 were estimated from fyke trap catches. A four by four Latin square sampling design (Cochran and Cox, 1957) randomized with respect to time periods within days was employed. The fyke traps, 12 inches wide and 36 inches high, were as described by Straty (1960). They were positioned in a series across a 15 foot width of stream approximately 110 yards above the mouth of Lake Creek. The four traps were set at right angles to the stream flow and three feet from each other. The two outermost traps were one foot from shore. The stream bed sloped downward from one shore to the other, and the trap positions were assigned letter designations A through D, position D being in the deepest location. Site C was used as an index site, since largest catches were usually made at this site. When water conditions permitted, this site was fished continuously before and after periods of Latin square sampling. One of the four nets was operated at random for each hour when counts were made from 2200 to 0200 hours during both years. The trap at the index site (C) was usually fished from 2000 to 2200 hours and from 0200 to 0800. In 1964, this trap was operated from 1600 to 2200 and from 0200 to 0800. Occasionally it was set during daylight. Early and late season estimates were based upon site C counts.

Daily estimates of the total number of out-migrating fry were calculated from the following formula:

$$X = (A_1)\frac{W}{F} + A_i\frac{W}{F}$$

Where X = number of fry

A_1 = adjusted daily catch from randomly fished nets

$$A_1 = \frac{\text{individual site catch}}{\text{site \% catch}}$$

Based on 4 hour catches (1000 = 0200)

at single sites that were weighted from

the total 4 day catch for all 4 sites.

$$\text{site \% catch} = \frac{\text{of individual site catches}}{\text{total catch for all sites}}$$

A_i = adjusted daily catch from site C

$$= \frac{\text{daily index site catch}}{\text{site \% catch}}$$

W = stream width in feet

F = width of stream covered by nets

$$\frac{W}{F} = 3.75$$

Some of the fish from the hourly catches were retained for fork length and weight measurements. Otherwise, the fry were counted and released. Lengths of preserved fish (two days in 10 per cent formalin) were recorded in 1963. In 1964, fry were anaesthetized with tricaine methanesulfonate (M S 222) before lengths and weights were taken.

Smolt Population Estimates

Estimates of smolts leaving the lake were also based on fyke net catches. A sampling station was established about 100 feet below the Auke Creek outfall from the Glacier Highway culvert. The stream is approximately 11 feet wide at this point. The four net frames were set one foot apart with two feet separating each outer net from shore. During operation of the trap, the detachable cod-end of the net was attached to a reinforced rubber tube six inches in diameter and four feet long. This tube conducted the fish from the trap to a floating live box. The trapping site with trap B (index site) in the fishing position is illustrated in Figure 2.

Daily counts were made of the numbers of smolts collected in the live box. Samples were taken infrequently in June and July for length and weight measurements and scale samples (three samples in 1963 and five in 1964). Fork length was measured to the nearest millimeter and live weight to the nearest one-tenth of a gram.

Lake Resident Sampling Gear

A tow net measuring one meter in diameter was used in the lake during the fall of 1963. The net was suspended near the surface

Figure 2. Smolt trapping site with trap B in the fishing position.

by an inflated rubber float counterweighted by two, three pound sinkers at each towing bridle. The net was towed by two skiffs, each attached to the net by a plastic rope 100 feet long. This sampling method was subsequently abandoned, since captured fish were often damaged so badly as to prevent scale collection.

During 1964, a 20 by 210 foot roundhaul seine (Figure 3) was operated from a skiff. Catches from each net set were held separately in large covered plastic containers. Time and approximate location of each catch, surface water temperature and light level were recorded.

Sample Procedure

Auke Lake was divided visually into three sectors (Figure 4) to allow comparison of growth in each age group and to insure unbiased sampling throughout the lake. These sectors were fished in the evening at three-week intervals. Fishing effort was extended for several consecutive evenings when adequate numbers of fish of each major size group could not be obtained during the first evening. All three sectors were normally sampled during the same evening and the order of sampling was changed when sampling took place on consecutive nights. Usually one set was made in each sector, but occasionally this was increased to two when the sample was considered inadequate. Early in the summer, some sets were made after fish were

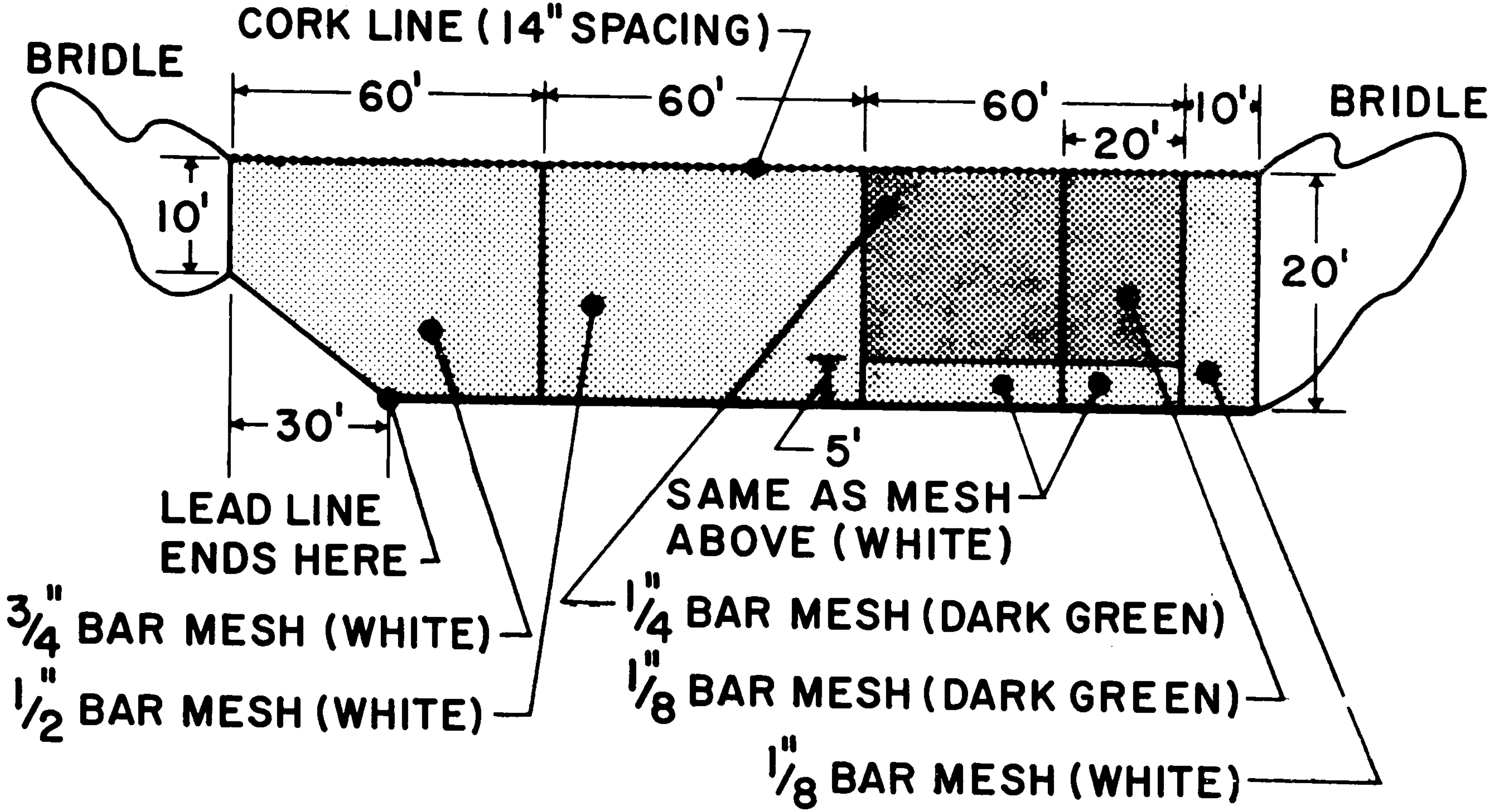

Figure 3. Diagrammatic sketch of 210 foot roundhaul seine.

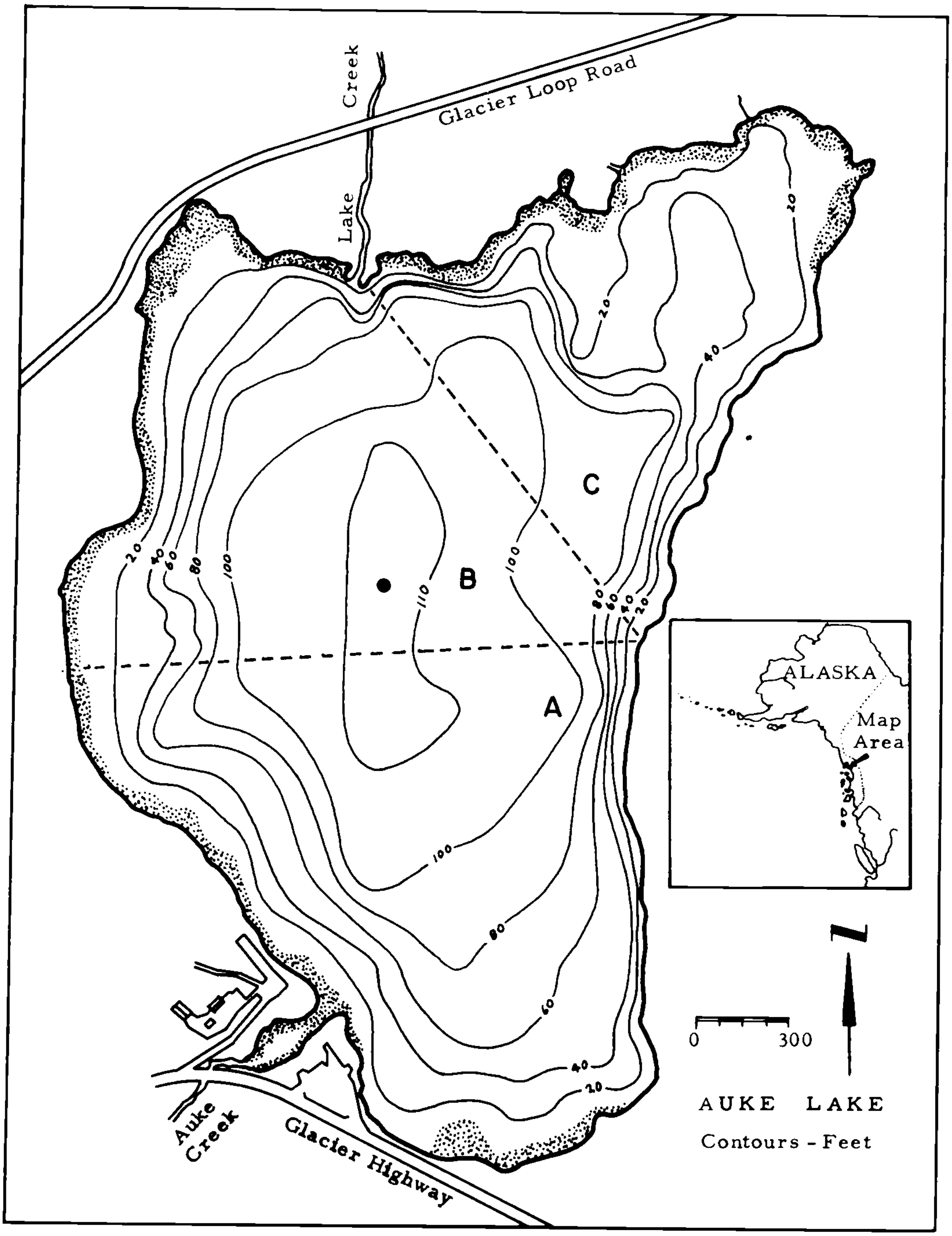

Figure 4. Contour map of Auke Lake showing the three sampling areas--A, B, and C.

observed to break the water surface. Later, sets were made without prior knowledge of the location of fish.

It was necessary to subsample on several occasions when extremely large catches were made. The numbers of fish captured were estimated when subsampling was accomplished by dipping out equal portions of fish and retaining every other panfull until the size of the catch was reduced. Estimates of these large catches were thought to be conservative.

Measurement and Aging of Lake Resident Fish

The majority of underyearlings (age-group 0) were weighed to the nearest 1/100 of a gram through August 30. After that date, fish of this age group had increased in size and were weighed to the nearest one-tenth of a gram. Fingerlings (age groups I, II and III) were weighed individually, Large samples of underyearlings were weighed en masse and average weights calculated. Fork lengths to the nearest millimeter were obtained for all fish after they had been anaesthetized.

Scales, taken from the region near the lateral line anterior to the adipose fin, were mounted between glass slides for later examination. Scales were projected with a magnification of 390X.

Sampling data were entered on punch cards and processed by I B M computer.

Food Analysis

The composition and bulk of food items within the anterior half of the stomachs of age I and older sockeye were determined using the points method. This method of food analysis developed by Synnerton and Worthington (1940) and modified by Hynes (1950) was essentially a volumetric technique. Food items were judged as common, frequent, etc. on the basis of subjective judgements as to the prevalence and size of an individual organism. Particular food items were related in terms of abundance and volume according to a point scale consisting of 1, 2, 4, 8 or 16 points. These numerical values were summed for each food category and percentage composition was calculated for each major food group encountered.

Slight changes were made in the points method to better fit use with Auke Lake juvenile sockeye. The subjectivity of the technique was reduced by maintaining a standard consisting of a glass vial marked off in volumes equivalent to each of the point categories. In addition, another point group (30 points) was added to the scale to account for stomachs greatly distended with food.

The points method was not suitable for underyearlings in early summer. Fish of age group 0 collected through August contained such small volumes of food that they could not be included in even the smallest point category. The numbers method was most suitable for these small fish and involved counting all individual organisms in the anterior half of each stomach. The results were expressed as the percentage number of each organism in half stomachs for all fish examined. After August, the points system was used, since total counts (numbers method) were not practical.

The points method and the number method should be interchangeable in determining the major food items in the diet of young sockeye salmon. Hynes (1950) reports the following:

> Those food items important in the diet will always stand out clearly from those that are occasional or rare and so unimportant, and the variation between the different methods will probably not be greater than between different samples of fish.

Classification of food items was according to Edmondson (1963). Generic designations were made for the Order Cladocera (Bosmina sp. and Daphnia sp.). Cyclops sp. predominated among the Order Copepoda encountered. Occasional Diaptomus sp. were found among plankton samples, but this species could not easily be distinguished among stomach contents. Copepods were therefore listed under Order Copepoda, Identifications were made to family of aquatic Diptera, but percentages were listed under order. Other organisms were identified as specifically as was practical.

Physical Features and Water Chemistry

Water temperatures were obtained from a station near midlake, usually once a month during the summer, but less frequently in the winter (Appendix 1). During the spring and fall, readings were taken at meter intervals down to at least ten. Temperature series were taken other times at from one to five meter intervals down to a maximum depth of 30 meters. A thermocline, extending from between two and three meters to seven or eight meters, was well formed by June of both years. Maximum surface temperatures of 18.3°C. (64.9°F.) and 19°C. (66.2°F.) were recorded during July of 1963 and 1964, respectively.

Auke Lake's surface freezes during the winter. On December 20, 1962, and November 21, 1963, the lake was completely frozen-over. The ice cover melted by late April of both years.

Water samples for chemical analysis were collected at 0, 5, 10 and 20 meter depths, usually on a monthly basis. The concentration of dissolved-oxygen was determined using the modified Winkler method described by Strickland and Parsons (1962). The highest oxygen concentrations occurred in late fall and winter and fell progressively during spring and summer. A value of 14.4 mg/l was recorded at the surface in December of 1963. The lowest value (6.2 mg/l) occurred at the 20 meter depth in mid-August, 1963 (Appendix 2). It appears that the fish fauna was not limited by oxygen conditions down to 20 meters at any time of the year.

Water transparency, measured with a Secchi disk, ranged from 2.0 meters in March, 1963, to 3.8 meters in June, 1963, and July, 1964. Auke Lake water is colored brown from humic materials leached from the surrounding drainage area. Turbidity was determined with a Hellige turbidimeter and recorded in milligrams per liter of silicon dioxide. Surface turbidity ranged from 1.2 mg/l to 5.2 mg/l. Values at other depths fell within this range (Appendix 3). Waters with a turbidity of 25 mg/l or less may be classified as clear (Lagler 1956).

The hydrogen-ion concentration was determined using a pH meter. Total alkalinity was determined using Moore's (1939) technique. The pH of surface water ranged from 6.2 to 7.2. As depth increased, pH values decreased. The lowest recorded was 5.7 at the

20 meter depth during April, 1964. Generally, Auke Lake waters have slightly acidic properties. Calcium carbonate alkalinity ranged from 5.5 mg/l in April, 1964, to 14.1 mg/l in July, 1964. Total hardness was determined according to the procedure described in Strickland and Parsons (1962). During the period from May, 1963, through October, 1964, total hardness ranged from 10.1 mg/l to 45.8 mg/l. Higher values, above 48 mg/l, recorded between November, 1962, and March, 1963, depart markedly from most other readings and may not represent the true pattern (Appendix 3). Values for calcium carbonate alkalinity and total hardness indicate that Auke Lake is a soft water lake.

Chemical analysis of biogenic salts were made by technicians at the Auke Bay Biological Laboratory. Procedures described by Strickland and Parsons (1962) were used to determine reactive phosphate, using the modified stannus chloride method and nitrate based on its reduction to nitrite. Concentrations of sodium, calcium, potassium and magnesium metals were determined using a Beckman D U Flame Photometer. The results of these analyses are provided in Appendix 3.

RESULTS

Adult Population Counts

Numbers of adult sockeye entering Auke Lake in late June, 1963, and mid-June, 1964, were compared with counts of those same fish after they had migrated to known spawning locations in early July through late August of both years. Comparisons of the two counts are shown in Table 2.

Table 2. Numbers of adult sockeye counted on entering Auke Lake and re-counted in known spawning locations during 1963 and 1964

	1963	1964	Difference between years
Total adults counted into Auke Lake	6, 391	5, 464	927
*Lake Creek population estimate	3, 407	2, 804	603
Lake Two Creek count	100	17	83
Lake spawning count	20	10	10
Total spawners	3, 527	2, 831	696
Differences between counts for each year	2, 864	2, 633	231

*Based upon data presented in Appendix 4.

A total of 6,391 adult fish were counted into the lake from June 24 to July 22, 1963. Spawning ground counts were obtained by summing the numbers of live and dead fish made during peaks of influx into the stream from July 24 to September 6, 1963 (Appendix 4). The total spawning ground count in 1963 was 3,527 fish. Most fish spawned in the first 1,000 yards of Lake Creek. New arrivals usually entered the stream during freshets, while dead and dying fish were removed by these high stream flows. An estimate of 3,407 adult sockeye was obtained in 1963 for the spawning population in Lake Creek. An additional 100 fish were seen using Lake Two Creek. Another 20 active spawners were counted at the mouth of a small intermittent tributary along the eastern shore of the lake. The disparity between the two estimates amounted to 2,864 fish.

In 1964, the adults first moved into Auke Lake on June 14 and continued through early August. A total of 5,464 fish was counted into the lake during this period. Spawning ground counts amounted to 2,831 sockeye. Spawners entered Lake Creek on July 24, 1964, and a total of 2,804 sockeye utilized Lake Creek during the spawning season (Appendix 4). In contrast to the 100 fish in Lake Two Creek in 1963, only 17 fish were seen there in 1964. During 1964, the mouth of the creek was blocked by a beaver dam that prevented passage of fish at low stream flows. An additional ten fish were seen spawning off the mouth of the intermittent stream. Differences between counts of adults into the lake and at all known spawning locations were 2,633 fish during 1964. This discrepancy between the spawning ground counts made for 1963 and 1964 will be considered further in the discussion section.

Extent of ocean life for Auke Lake sockeye was determined by Hoopes (1965) by means of scale analysis technique (Table 3). During both 1963 and 1964, most of the female spawners (90 per cent) spent three years in the ocean. Sockeye males appeared to be nearly equally distributed among two age classes. Two and three year ocean males contributed 48 per cent in each age class in 1963 and 43 and 56 per cent respectively in 1964. Precocious males ("jacks") contributed four per cent in 1963 and one per cent in 1964.

Table 3. Ocean history of adult sockeye salmon in Auke Lake escapement

Year	Sex	Number of fish in sample	Years of ocean residence .1	.2	.3
1963	Males	159	4%	48%	48%
	Females	150	--	10%	90%
1964	Males	163	1%	43%	56%
	Females	141	--	9%	91%

Fry Population Estimates

Population estimates of out-migrating Lake Creek fry were obtained from fyke trap catches from April 17 through June 18, 1963. Sampling was discontinued in mid-June, when catches fell below 100 fry per night. In 1964, nets were installed on the first of April, when Lake Creek was clear of ice. Initial catches were small (under 100 fry per night in index site C trap through April 5, 1964), but catches increased rapidly until May 7, when about 50 per cent of the fry had left the stream (Hoopes, 1964). Most juvenile sockeye had entered Auke Lake by June 30. It was estimated that 134, 666 fish left Lake Creek in 1963 and 118, 129 fry in 1964.

Lake Creek fry moved downstream at night and ceased to move as dawn approached. Few fry migrated during daylight hours under usual flow conditions. Similar nocturnal behavior for sockeye fry has been described by McDonald (1960) and Hartman *et al*. (1962).

Smolt Out-migration

Three age groups were represented among smolts sampled as they moved out of Auke Lake from May 4 to June 14, 1964. Mean fork length of each age group for all collections were as follows: age I - 65 mm, age II - 73 mm, age III - 79 mm. Mean fork length and confidence intervals for fish taken during the periodic samplings are shown in Appendix 5.

Figure 5 illustrates smolt length frequency histograms for 1963 and 1964. During 1964, larger smolts dominated the early part of the downstream migration. These predominantly age II and III sockeye were followed by age I smolts in late May and early June. Average size of age I migrants was 65.8 mm on May 26 to 64.4 mm on May 31, 1964, a difference of 1.4 mm and probably not significant. By June 8, this age class averaged 67.3 mm (Appendix 5). Mean weight of age I smolts followed a similar trend. The May 26 sample averaged 2.05 gm, while the May 31 sample averaged 1.98 gm, a difference of 0.07 gm. June 8 samples averaged 2.28 gm (Appendix 6). There was a slight increase in condition factor of yearling smolts from May 26 to May 31 (0.72 $\pm$0.01 to 0.74 $\pm$0.01). Thereafter, condition factor remained at about 0.74 through June (Appendix 7).

Increases in length and weight toward the end of the migration from Auke Lake may be attributed to growth that occurred in late spring while these fish were still resident in the lake. Spring scale growth for Auke Lake smolts is illustrated in Figure 6D. Growth during this period was reflected by additional wide circuli beyond the year I annulus. In other lakes, early season growth has been observed for sockeye which emigrate as smolts. Foskett (1958) reported spring growth among sockeye that went to sea as age I

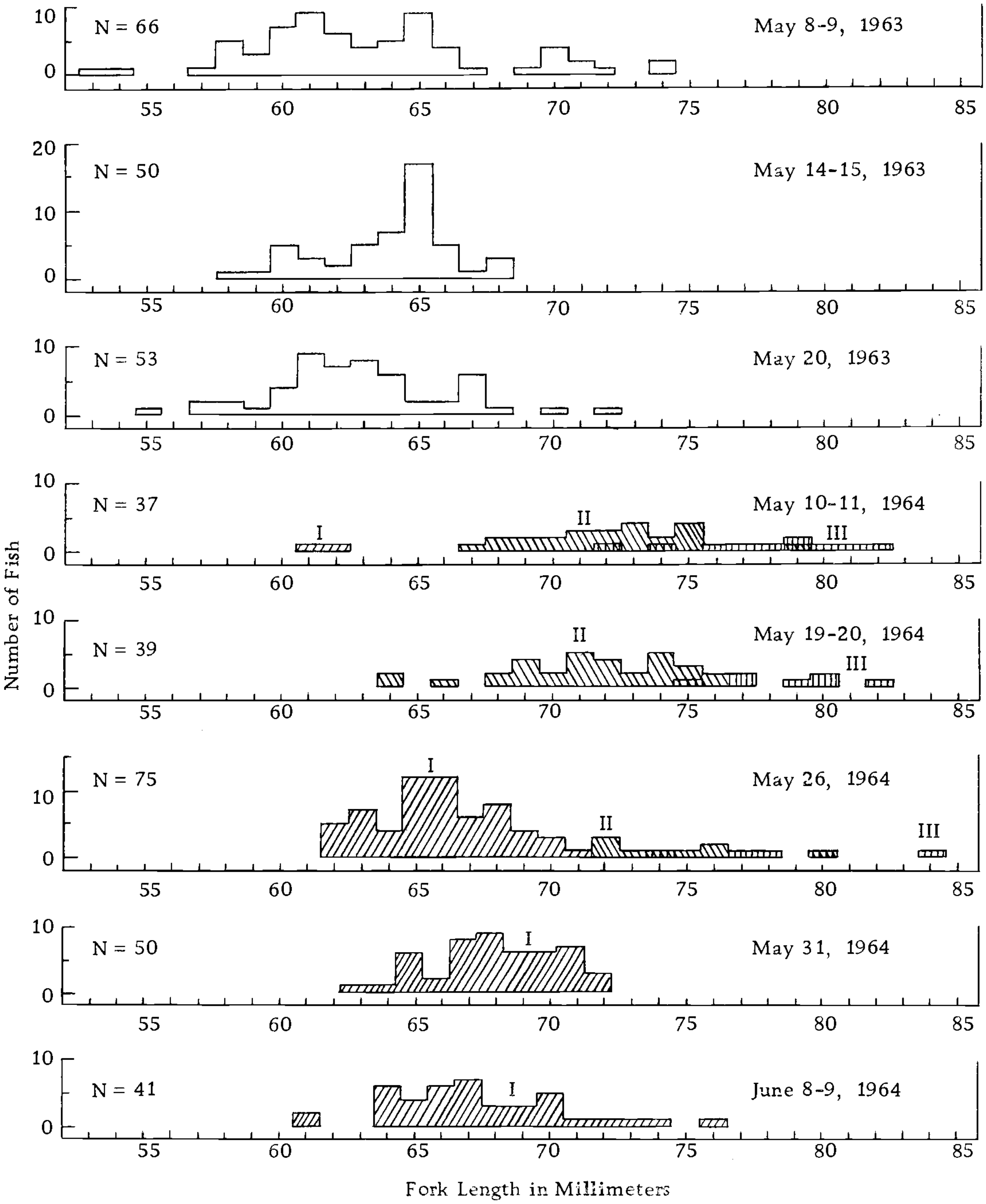

Figure 5. Length frequency historgrams for sockeye smolt outmigrants from Auke Creek during the spring of 1963 and 1964. ☐ - not aged; ▨ - age class I; ▧ - age class II; ▥ - age class III

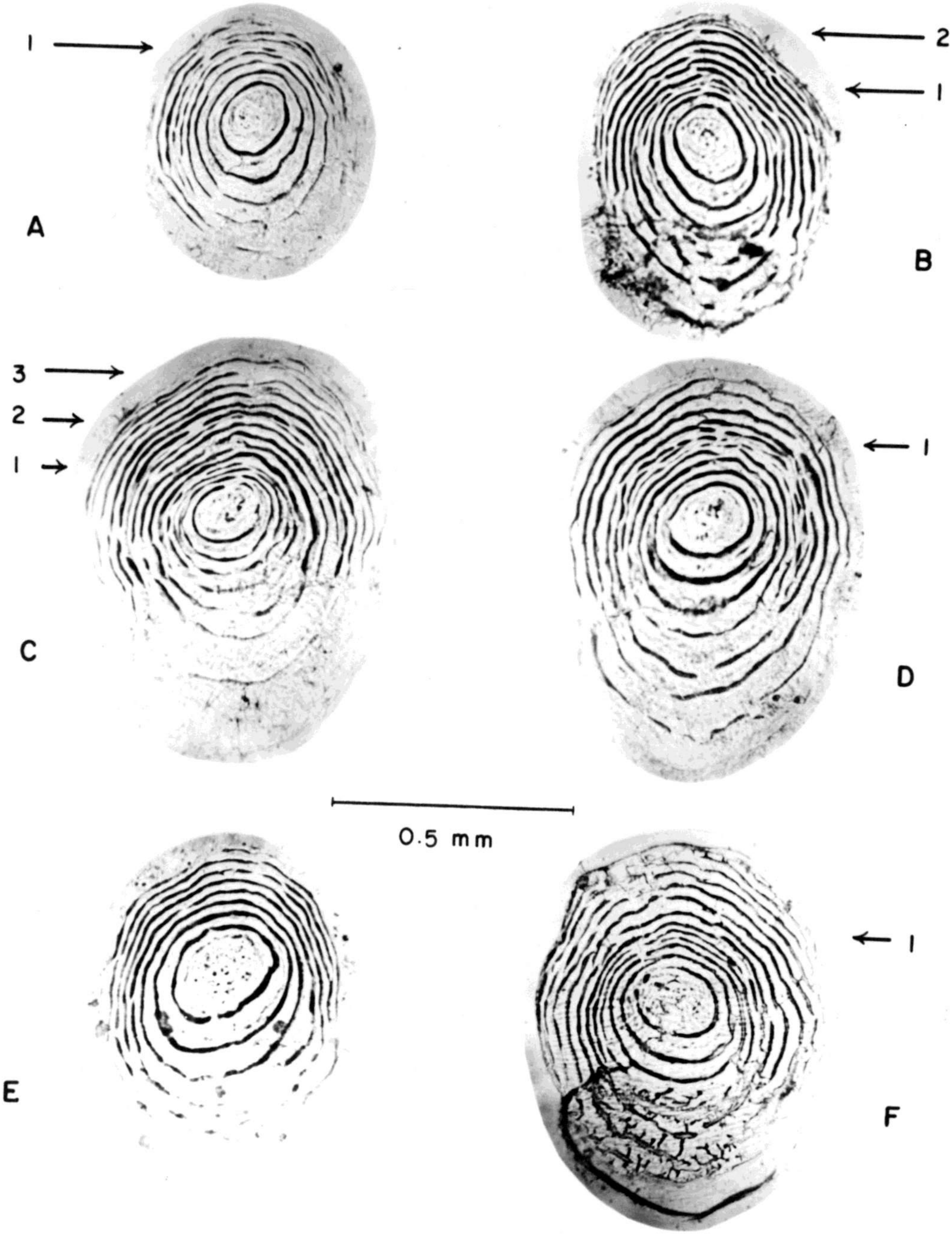

Figure 6. Juvenile sockeye scales collected in 1964. Arrows and numerals indicate position and number of annuli. A - May 20, lake resident, 58 mm; B - May 1, lake resident, 69 mm; C - May 5, lake resident, 73 mm; D - June 9, smolt, 71 mm; E - August 29, lake resident, 57 mm; F - September 22, lake resident, 67 mm.

migrants from Columbia. Roelofs (1964) found that age II smolts migrated first and suspected that age I smolts grew in Afognak Lake, Alaska prior to out-migration. He based this supposition upon the fact that the mean fork length did not change for smolts sampled both in May and June.

Estimates of out-migrant smolt numbers during 1963 were incomplete because of construction activities near the outlet of Auke Lake. The number of the smolts migrating from the lake during 1964 was estimated from fyke trap catches to be 62,389 fish.

Age Composition and Numbers of Lake Residents

There were four age groups of juvenile sockeye in Auke Lake during the spring of 1964. Fish of age group 0 were usually distinguished from those of age groups I, II and III on the basis of their small size (under 60 mm through late August). Overlapping size groups were separated into respective age categories on the basis of length frequency distributions and scale analysis. Scale patterns encountered among lake residents sampled during 1964 are illustrated in Figure 6.

Modal shifts in the length frequency histograms (Figures 7A and 7B) reflect increases in length of fish due to growth as the season progressed. Changes in the population structure resulting from migration are also shown. After May 23, sockeye of ages II and III disappeared from catches and there was a noticeable decline in age I fish, indicating that at least some of these fish left the lake. Decreased catches of fingerlings coincided with downstream movement of many age I and lesser numbers of age II and III smolts (Figure 5). Age group 0 lake residents occurred infrequently in the seine hauls in May. This was partly due to gear limitations, since the seine would snag on the lake bottom and could not be operated effectively if the water was less than 20 feet deep. Lily pads and other vegetation along the shoreline prevented the use of other types of gear in shallow water. Age group 0 fish became available to capture in the lake as they left inshore regions in mid-June. This suggest that previous to this time, fry were not in abundance in areas of the lake deeper than 20 feet. Other investigators have discovered similar results. Krogius and Krokhin (n. d.) reported that fry remained in the littoral areas during early summer in Lake Dalnee, Kamchatka. Burgner (1962b) made similar observations in Wood River Lakes, Bristol Bay area, Alaska. Pella (1964) in Lake Aleknagik, Wood River Lakes region, Alaska noted a decline in beach seine catches of fry and an increase in the occurrence of fry in the limnetic zone in midsummer.

Figure 8 illustrates mean catches for juvenile sockeye age groups. Average number of age I and older sockeye was 11.8 fish per net set during early May, 1964, but catches increased sharply

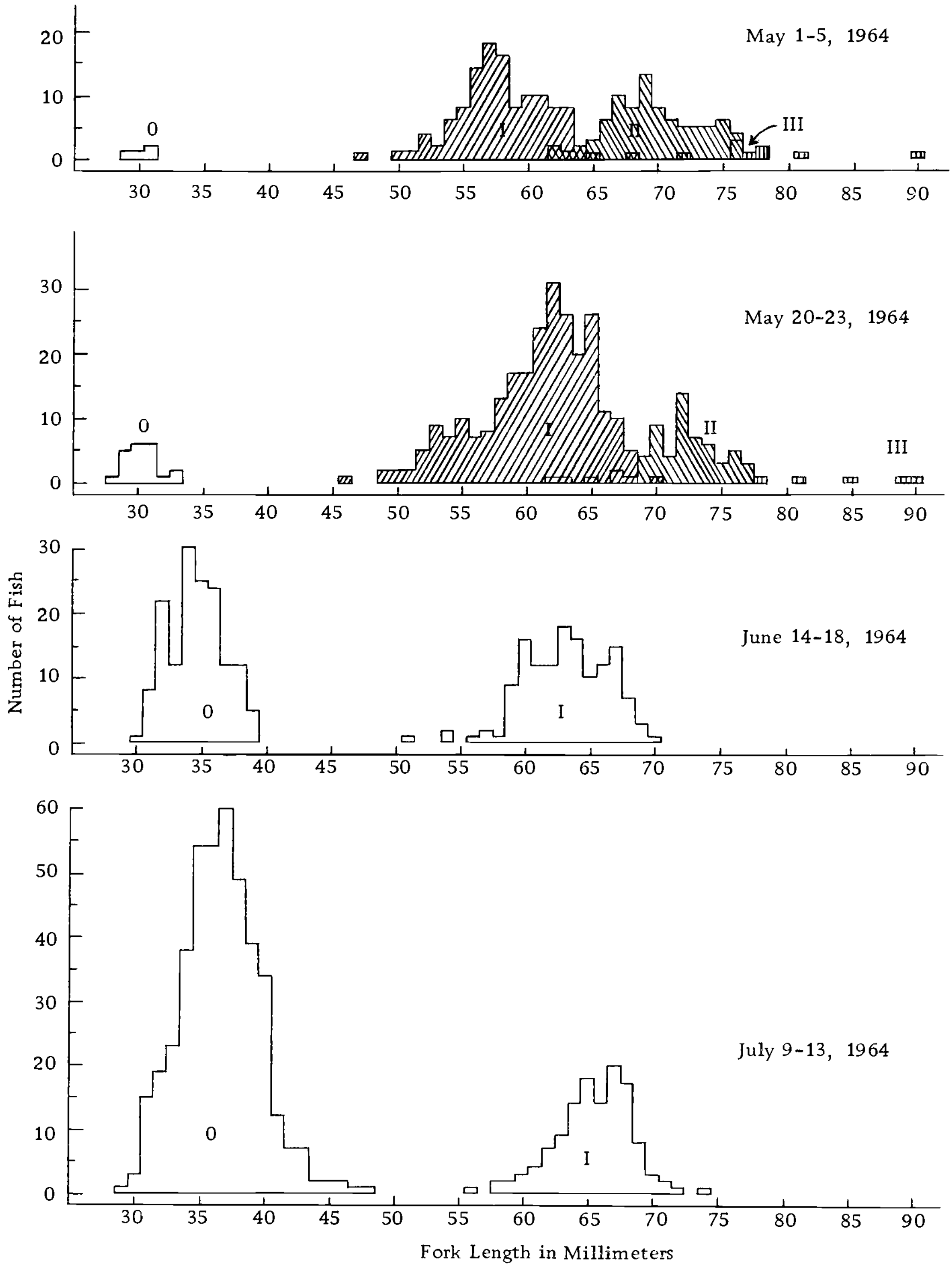

Figure 7A. Length frequency histograms for juvenile sockeye salmon in Auke Lake during the summer and fall of 1964.

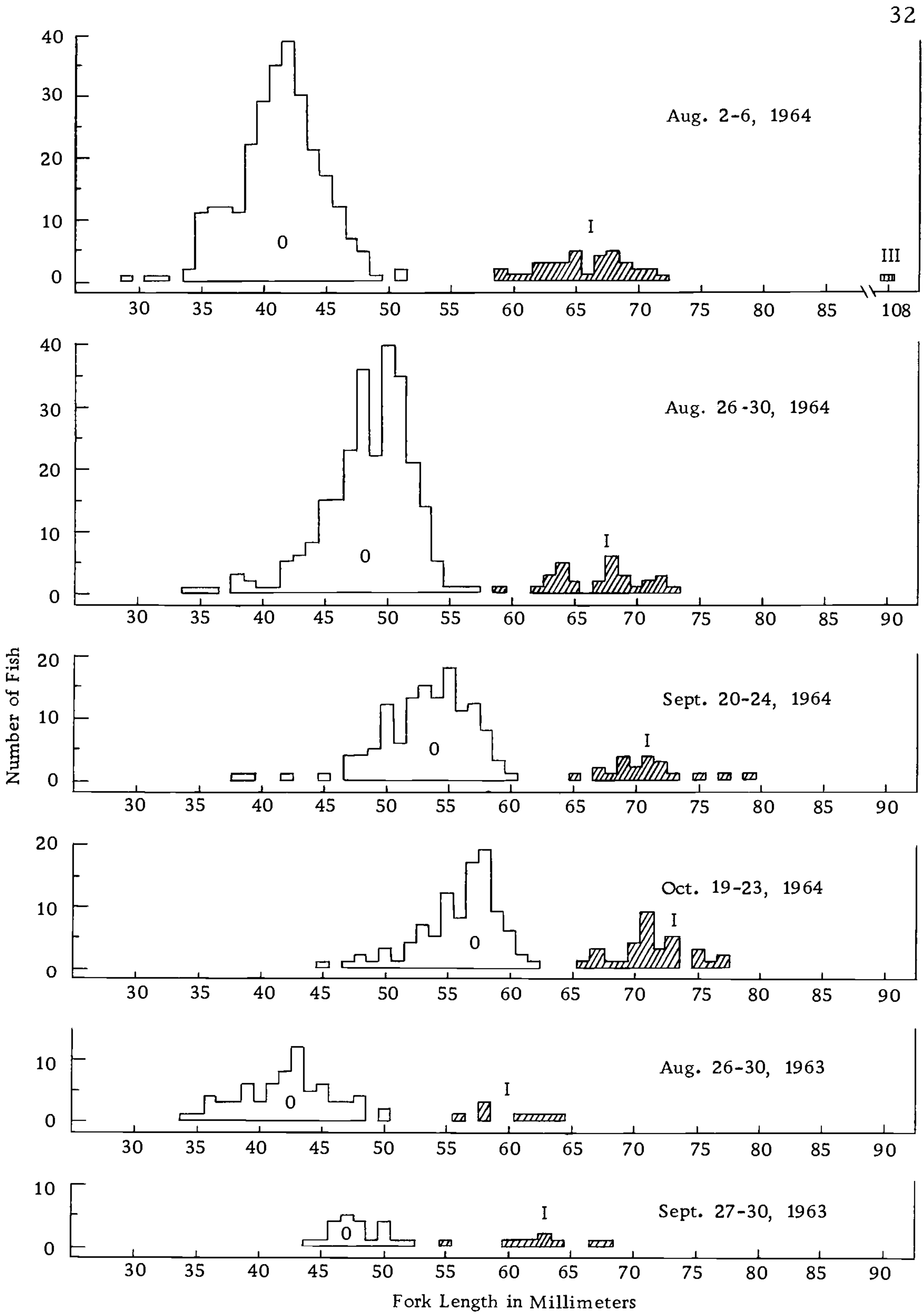

Figure 7B. Length frequency histograms for juvenile sockeye salmon in Auke Lake during the summer and fall of 1963 and 1964.

to 66.7 fish per seine haul during the May 20 to 23 sampling period. The latter extremely large average number of fish was due to one catch taken on May 21 and estimated to include at least 500 fish. This large number of fish probably was not representative of sockeye abundance for the whole lake. This particular group of fish caught in sector A, approximately 100 yards off the mouth of Auke Creek, was slender and silvery in appearance and did not possess parr marks, indicating these fish may have been out-migrating smolts. During the mid-June early July sample periods, average number of age I and older sockeye was approximately 6.9 per seine haul. The mean number of fish in the older age categories declined to 2.3 fish per set in early August and thereafter remained at or below this level (Appendix 8).

During early May, catches of age group 0 averaged 0.2 fish per seine haul. Gradual increases in the average number of lake residents per haul was the rule during late May, mid-June and mid-July, amounting to 1.8, 7.2 and 23.6 fish per set. The average number of fry caught during the August 2-6 sampling period was 44 fish per net set. Thereafter, catches declined to 13.2 fish per set in late August and 8.6 and 9.9 fish per seine haul in late September and October. In spite of the rather large decline in mean catch for age group 0 after early August, numbers of these fish remained

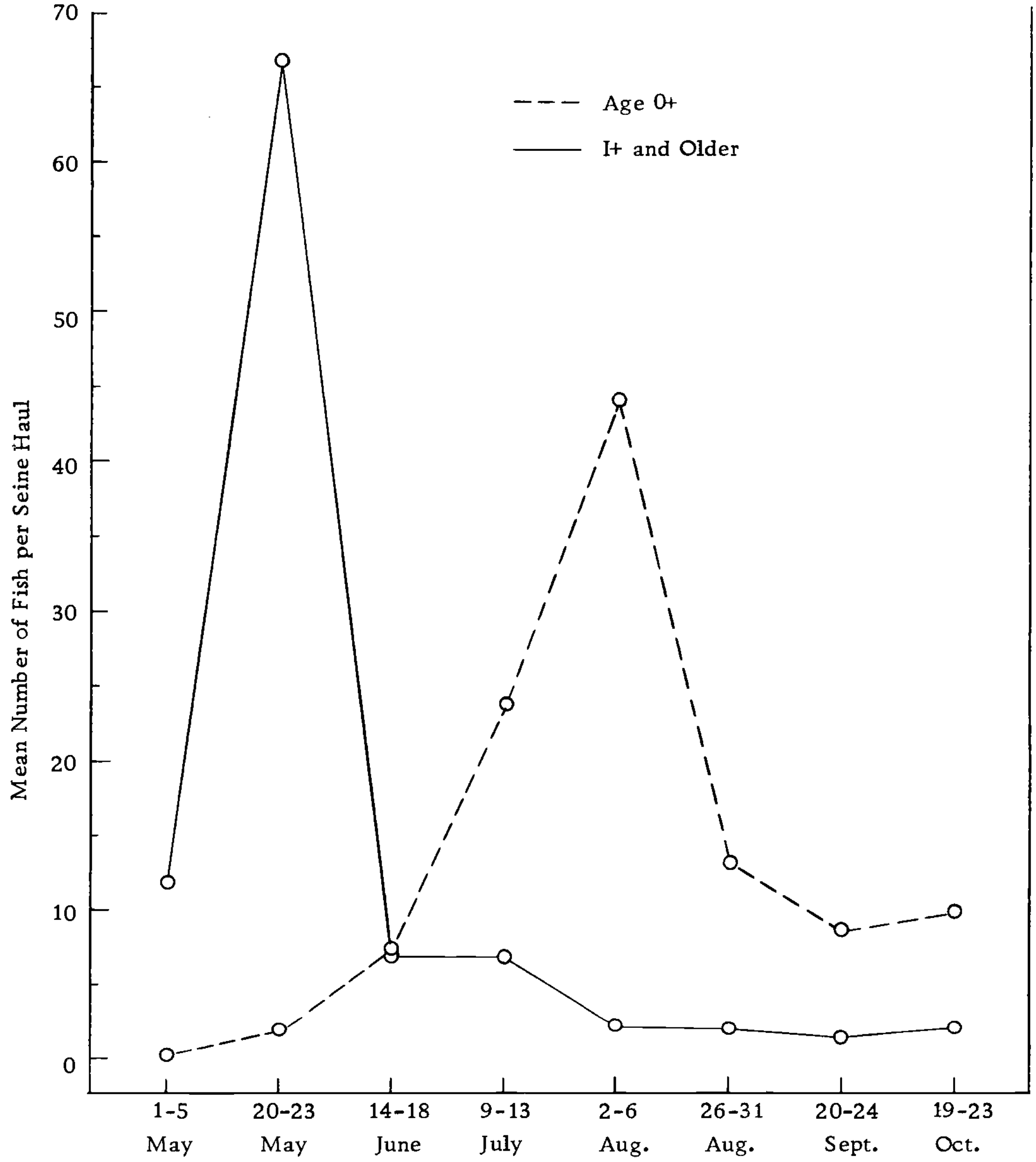

Figure 8. Trends in abundance of juvenile sockeye in Auke Lake, Alaska from dusk to dark roundhaulseine sets during 1964.

much higher than for the age I and older categories of juvenile sockeye (Figure 8).

The large average catches recorded for the early August period were due, in part, to one large sample (estimated to be at least 500 fish) made on the night of August 6. Such clustering of sockeye fry has been described by Pella (1964) based upon ecograms, made with sonar equipment, coordinated with nocturnal tow net catches on Lake Aleknagik. The extremely large number of age 0 sockeye taken in the round haul seine in Auke Lake probably resulted from an aggregation of sockeye similar to the ones recorded by Pella.

Auke Lake is a small unibasinal lake and after early August, when most age 0 fish seemed to have moved out of the littoral region, changes in horizontal distribution among juvenile sockeye were not evident from seine catches. According to Johnson (1956), there was uniform distribution among young sockeye in Lakelse Lake. In the much larger Babine Lake, there was limited dispersal in the region of entrance of young sockeye into the lake and a gradual dispersal during the whole period of lake residence. In such large lakes, Johnson noted that areas of local concentration seem to occur.

Sporadic daylight catches (12 sets of which three produced only a few fish--one of which resulted in 111 sockeye) were made in late August, but round haul seine fishing consistently produced greater numbers at night. This seems to indicate that sockeye may move nearer to the surface at night. Hoar (1954) found that sockeye, under controlled laboratory conditions, prefer mid-water depths during the day and observed that under low light intensities smolts were more active and were more widely distributed vertically. He postulated that larger juveniles are often found deeper than small ones of the same species. Pella (1964) found that daytime distribution of sockeye fry in late summer was near bottom, down to 25 meters depth, but at night was near the surface (upper six meters). Changes in depth of occurrence by age I and older sockeye in Auke Lake during late summer may have been a partial explanation for the small average number of fingerlings taken.

The rapid decline in average numbers of age 0 fish suggests that mortality may have occurred, but perhaps the fish may not have been accessible to gear in late summer. Foerster (1938) reported highest mortality for juvenile sockeye during the early months of life, with deaths decreasing as the season progressed and as fish grew larger. In Auke Lake, decreased catches of age 0 sockeye could partly reflect mortality-induced reductions in the population; extremely low average catches of older fingerlings may have resulted from movement of these fish to deeper water.

Growth in the Lake

Increase in size of all categories of lake resident sockeye was measured in terms of increments of length and weight and also condition factors were computed. Young sockeye in each age group were measured and average length of each age group compared to determine if fish in different areas of Auke Lake grew at different rates. Growth in length by age class was compared for each collecting period. Average change in weight was also determined throughout the summer and fall of 1964. Length and weight information obtained during 1963 and 1964 were used for condition factor determinations. Where possible, growth information has been compared between age classes collected during both years.

To detect possible differences in length of fish captured in different parts of the lake, linear regressions of mean fork lengths on time were fitted by the least squares method for age 0 and age I sockeye caught in each of three sectors of Auke Lake (designated A, B and C, Figure 4). Regression slopes were compared by t-test. Differences in growth in length of fish between sectors were not significant at the five per cent level (Table 4).

Table 4. Comparisons of growth in mean length by age class for three sectors at Auke Lake during 1964

Age	Sector Comparisons	Calculated "t" Values	"t" Value for Significance at 0.05	Significant
0	A vs B	-0.65	2.18	No
0	B vs C	0.28	2.18	No
0	A vs C	0.61	2.18	No
I	A vs B	0.43	2.18	No
I	B vs C	0.38	2.18	No
I	A vs C	0.64	2.18	No

Since no significant difference in length of sockeye between sectors occurred during 1964, linear regressions for catches have been combined by age class for all sectors (Figure 9).

Seasonal increases in length of juvenile sockeye sampled during 1963 and 1964 are illustrated in Figure 10 and confidence limits of mean fork length are presented in Appendix 5.

Three samples of lake resident sockeye were obtained in 1963 while testing netting techniques. The late August collection represented 70 age 0 fish averaging 42.2 $\pm$1.0 mm in length. Twenty-two underyearlings collected in September were 47.8 $\pm$0.9 mm in length, while the final mid-October, 1963 sample averaged 48.3 $\pm$0.9 mm in fork length; however, the reliability of the latter value is questionable, since only three fish were represented.

Underyearlings (age 0) collected as downstream migrants during April through late June, 1964, averaged 29.9 $\pm$0.1 mm in length. Only small numbers of age 0 fish were collected in May in

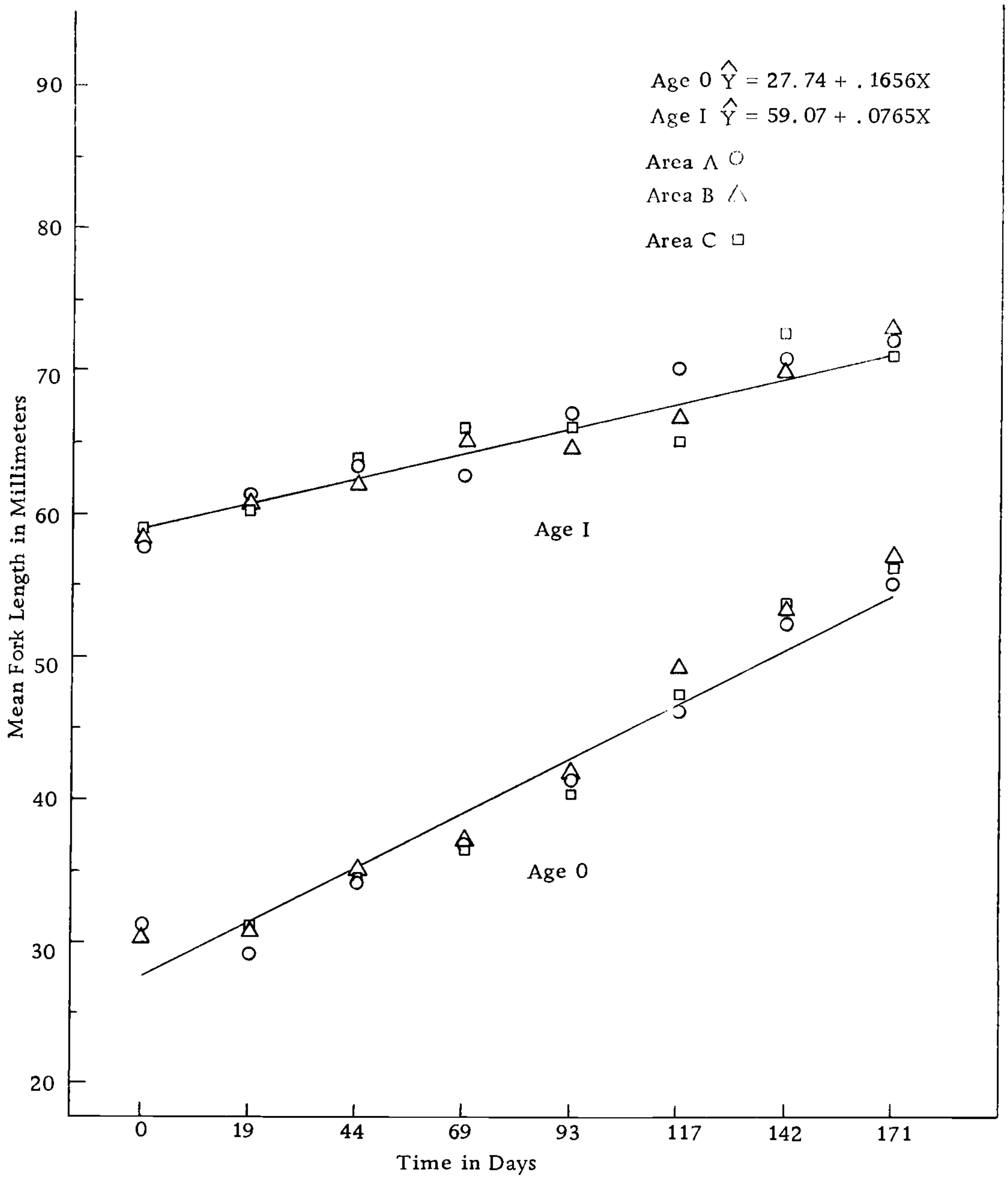

Figure 9. Mean length-time regression for Age 0 and Age I sockeye in Auke Lake.

the limnetic region of the lake, and growth in length appeared to be negligible during this period - average fork length was only 30.3 $\pm$ 0.6 mm by May 20-23. A pronounced increase in fork length to 34.7 $\pm$0.3 mm was evident by mid-June, but through July 13, the rate of increase declined (Figure 10), when underyearlings averaged 36.6 $\pm$0.3 mm. Inspection of the growth curve indicates that the rate of growth accelerated from mid-July to early August and was highest during late August, when age 0 sockeye were 48.3 $\pm$0.4 mm long. Less rapid increases in length continued through late September, when underyearlings were 53.2 $\pm$0.7 mm in length. Growth rates declined thereafter, though these fish had increased to 56.1 $\pm$0.6 by late October, 1964.

Age I lake residents collected in 1963 were difficult to obtain in quantity. The eight fish taken in August averaged 60.0 $\pm$2.6 mm in fork length; the nine sampled in September averaged 62.6 $\pm$3.0 mm and the two collected in October averaged 59.5 $\pm$19.1 mm in fork length. The latter sample probably was too small to be representative of the mean length of the 1963 population of yearling sockeye.

Yearling sockeye sampled early in May, 1964, averaged 57.9 $\pm$0.6 mm fork length. The growth of these age I fish increased to 60.8 $\pm$0.5 mm by May 20-23. Further increases in length amounted to 63.1 $\pm$0.6 mm by June 14-18 with continued growth in length amounting to 65.5 $\pm$0.5 mm by mid-July. Through the July collection period, catches of age I fish exceeded 100 fish per sample; thereafter

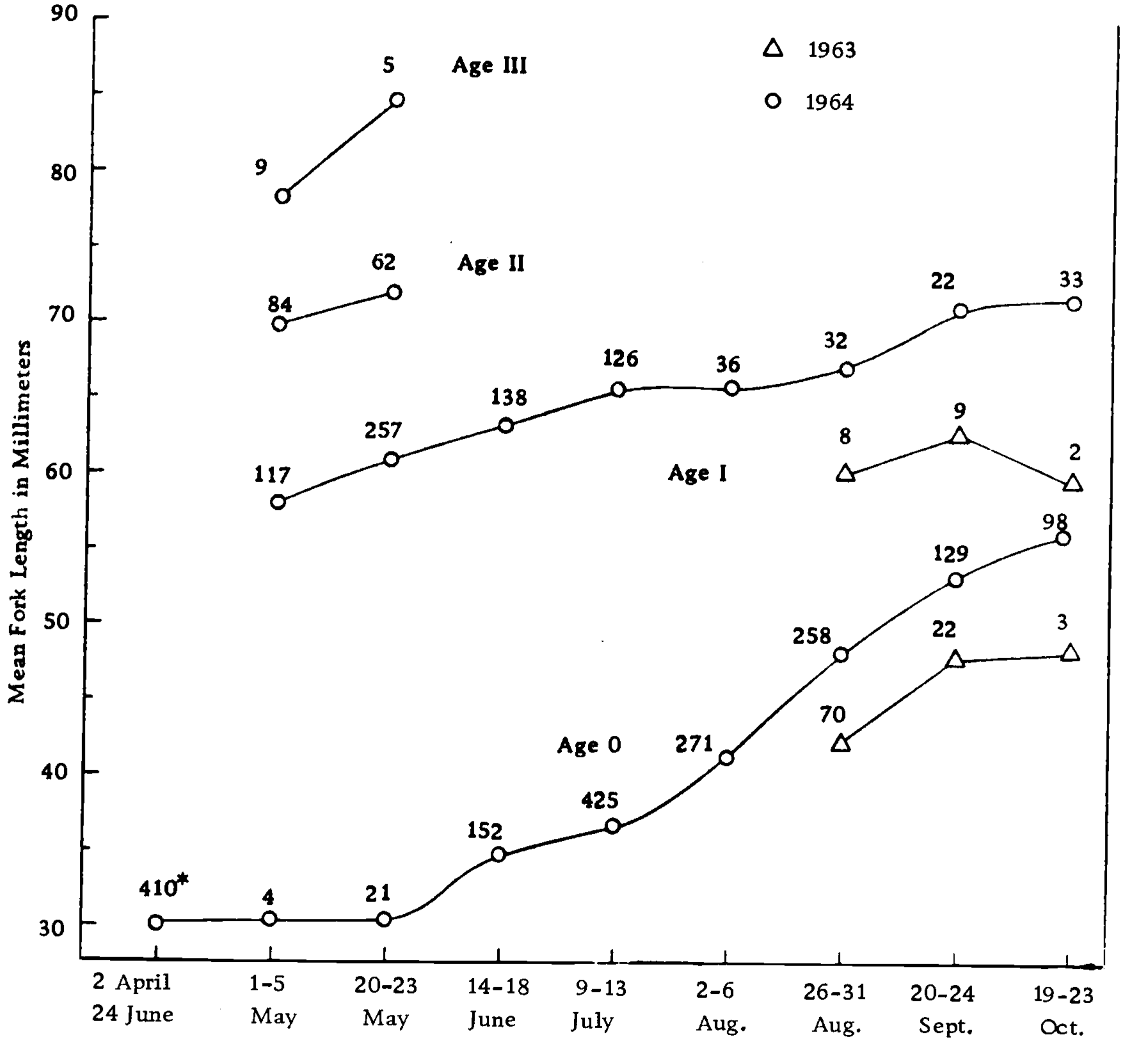

Figure 10. Growth in length of juvenile sockeye in Auke Lake during 1963 and 1964. *The April 2nd to June 24th collections represent fry sampled during their downstream migration into the lake and therefore probably consist of newly emerged fry.

samples contained between 20 to 30 fish. Growth in length declined during early and late August, when fish samples averaged 65.7 $\pm$1.2 mm fork length and 67.0 $\pm$1.3 mm, respectively. Growth accelerated slightly in the September 20-24 collections, when mean fork length was 71.0 $\pm$1.5 mm. Small increases in mean fork length were evident for the final sample obtained during October 19-23, when a maximum size of 71.5 $\pm$1.0 mm was recorded for yearling sockeye. Yearlings appeared smaller in size by late summer in 1963 than in 1964 (Figure 10).

Two and three year-old sockeye were encountered before outmigration as smolts in May. The May 1-5 collection of 84 age II sockeye averaged 69.7 $\pm$0.8 mm. A May 20-23 sample of 62 age II fish grew to 71.9 $\pm$0.8 mm. Probably growth increases also occur before age III fish leave the lake, but the growth relationship cannot be confirmed because of the small sample size. Just nine fish averaging 78.2 $\pm$3.9 mm were collected in early May and five fish averaging 84.6 $\pm$6.4 mm were taken on May 20-23.

A t-test was used to compare growth in length within age group 0 and age group I collected in late summer and fall during the two years. Differences in growth were significantly greater in 1964 at the five and one per cent level (Table 5).

Table 5. Comparison of mean size (fork length in millimeters) of underyearling and yearling sockeye in Auke Lake in late summer - early fall 1963 and 1964

Age Class	Sampling date	N	Mean FL (mm)	Standard error	Calculated "t" values	"t" value for significance at .05	.01
0	8/26/63	70	42.2	0.19	11.02	1.96*	2.58*
	8/26/64	158	48.0 1/	0.09			
0	9/27/63	22	47.8	0.19	9.80	1.96*	2.58*
	9/24/64	129	53.2	0.11			
0	10/20/63	3	48.3	1.44	6.21	1.99*	2.64*
	10/20/64	98	56.1	0.10			
I	8/26/63	8	60.0	1.13	5.55	2.04*	2.75*
	8/26/64	25	67.2 1/	0.53			
I	9/27/63	9	62.6	1.64	5.75	2.05*	2.76*
	9/24/64	22	71.0	0.49			
I	10/20/63	2	59.5	2.25	7.61	2.04*	2.75*
	10/20/64	33	71.5	0.24			

*Significant at the five and one per cent level.

1/ Mean FL calculated from nocturnal catches only.

Periodic weighings of juvenile sockeye were made throughout the spring, summer and fall of 1964 to determine the pattern of growth in weight for the season. To establish the weight of under-yearling sockeye entering the lake, nine samples, each comprising from 40 to 58 fish, were weighed from fry collected as they moved down Lake Creek into Auke Lake. Average weight of migrant sock-eye fry obtained from the pooled April 3 to June 8, 1964, samples was 0.14 $\pm$0.002 gm (Figure 11). During May, 1964, few age 0 fish

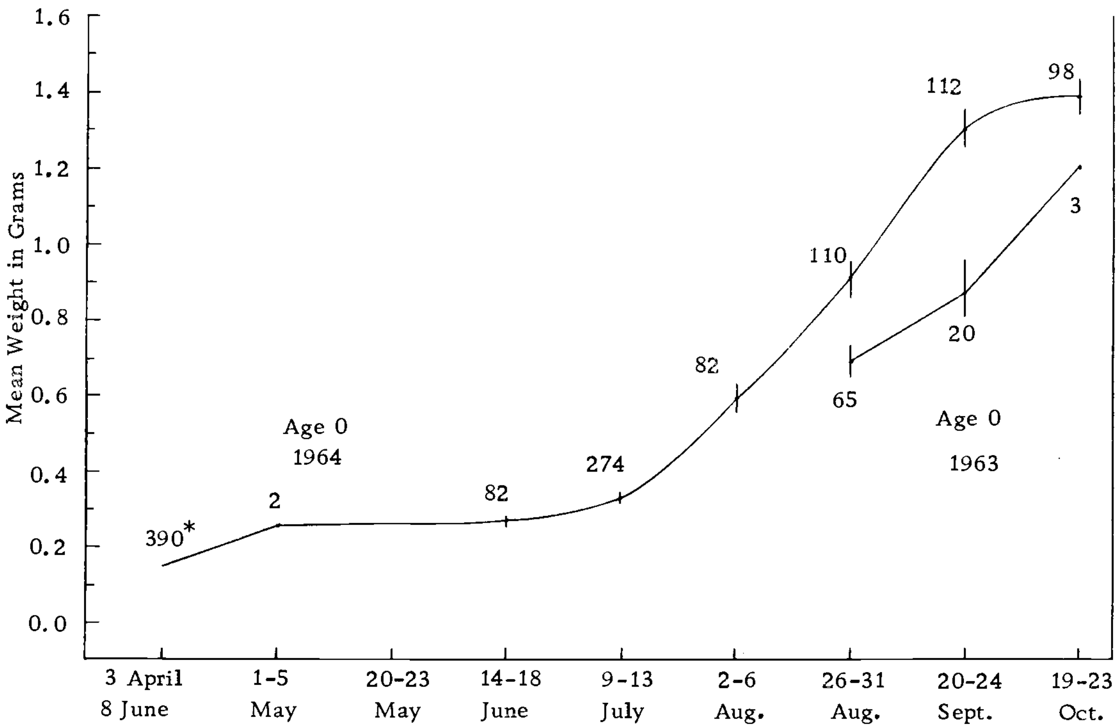

Figure 11. Growth in weight of Age 0 sockeye in Auke Lake during 1963 and 1964.
* The April 3rd to June 8th sample represents the average weight of fry out-migrants from Lake Creek.

were caught in the offshore regions of the lake. Weight gain probably was small during this period, since by mid-June mean weight of underyearlings was only 0.27 $\pm$0.02 gm. Rate of increase in average weight was slightly greater by mid-July, when age 0 fish weighed 0.33 $\pm$0.01 gm, but by early August fish nearly doubled in weight, when mean weight was 0.59 $\pm$0.04 gm. Continued rapid growth in weight occurred through the August 26-30 period, when age 0 sockeye weighed 0.90 $\pm$0.04 gm. A reduction in the rate of weight gain was evident by September 20-24, when fish averaged 1.30 $\pm$0.05 gm; and sharp reductions in growth rate occurred by October, when mean weight of underyearling sockeye reached the season high of 1.38 $\pm$0.05 gm.

The mean weight for age 0 fish collected in August, 1963, was 0.69 $\pm$0.05 gm as compared to 0.90 $\pm$0.04 gm for fish taken the same period in 1964. In September, 1963, the mean weight of age 0 fish was 0.88 $\pm$0.07 gm as compared to 1.30 $\pm$0.05 gm for the 1964 fish (Appendix 6). Gain in average weight between August and September in 1963 was smaller, 0.19 gm, than for the same period in 1964, 0.40 gm (Figure 11). The smallness of the October, 1963 sample, only three fish, precludes accurate comparison between fish of the two years.

The mean weight increment for age group I fish taken in early May, 1964, and in late October was approximately 1.5 gm. The mean weight for fish in the May 1-5 sample was 1.49 $\pm$0.05 gm and for those collected from the 19 to 23 October the mean weight was 2.99 $\pm$0.14 gm. After the initial May collection, continued growth in weight of yearling fish was indicated (Figure 12) by the increase of average weight to 1.78 $\pm$0.06 gm in the May 20-23 sample

Steady gains in weight occurred through June 14-18, when fish weighed 2.08 $\pm$0.06 gm, but the rate of growth in weight of age I sockeye appeared to decline slightly through July 9-13, when average weight of the fish was 2.23 $\pm$0.06 gm. It was during this period that age class 0 first appeared in large numbers along with the age I group. Confidence intervals (Figure 12, Appendix 6) for late summer and fall mean weights were wide and generally overlapped.

It seems unlikely that the size of samples would have influenced confidence intervals during early collecting periods, but during later sampling periods, sample sizes were somewhat reduced. The May through July collections ranged from 97 to 162 fish per sample, but from early August through October, considerably fewer age I fish, from 22 to 33 per sample, were obtained. The decline in rate of growth of age I fish and the concurrent appearance of age 0 fish in the same area of the lake may suggest possible competition for food. The relationship will be covered further in the section on food analysis and in the Discussion.

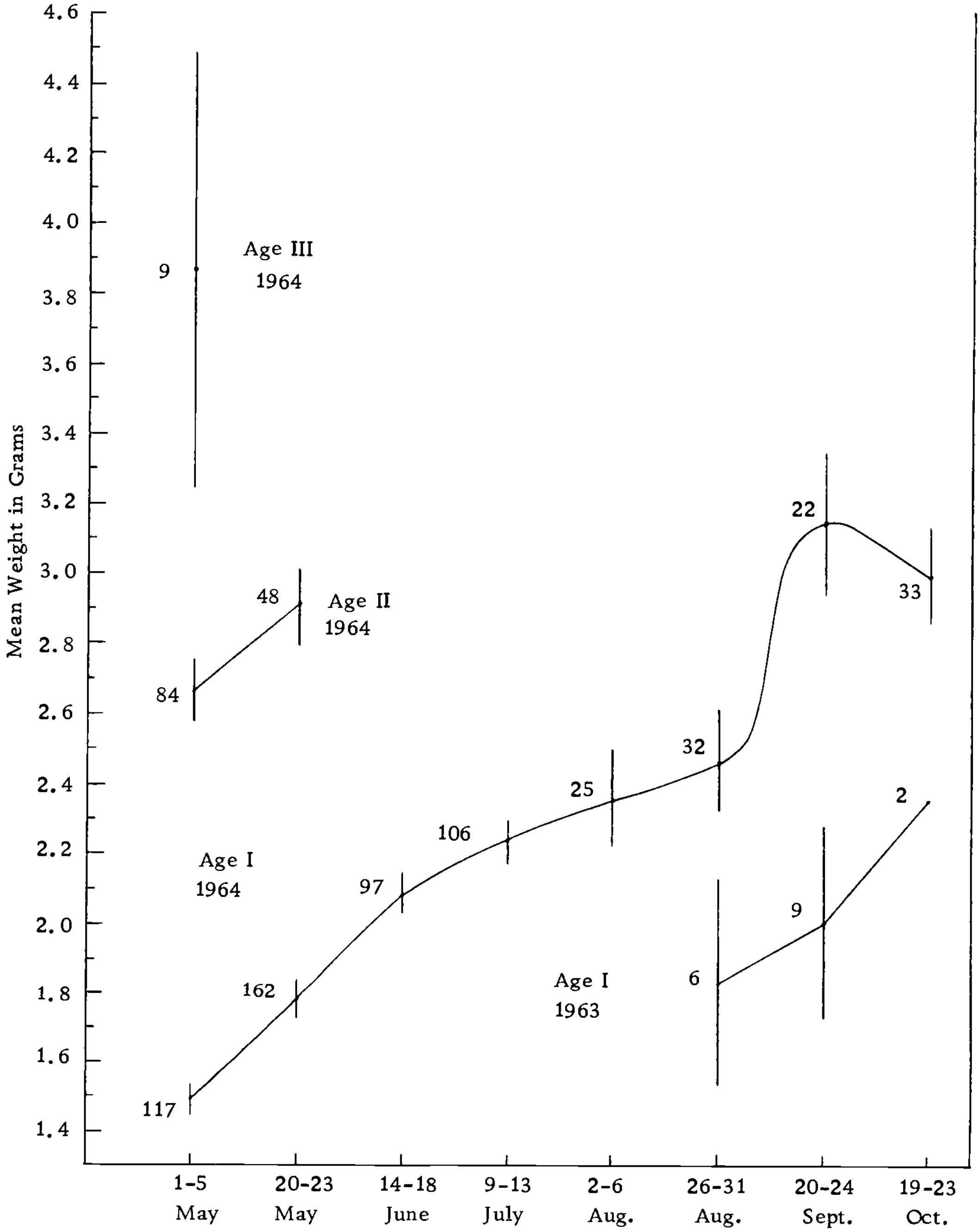

Figure 12. Growth in weight of age I, II, and III sockeye in Auke Lake during 1963 and 1964.

During early and late August sampling periods, a decline in the rate of weight gain was indicated, when age I fish averaging 2.35 $\pm$0.14 gm through August 6 and 2.46 $\pm$0.15 gm by August 26, 1964. The sharp rise and the mean weight of 3.14 $\pm$0.21 gm for September collections appears too high in view of the October 19-23 mean of 2.99 $\pm$0.14 gm. Since confidence intervals between the late August and September samples do not overlap and the gain corresponds with increased mean fork length for the same period, it may be that a marked increase in food was responsible for the peak in the September weight. The apparent decline by October may have been due to a corresponding decrease in food. A possibility exists that the October decrease in mean weight may not be significant in view of overlapping confidence intervals with September weights. The September sample may have biased the population mean for the period, and it could be speculated that the true value may have been at a slightly lower level--perhaps closer to the October value.

In 1964 collections, May through October, specimens of age groups II and III were obtained only during May. Two year-old sockeye averaged 2.66 $\pm$0.09 gm by May 1-5, 1964, and increased in average weight to 2.91 $\pm$0.12 gm by May 23 (Figure 12). After this date, this age class was no longer encountered in seine hauls. Apparently, most left the lake as smolts before the mid-June sampling period. Only nine, three year-old fingerlings were collected in early May. Mean weight for the May 1-5 collections was 3.86 $\pm$0.62 gm.

Growth relations among age I sockeye obtained in 1963 were not well defined, since only small numbers of fish were weighed.

Mean condition factors were calculated using the following formula:

$$\bar{K} = \frac{K}{N}$$

$\bar{K}$ = mean coefficient of condition

K = coefficient of condition

N = number of observations

The condition factor equation (K) was taken from Rounsefell and Everhart (1953). Calculations were based upon fork length measurements and weights made during periodic collections from mid-June through October, 1964, and in August and September of 1963.

Figure 13 illustrates the mean condition factors obtained for all juvenile age groups collected during the 1963 and 1964 study periods.

The greatest rate of increase of mean condition factor occurred between July 9-13 and August 2-6, when condition increased by 0.14 and age 0 fish reached a $\bar{K}$ of 0.80 $\pm$0.03. When the fish were first encountered in numbers in the limnetic zone during June 14-18, their mean condition factor was recorded at 0.62 $\pm$0.02. This value increased to 0.66 $\pm$0.01 by July 9-13, 1964. After the peak rate of

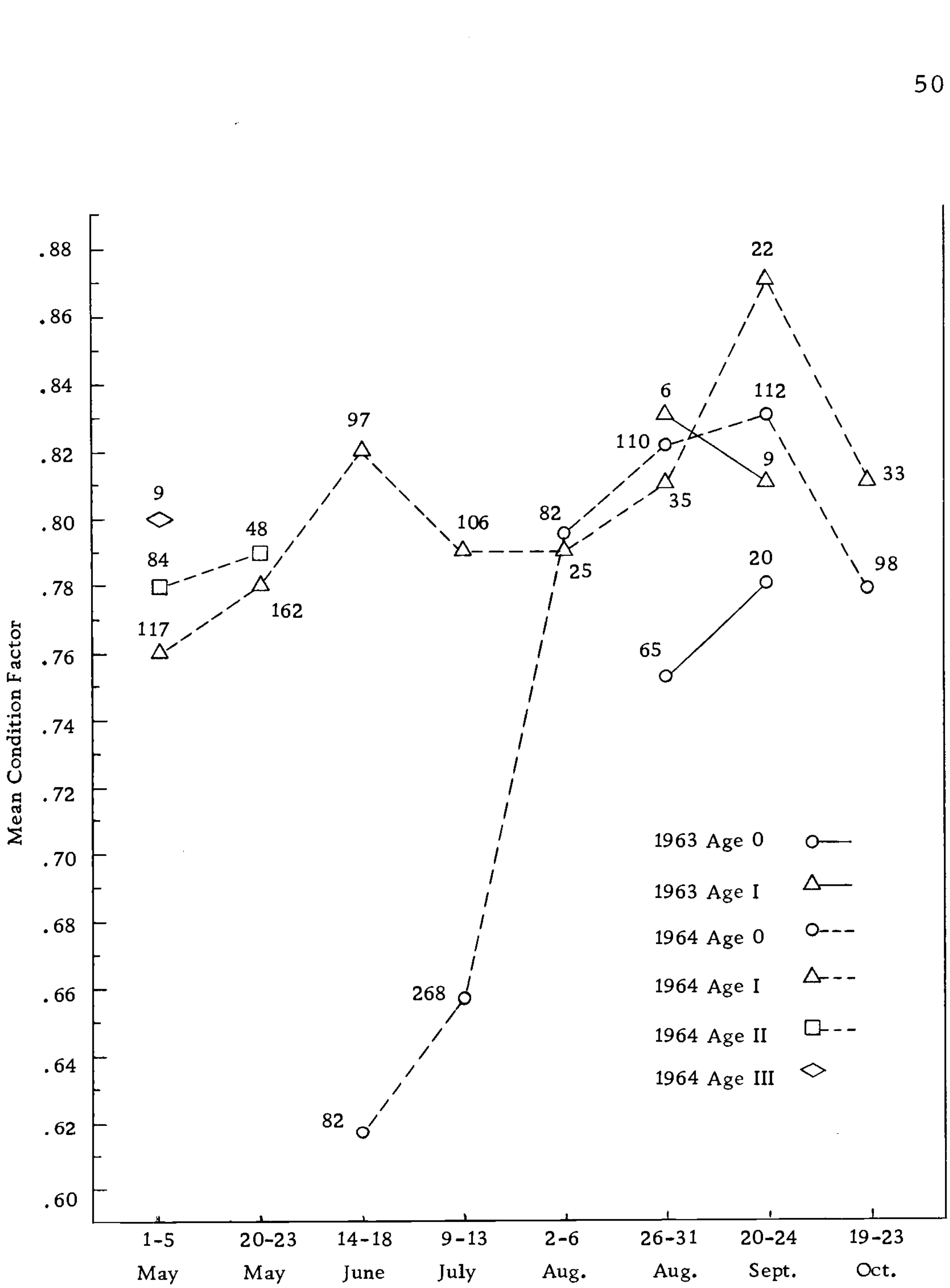

Figure 13. Mean condition factor for juvenile sockeye in Auke Creek during 1963 and 1964.

increase in late July and early August, the mean condition factor continued to increase, but at a noticeably slower rate (0.02). From August 2-6 to August 26-30, $\bar{K}$ was 0.80 $\pm$0.03 and 0.82 $\pm$0.01, respectively. Age 0 sockeye reached a maximum condition of 0.83 $\pm$ 0.02 by late September, 1964. Mean condition factor had declined to 0.78 $\pm$0.01 by October 23, 1964. Probably, the onset of winter limited the food supply of these age 0 fish. Fluctuations in environmental conditions no doubt, can greatly influence growth conditions.

During 1963, condition factors of age 0 fish increased from 0.75 $\pm$0.04 between August 26-30 to 0.78 $\pm$0.04 by September 27. Apparently, condition of the age 0 group was higher during 1964, but the rate of gain in $\bar{K}$ was greater during 1963 (Figure 13).

During May 1-5, 1964, condition factor of age I sockeye increased from 0.76 $\pm$0.01 to 0.78 $\pm$0.01 by May 20-23 and to 0.82 $\pm$ 0.01 by June 14-18. A small loss in $\bar{K}$, 0.03, was evident (Figure 13) during July 9-13, when it averaged 0.79 $\pm$0.01. This value increased slightly through August 2-6, when $\bar{K}$ was 0.79 $\pm$0.07. The possibility that inadequate amounts of food may have induced the lower condition factor will be discussed later. Age I fish improved in condition factor through August 26-31, when they reached a $\bar{K}$ of 0.81 $\pm$0.02 and gained their highest level of 0.87 $\pm$0.02 by September 20-24. Thereafter, during the final October 19-23 collection, $\bar{K}$ dropped to 0.81 $\pm$0.01. This drop corresponds well with the marked drop in condition of the 1964 age 0 group. Environmental conditions during October probably affected the growth capabilities of the young sockeye by restricting their food supply.

Age II fingerlings increased in $\overline{K}$ from 0.78 $\pm$0.01 in early May to 0.79 $\pm$0.01 by May 20-23, 1964.

Only nine, three-year-old sockeye were collected during early May, 1964. The average condition factor of age III fish was 0.80 $\pm$ 0.03.

August and September, 1963 samples of one year-old fish were small (six and nine fish respectively) and mean condition factors may not represent the true values (Figure 13). The August 26-30 condition factor was 0.83 $\pm$0.04 and the September 27, 1963 value was 0.81 $\pm$0.05 with confidence limits for these two samples overlapping (Appendix 7). While condition factor values were lower in 1963 than those for the 1964 age I group, there was a corresponding upswing in condition during September in both years.

Samples of smolts taken from May through early June, 1964, as they emigrated from Auke Lake had $\overline{K}$ ranging from 0.72 to 0.79 (Appendix 7).

Food Analysis

From 12 to 29 stomachs were examined from age 0 fish taken during six collection periods from the middle of June into October,

1964. Percentages of food organisms found in age 0 sockeye are shown in Table 6A. Data for samples collected from June through August represent percentages of total numbers of organisms encountered, while September and October figures show percentage of points accumulated for food taken by age 0 fish. The latter method has already been described on pages 16 to 17.

The crustacean food items found in the stomach samples of age 0 sockeye comprised species belonging to the orders Copepoda (Cyclops and Diaptomus) and Cladocera (Daphnia and Bosmina). Copepods primarily Cyclops sp., represented approximately 90 per cent of all food items examined for age 0 sockeye from June through early August, 1964. By late August, a change in diet was noted when copepods represented 25 per cent of all food items analyzed. Marked utilization of immature copepodid stages of copepods was also evident during August. A shift in diet to 75 per cent Cladocera was also recorded during late August. Cladocerans continued to predominate, representing 97 per cent of stomach contents checked in September and 76 per cent of those examined in October.

By October 23, 1964, age 0 sockeye had begun using Diptera. This insect group made up of adults of family Chironomidae constituted 18 per cent of the food items tabulated.

Among the Cladocera encountered, Daphnia represented a very small percentage of total numbers of food items in age 0 sockeye stomachs, never more than two per cent during June through August. Then in September, this species amounted to 44 per cent of the organisms in the stomach contents. A noticeable decline in the use of Daphnia resulted in a final October value of 6.5 per cent.

Bosmina gradually increased in importance in the diet of age 0 sockeye from about one per cent of the total items tabulated in mid-June to ten per cent of the points summed for the food consumed in early August and to over 70 per cent of total food items taken in late August. The utilization of Bosmina declined to 53 per cent of the points accumulated for food ingested in September, but rose to nearly 70 per cent in October.

Stomach samples were taken from 20 to 22 fingerling sockeye (age I and older) from May through July and dietary composition was determined by the points method already described. Smaller numbers (6-15 sockeye stomachs per sample) of fish were examined from August through October, 1964. The lengths of fingerlings used in stomach analysis during the 1964 season ranged from 51 to 90 mm fork length. Percentage points of food items composing the diet of fingerling sockeye salmon are presented in Table 6B.

The cladoceran, Daphnia was the dominant organism in the diet of fingerling sockeye from May through mid-June and represented nearly 50 per cent of all food materials consumed. Bosmina occurred only in trace amounts from May through June. Copepods, consisting predominantly of Cyclops, were next in importance with from 15 to 35 per cent of points accumulated for all food items recorded during the May to June period.

During July and August, intake of copepods increased to nearly 80 per cent of all points tabulated for items consumed. Among Cladocera recorded, utilization of Bosmina ranged from 4.1 to 4.7 per cent of all points totaled. Consumption of Daphnia by fingerlings was recorded at 4.1 per cent of the total points for the August 2-6 sampling period; this species occurred in only trace amounts during July and late August collections.

From May through August, utilization of Diptera by fingerlings varied from 12 to 20 per cent of all food eaten. Pupal and adult stages of family Chironomidae predominated among dipterans consumed. Other Diptera taken included larvae and adults belonging to families Ceratopoginidae and Dolichopodidae.

The use of Copepoda decreased sharply from the late August level of 80 per cent to 33 per cent in September. In October, the use of Copepoda decreased further to 19 per cent.

Fingerlings contained 61.2 per cent Daphnia in September, but only 2.7 per cent Daphnia were recorded for the October sample. Bosmina made up 6.1 per cent of the food eaten in September, slightly over the August values, but greatly increased in importance by

October 19-23, when it amounted to 38 per cent of the total food recorded.

In September, only six stomach samples were examined and no dipterous insects were found; however, 40 per cent of the October food point ratings based on ten stomachs contained adults of family Chironomidae. Perhaps decreased amounts of the food item or the small sample of fish analyzed may explain why Diptera were not found in stomach contents in September.

During all collection periods, occurrences of aquatic Collembola, aquatic Hemiptera, larval Coleoptera, Hydracarina, Ostracoda and salmonid fry were infrequent in the diet of fingerling sockeye.

In summary, results of stomach analysis indicate that 90 per cent of the diet of age 0 sockeye consisted of the copepod Cyclops from mid-June to early August, 1964. This food item declined to 25 per cent by late August and to a level of seven per cent of food points by October. With the decline in consumption of copepods in late August through the remainder of the sampling season, the order Cladocera made up over 75 per cent of stomach contents.

Diptera were not utilized by age 0 sockeye until October, when 18 per cent of stomach contents were made up of adults of family Chironomidae.

The Cladoceran Daphnia averaged 57 per cent of the stomach contents of fingerlings (age group I and older) through June, 1964. Bosmina occurred in only trace amounts. Copepods, principally Cyclops, ranged from 16 to 35 per cent of the May through mid-June diet.

A major shift to copepods was evident from July through August, when this group made up from 74 to 82 per cent of food consumed.

A rather uniform amount of Diptera (12.4-20.6 per cent points) occurred in the stomach content samples of fingerlings from the first of May through August. In September, no dipterous species were found, and Daphnia and Cyclops became the main food items encountered, comprising 61.2 and 32.7 per cent by points, respectively. However, adult Diptera were again an important food item, 40.5 per cent points, in the October 19-23 samples, also were the crustaceans (Bosmina and Cyclops) which totaled approximately 56.7 per cent points.

Table 6A. Percentage of total numbers of food organisms found in age 0 sockeye from June through August 1964; September and October samples represent percentage (points) composition for age 0 fish.

	June 14-18	July 9-13	August 2-6	August 26-30	September 20-24	October 19-23
	% by number				% by points	
Number of fish	20	20	29	14	20	12
Average fork length (mm)	34.3	36.5	41.0	46.6	53.3	56.6
Size range (mm)	31-38	31-40	35-46	34-52	48-59	53-59
Order Cladocera						
<u>Daphnia</u> <u>sp</u>.	.4	1.8	+	1.2	43.8	6.5
<u>Bosmina</u> <u>sp</u>.	1.3	8.5	10.1	74.1	53.1	69.4
Order Copepods	98.3	89.7	89.9	24.8	3.1	6.5
Order Collembola						
Order Hemiptera						
Order Acarina						
Hydracarina						
Subclass Ostracoda						
Salmonid fry						
Order Diptera						17.7
larvae						
pupae						
adult						17.7

+ = trace amounts

Table 6B. Percentage (points) composition of food for age I and older sockeye from Auke Lake during the summer and fall of 1964

	May 1-5	May 20-23	June 14-18	July 9-13	August 2-6	August 26-30	September 20-24	October 19-23
Number of fish	21	22	20	21	15	10	6	10
Average fork length (mm)	64.4	68.7	63.7	65.5	65.2	67.9	70.5	72.6
Size range (mm)	54-74	52-90	51-69	61-70	53-71	59-72	67-74	71-75
Order Cladocera								
Daphnia sp.	54.8	68.0	47.8	+	4.1	+	61.2	2.7
Bosmina sp.	+	+	+	4.7	4.1	4.5	6.1	37.8
Order Copepoda	24.6	15.5	34.8	79.7	73.5	81.8	32.7	18.9
Order Collembola	+							
Order Hemiptera			+					
Order Acarina								
Hydracarina				+	+			
Subclass Ostracoda					+			
Salmonid fry		4.1*						
Order Diptera	20.6	12.4	17.4	15.6	16.3	13.6		40.5
larvae	2.4	1.5	1.1	1.6	6.1	13.6		
pupae	7.9	8.8	10.8	1.6				
adult	10.3	2.1	5.4	12.5	10.2			40.5
Unident. Copepod	+			+	+			
Unident. Cladocera			+					
Order Coleoptera				+				
Unident. insect					+			

+ = trace amounts
* = one representation

DISCUSSION

A major outcome of the Auke Lake investigation was the recognition of large discrepancies between the numbers of adult sockeye salmon that entered the lake and the numbers subsequently observed on spawning grounds. The investigation also contributed considerable information on juvenile sockeye, especially with regard to age composition, growth and food habits of lake resident fish.

The difference between the numbers of adult sockeye entering Auke Lake and those accounted for on the spawning grounds appears too large, 55 per cent of those counted into the lake spawned during 1963 compared to 52 per cent in 1964. Sources of error did exist in tabulating these fish such as mass movement of spawners ahead of the observer, predation by bears and disturbances by humans.

Not knowing the magnitude of predation, nor the degree of disturbance by humans, an effort was made to discover additional spawning sites within Auke Lake. Lake spawning commonly occurs among sockeye in regions of springs or areas of outflowing water along shoreline areas (Foerster, 1929; Krogius and Krokhin, n. d.). Shallow regions in Auke Lake were explored in 1963 by skin diving along the shore, but only one spawning site was located near the eastern shore in zone A. At this site, 20 or fewer adult fish were counted during each year. Additional spawning locations may have been present in deep areas off the two major spawning streams, especially Lake Creek. A large shale-delta has accumulated at the mouth of this creek and subsurface flows were probably large. If this area were used for spawning, contributions of numbers of sockeye fry of the potential magnitude possible from the unaccounted for adults could have greatly confused initial estimates of fry population densities. This, in turn, may have caused underestimates of the population of fry producing a given year class of smolts leaving the lake. Further investigation into the possible occurrence of lake spawning should be carried out with scuba gear.

The program at Auke Lake traced the activity of juvenile sockeye and followed seasonal growth patterns. Changes in the age structure and the population in the lake from May through October were shown from the results of periodic roundhaul seine samples. Four age classes (age 0, I, II and III) were encountered in the lake during the spring and summer of 1964. Most fingerlings in the second and third year of residence left the lake by May 20, followed by substantial numbers of age I fingerlings by May 26, 1964 (Figures 7A, 7B and 5).

Spring growth in average length and incremental changes in average weight and condition factor were evident for age I and II smolt prior to leaving the lake. Fork length increased to 1.5 mm for age I smolt during the period from May 26 to June 8. Yearling smolts averaged 67.3 mm by June 8, 1964. For the same May to June period, weight of age I smolts increased from 2.05 gm to 2.28 gm and condition factor increased from 0.72 to 0.74. From May 10 to May 26, 1964, age II fish increased in length from 72.4 mm to 74.3 mm, while weight increased from 2.91 gm to 3.14 gm. Mean condition factor did not appear to change significantly, but remained approximately at 0.76.

Comparisons by t-test indicated that growth in length among age 0 and age I sockeye was significantly greater in 1964 than in 1963. Upon entering the lake in 1964, age 0 sockeye grew from 29.9 mm to 56.1 mm by October. For the same period, weight increased from 0.14 to 1.38 gm and condition advanced to 0.78. Age I fish were initially 57.9 mm in length in May, 1964, and increased to 71.5 mm by October. Weight increased from 1.49 gm to 2.99 gm and condition advanced from 0.76 to 0.81 during the spring through fall period.

While they were in the lake, age II fish increased from 69.7 mm to 71.9 mm by May 23, 1964. Weight gain amounted to 0.25 gm for this group as these fish advanced from 2.66 to 2.91 gm. Mean coefficient of condition improved slightly from 0.78 in early May to 0.79 by late May. Early season length, weight and $\overline{K}$ for age III fish amounted to 78.2 mm, 3.86 gm and 0.80, respectively.

The 1963 age 0 lake residents were represented by 70 specimens which averaged 42.2 mm length in August. These fish averaged

0.69 gm and their average condition, $\overline{K}$, was 0.75. The three fish collected in October were 48.3 mm in length and averaged 1.20 gm.

Only eight age I fish were available from August 1963 collections and these fish averaged 60.0 mm in length, weighed 1.83 gm and had an average condition factor of 0.83. The two representatives collected in October were 59.5 mm long and weighed 2.35 gm.

The numbers of fry entering Auke Lake were one of a variety of factors contributing to the greater growth rate of fish in 1964. Population estimates indicated that numbers of fry entering the lake in 1963 were greater (134,666 fish) than in 1964 (118,129), a difference of 26,537 fry. This difference was probably somewhat greater when one considers that fry counts were terminated on June 18, 1963, while those in 1964 were carried out through June 30. It is impossible to project the potential contributions to fry populations due to adult spawning in the lake.

Shifts in movement of age 0 sockeye from inshore to the limnetic region of the lake in early summer were recorded from increased numbers of age 0 fish appearing in roundhaul seine gear operated throughout the lake.

Declining numbers of underyearlings were recorded in seine hauls after early August, 1964, when the mean number of fish per seine haul fell from the season high of 44.0 to 9.9 in October, 1964. Similarly, catches of age I and older fingerlings dropped in mid-May from 66.7 fish per seine haul to the low level of 2.1 in October, 1964. Part of the decline of average catches from peak levels resulted from the chance capture of large aggregations of young sockeye on two occasions. Continued declines of age I and older fish through mid-June and early July sampling periods probably represented the normal decrease of this group as they underwent physiological change and left the lake as smolts. The decline in abundance of juvenile sockeye from early August through October may have been related to limitations in sampling gear or methods of sampling, changes in sockeye distribution or to mortality. It is possible that some young sockeye escaped through the large meshes before being trapped in the bunt after the net had been hauled. However, such loss was not verified and was assumed to be constant throughout the summer of 1964.

Decreases in numbers of young sockeye in midsummer have been reported by other individuals. Rogers (1961) at Wood River Lakes noted a decline in both juvenile sockeye as well as stickleback, G. aculeatus, at all stations after July 8. Fortune (1964) noted at Odell Lake a trend of descending depth distribution of young kokanee as the summer passed.

Mortality and distributional changes have been suggested as influencing late summer presence of young sockeye. More detailed explanations have been advanced by other investigators to account for the decreased numbers of juvenile sockeye in late summer. Foerster

(1925) suggested that young sockeye leave the surface of Cultus Lake during the summer in order to follow their principle food source (Cyclops biscuspidatus) into deep water. Also, Pella (1964) observed that sockeye fry appeared more evenly distributed in Lake Aleknagik in late summer.

The declining numbers of young sockeye in Auke Lake in late summer may have resulted from the combined effects of mortality, vertical changes in distribution and a more even dispersal of young fish throughout the lake; however, these factors were not adequately investigated during 1963 and 1964.

Intraspecific competition between age 0 and age I fingerlings was suggested from weight and condition factor and stomach analysis data collected in 1964. During the period from June 18 through August 31, numbers of age 0 sockeye, as indicated by catch sample size, equaled or exceeded those of yearlings by at least 50 per cent. At the same time, age 0 condition, as reflected by condition factor values, increased from 0.62 to 0.82. From June 18 to August 6, one year-old fingerlings showed a slight decline in condition factor from 0.82 in June to 0.79 in early August (Figure 13). Concurrent with the decline in condition factor of age I sockeye was their increased use of Copepoda as food. Over 70 per cent of the stomach bulk of yearling and older fish in July and early August consisted of this food category. Age 0 sockeye also made use of copepods (up to 90 per cent) during

July and early August. By late August, age I fish increased in condition factor to 0.81, while condition factor of age 0 sockeye began to decline. In late August, age 0 sockeyes shifted in their major food consumption to Bosmina (74 per cent), while age I and older sockeye continued with heavy use of copepods.

Ricker (1937) believed interspecific competition among plankton feeders to be minor in summer, but intraspecific competition during years of large sockeye populations could be sufficient to reduce growth rate by causing early declines in populations of Entomostraca.

At Auke Lake, other factors must be considered before attributing the simultaneous occurrence of decreasing condition of yearlings and increasing values of condition factor of underyearlings to intraspecific competition. The abundance of plankton populations and the effect of interspecific competition may also be important. Data is completely lacking for Auke Lake in the case of the former and is limited in terms of the latter.

Stickleback were present in almost every seine haul, often in greater abundance than all age groups of juvenile sockeye (Appendices H and I). A possibility of competition between the fingerlings sockeye and stickleback, therefore, exists, but no comparison was made between these species in Auke Lake. Rogers (1961) working with stickleback and sockeye fry in Wood River Lakes found that the size of combined populations had an effect on feeding and growth of the two species, but he was unable to determine whether it was due to interspecific or to intraspecific competition. He felt that the former intensified the latter.

Knowledge of the growth of fingerling sockeye does not satisfy the important purpose of being able to determine the capacity of a lake to produce young salmon . In considering future fishery management applications, perhaps the most significant outcome of the Auke Lake program was the 1964 estimate of the smolt outmigration -- 62, 389 fish; yet little is known of the numbers and composition of the parent population or the success of spawning to produce these smolt. The project in 1964 was initiated with the understanding that at least one and perhaps two age categories of sockeye would be followed through the summer growing period and later to the point of leaving the lake as smolts and eventually to their return as adults. Such information would allow for a better understanding of the productive capacity of Auke Lake for sockeye salmpn. Unfortunately, the project was terminated in 1965. In spite of this, results obtained from growth and food analysis may prove helpful in the event further studies are carried out at Auke Lake. Questions concerning the possibility of additional lake spawning of adult sockeye and the reasons for the decline in numbers of fingerlings in late summer catches remain open for further investigation.

BIBLIOGRAPHY

Beck, Paul L. 1964. District ranger, North Tongass National Forest, Chatham District. Personal correspondence. Juneau, Alaska. February 20.

Burgner, Robert L. 1962a. Studies of red salmon smolts from the Wood River Lakes, Alaska. In: Studies of Alaska red salmon, ed. by Ted S. Y. Koo. Seattle, University of Washington. p. 251-298.

________________ 1962b. Sampling red salmon fry by lake trap in the Wood River Lakes, Alaska. In: Studies of Alaska red salmon, ed. by Ted S. Y. Koo. Seattle, University of Washington. p. 319-347.

Cochran, William G. and Gertrude M. Cox. 1950. Experimental designs. New York, John Wiley. 454 p.

Edmondson, W. T. 1963. Fresh-water biology. 2d ed. New York, John Wiley. 1248 p.

Foerster, R. Earle. 1925. Studies in the ecology of the sockeye salmon (Oncorhynchus nerka). Contributions to Canadian Biology 2: 335-422.

________________ 1929. An investigation of the life history and propagation of the sockeye salmon (Oncorhynchus nerka) at Cultus Lake, British Columbia. 1. Introduction and the run of 1925. Contributions to Canadian Biology and Fisheries 5: 3-35.

________________ 1938. An investigation of the relative efficiencies of natural and artificial propagation of sockeye salmon (Oncorhynchus nerka) at Cultus Lake, British Columbia. Journal of the Fisheries Research Board of Canada 4: 151-161.

Foerster, R. E. and W. E. Ricker, 1941. The effect of reduction of predaceous fish on survival of young sockeye salmon at Cultus Lake. Journal of the Fisheries Research Board of Canada 6: 267-280.

Foerster, R. E. 1944. The relation of lake population density to size of young sockeye salmon (Oncorhynchus nerka). Journal of the Fisheries Research Board of Canada 6: 267-280.

Fortune, John David, Jr. 1964. Distribution of kokanee (Oncorhynchus nerka) fingerlings in summer as related to some environmental factors. Master's thesis. Corvallis, Oregon State University. 53 numb. leaves.

Foskett, D. R. 1958. The rivers inlet sockeye salmon. Journal of the Fisheries Research Board of Canada 15: 867-889.

Hartman, Wilbur L., Charles W. Strickland and David T. Hoopes. 1962. Survival and behavior of sockeye salmon fry migrating into Brooks Lake, Alaska. Transactions of the American Fisheries Society 91: 133-139.

Hoar, William S. 1954. The behavior of juvenile Pacific salmon, with particular reference to the sockeye (Oncorhynchus nerka). Journal of the Fisheries Research Board of Canada 11: 69-97.

Hoopes, David T. 1964. Unpublished review of physical and chemical data from Auke Lake, Auke Bay, Alaska. U. S. Bureau of Commercial Fisheries, Biological Laboratory.

________________ 1965. Supervisor, Auke Lake Investigations. Personal correspondence. Auke Bay, Alaska. May 11.

Hynes, H. B. N. 1950. The food of fresh-water sticklebacks (Gasterosteus aculeatus and Pygosteus pungitius), with a review of methods used in studies of the food of fishes. Journal of Animal Ecology 19: 36-58.

Johnson, W. E. 1956. On the distribution of young sockeye salmon (Oncorhynchus nerka) in Babine and Nilkitkwa Lakes, B. C. Journal of the Fisheries Research Board of Canada 13: 695-708.

Krogius, F. V. and E. M. Krokhin. n. d. On the production of young sockeye salmon (Oncorhynchus nerka Walb.) Izvestiia Tikhookeanskovo Nauchno-Issledovatelskovo Instituta Rybnovo Khoziaistva i Okeanografii, 28: 3-27. (Translated in Fisheries Research Board of Canada. Translation ser., no. 109, 1958. 27p.)

________________ 1956. Results of a study of the biology of sockeye salmon, the conditions of the stocks and the fluctuations in numbers in Kamchatka waters. Voprosy Ikhtiologii 7: 3-20. (Translated in Fisheries Research Board of Canada. Translation ser., no. 176, 1958. 19p.)

Lagler, Karl F. 1956. Freshwater fishery biology. Dubuqe, Wm. C. Brown. 421p.

McDonald, J. 1960. The behavior of Pacific salmon fry during their downstream migration to freshwater and saltwater nursery areas. Journal of the Fisheries Research Board of Canada 17: 655-676.

Moore, Edward W. 1939. Graphic determination of carbon dioxide and the three forms of alkalinity. Journal of the American Water Works Association 31: 51-66. (Cited in: Ellis, M. M., B. A. Westfall and Marion D. Ellis. Determination of Water Quality. U. S. Fish and Wildlife Service, Research Report 9, 1948. 122p.)

Pella, Jerome Jacob. 1964. Sockeye salmon fry distribution and growth in Lake Aleknagik, Alaska, during the summer of 1962. Master's thesis. Seattle, University of Washington. 132 numb. leaves.

Ricker, William E. 1937. The food and food supply of sockeye salmon (Oncorhynchus nerka Walbaum) in Cultus Lake, British Columbia. Journal of the Biological Board of Canada 3: 450-468.

Roelofs, Eugene W. 1964. Further studies of Afognak Lake System. Juneau. 18p. (Alaska Department of Fish and Game. Informational Leaflet no. 41.)

Rogers, Donald Eugene. 1961. A comparison of the food of red salmon fry and threespine sticklebacks in the Wood River lakes. Master's thesis. Seattle, University of Washington. 60 numb. leaves.

Rounsefell, George A. and W. Harry Everhart. 1953. Fishery science its methods and applications. New York, John Wiley. 444p.

Straty, Richard R. 1960. Methods of enumerating salmon in Alaska. In: Transactions of the North American wildlife and natural resources conference, ed. by James B. Trefethen. Washington D. C., Wildlife Management Institute. p. 286-297.

Strickland, J. D. H. and T. R. Parsons. 1960. A manual of sea water analysis. Ottawa. 185p. (Fisheries Research Board of Canada. Bulletin no. 125.)

Swynnerton, G. H. and E. B. Worthington. 1940. Note on the food of fish in Haweswater (Westmorland). Journal of Animal Ecology 9: 183-187.

U. S. Weather Bureau. 1948-1950. Climatological data. Alaska annual summary, Seattle.

________________ 1951. Climatological data. Alaska annual summary. San Francisco.

________________ 1952. Climatological data. Alaska annual summary. Chattanooga.

________________ 1953. Climatological data. Alaska annual summary. Kansas City.

________________ 1954-1964. Climatological data. Alaska annual summary. Asheville.

APPENDIX

Appendix 1. Water temperatures (°C) at different depth in Auke Lake during the period 1962-1964.

Depth in meters	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Sample Date																															
21 Nov 1962	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	-	-	-	-	5.0	-	-	-	-	5.0	-	-	-	-	4.5
22 Jan 1963	0.0	-	-	-	-	2.0	-	-	-	-	2.5	-	-	-	-	-	-	-	-	-	3.0	-	-	-	-	-	-	-	-	-	-
20 Feb 1963	1.0	-	-	-	-	3.0	-	-	-	-	4.0	-	-	-	-	-	-	-	-	-	5.0	-	-	-	-	-	-	-	-	-	-
25 March 1963	1.0	-	-	-	-	2.8	-	-	-	-	3.5	-	-	-	-	-	-	-	-	-	4.3	-	-	-	-	-	-	-	-	-	-
8 May 1963	5.6	7.2	6.7	6.7	5.6	5.0	5.0	5.0	4.4	4.4	4.4	-	-	-	-	4.4	-	-	-	-	3.9	-	-	-	-	-	-	-	-	-	-
13 June 1963	12.8	13.3	13.3	12.2	10.0	8.3	7.2	5.6	5.6	5.0	5.0	-	-	-	-	5.0	-	-	-	-	4.4	-	-	-	-	-	-	-	-	-	-
9 July 1963	18.3	18.3	16.1	12.8	11.7	10.6	7.8	6.7	6.1	5.6	5.6	5.6	5.0	5.0	5.0	5.0	5.0	4.4	4.4	4.4	4.4	4.4	4.4	4.4	4.4	4.4	4.4	4.4	4.4	4.4	4.4
15 July 1963	15.6	-	-	-	-	9.4	-	-	-	-	6.7	-	-	-	-	-	-	-	-	-	4.4	-	-	-	-	-	-	-	-	-	-
26 July 1963	14.4	14.4	14.4	12.8	11.7	10.6	10.0	8.3	7.2	6.7	6.7	6.1	5.6	5.6	5.0	5.0	5.0	5.0	4.4	4.4	4.4	4.4	4.4	4.4	4.4	4.4	4.4	4.4	4.4	4.4	3.9
9 Aug 1963	15.2	15.0	14.3	14.0	12.8	11.5	10.1	8.5	7.8	7.0	6.5	6.0	6.0	5.6	5.1	5.1	5.0	5.0	4.9	4.7	4.7	4.5	4.4	4.2	4.2	4.1	4.1	4.2	4.2	4.1	4.0
15 Aug 1963	17.2	17.2	17.2	13.3	11.4	10.6	9.3	7.8	6.6	6.3	6.0	5.4	5.0	5.1	4.9	4.9	4.8	4.4	4.4	4.4	4.2	4.4	4.3	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2
14 Oct 1963	9.0	8.9	8.9	8.9	8.9	8.9	8.9	8.6	8.9	8.3	8.3	6.7	6.7	5.6	5.0	5.0	-	-	-	-	3.9	-	-	-	-	3.9	-	-	-	-	-
4 Nov 1963	6.5	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	-	-	-	-	5.5	-	-	-	-	5.0	-	-	-	-	-
23 Dec 1963	1.0	2.0	3.0	3.0	3.0	3.5	3.5	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	-	-	-	-	4.0	-	-	-	-	4.0	-	-	-	-	-
6 April 1964	2.0	2.8	3.0	3.0	3.0	3.0	3.0	3.0	3.5	3.9	4.0	4.0	4.0	4.0	4.0	4.0	-	-	-	-	4.0	-	-	-	-	4.2	-	-	-	-	-
30 April 1964	4.6	5.1	4.9	4.9	4.9	4.9	4.9	4.9	4.9	4.8	4.8	4.8	4.8	4.8	4.8	4.8	-	-	-	-	4.3	-	-	-	-	4.3	-	-	-	-	4.3
26 May 1964	8.5	9.0	9.0	7.0	6.5	6.0	6.0	5.5	5.5	5.0	5.0	5.0	5.0	5.0	4.5	4.5	-	-	-	-	4.0	-	-	-	-	4.0	-	-	-	-	-
24 June 1964	15.0	14.6	11.5	10.4	9.4	8.5	7.5	7.0	7.3	7.0	6.8	6.2	6.1	6.1	5.9	5.8	-	-	-	-	5.1	-	-	-	-	5.0	-	-	-	-	-
15 July 1964	19.0	16.0	13.0	11.0	10.0	8.0	8.0	8.0	7.4	7.0	7.0	6.4	6.4	6.0	6.0	5.2	-	-	-	-	5.0	-	-	-	-	5.0	-	-	-	-	-
14 Aug 1964	14.5	14.8	14.0	12.8	12.0	10.8	9.4	8.3	7.5	7.0	6.5	6.5	6.0	5.4	5.1	5.0	-	-	-	-	4.2	-	-	-	-	4.0	-	-	-	-	-
3 Sept 1964	14.1	13.8	13.5	12.2	11.6	10.8	9.8	8.8	7.8	7.2	7.0	6.9	6.2	6.0	5.6	5.1	-	-	-	-	4.6	-	-	-	-	4.5	-	-	-	-	-

Appendix 2. Concentration of dissolved oxygen (mg/l) at different depths in Auke Lake during the period 1962-1964.

Sampling Date	Depth in Meters 0	5	10	20
21 November 1962	13.2	13.3	13.0	11.6
22 January 1963	13.8	10.5	9.1	8.6
20 February 1963	13.9	10.4	9.7	8.1
25 March 1963	12.6	11.5	9.9	9.2
8 May 1963	10.5	10.0	9.3	7.8
13 June 1963	8.9	9.2	8.0	7.9
15 July 1963	8.9	8.7	8.1	6.9
15 August 1963	9.0	7.9	7.5	6.2
14 October 1963	9.3	9.5	8.8	6.4
4 November 1963	13.7	13.7	14.1	9.3
23 December 1963	14.4	9.3	9.2	8.7
6 April 1964	12.2	10.7	9.1	7.5
30 April 1964	9.9	9.6	9.6	7.8
26 May 1964	11.3	11.1	9.5	7.0
15 July 1964	10.1	9.9	9.7	6.6
14 August 1964	9.5	8.9	8.6	6.5
16 September 1964	9.7	9.0	8.0	6.6
16 October 1964	9.5	9.3	8.9	6.7

Appendix 3. Physical and chemical properties from monthly observations at Auke Lake (1962-1964).

Date	Depth meters	Average Secchi disc data meters	Turbidity (mg/l) SiO_2	pH	Alkalinity Ca Co_3 (mg/l)	Total Hardness (mg/l)	PO_4 (mg/l)	NO_3 (mg/l)	SiO_2 (mg/l)	Na (mg/l)	Ca (mg/l)	K (mg/l)	Mg (mg/l)
21 Nov 62	0	2.6	-	6.7	9.9	108.0	0.02	0.69	0.13	-	18.5	-	15.0
	5		-	6.6	9.5	118.0	0.02	< 0.05	0.14	-	15.8	-	19.0
	10		-	6.5	9.9	114.0	0.02	< 0.05	0.11	-	12.9	-	20.0
	20		-	6.5	9.9	108.0	0.01	0.05	0.13	-	8.8	-	21.0
22 Jan 63	0	2.3	-	6.3	6.9	125.0	0.11	0.54	1.20	1.3	16.5	1.1	20.5
	5		-	6.4	8.9	116.0	0.06	0.90	1.68	1.2	15.2	1.0	19.0
	10		-	6.4	9.2	170.0	0.07	1.37	1.60	1.5	20.3	1.4	28.9
	20		-	6.4	8.9	170.0	0.06	1.43	0.80	1.5	20.0	1.4	29.2
20 Feb 63	0	2.6	4.6	6.3	6.3	59.2	0.01	0.08	0.04	0.9	6.9	1.4	10.2
	5		5.2	6.6	8.4	78.2	0.02	1.13	0.56	1.8	10.7	1.7	12.5
	10		5.0	6.4	9.2	79.6	0.01	1.65	0.45	1.9	7.8	1.9	14.6
	20		4.9	6.5	10.0	124.7	0.01	1.90	0.07	1.9	8.9	2.1	24.9
25 Mar 63	0	2.0	5.0	6.6	7.9	47.9	-	0.41	0.73	8.9	4.5	0.9	8.9
	5		2.9	6.4	8.4	62.3	-	0.39	0.77	9.0	5.0	1.0	12.1
	10		2.1	6.3	9.1	74.2	-	0.79	0.90	9.0	5.8	1.6	14.5
	20		1.8	6.4	10.1	85.8	-	1.01	0.86	12.0	6.0	2.0	17.2
8 May 63	0	3.2	2.1	6.5	8.3	22.7	0.04	1.15	0.51	2.4	5.8	1.4	2.0
	5		-	6.3	8.7	19.9	0.04	1.15	0.50	2.4	3.7	1.1	2.6
	10		-	6.1	8.9	-	-	-	-	-	-	-	-
	20		0	6.0	9.0	26.5	0.01	1.90	0.50	3.1	5.0	0.9	3.4
13 June 63	0	3.8	1.6	7.1	8.8	22.7	0.03	1.50	0.57	1.9	4.8	0.7	2.6
	5		2.9	6.5	8.7	19.1	0.04	1.23	0.61	2.3	3.0	0.8	2.8
	10		2.5	6.3	10.3	19.8	0.03	1.90	0.62	2.1	4.3	1.0	2.2
	20		3.6	6.2	10.2	30.0	0.03	1.60	0.56	2.0	5.1	1.0	4.2

Appendix 3. (continued)

Date	Depth meters	Average Secchi disc data meters	Turbidity (mg/l) SiO_2	pH	Alkalinity $CaCO_3$ (mg/l)	Total Hardness (mg/l)	PO_4 (mg/l)	NO_3 (mg/l)	SiO_2 (mg/l)	Na (mg/l)	Ca (mg/l)	K (mg/l)	Mg (mg/l)
15 July 63	0	2.7	1.7	7.2	9.8	23.5	-	<0.01	0.11	1.1	3.0	0.3	3.9
	5		0.7	6.5	10.0	25.2	-	<0.01	0.06	1.2	3.5	0.2	4.0
	10		0.8	6.5	10.6	27.6	-	0.01	0.06	1.7	3.8	0.5	4.4
	20		0.8	6.4	11.4	30.6	-	0.01	0.12	2.2	4.0	0.6	5.0
15 Aug 63	0		1.2	6.7	9.3	24.8	0.02	<0.01	0.25	1.2	3.5	0.3	3.9
	5		1.2	6.5	10.0	45.8	0.02	<0.01	0.23	4.1	6.8	0.2	7.0
	10		1.6	6.0	11.0	25.2	0.03	<0.01	0.25	2.8	3.5	0.2	4.0
	20		1.5	6.4	12.2	25.1	0.02	0.01	0.24	1.5	3.8	0.4	3.8
14 Oct 63	0	2.9	4.8	6.8	12.8	43.2	<0.01	0.04	0.50	1.0	4.1	0.3	8.0
	5		4.5	6.8	12.0	41.3	<0.01	0.05	0.49	1.0	4.0	0.3	7.6
	10		4.2	6.7	12.0	42.3	<0.01	0.07	0.43	1.0	4.1	0.3	7.8
	20		4.4	6.4	12.0	42.2	<0.01	0.30	0.45	1.1	4.2	0.4	7.7
4 Nov 63	0	3.2	2.9	6.5	10.0	10.1	0.20	0.11	0.50	1.7	2.9	0.5	0.7
	5		3.0	6.5	10.0	12.0	0.02	0.09	0.44	1.5	3.0	0.4	1.1
	10		2.3	6.5	9.8	12.0	0.02	0.10	0.47	1.3	3.0	0.3	1.1
	20		1.8	6.2	10.8	14.7	0.01	0.22	0.45	1.3	3.4	0.4	1.5
23 Dec 63	0	2.9	1.5	6.7	11.7	15.4	0.01	0.15	1.57	1.4	3.2	0.4	1.8
	5		2.2	6.4	10.2	16.3	0.02	0.20	1.53	1.2	3.4	0.6	1.9
	10		3.2	6.3	10.2	16.3	0.01	0.22	1.53	1.1	3.4	0.4	1.9
	20		2.2	6.2	10.2	16.2	0.01	0.22	1.55	1.2	3.2	0.5	2.0
6 April 64	0	2.9	5.2	6.2	5.5	21.2	0.06	0.06	0.26	2.7	1.9	0.3	4.0
	5		2.9	6.2	9.3	31.2	0.06	0.13	0.33	1.1	3.1	0.2	5.7
	10		1.2	6.2	9.9	28.6	0.04	0.02	0.56	1.1	3.2	0.2	5.0
	20		1.6	6.1	10.0	29.3	0.04	0.16	0.40	1.3	3.5	0.2	5.0

Appendix 3. (continued)

Date	Depth meters	Average Secchi disc data meters	Turbidity (mg/l) SiO_2	ph	Alkalinity Ca Co_3 (mg/l)	Total Hardness (mg/l)	PO_4 (mg/l)	NO_3 (mg/l)	SiO_2 (mg/l)	Na (mg/l)	Ca (mg/l)	K (mg/l)	Mg (mg/l)
30 April 64	0	3.2	2.1	6.5	10.6	18.6	0.12	0.25	0.26	4.2	3.8	0.6	2.2
	5		2.1	6.2	10.0	17.0	0.08	0.14	0.28	1.6	3.7	0.4	1.9
	10		1.8	5.9	8.4	17.4	0.12	0.16	0.26	1.6	3.7	0.4	2.0
	20		2.9	5.7	8.9	17.5	0.12	0.20	0.28	1.7	3.9	0.3	1.9
26 May 64	0	3.2	1.5	6.6	10.2	12.3	0.10	0.07	0.26	1.6	3.3	0.0	1.0
	5		1.5	6.3	9.8	12.6	0.07	0.09	0.28	1.5	3.1	0.3	1.2
	10		4.6	6.3	9.9	13.6	0.05	0.10	0.31	1.6	3.3	0.3	1.3
	20		4.9	6.1	10.4	14.4	0.08	0.21	0.26	1.7	3.8	0.3	1.2
15 July 64	0	3.8	4.0	7.1	11.3	12.3	0.04	0.04	0.25	1.2	2.8	0.2	1.3
	5		4.9	7.1	11.4	12.9	0.04	0.05	0.23	1.1	2.7	0.2	1.5
	10		5.0	6.5	12.0	12.6	0.03	0.05	0.25	1.1	2.9	0.3	1.3
	20		4.7	6.4	14.1	16.0	0.02	0.22	0.24	1.4	3.6	0.3	1.7
14 Aug 64	0	2.6	2.1	7.1	12.7	18.3	0.32	0.03	0.65	1.0	3.2	<0.2	2.5
	5		3.4	6.6	11.4	19.7	0.28	0.03	0.43	1.1	3.3	<0.2	2.8
	10		2.5	6.3	12.1	20.0	-	0.05	0.36	1.2	3.1	<0.2	3.0
	20		3.2	6.3	14.1	16.8	0.13	0.24	0.53	1.5	3.6	<0.2	1.9
16 Sept 64	0			7.2	11.5	17.6	0.30	0.03	0.49	1.1	3.6	0.2	2.1
	5			6.8	10.8	16.9	0.42	0.04	0.53	1.1	3.5	<0.2	2.0
	10			6.4	10.6	19.2	0.15	0.09	0.43	1.2	3.4	0.2	2.6
	20			6.3	12.3	18.1	0.20	0.25	0.39	1.5	3.8	0.2	2.1
16 Oct 64	0			7.0	11.1	16.4	0.04	0.06	0.62	1.2	3.3	<0.2	2.0
	5			6.6	10.5	17.7	0.19	0.05	0.46	1.2	3.3	<0.2	2.3
	10			6.3	10.1	17.3	0.04	0.04	0.66	1.2	3.3	<0.2	2.2
	20			6.2	11.9	19.8	0.06	0.21	0.66	1.4	3.8	<0.2	2.5

Appendix 4. Counts of spawning sockeye salmon in Lake Creek during 1963 and 1964.

1963 Date	Approximate Water Level	Numbers of Fish Live	Dead	All Fish	1964 Date	Approximate Water Level	Numbers of Fish Live	Dead	All Fish
July 24	Low	9	1	10	July 27	Low	783	3	786
Aug 5	Low	669	133	802	July 30	--	1,384	8	1,392
Aug 9	Medium	1,820	154	1,974 1/	Aug 3	Low	1,278	84	1,362
Aug 13	Low	1,001	550	1,551	Aug 6	Low	1,059	388	1,447 1/
Aug 16	Low	285	1,315	1,600	Aug 10	Low	407	801	1,208
Aug 20	Low	8	1,821	1,829	Aug 13	High	1,221	88	1,309
Aug 23	Low	903	125	1,028 1/	Aug 17	Medium	1,253	104	1,357 1/
Aug 28	Low	101	--	101	Aug 20	Medium	984	282	1,266
Sept 6	High	404	1	405 1/	Aug 24	Low	363	845	1,208
					Aug 28	Medium	152	183	335
					Aug 31	Low	43	104	183
Grand Total				3,407	Grand Total				2,804
Total Weir Counts				6,391	Total Weir Counts				5,464

1/ These counts were summed to arrive at the population estimate.

Appendix 5. Confidence limits for mean fork lengths of juvenile sockeye salmon, 1963 and 1964.

Date	Status	Age Class	Mean Fork Length - mm	Sample Size	Standard Deviation s	95% Confidence Limits L	U
1963							
Aug 26 & 30	LR [1]	0	42.2	70	4.1	41.2	43.1
Sept 27		0	47.8	22	2.0	46.5	48.7
Oct 20		0	48.3	3	2.1	47.5	49.2
1964							
April 2 - June 24	DFM [2]	0	29.9	410	0.0	29.9	30.1 [4]
May 1 - 5	LR	0	30.3	4	1.0	28.7	31.8
May 20 - 23		0	30.3	21	1.3	-	-
June 14 - 18		0	34.7	152	2.1	34.4	35.1
July 9 - 13		0	36.6	425	3.0	36.3	36.9
Aug 2 - 6		0	41.3	271	3.5	40.9	41.7
Aug 26 - 30		0	48.3	258	3.6	47.9	48.8
Sept 20 - 24		0	53.2	129	3.8	52.5	53.8
Oct 19 - 23		0	56.1	98	3.2	55.4	56.7
1963							
Aug 26 & 30	LR	I	60.0	8	3.1	57.4	62.6
Sept 27		I	62.6	9	3.8	59.6	65.5
Oct 20		I	59.5	2	2.1	40.4	78.6
1964							
May 1 - 5	LR	I	57.9	117	3.3	57.3	58.6
May 20 - 23		I	60.8	257	4.4	60.3	61.3
June 14 - 18		I	63.1	138	3.3	62.6	63.7
July 9 - 13		I	65.5	126	3.0	65.0	66.0
Aug 2 - 6		I	65.7	36	3.5	64.5	66.9
Aug 26 - 30		I	67.0	32	3.6	65.7	68.3
Sept 20 - 24		I	71.0	22	3.3	69.5	72.4
Oct 19 - 23		I	71.5	33	2.8	70.5	72.4

Appendix 5. (continued)

Date	Status	Age Class	Mean fork Length - mm	Sample Size	Standard Deviation s	95% Confidence Limits L	U
1964							
May 1 - 5	LR	II	69.7	84	3.5	68.9	70.4
May 20 - 23		II	71.9	62	4.0	71.1	72.7
1964							
May 1 - 5	LR	III	78.2	9	5.0	74.4	82.1
May 22 - 23		III	84.6	5	5.1	78.2	91.0
1964							
May 10	S 3/	I	61.5	2	0.7	55.1	67.9
May 26		I	65.8	61	2.3	65.2	66.4
May 31		I	64.4	50	2.4	63.7	65.1
June 8		I	67.3	41	3.2	66.3	68.3
1964							
May 10	S	II	72.4	25	3.0	71.2	73.6
May 19		II	71.3	32	3.2	70.2	72.5
May 26		II	74.3	11	3.1	72.2	76.4
1964							
May 10	S	III	77.8	10	3.1	75.6	80.0
May 19		III	78.6	7	2.4	76.4	80.8
May 26		III	80.3	3	3.5	71.6	89.1

1/ LR = Lake resident

2/ DFM = Down stream fry migrant

3/ S = Smolt

4/ Confidence limits calculated using the pooled estimate of the population variances.

Appendix 6. Confidence limits for mean weight of juvenile sockeye salmon, 1963 and 1964.

Date	Status	Age Class	Mean Weight in gm	Sample Size	Standard Deviation s	95% Confidence Limits L	U
1963							
Aug 26 & 30	LR 1/	0	0.69	65	0.19	0.65	0.74
Sept 27		0	0.88	20 4/	0.15	0.80	0.95
Oct 29		0	1.20	3	-	-	-
1963							
Aug 26 & 30	LR	I	1.83	6	0.29	1.53	2.12
Sept 27		I	2.00	9	0.36	1.72	2.28
Oct 29		I	2.35	2	0.35	-	-
1964							
April 3 - June 8	DFM 2/	0	0.14	390	0.01	0.14	0.15
May 1 - 5	LR	0	0.25	2	-	-	-
May 20 - 23		0	-	-	-	-	-
June 14 - 18		0	0.27	82 5/	0.07	0.25	0.28
July 9 - 13		0	0.33	274	0.11	0.32	0.34
Aug 2 - 6		0	0.59	82	0.18	0.55	0.63
Aug 26 - 30		0	0.90	110	0.23	0.86	0.95
Sept 20 - 24		0	1.30	112 4/	0.27	1.25	1.35
Oct 19 - 23		0	1.38	98	0.24	1.34	1.43
1964							
May 1 - 5	LR	I	1.49	117	0.26	1.44	1.53
May 20 - 23		I	1.78	162	0.38	1.72	1.84
June 14 - 18		I	2.08	97	0.30	2.02	2.14
July 9 - 13		I	2.23	106	0.31	2.17	2.28
Aug 2 - 6		I	2.35	25	0.34	2.21	2.49
Aug 26 - 30		I	2.46	32	0.41	2.31	2.61
Sept. 20 - 24		I	3.14	22	0.47	2.93	3.35
Oct 19 - 23		I	2.99	33	0.39	2.85	3.13

Appendix 6. (continued)

Date	Status	Age Class	Mean Weight in gm	Sample Size	Standard Deviation s	95% Confidence Limits L	U
1964							
May 1 - 5	LR	II	2.66	84	0.41	2.57	2.75
May 20 - 23		II	2.91	48	0.40	2.79	3.03
1964							
May 1 - 5	LR	III	3.86	9	0.81	3.24	4.48
1964							
May 10	S 3/	I	1.70	2	0.14	0.43	2.97
May 26		I	2.05	61	0.21	2.00	2.12
May 31		I	1.98	50	0.26	1.91	2.06
June 8		I	2.28	41	0.35	2.17	2.39
1964							
May 10	S	II	2.91	25	0.40	2.75	3.08
May 19		II	2.81	32	0.42	2.66	2.97
May 26		II	3.14	11	0.35	2.90	3.37
1964							
May 10	S	III	3.75	10	0.41	3.45	4.05
May 19		III	3.70	7	0.40	3.33	4.07
May 26		III	3.90	3	0.46	2.76	5.04

1/ LR = Lake resident

2/ DFM = Down stream fry migrant

3/ S = Smolt

4/ September fish weighed to nearest 1/10th gm; remainder weighed to nearest 1/100th gm.

5/ June 14 - 18, a few (18) fish weighed to nearest 1/10th gm; remainder of sample weighed to nearest 1/100th gm.

Appendix 7. Confidence limits for mean coefficient of condition ($\overline{K}$) of juvenile sockeye salmon, 1963 and 1964.

Date	Status	Age Class	Mean Condition Factor $\overline{K}$ (FL)	Sample Size	Standard Deviation s	95% Confidence Limits L	U
1963							
Aug 26 & 30	LR [1/]	0	0.75	65	0.32	0.67	0.83
Sept 27		0	0.78	20	0.09	0.74	0.82
1963							
Aug 26 & 30	LR	I	0.83	6	0.04	0.79	0.87
Sept 27		I	0.81	9	0.07	0.76	0.86
1964							
June 14 - 18	LR	0	0.62	82	0.10	0.60	0.64
July 9 - 13		0	0.66	268	0.07	0.65	0.67
Aug 2 - 6		0	0.80	82	0.12	0.77	0.82
Aug 26 - 30		0	0.82	110	0.07	0.81	0.84
Sept 20 - 24		0	0.83	112	0.10	0.81	0.85
Oct 19 - 23		0	0.78	98	0.06	0.77	0.79
1964							
May 1 - 5	LR	I	0.76	117	0.06	0.75	0.77
May 20 - 23		I	0.78	162	0.05	0.77	0.79
June 14 - 18		I	0.82	97	0.04	0.82	0.83
July 9 - 13		I	0.79	106	0.05	0.78	0.80
Aug 2 - 6		I	0.79	25	0.16	0.72	0.86
Aug 26 - 30		I	0.81	32	0.05	0.79	0.83
Sept 20 - 24		I	0.87	22	0.04	0.85	0.89
Oct 19 - 23		I	0.81	33	0.04	0.80	0.83
1964							
May 1 - 5	LR	II	0.78	84	0.05	0.77	0.79
May 20 - 23		II	0.79	48	0.04	0.78	0.80

Appendix 7. (continued)

Date	Status	Age Class	Mean Condition Factor $\bar{K}$ (FL)	Sample Size	Standard Deviation s	95% Confidence Limits L	U
1964							
May 10	S [2/]	I	0.73	2	0.04	0.41	1.04
May 26		I	0.72	61	0.04	0.71	0.73
May 31		I	0.74	50	0.05	0.73	0.76
June 8		I	0.74	41	0.04	0.73	0.76
1964							
May 10	S	II	0.76	25	0.04	0.75	0.78
May 19		II	0.77	32	0.05	0.75	0.78
May 26		II	0.76	11	0.03	0.74	0.78
1964							
May 10	S	III	0.79	10	0.05	0.76	0.83
May 19		III	0.76	7	0.04	0.72	0.79
May 26		III	0.75	3	0.03	0.67	0.82

[1/] LR = Lake resident

[2/] S = Smolt

Appendix 8. Sockeye roundhaul seine catch data for 1964.

Date	No. of sets	Total catch of 0	Mean catch per set	Total catch of 1 and older	Mean catch per set	Total catch all ages	Mean over-all catch per set
May 1-5	18	4	0.2	212	11.8	216	12.0
May 20-23	12	21	1.8	800 1/	66.7	821	68.4
June 14-18	21	152	7.2	146	7.0	298	14.9
July 9-13	18	425	23.6	125	6.9	550	30.6
August 2-6	18	792 2/	44.0	42	2.3	834	46.3
August 26-31 3/	12	158	13.2	25	2.1	183	15.3
August 26-31 4/	12	100	8.3	8	0.7	108	9.0
August 26-31 5/	24	258	10.8	33	1.4	291	12.1
September 20-24	15	129	8.6	22	1.5	151	10.1
October 19-23	15	148	9.9	32	2.1	180	12.0

1/ May 21st - estimate of 500 age 1 and older sockeye taken in one set from area A.

2/ August 6th - estimate of 500 age 0 sockeye taken in first set from area B.

3/ Nocturnal roundhaul seine catches.

4/ Diurnal roundhaul seine catches.

5/ Noctural-diurnal seine catches combined.

Appendix 9. Stickleback roundhaul seine catch data for 1964.

Date	No. of Sets	Total Catch	Mean Catch per Set
May 1 - 5	18	91	5.05
May 21 - 23	8	273	34.12
June 14 - 18	21	976	46.47
July 9 - 13	18	538	29.88
Aug 2 - 6	18	944	52.44
Aug 26 - 31 1/	12	568	47.33
Aug 26 - 31 2/	12	432	36.00
Aug 26 - 31 3/	24	1000	41.66
Sept 20 - 24	15	487	32.46
Oct 19 - 23	15	153	10.20

1/ Nocturnal roundhaul seine catches

2/ Diurnal roundhaul seine catches

3/ Nocturnal-diurnal seine catches combined