FLATHEAD LAKE FISH FOOD HABITS STUDY

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EXECUTIVE SUMMARY

This report is part of the Flathead River Basin Impact Study which is a federally funded project concerned with potential adverse affects of accelerated resource development on the air, land, and water of the Flathead River Basin. This document summarizes the results of the first half of a two year baseline environmental assessment concerning aspects of the biology of three important gamefish species in Flathead Lake. Two of these fish species, the westslope cutthroat trout (*Salmo clarki lewisi*) and bull trout (*Salvelinus confluentus*), are highly migratory and depend upon spawning and rearing areas in numerous tributaries of the Flathead River system. A large number of kokanee salmon (*Oncorhynchus nerka*) also utilize the river system for spawning purposes and provide the basis for a popular fall snagging fishery.

This study was designed to assess the seasonal food habits of westslope cutthroat trout, bull trout, and kokanee salmon in representative areas of Flathead Lake. Additional objectives include the initiation of long-term monitoring of the relative abundance of westslope cutthroat trout and bull trout and the determination of growth rates and condition of these species in the lake. This is intended to provide sound baseline information which is essential to the processes of predicting and identifying potential environmental impacts of resource development in the upper Flathead River Basin.

Crustacean zooplankton were sampled monthly at six locations on the lake and biweekly in the Bigfork area to document existing species composition and abundance trends and also to monitor zooplankton availability as a food source for kokanee salmon. The copepods *Diaptomus* and *Cyclops* comprised 81 percent of the surface (to 30 m) crustacean plankton population and 95 percent of the deepwater (30-60 m) fauna. *Daphnia thorata*, *Bosmina*, *Leptodora*, and adult *Epischura* were more numerous in the surface waters (to 30 m) than in deep water whereas the reverse was true for *Daphnia longiremis*. No consistent differences in zooplankton populations at seven different locations was found during the period June through December.

Kokanee salmon fed almost exclusively on zooplankton during the period July through December. *Daphnia thorata* was the principal species ingested by all age classes of kokanee and frequently comprised more than 90 percent of the ingested organisms. Young-of-the-year kokanee fed more intensively on the large copepod *Epischura* and less intensively on *Leptodora* than did large (III+ and older) kokanee whereas during early October all kokanee age classes selected for the largest *D. thorata* available.

Seasonal westslope cutthroat and bull trout food habits in Flathead Lake were studied to provide baseline information which will be useful in predicting and identifying potential future impacts of resource development in the upper River Basin on the lake ecosystem. During the summer and fall, westslope cutthroat trout fed almost entirely on winged and non-winged terrestrial insects that were presumably blown onto the lake surface. Fish remains were found in over 90 percent of the non-empty bull trout stomachs and no tendency was observed for small bull trout (<300 mm, $n = 8$)

to feed on items other than fish. Bull trout fed on at least nine forage fish species during July and August with three whitefish species being the most important food items. During October, bull trout ingested a minimum of seven forage fish species with lake whitefish (*Coregonus clupeaformis*) being the most important food item. Yellow perch (*Perca flavescens*) were the major food item in a small sample of bull trout stomachs collected in November and December of 1979. This was considered to be unusual since perch were rarely caught in gill netting activities. However, these bull trout were taken in the vicinity of an isolated weedy bay which was preferred habitat for yellow perch. Anomalous items that appeared infrequently in bull trout stomachs included discarded kokanee viscera and the planktonic organism *Leptodora*.

Age and growth analysis on westslope cutthroat and bull trout was conducted to aid in impact assessment as well as to help clarify the life history of these migratory species and help determine the ability of the lake to produce trout. Growth of 318 westslope cutthroat trout collected from Flathead Lake during the years 1962-1980 was found to be slower than has been observed in numerous other studies on lake dwelling cutthroat trout populations, but was faster than cutthroat trout in the North and Middle Forks of the Flathead River. Over 98 percent of the cutthroat trout from Flathead Lake were three or more years of age and nearly two-thirds of the fish were four or five years old. The majority of the cutthroat trout apparently spent two or three years in tributary streams prior to entering the lake. The mean length increments for the first year of lake residence for migratory cutthroat ranged between 77 and 95 mm which was low in comparison to other studies of adfluvial westslope cutthroat trout. Growth of a combined sample of 533 bull trout from Flathead Lake was less than has been previously reported for the lake but was similar to that displayed by bull trout in Upper Priest Lake, Idaho. Growth between years was similar although it appeared that bull trout were larger in 1963 than in 1968 or 1980. Bull trout collected by creel census in 1963 were 18, 27, and 55 mm longer at annuli V through VII, respectively, than bull trout taken in gill nets during 1980. The mean length of bull trout captured in gill nets during 1980 (420 mm) was larger than the average for the years 1967 through 1970 as was the percentage of the catch larger than 457 mm or 18 inches (34 percent in 1980). However, the percent of bull trout larger than 635 mm (24 inches; 3.5 percent) in the 1980 gill net catch was lower than was observed in 1967, 1969, or 1970.

Gill netting was employed to begin to monitor long-term changes in the relative abundance of several fish species in Flathead Lake, including westslope cutthroat and bull trout. Gill netting provided fish specimens for age and growth and food habits analysis and also furnished information on the vertical and horizontal distribution of fish species in the lake. The catch of westslope cutthroat trout in floating gill nets increased from 0.2 fish per net during the summer to 0.5 and 1.3 fish per net during October and January, respectively. No cutthroat were captued in sinking gill nets although 93.3 percent of the total bull trout catch was taken in sinking nets. The seasonal catch rate for bull trout in sinking gill nets was relatively stable and ranged between 2.0 and 2.4 fish per net.

ACKNOWLEDGEMENTS

The authors gratefully acknowledge the assistance rendered by numerous persons directly or indirectly associated with the study. Wade Fredenberg was a most capable technical assistant whose contributions in the field and laboratory were invaluable to the progress of the study. Delano Hanzel and Scott Rumsey spent many an evening cruising Flathead Lake aboard the research vessel *Dolly Varden* in search of kokanee salmon and their efforts are gratefully appreciated. They also collected fish stomachs incidentally to their normal Department activities on Flathead Lake. Bill Johnston ably assisted in field work and in plankton counting in the laboratory, and Dave Donaldson also rendered assistance in the field. Additional cutthroat or bull trout stomachs were provided by Tom Hall (U.S. Fish and Wildlife Service) and Gene Albert. Jack Stanford, director of the University of Montana Yellow Bay Biological Station on Flathead Lake, kindly provided docking facilities for Department research vessels and also provided the Van Dorn water sampler which was used in comparative plankton work. The Schindler transparent plankton trap was borrowed from the Montana Cooperative Fishery Research Unit at Montana State University in Bozeman. Delano Hanzel and Bob McFarland assisted during computer analysis of trout age and growth.

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INTRODUCTION

The Flathead River Basin Environmental Impact Study was born out of concern over potential adverse environmental effects of coal mining in the Canadian portion of the North Fork Flathead River drainage. The study is unique in that it is designed to gather substantial amounts of baseline information throughout the basin prior to the initiation of projected large-scale exploitation of such resources as coal, gas, oil, timber, and water.

Aquisition of baseline fisheries information for the study began in 1978 when the Montana Department of Fish, Wildlife and Parks initiated work on the North Fork of the Flathead River and its tributaries. Department work expanded to the Middle Fork drainage in 1979 and subsequently to Flathead Lake during 1980. Perspectives and objectives of these studies and other related Department projects have been detailed by Graham (1980).

In order to understand the dynamic fisheries of the whole Flathead Lake-River system, one must gather information on each of its parts. This is true because of the migratory habits of two game fish species of prime concern, the westslope cutthroat trout (*Salmo clarki lewisi*) and the bull trout or Dolly Varden (*Salvelinus confluentus*). Neither of these species is able to attain the large sizes (cutthroat up to 480 mm, bull trout larger than 800 mm and 10.0 kg) for which they are noted in the Flathead system without experiencing the benefit of the favorable growth environment in Flathead Lake. These large lake-dwelling fish are in turn dependent upon spawning and rearing areas in numerous tributaries to the North and Middle Forks to perpetuate their stocks.

Kokanee salmon (*Oncorhynchus nerka*) are the principal sport fish sought by anglers in Flathead Lake during the summer months and are also subjected to an intense sport snag fishery during the fall spawning run up the Flathead Rivers. This species is of concern because of its recreational value as well as the fact that it feeds on zooplankton, which occupy a relatively low position in the trophic web of Flathead Lake. Kokanee salmon and other fish species that feed on plankton would probably be more directly affected by changes in lake water quality than would bull trout that feed principally on fish or cutthroat trout which feed mostly on terrestrial insects.

This report summarizes the first half of a two-year study on Flathead Lake. The objectives of this study were outlined by Graham (1980) as:

1. Assess food habits of cutthroat trout, bull trout and kokanee seasonally in representative areas of the lake to predict, and if need be, document negative impacts of development in the upper basin on the food chain.

2. Begin to develop a method for long-term monitoring of relative abundance of westslope cutthroat and bull trout in the lake.

3. Determine growth rates and condition of bull and cutthroat trout in the lake.

Population abundance, growth rates, and condition of kokanee salmon in Flathead Lake are being investigated by other Department personnel (Hanzel 1974b; 1977a).

DESCRIPTION OF STUDY AREA

Flathead Lake is one of the largest natural lakes in the United States west of the Mississippi and is located in northwestern Montana (Figure 1). Though it is not particularly deep in comparison to morphometrically similar large lakes (Potter 1978), Flathead has a mean depth of 32.5 meters and a maximum depth of 113 meters. As is illustrated in Figure 1, much of the lake exceeds 20 m in depth except for Polson Bay (maximum depth 10 m). Kerr Dam is located 6.4 km downstream from the lake on the Flathead River and has regulated the upper three meters of the lake since its completion in 1938. Morphometric information for the lake is summarized in Table 1.

The pristine nature of Flathead Lake is primarily due to the fact that most of the 18,379 km^2 drainage area is underlain by nutrient-poor Precambrian sedimentary rock which is frequently deficient in carbonates. The largest tributary to the lake is the Flathead River which has an average flow of 9753 cfs at Columbia Falls (U.S. Geological Survey 1979). The three forks of the Flathead River (North, Middle and South) drain large tracts of undisturbed lands including all of Glacier National Park west of the Continental Divide (2266 km^2), all of the Great Bear Wilderness (1156 km^2) and a large portion of the 3842 km^2 Bob Marshall Wilderness. Other major tributaries to the lake include the Swan, Stillwater and Whitefish rivers which have average discharges of 1166, 336, and 192 cfs, respectively (U.S. Geological Survey 1979). The completion of Hungry Horse Dam on the South Fork of the Flathead River in 1952 has effectively isolated 23 percent of the Flathead Lake drainage from the remainder of the lake-river system.

Of the 25 fish species listed for Flathead Lake by Gaufin et al. (1976), only ten are native. Four of the seven common game fish species are native to the lake and include the westslope cutthroat trout, bull trout, mountain whitefish (*Prosopium williamsoni*), and pygmy whitefish (*Prosopium coulteri*). The other three species of common game fish were introduced to the lake and include the kokanee salmon, lake trout (*Salvelinus namaycush*), and lake whitefish (*Coregonus clupeaformis*).

With the exception of the yellow perch (*Perca flavescens*) all the common nongame fish species are native. This group includes the northern squawfish (*Ptychocheilus oregonensis*), peamouth (*Mylocheilus caurinus*), longnose and largescale suckers (*Catostomus catostomus and C. macrocheilus*) and the redside shiner (*Richardsonius balteatus*).

Data presented by Robbins (1966) indicates that the sport fish catch during the period 1962 through 1963 was dominated by kokanee salmon (76-95%) with fewer numbers of yellow perch (2-17% ; mainly from Polson Bay). Cutthroat trout, bull trout, lake trout and whitefish together comprised approximately 3 to 6 percent of the catch. An EPA sponsored Flathead

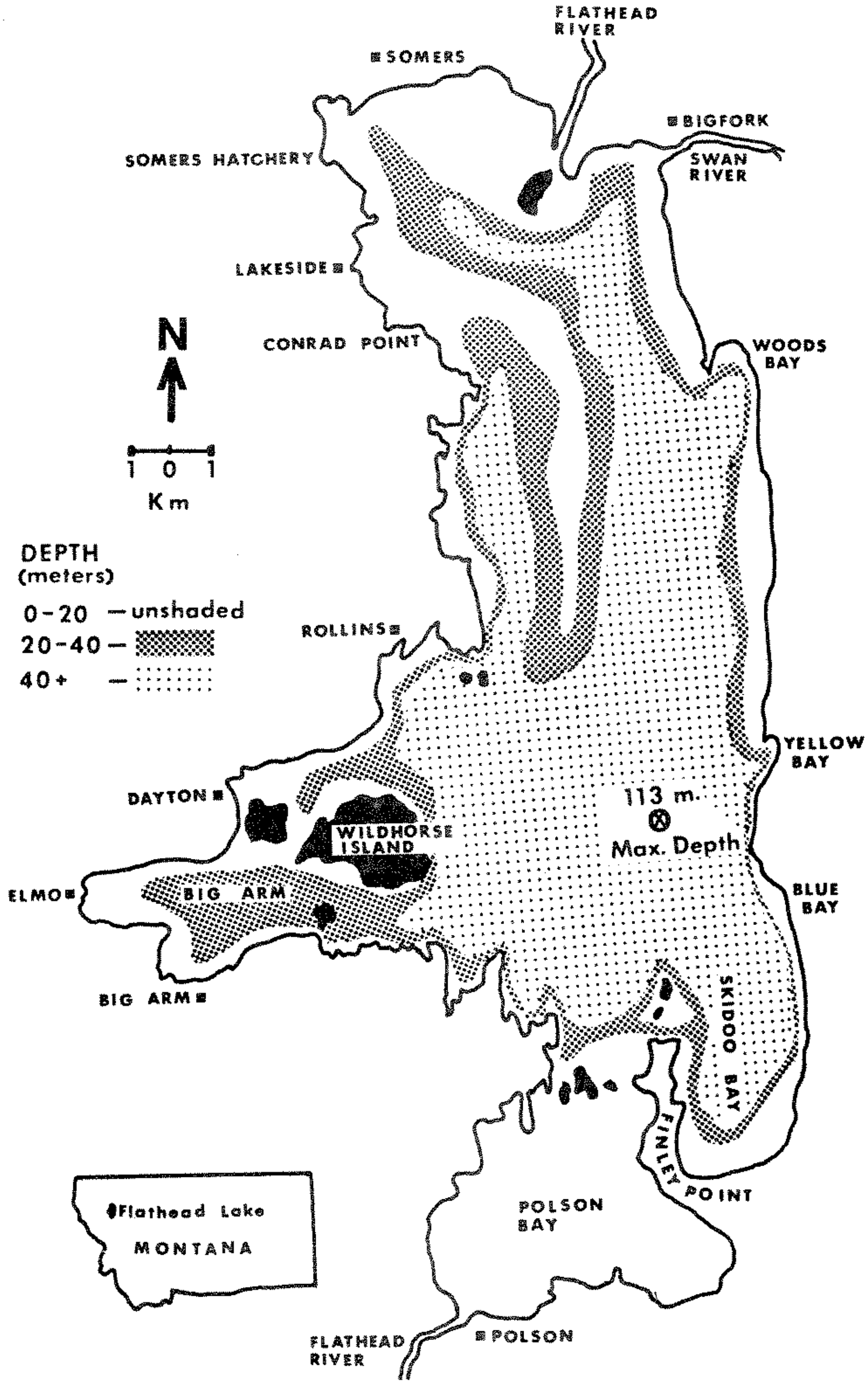


Figure 1. Map of Flathead Lake, Montana including 20 meter depth contours.

Table 1. Morphometric data for Flathead Lake (from Potter 1978).

Elevation (maximum regulated)	882.4 m
Maximum length	43.9 km
Maximum breadth	24.9 km
Mean breadth	10.5 km
Maximum depth	113.0 m
Mean depth	32.5 m
Maximum length Main Basin	39.4 km
Maximum length Polson Bay	10.5 km
Area	
Total	476.6 km^2
Islands	14.3 km^2
Water	462.3 km^2
Drainage	18378.6 km^2
Volume	24.9 km^3
Shoreline	
Total	301.9 km
Islands	42.2 km
Mainland	259.7 km
Shoreline development	3.9
Volume development	0.86

Lake creel census is scheduled to begin this spring (1981).

METHODS

PHYSICAL LIMNOLOGY

Temperature was measured to 0.5° C at one meter intervals to a depth of 30 m using an Applied Research FT3 hydrographic thermometer. Relative turbidity was estimated to 0.5 m using a Secchi disc.

FISH COLLECTION

Westslope Cutthroat and Bull Trout

A gill netting program was initiated to obtain cutthroat and bull trout for age and growth analysis, food habits study, and long-term monitoring of relative abundance. Five of the lake's 12 major areas were selected for gill netting (Figure 2) in an attempt to obtain a representative sample of the entire lake. Nets were set at three sites within each netting area hence 15 sites were netted per season with the exception that only areas 1, 2, 4 and 8 were netted during summer 1980 (29 July - 14 August). Fall gill netting was carried out during the period 6-20 October 1980. Winter netting, 7-21 January 1981, was facilitated by unusually mild weather conditions and a resultant lack of ice cover.

A combination of floating and sinking nets was used in each netting area. Two standard (1.83 x 38.1 m; equivalent to 6' x 125') experimental mesh floating gill nets were tied end to end and set at each of three sites in each gill netting area. Fall and winter floating net sets were tied off to the shoreline; summer sets were anchored over deep (20-30 m) water. During the summer period two experimental mesh sinking gill nets (one 2.44 x 76.2 m; one 2.44 x 64 m) were also set in each area. During the fall and winter series two sites within each area were fished with a single standard (1.83 x 38.1 m) experimental mesh sinking net and the remaining site was fished with the 2.44 m x 76.2 m (equals 8' x 250') net. Sinking nets were usually set along sloping shorelines at depths ranging between 15 and 35 meters. All nets consisted of equal length panels of 38, 51, 64, 76 and 102 mm stretched measure meshes which correspond to 1.5, 2.0, 2.5, 3.0, and 4.0 inch stretch measure, respectively. Nets were usually set one to two hours before sunset and retrieved one to four hours after sunrise.

Information for a few fish of each species was collected via creel census through the year.

Kokanee Salmon

Young of the year and age I+ kokanee were collected using a 2.43 m x 2.43 m midwater trawl towed behind the Department's 9.7 m research vessel, the "Dolly Varden". The trawl was developed by Hanzel (1976a, 1976b, 1977) and is 12.16 m long with 3.2 mm stretched measure mesh in the cod end and is capable of retaining fish as small as 13 mm (Hanzel 1976a). Trawling was conducted at night in areas where concentrations of small kokanee were

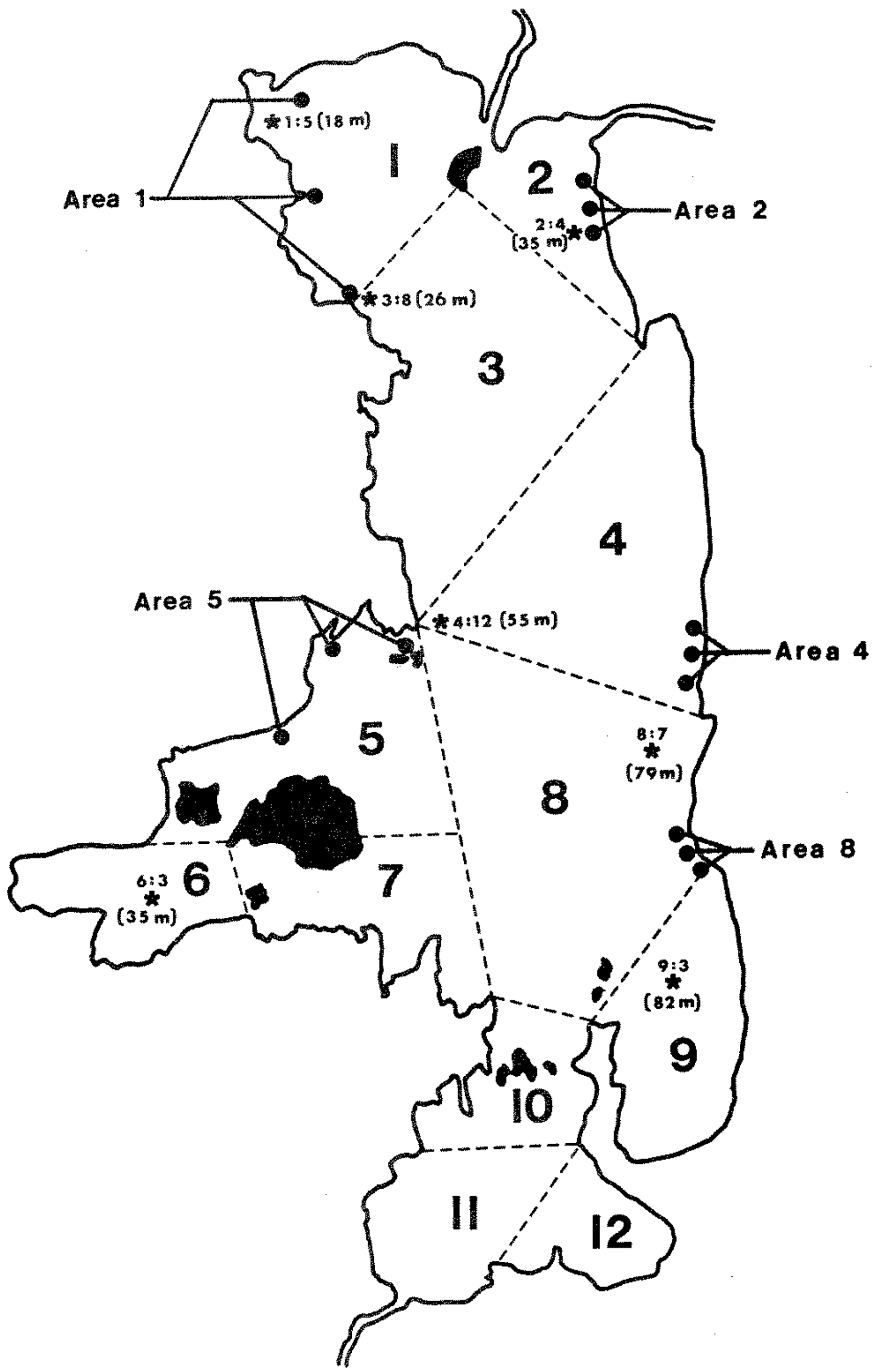


Figure 2. Map of Flathead Lake, Montana depicting major lake areas (1-12), seven zooplankton sampling stations (indicated by asterisks) with associated average depths (meters), and five gill netting areas.

detected using hydroacoustical gear aboard the Dolly Varden. Hanzel (1974a) has shown that kokanee in Flathead Lake tend to concentrate in deeper water at night hence trawling success was best after dark near the bottom in 20-30 meters of water. Since the midwater trawl is effective only on small fish (i.e. age 0+ and I+), larger fish (age III+ and IV+) were collected by creel census.

ZOOPLANKTON

Crustacean zooplankton populations were sampled monthly at seven locations on Flathead Lake (Figure 2) beginning in late June, 1980. Biweekly collections were taken at Station 2:4 to obtain a better representation of crustacean zooplankton population dynamics in the lake. Area 2 was selected for biweekly sampling because it has been consistently utilized by kokanee (and kokanee anglers) during the summer months (Hanzel, Montana Department of Fish, Wildlife and Parks, Kalispell; personal communication).

Zooplankton were collected using a 0.5 meter diameter Wisconsin-type closing net with a one meter long filtering cone constructed of 80 micron Nitex netting. The net was initially equipped with a Kahlisico TS flowmeter which was replaced in August 1980 by a General Oceanics Model 2030 flowmeter equipped with a low speed rotor. The net was modified to prevent back-spinning of the meter during descent. A two kilogram piece of lead was attached at the bottom to insure swift vertical descent. Plankton hauls were made from a 4.9 m boat equipped with a boom and snatch block. The net was retrieved by hand at a rate of 0.8 to 0.9 meters per second. Boat position was maintained by rowing to insure vertical tows.

Duplicate vertical tows were made at each station on each sampling date. The water column was generally divided into two strata (surface to 30 m, 30 m to 60 m) in July. Beginning in August the surface stratum was further divided into surface water and midwater. The top of the thermocline was defined as the lower limit of surface tows. Midwater tows sampled water from a depth of 30 m to the top of the thermocline. When no thermocline was present, surface tows were made down to 15 m and midwater tows sampled the 15-30 m stratum.

The average efficiency of our Wisconsin net has been found to be 48 percent for shallow surface tows (<20 m), 43 percent for midwater tows, and 33 percent for deep (30 m to 60 m) tows. Net efficiency appeared to drop off significantly in long surface tows (i.e. surface to 30 m; efficiency = 21%). Due to problems with the TS flowmeter, July plankton densities were calculated using these average efficiencies.

The effectiveness of the Wisconsin net was tested by comparing it to two other plankton sampling devices, a 15 liter Van Dorn water bottle and a 28.1 liter Schindler transparent plankton trap. Metered Wisconsin net plankton densities (using a calculated net efficiency of 47 percent) were quite similar to Van Dorn results (Table 2). The Wisconsin net appeared to be inefficient for *Leptodora* and copepod nauplii relative to the Van Dorn. Calculated Wisconsin net densities (corrected for net efficiency) averaged 87 percent of Schindler densities in surface tows (Table 2). For unknown reasons, Wisconsin net densities were even lower than Schindler

Table 2. Relative effectiveness of metered Wisconsin net as compared to a 15 liter Van Dorn sampler and a Schindler transparent plankton trap on Flathead Lake. The latter two samplers were assumed to be 100 percent efficient.

Date	Tow length	Sampling device	*Daphnia*	*Bosmina*	*Diaptomus*	*Cyclops*	*Epischura*	Nauplii	Adult *Epischura*	*Leptodora*	$\overline{X}$
4 Sep.	0-16m	Van Dorn	100	100	100	100	100	100	---	100	100
		Wisconsin net	110	100	124	84	100	65	---	54	91
30 Oct.	0-15m	Schindler trap	100	100	100	100	---	100	100	---	100
		Wisconsin net	71	93	87	91	---	69	109	---	87
	15-30m	Schindler trap	100	100	100	100	---	100	---	---	100
		Wisconsin net	31	33	44	73	---	79	---	---	52

densities in midwater tows (average = 52 percent). Schindler (1969) obtained similar results using metered tow nets and the Van Dorn sampler but these samplers were 64 and 69 percent as effective as the transparent plankton trap.

Duplicate zooplankton samples were combined in the field and preserved in a mixture of 4 percent formalin with 40 g/liter sucrose (Haney and Hall 1973). Combined samples were diluted in the laboratory and counts were made on each of five one-ml subsamples in a Sedgewick-Rafter cell. Counts were made using either a compound scope at 40x total magnification or a dissecting scope at 45x. The percent of the total sample actually counted ranged between 0.3 and 1.9, depending upon plankton density.

Separate counts were made to estimate the densities of *Leptodora* and adult *Epischura*. These organisms are relatively large and seldom appeared in subsamples, yet they were important in the kokanee diet. Seven percent of each combined sample was examined under low power using a dissecting microscope. These organisms were counted and their densities were calculated as numbers per cubic meter of water.

KOKANEE FOOD HABITS

Kokanee stomach contents were emptied into labeled plastic vials and preserved with a solution of 4 percent formalin with 40 grams per liter sucrose. Stomachs from all fish in each age group collected on a given date were combined in the lab and diluted for enumeration. The contents of five 1 ml subsamples (taken with a Hensen-Stempel pipette) were counted using a Sedgewick-Rafter cell at 40x total magnification under a compound microscope.

Intact food organisms in kokanee stomachs were measured to the nearest 0.01 mm at 40x (total magnification) using an ocular micrometer. Most of the *Daphnia* were distorted by digestive processes and could not be accurately measured. Consequently, the body length of these organisms was estimated by measuring the length of their postabdominal claw to the nearest 0.005 mm at 100x. The relationship between body length and claw length for 33 *Daphnia thorata* collected at Station 4:12 in August is depicted in Figure 3. The average difference between actual body length and body length predicted based on claw length was 0.08 mm. The maximum difference was 0.18 mm. Dodson (1970) also observed a strong positive linear body-claw relationship. Measurements were made on 50 *Daphnia* claws in most kokanee stomach collections. Claws frequently had to be dissected from the body to obtain accurate measurements.

Vertical plankton tows were usually taken from 30 m to the surface in conjunction with kokanee stomach collections. Plankton were collected and enumerated using previously described methods. The lengths of principal kokanee food items (mostly *Daphnia thorata*) in plankton samples were measured to the nearest 0.01 mm. Few copepods were measured because kokanee selected nearly exclusively for adult instars which display little variation in body length. Usually 50 individuals of each *Daphnia* species (when available) were measured. Measurements on all crustaceans were made from the anterior margin of the head to the posterior margin of the body, excluding terminal

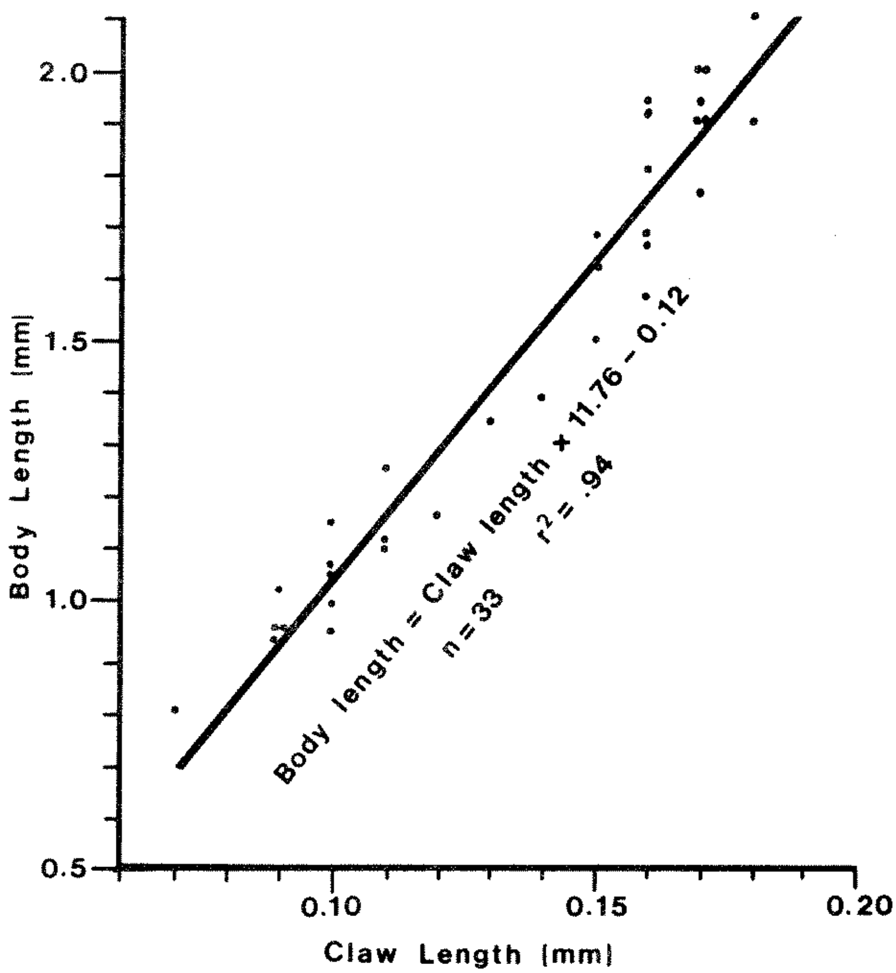


Figure 3. The relationship between body length and length of postabdominal claw for *Daphnia thorata* from Station 4:12 of Flathead Lake on 26 August 1980.

spines or setae.

Species and size selection of zooplankton by kokanee were expressed using Ivlev's (1961) electivity index (E_i) which is computed as follows: $E_i=(C_i - P_i)/(P_i + C_i)$ where P_i is the percentage of prey species i in the plankton sample and C_i is the percent composition of prey species i in the fish stomachs. This index ranges from -1 to +1. A value of -1 indicates total avoidance of a particular food item whereas a value of +1 indicates maximum positive selection for prey species. An electivity value of zero indicates that the percent composition of a prey species in the diet is the same as the composition of that species in the plankton sample.

Biomass of cladoceran species was calculated directly as dry weight using formulae presented by Bottrell et al. (1976). Copepod biomass was estimated as wet weight using the formula of Klekowski and Shuskina (1960) as cited in Edmondson and Winberg (1971). A factor of 0.10 was used to convert copepod wet weight to dry weight (Rieman and Bowler 1980). Energy content of zooplankton species was calculated using calorific equivalents presented by Cummins and Wuycheck (1971).

TROUT FOOD HABITS

Cutthroat and bull trout from gill net catches were immediately placed on ice (except during winter) and transported to the lab. Stomach contents were removed and placed in labeled plastic vials and preserved in 10 percent formalin and stored for future analysis.

Numbers and wet weight of each taxonomic group of food items in each cutthroat stomach were recorded. Wet weights of food categories were measured to 0.01 g after removing excess water using paper towels. Total volume (to 0.05 ml) of the combined contents in each cutthroat stomach was also measured. Quantitative estimates of ingested material based on displacement volume and wet weight were similar. For nine stomachs collected in the summer, one gram wet weight was equivalent to 1.02 ml displacement. The ratio was 1.22 ml per gram for 15 stomachs collected in the winter. Numbers and wet weight (to 0.1 g) of bull trout food categories were also recorded.

An index of relative importance (IRI) was calculated to estimate the importance of a particular food item in the diet (McMullin 1979). The IRI incorporates the number, frequency of occurrence, and volume of a food item in the diet. It is the arithmetic mean of these parameters (all expressed as percentages) and ranges from zero to 100, with a value of 100 indicating exclusive use of a food item.

TROUT AGE AND GROWTH

Body weights of cutthroat and bull trout captured in gill nets were measured to the nearest 5 gm and total body length was measured to the nearest millimeter. Scales were taken from an area just above the lateral line between the posterior insertion of the dorsal fin and the adipose fin. Cellulose acetate impressions of scales were examined at 43x and distance from the focus to annuli were measured in millimeters.

Research conducted on cutthroat trout populations in tributaries to the North and Middle Forks of the Flathead River has shown that 61-69 percent of these fish did not form a first annulus (Graham et al. 1980, Fraley et al. 1981). Scales from these fish typically had an enlarged focus and more than seven circuli to the first annulus. Similar techniques were employed by Laakso and Cope (1956) to identify retarded growth in Yellowstone Lake cutthroat trout. First annuli were missing in 10 percent of the juvenile bull trout collected in upper Middle Fork tributaries (Fraley et al. 1981) and similar methods were used to identify such fish. The location of the first annulus on scales from these fish was placed at the first complete circulus from the focus.

Age and growth information was analyzed using the FIRE I computer program described by Hesse (1977). Computer analysis was conducted using a remote terminal at the Montana Department of Fish, Wildlife and Parks headquarters in Kalispell which is linked to Montana State University's Sigma 7 computer in Bozeman. Body length-scale radius relationships were most accurately described by log-log plots, hence backcalculated lengths at annuli were computed using this technique. Body-scale relationships for Flathead Lake cutthroat and bull trout were obtained using pooled samples of tributary and lake fish. Condition factors were calculated as $(W \times 10^5)/L^3$.

Historical information concerning cutthroat and bull trout growth in Flathead Lake was obtained using scales collected by Department personnel in years past. Most of these scales were collected during a 1963 creel census (Robbins 1966) and by gill netting during the years 1967-72 (Hanzel 1970; 1971; 1972). Additional scales were infrequently collected by game wardens.

RESULTS AND DISCUSSION

PHYSICAL LIMNOLOGY

Water temperature is an important factor regulating the biological community within Flathead Lake. Seasonal changes in water temperature directly affect the depth distribution, growth rates, and feeding habits of fish and also influence the species composition and abundance of crustacean zooplankton within the lake.

A thermocline was present at Station 2:4 on the first sampling date (7 July) and remained through early October. Maximum surface water temperatures (up to 23° C) occurred during late July and early August. The location and width of the metalimnion (defined as a zone where water temperature changes at least one degree centigrade per meter of depth) was variable. The top of the metalimnion was as shallow as 5 m on 7 August and as deep as 21 m on 26 September (Figure 4). The width of the metalimnion ranged between one and six meters.

Temperature profiles at the seven sampling stations for the months when the lake was stratified are presented in Figure 5. The strongest similarity between stations was noted in August and thermal stratification was also most well defined during this month.

The secchi disc is useful in monitoring turbidity which can have a significant effect on the distribution of fish and zooplankton in the lake. The lowest secchi reading (3.0 m) occurred during late June at the three most northerly stations (1:5, 2:4 and 3:8; Table 3). These stations are more directly influenced by turbid runoff waters discharged into the lake by the Flathead River (Figure 1). Secchi disc readings generally ranged between 6.5 and 10.0 m throughout the period July through December. The maximum secchi reading was 11.0 m and was noted once during July and once during September (Table 3).

Abnormal decreases in water clarity were noted at Stations 1:5 and 3:8 during December and January (Table 3). This may have been due to increased turbidity in the Flathead River resulting from unusual winter thaws.

ZOOPLANKTON

Crustacean zooplankton are seasonally important in the diets of many fish species in Flathead Lake. Some of these fish species are significant components of the bull trout diet. Kokanee salmon, an important sport fish, feed almost exclusively on crustacean zooplankton during the summer and fall months. Thus an understanding of the seasonal changes in the species composition and abundance of the zooplankton is prerequisite to the analysis of kokanee feeding habits and can also help in analyzing trends in the abundance and vigor of forage fish populations.

The zooplankton community of Flathead Lake was dominated by four cladoceran and three copepod species (Table 4). *Leptodora* was the largest cladoceran in the crustacean zooplankton community and *Daphnia thorata*

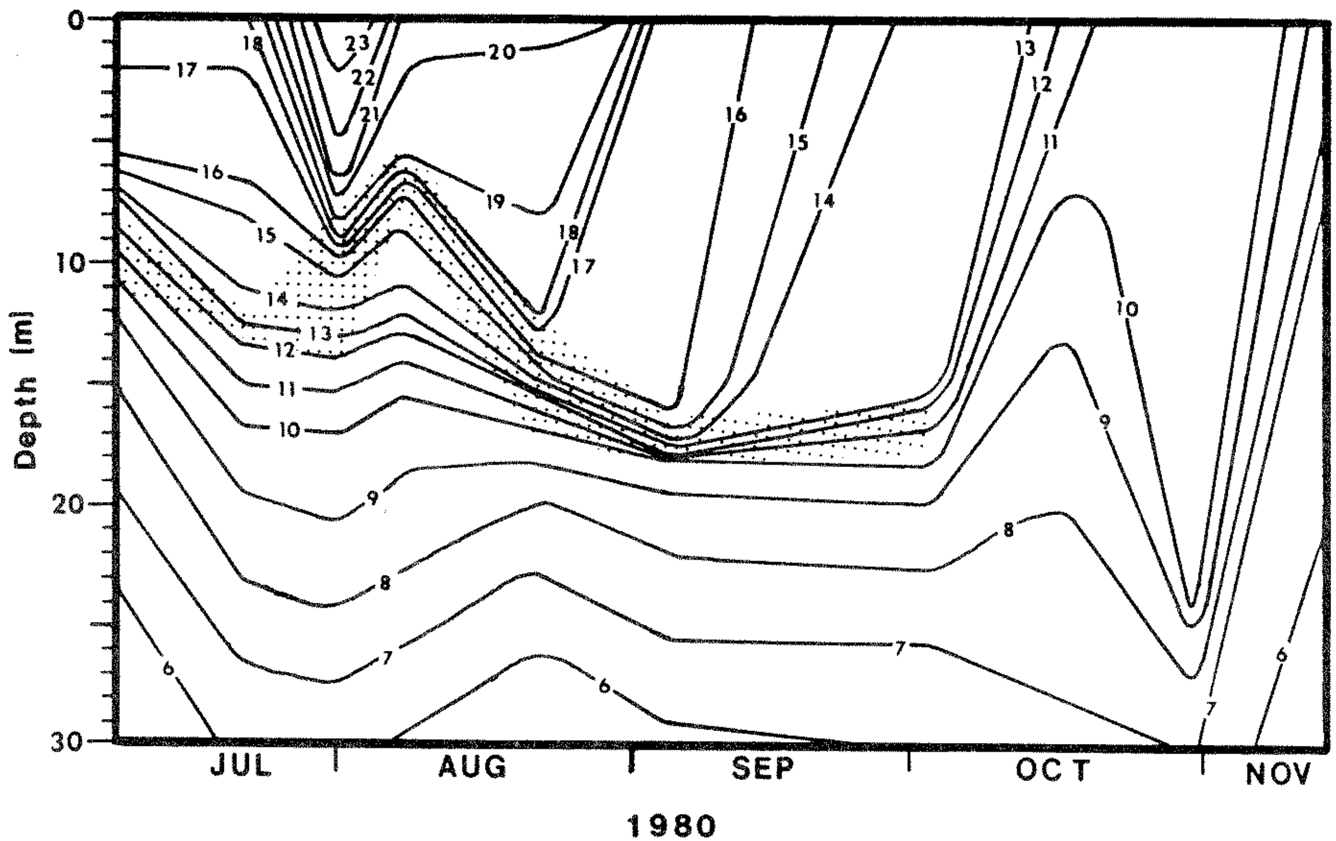


Figure 4. Seasonal distribution of isotherms (°C) at Station 2:4 of Flathead Lake during 1980. Shading indicates location and width of the metalimnion.

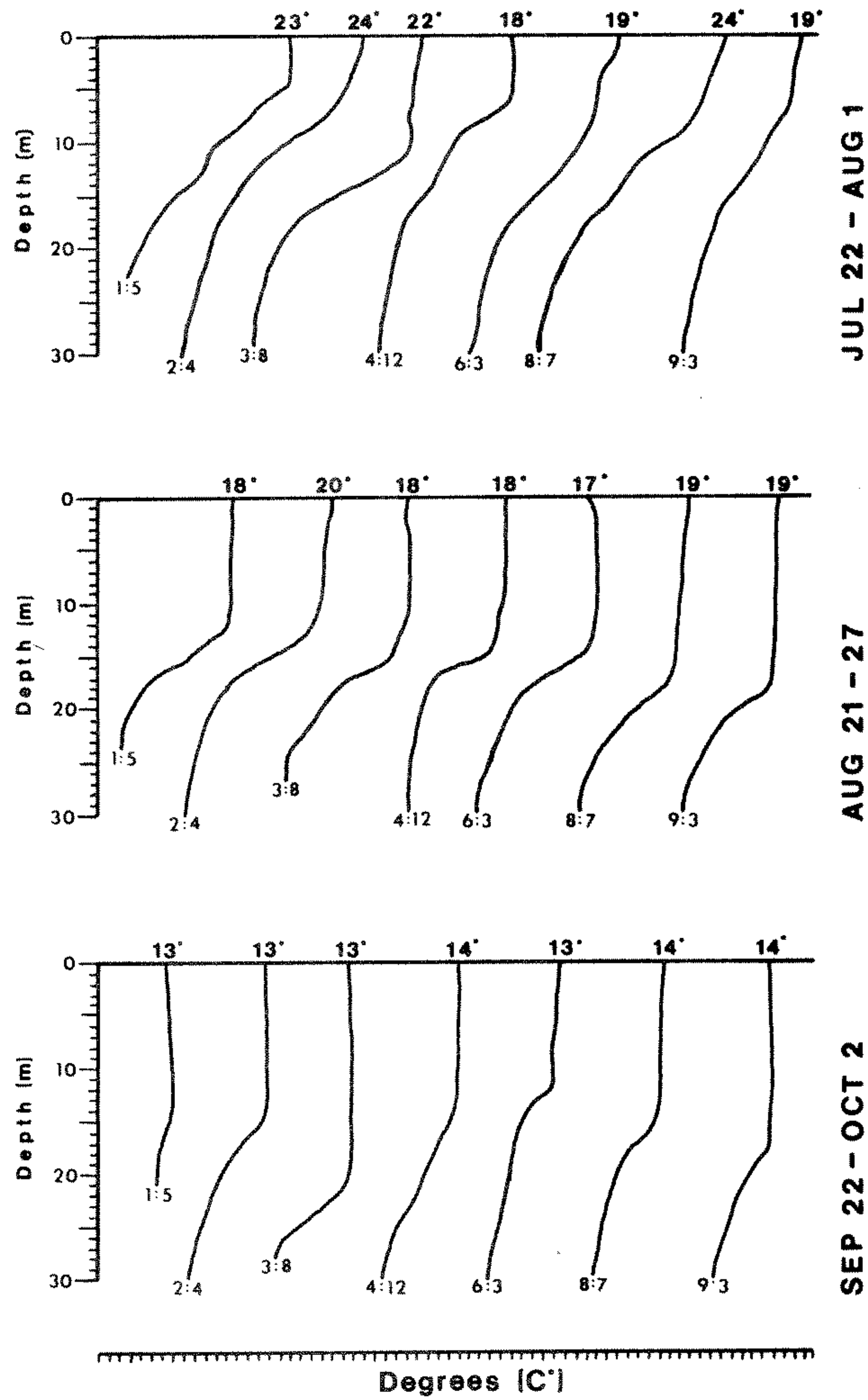


Figure 5. Temperature-depth profiles for seven stations on Flathead Lake during three time periods, 1980.

Table 3. Secchi disc readings (meters) at seven stations on Flathead Lake, June 1980 through January 1981.

Date	Station						
	1:5	2:4	3:8	4:12	6:3	8:7	9:3
Jun 24-26	3.0	3.0	3.0	4.0	6.0	7.0	5.0
Jul 21-31	8.5	9.0	8.0	10.5	9.5	11.0	9.0
Aug 21-27	---	9.0	7.0	10.5	---	9.5	9.5
Sep 22-26	6.5	9.0	6.5	7.0	7.5	10.0	11.0
Oct 23.30	7.5	9.5	8.5	8.5	8.5	9.0	9.0
Nov 24-26	7.0	9.0	9.0	8.5	8.5	7.5	9.0
Dec 22-29	4.5	8.5	5.0	---	8.5	10.0	8.5
Jan 21-30	3.0	6.5	4.5	6.0	10.0	---	10.0

Table 4 . Length, biomass, and caloric content of the principal crustacean zooplankton species in Flathead Lake.

Species	Length range adult female (mm)	Mean length adult female (mm)	Mean biomass adult female (mg dry wt.)	Mean caloric content adult female
Cladocera				
Daphnia thorata	1.37 - 2.16	1.73	26.2	.13
Daphnia longiremis	1.01 - 1.53	1.23	10.4	.05
Bosmina longirostris	.34 - .60	.46	2.1	.01
Leptodora kindtii	2.8 - 5.5	4.1	80.0	.44
Copepoda				
Epischura nevadensis	1.74 - 2.26	2.01	37.0	.21
Diaptomus ashlandi	.99 - 1.17	1.09	7.0	.04
Cyclops bicuspidatus thomasi	.94 - 1.07	1.00	5.5	.03

was the largest daphnid. *Epischura* was the largest copepod; adults of this species were nearly twice as large as *Diaptomus* or *Cyclops*.

Mean zooplankton density declined steadily throughout the summer in the surface waters from a high of 37.5/ℓ in late June to 10.0/ℓ in late August (Figure 6). Mean density in deep water tows was usually lower and consistently ranged between 4.0 and 8.0 organisms per liter (Figure 7). Populations in both strata were dominated by copepods, however, this group comprised an average of 95 percent of deep water populations compared to an average of 81 percent of shallow water populations (Figures 6 and 7). During early October, *Diaptomus* was replaced by *Cyclops* as the dominant organism in each stratum.

Cladocerans were much more common in shallow tows than in deep tows (Figures 6 and 7). *Daphnia thorata* was strongly surface oriented, comprising an average of 9.4 percent of the crustacean zooplankton population in this stratum. The maximum percent composition of this species in deep water populations was 2.6 percent in November (Figure 7). *Daphnia longiremis* was equally represented in surface and deep water tows whereas *Bosmina* occurred more commonly in surface tows. The two largest organisms, *Leptodora* and *Epischura* never comprised more than one percent of the plankton density in either stratum.

More detailed study of the vertical distribution of zooplankton was carried out during the months August through December. During this time-span the upper 30 m of the lake was sampled in two segments. The boundary between surface and midwater tows was either the top of the thermocline or the 15 m depth depending upon the degree of thermal stratification.

During August and September *Diaptomus* tended to be under-represented in the surface waters of Flathead Lake. However, this copepod was a significant component of the plankton throughout the water column (Figure 8). With some exceptions, *Cyclops* was evenly distributed in the three strata.

Daytime depth distribution patterns of the Cladocera were more distinct than those of copepods (Figure 9). *Daphnia longiremis* was seldom present in surface tows but comprised a small percentage of mid and deep water populations on almost all sampling dates. The reverse was true for *Daphnia thorata*. This species was always most numerous in surface tows although differences between strata became less distinct in November and December. *Bosmina* were concentrated in the surface waters throughout most of the period. However, as water temperature declined this organism became more evenly distributed through the water column. These findings are consistent with those of Potter (1978).

The actual densities (numbers per cubic meter) of *Leptodora* and adult *Epischura* within each stratum are depicted in Figure 10. August *Leptodora* densities were largest in the surface and midwater tows whereas densities in all strata were similar in September. *Leptodora* was present in reduced numbers during November in surface tows. Potter (1978) collected few *Leptodora* in October and none in November during an intensive study of Flathead Lake zooplankton. He reported that *Leptodora* avoided surface waters during most of the daylight hours.

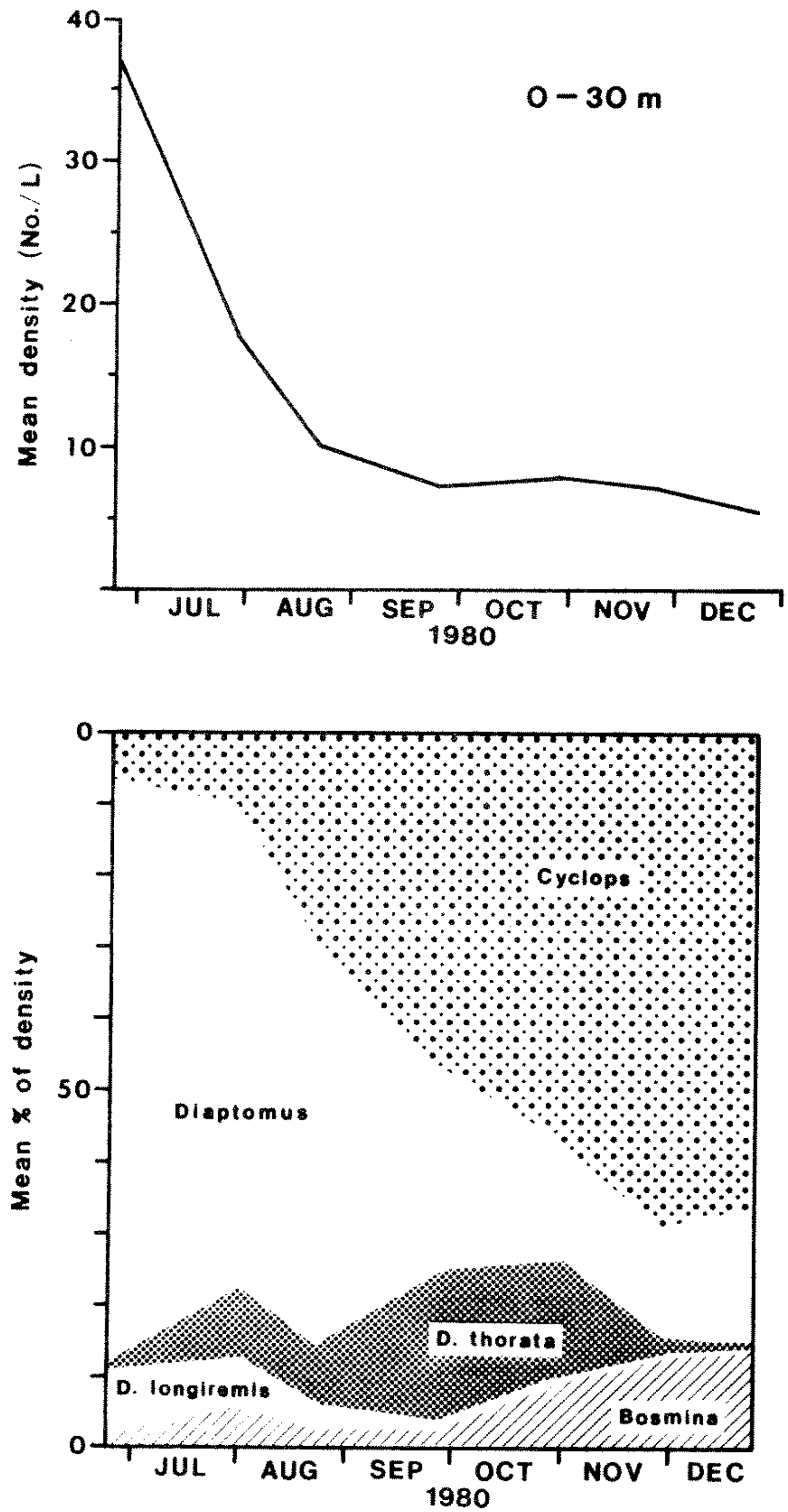


Figure 6. Seasonal fluctuations in total density (No./ℓ; upper figure) and species composition (percent; lower figure) of the principal crustacean zooplankton in the surface waters (0-30 m) of Flathead Lake, 1980.

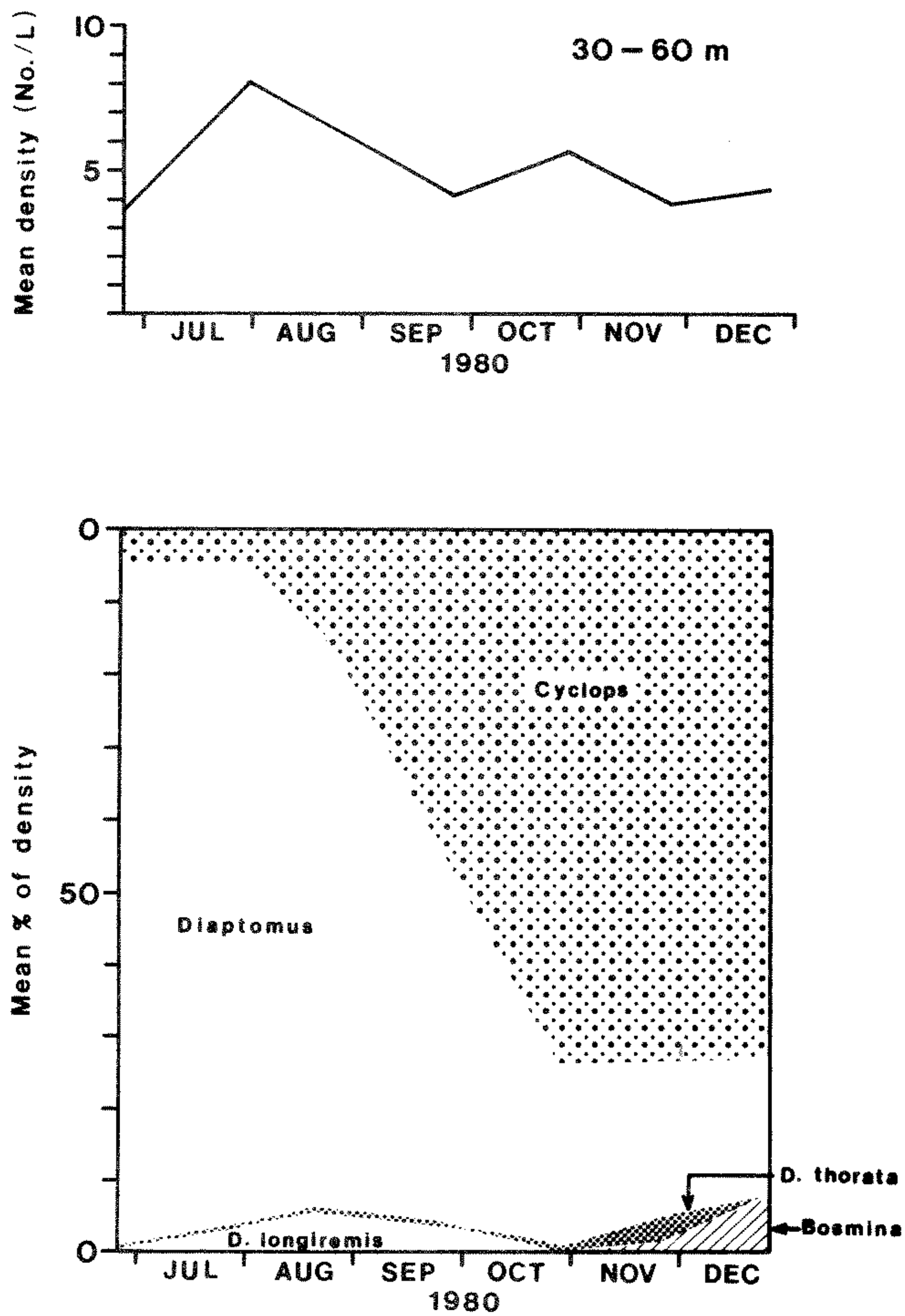


Figure 7. Seasonal fluctuations in total density (No./ℓ; upper figure) and species composition (percent; lower figure) of the principal crustacean zooplankton in the deep waters (30 - 60m) of Flathead Lake, 1980.

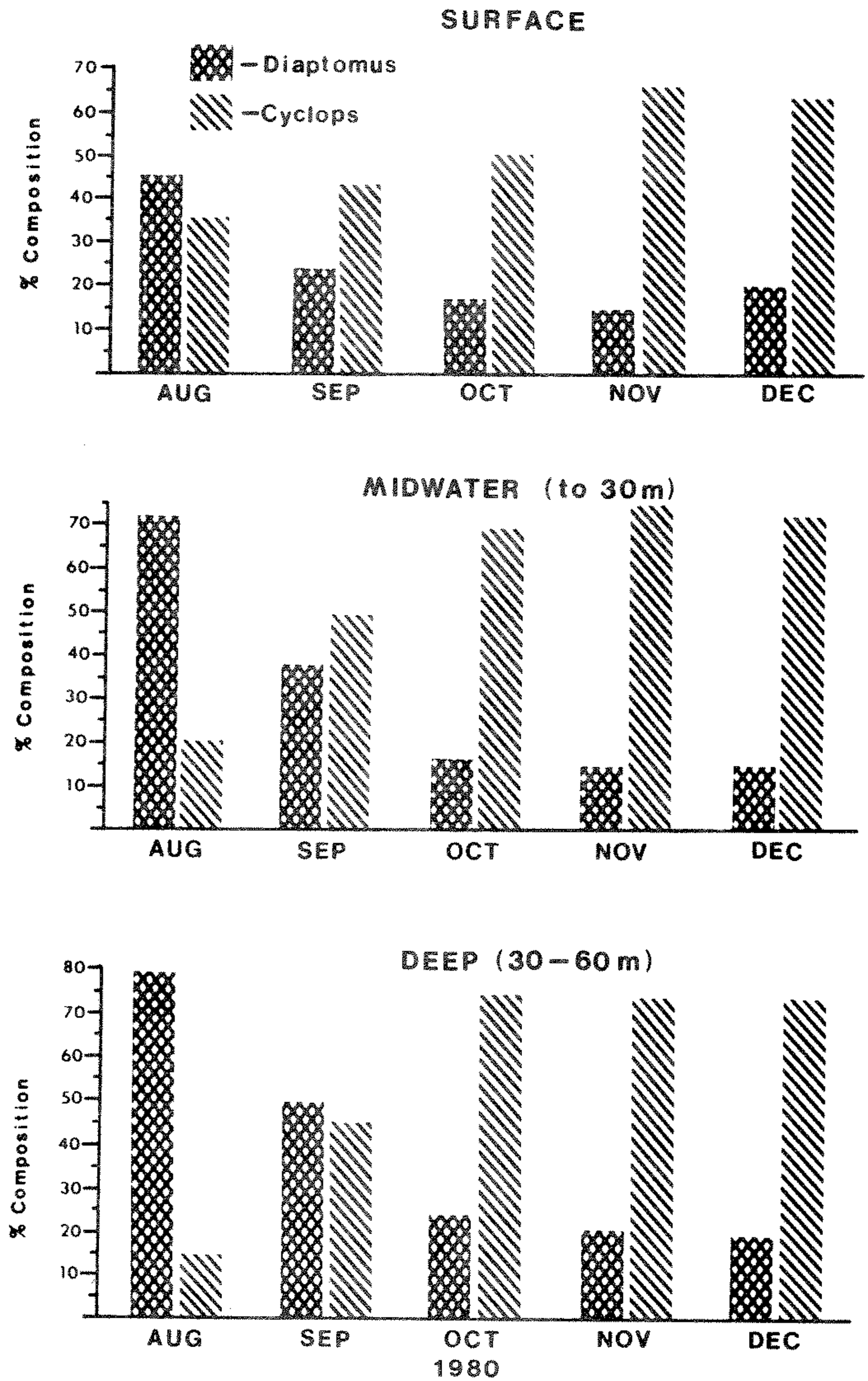


Figure 8. Percent contribution of *Diaptomus ashlandi* and *Cyclops bicuspidatus thomasi* to total zooplankton density in three strata of Flathead Lake during 1980.

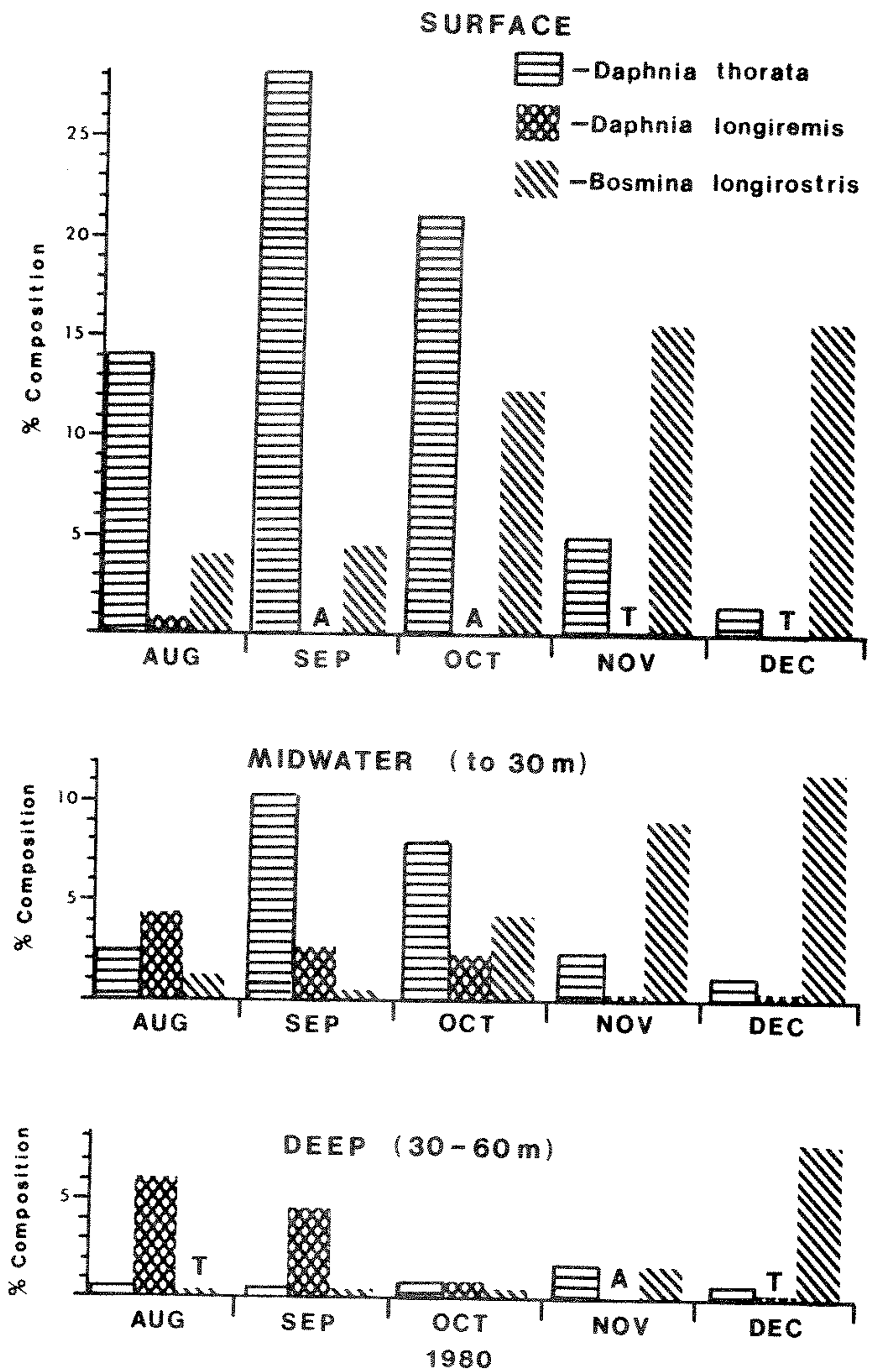


Figure 9. Percent contribution of *Daphnia thorata*, *D. longiremis*, and *Bosmina* to total zooplankton density in three strata of Flathead Lake during 1980. A = absent, T (Trace) = $\leq$ 0.2% of density.

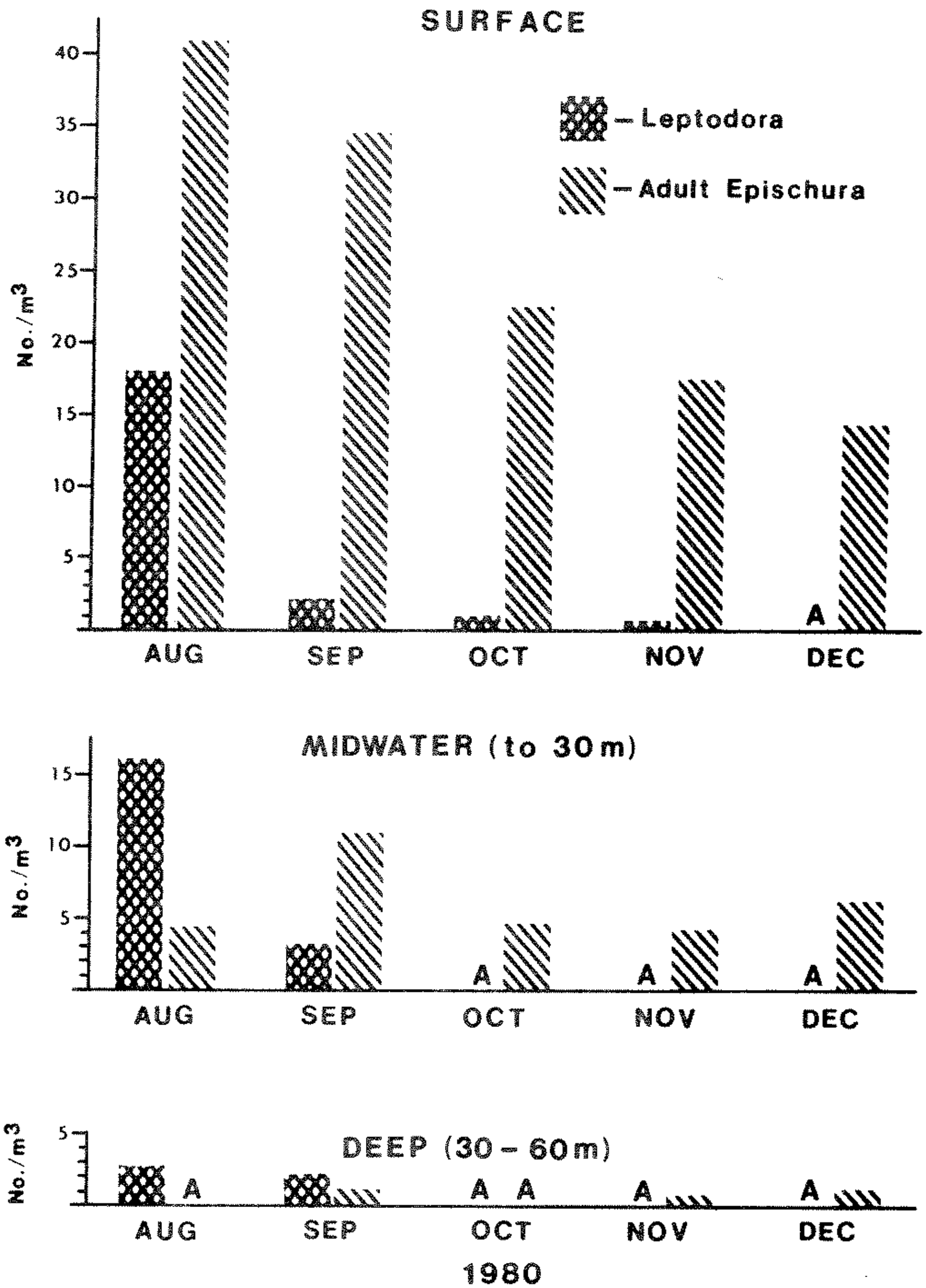


Figure 10. Density (No./m³) of *Leptodora* and adult *Epischura* in three strata of Flathead Lake during 1980. A = absent.

Daytime surface densities of adult *Epischura* were usually three to eight times as large as midwater densities (Figure 10). Adult *Epischura* were infrequently collected in deep tows and never achieved densities larger than two per cubic meter in deep waters. Potter (1978) observed that *Epischura* density declined abruptly 15 m below the surface and frequently found adult densities of two to six per liter (2,000 - 6,000 per cubic meter) within 10 m of the surface. Our largest observed density of adult *Epischura* was approximately 0.2/ℓ or 200/m^3.

Population fluctuations of the principal crustacean zooplankton species in biweekly samples at Station 2:4 are depicted in Figure 11. *Daphnia longiremis* was most abundant during July and attained a maximum density of 2.86/ℓ on 7 July. *Daphnia thorata* densities commonly exceeded 1.0/ℓ during the months July through October. Peak density for this organism (3.56/ℓ) was noted on 7 August. Observed *Daphnia thorata* densities were similar to those reported for Flathead Lake by Potter (1978). He found densities ranging between 0.8/ℓ and 1.5/ℓ during 1971 and 1973. Average *Daphnia thorata* density peaked at approximately 2.0/ℓ and 4.0/ℓ in Pend Oreille Lake, Idaho during 1953 and 1975 (Riemann and Falter 1975).

Bosmina densities at Station 2:4 showed little seasonal variation and seldom exceeded 1.0/ℓ (Figure 11). Potter (1978) observed densities of between 4.5/ℓ and 6.2/ℓ in the upper 25 m of Flathead Lake during July and August 1972. *Bosmina* peaked at approximately 5.5/ℓ and 3.0/ℓ during July 1953 and 1975 in Pend Oreille Lake (Riemann and Falter 1975).

Seasonal density trends of the copepods *Diaptomus* and *Cyclops* at Station 2:4 were similar to those observed by Potter (1978). *Diaptomus* frequently exceeded 15 organisms per liter during early and midsummer and declined to much lower numbers during the fall (Figure 11). *Cyclops* density typically ranged between two and five organisms per liter.

Leptodora steadily increased in abundance during July at Station 2:4 and attained a peak density of 136.7/m^3 (.14/ℓ) on 7 August (Figure 11). The seasonal trend in *Leptodora* abundance is very similar to that described by Potter (1978) for Flathead Lake and by Riemann (1980a) for Pend Oreille Lake. However, peak density in Pend Oreille seldom exceeded 4.0/m^3 over the course of the six-year study.

Population densities of *Daphnia thorata* and *Bosmina* at seven locations on Flathead Lake are presented by month in Figure 12. Interstation differences for both species were noted within a given month but no consistent trends were discernable. Similar results were obtained for *Diaptomus and Cyclops* (Figure 13) and also for *Leptodora* and adult *Epischura* (Figure 14). Much of the interstation variation in species density occurred during June and July and may have been due to sampling error since sampling techniques were being refined during this period.

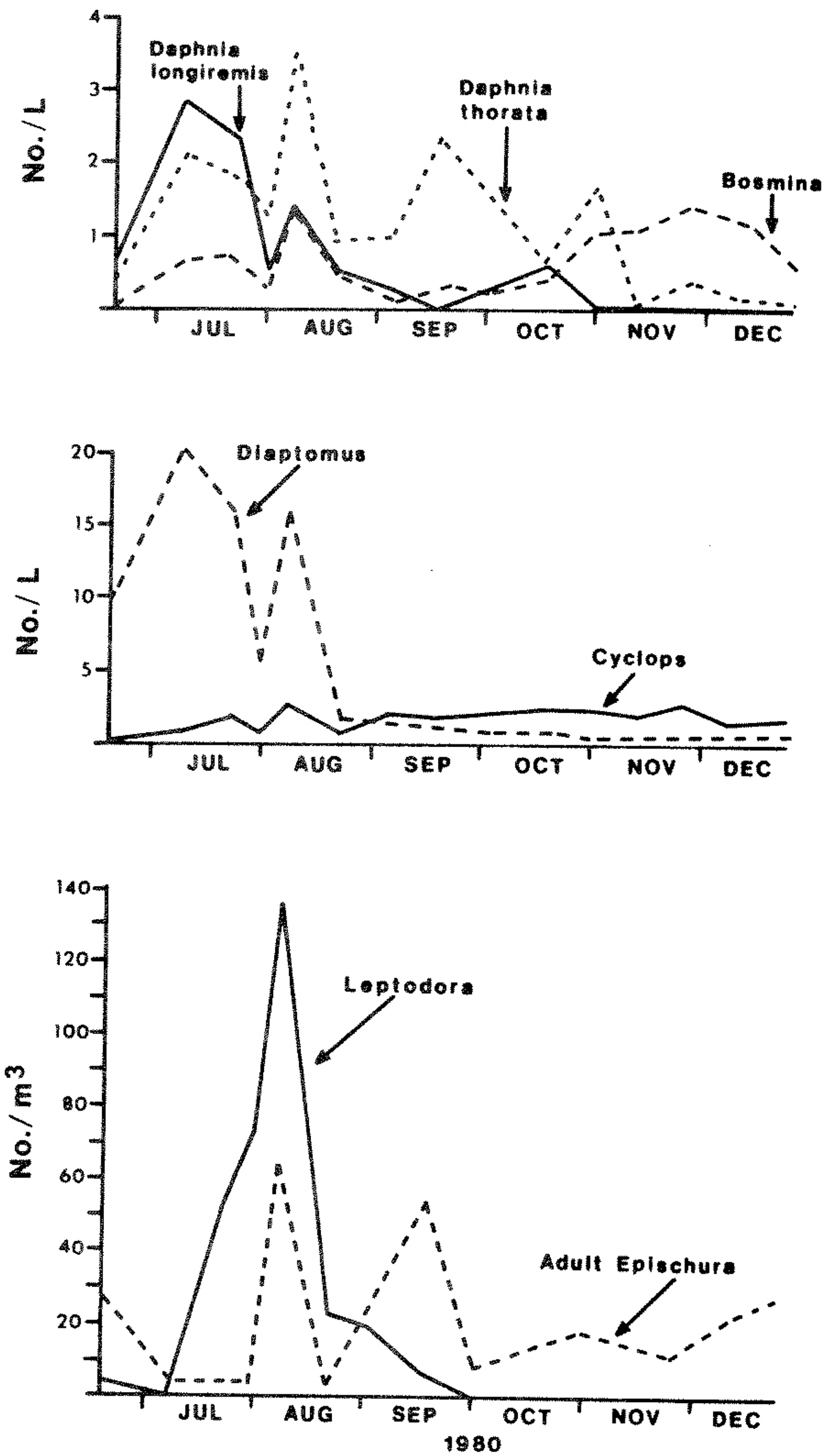


Figure 11. Seasonal population trends of the principal crustacean zooplankton species in surface tows (0-30 m) at Station 2:4 in Flathead Lake, 1980.

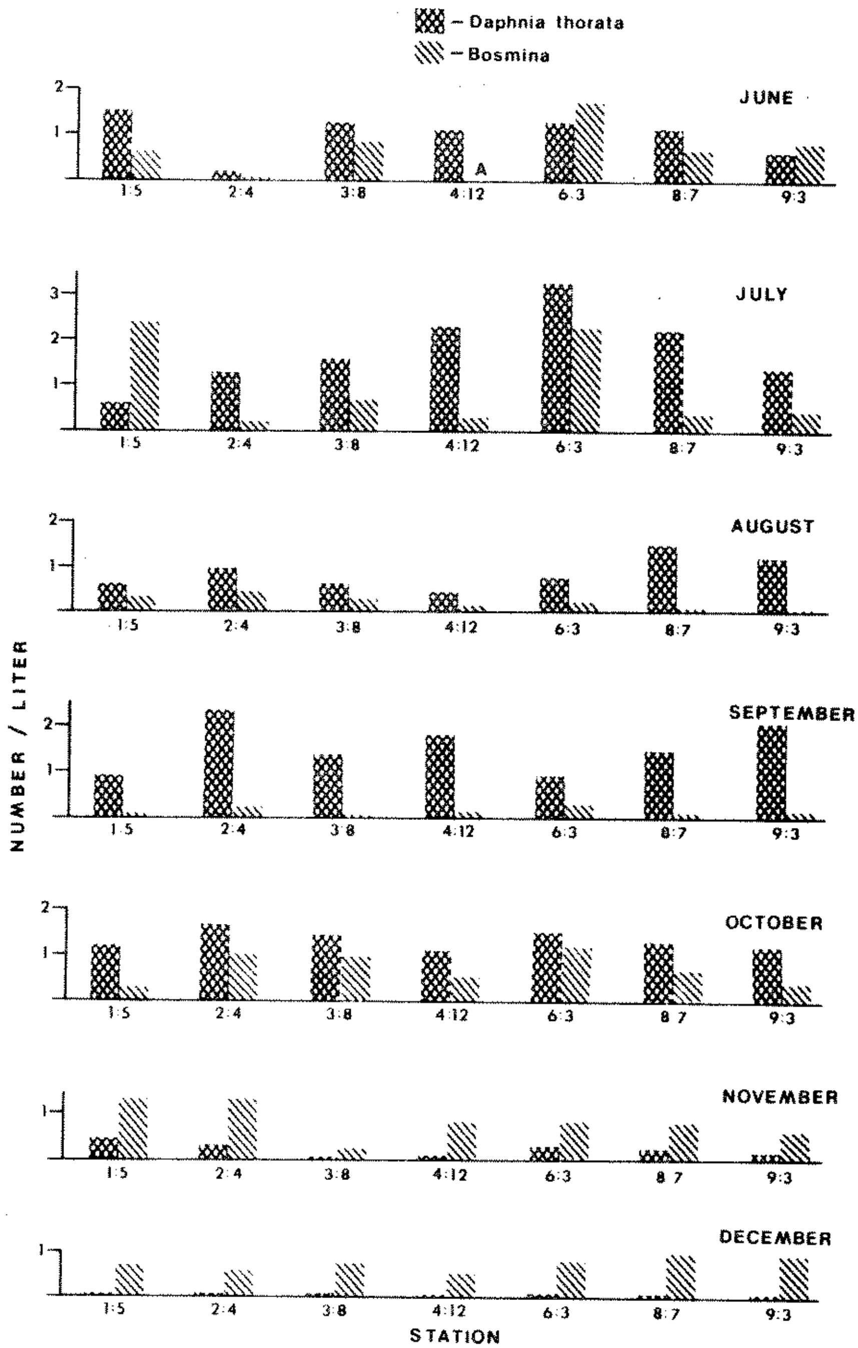


Figure 12. Densities (No./ℓ) of *Daphnia thorata* and *Bosmina* in the upper 30 m at seven different stations on Flathead Lake, June-December 1980. A = absent.

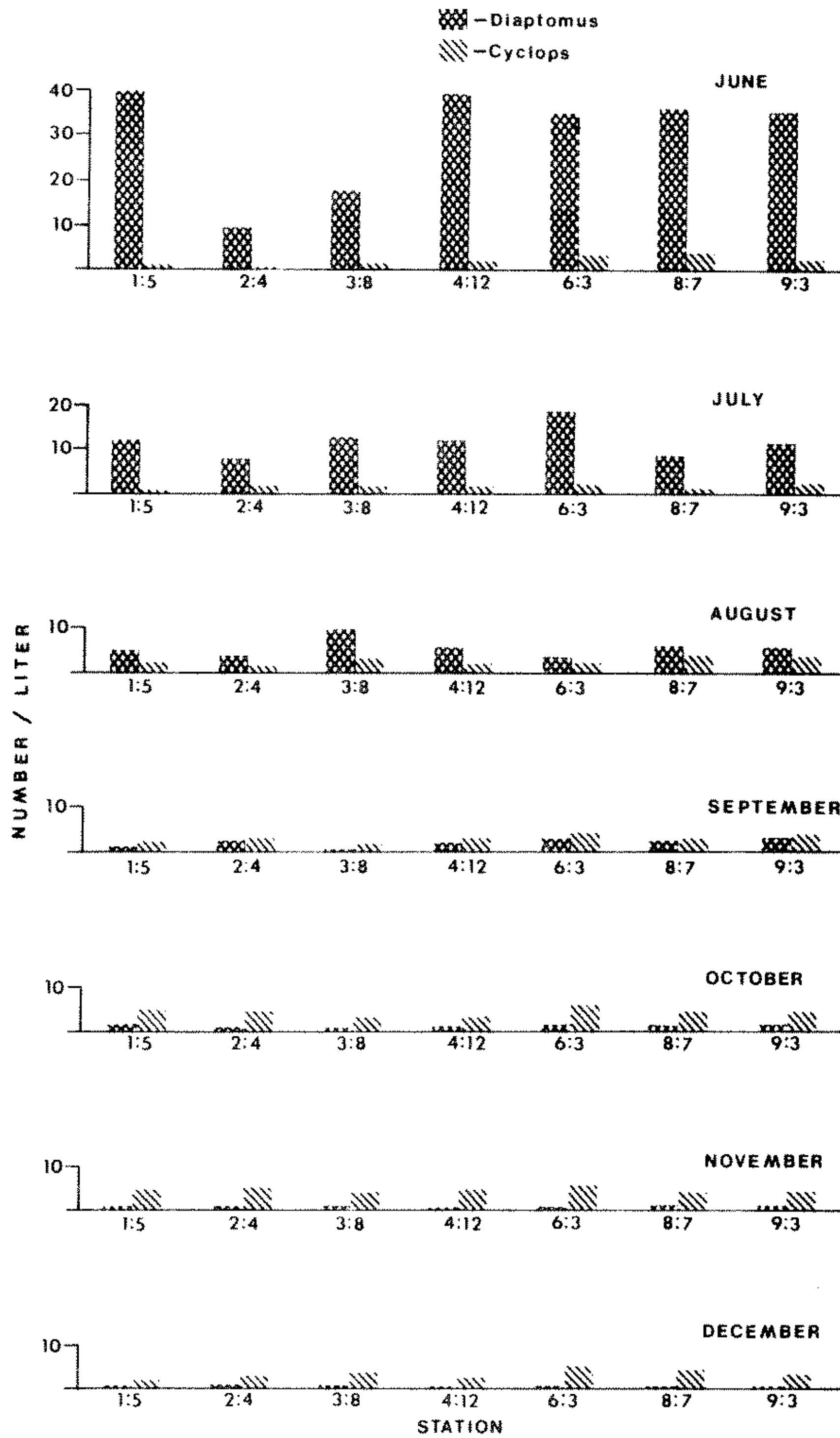


Figure 13. Densities (No./ℓ) of *Diaptomus* and *Cyclops* in the upper 30 m at seven different stations on Flathead Lake, June - December 1980.

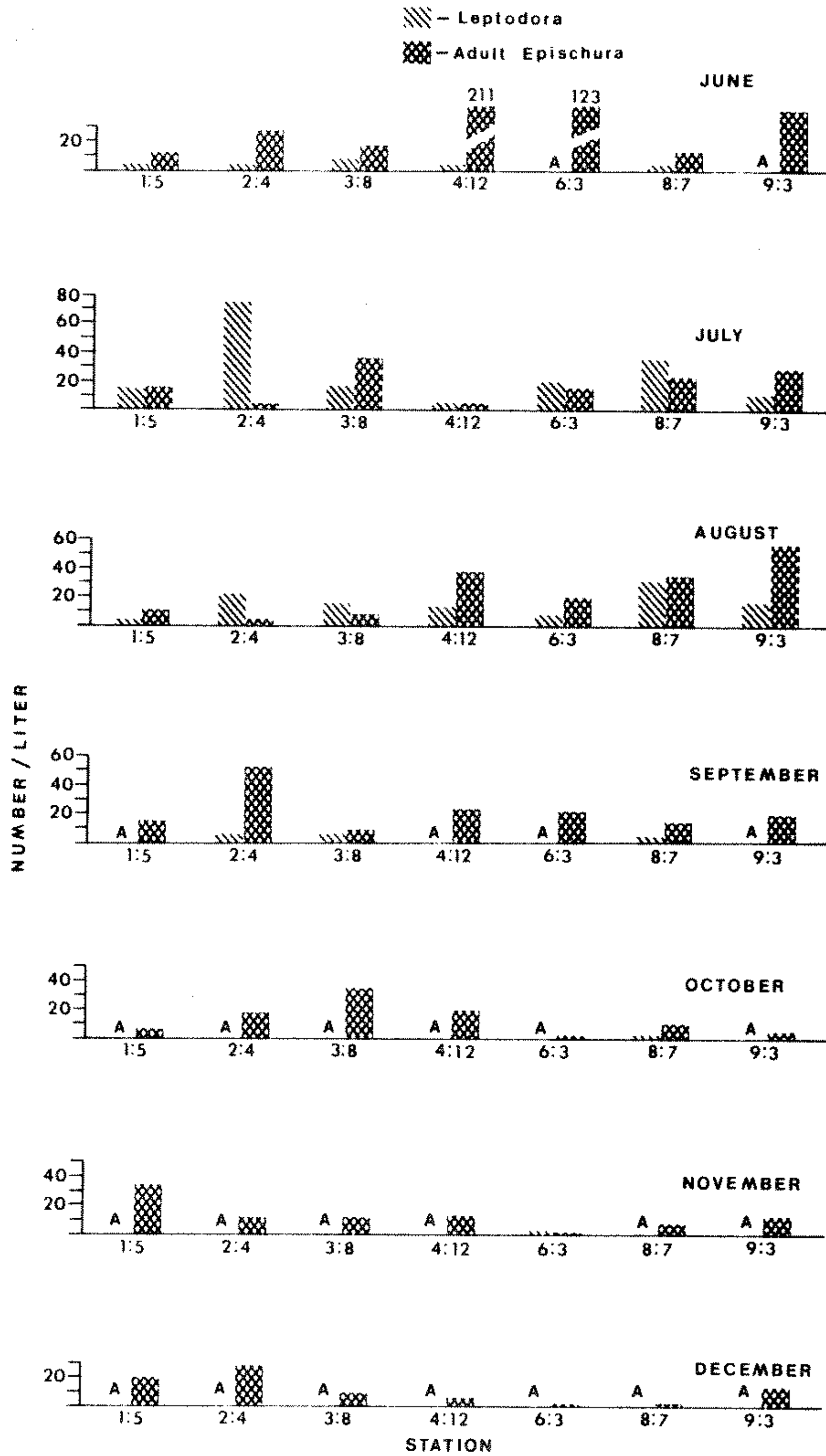


Figure 14. Densities (number per meter cubed) of *Leptodora* and adult *Epischura* in the upper 30 m at seven different stations on Flathead Lake, June - December 1980. A = absent.

KOKANEE FOOD HABITS

Crustacean zooplankton comprise the primary food source for kokanee salmon in Flathead Lake. Potential changes in lake water quality induced by resource development activities within the upper Flathead Basin could alter the species composition and abundance of the zooplankton which could in turn impact kokanee. Documentation of present kokanee food habits will provide a sound basis to which future findings can be compared. This will facilitate the process of monitoring environmental quality and will aid in identifying impacts if and when they occur.

Collections of age II+ and III+ and older kokanee were made during the months of July through early October (Appendix Table 23). This corresponded roughly to the duration of the summer sport trolling fishery for kokanee in the lake. The midwater trawl and a variety of gill nets were ineffective in capturing age II+ and older kokanee. Therefore, we employed creel census as a method of obtaining stomachs from these fish. Stomachs collected via creel census usually contained large amounts of food and were in good condition.

The midwater trawl was effective in capturing young-of-the-year (age 0+) kokanee, particularly in Area 1. Consequently, a sample of age 0+ fish was obtained most months in Area 1 from July through December (Appendix Table 23).

Daphnia thorata was the dominant food item in the diet of 0+ kokanee and comprised 71 to 97 percent of the ingested organisms during the period 2 July through 3 December (Figure 15; Appendix Table 24). Electivity values were always positive for *Daphnia thorata* and ranged between +.60 and +.91 (Appendix Table 24). This species remained the principal item in the 0+ kokanee diet even in early December when *Daphnia thorata* densities in lake plankton were exceedingly low and averaged only $0.07/\ell$ in surface tows. Maximum utilization of *Daphnia thorata* by 0+ kokanee corresponded to maximum representation of this organism in the plankton community (Figure 15).

Epischura never comprised more than 0.1 percent of the zooplankton population. However, this species comprised 2.6 to 29 percent of the food items in 0+ kokanee stomachs collected in Area 1 (Figure 15; Appendix Table 24).

Daphnia longiremis was a significant component of the plankton community during July and August. However, this species was seldom utilized by 0+ kokanee (Figure 15; Appendix Table 24). This is probably due to a combination of factors. *Daphnia longiremis* is the smaller of the two common *Daphnia* species (Table 4), and also tends to occupy deeper strata than does *Daphnia thorata* (Figure 9; also Potter 1978).

The copepods *Diaptomus* and *Cyclops* were seldom an important part of the 0+ kokanee diet. The same was true for the large cladoceran *Leptodora* although electivity values for this organism were occasionally positive

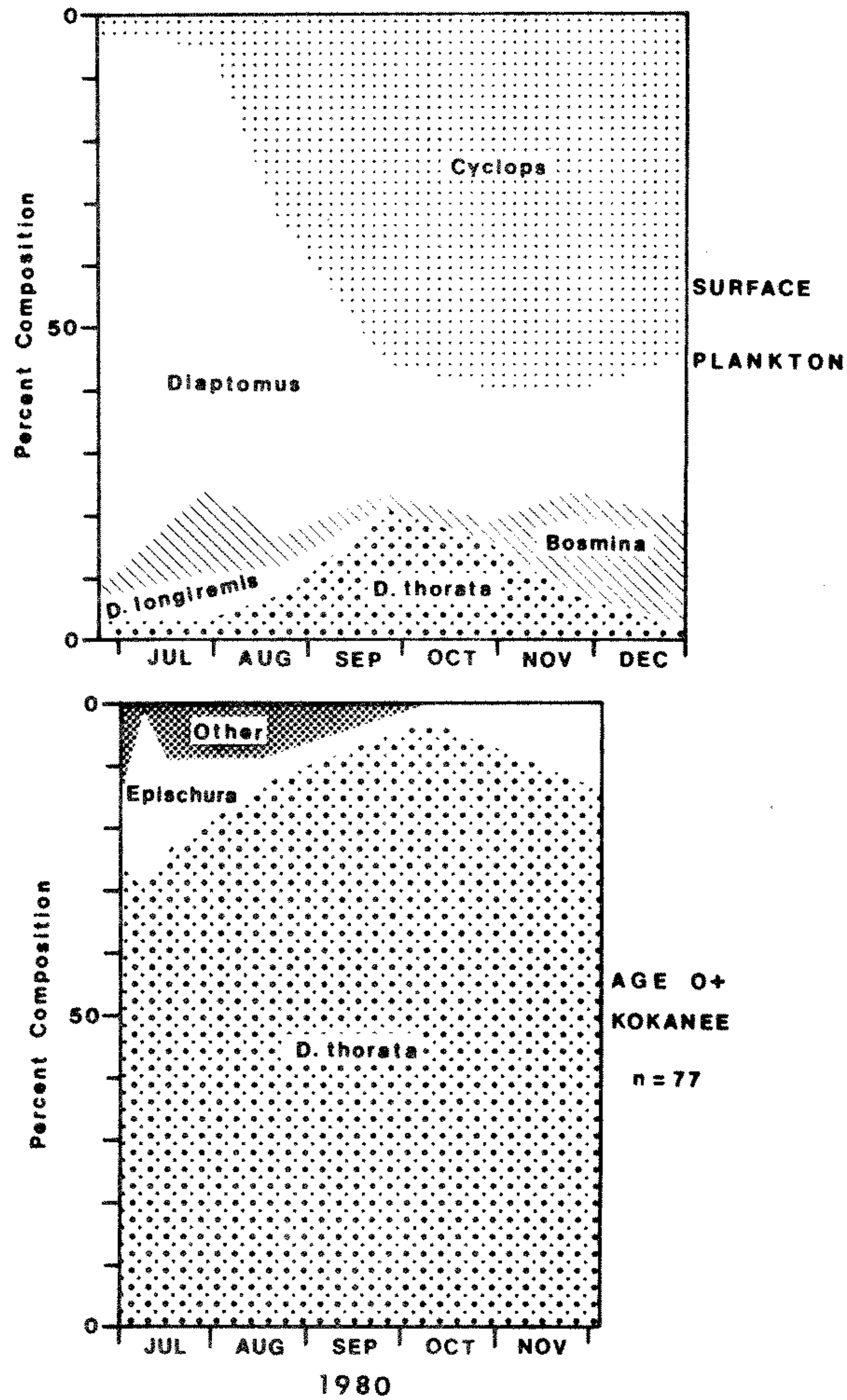


Figure 15. Percent composition (by number) of organisms in the surface plankton (0-30 m; upper figure) and in the stomachs of age 0+ kokanee (lower figure) in Area 1 of Flathead Lake during 1980.

(Appendix Table 24). Insect remains were found in only three stomachs and consisted of a few chironomid (Diptera) pupae and adults.

Daphnia thorata was the dominant item in the diet of age II+ and age III+ and older kokanee as it was in age 0+ fish (Figures 15 and 16). *Epischura* comprised a smaller percentage of the diet in larger kokanee than in 0+ kokanee although occasional exceptions were noted (Appendix Tables 24 through 27). *Leptodora* comprised a larger portion of the diet in age III+ and older kokanee than in smaller fish (Figures 16 and 15). The maximum representation of *Leptodora* in the diet of large fish (10.% on 15 August) corresponded with peak population density observed in the lake plankton at Station 2:4 (Figure 11). Because of its large size (Table 4) the contribution of *Leptodora* to the kokanee diet would be significantly greater if these results were expressed in terms of biomass.

Items other than zooplankton rarely occurred in the stomachs of age II+ and III+ and older kokanee. A few winged adult insects of the orders Hymenoptera, Homoptera, and Diptera were found in the stomachs of three kokanee (total lengths 136-179 mm) collected in Area 3 on 20 August.

Direct comparisons of the food habits of various age classes of kokanee collected in Area 1 could be made on two dates (Table 5). *Epischura* appeared more commonly in the stomachs of small fish, particularly during July. *Leptodora* was more commonly ingested by large salmon ($\geq$ III+) on both dates.

Feeding habits of age III+ and older kokanee in early July were alike in most lake areas (Table 6). Similar findings were obtained by Northcote and Lorz (1966). An exception to this was noted on 3 July in Area 5 (Table 6). On this date groups of fish were collected from sites less than 2 km apart but their utilization of *Epischura* was noticeably different even though there were no noticeable differences in *Epischura* or *Daphnia* densities in either area. It is interesting to note that the fish which fed more heavily on *Epischura* were collected from a shoal area (between Cromwell and Wild Horse Islands) whereas the other group were taken in a more typical deep water area (the vicinity of Cedar Island). Our zooplankton depth distribution data and that of Potter (1978) have shown *Epischura* to be most numerous in the surface waters (to 15 m).

Size selection of *Daphnia thorata* by various age classes of kokanee in Area 1 are presented in Figure 17. In early July, all kokanee positively selected *Daphnia* larger than 1.2 mm long. Only the largest kokanee (age III+ and older) positively selected for *Daphnia* larger than 1.6 mm. As kokanee size decreased, the degree of selection for large *Daphnia* (> 1.6 mm) became progressively more negative, i.e. small fish selected smaller sized *Daphnia* (Figure 17). This trend was not noted in October when all age groups selected for the largest *Daphnia* available. Goodlad et al. (1974) also noted that sockeye salmon fry in lakes of the Fraser River system selected medium sized zooplankton during the spring and selected the largest planktonic organisms available by early summer.

Differences in prey species selectivity between size groups of kokanee and juvenile sockeye salmon have been noted in several lakes. Juvenile

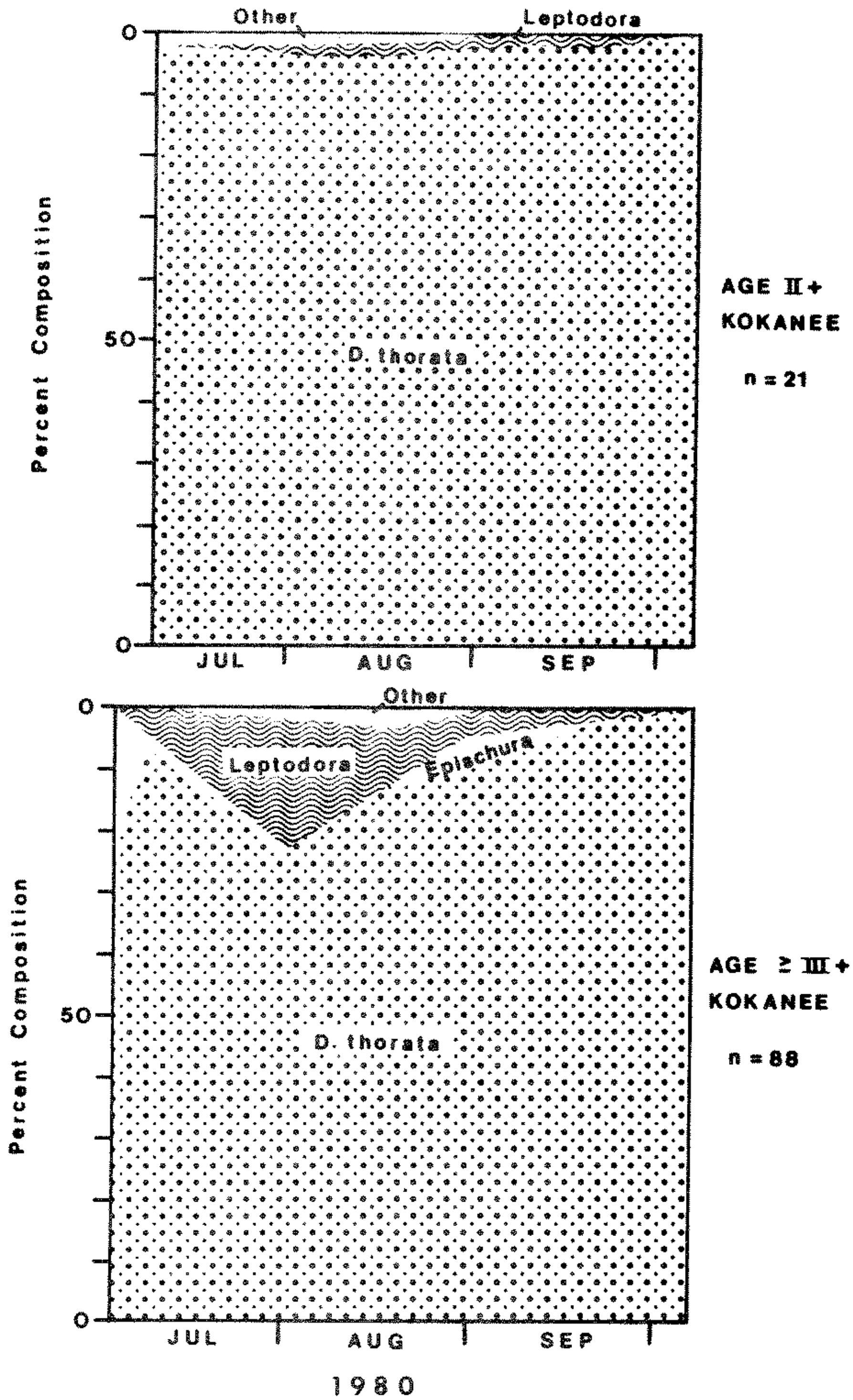


Figure 16. Percent composition (by number) of organisms in the stomachs of age II+ (upper figure) and age III+ and older (lower figure) kokanee in Flathead Lake during 1980.

Table 5. Age-specific feeding habits of kokanee salmon in Area 1 of Flathead Lake during 1980.

Date	Age class	n	Percent of total organisms						
			Daphnia thorata	*Daphnia longiremis*	*Bosmina*	*Diaptomus*	*Cyclops*	*Epischura*	*Leptodora*
Jul 7-9	0+	17	70.9	0	0	0	0	29.1	0
	I+	29	85.5	0	0.6	0.6	0	12.1	1.2
	II+	2	95.4	0	1.5	0	3.1	0	0
	≥III+	10	95.3	1.0	0	0	0	0.7	3.0
Oct 6	0+	12	97.4	0	0	0	0	2.6	0
	II+	2	100.0	0	0	0	0	0	0
	≥III+	4	99.3	0	0	0	0	0	0.7

Table 6. Comparative feeding habits of age III+ and older kokanee collected from several different locations on Flathead Lake during early July, 1980.

			Percent of total organisms						
Area	Date	n	*Daphnia thorata*	*Daphnia longiremis*	*Bosmina*	*Diaptomus*	*Cyclops*	*Epischura*	*Leptodora*
1	7 Jul	5	98.5	1.5	0	0	0	0	0
1	9 Jul	5	89.7	0	0	0	0	2.1	8.2
2	8 Jul	23	93.7	0	0	0	0	1.1	5.3
5	3 Jul	5	99.1	0	0	0	0	0.9	0
5	3 Jul	12	69.4	0	0	0	0	29.8	0.8

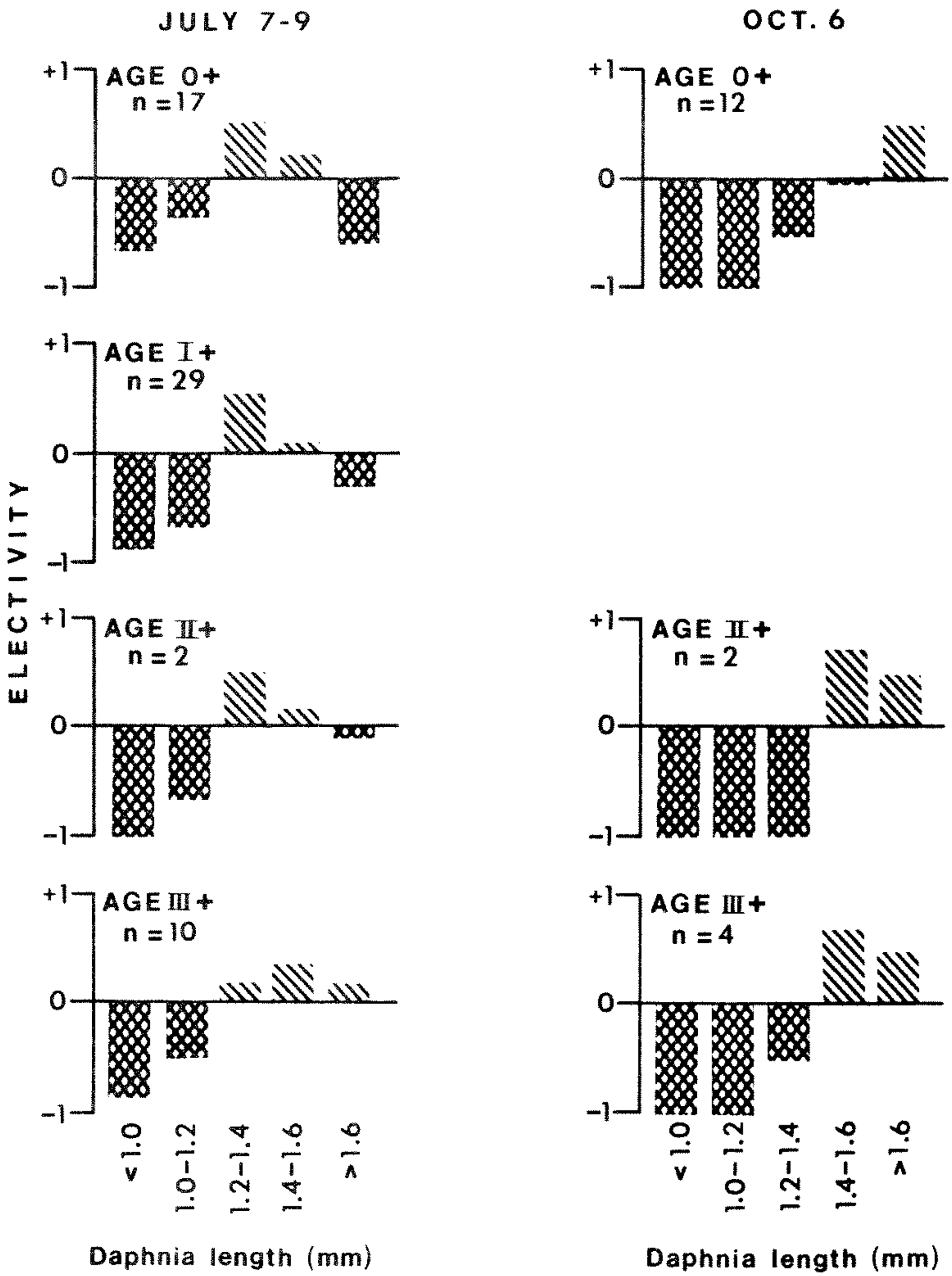


Figure 17. Size selection of *Daphnia thorata* by various age groups of kokanee salmon in Area 1 of Flathead Lake on 7-9 July and 6 October 1980.

sockeye in Lake Washington did not feed as heavily on *Diaphanasoma* (a large motile cladoceran) as did larger fish (Doble and Eggers 1978). Young-of-the-year kokanee did not use *Diaphanasoma* extensively in Coeur d'Alene Lake until late September whereas other age classes fed on this species almost exclusively during August and September (Rieman 1980b). Our data for Flathead Lake indicate that only large kokanee (II+ and III+ and older) fed to any signficant degree on *Leptodora*, which is also a large motile cladoceran. The same appears to hold true for Coeur d'Alene kokanee, although the incidence of *Leptodora* in fish stomachs was low (Table 3 in Rieman 1980b). This implies that small kokanee are ineffective at capturing and/or utilizing *Leptodora*.

Epischura is a large copepod that is a common prey species for kokanee and juvenile sockeye in many lakes (Doble and Eggers 1978, Goodlad et al. 1974, Northcote and Lorz 1966, Rieman and Bowler 1980). Young-of-the-year kokanee in Flathead Lake fed more selectively on *Epischura* than did larger fish. Similar findings were noted by Rieman (1978) for Lake Pend Oreille kokanee; however, it was later concluded that overall feeding habits were similar among age classes (Rieman and Bowler 1980). The observed affinity of 0+ kokanee in Flathead Lake for *Epischura* is perplexing in light of the fact that this species is highly mobile. In a laboratory experiment conducted at the Yellow Bay Biological Station on Flathead Lake, 30 mm long kokanee reared in a hatchery with four days experience as planktivores captured *Daphnia* with 100 percent success but were only 40 percent successful at capturing diaptomid copepods (Vinyard et al. unpub.).

Daphnia is the preferred prey of kokanee and juvenile sockeye in many lakes, including Flathead. Kokanee feed heavily on this organism when it is available, and frequently feed on less desirable species such as *Bosmina, Cyclops* and *Diaptomus* during early life and during periods of low *Daphnia* abundance (Goldman et al. 1979, Rieman 1977; 1980b). The dependence of kokanee on cladoceran populations is best exemplified by observed declines and even virtual extinction of kokanee populations in Lake Tahoe, Lake Pend Oreille, and Priest Lake (Goldman et al. 1974, Rieman and Bowler 1980, Rieman 1979). These changes have been attributed to declines or temporal shifts in cladoceran populations induced by competitive and/or predatory interaction with introduced *Mysis* shrimp. Montana Department of Fish, Wildlife and Parks biologists suspect that a similar set of circumstances is responsible for the disappearance of kokanee from Whitefish Lake in the Flathead drainage.

Numerous researchers have documented shifts in kokanee feeding habits towards *Bosmina* (a small cladoceran) and the copepods *Cyclops* and *Diaptomus* during periods when large cladocerans such as *Daphnia* or *Diaphanasoma* are unavailable (Doble and Eggers 1978, Northcote and Lorz 1966, Rieman and Bowler 1980). This frequently occurs in the winter and spring months since *Diaphanasoma* and some *Daphnia* species overwinter as ephippial (resting) eggs produced during late fall. In Flathead Lake, the first male *Daphnia thorata* appeared at Station 2:4 on 17 September and females bearing ephippial appeared in the 2 October sample. By early December in Area 1, 28 percent of the population was comprised of ephippium-bearing females and 36 percent were males. No females carrying normal parthenogenetic eggs were noted on this date. Potter (1978) reported that the *Daphnia thorata* population dwindled during November and December and then reappeared in early May due to the hatching of ephippial eggs as spring water temperature warmed to 8° C.

Preliminary analysis of kokanee stomachs collected from fishermen on Flathead Lake during January indicate that the shift towards copepods in response to reduced *Daphnia* numbers did occur. The most numerous organism in these stomachs was adult female *Diaptomus*, many of which were carrying egg sacs.

Attempts will be made this spring to document kokanee feeding habits prior to the establishment of *Daphnia thorata* in the lake plankton community. Effort will also be directed towards documenting the feeding habits of newly emergent kokanee fry since fry growth and survival is considered to be a critical factor affecting year class strength (Rieman 1980b).

TROUT FOOD HABITS

An understanding of the seasonal food habits of westslope cutthroat trout and bull trout in Flathead Lake will help in predicting impacts on these species which could result from influences on the food chain induced by resource development in the upper Flathead Basin. This will also establish sound baseline information which is essential to the process of monitoring environmental quality and identifying impacts on lake biota.

Westslope Cutthroat Trout

Food habits analysis has been completed for westslope cutthroat trout stomachs collected in the summer and fall of 1980. The percentage of empty stomachs was similar in both seasons and averaged approximately 11 percent (Table 7). The stomachs collected during the summer contained an average of 3.93 g of food compared to an average of 0.78 g in the fall even though the fall fish were larger (302 mm) than those collected during the summer (281 mm; Table 7). Preliminary results indicate that stomachs collected during January contained even smaller amounts of food than fall samples. Seventy-one percent of the 55 winter stomachs collected via gill nets and creel census were empty.

Westslope cutthroat trout collected from Flathead Lake during the summer and fall fed almost exclusively on winged insects and non-winged terrestrial insects that were presumably blown onto the surface of the lake (Appendix Tables 28 and 29). Flying ants (Hymenoptera) and grasshoppers (Orthoptera) displayed the highest IRI values and accounted for nearly 81 percent of the food biomass in stomachs collected during the summer (Appendix Table 28). Aquatic forms appearing in summer cutthroat stomachs were limited to several chironomid (Diptera) larvae and pupae, and also a single copepod.

Adult flies (Diptera), terrestrial beetles (Coleoptera), spiders (Arachnida), and flying ants displayed the highest IRI values and comprised

Table 7. Summary data for cutthroat trout stomachs collected from Flathead Lake during 1980.

Season	No. stomachs collected	Percent empty	Mean fish length(mm)	Range(mm)
Summer	10	10.0	281	221 - 418
Fall	17	11.7	302	188 - 380

79 percent of the biomass of items in westslope cutthroat trout stomachs collected during the fall (Appendix Table 29). Aquatic items consisted of a few larval dipterans, a single leech (Hirudinea), and a single amphipod.

Seasonal variation in the food habits of westslope cutthroat trout in Flathead Lake is suggested by the findings of other researchers. *Leptodora* and *Daphnia* were common items in the stomachs of 28 cutthroat collected near Yellow Bay on Flathead Lake on December 9, 1951 (Brunson et al. 1952). These organisms have not been found in the stomachs collected during 1980 but those collected in January 1981 have not yet been analyzed. Hanzel (1972) reported cutthroat feeding on fish eggs in shoreline kokanee and whitefish spawning areas during the winter in Flathead Lake. This is a seasonal occurrence which has not been observed in the present study to date.

The food habits of cutthroat trout in lakes are variable, and are likely related to the types of food available and the subspecies of cutthroat under consideration. This variability is evident in several northwestern Montana lakes. Yellow perch fry were found in 40 percent of the cutthroat stomachs collected from the Thompson Lakes (Echo 1955), but Department personnel suspect that these lakes were inhabited by Yellowstone cutthroat trout (*Salmo clarki bouvieri*). Cutthroat trout in the Thompson Lakes also fed on dipterans, damselflies, mayflies, amphipods, zooplankton, and adult insects. *Daphnia* was the most important year around food source for westslope cutthroat in Lake Koocanusa, although terrestrial insects were generally the preferred food during the summer months (McMullin 1979). Redside shiners were rarely utilized by large cutthroat (>330 mm) in Lake Koocanusa and pupae of aquatic Diptera were seasonally important. *Daphnia* densities exceeded 12.0/ℓ in Lake Koocanusa (McMullin 1979), whereas peak densities in Flathead Lake seldom exceeded 4.0/ℓ (This study; Potter 1978). Westslope cutthroat trout in Hungry Horse Reservoir ingested more terrestrial insects and less *Daphnia* than did Lake Koocanusa cutthroat during the same period (McMullin 1979).

Westslope cutthroat trout fed almost entirely on terrestrial insects in several northern Idaho lakes (Bjornn 1957, Jeppson and Platts 1953). Yellowstone cutthroat from Yellowstone Lake fed principally on *Daphnia*, *Gammarus*, and chironomid pupae and adults (Benson 1961). The importance of *Daphnia* in the diet of Yellowstone Lake cutthroat may be related to the observation that *Daphnia schoedleri* frequently "swarmed" and attained densities up to 500/ℓ in inshore areas (Benson 1961). The diversity of cutthroat trout food habits in lakes is further illustrated in the summary presented in Carlander (1969).

Bull trout

Analysis has been completed on the stomachs from 87 bull trout collected from Flathead Lake during 1979 and 1980. Eleven stomachs were collected by Department personnel during kokanee salmon netting operations in November and December 1979. The remaining stomachs were collected in the seasonal gill netting described in this report with the exception of three collected by creel census.

The percentage of empty stomachs ranged between 30 and 50 percent (Table 8) which was similar to that observed by Bjornn (1957) in Priest Lakes, Idaho. Fish remains were found in 90 percent or more of the stomachs in each seasonal sample, but only 50 to 80 percent of those stomachs contained fish that were identifiable to species.

Fish dominated the diet of all size groups of bull trout. There was no tendency for small bull trout to feed on items other than fish. Fish remains have been found in eight of the nine stomachs of bull trout shorter than 300 mm analyzed thus far. Food items other than fish were found in only one of the above stomachs and comprised two tenths of one percent of the total biomass ingested by this group. Food items other than fish comprised only one tenth of one percent of the total food biomass of the entire 87 fish sample.

Bull trout ingested at least nine species of forage fishes during the summer of 1980 (Table 9; Appendix Table 30). The highest IRI was noted for total whitefish species combined (40.7) with unidentified fish, nongame fish, and trout and salmon following in order of decreasing importance (Figure 18). The individual IRI's for the three species of whitefish were higher than those calculated for other individual species during the summer (Table 9). The large number of pygmy whitefish identified in the summer sample was primarily due to the fact that 11 of these were found in the stomach of a 561 mm bull trout. The data indicate that bull trout fed on a wide range of forage species during the summer and were not particularly selective for an individual species although they apparently preferred whitefish. Lake whitefish were the dominant species in the summer sinking gill net catch (Figure 24).

Bull trout ingested at least seven species of forage fish during the fall of 1980 (Table 9; Appendix Table 31). Whitefish were again the most important group and displayed an IRI of 43.2 (Figure 18). The next important items were unidentified fish, trout and salmon, and nongame species, respectively. The highest specific IRI was noted for lake whitefish (eight fish in six stomachs, IRI = 23.4). Mountain whitefish and kokanee salmon were the second and third most important species, respectively. Peamouth and squawfish were not found in bull trout stomachs during the fall, but these species comprised over 50 percent of the fall sinking gill net catch (Figure 24).

An instance of cannibalism was noted during the fall when a small bull trout (approximately 150 mm) was found in the stomach of a 542 mm fish. Sculpins appeared in small numbers in the fall stomach collection as was the case for all seasons (Table 9) and a few yellow perch were also identified.

Results from the small early winter 1979 sample of 11 bull trout stomachs differed markedly from the summer and fall collections (Table 9; Appendix Table 32). A total of 22 yellow perch was found in seven bull trout stomachs, accounting for an IRI of 62.3. The only other species detected in these stomachs were redside shiners, pygmy whitefish, and sculpins in order of importance. The high incidence of perch in these stomachs is surprising

Table 8. Information pertaining to bull trout food habits analysis for Flathead Lake, 1979-1980.

Season	Dates	Mean DV length (mm)	DV (Range) (mm)	No. stomachs collected	No. empty	% empty	Mean weight stomach contents (wet wt. g)	% of non-empty stomachs containing fish remains	% of non-empty stomachs containing fish remains identifiable to species	No. of food fish ident. to species
Summer 1980	8 Jul-14 Aug.	395	(214-623)	46	14	(30.4)	23.4	90.6	53.1	34
Fall 1980	6 Oct-20 Oct.	460	(212-658)	87	43	(49.4)	35.1	93.0	51.1	26
Early Winter 1979	27 Nov, 12 Dec	349	(256-514)	11	?	?	7.2	100.0	81.8	27

Table 9. Seasonal Index of Relative Importance (IRI) values for the major food items in bull trout stomachs from Flathead Lake, 1979-1980.

Season	No stomachs	PWF	LWF	MWF	Unid. WF	Total WF	KOK	DV	Unid. trout/ salmon	Total trout/ salmon	SCUL	Reds. shin.	PM	SQ	YP	SU	Total non-game	Unid. fish
Summer 1980	32	12.6	12.5	10.3	7.4	40.7	5.1	—	1.9	7.1	3.2	4.8	7.2	8.6	—	1.8	24.6	35.0
Fall 1980	44	4.5	23.4	12.5	3.7	43.2	12.4	1.6	2.8	16.9	2.8	—	—	—	4.0	—	6.8	35.4
Early Winter 1979	11	7.0	—	—	—	7.0	—	—	—	—	6.7	12.3	—	—	62.3	—	78.2	14.8

PWF = pygmy whitefish
LWF = lake whitefish
MWF = mountain whitefish
WF = whitefish
KOK = kokanee
DV = bull trout

SCUL = sculpins
Reds. shin = redside shiner
PM = peamouth
SQ = squawfish
YP = yellow perch
SU = suckers

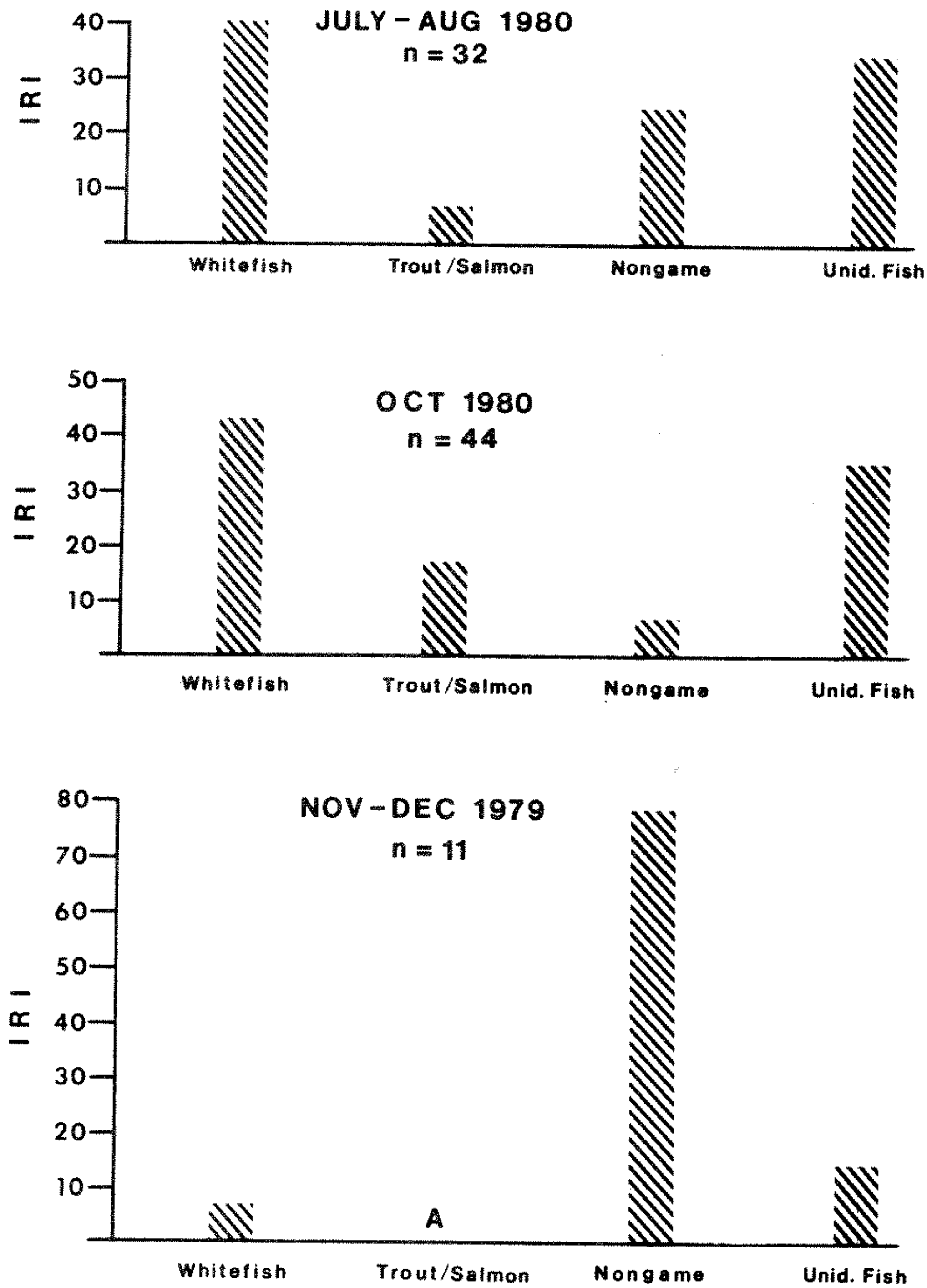


Figure 18. Seasonal Index of Relative Importance (IRI) values for major groups of forage fish consumed by bull trout in Flathead Lake, 1979-1980.

in light of the fact that only four perch have been collected to date in our gill netting (Table 20).

Perch distribution in the lake is patchy. Throughout much of the year this species is confined to shallow weedy bays that are scattered along the edges of the lake (Hanzel, Montana Department Fish, Wildlife, & Parks, Kalispell; personal communication). Eight of the early winter bull trout stomachs summarized in Appendix Table 32 were collected in such a location (Area 4; Woods Bay) on 28 November and contained a total of 18 perch. The size range of perch in these stomachs was small (40-60 mm) relative to the size of the seven perch captured in the gill nets (222-295 mm) on that date. The bull trout ranged between 304 mm and 370 mm in length.

Miscellaneous items that appeared in bull trout stomachs are summarized by season in Table 10. Complete or partial sets of kokanee salmon viscera were found in the stomachs of two bull trout collected in Area 2 on 11 August 1980. The viscera were in excellent condition and were easily identified to species by gill arch characteristics and reproductive condition. These bull trout were apparently scavenging viscera discarded by anglers. Area 2 is heavily fished for kokanee during the summer.

Large numbers of the planktonic organism *Leptodora* were noted in four stomachs from the fall collection (Table 10). These fish were collected in Areas 2, 4, and 5 between 9 October and 20 October 1980. Results from our biweekly plankton sampling in Area 2 (Figure 11) and monthly samples from the whole lake (Figure 14) indicate that *Leptodora* had practically disappeared from the plankton during October. It is possible that these bull trout were bottom feeding on dead or senescent *Leptodora*. Brunson et al. (1952) reported large numbers of *Leptodora* in cutthroat stomachs colleted near Yellow Bay on Flathead Lake on 9 December, 1951.

Other items that were seasonally present in bull trout stomachs in small amounts include chironomid larvae and pupae, mayfly larvae, oligochaetes, amphipods, kokanee eggs, and ephippial (resting) eggs from *Daphnia*. The presence of *Daphnia* ephippia is surprising because of their very small size.

The food habits of coastal bull char (*Salvelinus malma*) have been well documented. Most research has centered on the importance of this fish as a predator on the juvenile stages of anadromous sockeye salmon (i.e. Thompson and Tufts 1967). Comparatively little is known of the feeding habits of the inland form of bull char or bull trout (*Salvelinus confluentus*). In three North Idaho lakes, Jeppson and Platts (1959) found that bull trout smaller than 305 mm (12 inches) fed entirely on insects whereas larger bull trout fed mostly on kokanee. Bjornn (1957) found that bull trout fed primarily on kokanee and whitefish in Priest Lakes, Idaho. Flathead Lake bull trout apparently differ from the Idaho studies in that small fish were decidedly more piscivorous and large fish fed much more heavily on whitefish than on kokanee.

Bull trout predation on kokanee is probably a function of size and

Table 10. Summary of miscellaneous food items found in Flathead Lake bull trout stomachs, 1979-1980.

Season	Item	No.	Total wet wt. (g)	Size range of bull trout (mm)	Frequency
Summer 1980	Discarded kokanee viscera	3	62.3	282 - 417	2
	Chironomid larvae and pupae	4	0.3	336 - 390	3
	Mayfly nymphs	5	0.2	363 - 390	2
Fall 1980	Chironomid larvae and pupae	6	0.4	375 - 443	3
	Mayfly nymphs	1	0.1	414	1
	Oligocheates	1	0.1	414	1
	Amphipods	2	0.2	384 - 528	2
	Leptodora	1774	1.6	382 - 453	4
Early Winter 1979	Kokanee eggs	1	<.1	340	1
	Daphnia ephippial eggs	100	<.1	367	1

abundance of the latter. The length of mature Flathead Lake kokanee during the fall of 1980 exceeded 360 mm whereas Priest Lake kokanee matured at approximately 304 mm (Bjornn 1957). A higher incidence of kokanee in the stomachs of Priest Lake bull trout in comparison to Upper Priest Lake bull trout was directly related to kokanee population levels in the two lakes (Bjornn 1957).

TROUT AGE AND GROWTH

Analysis of the age and growth of westslope cutthroat trout and bull trout is useful in identifying long term changes in growth patterns and population age structures, which could be influenced by resource development in the upper basin. This information will also aid in the determination of the ability of the lake to produce trout and will also help clarify the life history of these migratory species.

Westslope Cutthroat Trout

A total of 318 scale samples from westslope cutthroat trout collected from Flathead Lake were examined. These scales were collected by various Department personnel throughout the period 1962-1980 during creel census, gill netting, and purse seining operations (Table 11). Data from all collections have been pooled to represent average age and growth for Flathead Lake cutthroat.

The first annulus was found to be missing in 41.8 percent of the total sample. Fraley et al. 1981 found that 61 percent of the cutthroat collected in the North and Middle Fork Flathead River drainages were missing the first annulus. Department personnel working on the mainstem Flathead River above the lake have found a 35.6 percent incidence of missing first annuli (McMullin, Montana Department Fish, Wildlife, & Parks, Kalispell; unpub. data). Missing first annuli were rare in westslope cutthroat trout from Priest and Upper Priest Lakes (Bjornn 1957), but were observed in 35-50 percent of cutthroat from Yellowstone Lake (Laakso and Cope, 1956).

A relatively low correlation (r=.763) was obtained for the body length-scale radius relationship for cutthroat collected from Flathead Lake during 1962-80 (Figure 19; Appendix Table 33). The regression line for lake fish inadequately portrayed early growth of juvenile fish in tributary streams which could be expected since few small fish have been collected in the lake. The best correlation between body length and scale radius was obtained when data for 318 lake fish, 127 North Fork River fish, 183 Middle Fork River fish, 104 mainstem Flathead River fish, and 992 tributary fish were pooled (Figure 19; Appendix Table 33). This combined line was used to backcalculate length at annulus for the lake population because it accurately depicted juvenile growth and also closely approximated the empirical data for lake fish.

Calculated growth of westslope cutthroat trout in Flathead Lake (Table 12) was lower than that found in 14 of the 15 lake studies summarized by Carlander (1969). Growth was also slower than that reported for westslope cutthroat trout in Hungry Horse Reservoir (Huston 1972) and in Lake Koocanusa

Table 11. Yearly summary by collection method for cutthroat trout collected from Flathead Lake during the period 1962-1980.

		Collection method					
		Creel census		Gill nets		Purse seine	
Year	aged	No.	(%)	No.	(%)	No.	(%)
1962	2	2	(100)				
1963	56	56	(100)				
1964	0						
1965	0						
1966	3	3	(100)				
1967	5	5	(100)				
1968	26	14	(54)	12	(46)		
1969	27	5	(19)	22	(81)		
1970	32	20	(62)	12	(38)		
1971	21	12	(57)	9	(43)		
1972	68	65	(96)	1	(1)	2	(3)
1973	12	6	(50)			6	(50)
1974	27	17	(63)	4	(15)	6	(22)
1975	14	3	(21)	11	(79)		
1976	1	1	(100)				
1977	0						
1978	0						
1979	0						
1980	25	2	(8)	23	(92)		
Total	318	210	(66)	94	(30)	14	(4)

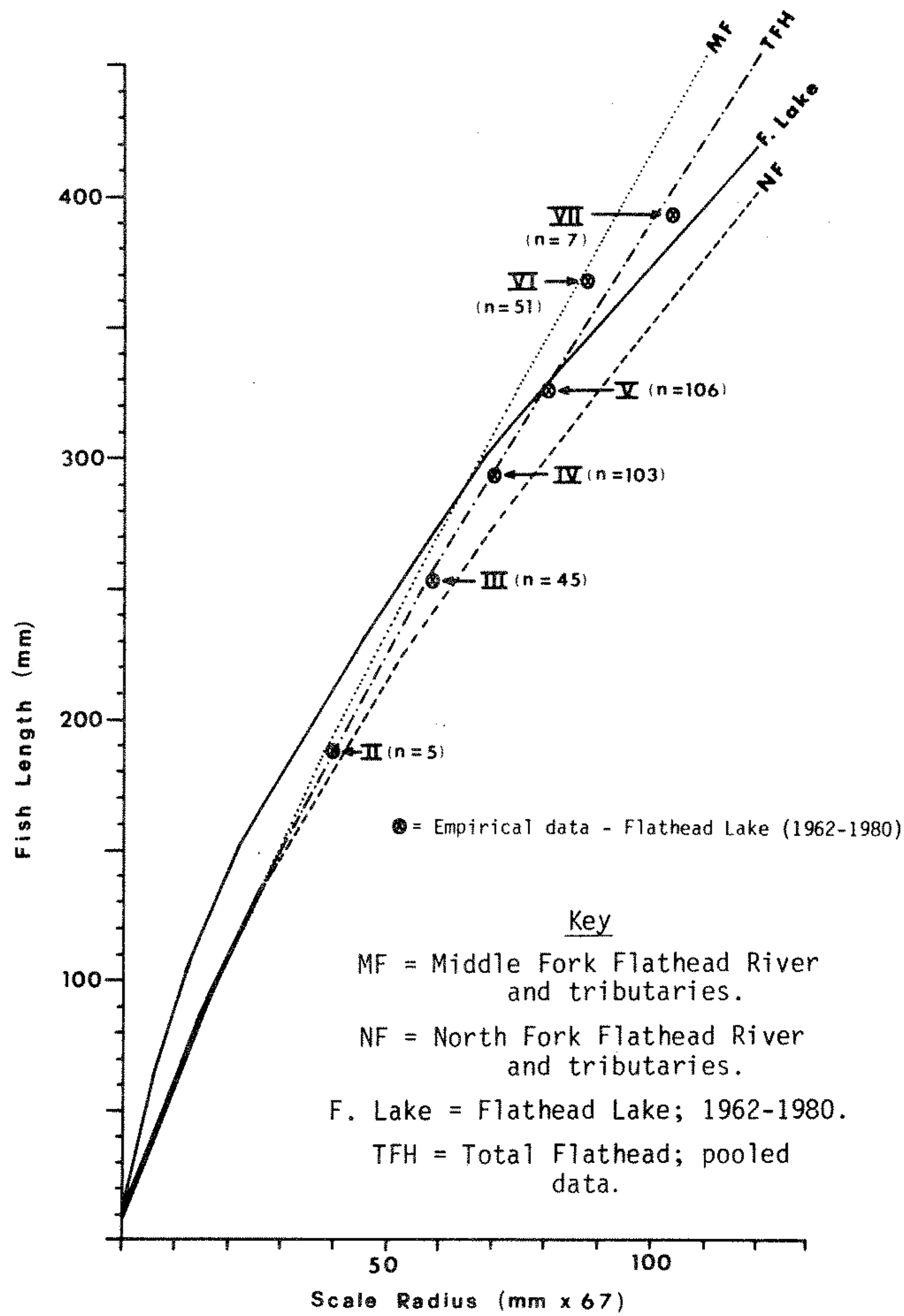


Figure 19. Body length-scale radius relationships for westslope cutthroat trout in the Flathead River drainage.

Table 12. Calculated lengths and growth increments for 318 Flathead Lake cutthroat collected during the period 1962-1980.

		Length (mm) at annulus							
Age	n	I	II	III	IV	V	VI	VII	VIII
2	5	58	109						
3	45	59	112	189					
4	103	57	109	173	252				
5	106	56	107	170	246	302			
6	51	56	108	165	240	298	338		
7	7	57	108	161	235	301	352	393	
8	1	40	94	156	198	248	307	362	413
Grand mean calculated length		57	109	173	247	300	339	389	413
(n)		(318)	(318)	(313)	(268)	(165)	(59)	(8)	(1)
Length increment		57	52	64	77	57	42	43	51

(May et al. 1979), but was comparable to growth observed in lakes and rivers in the Flathead drainage by Johnson (1963). Growth was better than that found by Fraley et al. (1981) for the rivers and tributaries of the upper Flathead River basin (Table 13). No sex-related growth differences were noted (Appendix Tables 34 and 35).

Over 98 percent of the fish in the Flathead Lake collection were three or more years of age with nearly two-thirds of the fish being four or five years old (Table 12). This was typical of adfluvial cutthroat populations and was similar to the situation observed in Priest and Upper Priest Lakes (Bjornn 1961).

Many researchers have observed marked increases in the growth of adfluvial juvenile westslope cutthroat when these fish leave their natal streams and move into large rivers or lakes where the growth environment is more favorable (Bjornn 1961, Johnson 1963, Huston 1972, May et al. 1979). This change in growth was frequently reflected by wider spacing of circuli on the scales, hence age at outmigration from tributaries could be identified by scale characteristics.

Migration class was easily recognized using scale characteristics on 192 (60%) of the 318 fish examined. Of the Flathead Lake fish for which migration class was identified, 39 percent spent two years (X_2), 57 percent spent three years (X_3), and 4 percent spent four years (X_4) in tributary streams. These figures were similar to those reported by Bjornn (1961) for two Idaho lakes (Table 14). All studies presented in Table 14 have shown fluvial and adfluvial westslope cutthroat populations in rivers and lakes to be comprised chiefly of X_2 and X_3 migrants. Fish trapping results from tributaries to the North Fork Flathead River have shown that the majority ofemigrating cutthroat were two and three years old (Graham et al. 1980).

Calculated lengths at annuli for adfluvial cutthroat trout in Flathead Lake are presented for each migration class in Table 15 and also in Appendix Tables 36 through 39. Fish that spent two years in tributaries were 50-60 mm longer at the third annulus than fish that spent three or more years in tributaries. Two and three year old migrants reached approximately the same length (350 mm) by age six. The mean length increments for the first year of lake residence were 90, 95, and 77 mm for X_2, X_3, and X_4 migrants, respectively (Table 16). These values were low in comparison to other studies. Priest and Upper Priest Lake migrants typically increased 105-127 mm in length during their first year of lake residence (Bjornn 1957; 1961). Similar growth was exhibited by Hungry Horse Reservoir cutthroat (Huston 1972) and first year lake growth was greater than 190 mm for Lake Koocanusa X_2 migrants (May et al. 1979). McMullin (Montana Department Fish, Wildlife & Parks, Kalispell; unpub. data) found the first year increment to range between 105 mm and 118 mm in lower Flathead River cutthroat.

Calculated lengths of cutthroat trout whose migration class could not be determined (Table 15) were similar to those of X_2 and X_3 fish through annulus V. The same was true for length increments (Table 16) which suggests that the undesignated group was comprised mostly of X_2 and X_3 fish.

Table 13. Calculated mean length at annuli for cutthroat trout in Flathead Lake compared to growth in upper Flathead rivers and tributaries.

Area	(n)	Length (mm) at annulus							
		I	II	III	VI	V	VI	VII	VIII
Flathead Lake (1962-1980)	(318)	57	109	173	247	300	339	389	413
North Fork River*	(127)	64	108	150	180	213			
Middle Fork River*	(184)	50	99	156	217	269			
North Fork tributaries*	(730)	54	96	135	166	202			
Middle Fork tributaries*	(377)	51	95	139	193	251			

* From Fraley et al. (1981)

Table 14. Percent composition of migration classes in fluvial and adfluvial westslope cutthroat trout populations in various lakes and rivers in Montana and Idaho.

Migration class	Flathead Lake	Priest Lake1/	Upper Priest Lake1/	Lower Flathead River2/	Middle Fork River3/	North Fork River3/	Hungry Horse Reservoir4/
X_1	---	---	6%	2%	22%	21%	6%
X_2	39%	38%	35%	60%	33%	33%	74%
X_3	57%	57%	58%	33%	42%	39%	19%
X_4	4%	5%	---	6%	3%	6%	1%

1/ Bjornn (1961)

2/ McMullin (Mont. Dept. Fish, Wildlife & Parks, Kalispell; unpub. data)

3/ Fraley et. al. (1981)

4/ Huston (1972)

Table 15. Mean calculated total length of cutthroat trout that entered Flathead Lake after spending 2-4 (or undetermined) years in tributary streams. Fish collected 1962-1980.

Migration class	(n)	Length (mm) at annulus I	II	III	IV	V	VI	VII	VIII
X_2	(73)	60	115	205	271	316	353	---	---
X_3	(104)	55	102	151	246	305	348	431	---
X_4	(8)	53	99	140	180	257	311	---	---
Undetermined	(126)	57	112	175	239	295	330	364	413

Table 16. Mean calculated total length increments for cutthroat trout that entered Flathead Lake after spending 2-4 (or undetermined) years in tributary streams. Fish collected 1962-1980.

Migration class	(n)	Length increments (mm) between annuli I	II	III	IV	V	VI	VII	VIII
X_2	(73)	60	55	90	66	48	33		
X_3	(104)	55	47	49	95	60	43	46	
X_4	(8)	53	46	41	40	77	53		
Undetermined	(126)	57	55	63	66	57	43	40	

The equation describing the length-weight relationship for Flathead Lake cutthroat (Figure 20) was similar to that reported by Fraley et al. (1981) for cutthroat in the upper Flathead drainage. The slope for this relationship was approximately 3.0 which indicates that these fish grew isometrically. The mean condition factor for Flathead Lake cutthroat was 0.94. Condition factor did not increase with increasing body length as was found for bull trout in Flathead Lake.

Bull Trout

Age and growth analysis was conducted on scales taken from 155, 232, and 146 bull trout collected during 1963, 1968, and 1980, respectively. Analysis was also conducted on the combined sample of 533 fish.

Otoliths were also collected from 127 of the bull trout during 1980 to compare aging techniques. Agreement between the two methods was 52 percent with neither method consistently over or underestimating the number of annuli. The maximum difference observed between the number of annuli using both methods was two and occurred in eight cases (6.3%) of the sample. Fraley et al. (1981) reported nearly 100 percent agreement between scale and otolith estimates of fish age for juvenile bull trout (one to three years of age) from tributaries to the North and Middle Forks of the Flathead River. All of the bull trout in the lake sample were from three to seven years of age.

The percentage of bull trout having a missing first annulus was 7.7, 6.6, and 11.0 percent in 1963, 1968, and 1980, respectively. Approximately 10 percent of the juvenile bull trout collected from tributaries to the upper Middle Fork of the Flathead River were found to be missing the first annulus (Fraley et al. 1981). Annulus formation was estimated to occur in early April and be complete by 1 May in Flathead Lake samples. Block (1955) estimated annulus formation in Flathead Lake bull trout to occur in late winter.

Body length-scale radius relationships for juvenile bull trout in Middle and North Fork tributaries (Fraley et al. 1981) differed substantially from the relationship observed for lake fish (Figure 21; Appendix Table 40). The line generated from a pooled sample of juvenile and adult fish (N=840; r=.973) closely approximated the mean empirical data for Flathead Lake bull trout. Consequently, the equation for this line was used to backcalculate length at previous annuli for Flathead Lake fish.

Lengths at annuli of bull trout collected during 1968 and 1980 were similar; however, fish collected during 1963 were longer (Table 17; Appendix Tables 41 through 43). Differences between years were most pronounced at annuli V through VII. Seven-year-old fish in 1963 were 8 mm and 55 mm longer than the same aged fish in 1968 and 1980, respectively (Table 17). Growth differences between years may be related to collection method since the 1963 sample was obtained entirely through creel census whereas the 1968 and 1980 fish were captured in gill nets. Creel census collections are biased towards larger fish because of the minimum legal size limit of 457 mm for angler caught fish.

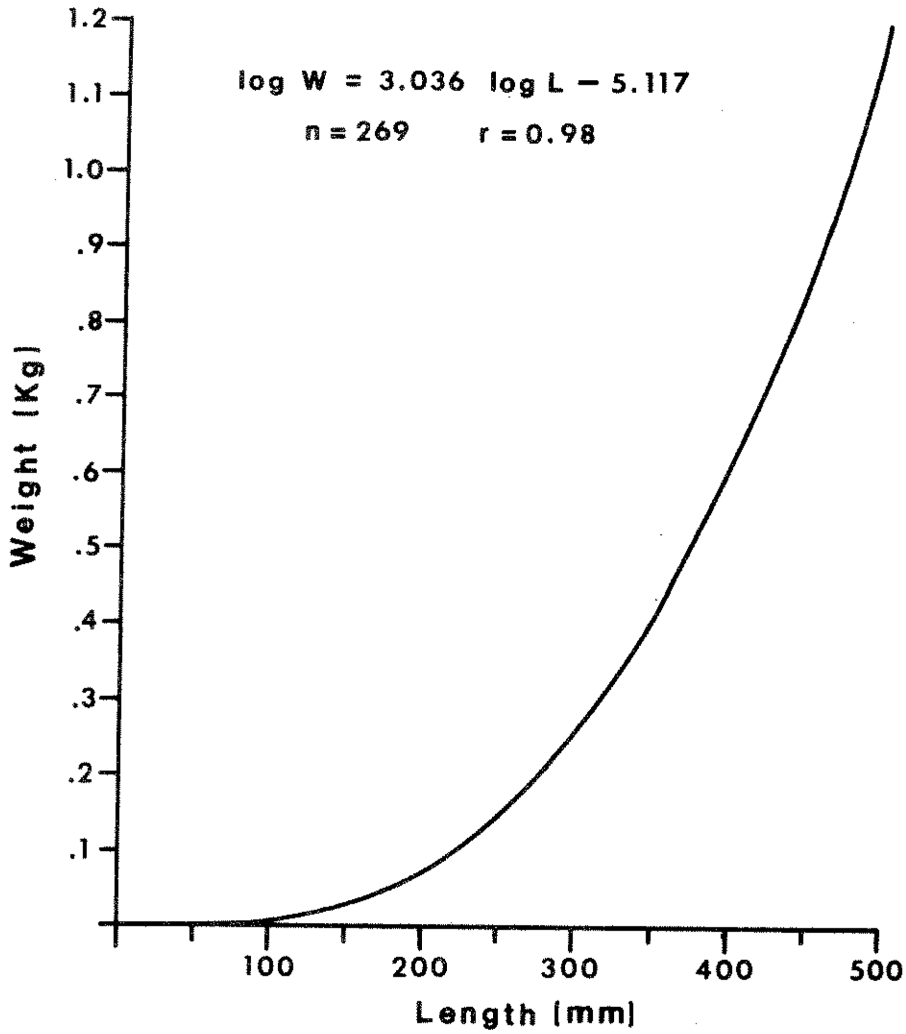


Figure 20. Length-weight relationship for cutthroat trout in Flathead Lake, 1962-1980.

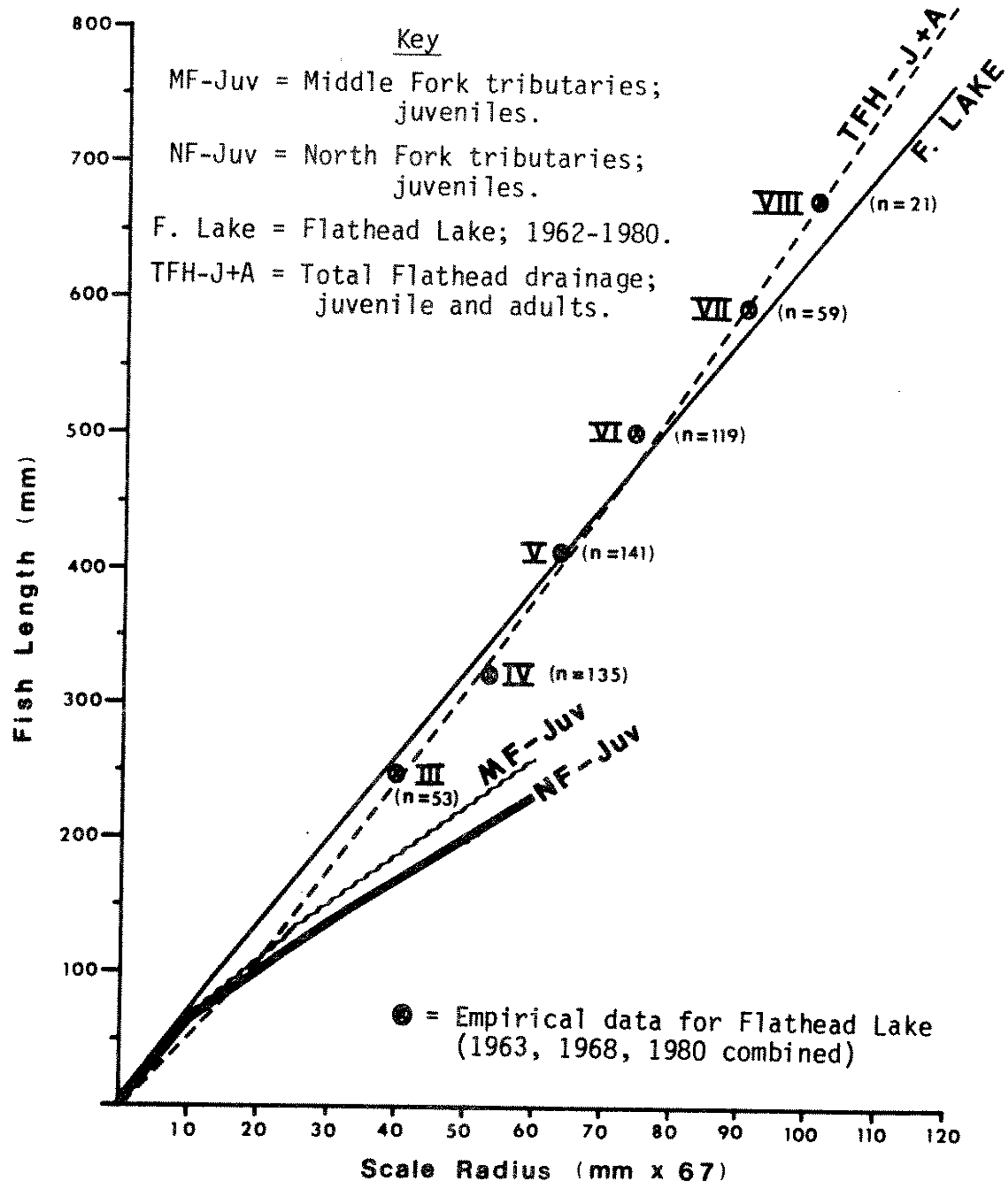


Figure 21. Body length-scale radius relationships for bull trout in the Flathead River basin.

Table 17. Summary of grand mean calculated length and increments of growth for Flathead Lake bull trout collected during 1963, 1968, and 1980.

Sample		Length (mm) at annulus								
		I	II	III	IV	V	VI	VII	VIII	IX
1963	Length	52	106	174	257	350	446	559	653	863
	Increment	*52*	*54*	*68*	*83*	*94*	*99*	*99*	*98*	*137*
	(n)	(155)	(155)	(155)	(155)	(147)	(118)	(58)	(22)	(2)
1968	Length	57	112	179	255	340	433	551	677	760
	Increment	*57*	*55*	*67*	*76*	*85*	*88*	*113*	*81*	*83*
	(n)	(232)	(232)	(232)	(190)	(101)	(46)	(11)	(1)	(1)
1980	Length	49	105	173	251	332	419	504	685	859
	Increment	*49*	*56*	*68*	*80*	*85*	*95*	*107*	*133*	*99*
	(n)	(146)	(146)	(146)	(135)	(97)	(40)	(15)	(2)	(1)

Table 18. Calculated length and growth increments for Flathead Lake bull trout collected during 1963, 1968, and 1980.

Age	n	Length (mm) at annulus								
		I	II	III	IV	V	VI	VII	VIII	IX
1	0									
2	0									
3	53	59	115	183						
4	135	55	111	182	258					
5	141	54	109	178	257	342				
6	120	51	104	167	248	339	432			
7	59	53	107	172	255	349	446	545		
8	21	49	103	166	244	342	442	547	645	
9	4	44	92	176	263	349	472	607	722	836
Grand mean calculated length		54	108	176	254	342	438	548	657	836
(n)		(533)	(533)	(533)	(480)	(345)	(204)	(84)	(25)	(4)
Length increment		54	54	68	79	89	95	102	101	114

Comparison of the growth of 62 male and 63 female bull trout gill netted during 1980 revealed slight sex-related growth differences (Appendix Tables 44 and 45). Length at annuli I through III was identical between sexes, but females were 5-18 mm larger at ages four through six.

Calculated lengths at annuli for Flathead Lake bull trout determined by this study (Table 18) were much lower than those reported by Block (1955) and Rahrer (1963), but were similar to Upper Priest Lake bull trout (Bjornn 1957) (Figure 22). Our calculated lengths at annuli V through VIII were frequently more than 100 mm shorter than has been previously reported for Flathead Lake (Figure 22). Some of this discrepancy may stem from bias inherent in techniques of backcalculation. Rahrer (1963) and Block (1955) both used a straight-line nomograph whereas we employed a curvilinear relationship as did Bjornn (1961).

Lengths at annuli IV through VI of lake fish were 32-46 mm shorter than spawning bull trout captured in the Middle Fork Flathead River (Fraley et al. 1981). However, lake fish were 82 and 200 mm larger than Middle Fork spawners at annuli VIII and IX.

The tendency for length increment to increase with fish age was noted in our analysis (Table 18; Figure 22) and also in studies by Block (1955) and Rahrer (1963) for Flathead Lake bull trout. Bjornn (1957) observed a similar phenomenon in Upper Priest Lake but not in Priest Lake. Increased length increments after age two in Flathead Lake fish (Table 18) likely reflects the movement of these and older juveniles from tributary streams to the lake where growth conditions are more favorable. Growth increments of juvenile bull trout in North and Middle Fork tributaries declined steadily after the completion of the first years growth (Fraley et al. 1981). Most of the juvenile bull trout emigrating from North Fork tributaries were found to be two or three years of age and 102-175 mm in length (Graham et al. 1980).

The calculated length to the first annulus for Flathead Lake bull trout ranged between 49 and 57 mm (Appendix Tables 41 through 43) and averaged 54 mm (Table 18). This is low in comparison to that observed in North and Middle Fork tributaries (64-80 mm) (Fraley et al. 1981). The combined adult and juvenile body-scale relationship does not adequately describe the early portion of the life cycle (Figure 21) and use of this line results in inaccurate backcalculated length at annulus I. Body length-scale radius relationships derived using only juvenile fish have been found to provide more accurate estimates of early growth (Fraley et al. 1981).

The length-weight relationship for the combined sample of Flathead Lake bull trout is presented in Figure 23. The slope of this relationship (3.321) is larger than that observed for juveniles in Flathead tributaries (b=3.050 and 2.999; Fraley et al. 1981) and indicates allometric growth. Lake trout (*Salvelinus namaycush*) typically increase in weight at a rate greater than the cube of their length (Carlander 1969).

A significant positive relationship (r=.64, p=.000) was observed between condition factor and fish length (Figure 23). The same is generally true

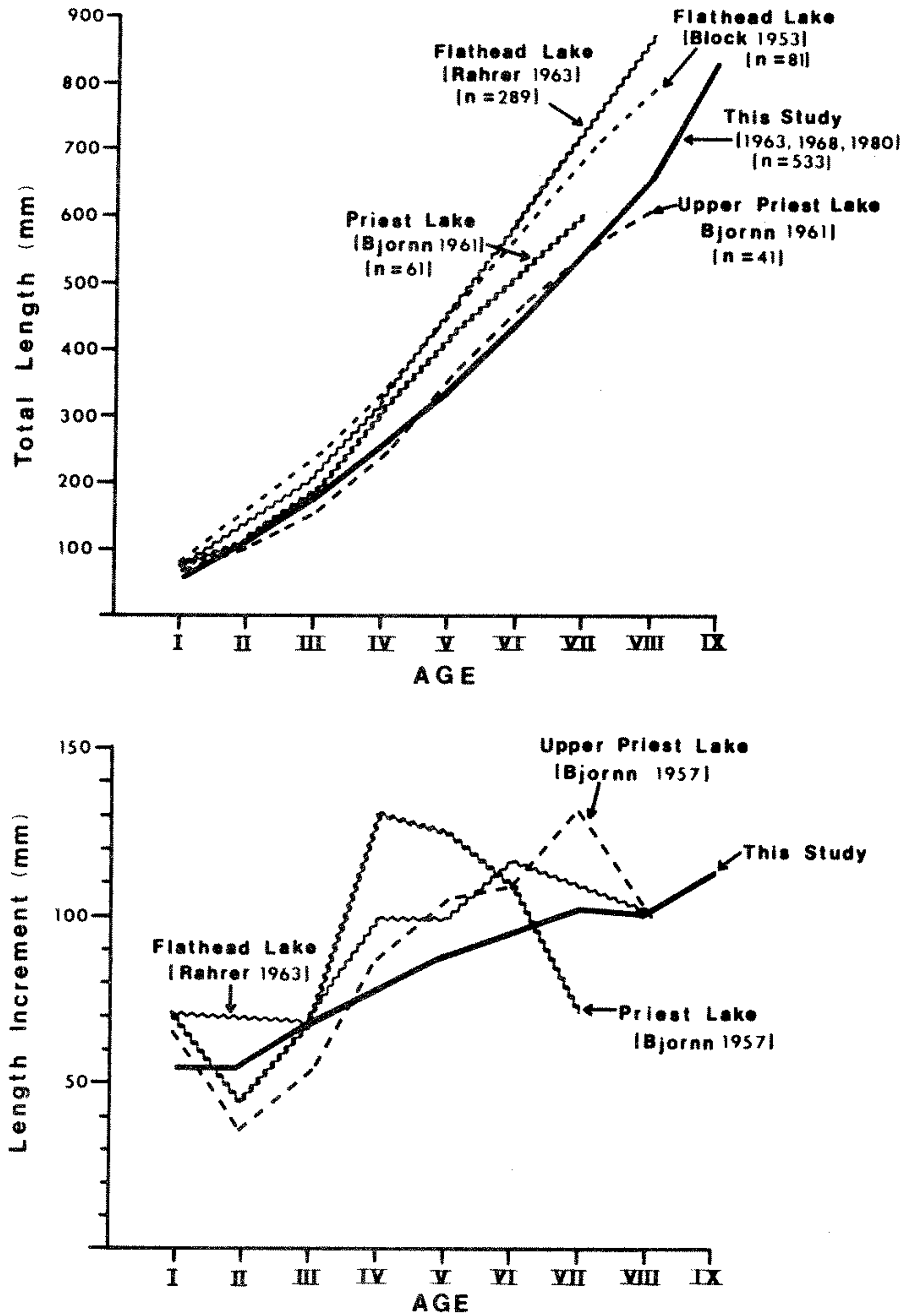
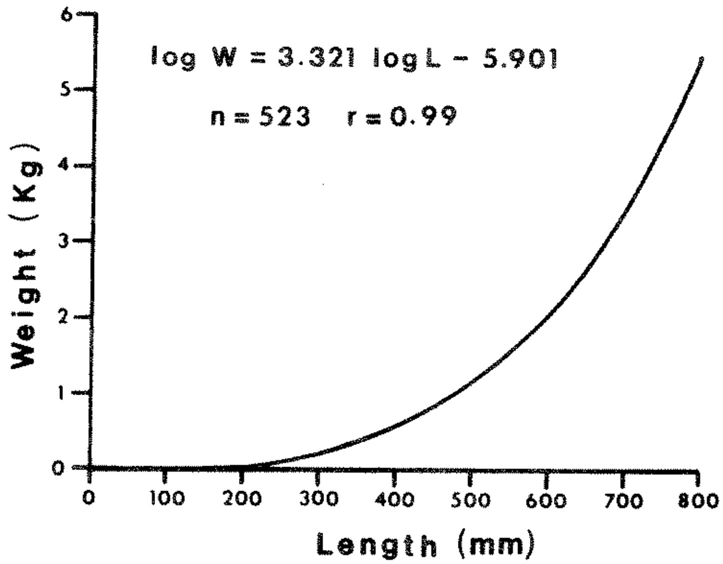


Figure 22. Age-length relationship (*Top*) and mean length increment (*Bottom*) for a combined sample of 533 bull trout from Flathead Lake in comparison with other studies.



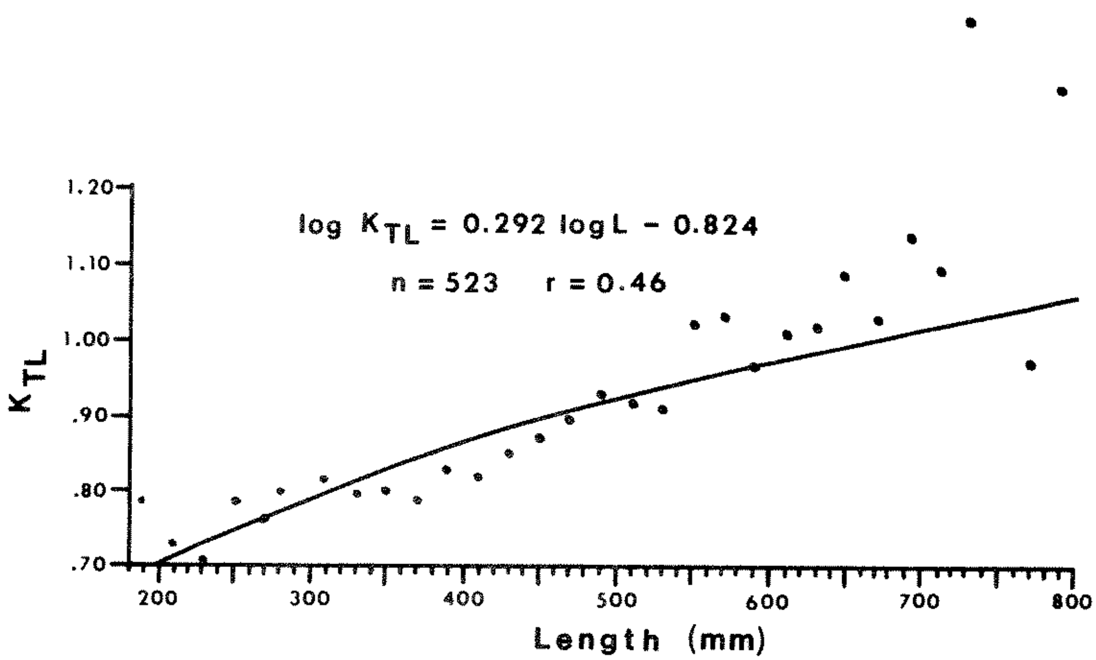


Figure 23. Length-weight relationship (upper figure) and condition factor (K_{TL}) versus fish length (lower figure) for a combined sample of Flathead Lake bull trout collected during 1963, 1968, and 1980. Plotted points on lower graph represent mean condition factors for 20 mm length intervals.

for lake trout (Carlander 1969).

The relative size of fish in the 1980 bull trout gill net catch is compared to the 1967 through 1970 catches in Table 19. The 1967-1970 catches were obtained using gill nets having identical mesh sizes to those employed in this study. The mean length of 1980 fish (420 mm) was similar to other years and was larger than the combined 1967-1970 average of 388 mm. Thirty-four percent of the 1980 catch was longer than the minimum legal size limit (457 mm or 18 inches). This percentage was higher than that observed during 1968, 1969, or 1970, and was higher than the 1967-1970 average of 26.2 percent. About 3.5 percent of the 1980 catch was longer than 635 mm (25 inches) which is somewhat less than the 1967-1970 average of 4.9 percent.

GILL NETTING

When repeated on a regular basis, gill net catches can be used to monitor long term changes in the abundance of fish species in Flathead Lake. Seasonal gill netting also provides specimens for age and growth and food habits analysis and furnishes information on the vertical and horizontal distribution of fish species in the lake.

A total of 2,118 fish comprised of 11 species has been captured to date in gill netting operations (Table 20). Most of these fish (69.5%) were captured in sinking nets. Catch data indicate strong differences between the two net types. All cutthroat trout captured were taken in floating nets whereas only 6.7 percent of the total bull trout catch was taken in floaters. Hanzel (1970) also found cutthroat to be directly associated with the lake surface.

Kokanee, squawfish, and peamouth all appeared more commonly in floating sets whereas lake trout, lake and mountain whitefish, and suckers were more common in sinking net catches (Table 20). A total of 49 longnose suckers were caught compared to only eight largescale suckers. Hanzel (1971) reported catching 1.7 longnose per largescale sucker in his netting.

Seasonal variations in the species composition of sinking gill net catches are presented in Figure 24. The bull trout segment of the catch was fairly consistent and ranged between nine and 13 percent of the catch. Hanzel (1970) noted that bull trout showed the most stable numbers during his netting series and comprised from 12 to 16 percent of the catch. Lake whitefish dominated our summer catch (54%) compared to 26 and 36 percent of the fall and winter catches. Kokanee were a significant portion of the catch only in the fall when they comprised more than seven percent of the catch. Virtually all of the kokanee caught in the fall series were in spawning condition. Lake trout also increased in numbers in the fall (Figure 24). This was due to the fact that 18 lake trout were captured in Area 5 on 20 October. Twelve of these fish were in spawning condition and the largest fish was 940 mm long and was estimated to weigh more than 10 kg. Most of the large lake trout were released unharmed since they were typically only tooth-hooked in the net.

Fluctuations in numbers and species composition of the floating net catch (Figure 25) were more dramatic than were changes in sinking net catches.

Table 19. Size composition of the 1980 Flathead Lake bull trout gill net catch as compared to previous gill netting conducted by Hanzel (1971).

Year	n	Mean length(mm)	Range	Percent >457mm	Percent ≥635mm
1967	97	443	193-757	50.5	8.2
1968	274	365	165-785	20.4	2.9
1969	296	376	168-869	19.6	4.7
1970	175	416	186-748	33.1	6.3
1980	144	420	187-731	34.0	3.5
Average of 1967-1980	986	393	165-869	27.4	4.7
Average of 1967-1970	842	388	165-869	26.2	4.9

Table 20. Percent composition by species and net type of combined summer, fall, and winter gill net catch on Flathead Lake 1980-81.

Species	Abbreviation	Percent of catch Sinking Nets	 Floating Nets	Total Catch
Cutthroat	(WCT)	0.0	9.6	62
Bull trout	(DV)	10.4	1.7	164
Lake Trout	(LT)	1.3	0.2	20
Kokanee	(KOK)	3.5	19.3	177
Lake Whitefish	(LWF)	35.9	1.4	537
Mountain Whitefish	(MWF)	3.3	0.6	52
Suckers	(SU)	3.9	0	57
Northern Squawfish	(NSQ)	15.3	22.7	372
Peamouth	(PM)	26.2	44.4	673
Yellow Perch	(YP)	0.2	0.2	4
TOTAL CATCH		1,411	647	2,118

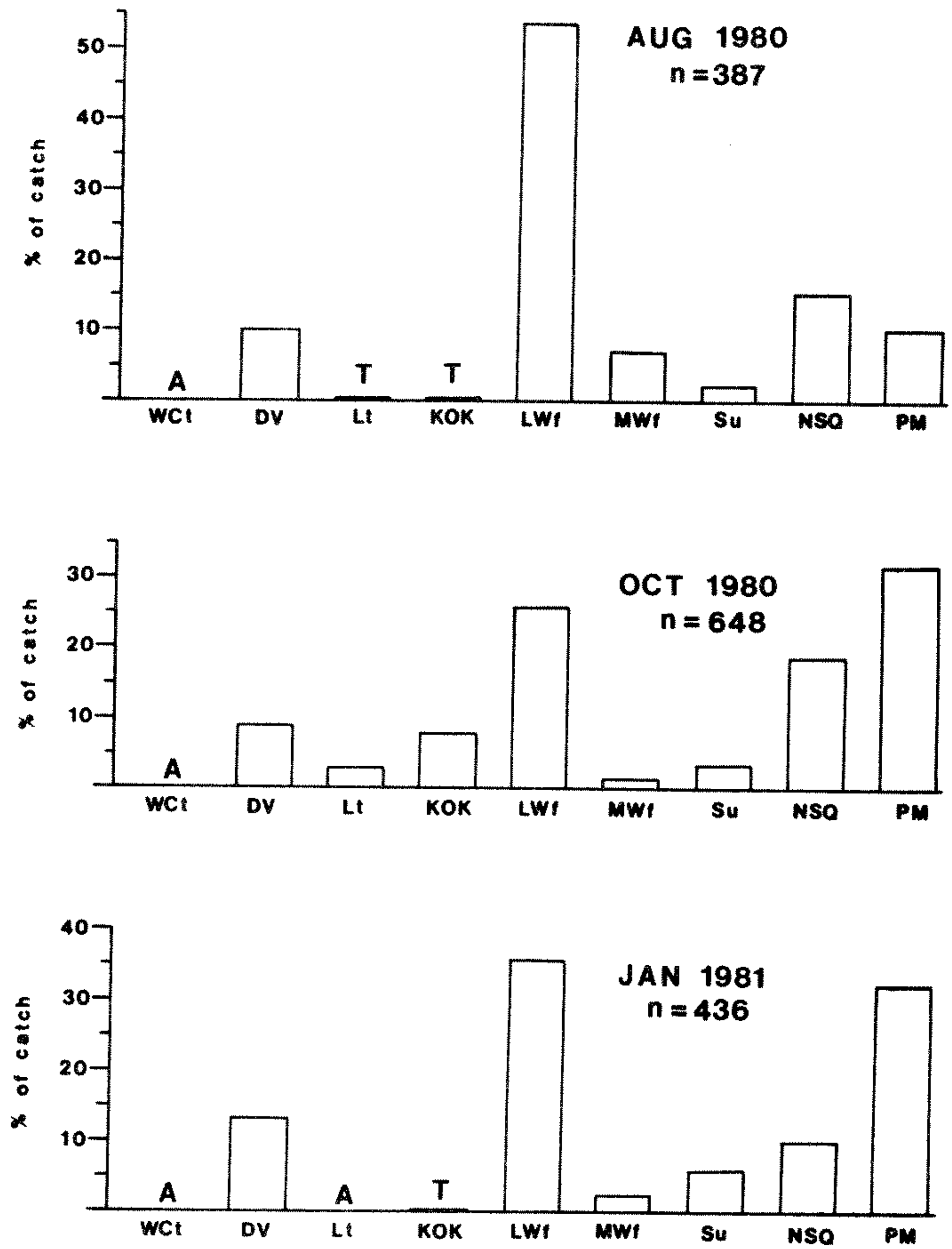


Figure 24. Percent composition by species in sinking gill nets set during the summer, fall, and winter 1980-81 in Flathead Lake. A = absent, T (trace) = <1% of catch.

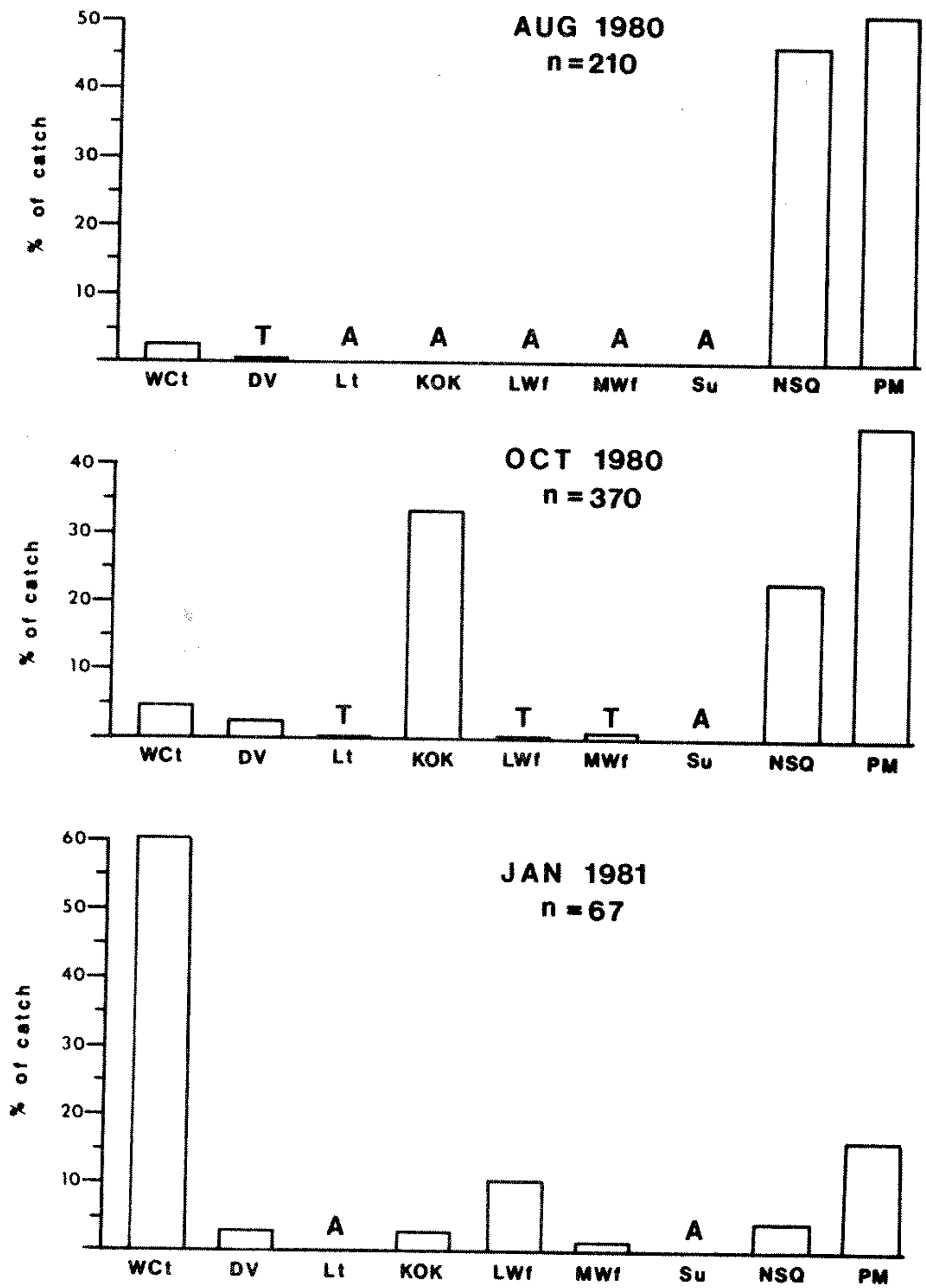


Figure 25. Percent composition by species in floating gill nets set during the summer, fall, and winter 1980-81 in Flathead Lake. A = absent; T(trace) = <1% of catch.

The combined percentage of peamouth and squawfish declined steadily from 96 percent in the summer catch to 69 percent in the fall and 20 percent of the winter catch. Kokanee increased markedly in the fall catch which reflects movement of mature fish to lakeshore spawning areas. Cutthroat increased from 2 and 5 percent of the summer and fall catch to 60 percent of the winter catch. The total cutthroat catch was seven in the summer, 17 in the fall, and 40 in the winter netting. Cutthroat are difficult to net during the summer on Flathead Lake (Elrod et al. 1929, Brunson et al. 1952, Hanzel 1970) apparently because they disperse over the entire lake area. All of the above researchers have noted the tendency for cutthroat to concentrate along the shoreline in the fall and winter.

Data presented in Table 21 revealed a steady progression in the catch rate of cutthroat in floating nets from a low of 0.2 fish per net-night in the summer to 1.3 fish per net-night in the winter. Using similar methods, McMullin (1979) observed a similar trend in seasonal cutthroat catch in Lake Koocanusa (a large impoundment approximately 125 km northwest of Flathead Lake) with averages ranging from 1.3 fish per net in the summer to 4.9 fish per net in the winter.

The seasonal catch rate for bull trout was fairly stable and ranged between 2.0 and 2.4 fish per standard net night (Table 22). Catch rates were highest in Areas 1 and 2 in the north end of the lake during all three seasons.

Length distributions for cutthroat trout caught in gill nets were similar in the fall and winter (Figure 26). The size distribution of the summer cutthroat catch was difficult to interpret due to the small sample size.

Examination of length-frequency distributions for bull trout captured in gill nets reveals that few large bull trout were captured in the summer of 1980 as compared to the fall of 1980 or winter of 1981 (Figure 27). Fish trapping operations conducted by Department personnel during the past 25 years have shown that bull trout larger than 457 mm (18 inches) generally comprise more than 95 percent of the spawning run. The relative absence of large bull trout in the summer 1980 gill net catch may be related to spawning migration. Fish larger than 460 mm comprised 19 percent of the summer catch compared to 50 and 36 percent of the fall and winter catches, respectively.

Table 21. Catch per standard floating gill net (69.7 m^2)[1/] per night for cutthroat in five areas on Flathead Lake, 1980.

Area	Summer		Fall		Winter		
	No. of nets	Mean catch	No. of nets	Mean catch	No. of nets	Mean catch	Mean catch
1	6	0.3	6	0	6	0.5	0.3
2	6	0.2	6	0	6	2.7	1.0
4	6	0.3	6	0.8	6	1.2	0.8
5	---	---	6	0.2	6	1.3	0.8
8	6	0	6	1.7	6	1.0	0.9
MEAN		0.2		0.5		1.3	

1/ All fish collected using 1.83 x 38.1 m = 69.7 m^2 nets (equivalent to 6' x 125' = 750 ft^2).

Table 22. Catch per standard sinking gill net (67.2 m^2)[1/] per night for bull trout in five areas on Flathead Lake, 1980.

Area	Summer		Fall		Winter		Mean catch
	No. of nets[2/]	Mean catch	No. of nets[2/]	Mean catch	No. of nets[3/]	Mean catch	
1	4.9	3.5	4.9	3.7	4.7	4.3	3.8
2	4.9	1.8	4.7	3.8	4.7	3.4	3.0
4	4.9	1.0	4.7	1.5	4.7	0.9	1.1
5	---	---	4.7	1.5	4.7	1.9	1.7
8	4.9	1.6	4.7	1.5	4.7	1.7	1.6
MEAN CATCH		2.0		2.4		2.4	

1/ Standard net defined as 1.83 x 38.1 m = 69.7 m^2 (equivalent to 6' x 125' = 750 ft^2).

2/ Fish collected using one 2.44 x 76.2 m and one 2.44 x 64 m sinking gill net (experimental mesh) per area per night.

3/ Fish collected using one 2.44 x 76.2 m and two 1.83 x 38.1 m sinking gill nets (experimental mesh) per area per night.

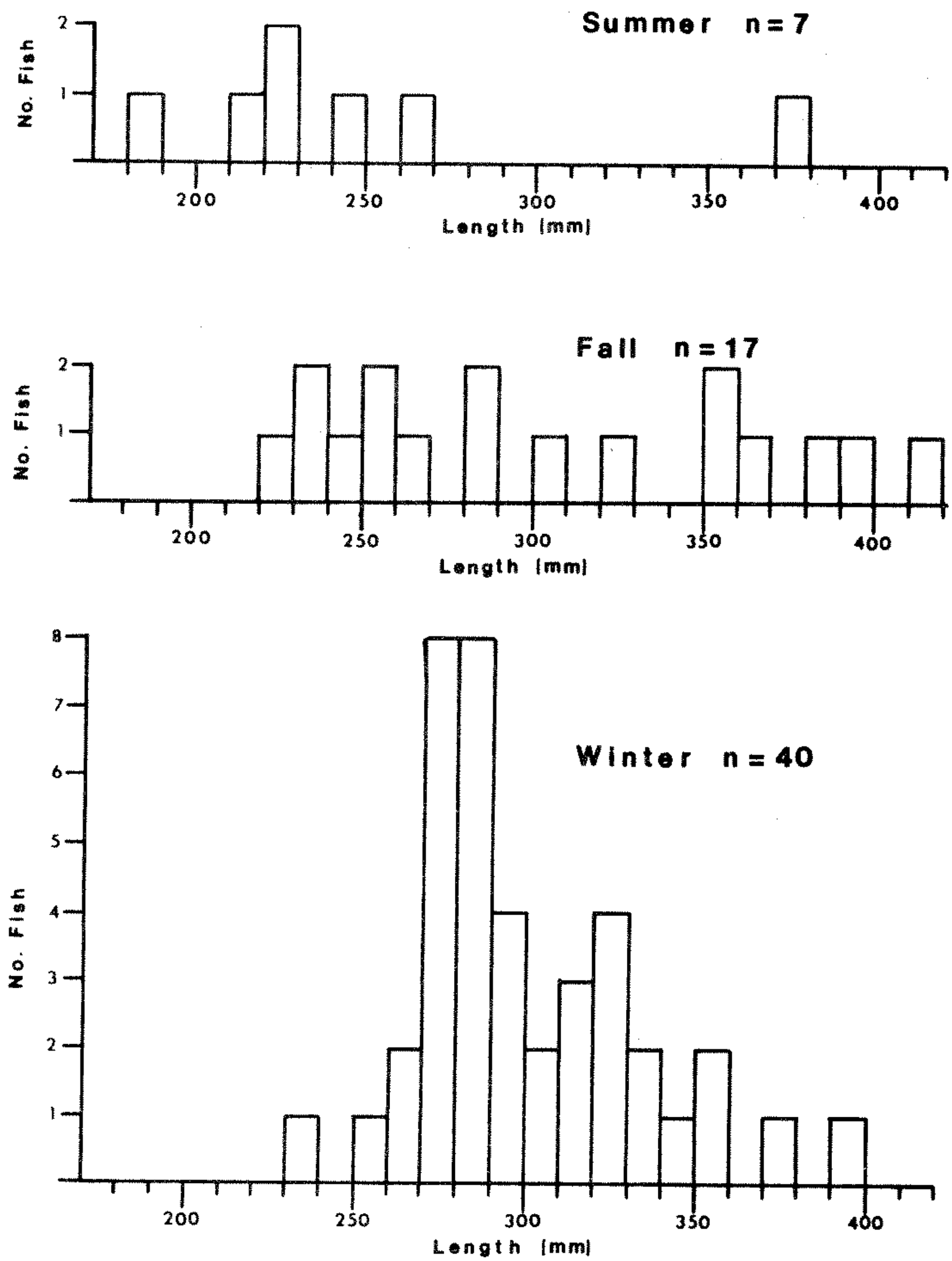


Figure 26. Seasonal length-frequency diagrams for cutthroat trout from Flathead Lake captured in gill nets, 1980-1981.

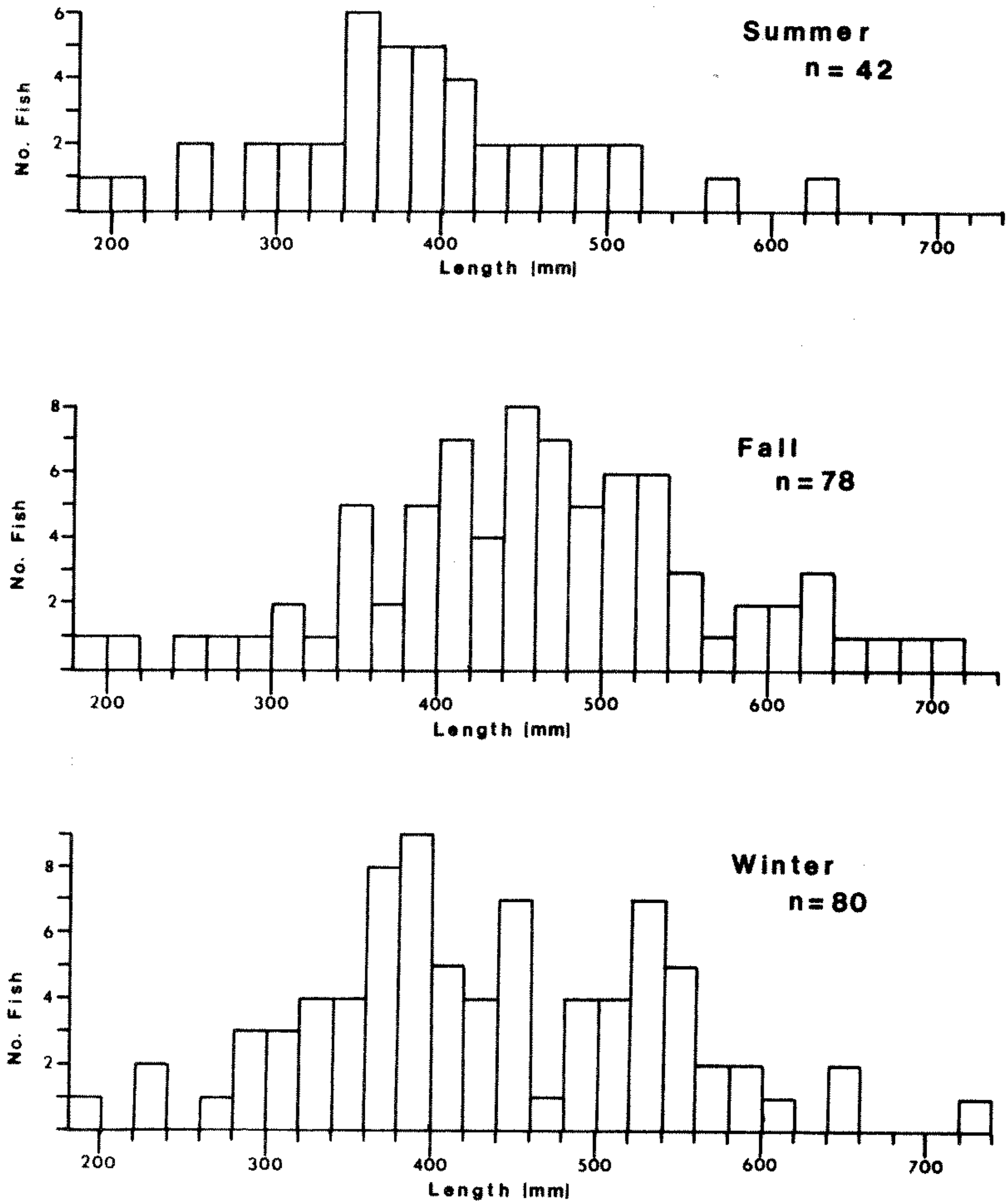


Figure 27. Seasonal length-frequency diagrams for bull trout from Flathead Lake captured in gill nets, 1980-1981.

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APPENDIX

Table 23. Summary of kokanee stomach collections by age class in Flathead Lake during 1980.

0+ (27-100 mm)			I+ (100-165 mm)			II+ (165-250 mm)			≥ III+ (≥ 250 mm)		
Date	Area	n	Date	Area	n	Date	Area	n	Date	Area	n
2 Jul	3	8	2 Jul	3	1				3 Jul	5	17
7 Jul	1	18	7 Jul	1	29	8 Jul	2	2	7 Jul	1	5
17 Jul	1	9	17 Jul	1	20	9 Jul	1	2	8 Jul	2	23
									9 Jul	1	5
									30 Jul	8	2
20 Aug	3	19	20 Aug	3	12	15 Aug	2	3	15 Aug	2	10
						29 Aug	2	2	29 Aug	2	6
						29 Aug	1	5	29 Aug	1	9
						8 Sep	8	2			
25 Sep	2	24				18 Sep	2	2	18 Sep	2	9
						22 Sep	5	1	22 Sep	5	2
6 Oct	1	12				6 Oct	1	2	6 Oct	1	4
3 Dec	1	12									
TOTAL		102			62			21			92

Table 24. Percent composition (by numbers) and associated electivity (*Ei*) of potential prey items in the diet of age 0+ kokanee salmon from Flathead Lake during 1980.

Date	n		*Daphnia thorata*	*Daphnia longiremis*	*Bosmina*	*Diaptomus*	*Cyclops*	*Epischura*	*Leptodora*
2 Jul	8	%	74.4	8.3	0.1	0.3	3.1	13.6	0.2
		Ei	+.86	-.17	-.97	-.99	-.57	+1.00	+1.00
7 Jul	17	%	70.9	0	0	0	0	29.1	0
		Ei	+.91	-1.00	-1.00	-1.00	-1.00	+1.00	---
17 Jul	9	%	77.5	0	0	1.6	8.0	12.9	0
		Ei	+.91	-1.00	-1.00	-.96	+.28	+.90	-1.00
20 Aug	19	%	88.1	0	0	3.4	3.4	3.4	1.7
		Ei	+.90	-1.00	-1.00	-.91	-.74	+.62	+.88
25 Sep	24	%	72.4	0	0	0.9	1.7	25.0	0
		Ei	+.60	---	-1.00	-.87	-.95	+.99	-1.00
6 Oct	12	%	97.4	0	0	0	0	2.6	0
		Ei	+.61	---	-1.00	-1.00	-1.00	+.73	---
3 Dec	12	%	86.4	0	0	0	0	13.6	0
		Ei	+.91	-1.00	-1.00	-1.00	-1.00	+.90	---

Table 25. Percent composition (by numbers) and associated electivity (*Ei*) of potential prey items in the diet of age I+ kokanee salmon from Flathead Lake during 1980.

Date	n		*Daphnia thorata*	*Daphnia longiremis*	*Bosmina*	*Diaptomus*	*Cyclops*	*Epischura*	*Leptodora*
2 Jul	1	%	88.9	0	0	1.0	1.0	8.1	1.0
		Ei	+.88	-1.00	-1.00	-.97	-.84	+1.00	+1.00
7 Jul	29	%	85.5	0	.6	.6	0	12.1	1.2
		Ei	+.92	-1.00	-.88	-.99	-1.00	+1.00	+1.00
17 Jul	20	%	97.6	0	.6	0	.6	1.2	0
		Ei	+.93	-1.00	-.92	-1.00	-.76	+.26	-1.00
20 Aug	12	%	96.2	0	1.9	0	.9	0	.9
		Ei	+.90	-1.00	-.14	-1.00	-.92	-1.00	+.78

Table 26. Percent composition (by numbers) and associated electivity (*Ei*) of potential prey items in the diet of age II+ kokanee salmon from Flathead Lake during 1980.

Date	n		*Daphnia thorata*	*Daphnia longiremis*	*Bosmina*	*Diaptomus*	*Cyclops*	*Epischura*	*Leptodora*
9 Jul	2	%	95.4	0	1.5	0	3.1	0	0
		Ei	+.93	-1.00	-.72	-1.00	-.34	---	---
8 Jul	2	%	98.7	0	0	0	0	0	1.3
		Ei	+.89	-1.00	-1.00	-1.00	-1.00	-1.00	+1.00
15 Aug	3	%	96.1	0	0	0	1.6	0	2.3
		Ei	+.77	-1.00	-1.00	-1.00	-.86	-1.00	+.76
29 Aug	2	%	99.3	0	0	0	0	0.3	0.3
		Ei	+.78	-1.00	-1.00	-1.00	-1.00	-.40	+.13
29 Aug	5	%	96.4	0	0	0	0	0	3.6
		Ei	+.84	-1.00	-1.00	-1.00	-1.00	-1.00	+.87
8 Sep	2	%	98.1	0	0	0.6	0	0.6	0.6
		Ei	+.80	-1.00	-1.00	-.98	-1.00	+.20	+.60
18 Sep	2	%	96.5	0	0	0	0	0	3.5
		Ei	+.56	---	-1.00	-1.00	-1.00	-1.00	+.96
22 Sep	1	%	100.0	0	0	0	0	0	0
		Ei	+.60	---	-1.00	-1.00	-1.00	-1.00	---
6 Oct	2	%	100.0	0	0	0	0	0	0
		Ei	+.65	---	-1.00	-1.00	-1.00	---	---

Table 27. Percent composition (by numbers) and associated electivity (*Ei*) of potential prey items in the diet of age III+ and older kokanee salmon from Flathead Lake during 1980.

Date	n		*Daphnia thorata*	*Daphnia longiremis*	*Bosmina*	*Diaptomus*	*Cyclops*	*Epischura*	*Leptodora*
3 Jul	12	%	69.4	0	0	0	0	29.8	0.8
		Ei	+.80	-1.00	-1.00	-1.00	-1.00	+.99	+.78
3 Jul	5	%	99.1	0	0	0	0	0.9	0
		Ei	+.88	-1.00	-1.00	-1.00	-1.00	+1.00	---
7 Jul	5	%	98.5	1.5	0	0	0	0	0
		Ei	+.93	0.00	-1.00	-1.00	-1.00	---	---
9 Jul	5	%	89.7	0	0	0	0	2.1	8.2
		Ei	+.93	-1.00	-1.00	-1.00	-1.00	+1.00	+1.00
8 Jul	23	%	93.7	0	0	0	0	1.1	5.3
		Ei	+.89	-1.00	-1.00	-1.00	-1.00	-.12	+1.00
15 Aug	10	%	86.6	0	0.6	0	1.9	0	10.8
		Ei	+.75	-1.00	-.84	-1.00	-.84	-1.00	+.94
29 Aug	1	%	15.3	0	0	0	0.6	83.4	0.6
		Ei	+.12	-1.00	-1.00	-1.00	-.97	+.98	+.45
29 Aug	5	%	93.9	0	0	0	0	0	6.1
		Ei	+.77	-1.00	-1.00	-1.00	-1.00	-1.00	+.93
29 Aug	9	%	95.4	0	0	0	0.6	0	4.0
		Ei	+.84	-1.00	-1.00	-1.00	-.96	-1.00	+.88
18 Sep	9	%	97.8	0	0	0	0	0.5	1.6
		Ei	+.57	---	-1.00	-1.00	-1.00	-.41	+.90
22 Sep	1	%	93.5	6.5	0	0	0	0	0
		Ei	+.58	+1.00	-1.00	-1.00	-1.00	-1.00	---
22 Sep	1	%	97.9	0	0	0	0	0	2.1
		Ei	+.59	---	-1.00	-1.00	-1.00	-1.00	+1.00
6 Oct	4	%	99.3	0	0	0	0	0	0.7
		Ei	+.65	---	-1.00	-1.00	-1.00	---	+1.00

Table 28. Composition by number, weight, and frequency of occurrence and calculated index of relative importance (IRI) for major food items in the stomachs of nine cutthroat trout collected during July and August 1980 in Flathead Lake.

Item	Number	(%)	Wet weight -g.	(%)	Frequency	(%)	IRI
Hymenoptera	928	(67.4)	10.42	(45.4)	7	(77.8)	63.5
Orthoptera	28	(2.0)	8.15	(35.5)	6	(66.7)	34.7
Coleoptera	77	(5.6)	.56	(2.4)	6	(66.7)	24.9
Hemiptera	30	(2.2)	.21	(0.9)	7	(77.8)	27.0
Homoptera	128	(9.3)	.80	(3.5)	6	(66.7)	26.5
Neuroptera	4	(0.3)	.04	(0.2)	3	(33.3)	11.3
Lepidoptera	10	(0.7)	.30	(1.3)	1	(11.1)	4.4
Arachnida	3	(0.2)	.05	(0.2)	1	(11.1)	3.9
Diptera	115	(8.4)	.44	(1.9)	7	(77.8)	29.4
Ephemeroptera	10	(0.7)	1.48	(6.5)	2	(22.2)	9.8
Trichoptera	33	(2.4)	.14	(0.6)	6	(66.7)	23.2
Hirudinea	—	—	—	—	—	—	—
Amphipods	—	—	—	—	—	—	—
Copepods	1	(0.1)	.01	(< .1)	1	(11.1)	3.8
Debris	11	(0.8)	.33	(1.4)	3	(33.3)	11.9

Table 29. Composition by number, weight, and frequency of occurrence and calculated index of relative importance (IRI) for food items in the stomachs of 15 cutthroat trout collected during October 1980 in Flathead Lake

Item	Number	(%)	Wet weight -g.	(%)	Frequency	(%)	IRI
Hymenoptera	56	(2.2)	.84	(10.6)	8	(53.3)	22.0
Orthoptera	11	(0.4)	.98	(12.3)	4	(26.7)	13.1
Coleoptera	226	(8.7)	2.19	(27.5)	14	(93.3)	43.2
Hemiptera	20	(0.8)	.33	(4.2)	5	(33.3)	12.8
Homoptera	19	(0.7)	.11	(1.4)	5	(33.3)	11.8
Neuroptera	3	(0.1)	.02	(0.3)	2	(13.3)	4.6
Lepidoptera	2	(0.1)	.02	(0.3)	2	(13.3)	4.6
Arachnida	75	(2.9)	.28	(3.5)	12	(80.0)	28.8
Diptera	2164	(83.7)	3.02	(38.0)	11	(73.3)	65.0
Ephemeroptera	4	(0.2)	.11	(1.4)	1	(6.7)	2.8
Trichoptera	—	—	—	—	—	—	—
Hirudinea	1	(< .1)	.02	(0.3)	1	(6.7)	2.3
Amphipods	1	(< .1)	.01	(0.1)	1	(6.7)	2.3
Copepods	—	—	—	—	—	—	—
Debris	2	(0.1)	.02	(0.3)	1	(6.7)	2.4

Table 30. Composition by number, weight, and frequency of occurrence and calculated index of relative importance (IRI) for major food items in the stomachs of 32 bull trout collected during summer of 1980 in Flathead Lake.

Item	Number	(%)	Wet weight -g.	(%)	Frequency	(%)	IRI
Pygmy whitefish	13	(18.6)	69.3	(9.8)	3	(9.4)	12.6
Lake whitefish	3	(4.3)	168.7	(23.8)	3	(9.4)	12.5
Mountain whitefish	4	(5.7)	89.7	(12.7)	4	(12.5)	10.3
Unid. whitefish	5	(7.1)	18.7	(2.6)	4	(12.5)	7.4
Total whitefish	*25*	*(35.7)*	*346.4*	*(48.9)*	*12*	*(37.5)*	*40.7*
Kokanee salmon	3	(4.3)	34.0	(4.8)	2	(6.3)	5.1
Unid. trout/salmon	1	(1.4)	9.3	(1.3)	1	(3.1)	1.9
Total trout/salmon	*4*	*(5.7)*	*43.3*	*(6.1)*	*3*	*(9.4)*	*7.1*
Sculpin	2	(2.9)	3.7	(0.5)	2	(6.3)	3.2
Redside shiner	4	(5.7)	16.7	(2.4)	2	(6.3)	4.8
Peamouth	3	(4.3)	77.3	(10.9)	2	(6.3)	7.2
Squawfish	1	(1.4)	151.0	(21.3)	1	(3.1)	8.6
Sucker	1	(1.4)	7.3	(1.0)	1	(3.1)	1.8
Total non-game	*11*	*(15.7)*	*256.0*	*(36.1)*	*7*	*(21.9)*	*24.6*
Unid. fish	30	(42.9)	63.0	(8.9)	17	(53.1)	35.0

Table 31. Composition by number, weight, and frequency of occurrence and calculated index of relative importance (IRI) for major food items in the stomachs of 44 bull trout collected during October 1980 in Flathead Lake

Item	Number	(%)	Wet weight -g.	(%)	Frequency	(%)	IRI
Pygmy whitefish	3	(5.5)	16.8	(1.1)	3	(6.8)	4.5
Lake whitefish	8	(14.5)	633.3	(42.0)	6	(13.6)	23.4
Mountain whitefish	4	(7.3)	316.9	(21.0)	4	(9.1)	12.5
Unid. whitefish	3	(5.5)	14.7	(1.0)	2	(4.5)	3.7
Total whitefish	*18*	*(32.7)*	*981.7*	*(65.1)*	*14*	*(31.8)*	*43.2*
Kokanee salmon	4	(7.3)	314.8	(20.9)	4	(9.1)	12.4
Bull trout	1	(1.8)	10.4	(0.7)	1	(2.3)	1.6
Unid. trout/salmon	2	(3.6)	5.7	(0.4)	2	(4.5)	2.8
Total trout/salmon	*7*	*(12.7)*	*330.9*	*(22.0)*	*7*	*(15.9)*	*16.9*
Sculpin	2	(3.6)	2.8	(0.2)	2	(4.5)	2.8
Yellow Perch	4	(7.3)	3.2	(0.2)	2	(4.5)	4.0
Total non-game	*6*	*(10.9)*	*6.0*	*(0.4)*	*4*	*(9.1)*	*6.8*
Unid. fish	24	(43.6)	188.2	(12.5)	22	(50.0)	35.4

Table 32. Composition by number, weight, and frequency of occurrence, and calculated index of relative importance (IRI) for major food items in the stomachs of 11 bull trout collected on 27 November and 12 December, 1979.

Item	Number	(%)	Wet weight -g.	(%)	Frequency	(%)	IRI
Pygmy whitefish	1	(3.1)	6.9	(8.7)	1	(9.1)	7.0
Sculpin	1	(3.1)	6.2	(7.8)	1	(9.1)	6.7
Redside shiner	3	(9.4)	14.5	(18.3)	1	(9.1)	12.3
Yellow perch	22	(68.8)	43.1	(54.5)	7	(63.6)	62.3
Total non-game	*26*	*(81.3)*	*63.8*	*(80.7)*	*8*	*(72.7)*	*78.2*
Unid. fish	5	(15.6)	8.4	(10.6)	2	(18.2)	14.8

Table 33. Regression equations describing body length-scale radius relationships for cutthroat trout in the Flathead River drainage.

Area	Equation	(n)	r
Middle Fork	log L =.841 log SR + .938	(556)	.939
North Fork	log L =.720 log SR + 1.105	(1020)	.917
Flathead Lake (1962-1980)	log L =.620 log SR + 1.331	(318)	.763
Total Flathead drainage	log L =.807 log SR + .978	(1724)	.961

Table 34. Calculated lengths and growth increments for 159 female Flathead Lake cutthroat collected during the period 1962-1980.

Age	n	Length (mm) at annulus I	II	III	IV	V	VI
1	0						
2	2	51	89				
3	22	62	117	192			
4	56	56	106	166	244		
5	56	58	108	171	242	297	
6	23	58	111	167	251	306	344
Grand mean calculated length		58	109	172	244	300	344
(n)		(159)	(159)	(157)	(135)	(79)	(23)
Length increment		58	51	63	76	55	38

Table 35. Calculated lengths and growth increments for 66 male Flathead Lake cutthroat collected during the period 1962-1980.

Age	n	Length (mm) at annulus I	II	III	IV	V	VI	VII
1	0							
2	2	64	131					
3	12	56	108	182				
4	21	54	103	162	245			
5	17	53	105	169	248	306		
6	13	55	113	174	244	298	335	
7	1	46	107	152	209	276	317	343
Grand mean calculated length		54	107	170	245	302	334	343
(n)		(66)	(66)	(64)	(52)	(31)	(14)	(1)
Length increment		54	53	63	78	57	37	26

Table 36. Calculated lengths and growth increments for cutthroat trout that spent two years in tributaries prior to entering Flathead Lake. Fish collected 1962-1980.

Age	n	Length (mm) at annulus I	II	III	IV	V	VI
3	16	60	111	205			
4	25	64	122	212	276		
5	24	55	109	199	266	314	
6	8	58	117	204	271	320	353
Grand mean calculated length		60	115	205	271	316	353
(n)		(73)	(73)	(73)	(57)	(32)	(8)
Length increment		60	55	90	66	48	33

Table 37. Calculated lengths and growth increments for cutthroat trout that spent three years in tributaries prior to entering Flathead Lake. Fish collected 1962-1980.

Age	n	Length (mm) at annulus I	II	III	IV	V	VI	VII
4	42	53	101	151	247			
5	39	55	101	150	244	304		
6	20	58	104	151	245	302	343	
7	3	61	105	154	257	329	385	431
Grand mean calculated length		55	102	151	246	305	348	431
(n)		(104)	(104)	(104)	(104)	(62)	(23)	(3)
Length increment		55	47	49	95	60	43	46

Table 38. Calculated lengths and growth increments for cutthroat trout that spent four years in tributaries prior to entering Flathead Lake. Fish collected 1962-1980.

Age	n	Length (mm) at annulus I	II	III	IV	V	VI
5	4	48	95	136	174	256	
6	4	57	102	144	185	258	311
Grand mean calculated length		53	99	140	180	257	311
(n)		(8)	(8)	(8)	(8)	(8)	(4)
Length increment		53	46	41	40	77	53

Table 39. Calculated length and growth increments for cutthroat trout from Flathead Lake whose migration class was not determined, 1962-1980.

Age	n	Length (mm) at annulus I	II	III	IV	V	VI	VII	VIII
2	3	58	114						
3	24	61	116	185					
4	36	56	111	173	242				
5	39	59	113	176	242	299			
6	19	53	110	167	234	291	332		
7	4	55	111	166	218	279	328	364	
8	1	40	94	156	198	248	307	362	413
Grand mean calculated length		57	112	175	238	295	330	364	413
(n)		(126)	(126)	(123)	(99)	(63)	(24)	(5)	(1)
Length increment		57	55	63	66	57	43	40	51

Table 40. Regression equations describing body length-scale radius relationships for bull trout in the Flathead River drainage.

Area	Equation	(n)	r
Middle Fork juveniles	$\log L = .768 \log SR + 1.044$	(103)	.899
North Fork juveniles	$\log L = .724 \log SR + 1.074$	(93)	.899
Flathead Lake (1963-1980)	$\log L = .986 \log SR + .832$	(533)	.899
Flathead drainage juveniles & adults	$\log L = 1.125 \log SR + .571$	(840)	.973

Table 41. Calculated length and growth increments of Flathead Lake bull trout collected via creel census during 1963.

Age	n	Length (mm) at annulus I	II	III	IV	V	VI	VII	VIII	IX
1	0									
2	0									
3	0									
4	8	52	111	186	276					
5	29	56	109	185	271	362				
6	60	51	105	168	246	337	433			
7	36	54	109	178	267	367	468	562		
8	20	50	103	167	246	347	446	551	646	
9	2	44	78	152	237	317	458	599	726	863
Grand mean calculated length		52	106	174	257	350	446	559	653	863
(n)		(155)	(155)	(155)	(155)	(147)	(118)	(58)	(22)	(2)
Length increment		52	54	68	83	94	99	99	98	137

Table 42. Calculated length and growth increments of Flathead Lake bull trout captured in gill nets during 1968.

Age	n	Length (mm) at annulus								
		I	II	III	IV	V	VI	VII	VIII	IX
1	0									
2	0									
3	42	60	115	182						
4	89	58	113	182	254					
5	55	57	111	177	254	336				
6	35	53	105	171	259	344	431			
7	10	57	112	173	244	345	436	547		
8	0	--	--	--	--	--	--	--	--	
9	1	44	96	203	290	366	465	596	677	760
Grand mean calculated length		57	112	179	255	340	433	551	677	760
(n)		(232)	(232)	(232)	(190)	(101)	(46)	(11)	(1)	(1)
Length increment		57	55	67	76	85	88	113	81	83

Table 43. Calculated length and increments of growth of Flathead Lake bull trout captured in gill nets during 1980.

Age	n	Length (mm) at annulus								
		I	II	III	IV	V	VI	VII	VIII	IX
1	0									
2	0									
3	11	57	113	190						
4	38	48	108	179	263					
5	57	50	106	174	253	337				
6	25	47	100	161	238	333	432			
7	13	47	97	157	231	306	391	497		
8	1	28	96	145	203	250	366	472	610	
9	1	44	114	197	290	394	508	632	760	859
Grand mean calculated length		49	105	173	251	332	419	504	685	859
(n)		(146)	(146)	(146)	(135)	(97)	(40)	(15)	(2)	(1)
Length increment		49	56	68	80	85	95	107	133	99

Table 44. Calculated lengths and increments of growth for 63 female Flathead Lake bull trout collected during 1980.

Age	n	Length (mm) at annulus I	II	III	IV	V	VI	VII	VIII
1	0								
2	0								
3	7	60	119	201					
4	17	45	104	176	263				
5	25	51	107	174	258	346			
6	13	46	99	155	234	330	425		
7	1	44	78	127	177	276	366	486	
8	0	--	--	--	--	--	--	--	
9	0	--	--	--	--	--	--	--	--
Grand mean calculated length		49	105	173	253	339	421	486	
(n)		(63)	(63)	(63)	(56)	(39)	(14)	(1)	
Length increments		49	56	68	83	91	95	120	

Table 45. Calculated length and increments of growth for 62 male Flathead Lake bull trout collected during 1980.

Age	n	Length (mm) at annulus I	II	III	IV	V	VI	VII	VIII
1	0								
2	0								
3	4	52	104	171					
4	17	52	113	187	268				
5	20	49	103	175	248	338			
6	10	45	98	162	230	314	410		
7	10	50	101	162	237	312	400	508	
8	1	28	96	145	203	250	366	472	610
9	0	--	--	--	--	--	--	--	--
Crand mean calculated length (n)		49 (62)	105 (62)	173 (62)	248 (58)	324 (41)	403 (21)	505 (11)	610 (1)
Length increment		49	56	68	75	84	93	108	138