FLATHEAD LAKE FISH FOOD HABITS STUDY

Final Report

Prepared By:

Stephen A. Leathe - Project Biologist

Patrick J. Graham - Project Leader

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EXECUTIVE SUMMARY

This document summarizes the results of a two-year baseline study concerning aspects of the biology of several gamefish species in Flathead Lake and is part of the Flathead River Basin Environmental Impact Study. Crustacean zooplankton populations were sampled monthly at several locations on the lake and biweekly in the Bigfork area to document species composition and abundance trends and also to monitor zooplankton availability as food for kokanee salmon and three species of whitefish. The copepods *Diaptomus* and *Cyclops* together comprised an average of 81 percent of the plankton density (exclusive of copepod nauplii) in Flathead Lake during the study period, while the Cladocera (mostly *Daphnia thorata* and *Bosmina*) comprised an average of 19 percent. The large predators *Leptodora* and *Epischura* were relatively rare and comprised only 0.1 and 0.2 percent of the average plankton density. No significant interstation population density differences were found for the four principal species (*Daphnia thorata*, adult *Epischura*, *Leptodora*, and *Diaptomus*) utilized by planktivorous gamefish in Flathead Lake.

Examination of stomach contents from 664 kokanee revealed that they fed almost exclusively on zooplankton throughout the year. *Daphnia thorata* was the principal food for all kokanee size classes and usually comprised 70 to 90 percent of the food biomass during the months of June through November. The large copepod *Epischura* was less important and comprised an average of about 10 to 20 percent of the kokanee diet during this timespan. *Leptodora* was seldom utilized by young-of-the-year kokanee, but comprised an average of six percent of the June through November diet (in terms of biomass) of age III and older kokanee. Age III and older kokanee utilized the smaller copepod *Diaptomus* during the winter months (mid-January to mid-April) when preferred prey species were absent from the lake plankton community. Dipteran pupae were the only significant non-zooplankton kokanee food item and were apparently consumed during the spring emergence period.

Terrestrial insects and adult and pupae of aquatic insects were the principal food items found in the stomachs of 191 westslope cutthroat trout collected from Flathead Lake throughout the year. Adult and pupal aquatic dipterans were the dominant food category during the spring, whereas terrestrial insects such as hymenopterans, coleopterans, hemipterans, and homopterans dominated the summer and fall diet. Zooplankton (primarily *Daphnia*) comprised about 20 percent of the food biomass found in cutthroat trout stomachs during January.

Fish comprised more than 99 percent of the food biomass found in the stomachs from 367 bull trout collected from Flathead Lake during the study. Lake, mountain and pygmy whitefish were the most important year around prey species, followed in order of importance by yellow perch, kokanee, and nongame species including slimy sculpins, redside shiners, peamouth, suckers and squawfish. Kokanee were the most important forage species during the spring, whereas lake and mountain whitefish were the most important summer and fall foods. Yellow perch were the most important

winter forage species, although perch never comprised more than two percent of the gill net catch in any season. Bull trout less than 300 mm utilized slimy sculpins more extensively than did larger fish, whereas bull trout larger than 500 mm and lake trout utilized kokanee and whitefish almost exclusively.

Zooplankton comprised almost 50 percent of the food biomass found in the stomachs of 131 lake whitefish collected from April through November. *Daphnia thorata* was the principal zooplankton prey and smaller amounts of *Leptodora* and *Epischura* were ingested. Lake whitefish fed mostly on organic debris and snails during the spring while zooplankton dominated the summer diet. Bryozoans and *Daphnia thorata* comprised most of the food biomass during the fall.

Daphnia thorata comprised 77 percent of the food biomass found in the stomachs of 91 mountain whitefish collected from April through November. Insect parts (primarily dipteran adults) and algae were the most important food items in April, but *Daphnia thorata* comprised 72 to 100 percent of the food biomass during the remainder of the period. *Daphnia thorata* and *Epischura* accounted for 70 to 13 percent of the food biomass found in the stomachs of 135 pygmy whitefish collected during July through December. All other food items comprised one percent or less of the pygmy whitefish diet with the exception of organic debris (10%) and chironomid larvae (6%).

Opossum shrimp (*Mysis relicta*) were collected from Flathead Lake for the first time during the fall of 1981. This organism had been introduced into lakes in the upper Flathead Basin and probably moved downstream into Flathead Lake. It appears as though *Mysis* can have a significant predatory impact on crustacean zooplankton populations in some lakes. However, the possible effects on the survival and growth of kokanee and other planktivorous fishes are incompletely understood and could vary from year to year with fluctuations in mysid density. *Mysis* will probably become established in Flathead Lake, but the process may take five to ten or more years. Continued monitoring and research is essential to understand the influence of *Mysis* on the biota of Flathead Lake.

Approximately 77 percent of the 573 westslope cutthroat trout collected from Flathead Lake during the years 1962 through 1981 were four or five years old. Four and five year old fish from Flathead Lake would range between 213 and 316 millimeters in average total length depending upon the number of years spent in rearing areas in the upper Flathead River drainage. Growth of cutthroat trout from Flathead Lake was slower than that reported for other lakes in the northwestern United States, but was faster than has been observed for this subspecies in the North and Middle Forks of the Flathead River.

Age determinations were made using scales from 928 bull trout collected from Flathead Lake during the years 1963, 1968, 1980 and 1981. The age structure of bull trout captured in gill nets in Flathead Lake during 1968 and during 1980 and 1981 were similar. Mature-aged bull trout (age six and older and about 450 mm total length) comprised 19 and 23 percent of the 1968 and 1980-81 catches, indicating that little change has occurred during that timespan. Bull trout collected during 1963 were generally four to eight percent larger at annuli than were those collected in 1968 and six to 17 percent longer than those collected in 1980 and 1981. Calculated lengths of Flathead Lake bull trout were as much as 18 to 25 percent smaller than was found in previous studies of Flathead Lake, but were similar to recent findings for spawning fish captured in tributaries to the North and Middle Forks of the Flathead River. Calculated growth was similar to that reported for four other lakes and reservoirs in the western United States.

More than 5,000 fish were captured in gill nets during the course of the study. Higher percentages of peamouth and squawfish and lower percentages of lake whitefish and kokanee in the 1980-1981 catch in comparison to catches made in the late 1960's were attributed to depths fished. The seasonal bull trout catch during 1980-1981 was largest in sinking nets and consistently ranged between 2.2 and 2.9 fish per net. The catch rate, average length, and percentage of trophy-sized bull trout (>634 mm or 25 inches) in the 1980-1981 gill net catch were similar to or larger than observed in the 1967-1970 catch. Almost all the 220 westslope cutthroat trout captured in gill nets during this study were taken in floating nets. The catch varied widely between seasons and ranged from a maximum of 3.3 fish per net in the spring to a minimum of 0.2 per net in the summer. Catches of kokanee and large lake trout increased in the fall, reflecting movement to shoreline spawning areas.

A limited program is recommended to monitor long-term fluctuations in fish and zooplankton populations in Flathead Lake so that potential adverse environmental conditions can be recognized. This program includes annual gill netting in the spring, biweekly zooplankton collections over a six-month period, and monthly kokanee stomach collections from anglers during four summer months.

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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 was designed to gather substantial amounts of baseline environmental and socio-economic information throughout the basin prior to the initiation of projected largescale exploitation of such resources as coal, gas, oil, timber and water.

The study has proven to be quite timely as this completion report has coincided with the submission of the Stage II Environmental Assessment of the proposed Cabin Creek coal mine (located on the North Fork of the Flathead River in Canada) to the provincial government of British Columbia. The Stage II Assessment is analagous to a final environmental impact statement in the United States.

Acquisition 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 July of 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 (*Oncorhynchus nerka*) are the principal sport fish sought by anglers in Flathead Lake during the summer months and are also the target of 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 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.

An interim report (Leathe and Graham 1980) summarized results obtained during the first half of the study. This completion document summarizes all results of the two-year study. The study objectives 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.

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 2, 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.

Flathead Lake is noted for its high quality waters which have an average alkalinity of 84 mg/L as $CaCO_3$ and average conductivity of about 150 micromhos per cm^2 (Stanford et al. 1981). The mean annual primary productivity was 123 grams carbon/m^2/year which was somewhat greater than was expected. While the lake was formerly thought to be quite oligotrophic, Stanford et al. (1981) concluded that it was in fact oligo-mesotrophic. Historical trends in lake productivity have not been determined but the fact that as much as 20 percent of the phosphorous input may have come from domestic sewage has raised concern for the future.

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 and nutrients. 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.

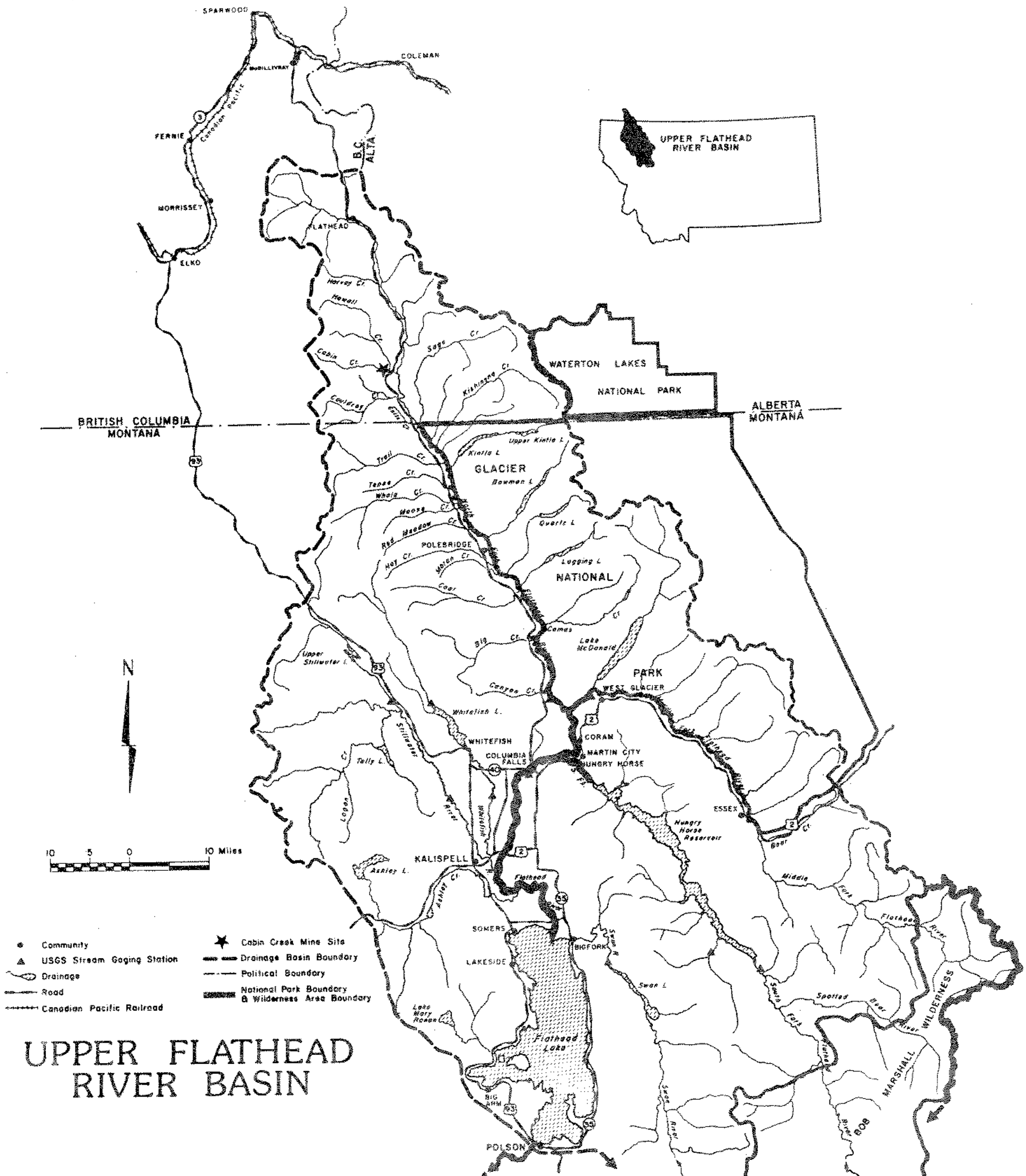


Figure 1. Map of the Upper Flathead River Basin. Adapted from Montana Department of Natural Resources and Conservation (1977).

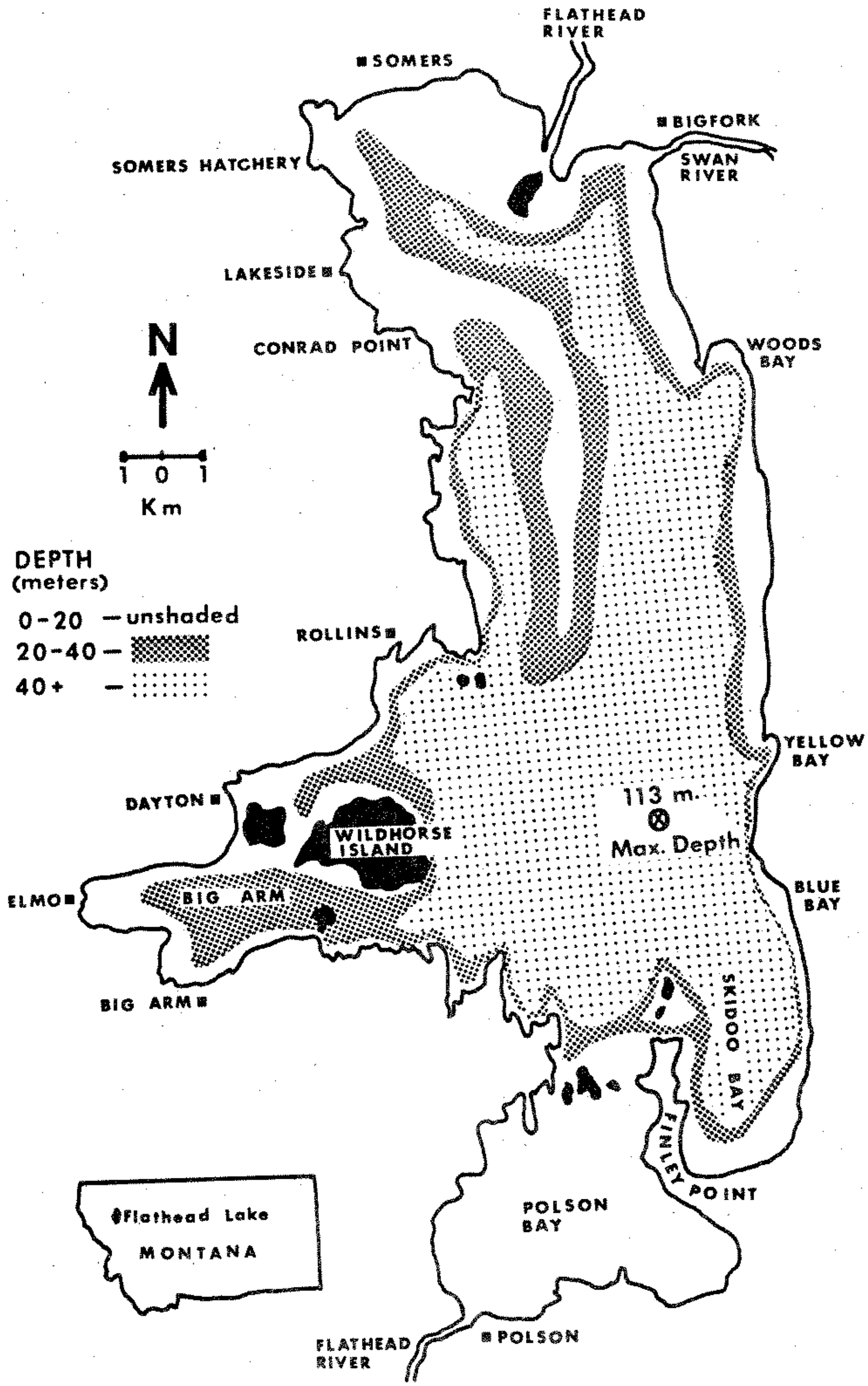


Figure 2. Map of Flathead Lake, Montana including 20 meter depth contours.

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

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*). Only a single rainbow trout (*Salmo gairdneri*) and one brook trout (*Salvelinus fontinalis*) were collected from the lake during this study.

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

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 three to six percent of the catch. A creel census and economic survey has been conducted on Flathead Lake by the Montana Department of Fish, Wildlife and Parks during the past year. The study was also funded by the Environmental Protection Agency and is part of the Flathead River Basin Environmental Impact Study. Results from that study will be published in late 1982.

More detailed descriptions of Flathead Lake and its drainage basin can be found in Potter (1978), Gaufin et al. (1976), and Stanford et al. (1981).

METHODS

PHYSICAL LIMNOLOGY

Temperature was measured to the nearest 0.5°C at one meter intervals to a depth of 30 m using an Applied Research FT3 hydrographic thermometer. Water transparency was estimated to the nearest 0.5 m using a 20 cm diameter Secchi disc.

FISH COLLECTION

Westslope Cutthroat and Bull Trout

A gill netting program was initiated to obtain westslope cutthroat and bull trout for age and growth analysis, food habits study and long-term monitoring of relative fish population size. Five of the 12 major regions of the lake were selected for gill netting (Figure 3) 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 usually netted per season. Only four areas were netted during the summer of 1980. A

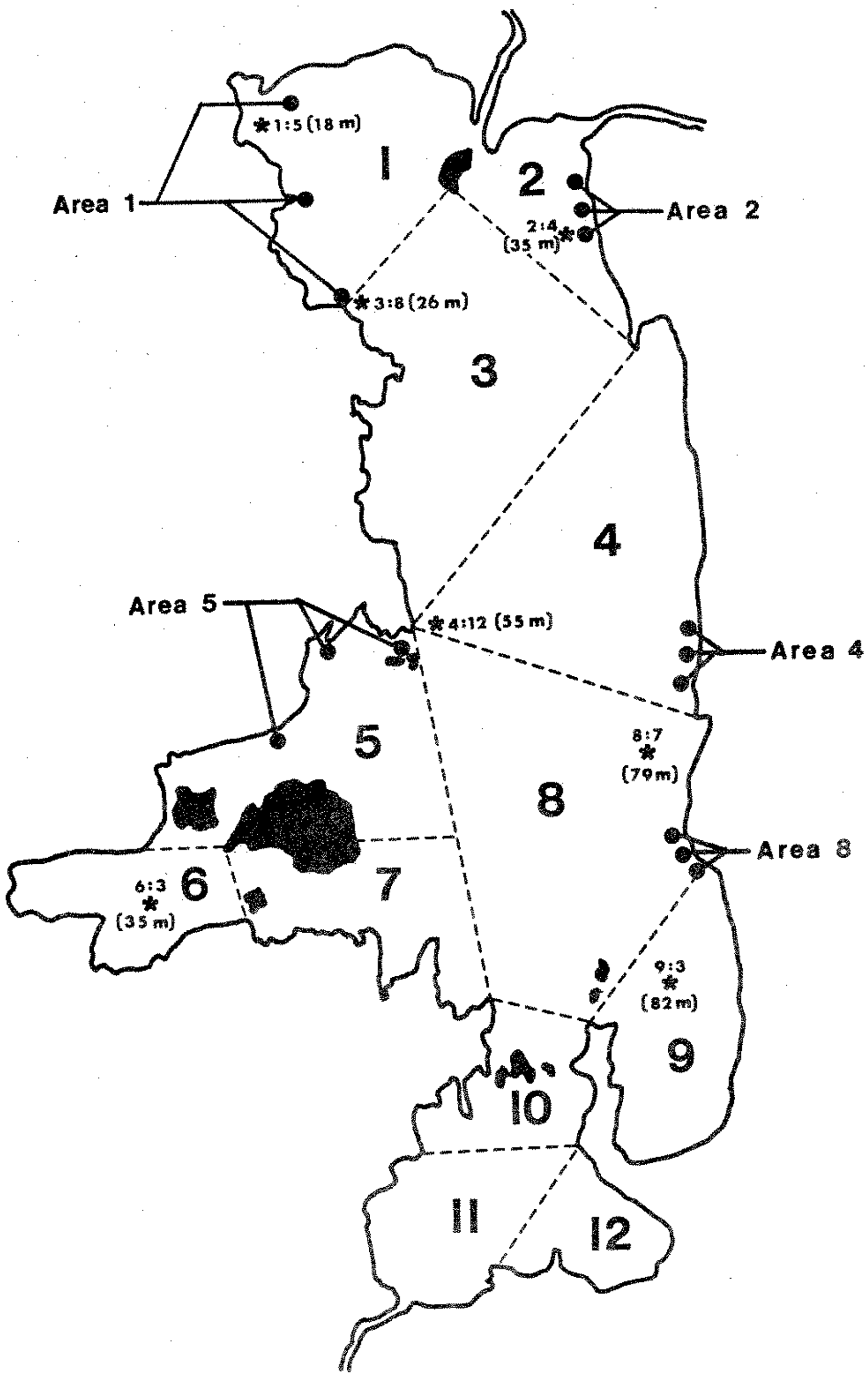


Figure 3. Map of Flathead Lake, Montana depicting major lake areas (1-12), seven zooplankton sampling stations (indicated by asterisks) with associated average depths (meters), and five gill netting areas.

summary of gill netting activities and corresponding limnological conditions during 1980 and 1981 is presented in Table 2.

A combination of multistrand nylon gill nets was used at each netting site. Two standard (1.83 m x 38.1 m; equivalent to 6' x 125') floating nets were tied end to end and set at each of three sites within each netting area. Floating sets were usually tied off to the shoreline. During the summer netting some floating sets were made offshore over deep water in an attempt to avoid excessive catches of rough fish (mainly northern squawfish and peamouth). The use of offshore floating sets did not alter the catch rates of westslope cutthroat trout which were the target species. The use of floating gill nets during the summer of 1981 was curtailed after two areas were netted (Table 2). This was due to the fact that an osprey was captured in one of these nets and cutthroat catches during this season were very low.

A variety of sinking gill nets was used in the 1980 netting and during the winter of 1981. During the summer of 1980, a single large sinking net was fished at two of the three netting sites within each area (Table 2). In October of 1980, two of the sites in Area One were fished with large sinking nets whereas each site in the remaining four areas was fished with either a large or a standard sinking net. In January of 1981, one site within each netting area was fished with a large sinking net and the remaining two sites in each area were fished with two standard sinking nets tied end to end. Sinking gill net sets were standardized for the remaining three 1981 netting periods. These sets consisted of two standard sinking nets tied end to end and set at each of three sites within each area.

Sinking nets were set perpendicular to the shoreline usually along sloping bottoms at depths ranging between 10 and 35 meters. Specific netting locations were determined using a Honda Si-Tex model HE-256 chart recording echosounder equipped with a 200 kHz transducer. Echosounder charts depicting lake bottom profiles are in Department files in Kalispell for all sinking gill net sets made during the spring, summer and fall of 1981.

All gill nets were constructed of equal length panels of 3/4, 1, 1¼, 1½, and 2 inch mesh (bar measure) which correspond to 19, 25, 32, 38, and 51 millimeters, respectively. Catch per unit effort data obtained using large sinking nets were converted to nets of standard size (1.83 x 38.1 m or 6' x 125') based on relative net area.

Additional cutthroat and bull trout scales and stomachs were obtained via creel census throughout the study and by purse seining during 1981.

Kokanee Salmon

Since standard gill netting procedures proved to be ineffective in capturing immature kokanee salmon, a variety of special techniques were employed to obtain specimens for food habits analysis. Young-of-

Table 2. Summary of gill netting activities and corresponding limnological conditions on Flathead Lake during 1980 and 1981.

Year	Dates	Net type a/	Total No. sets	No. areas	Mean secchi	Mean water temp. upper 15m, Sta 2:4	Thermocline present?
1980	Jul 29 - Aug 14	A	4	4	9.6m	17.7°C	yes
		B	4	4		(10.2-23.6) b/	
		D	24	4			
1980	Oct 6-20	A	5	5	8.3m	11.9°C	Oct 2 - yes
		B	1	1		(8.6-13.6)	Oct 16 - no
		C	8	4			
		D	30	5			
1981	Jan 7-21	A	5	5	7.3m	5.0°C	no
		C	20	5		(4.5-5.5)	
		D	30	5			
1981	Apr 9-22	C	30	5	5.8m	4.9°C	no
		D	30	5		(4.5-5.9)	
1981	Aug 10-18	C	30	5	8.3m	17.2°C	yes
		D	12	2		(12.5-20.5)	
1981	Oct 27 - Nov 10	C	30	5	7.1m	10.1°C	Oct 28 - yes
		D	30	5		(9.5-11.0)	Nov 12 - no

a/ Net types:
- A. Large sinking net; 2.44m x 76.2m (8'x250')
- B. Large sinking net; 2.44m x 64m (8'x210')
- C. Standard sinking net; 1.83m x 38.1m (6'x125')
- D. Standard floating net; 1.83m x 38.1m (6'x125')

b/ Temperature range: 15 m to surface

the-year and age I+ kokanee were collected using a 2.43 m x 2.43 m mid-water trawl towed behind the *Dolly Varden* which was a 9.7 m commercial seining boat owned and operated by the Department on Flathead Lake. The trawl was developed by Hanzel (1976a, 1976b, 1977b) and is 12.16 m long with 1.6 mm mesh (bar measure) in the cod end. This net was capable of retaining fish as small as 13 mm (Hanzel 1976a). Trawling was conducted at night in areas where concentrations of small kokanee were detected using hydroacoustical gear aboard the *Dolly Varden*. Hanzel (1974a) found that kokanee in Flathead Lake tended to concentrate in deeper water at night, hence trawling success was best after dark near the bottom in 20-30 meters of water. Inadequate docking facilities during periods of low pool elevation of Flathead Lake and icing problems during winter limited the use of the *Dolly Varden* to the period of June through early December. Consequently, food habits information on small kokanee was obtained almost solely during this timespan.

Shoreline tows using a one meter diameter fry net with 1.35 mm mesh were made in two known lakeshore kokanee spawning areas during mid-May of 1981 in an attempt to document the feeding habits of newly emergent kokanee fry. Five tows made during a three-hour period after dark in Hatchery Bay (Area 1) on 14 May collected eight redside shiners (39-96 mm), and one sculpin; but no kokanee fry. Six tows made during a five-hour period in Woods Bay spawning area (Area 4) on the night of 13 May produced 18 redside shiners (29-99 mm), four kokanee fry (26-28 mm) and one yellow perch. Only one of the kokanee fry collected had been feeding.

A total of 22 mid-water trawl hauls were made in the northwest portion of the lake during early June of 1981 in a continued effort to collect kokanee fry. The total catch consisted of 108 whitefish (8-158 mm), 151 yellow perch (9-15 mm), and only 10 kokanee fry (25-35 mm). Most of the kokanee fry were collected at night in the 20-60 foot depth interval. Young kokanee and sockeye have been found to concentrate in the surface waters of lakes at night during the spring and early summer (Rieman and Bowler 1980; Johnson 1961). However, our results indicated that this did not occur in the northwest quadrant of Flathead Lake.

Several techniques were employed to collect larger kokanee (age II+ and older) for food habits study. Creel census was used to gather most of the 1980 data and a smaller portion of the 1981 information for these fish. A 76.2 m x 7.6 m (250' x 25') single strand monofilament gill net with equal length panels of previously described mesh sizes was used sporadically. This net was effective when properly set at the correct depth interval in areas where sufficient concentrations of kokanee were detected using hydroacoustical gear. In addition to the above, a purse seine developed by Hanzel (1972a) was used during 1981 to obtain representative samples of two through four year old kokanee in the northwest portion of the lake. This net was 171 m long (560 feet) and 20 m deep (65 feet) and was designed to fish to a depth of approximately 15 meters. Operation of this net required the use of the *Dolly Varden* plus a large wooden barge, a small boat and a crew of five people. Detailed descriptions of the net and its operation have been presented by Hanzel (1971 , 1973).

Other Species

All pygmy whitefish obtained for food habits analysis were collected in the mid-water trawl during kokanee sampling. Mountain and lake whitefish stomachs were collected during seasonal gill netting activities around the lake in the spring, summer, and fall of 1981 and also by purse seining during 1981. Lake trout were collected by creel census and also during seasonal gill netting.

VERTICAL FISH DISTRIBUTION

Information on the depth preferences of the various fish species in Flathead Lake was obtained during the spring, summer, and fall of 1981 during gill netting operations. Depth fished by sinking gill nets was estimated by simultaneously operating the depth sounder while setting each net. Catches for each standard net were tallied separately and later were pooled for different depth strata. Depth strata were selected based on lake temperature profiles and on sample size for each stratum.

ZOOPLANKTON

Crustacean zooplankton populations were sampled monthly at seven locations on Flathead Lake during the period June 1980 through February 1981 (Figure 3). The number of monthly sampling stations was reduced to four (Stations 1:5, 2:4, 6:3 and 8:7) during the remainder of the study (April 1981 - January 1982) since no consistent differences were noted between stations during 1980 (Leathe and Graham 1981). Biweekly zooplankton collections were taken at Station 2:4 (Bigfork) to obtain a more accurate representation of crustacean zooplankton 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.

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 originally equipped with a Kalsico 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 of the net 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. Vertical surface (0-15 m), midwater (15-30 m), and deep (30-60 m) tows were taken at each station during 1980. Sampling in 1981 was restricted to short surface tows (0-15 m) and long surface tows (0-30 m). Short surface tows, long surface tows, and midwater tows were taken at the biweekly monitoring station throughout the course of the study.

The effectiveness of the Wisconsin net was tested by comparing it to collections made using a 28.1 liter Schindler plexiglass plankton trap (Schindler 1969). The plankton trap was also utilized to define the vertical distribution of crustacean zooplankton on several dates during 1981. Vertical distribution collections consisted of duplicate samples taken at each one meter interval to a depth of 25 or 30 meters. Duplicate samples were pooled by five meter intervals for enumeration. The same procedure was employed to evaluate the timing and extent of diel vertical zooplankton migrations in Area 1 during November of 1980.

Duplicate zooplankton samples were combined in the field and preserved in a mixture of four percent formalin with 40g/liter sucrose (Haney and Hall 1973). Samples were diluted in the laboratory and counts were made on each of five one-milliliter subsamples in a Sedgewick-Rafter cell. The enumeration of three to five subsamples typically results in a ± 10 to 15 percent estimate of true sample density (Kutkuhn 1958). Subsamples were withdrawn using a Hensen-Stempel pipette.

Plankton counts were made using either a binocular compound microscope at 40X or a dissecting microscope at 45X total magnification. Both microscopes were equipped with graduated mechanical stages. 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 were relatively large and seldom appeared in subsamples during zooplankton counts, yet they were important in the diet of kokanee salmon. Seven percent of each combined sample was examined under low power using a dissecting microscope. These organisms were counted and their densities were expressed as numbers per cubic meter of water.

Zooplankton from the south end of Whitefish Lake were collected and analyzed during 1981 using procedures identical to those described above.

KOKANEE FOOD HABITS

Kokanee stomachs were emptied into labeled plastic vials and preserved with a solution of four percent formalin with 40 grams per liter sucrose. Stomach contents from all fish in each age group collected on a given date were pooled except when differences in food composition were noted between fish or between groups of fish. The samples were diluted and the contents of five one-milliliter subsamples were counted using a Sedgewick-Rafter cell at 40X total magnification under a compound microscope.

Intact food organisms in kokanee stomachs and in associated vertical plankton tows were measured to the nearest 0.01 mm using an ocular micrometer at 40X (total magnification) during 1980. The size of *Daphnia thorata* ingested was inferred through measurements of the post-abdominal claw as was described in Leathe and Graham (1981). Few copepods were measured because kokanee selected almost exclusively for adult instars which displayed little variation in body length. Measurements on all crustaceans were made from the anterior margin of the head to the posterior margin of the body, excluding terminal spines or setae.

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 Shushkina (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). *Leptodora* biomass was estimated using data provided by Cummins et al. (1969).

TROUT FOOD HABITS

Cutthroat and bull trout from gill net catches were immediately placed on ice during warm weather periods and were 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 weight of each taxonomic group of food items in each cutthroat stomach were recorded. Cutthroat trout stomachs were subsampled when large numbers of small items were eaten. This was especially necessary in the spring when some stomachs were found to contain thousands of dipteran pupae and adults. Large food items were removed and weighed prior to subsampling. Wet weights of food categories were measured to the nearest .01 g after removing excess water using paper towels.

Similar techniques were employed in bull trout food habits analysis. Subsampling of bull trout stomachs was never necessary since the majority of the stomach contents were fish. A variety of morphological features were used to identify forage fish species. The original length and degree of digestion for each ingested fish were estimated.

An index of relative importance (IRI) was calculated to estimate the importance of a particular food item in the diet (George and Hadley 1979). The IRI incoporates 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 the latter value indicating exclusive use of a food item.

WHITEFISH FOOD HABITS

A combination of techniques was used to analyze the stomach contents of the three whitefish species. Some whitefish stomachs contained only zooplankton and these were analyzed using the same procedure used for kokanee stomachs. Other stomachs contained only macorinvertebrates and these were analyzed using the same technique employed for cutthroat trout. When a combination of food types was encountered, the non-zooplankton items were sorted and weighed and the zooplankton portion was subsampled. Biomass of zooplankton species was calculated using previously described length-weight equations. Index of relative importance calculations were not made for whitefish species due to problems encountered with the enumeration of food items such as bryozoa and organic debris.

DIET OVERLAP

The Schoener overlap index (Schoener 1970) was used to determine the degree of diet overlap between six fish species in Flathead Lake during the period April through November 1981. This index was recommended by Wallace (1981) and was calculated as follows:

$$a = 1 - 0.5 \left(\sum_{i=1}^{n} P_{xi} - P_{yi} \right)$$

where: a = Schoener overlap index
P_{xi} = proportion of food category i in the diet of fish species x
and P_{yi} = proportion of food category i in the diet of fish species y

The value for this index can range between zero and 1.0. A low value indicates a small degree of diet overlap whereas a value approaching 1.0 indicates a high degree of diet overlap between the two fish species.

ZOOPLANKTON CROPPING

Zooplankton cropping by planktivorous fishes was estimated using two approaches. The first approach included only age III and older kokanee. Their density was estimated on a lakewide basis during the late summer using hydroacoustical equipment (D.A. Hanzel, Montana Department of Fish, Wildlife and Parks, in preparation). The average number of each zooplankton prey species eaten per day by an individual kokanee was estimated by multiplying maximum number of organisms observed in any collection of kokanee stomachs during the entire study by a factor of two. Rieman (1978) concluded that daily meal estimates calculated for kokanee from Pend Oreille Lake using a similar technique were reasonably accurate when compared to estimates obtained using a more detailed approach involving measurements of feeding periodicity and rate of gastric evacuation.

In the second approach, seven purse seine hauls with concurrent plankton collections provided fish population density and food habits information for kokanee, lake whitefish and mountain whitefish as well as plankton density estimates in the immediate vicinity of each haul. Fish were collected by purse seining in the northwest portion of the lake (Area 1) from 22 June to 1 July, 1981. The number of *Daphnia* or *Epischura* consumed by a given age class of kokanee or by lake and mountain whitefish was estimated by multiplying the maximum number of plankton observed per stomach in each group collected during June and July by a factor of two based on the assumption that these fish consumed two stomachfuls of food per day.

TROUT AGE AND GROWTH

Total body length of cutthroat and bull trout collected during the study was measured to the nearest millimeter. Body weight was estimated to the nearest gram for fish weighing 500 grams or less or to the nearest five grams (.01 pound) for fish weighing more than 500 grams. Scales were taken from an area just above the lateral line along an imaginary line drawn between the posterior insertion of the dorsal fin and the anterior insertion of the anal fin. Otolith bones were removed from the fish and stored in scale envelopes in a dry state. Otoliths were later placed in water and examined at 15X total magnification using a dissecting microscope.

Cellulose acetate impressions of scales were examined at 43X magnification during 1980 and at 71X during 1981 using microfiche readers. Distances from the focus to annuli were measured to the nearest millimeter using transparent plastic rules and recorded directly onto computer coding sheets.

Age and growth information was analyzed using the FIRE 1 computer program described by Hesse (1977) and also the AGEMAT program devised by Department personnel. Body length-scale radius relationships were most accurately described using log-log plots constructed from pooled samples of tributary and lake fish. Condition factors were calculated as $(W \times 10^5)/L^3$, where "W" equaled weight in grams and "L" equaled total fish length in millimeters.

Historical trends in the growth of cutthroat and bull trout in Flathead Lake were obtained through scale collections made by Montana Department of Fish, Wildlife and Parks personnel in previous years. Most of these scales were obtained during a 1963 creel census (Robbins 1966) and by gill netting during the years 1967-1972 (Hanzel 1970, 1971, 1972b). Additional scales were infrequently collected by game wardens.

RESULTS AND DISCUSSION

PHYSICAL LIMNOLOGY

Water temperature is a very important factor regulating the biological community within Flathead Lake. Seasonal changes in lake thermal structure strongly 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.

Average temperature of the lake surface waters (to 15 m) at Bigfork displayed similar trends in both study years, although surface waters were warmer during the late summer and early fall of 1981 (Figure 4). Maximum average water temperatures in these waters were 18.6°C in 1980 and 19.4°C in 1981. Average surface water temperatures for Flathead Lake were similar to or higher than those reported for Pend Oreille Lake, Idaho during the period 1974-1978 (Rieman and Bowler 1980).

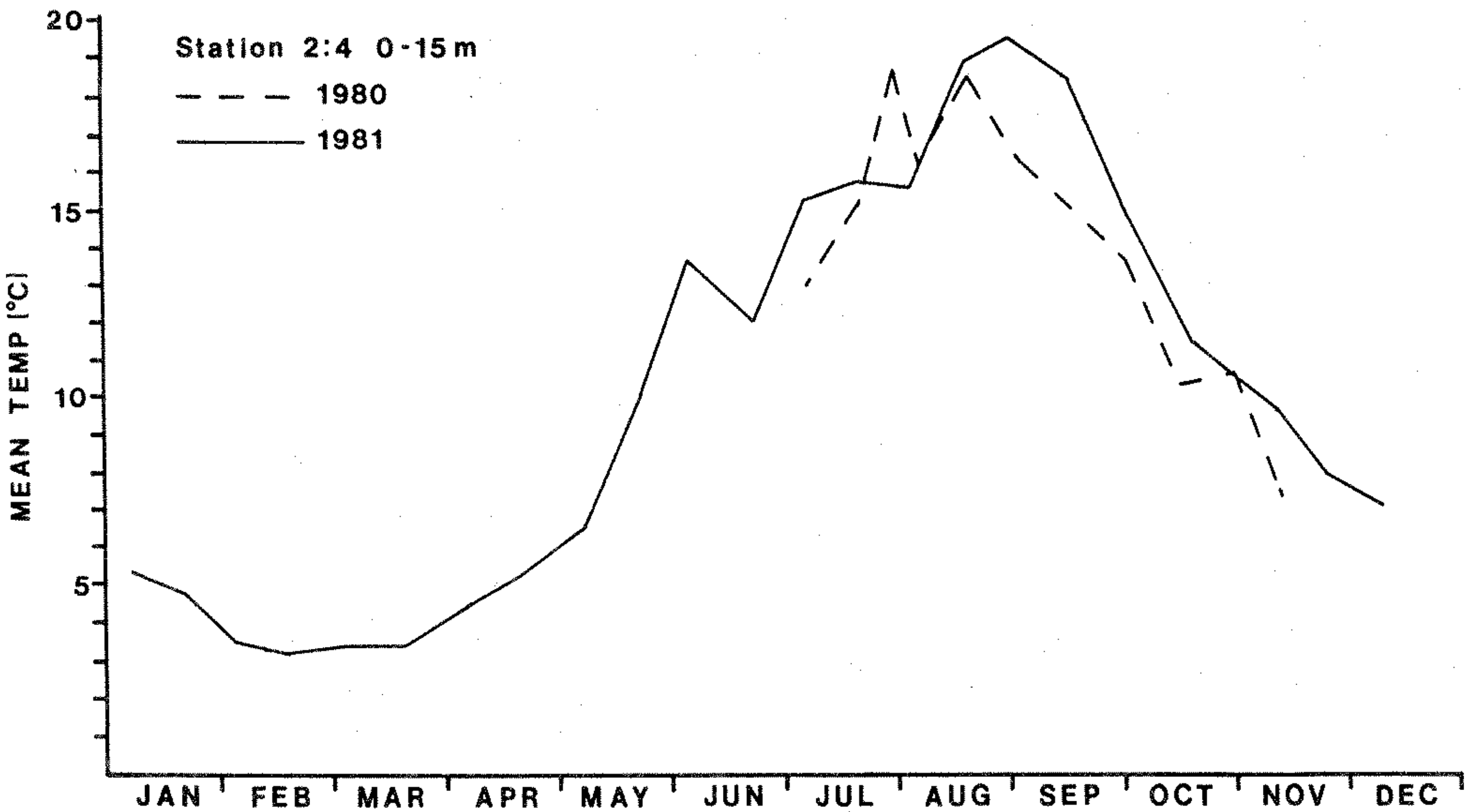


Figure 4. Mean water temperature (°C) in the surface waters (0-15m) at Station 2:4 of Flathead Lake during 1980 and 1981.

Seasonal isotherm plots for Station 2:4 indicate that the lake was isothermal during the months of December through May (Figure 5). Potter (1978) concluded that regions of the lake having deep water are usually monomictic and typically undergo continuous holomictic circulation when water temperatures are at or below 8°C. Many of the peripheral bays are dimictic because they freeze over during most winters, but instances of ice cover of the entire lake surface are rare and are usually brief. The longest period of total ice cover on record occurred during 1979 when total ice cover existed for a 75-day period extending between January 9 and March 25 (Hanzel 1980). Complete ice cover also occurred during the winter of 1968-1969, although there is some disagreement as to the duration of total ice cover (Hanzel 1970; Gaufin et al. 1976). Hanzel (1970) also reported total ice cover during 1962, but Gaufin et al. (1976) reported it only for 1969 and 1946.

A thermocline (depth where water temperature changes 1°C or more per meter of depth) was present at the Bigfork station during the month of June, 1981 and existed through late October in both years (Figure 5). The location and width of the thermocline was variable which is quite typical for Flathead Lake (Potter 1978; Gaufin et al. 1976). Thermal stratification was usually weak. Thermoclines usually occurred at depths ranging from five to 15 m and metalimnion width (zone where temperature changed at least 1°C per meter) was usually between one and three meters with a maximum of five to eight meters.

The degree of thermal stratification on large lakes such as Flathead and Pend Oreille is strongly influenced by wind speed and direction which can cause disruptive internal seiches as was found by Rieman and Falter (1976). These factors were probably responsible for the observed variations in temperature regimes at four locations on Flathead Lake during 1981 (Figure 6). Thermal stratification at most stations was most pronounced and deepest during late August and in early October, 1981 (Figure 6).

The secchi disc is useful in monitoring turbidity which can have an effect on the distribution and abundance of fish and zooplankton in the lake. Secchi disc readings at Bigfork ranged between 0.8 m and 11.0 m and averaged 7.6 m (n=39) throughout the course of this study (Figure 6). The minimum value of 0.8 m occurred on 7 May, 1981 when a large volume of sediment-laden runoff from the Flathead River entered the northeast corner of the lake. Highly variable lakewide secchi disc readings in May and June (Figure 6) resulted because turbid runoff waters had not dispersed down the lake. Maximum secchi disc readings ranged between 11m and 13 m and usually occurred between late July and early October. Potter (1978) reported that maximum secchi depths of 8 m to 12 m and even 17 m occurred during late summer in Flathead Lake during 1972 and 1973. Slight declines in fall and winter water transparency were attributed to increased phytoplankton densities stemming from increasing nutrient availability during periods of holomictic circulation (Potter 1978).

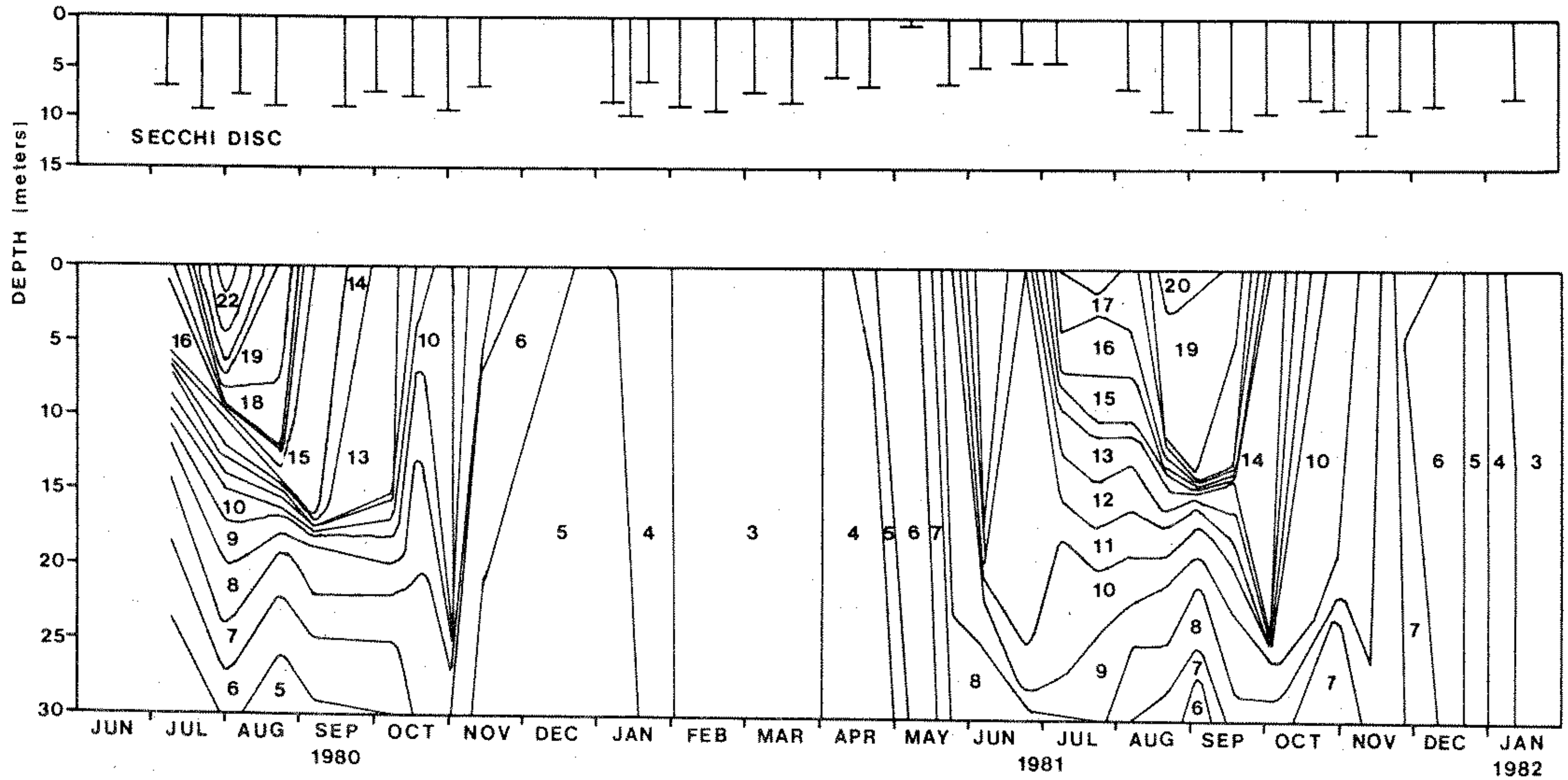


Figure 5. Seasonal isotherms (°C) and secchi disc readings (meters) at Station 2:4 on Flathead Lake during the period June 1980 to January 1982.

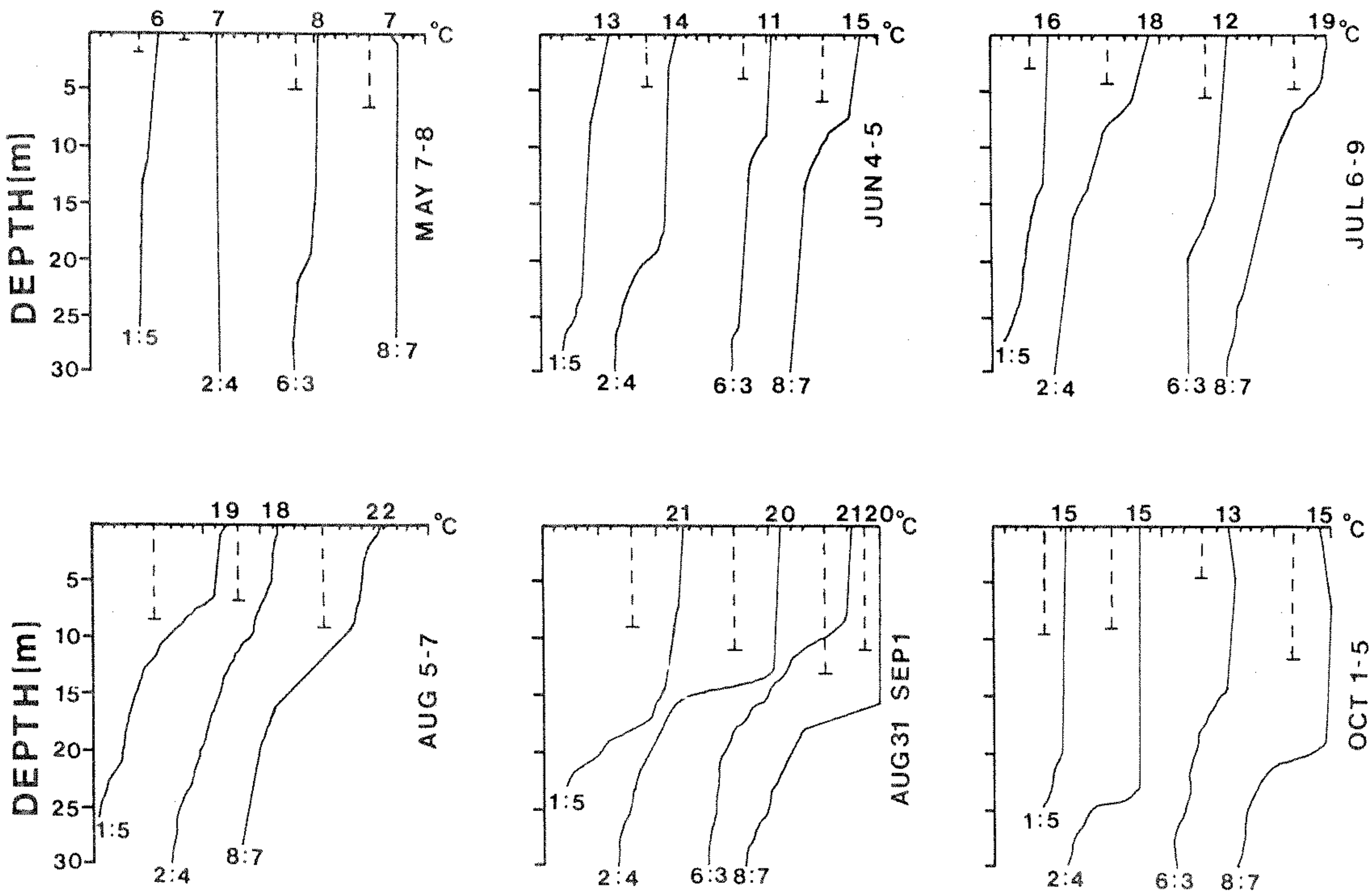


Figure 6. Monthly temperature profiles (°C) and secchi disc readings (meters) at four stations on Flathead Lake during the period May through October, 1981. Surface temperature is presented on the x-axis for each profile.

ZOOPLANKTON

As will be shown in the following sections of this report, crustacean zooplankton were important in the diets of many fish species in Flathead Lake. Many of these fish species were, in turn, significant components of the bull trout diet. Kokanee salmon, an important sport fish, fed almost exclusively on crustacean zooplankton throughout the year in Flathead Lake. An understanding of the seasonal changes in the species composition and abundance of the zooplankton was needed to analyze fish food habits in Flathead Lake and could be useful in analyzing trends in the abundance and vigor of forage fish populations. Potential changes in lake water quality resulting from developments such as coal mining in the North Fork drainage could alter the species composition and/or abundance of crustacean zooplankton populations in the lake. Such changes could have significant impacts on fish populations.

Methods Comparisons

The reliability of our plankton sampling method was determined by comparing results obtained using the metered Wisconsin net with those obtained using a Schindler plexiglass plankton trap. The latter sampler was considered to be one of the most efficient zooplankton sampling devices (Schindler 1969; Prepas and Rigler 1978); however, the exclusive use of this sampler on Flathead Lake was impractical for the purpose of this study because of the large amount of time reqired to obtain representative samples of the entire water column.

Shallow surface (0-15 m) comparisons between the Schindler plankton trap and the metered Wisconsin net were conducted on seven dates during 1980 and 1981 (Table 3). Although variations existed between dates, the average efficiency of the Wisconsin net was quite similar to the Schindler trap for all species (Table 3). Comparisons between calculated zooplankton densities using each sampler were made using a paired t-test (Lund 1979). Differences between samplers were nonsignificant ($.25 \leq p \leq .74$) for all species of zooplankton with one exception. The difference between densities of *Daphnia thorata* obtained using the two samplers was marginally significant ($p<.07$). This indicates that density estimates based on Wisconsin net tows may be lower than the "correct" density by an average of approximately 22 percent (Table 3). Schindler (1969) found metered tow nets to be an average of 60 percent as efficient as his plankton trap for collecting *Daphnia* in 10 m tows.

The Wisconsin net was found to be much less efficient in collecting most species than was the Schindler trap for midwater tows (Table 4). The reasons for this are unclear, but because of these findings zooplankton densities are not presented for midwater tows in this report. Comparisons between the two samplers for long surface tows (0-30 m) are also presented in Table 4. Considerable variation was noted for some species, particularly the cladocerans *Daphnia* and *Bosmina*. Densities of these organisms in Wisconsin net tows were apparently underestimated by an average of nearly 50 percent (Table 4). Statistical comparisons of the two sampling methods

Table 3. Sampling efficiency (percent) of metered Wisconsin net as compared to the Schindler plankton trap for short vertical surface tows (0-15 m) in Flathead Lake during 1980 and 1981. The Schindler trap was assumed to be 100 percent efficient.

Date	Station	*Daphnia*	*Bosmina*	*Diaptomus*	*Cyclops*	Nauplii	*Epischura*	*Leptodora*	Mean
30 Oct 1980	2:4	71	93	87	91	69	109	---	87
2 Jul 1981	1:12	74	80	92	80	69	70	140	86
6 Jul 1981	2:4	109	175	110	127	136	289	89	148
21 Jul 1981	2:4	94	92	105	96	189	79	70	104
7 Aug 1981	1:5	101	180	67	127	72	164	39	107
2 Sep 1981	2:4	36	16	82	95	87	40	194	59
19 Oct 1981	2:4	63	110	76	67	86	73	157	79
Mean		78	107	88	98	101	118	115	

Table 4. Sampling efficiency (percent) of metered Wisconsin net as compared to the Schindler plankton trap for midwater vertical tows (15-30 m) and long surface vertical tows (0-30 m) in Flathead Lake during 1980 and 1981. The Schindler trap was assumed to be 100 percent efficient.

Date	Station	*Daphnia*	*Bosmina*	*Diaptomus*	*Cyclops*	Nauplii	*Epischura*	*Leptodora*	Mean
Midwater (15-30 meter) tows									
30 Oct 1980	2:4	31	33	44	73	79	---	---	52
6 Jul 1981	2:4	58	102	28	62	177	---	---	85
2 Sep 1981	2:4	24	---	75	43	178	36	---	71
19 Oct 1981	2:4	20	39	70	56	231	---	---	59
Mean		33	58	54	59	166	---	---	
Long surface (Sur-30 meter) tows									
6 Jul 1981	2:4	78	81	80	85	198	327	65	131
2 Sep 1981	2:4	36	21	87	78	195	221	106	106
19 Oct 1981	2:4	46	61	69	70	152	89	161	93
Mean		53	54	79	78	182	212	111	

for midwater and long surface tows were not attempted due to small sample sizes.

The filtering efficiency of the Wisconsin net for short surface tows at the biweekly monitoring station varied seasonally between 38 and 68 percent. The average filtering efficiency for these tows was 56 percent (S.D. = 7%; n = 68). The filtering efficiency of the same net for long surface tows varied between 22 and 65 percent with an average of 45 percent (S.D. = 11%; n = 36).

Seasonal Abundance Trends

The crustacean zooplankton community of Flathead Lake was dominated by four species of cladocerans and three copepod species during the period June, 1980 to January, 1982 (Table 5). The largest organism found in plankton samples was *Leptodora* which is predatory on other zooplankton species and can attain a length of up to 18 mm (Edmondson 1966). The other three species of Cladocera are filter feeding herbivores and were usually less than 2.0 mm in length (Table 5). The largest copepod found in Flathead Lake was *Epischura*, which is predatory on smaller zooplankton species. The copepod *Diaptomus* is a filter feeding herivore, and the smallest copepod, *Cyclops*, is classified as an omnivore.

Most plankton species were present year-round except the two *Daphnia* species which were found mostly during the period April through December (Figure 7). The copepods *Cyclops* and *Diaptomus* together comprised an average of 81 percent of plankton density (excluding copepod nauplii) in the surface waters (0-30 m) at Station 2:4 during the study period. *Diaptomus* was the most numerous organism and comprised an average of 54 percent of the crustacean zooplankton population. Cladocera comprised approximately 19 percent of plankton density on the average with *Daphnia thorata* and *Bosmina* accounting for nine and seven percent of this total. The large predators *Leptodora* and adult *Epischura* comprised a small portion of the plankton community and accounted for only 0.1 and 0.2 percent of average density. Total plankton density peaked at approximately 30/L in July and August of 1980 and in late June of 1981 (Figure 7).

Daphnia thorata first appeared in the limnetic waters of Flathead Lake during early April of 1981 and was present in the plankton community until mid-January (Figure 8). *D. thorata* densities were similar during 1980 and 1981 with maximum densities of 3.56/L and 2.56/L recorded in surface (0-30 m) tows. The maximum density recorded in 1981 shallow surface tows (0-15 m) at this station was 4.5/L on 21 July. Potter (1978) reported maximum densities of 3.0 to 3.5/L for this organism in certain 5 m surface strata of Flathead Lake during 1971 and 1973.

Daphnia thorata was typically absent from winter plankton samples from Flathead Lake because it overwintered in the resting (ephippial) egg stage. Male *D. thorata* first appeared in Bigfork plankton samples in mid-September of both years. Females carrying ephippial eggs were first observed in early October, 1980 and mid-October of 1981. In

Table 5. Length (mm) and biomass (micrograms, dry weight) of the principal crustacean zooplankton species in Flathead Lake.

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

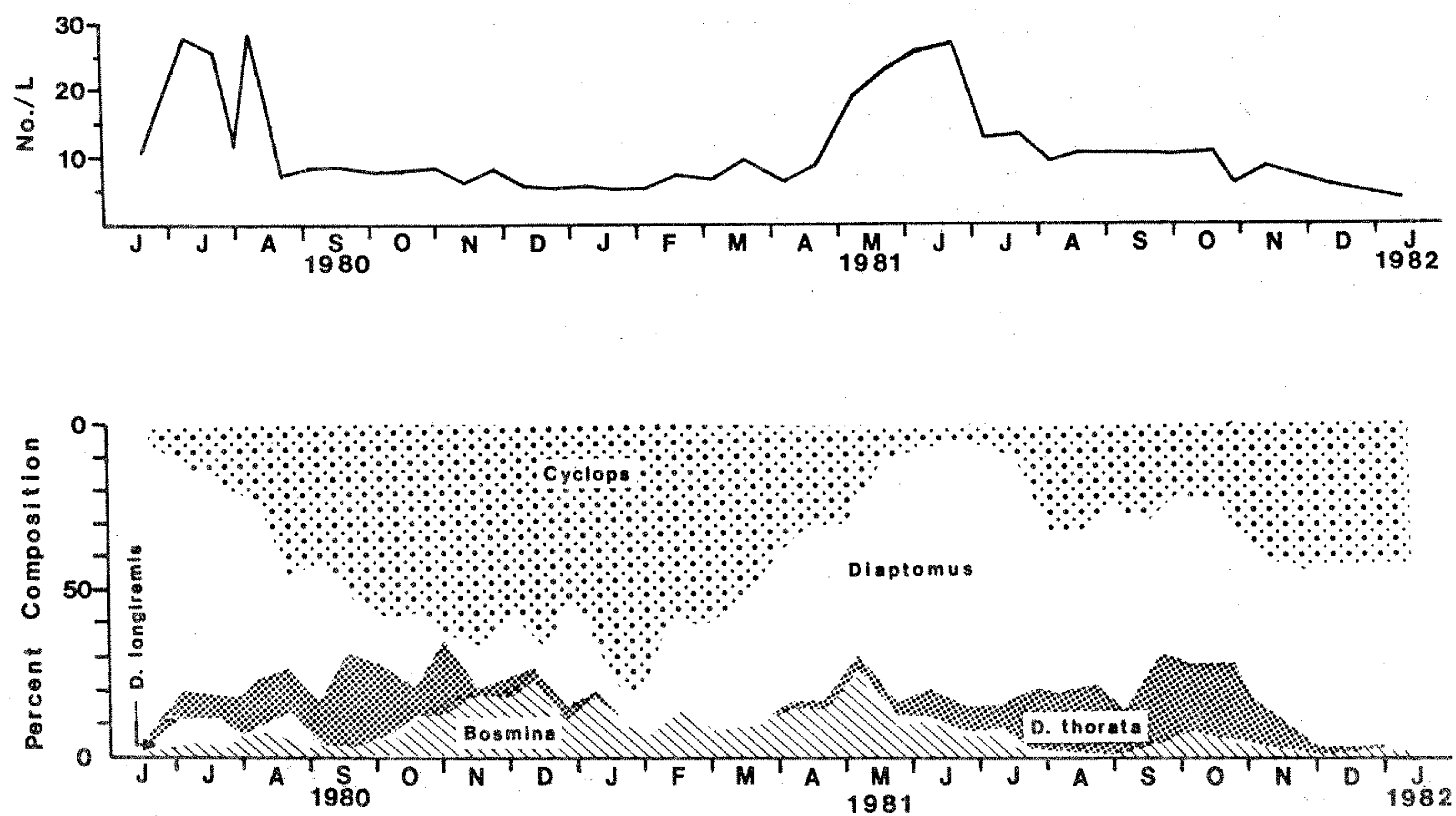


Figure 7. Seasonal fluctuations in total density (No./L; upper figure) and species composition (percent of density; lower figure) of the principal crustacean zooplankton exclusive of copepod nauplii in the surface waters (0-30m) at Station 2:4 of Flathead Lake during the period June 1980 to January 1982.

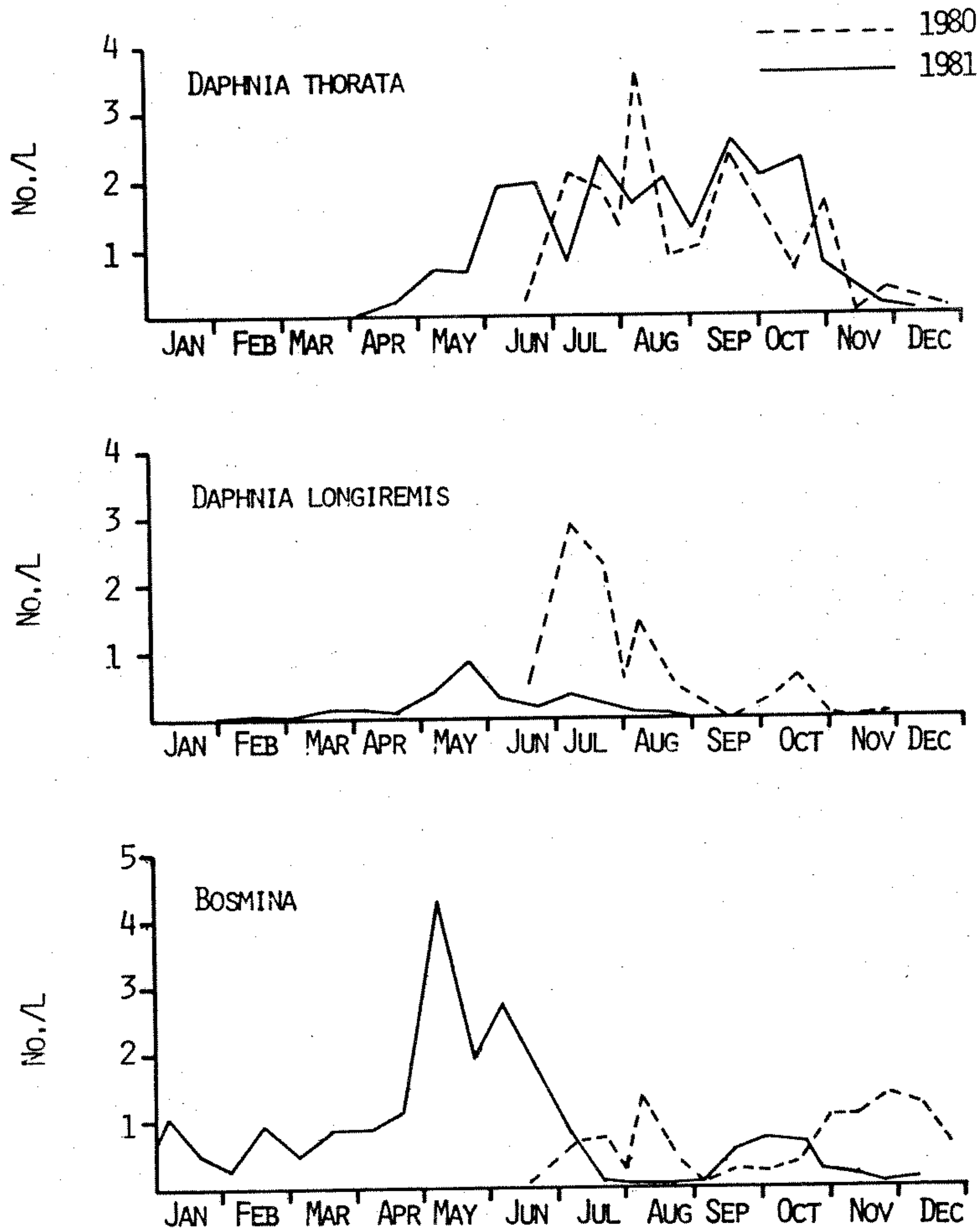


Figure 8. Seasonal density trends (No./L) of the three principal cladoceran species in the surface waters (0-30m) at Station 2:4 of Flathead Lake during 1980 and 1981.

November of each year, most of the *D. thorata* population was comprised of males and ephippium-bearing females. Similar findings were reported by Potter (1978).

The seasonal abundance pattern and population maxima for *D. thorata* in Flathead Lake were similar to that reported for Pend Oreille Lake in Idaho prior to the introduction of *Mysis* (Rieman and Falter 1981; Rieman and Bowler 1980). Trends were also similar for this species in Whitefish Lake during 1981 with the exception that maximum density in Whitefish Lake was 9.7/L in 0-15 m tows made in early July (Figure 28).

Densities of *Daphnia longiremis* were noticeably different between 1980 and 1981 at Bigfork (Figure 8). A peak *D. longiremis* density of 2.86/L occurred in early July of 1980 and the population remained at a relatively high level through the summer. This is unusual since Potter (1978) reported that population maximum for this species usually occurred in late February or early March. It is felt that the 1980 specimens were correctly identified as *D. longiremis* and were not *D. rosea*. The 1981 *D. longiremis* population was smaller than the 1980 population and peaked at approximately 0.8/L in late May.

Bosmina was present year-round in the plankton at Station 2:4 (Figure 8). The peak density was 4.3/L in early May which was similar to that reported by Potter (1978) for Flathead, and by Rieman and Bowler (1980) for Pend Oreille Lake in Idaho. Peak *Bosmina* densities in short surface tows (0-15 m) in Flathead and Whitefish lakes were similar during 1981 (Figure 28). Peak *Bosmina* density in 0-15 m tows in Whitefish Lake was 8.3/L.

The copepod *Diaptomus ashlandi* was the most numerous crustacean zooplankton species in Flathead Lake during 1980 and 1981 (Figure 9). Peak copepodite densities in excess of 20/L occurred during the summer of both years. These results were consistent with those of Potter (1978). *Diaptomus* numbers usually peaked in August at densities ranging between 10/L and 20/L in Pend Oreille Lake (Rieman and Bowler 1980). For unknown reasons, *Diaptomus* was virtually absent from the Whitefish Lake plankton community during 1981 (Figure 29). Substantial variation of *Diaptomus* populations in Coeur d'Alene Lake, Idaho has been observed over a four-year period (Bowler and Rieman 1981).

The *Cyclops* population in Flathead Lake fluctuated between 1.0 and 6.0/L during 1980 and 1981 (Figure 9). These densities were lower than those reported by Potter (1978) who found densities of up to 21/L in Flathead Lake during the early 1970's. *Cyclops* densities in Flathead Lake were also much lower than in Whitefish Lake during 1981 (Figure 29).

Seasonal density trends of *Leptodora* and adult *Epischura* were similar in 1980 and 1981 with the exception that maximum *Leptodora* density in 1980 was three times higher than it was in 1981 (Figure 10). The phenology and range of density for adult *Epischura* in Flathead Lake during 1980

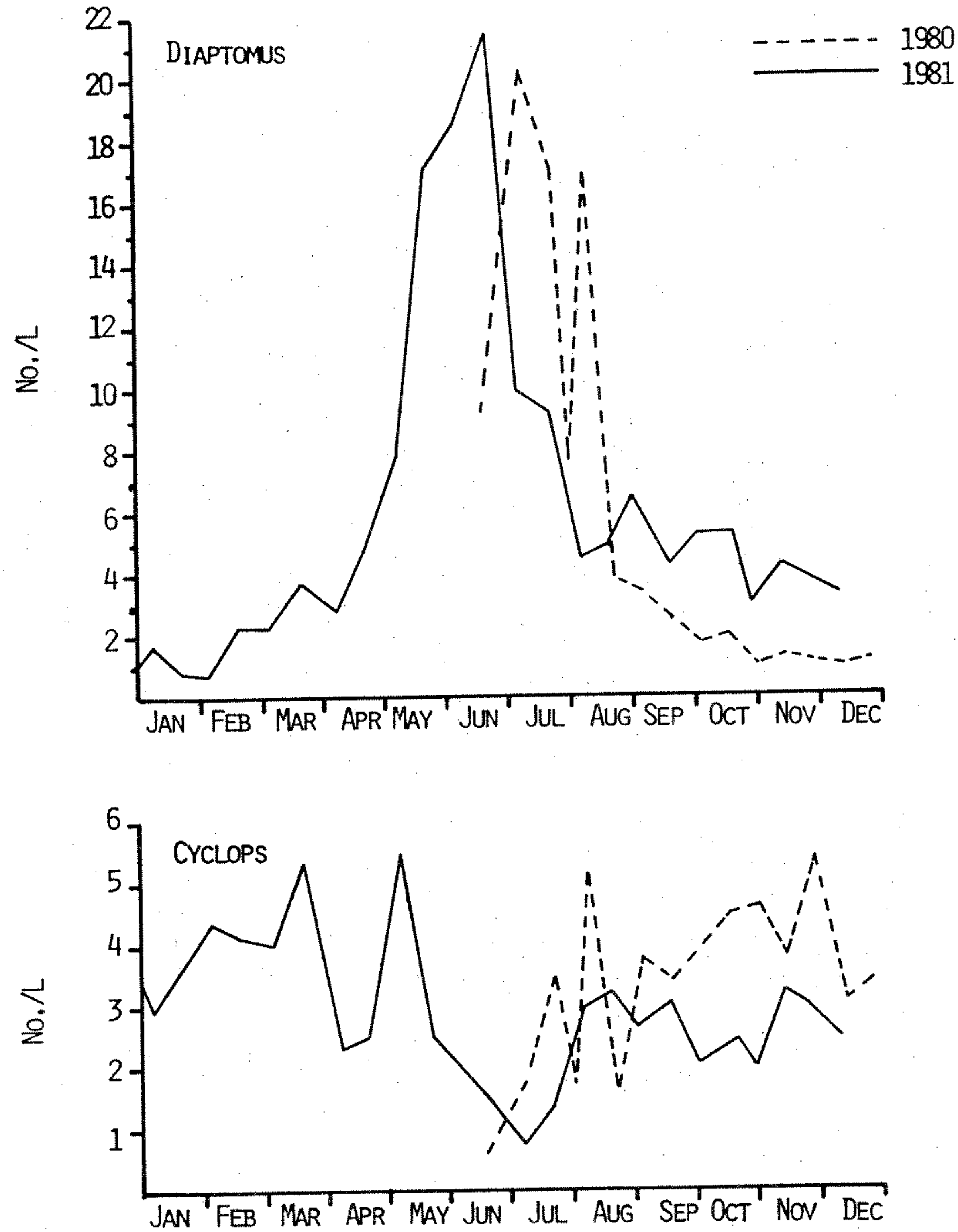


Figure 9. Seasonal density trends (No./L) of the copepods *Diaptomus* and *Cyclops* in the surface waters of Flathead Lake during 1980 and 1981.

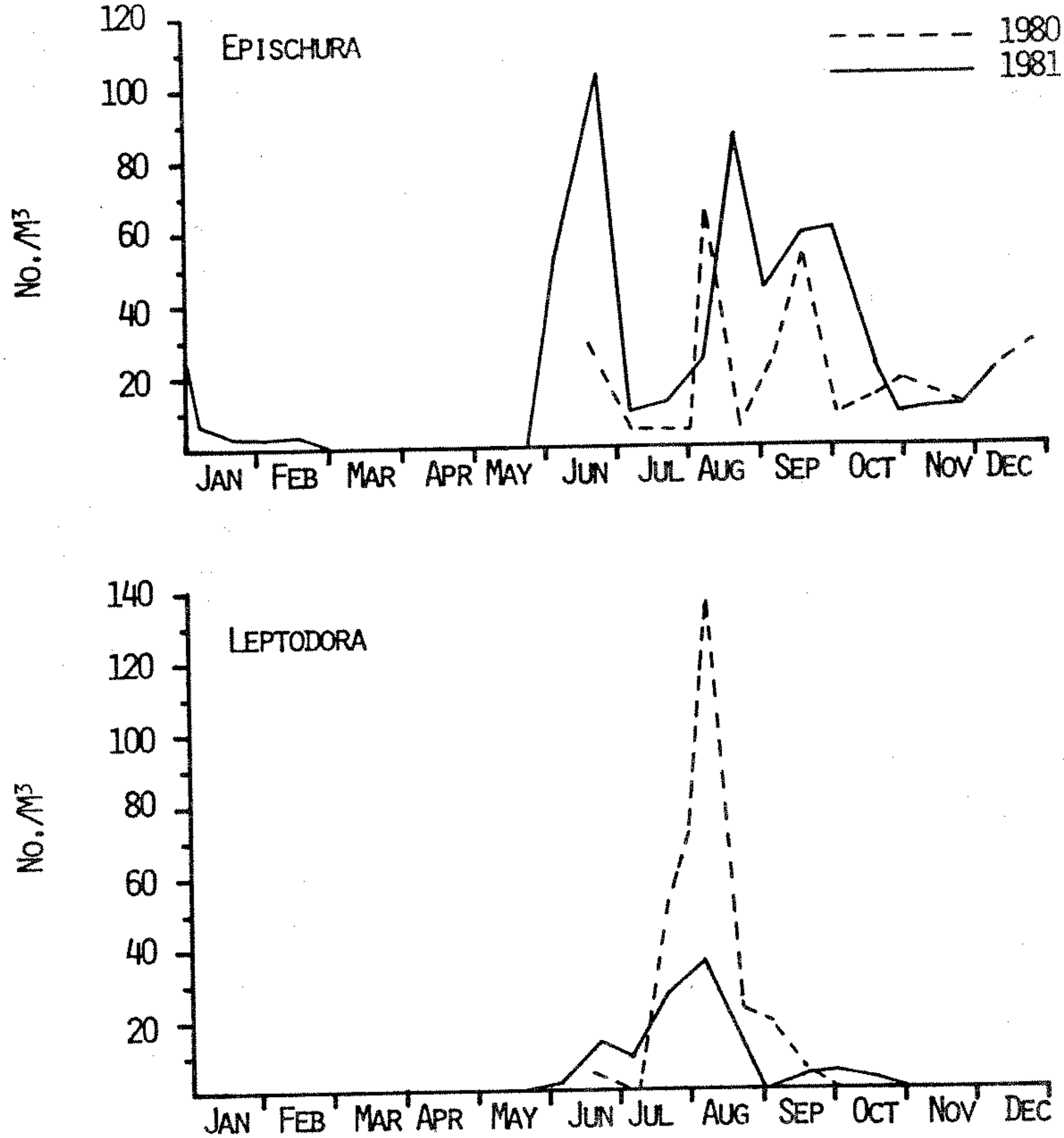


Figure 10. Seasonal density trends (No./m^3) of *Leptodora* and adult *Epischura* in the surface waters (0-30m) at Station 2:4 of Flathead Lake during 1980 and 1981.

and 1981 were quite similar to what has been observed in Pend Oreille Lake (Rieman and Bowler 1980). However, Potter (1978) reported maximum adult *Epischura* densities of two to six per liter (2,000-6,000 per m^3) in the upper 10 m of Flathead Lake during the early 1970's. Adult *Epischura* densities were noticeably higher in Flathead than in Whitefish lake during 1981 (Figure 30).

The observed midsummer population maxima for *Leptodora* during 1980 and 1981 in Flathead Lake (Figure 10) agree closely with Potter's (1978) findings for Flathead Lake and those of Rieman and Bowler (1980) for Pend Oreille Lake. *Leptodora* population levels in Flathead Lake were similar to those observed in Whitefish Lake during 1981 (Figure 30) but were much higher than those reported for Pend Oreille Lake (Rieman and Bowler 1980).

Interstation Differences

Monthly plankton sampling was conducted at seven locations on Flathead Lake during 1980 and at four locations during 1981. The objective of this work was to identify variations in lakewide plankton populations which could possibly influence fish distribution within the lake. One and one-half years of investigation revealed no significant interstation differences in the density of the four principal crustacean zooplankton species (*Daphnia thorata*, adult *Epischura*, *Leptodora*, and *Diaptomus*) utilized by planktivorous gamefish in Flathead Lake (Table 6 and 7). Densities of the copepod *Cyclops* were significantly higher at Station 6:3 (Big Arm) than at the four more northerly lake locations (Newman-Keuls test; Table 6) during 1980, but this organism was seldom found in fish stomachs during the study. Using similar procedures, mildly significant interstation differences in the density of *Bosmina* occurred during 1980, but no differences were significant at the .05 level (Table 6). This small cladoceran was seldom found in the stomachs of fish collected from the lake during this study.

Interstation variation in the density of *Cyclops* and *Bosmina* was not significant during 1981 ($p > .10$; Table 7). However, the density of *Daphnia longiremis* was found to vary significantly between stations during 1981 ($p < .05$). Multiple range testing (Newman-Keuls test) revealed that densities of this organism at Station 6:3 (Big Arm) were significantly larger than at Station 1:5 (Hatchery Bay; $p < .05$) but were not significantly different from the remaining two stations. *Daphnia longiremis* densities were low during 1981 (Table 7) and this organism was seldom utilized by gamefish possibly because this species resides in deep waters during the summer months (Potter 1978). Interstation density differences for this species during 1980 were not significant (Table 6).

Vertical Distribution

Plankton collections made using the Schindler trap served two purposes. These data enabled us to determine the sampling efficiency of the Wisconsin net and also provided information regarding the seasonal depth distribution

Table 6. Mean density (No./L) and range of density (in parenthesis) of the principal crustacean zooplankton species in 0-30 m tows collected monthly from seven stations on Flathead Lake during the period June through December 1980. Calculated F-values and associated levels of significance from randomized complete block ANOV analysis are presented where significant interstation differences existed. *Epischura* and *Leptodora* densities are No/m³.

	Station							F-
	1:5	2:4	3:8	4:12	6:3	8:7	9:3	value
Daphnia thorata	0.8 (0.1-1.6)	1.0 (0.1-2.4)	0.9 (0-1.6)	1.0 (0-2.3)	1.2 (0.1-3.3)	1.2 (0.1-2.3)	1.0 (0.1-2.1)	n.s.
Daphnia longiremis	0.4 (0-1.2)	0.2 (0-0.6)	0.4 (0-1.3)	0.5 (0-2.5)	0.9 (0-5.0)	0.9 (0-5.4)	1.1 (0-4.5)	n.s.
Bosmina	0.9 (0.1-2.5)	0.6 (0.1-1.4)	0.6 (0.1-1.0)	0.4 (0-0.9)	1.1 (0.3-2.4)	0.6 (0.1-1.0)	0.5 (0.1-0.9)	2.06*
Diaptomus	8.8 (0.9-39.5)	3.8 (1.0-9.5)	6.3 (0.4-18.0)	8.8 (0.9-39.3)	9.3 (1.0-35.2)	8.1 (1.2-36.2)	8.6 (1.2-35.3)	n.s.
Cyclops	2.7 (0.8-5.0)	2.9 (0.6-5.4)	3.0 (1.7-4.5)	3.0 (2.0-5.0)	4.4 (2.3-6.3)	3.7 (1.5-4.6)	3.8 (2.7-4.9)	4.20**
Adult *Epischura*	16.6 (7.3-33.4)	21.2 (4.0-53.6)	18.7 (7.5-36.6)	45.6 (4.8-211.0)	26.8 (1.7-123.2)	15.6 (1.8-34.6)	25.8 (4.8-58.2)	n.s.
Leptodora	3.3 (0.-15.2)	15.5 (0-73.4)	6.9 (0-16.3)	3.4 (0-14.0)	4.4 (0-20.5)	11.2 (0-34.4)	4.2 (0-17.7)	n.s.

** Significant at $p \leq .05$
* Significant at $p \leq .10$

Table 7. Mean density (No./L) and range of density (in parenthesis) of the principal crustacean zooplankton species in 0-15 m tows collected monthly from four stations on Flathead Lake during the period January through November 1981. Calculated F-values and associated levels of significance from randomized complete block ANOV analysis are presented where significant interstation differences existed. *Epischura* and *Leptodora* densities are No./m^3.

	Station				F-value
	1:5	2:4	6:3	8:7	
Daphnia thorata	0.9 ((0-2.3)	1.5 (0-3.6)	1.1 (0-2.6)	1.1 (0-3.3)	n.s.
Daphnia longiremis	.03 (0-.09)	.14 (0-.51)	.30 (0-1.10)	.14 (0-.87)	3.87**
Bosmina	0.5 (0.1-1.3)	1.4 (0-4.7)	1.7 (0.1-7.5)	0.9 (0-3.0)	n.s.
Diaptomus	5.5 (0.9-19.9)	9.2 (0.9-31.5)	4.9 (1.5-10.0)	8.0 (1.6-15.0)	n.s.
Cyclops	2.1 (0.4-4.2)	3.2 (1.2-6.1)	2.9 (0.9-4.6)	2.9 (1.4-5.0)	n.s.
Adult *Epischura*	39.7 (0-109.0)	34.5 (0-100.9)	28.9 (0-84.7)	22.7 (0-66.6)	n.s.
Leptodora	5.8 (0-29.4)	7.8 (0-40.9)	3.3 (0-17.1)	4.9 (0-20.5)	n.s.

** Significant at $p<.05$.

of the crustacean zooplankton in Flathead Lake. Variations in the vertical distribution of zooplankton prey on a seasonal or diel basis could account for variations in the vertical distribution of planktivorous fishes.

Maximum *Daphnia thorata* densities occurred in the upper 10 m on all four sampling dates during 1981 (Figures 11 through 14). The maximum *D. thorata* density observed was 8.5/L in the 6-10 m stratum on 2 September (Figure 13). The distribution of *Bosmina* was more variable, with peak density occurring in any of the three uppermost strata. This species was most concentrated near the surface on 2 September when thermal stratification was most pronounced (Figure 13). Maximum *Bosmina* density observed was 1.5/L in the 0.5 m stratum on 2 September (Figure 13).

The large predatory cladoceran *Leptodora* was present in significant numbers on the first two sampling dates (Figures 11 and 12). Maximum midday *Leptodora* density occurred in the 5-10 m and 10-15 m strata on these dates. Potter (1978) reported that most *Leptodora* were captured deeper than 20 m in midday summer collections.

The three copepod species and their larval stages (nauplii) tended to be less surface oriented than the cladocerans (Figures 11 through 14). Maximum adult *Epischura* densities were encountered in the upper 10 m of the water column on three of the four dates. Potter (1978) also found this copepod species to be strongly surface-oriented. *Diaptomus* tended to be more evenly distributed in the water column except on 2 July when maximum density (26.4/L) occurred in the 0-5 m stratum (Figure 11). The vertical distribution of *Cyclops* seemed to be closely related to water temperature profiles. During cooler periods maximum densities were found above 10 m (Figures 11 and 14). During mid and late summer however, *Cyclops* population densities were largest at depths greater than 10 m (Figures 12 and 13). This was especially true on 2 September when thermal stratification was particularly well established (Figure 13). Potter (1978) reported that *Cyclops* tended to avoid warm epilimnetic waters when lake surface temperatures were highest. With the exception of 2 July (Figure 11), copepod nauplii tended to concentrate in the deeper strata.

Kokanee in Flathead Lake typically spend the daylight hours feeding near the surface and migrate to deeper waters after sunset (Hanzel 1974a, 1977a). Our observations indicated that this diurnal movement can be quite pronounced. It was hypothesized that diurnal vertical plankton migration may influence the timing and extent of diurnal vertical fish migration. To test this hypothesis, plankton samples were collected at 5 m intervals at 0400, 0800, 1200, 1500 and 2100 hours at Station 1:12 on 19 November, 1980. The results of this experiment indicate that diurnal vertical movements of the principal zooplankton species were slight in November (Figures 15 and 16). The principal species ingested by young-of-the-year kokanee on this date were *Daphnia thorata* and adult *Epischura*, but no synchronous movements were noticed for these plankters (Figure 15).

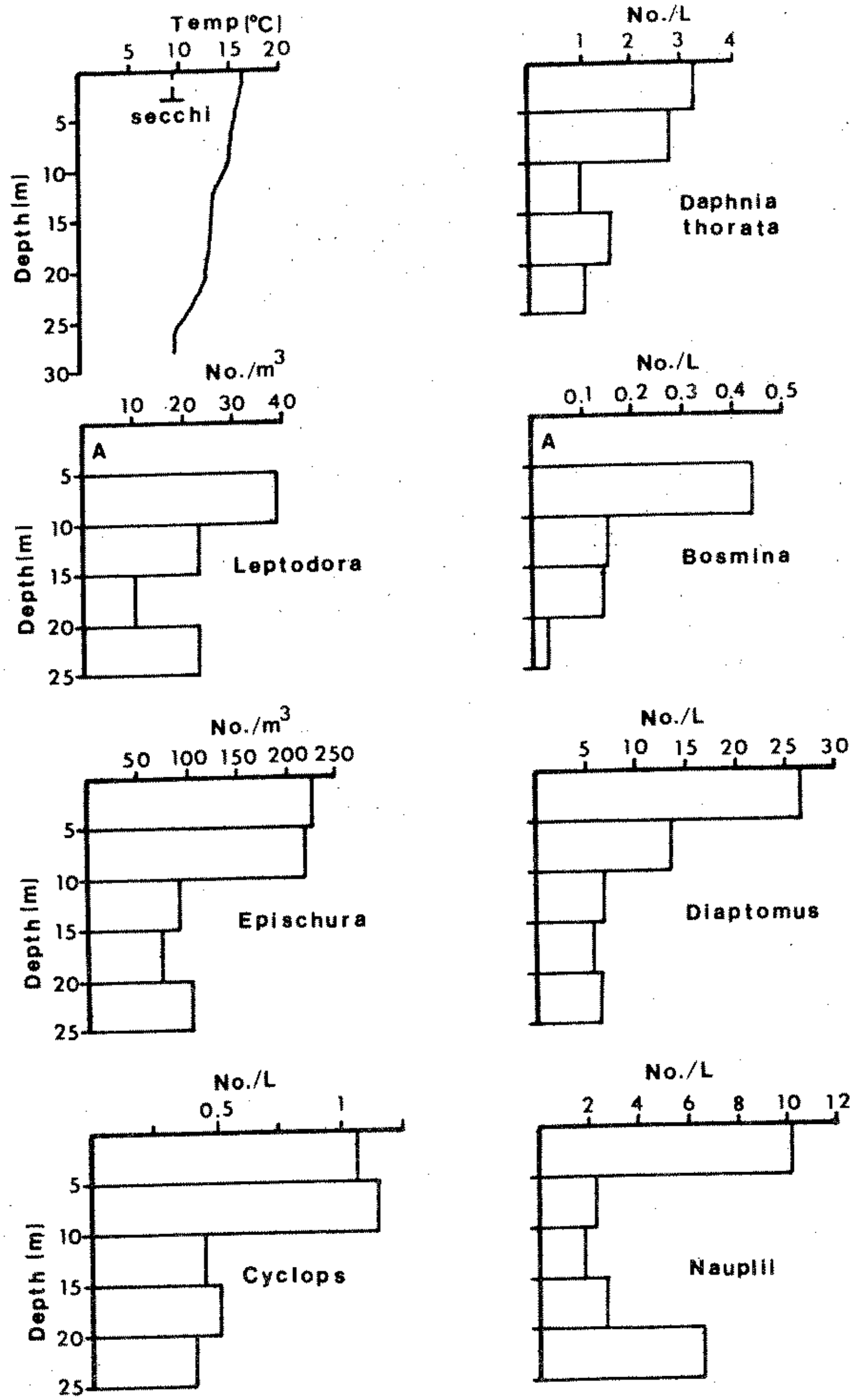


Figure 11. Afternoon depth distribution of the principal crustacean zooplankton in Flathead Lake at Station 1:12 on 2 July 1981. Temperature profile (°C) and secchi disc depth are depicted in upper left-hand diagram. A = absent.

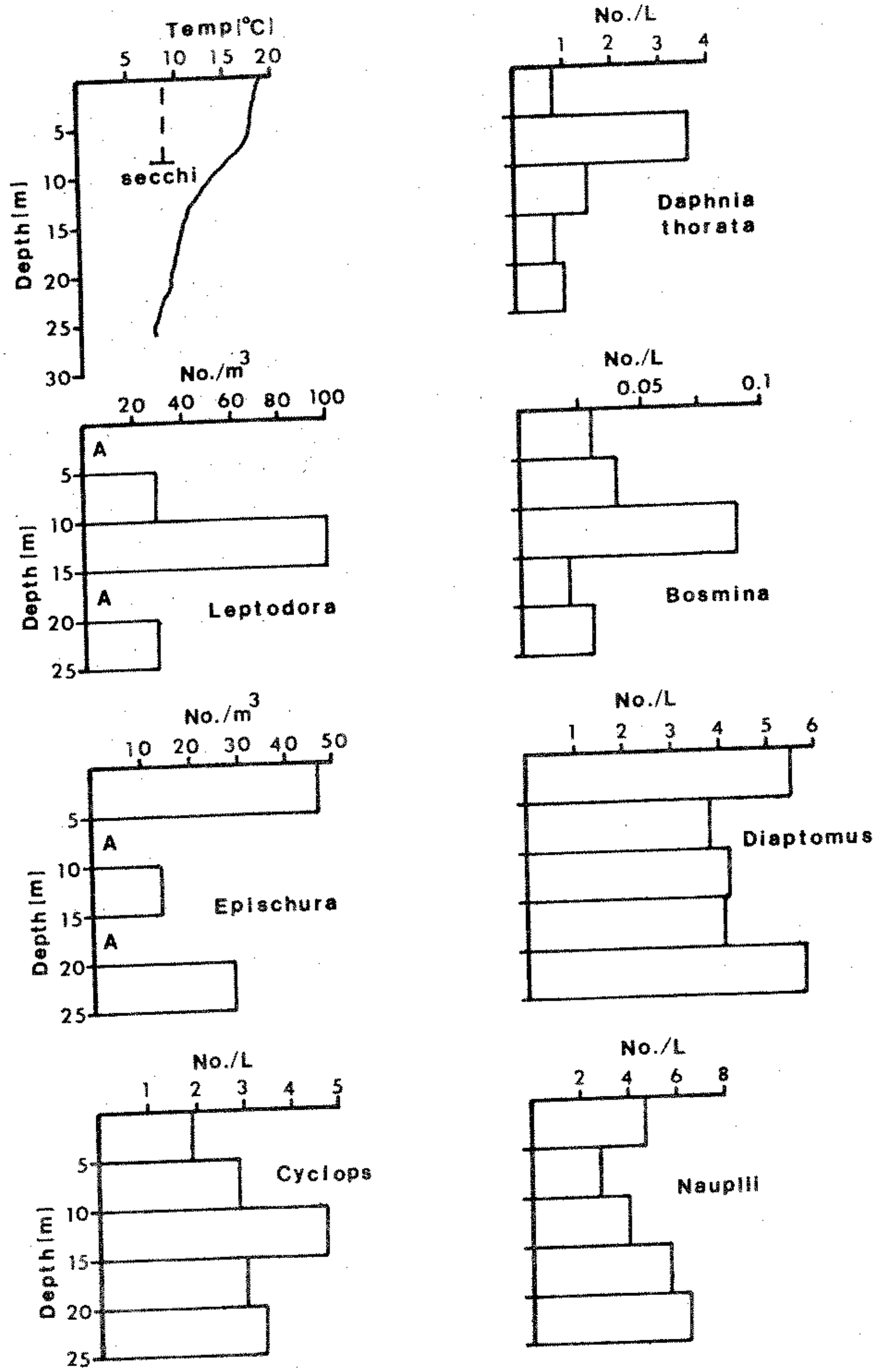


Figure 12. Afternoon depth distribution of the principal crustacean zooplankton in Flathead Lake at Station 1:5 on 7 August 1981. Temperature profile (°C) and secchi disc depth are depicted in upper left-hand diagram. A = absent.

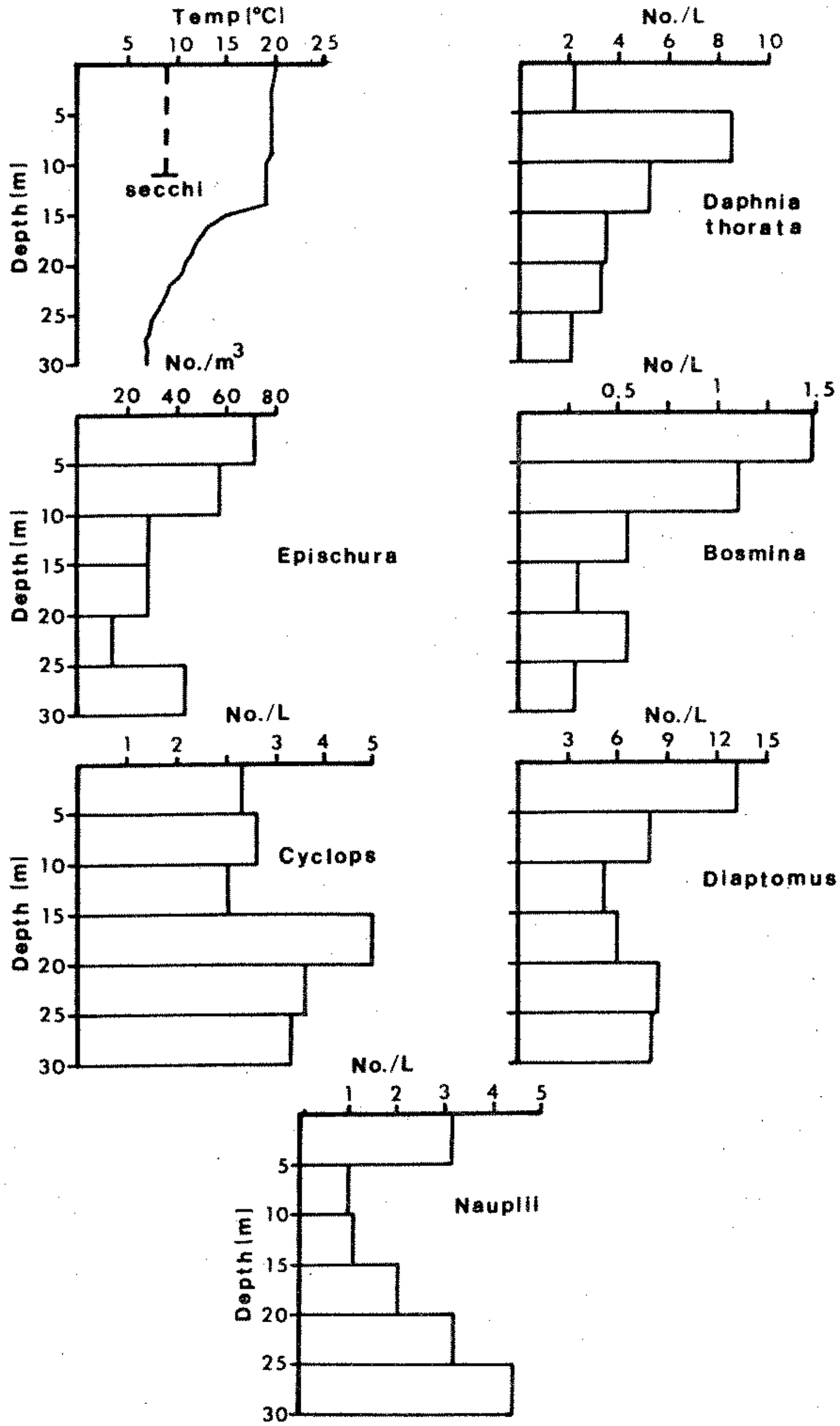


Figure 13. Afternoon depth distribution of the principal crustacean zooplankton in Flathead Lake at Station 2:4 on 2 September 1981. Temperature profile (°C) and secchi disc depth are depicted in upper left-hand diagram.

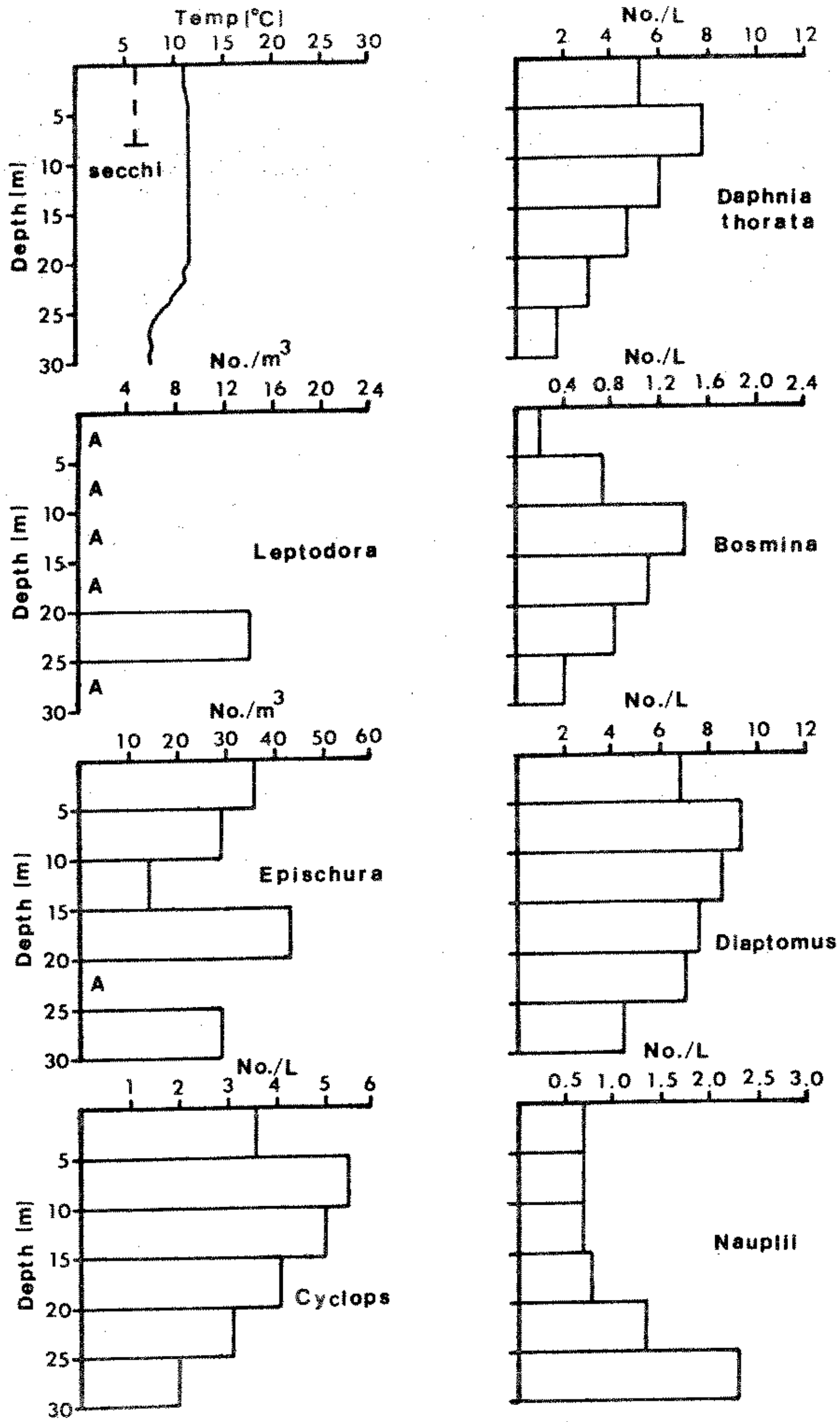


Figure 14. Afternoon depth distribution of the principal crustacean zooplankton in Flathead Lake at Station 2:4 on 19 October 1981. Temperature profile (°C) and secchi disc depth are depicted in upper left-hand diagram. A = absent.

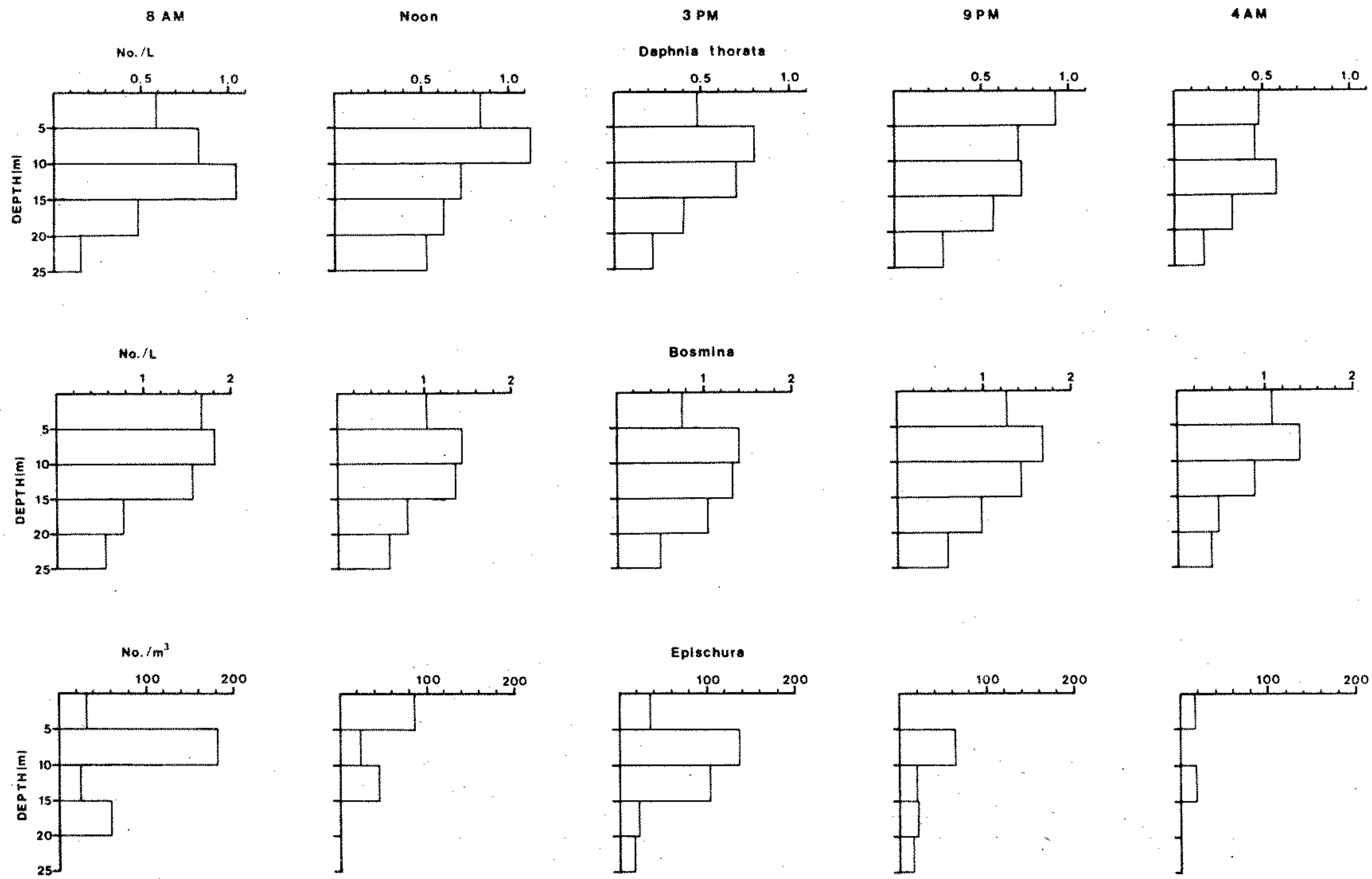


Figure 15. Diurnal changes in the vertical distribution of *Daphnia thorata*, *Bosmina* and adult *Epischura* in Flathead Lake at Station 1:12 on 19 November, 1980.

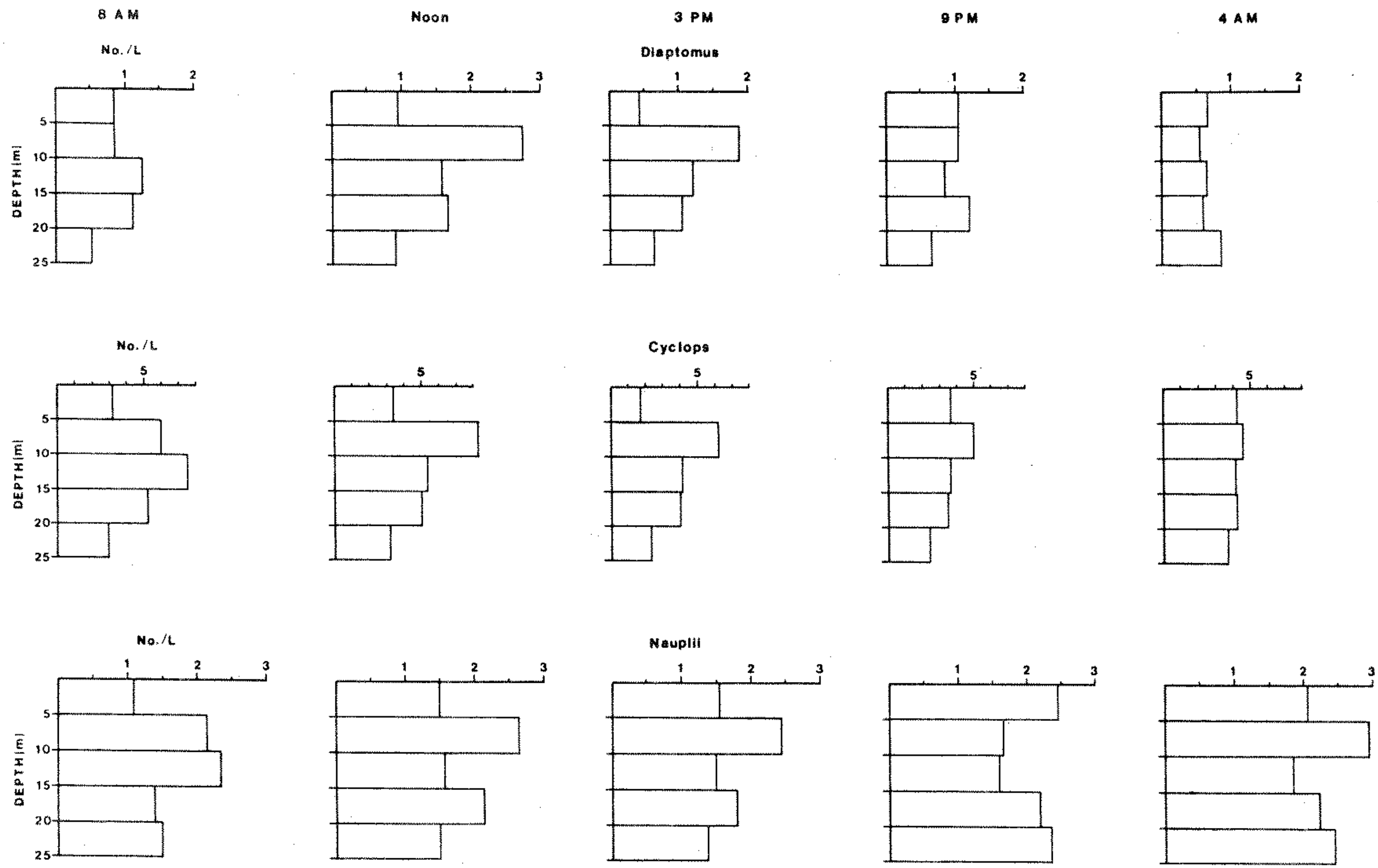


Figure 16. Diurnal changes in the vertical distribution of *Diaptomus*, *Cyclops* and copepod nauplii in Flathead Lake at Station 1:12 on 19 November, 1980.

KOKANEE FOOD HABITS

Crustacean zooplankton comprised the primary food source for kokanee salmon throughout the year in Flathead Lake. Potential changes in lake water quality induced by resource development within the upper Flathead River Basin could alter the species composition and abundance of the lake plankton which could in turn impact kokanee. Documentation of kokanee food habits at the present time 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.

Young-of-the-Year Kokanee

Food habits analysis was conducted for 102 young-of-the-year (25-108 mm) kokanee collected on seven dates between 2 July and 3 December, 1980 and on 68 fish collected on eight dates between 5 June and 23 November, 1981 (Appendix A1). *Daphnia thorata* was the principal food item and comprised an average of 78 and 90 percent of total food biomass during 1980 and 1981, respectively (Figure 17). Adult *Epischura* comprised 20 and 8 percent of the total biomass during 1980 and 1981. All other food categories comprised 0.5 percent or less of the total food biomass in either year.

Daphnia thorata and adult *Epischura* comprised more than 90 percent of the food consumed by kokanee fry collected during early June of 1981 (Figure 17; Appendix A2). Food habits data from a limited number of fry collected in May suggest that a shift in kokanee fry feeding habits from *Cyclops* in mid-May to *Daphnia* and *Epischura* in early June may have occurred. Shifts in feeding preference of kokanee or sockeye fry from small or medium sized prey such as *Cyclops* and *Bosmina* in the spring and early summer to larger prey such as *Daphnia, Diaphanosoma* and *Epischura* during the summer months have been documented in several lakes (Doble and Eggers 1978; Lindsay and Lewis 1978; Goodlad et al. 1974; Ricker 1937). If such a shift did occur in Flathead Lake during 1981, it apparently had taken place by early June.

The feeding habits of young-of-the-year kokanee and sockeye salmon are variable and depend to a large extent on zooplankton species composition and phenology in a particular lake. In Pend Oreille Lake, Idaho, the food habits of all kokanee size groups were similar, i.e. kokanee fed primarily on *Cyclops* through mid-June and switched to a mostly *Daphnia* diet as soon as this organism appeared in the plankton community (Rieman and Bowler 1980). Foerster (1968) indicated that young-of-the-year sockeye salmon utilized a variety of zooplankton species in various lakes. Juvenile sockeye utilized the large copepod *Heterocope*, as well as *Daphnia, Bosmina* and terrestrial insects in Babine Lake, British Columbia (Narver 1970). Juvenile sockeye salmon fed mostly on the relatively large and rare plankters, *Epischura* and *Diaphanosoma* in Lake Washington (Doble and Eggers 1978).

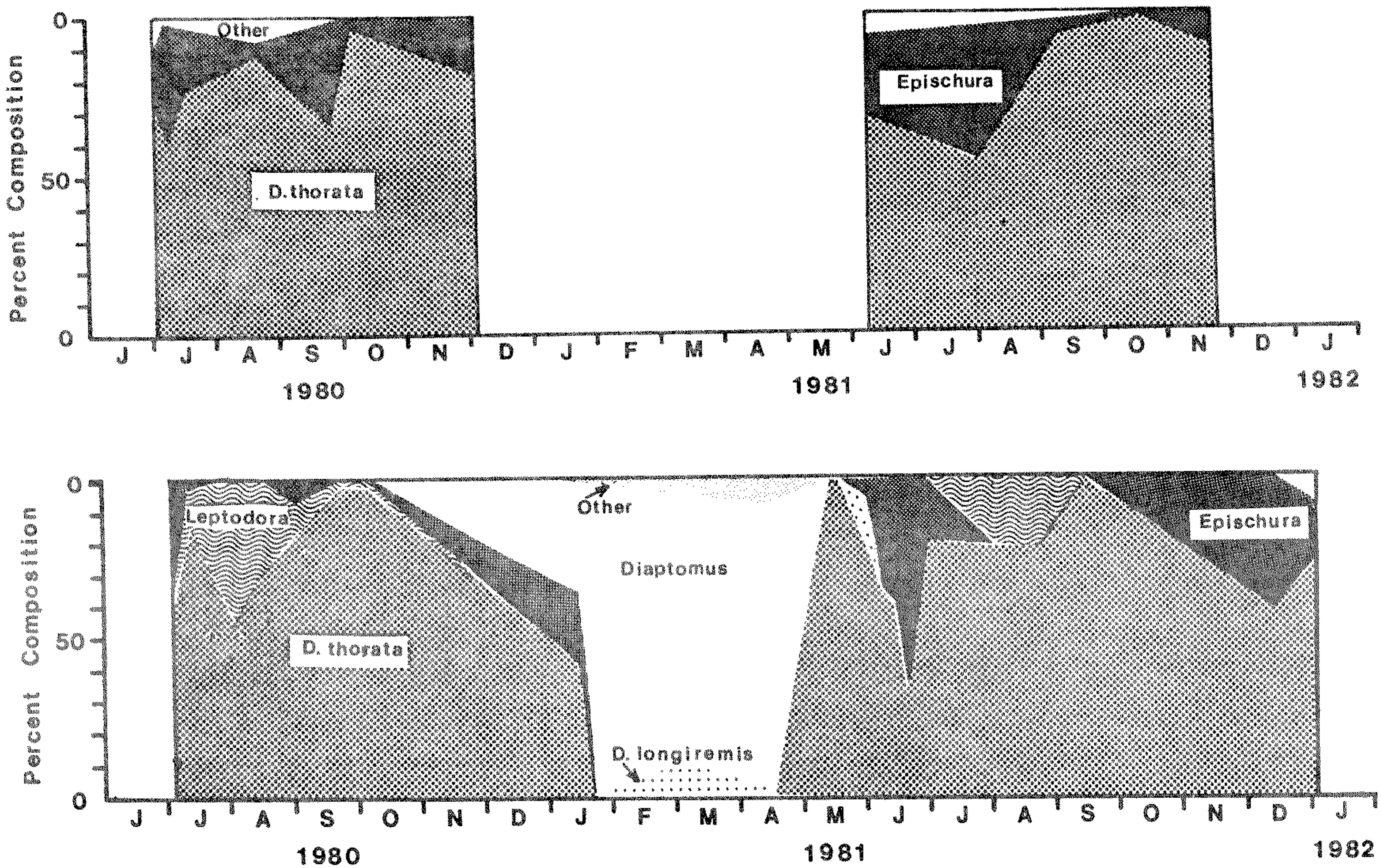


Figure 17. Percent of biomass of food items found in the stomachs of age 0+ (top diagram) and age III and older kokanee salmon (lower diagram) from Flathead Lake during the period July 1980 through January 1982.

Large Kokanee

A total of 84 age I+, 86 age II+ and 324 age III+ and older kokanee stomachs from Flathead Lake were examined during the study (Appendix A3 through A5). *Daphnia thorata* was the principal food item of large (age III and older) kokanee during much of the year (Figure 17). This organism comprised an average of 72 percent of the total food biomass during the period June through November of both years (Appendix A6). *Epischura* and *Leptodora* comprised 21 percent and six percent of this total during the same timespan. The seasonal occurrence of these items in the kokanee diet closely corresponded to their abundance in the plankton community (Figure 10).

The food habits of all age classes of Flathead Lake kokanee were similar with the exception that large fish utilized *Leptodora* to a greater extent than did small kokanee (Figure 17; Leathe and Graham 1980 ; Appendix A6 through A8). The degree of utilization of large and evasive cladocerans such as *Diaphanosoma* and *Leptodora* has been positively related to kokanee size in other studies (Rieman 1980b and 1978; Doble and Eggers 1978; Goodlad et al. 1974).

Comparisons between *Daphnia* in kokanee stomachs and in plankton samples revealed strong size-selective feeding. All kokanee age classes exhibited similar positive selection for *Daphnia* that were 1.2 mm and larger in early July and 1.4 mm and larger in early October of 1980 (Leathe and Graham 1980). Kokanee in Odell Lake, Oregon only consumed *Daphnia* larger than about 1.0 mm in length (Lewis 1971).

Flathead Lake kokanee continued to feed heavily on *Daphnia thorata* and *Epischura* during the month of January in 1981 and 1982. During this time the densities of these organisms were exceedingly low (Figures 8 and 10) and they comprised less than one percent of the plankton (Figure 7). However, these organisms continued to constitute up to 90 percent or more of the kokanee diet (Figure 17). As *Daphnia thorata* and *Epischura* populations continued to decline during January of 1981, the kokanee utilized the copepod *Diaptomus* as an alternate food source. These fish positively selected for *Diaptomus* since this organism was less abundant in the lake plankton than *Cyclops* during most of the winter months (Figure 9). This selectivity may be related to the finding that on most dates, the majority of *Diaptomus* found in kokanee stomachs were mature females bearing egg sacs. It is interesting to note that kokanee in Pend Oreille Lake, Idaho fed heavily on *Cyclops* during the winter months in spite of the fact that *Diaptomus* levels were similar to those in Flathead Lake (Rieman and Bowler 1980).

Daphnia reappeared in the kokanee diet in mid-April (Figure 17) paralleling its re-establishment in the lake (Figure 8). Dipteran pupae comprised a small portion of the large kokanee diet (up to seven percent) in April (Appendix A6). Gill netting results indicated that an inshore movement of kokanee occurred during the spring of 1981 possibly in response to the large number of emerging chironomids. Chironomids were also abundant in the stomachs of cutthroat trout collected from shoreline areas during April. The utilization of dipteran pupae by kokanee during the spring and early summer has been reported elsewhere (Rieman and Bowler 1980; Lewis 1971; Northcote and Lorz 1966; Goodlad et al. 1974).

The degree of prey size and species selectively exhibited by kokanee in Flathead Lake was striking yet not unusual. Numerous other studies have documented the fact that kokanee usually select for the largest food organisms available in limnetic feeding zones. *Daphnia* are a particularly valuable kokanee food because of their large size and slow swimming speed (Vinyard et al. 1982). *Daphnia* were the preferred food of kokanee salmon in many lakes including Pend Oreille in Idaho (Rieman and Bowler 1980); Banks Lake in Washington (Stober et al. 1977); Odell Lake in Oregon (Lewis 1971 and 1972); Lake Tahoe (Goldman et al. 1979); and of sockeye salmon in nursery lakes in Canada (Goodlad et al. 1974).

Winter Kokanee Concentrations

Unusually high concentrations of kokanee have been detected in Flathead Lake at the southern end of Skidoo Bay during the winter months (January through March or April) in recent years. Extremely dense schools comprised mostly of age III and older fish have been recorded on echosounding charts and these fish have been observed porpoising at the lake surface during calm periods. Similar concentrations of kokanee in the south end of Pend Oreille Lake, Idaho were recorded in January and February (Bowler 1975; 1976) and these fish were the basis of an intensive winter hand-lining fishery (Bruce Rieman, Idaho Fish and Game, personal communication).

Such a winter fishery is presently developing in the south end of Flathead. Anglers have frequently taken limit catches (35 fish) and have enjoyed average catch rates of 3.7 fish per hour as compared to approximately one to two fish per hour during the summer months (Montana Department of Fish, Wildlife and Parks, unpublished data; and D.A. Hanzel, personal communication).

Zooplankton samples were collected in Skidoo Bay and other lake locations during the winters of 1981 and 1982 in an attempt to determine if food supply differences between lake areas were responsible for winter kokanee aggregations. No consistent differences in zooplankton species composition or abundance at Skidoo Bay versus other locations were found. In January and March of 1981, the densities of *Diaptomus* (primary food item at this time of year) were usually higher in 15 meter vertical tows at Bigfork (Station 2:4) than at Skidoo Bay (Table 8). However, in January of 1982, *Diaptomus* densities were larger in Skidoo Bay than at three other locations. Densities of prime early-January kokanee foods (*Daphnia thorata* and adult *Epischura*) in Skidoo Bay were similar to or smaller than densities at other locations during both years (Table 8).

Table 8. Zooplankton densities in 15 meter vertical tows made in Skidoo Bay (winter kokanee congregation area) as compared to other locations on Flathead Lake during discrete time intervals in 1981 and 1982.

Date	Location	Number per liter					Adult *Epischura* (no./m³)
		Daphnia thorata	*Daphnia longiremis*	*Bosmina*	*Cyclops*	*Diaptomus*	
14 Jan 1981	Skidoo Bay(9:4)	.02	---	.94	4.54	1.40	---
7 Jan 1981	Bigfork (2:4)	.10	.03	1.39	3.26	1.86	13.3
21 Jan 1981	Bigfork (2:4)	---	---	.69	3.86	.89	3.0
3 March 1981	Skidoo Bay(9:5)	---	---	.06	3.21	1.72	0
4 March 1981	Bigfork (2:4)	---	.05	.71	4.38	3.32	3.3
8 Jan 1982	Skidoo Bay(9:4)	.02	---	.07	2.58	3.55	---
4 Jan 1982	Big Arm (6:3)	.02	---	.04	1.23	1.56	---
8 Jan 1982	Yellow Bay(8:7)	---	---	.07	1.74	2.50	5.9
11 Jan 1982	Bigfork (2:4)	.03	---	.03	1.29	2.68	6.9

TROUT FOOD HABITS

Westslope Cutthroat Trout

The stomachs from 291 westslope cutthroat trout were collected during the course of our study on Flathead Lake (Table 9). Most (74 percent) of the cutthroat stomachs collected during the summer months were gathered during creel census activities since gill nets were relatively ineffective in capturing cutthroat trout during those months. Sixteen percent of the summer cutthroat trout stomachs were taken from fish captured in gill nets. Five stomachs were taken from cutthroat trout captured in the purse seine during the summer months. Almost all (97 percent) of the cutthroat trout stomachs collected during the non-summer months were from fish captured in floating gill nets.

Food habits analysis was conducted on stomachs from 196 westslope cutthroat trout from Flathead Lake during the course of the study. Stomachs from all cutthroat length groups and lake areas were pooled since little variation in feeding preferences could be attributed to these factors.

Adult and pupal aquatic dipterans were the most important year around food category for westslope cutthroat trout from Flathead Lake (Figure 18). Other food groups in order of importance were hymenopterans (ants and bees), coleopterans (beetles), hemipterans (stink bugs, etc.), homopterans (plant hoppers), zooplankton, and aquatic insects. Miscellaneous food items included a wide variety of winged insects as well as leeches, snails, millipedes, amphipods and spiders.

Terrestrial insects and adult or pre-emergent aquatic insects were the principal food items of westslope cutthroat trout in Flathead Lake during most seasons of the year (Figure 19). Aquatic dipteran pupae and adults were the dominant food item during the spring (Figure 19; Appendix A9). These organisms were apparently consumed during the period of spring aquatic dipteran emergence. Large numbers of recently emerged dipteran adults were observed on the lake surface during April gill netting activities. Other important spring food groups in order of importance were coleopterans (beetles), hymenopterans (ants and bees), hemipterans (stink bugs etc.), and arachnids (spiders). Zooplankton were an insignificant dietary component during the spring.

Cutthroat trout food habits were similar during the summer and fall (Figure 19). Winged insects dominated the diet during these months, especially in terms of biomass (Appendix A10 and A11). Zooplankton had lower IRI values than did the main insect groups. Zooplankton comprised less than four percent of the total food biomass (excluding insect parts) found in cutthroat trout stomachs during the summer and fall.

The stomachs from fourteen cutthroat trout were collected during fall creel census efforts on the lower portion of the Flathead River above Flathead Lake. This 37 kilometer river section (from the Salmon Hole to the river mouth) serves as an extension of Flathead Lake because

Table 9. Summary data for cutthroat trout stomachs collected from Flathead Lake during 1980 and 1981.

Season	No. stomachs collected	Percent empty	No. stomachs analyzed	Mean fish length(mm)	Range(mm)	Mean wet weight(g) of stomach contents
Summer 1980	10	10.0	9	281	221-418	3.93
Fall 1980	17	11.7	15	302	188-380	.78
Winter 1980-81	44	63.6	16	316	267-432	.05
Spring 1980	124	4.0	61[a/]	301	209-444	.67
Summer 1981	40	---	40	330	232-400	1.10
Fall 1981	57	3.6	55	303	227-446	.90

a/ A representative subsample of stomachs was analyzed.

Westslope Cutthroat

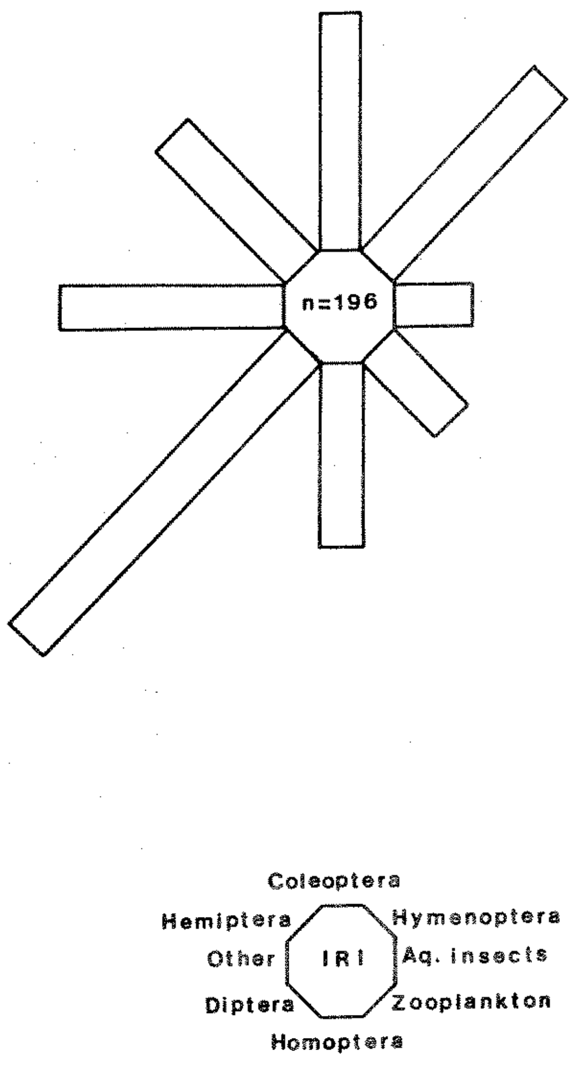


Figure 18. Relative importance (Index of Relative Importance) of principal food items in the diet of 196 westslope cutthroat trout collected from Flathead Lake during the period 29 July 1980 through 25 November 1981.

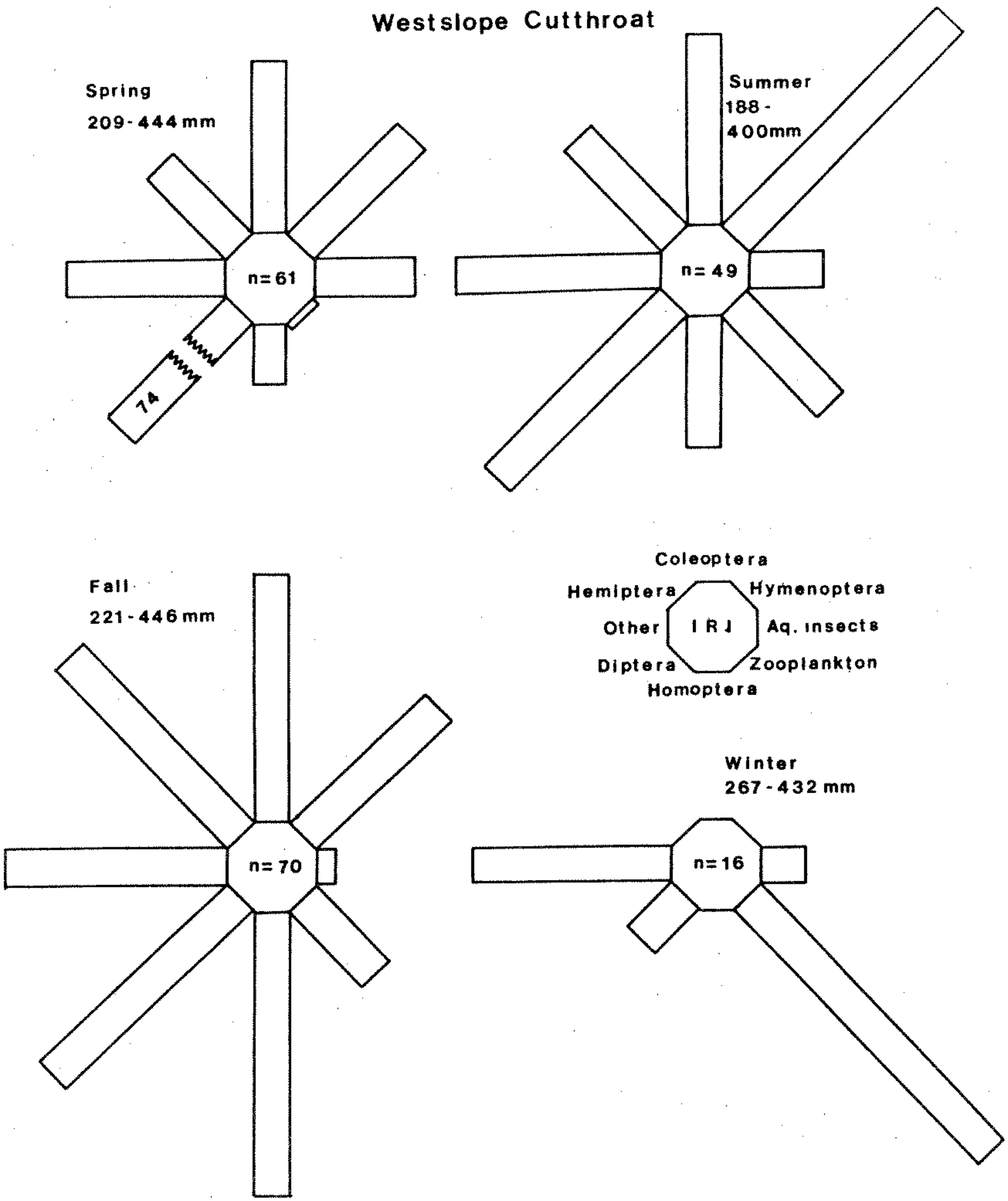


Figure 19. Seasonal importance (Index of Relative Importance) of various food items in the diet of westslope cutthroat trout collected from Flathead Lake during 1980 and 1981.

it was partially inundated when Kerr Dam was constructed at the outlet of the lake. Fall cutthroat trout food habits in this section were similar to those observed in the main lake (Appendix A12 and A11). Terrestrial insect groups were the dominant food categories in both areas.

The relative importance of terrestrial insects in the diet of cutthroat trout was dramatically reduced during the winter months as compared to other seasons (Figure 19; Appendix A13). The availability of terrestrial insects was likely reduced during the winter due to temperature-induced diapause. Ice cover was ruled out as a factor that could have influenced winter cutthroat food habits during 1981 since the lake was ice-free when the sample was collected.

The dependence of westslope cutthroat trout on terrestrial insects as a primary food source in Flathead Lake was emphasized by the winter food habits results. The percentage of empty stomachs (64 percent) in the winter collection was nearly six times higher than was observed in any other seasonal collection (Table 9). The mean weight of food in the winter stomachs was more than an order of magnitude less than that observed in other seasons in spite of the fact that the average length of fish collected was similar between seasons (Table 9).

The above evidence indicates that Flathead Lake cutthroat trout were unable to effectively utilize zooplankton as an alternate food source during the winter. This was probably related to the fact that populations of preferred zooplankton prey (*Daphnia*, *Epischura*, *Leptodora*) in Flathead Lake typically declined to negligible levels during the late fall (Figures 8 and 10). Kokanee salmon responded to winter zooplankton population declines by utilizing the copepod *Diaptomus* as an alternate food source. Cutthroat trout apparently did not utilize *Diaptomus* during January of 1981.

Eight cutthroat trout were captured by electrofishing in the Salmon Hole area of the Flathead River on 26 January, 1981. These fish fed mostly on riverine aquatic insects such as stoneflies (Plecoptera), mayflies (Ephemeroptera), and chironomid adults (Diptera; Appendix A14). Food availability during January appeared to be higher in this area of the river than in Flathead Lake. Cutthroat stomachs from the Salmon Hole area contained an average of more than 0.5 gram of food whereas stomachs from lake fish collected during January contained an average of only .05 gram of ingested material (Table 9). Adult adfluvial cutthroat trout may have responded to the possible increased food availability in the lower river by migrating from the lake to this area at a much earlier date (i.e. during the winter months) than is normally expected (McMullin and Graham 1981).

The food habits of cutthroat trout in lakes are extremely variable and are most likely determined by the relative abundance and types of food available, the subspecies of cutthroat trout being considered, and the species composition of the fish community of the lake in question. This was exemplified by the findings of other cutthroat trout food habits studies in northwestern Montana lakes. Westslope cutthroat trout fed mostly on *Daphnia*, terrestrial insects, and aquatic diptera in Lake Koocanusa (McMullin 1979). This same subspecies consumed primarily terrestrial insects and aquatic diptera and very few *Daphnia* in Hungry Horse Reservoir which is located in the Flathead drainage (McMullin 1979). Cutthroat trout (probably the Yellowstone subspecies) fed mostly on small yellow perch, aquatic diptera, damselflies, and mayflies in the Thompson Lakes (Echo 1954). The planktonic organism *Leptodora* was common in the stomachs from a small number of cutthroat trout collected from Yellow Bay on Flathead Lake (Brunson et al. 1952). *Leptodora* was not an important food item in the Flathead Lake cutthroat stomachs examined during this study.

Cutthroat trout fed almost entirely on terrestrial and aquatic insects in a number of northern Idaho lakes (Bjornn 1957; Jeppson and Platts 1959). Zooplankton was an important component of the cutthroat trout diet in many other lakes in the western portion of the United States and Canada (Benson 1961; Antipa 1974; and numerous studies summarized by Carlander 1969). Coastal cutthroat trout displayed a significant amount of diet plasticity and specialized on surface prey in littoral areas when in sympatry with Dolly Varden (*Salvelinus malma*) in small coastal British Columbia lakes (Andrusak and Northcote 1971; Schutz and Northcote 1972). Coastal cutthroat trout were more piscivorous than rainbow trout in sympatric populations in coastal British Columbia lakes (Nilsson and Northcote 1981). The reverse was true for sympatric westslope cutthroat trout and rainbow trout in Lake Koocanusa in northwestern Montana (McMullin 1979).

Bull Trout

The stomachs from 593 bull trout collected from Flathead Lake were examined for the presence of food material during the study period (Table 10). Approximately 40 percent of the bull trout captured in gill nets had empty stomachs which was similar to that observed by Bjornn (1957). A similar percentage of empty bull trout stomachs was observed by Flathead Lake creel census clerks during the summer of 1981. About 92 percent of the 367 bull trout stomachs that contained food were captured in gill nets with the remainder obtained through creel census.

Fish was the most important dietary component for bull trout in Flathead Lake. Fish were present in approximately 91 percent of the bull trout stomachs containing food (Table 10). Aquatic and terrestrial invertebrates were eaten infrequently and comprised less than one percent of the total food biomass for the entire sample (Table 11). Small bull trout also fed almost exclusively on fish. Aquatic and terrestrial invertebrates comprised less than one percent of the food biomass found in the stomachs of small bull trout ($\leq$350 mm, n = 25).

Forty-one percent of the bull trout stomachs containing fish had remains that could be identified to species. A total of 298 forage fish were identified at the species level (Table 10).

Table 10 . Information pertaining to bull trout food habits analysis for Flathead Lake, 1979-1981.

Season	Dates	Mean DV length (mm)	DV (Range) (mm)	No. stomachs examined	% 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	(30%)	23.4	91%	53%	34
Fall 1980	6 Oct-20 Oct.	460	(212-658)	87	(49%)	35.1	93%	51%	26
Early Winter 1979	27 Nov-12 Dec.	349	(256-514)	11	?	7.2	100%	82%	27
Winter 1980-81	19 Nov-21 Jan.	442	(177-731)	83	(58%)	14.9	92%	42%	25
Spring 1981	3 Apr-22 Apr.	441	(194-710)	112	(39%)	13.4	83%	42%	36
Summer 1981	31 May-16 Sep.	431	(220-755)	139	(25%)	17.5	95%	41%	91
Fall 1981	23 Oct-17 Dec.	463	(180-632)	115	(44%)	10.0	89%	22%	59
TOTAL			(177-755)	593					298
AVERAGE		438			(40%)	17.4	91%	41%	

Table 11. Seasonal summary (frequency of occurrence and total wet weight in grams) of miscellaneous food items found in the stomachs of 367 bull trout collected from Flathead Lake during the years 1979 through 1981.

	Spring		Summer		Fall		Winter	
	Freq.	Wet wt. (g)	Freq.	Wet wt. (g)	Freq.	Wet wt. (g)	Freq.	Wet wt. (g)
Fish eggs	1	.1			4	7.2	5	17.4
Fish viscera and other parts			8	165.5				
Diptera	19	.1	4	.4	3	.4		
Ephemeroptera	8	.2	4	.3	2	.2		
Trichoptera			6	.1				
Hemiptera					1	.1		
Orthoptera					1	.3		
Unid. insects			3	.1	1	.1	2	.1
Amphipods	14	.6	1	.1	3	.3	1	.1
Oligochaetes	1	.1				.1		
Molluscs							1	.1
Hirudinea	2	.2						
Leptodora			2	.1	1	1.7		
Daphnia ephippia							1	.1

Bull trout utilized a wide variety of forage fish species in Flathead Lake. The three whitefish species were the most important year around identifiable food item (Figure 20; Appendix A15). Whitefish were followed in order of importance by yellow perch, kokanee salmon, and a variety of non-game species including slimy sculpin, redside shiners, peamouth, suckers, and squawfish. Lake and mountain whitefish were the two most important whitefish species in the year around in the lake resident bull trout diet (Appendix A15).

Substantial seasonal variation in bull trout food habits was observed (Figure 21; Appendix A15). Unidentified fish were prevalent in stomachs collected during all seasons. Kokanee salmon were the most important food item in the spring sample. This was the only period of the year when significant numbers of immature kokanee were captured in sinking gill nets, yet they comprised only four percent of the catch (Table 36).

Lake and mountain whitefish were the most important bull trout food during the summer and fall (Figure 21; Appendix A16 and A17). These species comprised 56 percent of the summer sinking gill net catch, but made up only 22 percent of the fall sinking gill net catch (Table 36).

The presence of fish viscera and other body parts in the stomachs of bull trout collected from gill nets suggested that scavenging was an important feeding mode during the summer months (Table 11). Most of the fish viscera and other body parts were from kokanee salmon that had obviously been cleaned by fishermen. Such remains were found in the stomachs of two bull trout during the summer of 1980 and in six bull trout stomachs during the summer of 1981.

A sample of ten bull trout stomachs was collected by creel census clerks during October and November of 1981 from the impounded section of the Flathead River above Flathead Lake. These fish had extensively utilized pygmy whitefish (Appendix A18). One of these bull trout had consumed 12 pygmy whitefish, all of which were between 120 and 140 millimeters total length. Mature pygmy whitefish in this size range have been found to concentrate at the mouth of the Flathead River during the late fall spawning season (Weisel et al. 1973).

Yellow perch were consumed during all seasons but were used most extensively during the winter (Figure 21). This was somewhat anamalous because perch never comprised more than two percent if the sinking gill net catch in any season (Table 36). Almost all of the yellow perch found in winter bull trout stomachs were small and ranged between 40 and 60 mm total length. These perch were probably too small to be captured in standard gill nets.

Yellow perch distribution in the main portion of the Flathead Lake (excluding Polson Bay) is patchy. During most of the year, this species is confined to small weedy bays that are scattered along the edges of the lake. The increased importance of yellow perch in the winter bull trout diet may have occurred as a result of dispersal of young-of-the-

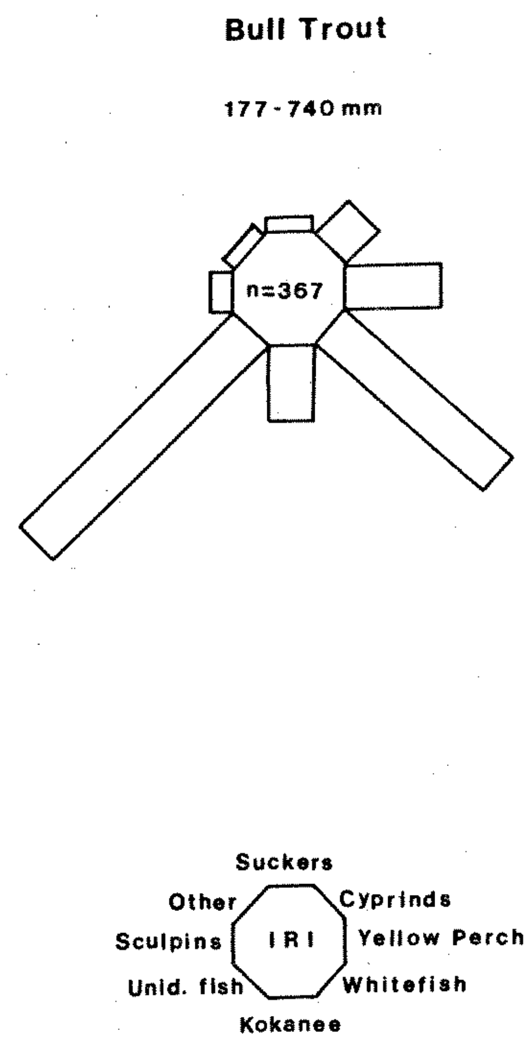


Figure 20. Relative importance (Index of Relative Importance) of various forage fishes in the diet of bull trout collected from Flathead Lake during the years 1979-1981.

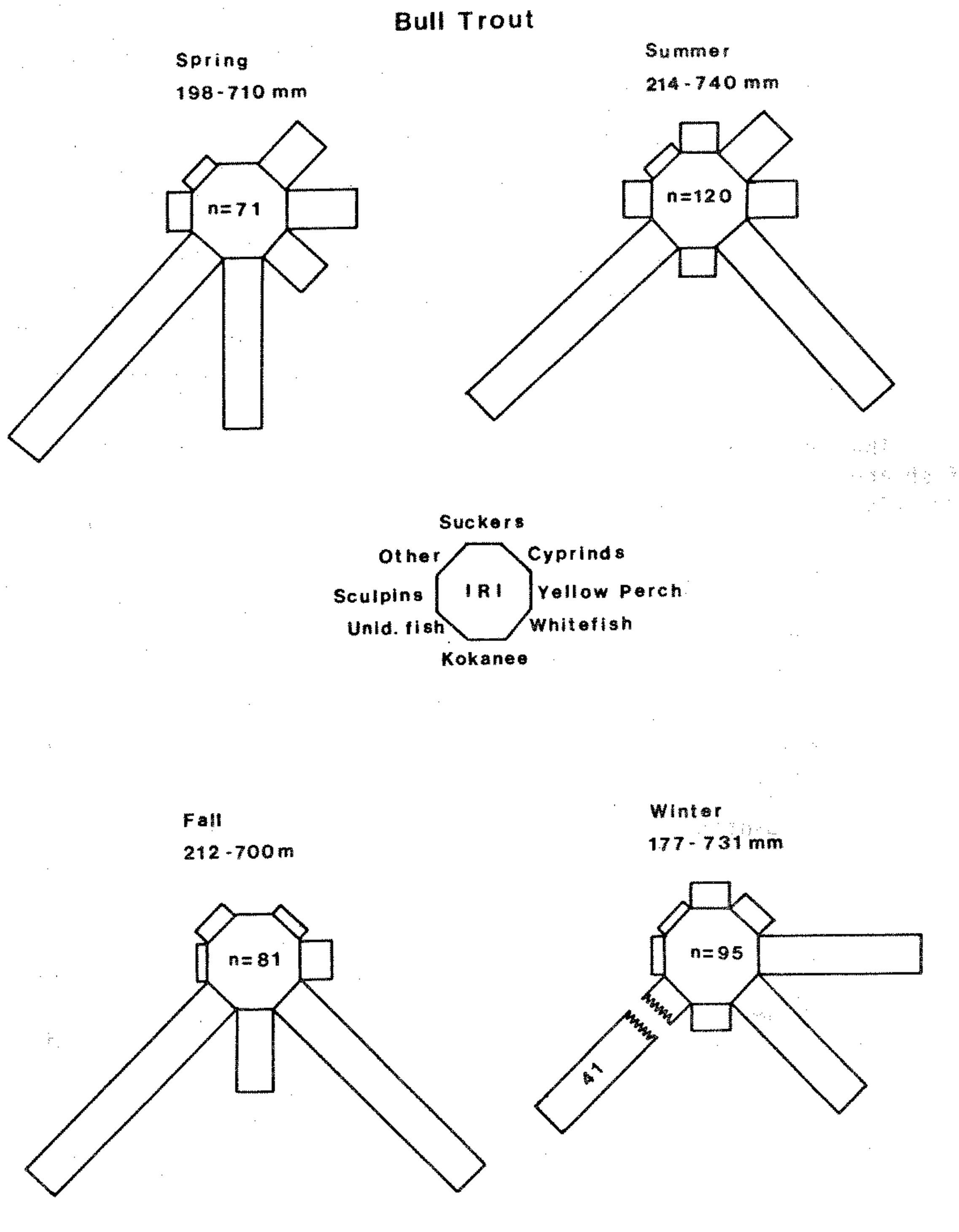


Figure 21. Seasonal importance (Index of Relative Importance) of various forage fishes in the diet of bull trout collected from Flathead Lake during the years 1979-1981.

year perch from these littoral habitats. This may also have been due to increased bull trout access to littoral areas as lake water temperature declined during the fall.

Small bull trout (<300 mm) fed much more extensively on slimy sculpins than did larger fish (Table 12). Large bull trout (>550 mm) utilized kokanee salmon and whitefish almost exclusively. Yellow perch, northern squawfish, peamouth, and suckers were utilized to a similar extent by all size classes of bull trout. Redside shiners appeared more frequently in the stomachs of small and medium-sized bull trout (Table 12).

A significant ($p<.01$) positive relationship was observed between bull trout length and the maximum size of ingested forage fish (Figure 22). On the average, bull trout were able to consume prey that were 43 percent of their own length. This value ranged between 18 and 62 percent for various 25 millimeter bull trout length groups.

The feeding habits of Dolly Varden have been well documented. These fish are typically smaller than bull trout and have been found to feed on insects and invertebrates in some lakes (Andrusak and Northcote 1971; Roos 1959). Other studies have shown that coastal Dolly Varden feed mostly on fish (Godfrey 1955) and can be significant predators on small sockeye salmon (Ricker 1941; Thompson and Tufts 1967).

The food habits of bull trout are much less well documented than those of Dolly Varden. Bull trout fed mostly on kokanee salmon in Pend Oreille Lake, Idaho (Jeppson and Platts 1959) and in Priest Lake, Idaho (Bjornn 1957). Bull trout utilized whitefish more heavily than kokanee in upper Priest Lake, Idaho presumably because kokanee were less abundant than in Priest Lake (Bjornn 1957). In a more recent survey, mysids were found to be the most important bull trout food item in Priest Lake along with lesser quantities of terrestrial insects and unidentified fish (Rieman and Lukens 1979).

Lake Trout

The stomach contents from 15 lake trout were analyzed during the study period. These fish ranged between 199 and 912 mm in length and averaged 685 mm total length. Twelve of the stomachs were obtained by creel census. Lake trout were seldom caught in seasonal gill netting efforts except during the fall when these fish moved to inshore spawning areas. Almost all the stomachs examined from lake trout caught in fall gill nets were empty.

Fish comprised 100 percent of the total food biomass found in lake trout stomachs. The smallest lake trout (199 mm) was caught in a sinking net and had eaten a slimy sculpin. All the other lake trout were larger than 500 mm and had fed mostly on kokanee salmon and whitefish (Table 13). A single yellow perch was found in the stomach of a lake trout that was captured by a fisherman in Yellow Bay during the late fall.

Table 12. Frequency of occurrence (percent) of principal forage fish species in the diet of bull trout of various sizes collected from Flathead Lake during the years 1979-1981.

Bull trout length(mm)	No. stomachs with identifiable fish	Frequency of occurrence (percent)							
		KOK[a/]	WF	YP	NSQ	PM	SU	SCUL	RSS
≤300	16	---	13	19	---	--	--	56	13
301-350	16	6	13	38	---	6	6	19	25
351-400	27	---	63	19	4	4	4	7	4
401-450	27	15	26	41	---	7	--	4	11
451-500	26	8	46	19	---	12	--	12	8
501-550	24	4	63	29	---	--	8	---	4
>550	30	47	53	--	3	3	3	---	---

a/ KOK = kokanee salmon
WF = whitefish species
YP = yellow perch
NSQ = northern squawfish
PM = peamouth
SU = sucker species
SCUL = sculpins
RSS = redside shiner

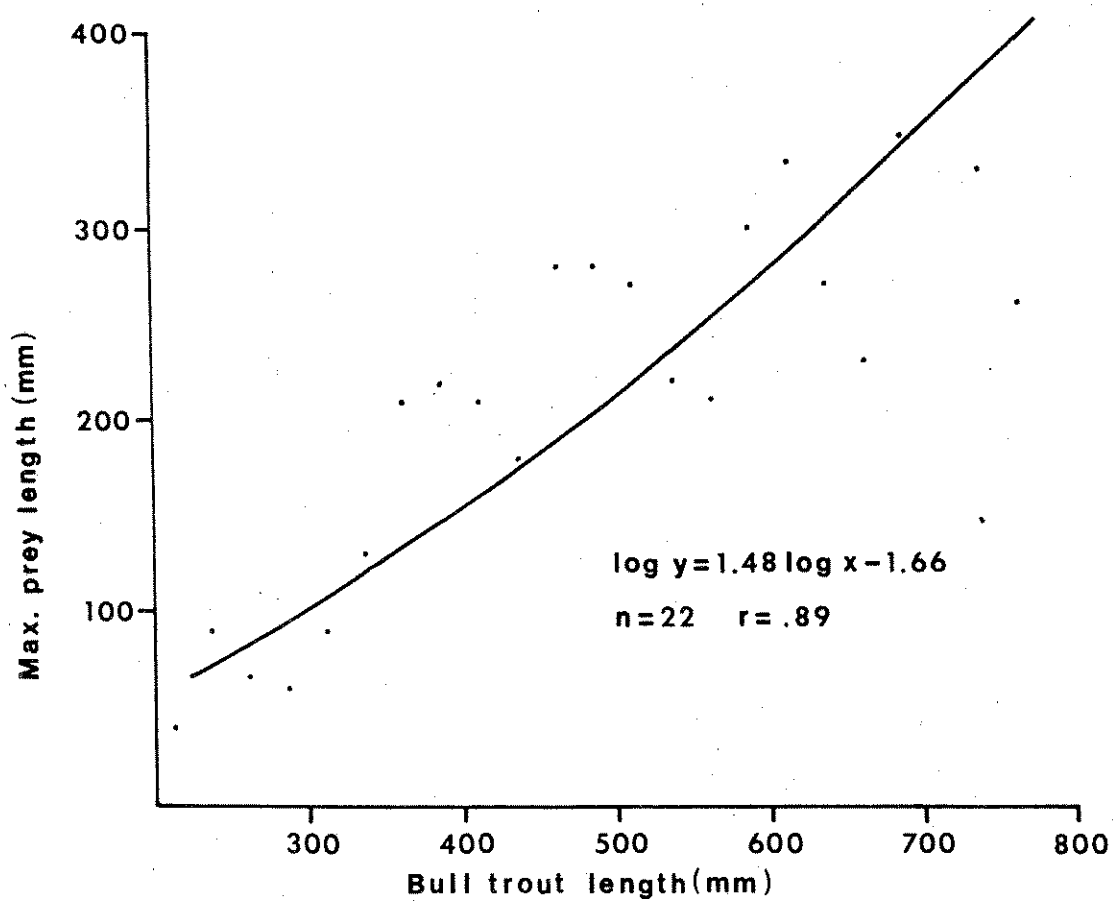


Figure 22. Relationship between bull trout length (mm) and the maximum length (mm) of ingested forage fish. The relationship was constructed using maxima observed for 25mm bull trout length groups and only prey species judged to be less than one-third digested.

Table 13. Summary of food items found in the stomachs of 15 lake trout collected from Flathead Lake during the period October 1980 through January 1982.

Item	No.	(%)	Freq.	(%)	Wet wt. (g)	(%)	Index of Relative Importance
Mountain whitefish	1	(5)	1	(7)	39.6	(9)	7
Unid. whitefish	3	(15)	3	(20)	66.2	(14)	18
Total whitefish	*4*	*(20)*	*3*	*(20)*	*105.8*	*(23)*	*21*
Kokanee	4	(20)	2	(13)	286.7	(63)	32
Sculpin	1	(5)	1	(7)	0.4	(0.1)	4
Yellow perch	1	(5)	1	(7)	2.7	(0.6)	4
Unid. fish	10	(50)	9	(60)	63.2	(13.8)	41

WHITEFISH FOOD HABITS

Research efforts were extended to include the food habits of the three whitefish species to determine their importance in the trophic structure of the fish community in Flathead Lake. Such information is useful because these three species were the most important year-around forage items in the diet of bull trout. Changes in whitefish populations resulting from impacts on their food supplies resulting from upstream developments could directly affect bull trout populations. Such changes could also indirectly affect cutthroat trout and kokanee populations by altering the degree of trophic interaction among species.

Lake Whitefish

Stomach contents were analyzed from 131 lake whitefish collected during the period of April through November of 1981 (Appendix A21). These fish were collected incidentally in the purse seine and in various gill net types which were set to capture target species (cutthroat trout, bull trout and kokanee salmon).

Zooplankton comprised more than 49 percent of the food biomass ingested by lake whitefish during the period April through November (Appendix A21). The principal zooplankton species ingested was *Daphnia thorata*. *Leptodora* and adult *Epischura* were utilized to a lesser extent during this time span. The principal non-zooplankton foods consumed were organic debris, gastropods, and bryozoans in order of importance. These items together accounted for about 40 percent of the April to November diet (Appendix A21). Fish remains (probably sculpins) were found in stomachs from a few of the larger lake whitefish.

Significant seasonal variations in lake whitefish feeding habits were noted during 1981 (Figure 23; Appendix A21). During April, these fish fed mostly on organic debris (46%) and snails (28%) and did not utilize zooplankton. Food habits shifted markedly during June and July when *Daphnia thorata* and *Epischura* comprised 54 and 43 percent, respectively, of the total food biomass. *Daphnia thorata* remained an important dietary component throughout the summer and fall. Bryozoans comprised ten percent of August and September food biomass and 41 percent of October and November food biomass.

The observed shift in lake whitefish feeding habits from a diet comprised mostly of benthic organisms in April to one based on zooplankton during the summer months is evidently not unusual. Bjorklund (1953) noted a similar "dramatic" mid-summer shift in lake whitefish feeding habits in all areas of Flathead Lake during 1951 and 1952. Bjorklund (1953) concluded that micro-crustaceans (probably *Daphnia* and *Epischura*) were the principal lake whitefish food in Flathead Lake during the months of July through November.

Chironomid larvae were the most important lake whitefish food item in Flathead Lake during the summers of 1948 and 1949 (Brunson and Newman

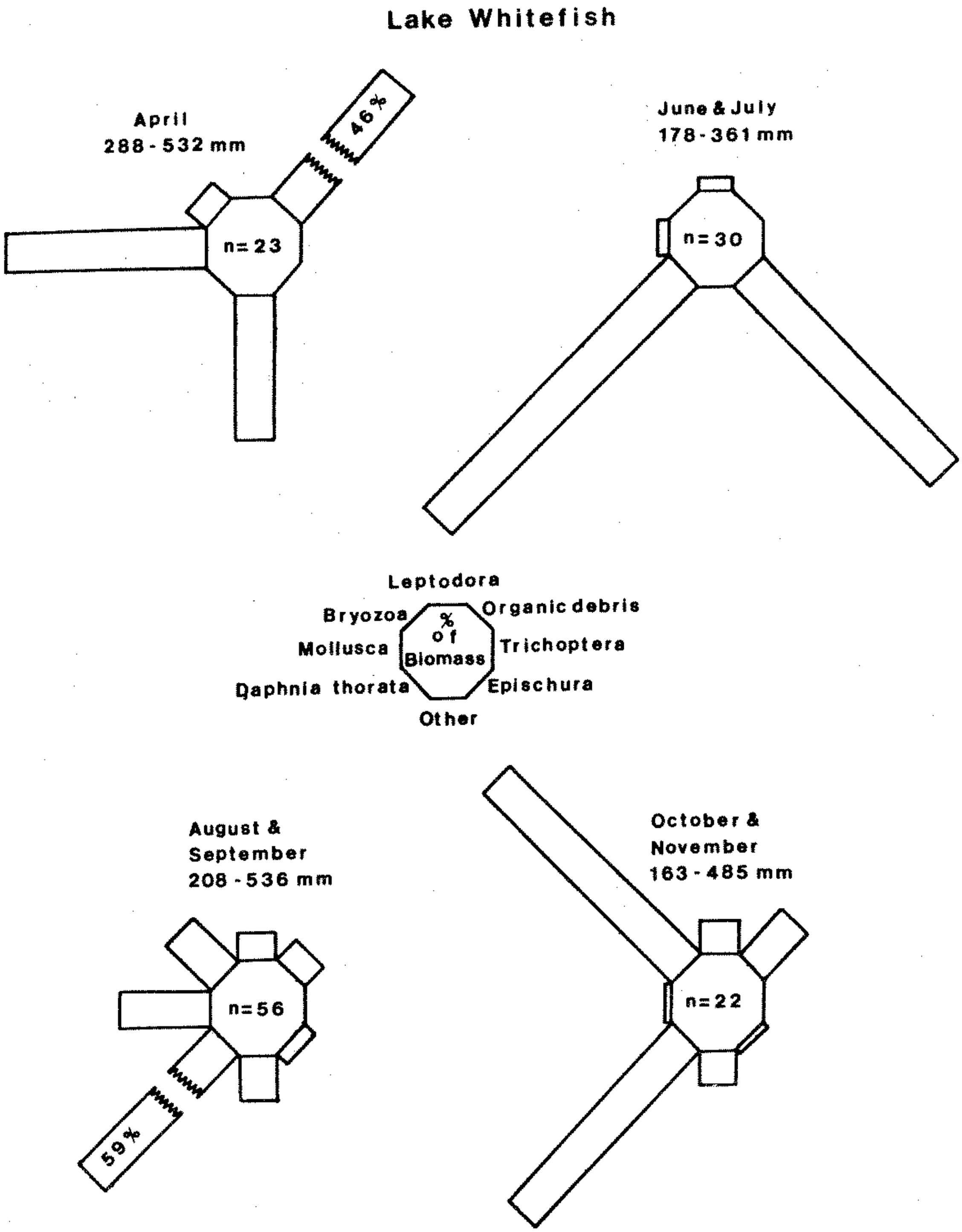


Figure 23. Relative contribution (percent of food biomass) of various food categories to the diet of lake whitefish collected from Flathead Lake in four time periods during 1981.

1951) and during months when micro-crustaceans were not heavily utilized (Bjorklund 1953). Chironomid larvae usually comprised less than ten percent of the lake whitefish diet during the period April through November 1981 (Appendix A21 and A22).

Many studies have shown lake whitefish to be bottom feeders although zooplankton was an important dietary component in some lakes (Carlander 1969). Lake whitefish fed mostly on bottom organisms during the summer in Babine Lake, British Columbia, yet the same species fed almost entirely on crustacean zooplankton (especially the large copepod *Heterocope*) in nearby Morrison Lake during the same timespan (Godfrey 1955). The observed divergence in lake whitefish food habits between the two adjacent lakes was attributed to a relatively impoverished bottom fauna in Morrison Lake (Godfrey 1955). Lake whitefish fed exclusively on plant material (bryozoans?),molluscs, and insects in Pend Oreille Lake, Idaho (Jeppson and Platts 1959).

Substantial variation in lake whitefish stomach contents was noted for similar sized fish collected in the same location on the same date during this study. It appeared as though individual fish specialized on particular food types (i.e. zooplankton vs. benthos). Similar food specialization patterns were observed in a bluegill sunfish population inhabiting a small pond (Werner et al. 1981).

Mountain Whitefish

Food habits analysis was conducted on 91 mountain whitefish stomachs. These fish were collected from many regions of the lake during 1980 and 1981 using several different techniques (Appendix A23 and A24).

Daphnia thorata was the principal food item for mountain whitefish during the period April through November in 1980 and 1981. This organism comprised 77 percent of the total food biomass found in mountain whitefish stomachs (Appendix A23). Mountain whitefish did not utilize *Epischura* during this timespan. Case-dwelling caddisfly larvae (Trichoptera) were the only other important food item in the total sample and comprised 15 percent of total food biomass.

With the exception of the April sample, little seasonal variation in mountain whitefish food habits in Flathead Lake was noted (Figure 24; Appendix A23). Insect parts (primarily dipteran) and algae accounted for 48 and 28 percent, respectively, of April food biomass. Crustacean zooplankton were not utilized by mountain whitefish during April. *Daphnia thorata* was the dominant food item in all other periods and comprised 100 percent of the diet in the June sample (Figure 24).

Mountain whitefish typically feed primarily on aquatic insects, yet Cladocera have been found to be the principal food item in some lakes (Carlander 1969). Aquatic insects and other benthic macroinvertebrates were the principal food items of mountain whitefish in three northern British Columbia lakes (Godfrey 1955) and in two northern Idaho lakes

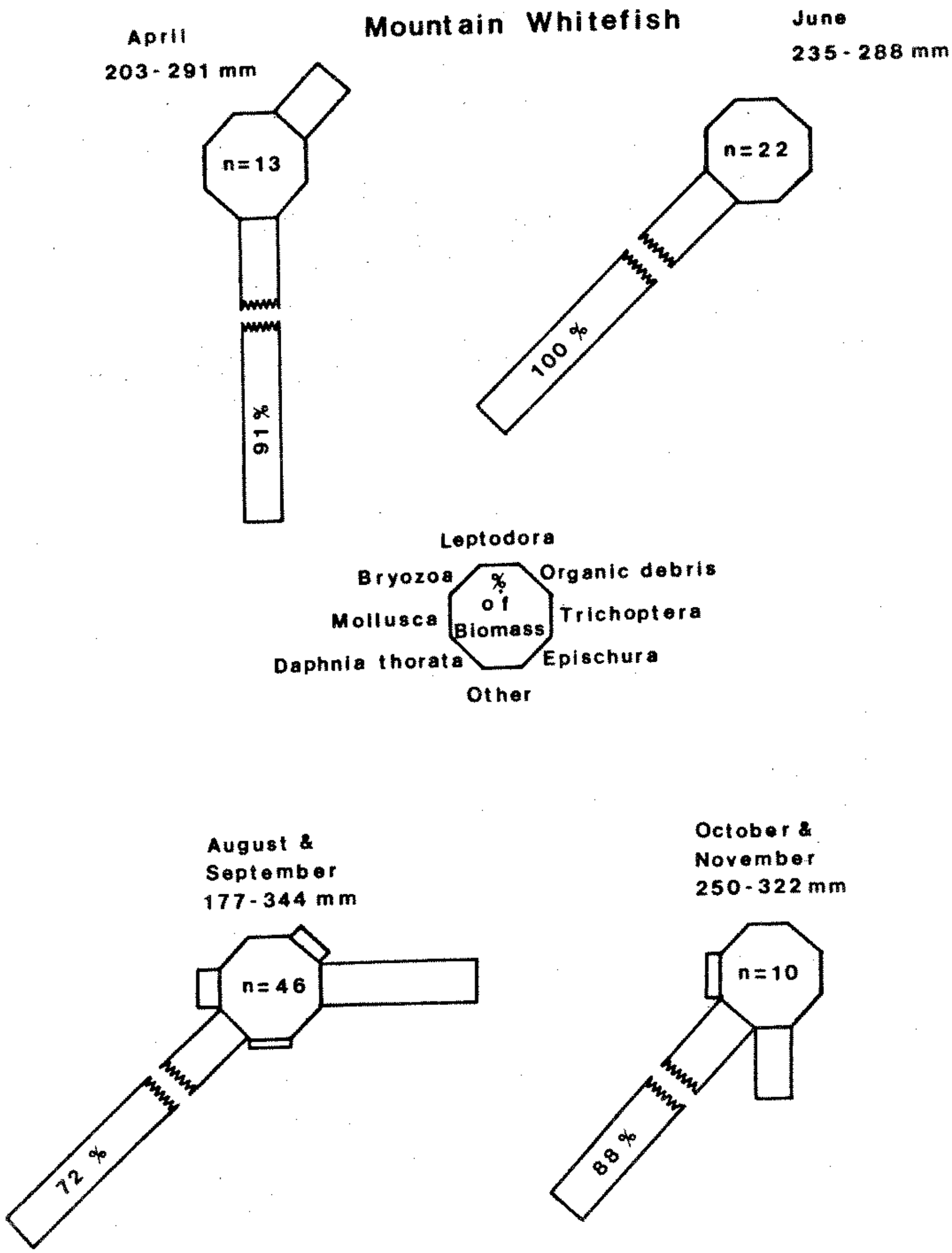


Figure 24. Relative contribution (percent of food biomass) of various food categories to the diet of mountain whitefish collected from Flathead Lake in four time periods during 1981.

(Jeppson and Platts 1959).

Pygmy Whitefish

Food habits analysis was conducted on stomachs from 98 pygmy whitefish collected during 1980, and 37 fish collected in 1981. All specimens were collected using the mid-water trawl during the months July through early December. Pygmy whitefish were usually closely associated with the bottom (within 5 m) at depths of 18 to 25 m at night during the summer and fall months.

Daphnia thorata and late instar *Epischura* were the two principal pygmy whitefish foods. These organisms comprised 70 and 13 percent, respectively, of total food biomass during the months July through December (Appendix A25). All other food items comprised one percent or less of total food biomass with the exception of organic debris (10%) and chironomid larvae (6%).

Daphnia and *Epischura* were the principal food items of pygmy whitefish during all sampling periods (Figure 25: Appendix A25). Organic debris was common in stomachs collected during July, October and November. Chironomid larvae comprised nine to 12 percent of food biomass in all sampling periods except December (Figure 25; Appendix A25 and A26).

The food habits of pygmy whitefish in Flathead Lake were similar to what has been observed in other lakes. Pygmy whitefish have been found to feed mostly on plankton in some lakes and on benthic organisms in others (Carlander 1969). This is probably related to gill raker size and number as well as the productivity and degree of littoral zone development in a given lake. In Chignik Lake, Alaska, short-rakered pygmy whitefish fed almost exclusively on zooplankton (McCart 1970). Pygmy whitefish in Flathead lake had intermediate sized gill rakers relative to the Chignik Lake population and fed primarily on chironomid larvae and pupae as well as cladocerans (Weisel et al. 1973). Chironomids comprised a smaller percentage of the diet in the stomachs we examined than in those analyzed by Weisel et al. (1973).

Comparative food habits of the three whitefish species in Flathead Lake revealed a consistent dependency on *Daphnia thorata* during the months April through December of 1980 and 1981 (Figure 26). Lake whitefish feeding habits were the most diverse of the three species. Lake whitefish utilized benthic foods such as molluscs and bryozoans to a greater extent than did the other two species. Mountain whitefish did not utilize *Epischura*, whereas this copepod was commonly found in pygmy and lake whitefish stomachs. The importance of caddisfly larvae (Trichoptera) in the mountain whitefish diet was somewhat anomalous. The importance of this group to the mountain whitefish diet was due to the fact that three fish collected at one site had consumed large numbers of Trichopteran larvae.

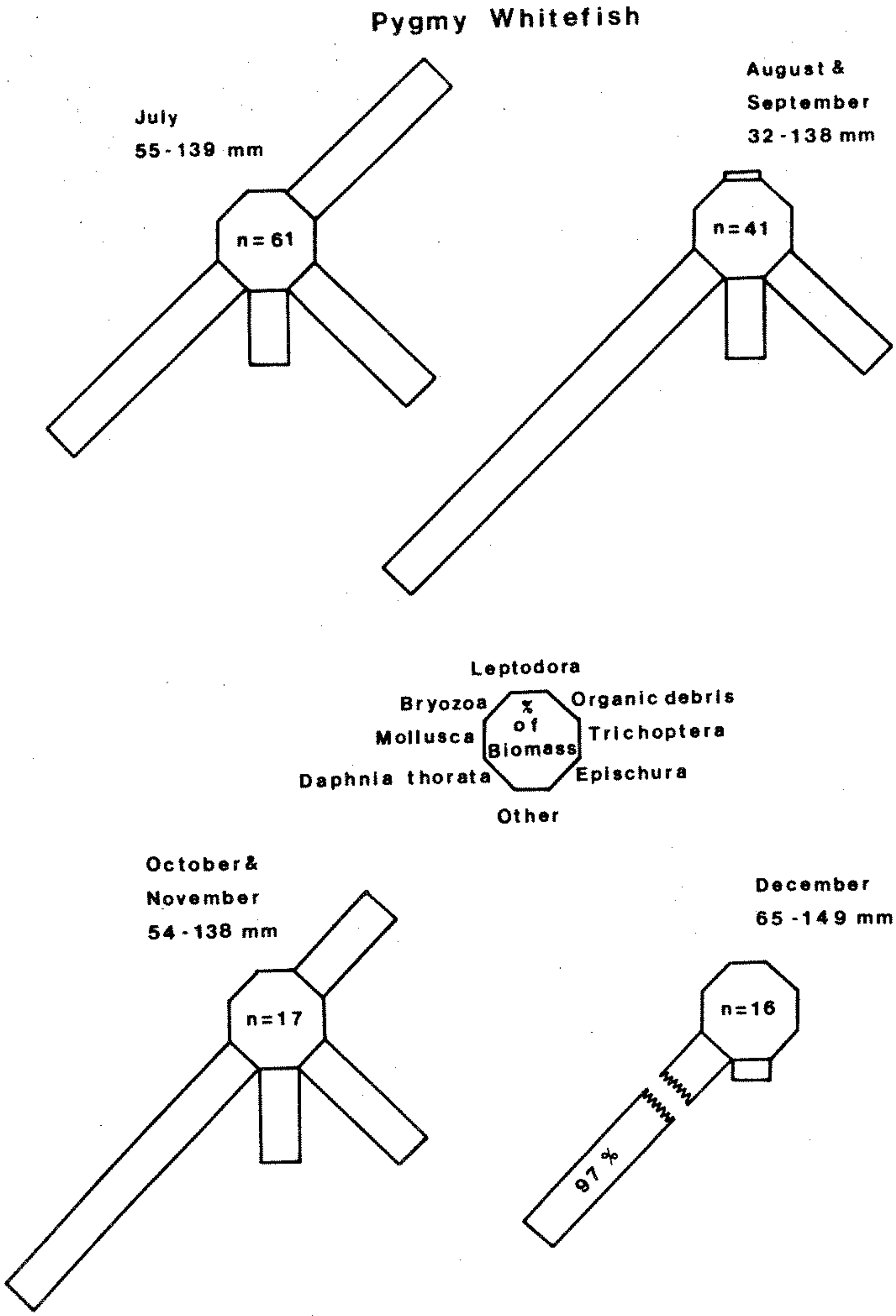


Figure 25. Relative contribution (percent of food biomass) of various food categories to the diet of pygmy whitefish collected from Flathead Lake in four time periods during 1980 and 1981.

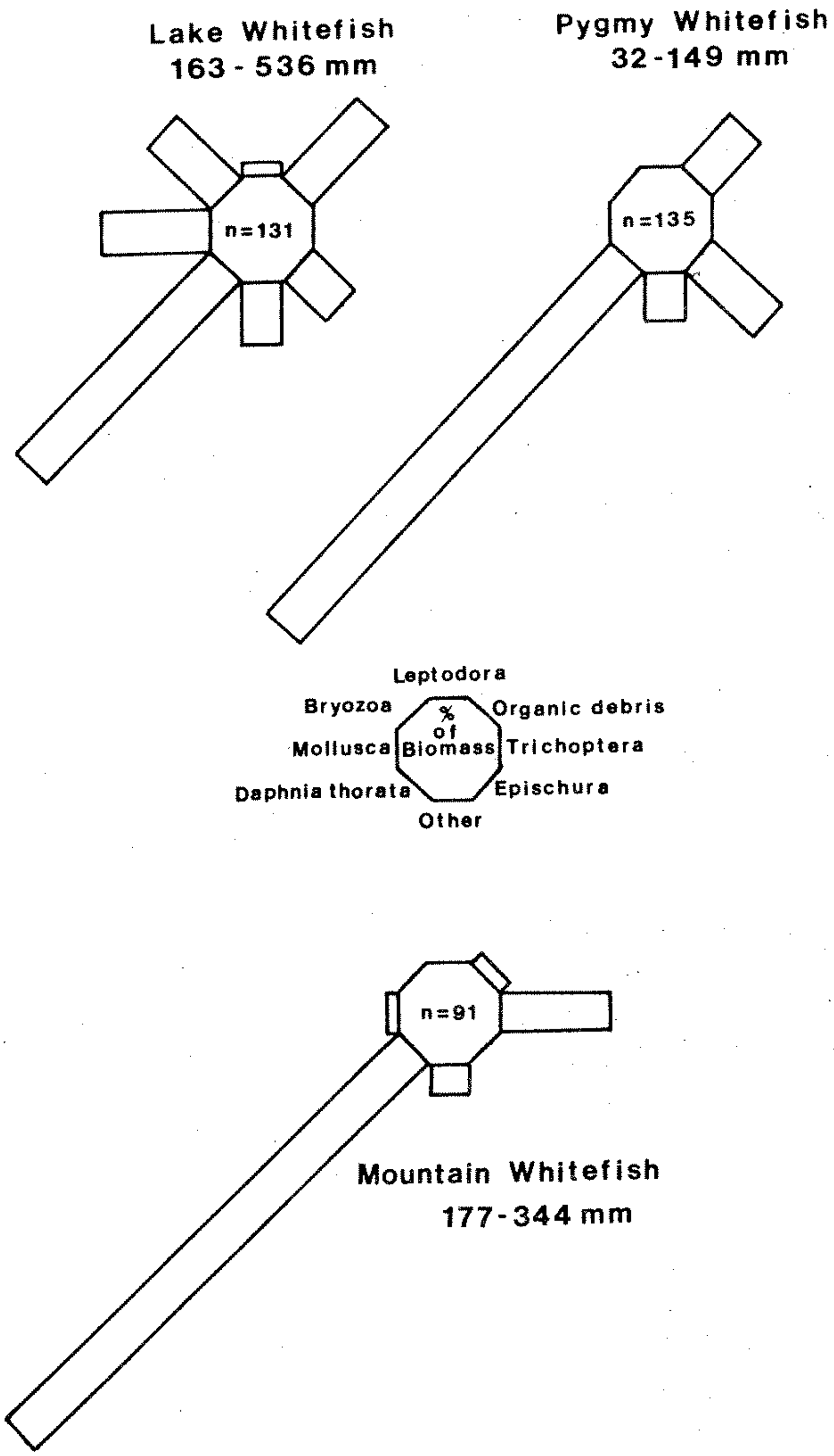


Figure 26. Dietary composition (percent of food biomass) of various food items in the diets of three species of whitefish collected from Flathead Lake during the months April through December of 1980 and 1981.

DIET OVERLAP

Diet overlap was calculated for six species of Flathead Lake fishes collected during the period April through November of 1981. This timespan comprised the main growing season for these fishes. Food biomass data (percent) was used in these calculations since percentage of occurrence and percentage of total numbers of food items are of little value in diet overlap determination (Wallace 1981). Diet overlap measurements are a useful tool which can be used to describe fish community structure and possible competitive interactions.

Diet overlap between westslope cutthroat and other fish species in Flathead Lake was very low during the period April through November (Table 14). This was not unexpected since cutthroat fed primarily on terrestrial insects during this timespan, whereas the other species utilized mostly aquatic invertebrates or fish. Bull trout food habits overlapped very little with other species because of the piscivorous nature of this predator.

The largest degree of diet overlap was observed in the kokanee salmon-whitefish species assemblage (Table 14). All of these fish were planktivores. Most of the overlap index values for this group of fish species exceeded 0.6 which is generally considered to indicate a significant amount of diet overlap (Wallace 1981). The largest amount of diet overlap occurred between pygmy whitefish and kokanee salmon (index value .83) and between pygmy and mountain whitefish (index value .79).

ZOOPLANKTON CROPPING

The predatory impact of planktivorous fishes on preferred zooplankton prey species populations was estimated for 1981. The results of this analysis indicated that the zooplankton food base (especially *Daphnia thorata*) was underutilized by planktivorous fish. Based on these findings, it is estimated that the kokanee population could be enhanced by a factor of two or more with no detrimental effect on the food supply. However, such an increase in the kokanee population level could result in smaller sized fish since growth is generally considered to be density dependent (McMullin and Graham 1981; Rieman and Bowler 1980).

The grazing pressure of age III and older kokanee during 1981 was estimated using late summer lakewide hydroacoustic density estimates (38.7 fish per hectare; D.A. Hanzel, personal communication) and average monthly plankton density in biweekly samples collected at Station 2:4. Results indicated that the large kokanee in Flathead Lake typically consumed far less than one percent of the *Daphnia thorata* population on a daily basis during the 1981 growing season (Table 15). Cropping estimates were much higher for adult *Epischura* and ranged up to 7.5 percent in July. A maximum of 1.6 percent of the *Leptodora* population was consumed by large kokanee during September. This analysis was limited because hydroacoustic estimates of kokanee population density were considered to be valid only for the larger fish.

Table 14. Schoener diet overlap index values calculated for six species of fish collected from Flathead Lake during the period April through November of 1981.

	WCT	DV	KOK	LWF	MWF	PWF
WCT	---	.01	.02	.06	.05	.08
DV	.01	---	.00	.01	.00	.00
KOK	.02	.00	---	.62	.68	.83
LWF	.06	.01	.62	---	.57	.61
MWF	.05	.00	.68	.57	---	.79
PWF	.08	.00	.83	.61	.79	---

WCT = Westslope cutthroat trout
DV = Bull trout
KOK = Kokanee salmon
LWF = Lake whitefish
MWF = Mountain whitefish
PWF = Pygmy whitefish

Table 15. Estimated monthly cropping rate of age III and older kokanee in Flathead Lake during 1981.

Prey species	Jun	Jul	Aug	Sep	Oct
Daphnia thorata					
max. no./fish[a/]	4341	3926	3445	6973	3792
% removal	.1%	.1%	.1%	.1%	.1%
Adult *Epischura*					
max. no./fish	4289	403	192	23	---
% removal	2.0%	7.5%	.1%	.01%	---
Leptodora					
max. no./fish	---	388	373	147	26
% removal	---	.8%	.7%	1.6%	.4%

a/ Multiply by two to estimate daily consumption.

Planktivorous fish collected through intensive purse seining consumed an average of approximately 0.3 of one percent of the *Daphnia thorata* population per day in the northwest portion of Flathead Lake during late June and early July of 1981 (Table 16). Using *Daphnia* egg density data and temperature-dependent egg hatching times (Bottrell et al. 1976), the average recruitment to the *Daphnia* population was estimated to be 1755 newborn animals per square meter of lake surface area per day. Fish consumed an average of 88 *Daphnia* per square meter per day which amounted to about five percent of daily *Daphnia* recruitment. The maximum *Daphnia thorata* consumption rate for any particular seining location was 0.6 of one percent, observed on June 30. The two whitefish species accounted for approximately 11 percent of the total average daily *Daphnia* consumption rate.

An average of 3.5 percent of the adult *Epischura* population was consumed per day by planktivorous fish (Table 16). Lake whitefish consumed far less than one percent of the *Epischura* population per day. Mountain whitefish apparently did not feed on *Epischura*. Maximum *Epischura* consumption was 7.4 percent of the population per day, observed on June 30.

Our calculated total cropping rate of *Daphnia thorata* (0.3% per day) was low in comparison to other studies. Rieman and Bowler (1980) estimated that kokanee in Pend Oreille Lake consumed up to 3.4 percent of *Daphnia* standing crop. The daily consumption of 8.4 percent of the *Daphnia* population by fingerling yellow perch in Oneida Lake, New York was not considered to be a significant impact on the population (Noble 1975). Hence it would appear that the population of kokanee in Flathead Lake was not food-limited.

Cropping rates presented in Table 16 are probably larger than actual lakewide rates during the same timespan. Daytime echograms indicated that most fish were located near the surface within the fishable depth range of the purse seine (48 feet). However, fish densities were higher in the northwest portion of the lake than in adjacent areas and the seine hauls were made in locations having particularly large concentrations of fish in order to maximize catches. The average density of large kokanee (age III and older) in purse seine hauls was 2.5 times larger than the lakewide hydroacoustic population estimate for these fish. Furthermore, cropping rates for each zooplankton species were calculated using the assumption that all fish fed exclusively on that species. However, with the exception of mountain whitefish, all fish species fed on both *Daphnia* and *Epischura*. This would act to decrease the actual predation pressure on a given prey species.

The percent composition of *Daphnia thorata* and adult *Epischura* in the stomachs of fish collected in purse seine hauls was compared to the density of these organisms in the lake plankton at five different locations during late June and early July of 1981 (Appendix A27). During this timespan, *Daphnia thorata* and *Epischura* were exclusively consumed by the three species of planktivorous fish. However, preference for either

Table 16. Average fish density and cropping rate (percent of zooplankton population removed per day) of kokanee salmon, lake whitefish, and mountain whitefish in the northwest portion of Flathead Lake during the period 22 June - 1 July, 1981.

	Kokanee			Lake whitefish	Mountain whitefish	Total
	I+	II+	>III+			
Mean density (no./hectare)	54.7	46.0	95.0	19.2	16.7	231.6
Daphnia thorata,						
max. no./fish[a/]	1310	6761	4341	2893	2549	
% removal	.02%	.09%	.13%	.02%	.01%	.27%
Adult *Epischura*						
max. no./fish	31	3339	4289	1376	0	
% removal	.02%	.80%	2.5%	.17%	0	3.5%

a/ Multiply by two to estimate daily consumption.

prey species varied considerably and was not consistently related to the relative density of these organisms.

Mountain whitefish fed exclusively on *Daphnia thorata* at all locations regardless of the availability of alternate prey. Lake whitefish and most age classes of kokanee exhibited similar prey preference at each site. The percentage of *Epischura* in the stomachs of kokanee and lake whitefish was highest at sites which had the lowest *Epischura* densities. These fish may have caused a decrease in *Epischura* numbers at these sites although the low cropping rate estimates for *Epischura* (up to 7.4% of the population per day) would not support this conclusion.

Although the feeding habits of age II+ and III+ and older kokanee were similar at most locations, substantial variation was noted at one site on 30 June (Appendix A27). On that date, age I+ kokanee fed primarily on *Daphnia*, whereas age III and older fish had consumed mostly *Epischura*. Stomach contents of age II+ fish were intermediate.

Variation in prey selection was noted even within the same age (size group) of kokanee collected in the same purse seine haul. Examination of the stomach contents from a group of eight similarly-sized kokanee (297-367 mm) from the same seine haul revealed that five of these fish fed nearly exclusively on *Daphnia* (96% of total food biomass) whereas the remaining three fish consumed *Epischura* (99% of total food biomass). This strongly suggests that individual fish "specialize" on certain prey species as was found for juvenile sockeye salmon by Ricker (1937). Recent evidence suggests that individual fish do indeed "decide" on what prey species or size category to consume and that the fish adhere strictly to that commitment (Gardner 1981; Werner et al. 1981). In fact, Werner et al. (1981) observed that a bluegill sunfish population in a small pond split into two factions, one fed on benthos, while the other fed on plankton. An identical "split" was observed in lake whitefish population in Flathead Lake during this study.

THE DISCOVERY OF *MYSIS RELICTA* IN FLATHEAD LAKE: POSSIBLE FUTURE RAMIFICATIONS

Introduction

Opossum shrimp (*Mysis relicta*) were collected in nighttime midwater trawl hauls on three separate occasions (9 September, 21 October, and 23 November) in the northwest quadrant of Flathead Lake during 1981. To our knowledge this is the first collection of this organism in the lake.

Mysis is a member of an almost exclusively marine order of shrimps. As the species name implies, *Mysis relicta* is believed to be a relict organism that became landlocked during the period of Pleistoscene glaciation in cold, deep oligotrophic lakes in many parts of the northern United States and in Canada (Pennak 1978). *Mysis* is not native to northwest

Montana, but is indigenous in nearby Waterton Lake in Canada. This organism is small in relation to other shrimps, but larger than most zooplankton and attains lengths of almost 30 millimeters.

Mysis has been introduced into many deep oligotrophic lakes in the northern United States and Canada during the past two or three decades to enhance the food supply for cold water fishes (Gosho 1975). *Mysis* is a desirable fish food because of its large size relative to other crustacean zooplankton species and the fact that it can attain high population densities in lakes having low productivity.

The impetus for widespread mysid introductions into lakes in the western United States was provided by a successful introduction of this organism into Kootenay Lake in British Columbia in 1949 and 1950. *Mysis* became established in this lake by the early 1960's and were apparently utilized extensively by kokanee in one area of the lake. Maximum length of kokanee increased from less than 30 to more than 45 centimeters and maximum weight increased from less than 0.2 kg (0.4 lb) to more than 3.0 kg (6 lb) following the introduction of *Mysis* (Northcote 1972). This enhanced growth may also have been partly due to accelerated eutrophication during that timespan.

Encouraged by the beneficial effects of mysid establishment on kokanee in Kootenay Lake, fisheries managers began introducing *Mysis* into many lakes in the United States to benefit kokanee, lake trout, and other fish species. Some of the more publicized introductions in the western United States include Lake Tahoe in California-Nevada and Priest and Pend Oreille Lakes in Idaho.

Mysids from Waterton Lake, Alberta were planted in thirteen lakes in northwestern Montana by Montana Department of Fish, Wildlife and Parks personnel during the period 1968 through 1976 (Domrose 1982). This organism has become established in at least five of these lakes, three of which drain into Flathead Lake (Figure 27). It is likely that the mysids found in Flathead Lake originated from one or more of these lakes.

Unfortunately, the Kootenay Lake success has not been duplicated in other kokanee lakes in which *Mysis* has become established. In fact, kokanee populations have declined significantly in a number of lakes following the introduction of *Mysis*. These include Lake Tahoe in California-Nevada (Morgan et al. 1978), Pend Oreille and Priest Lakes in Idaho (Rieman and Bowler 1980; Rieman 1979), and Whitefish Lake in Montana (Anderson and Domrose 1982). There are also a few lakes such as Upper Priest Lake in Idaho and Ashley Lake in Montana where kokanee populations have remained stable after *Mysis* establishment.

It is interesting to note that kokanee population declines in most of the "problem" lakes mentioned above have not been paralleled by a compensatory increase in growth rates of the fish. Compensatory increases in growth are expected to occur when populations of density-dependent

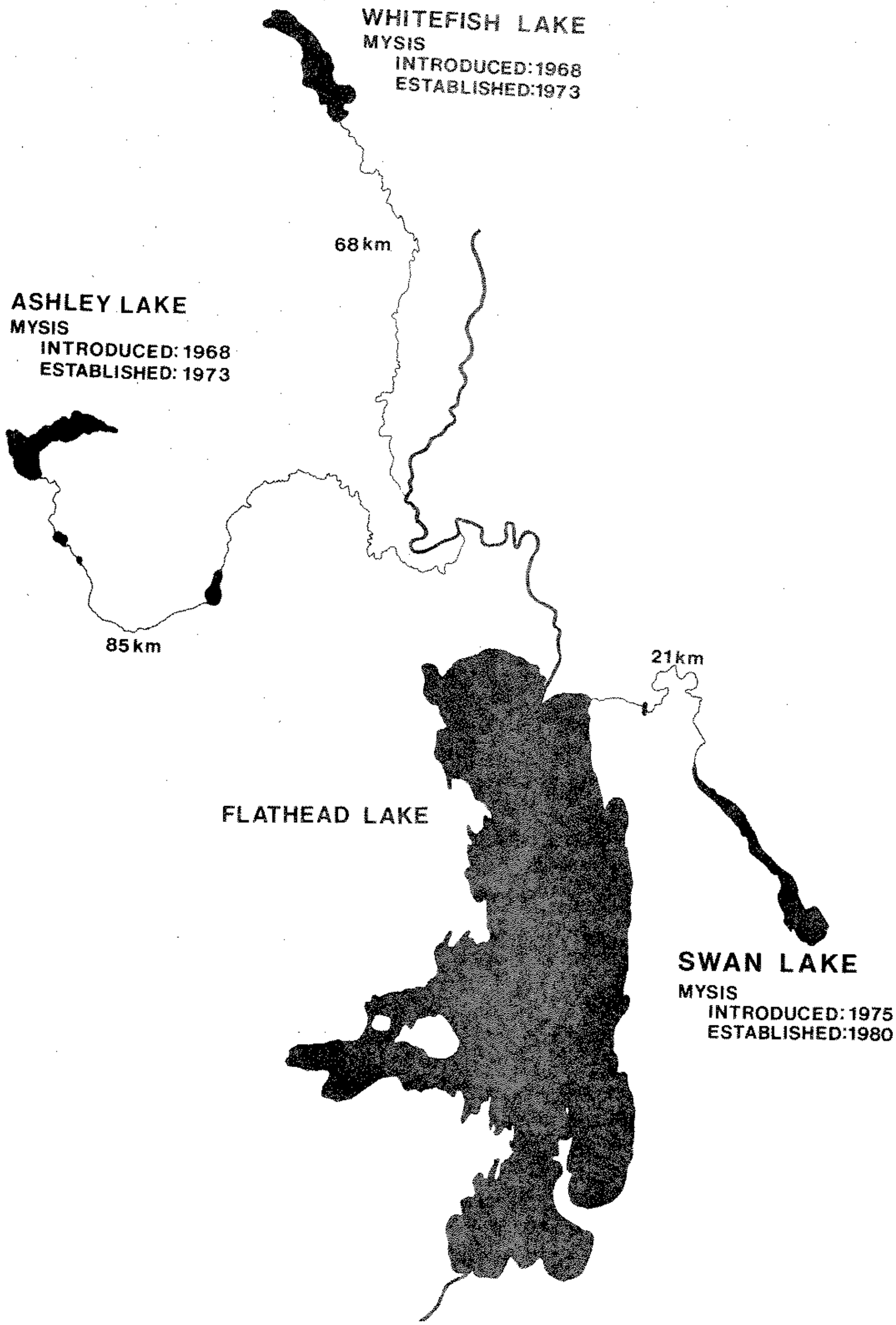


Figure 27. Map of the upper Flathead River drainage detailing lakes having established *Mysis* populations and distances (river kilometers) to Flathead Lake.

species like kokanee salmon decline (Goodlad et al. 1974). When such growth increases are not observed, one may suspect that the food base has been altered or reduced.

As was mentioned in this report, large cladocerans such as *Daphnia* were a preferred kokanee food item in Flathead and many other lakes. Recent studies have shown that *Mysis* can feed preferentially on *Daphnia* as well and can be a voracious predator on such organisms (Lasenby and Langford 1973; Cooper and Goldman 1980; Murtaugh 1981). Intense predation by mysids has been suggested to be at least partly responsible for the virtual elimination of *Daphnia* and other cladocerans from Lake Tahoe (Morgan et al. 1978; Goldman et al. 1979; Threlkeld 1981) and the reduction of *Daphnia* populations in Lake Washington (Murtaugh 1981).

Mysis were suspected to have a more subtle influence on *Daphnia* and *Bosmina* populations in Pend Oreille Lake, Idaho (Rieman and Falter 1981). Post-mysid populations of these preferred kokanee food items were shifted temporally and developed later in the year than in pre-*Mysis* years. Cladoceran populations were apparently depressed by mysid predation until surface water temperatures increased during early July to beyond the preferred range of the shrimp. Thus a thermal sanctuary was created near the lake surface where cladoceran populations could develop in the absence of mysid predation.

The failure of *Mysis* as a kokanee enhancement tool in many lakes is probably related to the fact that it can compete with kokanee for the same food items plus the fact that *Mysis* and kokanee seldom inhabit the same depth strata at the same time. Mysids avoid light and typically spend the daylight hours near the bottom in very deep waters (100 m or more) while kokanee are usually within 30 m of the surface and feeding actively. At night, when the kokanee cease feeding, mysids frequently migrate to the surface waters where they can feed on either phytoplankton or zooplankton. Mysids then descend to deeper waters before dawn and are therefore virtually unavailable to kokanee as a food item during most of the 24-hour day. A vertical migration of 100 m can be achieved by mysids in one or two hours (see summary by Gosho 1975).

It now appears that the accelerated kokanee growth observed in Kootenai Lake may have been due to the unusual morphometry of the lake basin. Most of the exceptionally large kokanee have been found in the shallow West Arm of the lake (H. Andrusak, B.C. Fish and Wildlife Branch, Nelson; personal communication). *Mysis* were apparently swept from the main lake at night into the outlet current that traveled through the West Arm (Daley et al. 1980). These mysids were extensively utilized by foraging kokanee during the day due to the absence of a deepwater mysid refuge in this shallow arm of the lake.

Comparison of Flathead and Whitefish Lakes

We compared crustacean zooplankton populations in Whitefish and Flathead lakes during 1981 following the decline of the kokanee population in Whitefish Lake to determine if *Mysis* had impacted the kokanee food base. This information would be useful in predicting mysid impacts on the biota of Flathead Lake.

The seasonal abundance patterns of *Daphnia* (probably *D. thorata* in both lakes) and *Bosmina* were quite similar in Flathead and Whitefish lakes during 1981 although peak densities were highest in Whitefish (Figure 28). The copepod populations were quite different in the two lakes (Figure 29). Whitefish Lake was dominated by *Cyclops* and had few *Diaptomus* whereas the reverse was true for Flathead. Populations of late instar *Epischura* were larger in Flathead than in Whitefish, whereas *Leptodora* populations were similar between lakes (Figure 30). The surface waters of Flathead Lake were usually warmer and more frequently isothermal than those of Whitefish Lake (Figure 31).

The similarity between cladoceran populations in the two lakes during 1981 indicates that *Mysis* had little impact on the kokanee food base in Whitefish Lake. We compared the 1981 Whitefish Lake results with those obtained in 1979 by Anderson and Domrose (1982) to identify other possible historical changes. Since the Wisconsin net used during 1979 was unmetered, data was compared in terms of percentage composition of certain species. Results of this comparison indicated that populations of *Daphnia* and *Bosmina* developed approximately one month later in 1979 than in 1981 (Figure 32). Calculated densities of these organisms for the two study years also showed the same trends. Maximum and average surface water temperatures in the lake during 1979 were similar to or higher than those of 1981 (Figure 33).

Elevated spring and early summer water temperatures generally favor earlier establishment of cladoceran populations and would reduce mysid abundance in surface waters since this organism prefers temperatures less than 14°C (55°F; Pennak 1978). However, *Mysis* density at the south end of Whitefish Lake was more than 50/m^3 in 15 m vertical tows on the night of 12 June 1979, yet was only 4.4/m^3 in similar tows at the same station on 10 June 1981.

Remains from as many as 14-29 *Daphnia* have been found in the guts of mysids collected from limnetic areas of lakes (Murtaugh 1981; Lasenby and Langford 1973). Assuming an average per capita consumption rate of 15 *Daphnia* per night, a mysid population of 50/m^3 (similar to Whitefish Lake in 1979) could theoretically have removed *Daphnia* from the 1981 Whitefish Lake population faster than they could be replaced by reproduction. This situation could have existed until late June and would explain the temporal delays in *Daphnia* abundance observed in Whitefish Lake during 1979 and in other lakes.

Conclusion

There appears to be ample field and laboratory evidence to support the hypothesis that substantial *Mysis* populations can impact zooplankton populations (particularly cladocerans) in some lakes. However, the degree

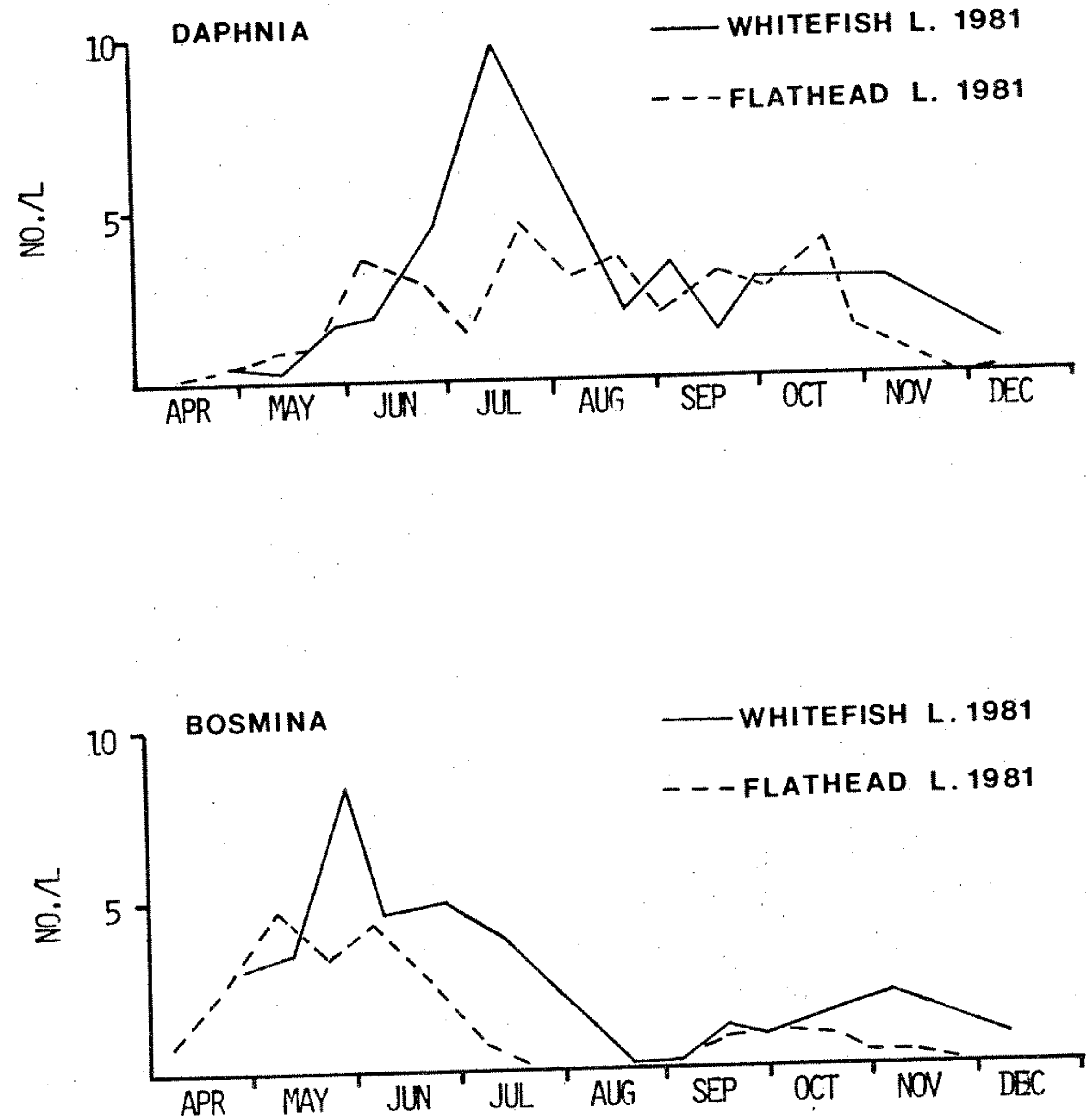
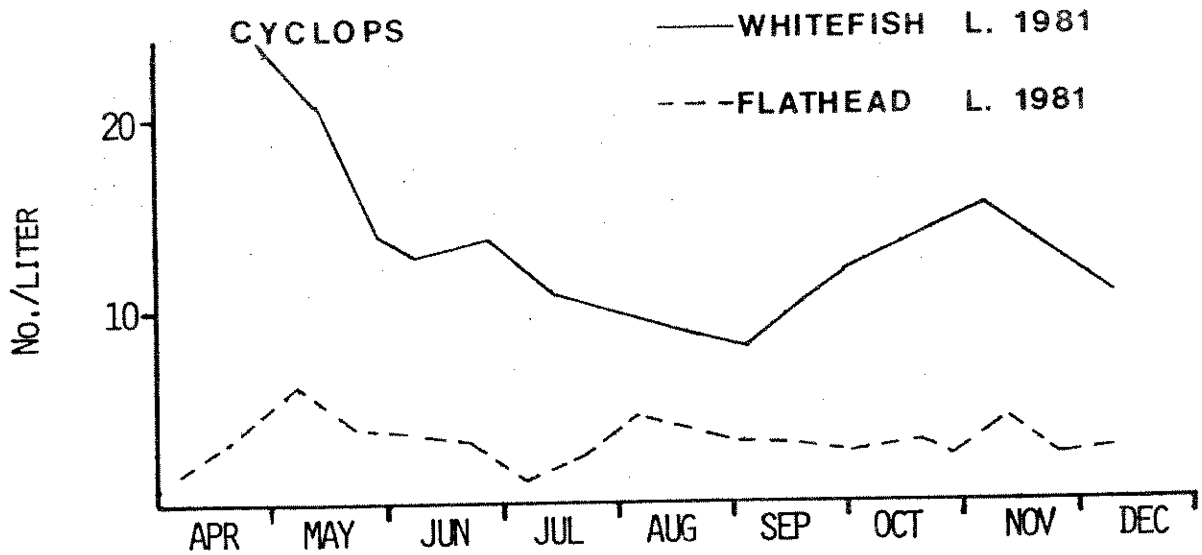


Figure 28. Seasonal population abundance trends (No./L) of *Daphnia* and *Bosmina* in the surface waters (to 15m) of Flathead and Whitefish lakes during 1981.



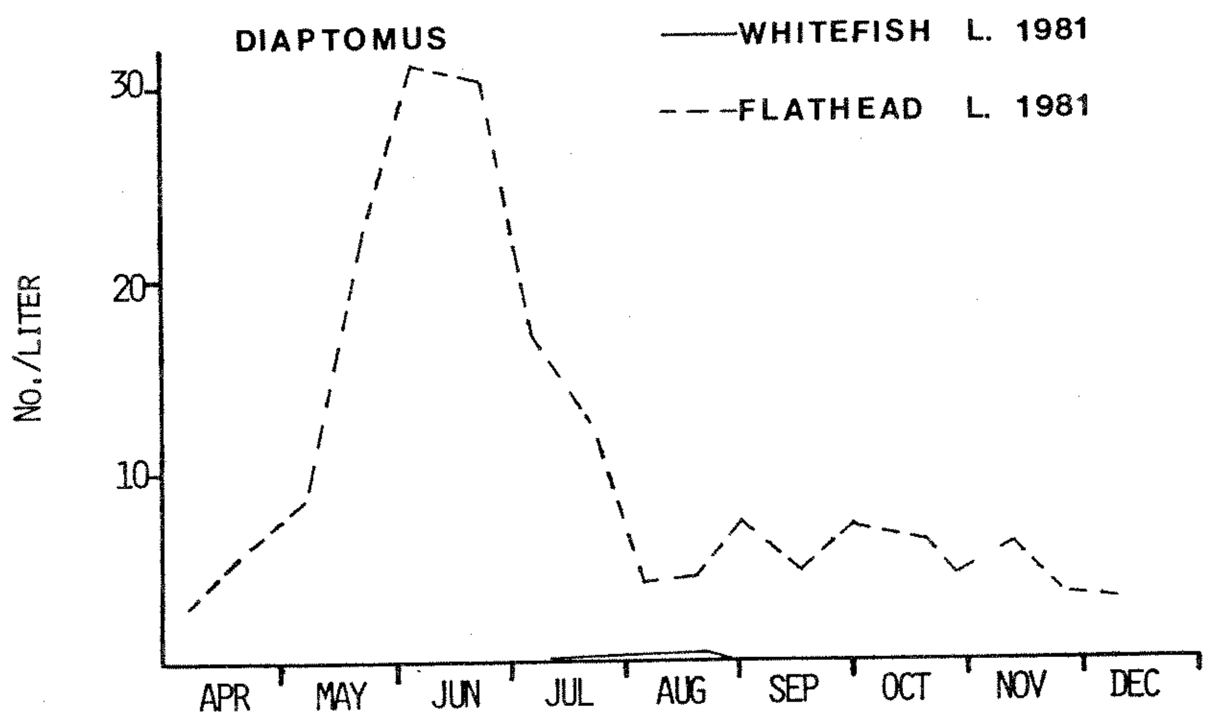
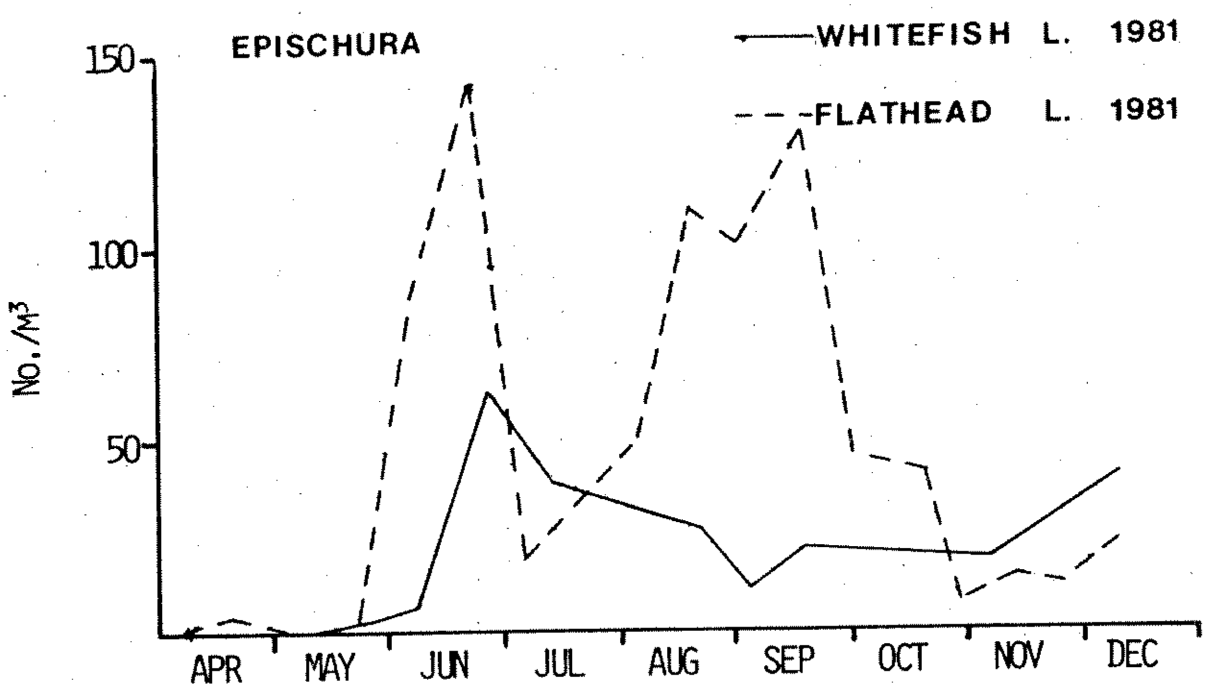


Figure 29. Seasonal population abundance trends (No./L) of *Cyclops* and *Diaptomus* in the surface waters (to 15m) of Flathead and Whitefish lakes during 1981.



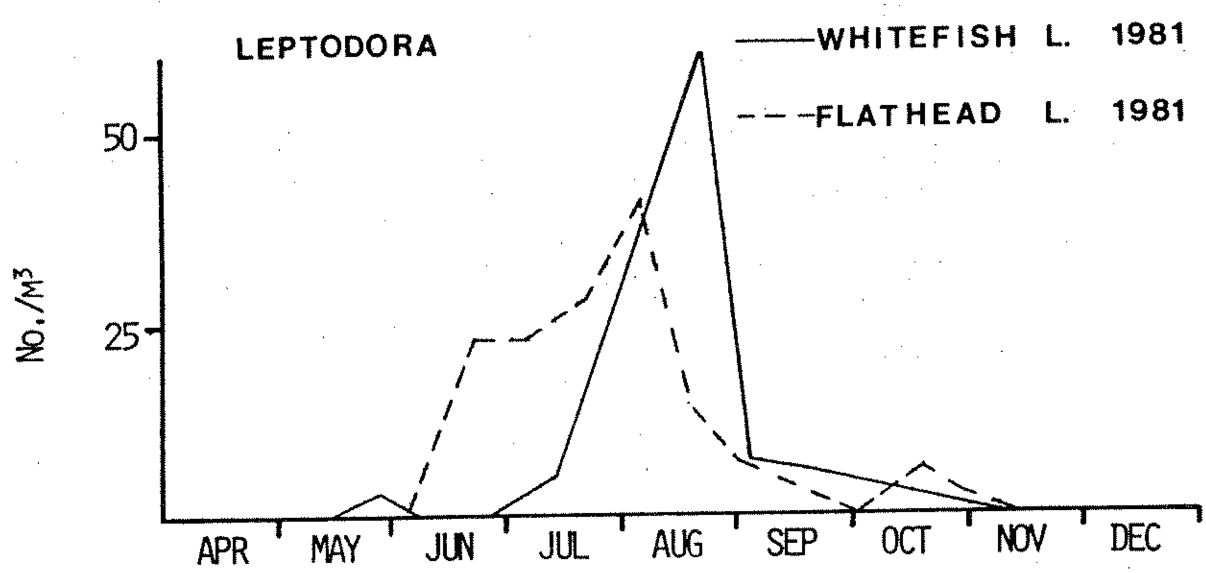


Figure 30. Seasonal population abundance trends (No./m^3) of *Leptodora* and late instar *Epischura* in the surface waters (to 15m) of Flathead and Whitefish lakes during 1981.

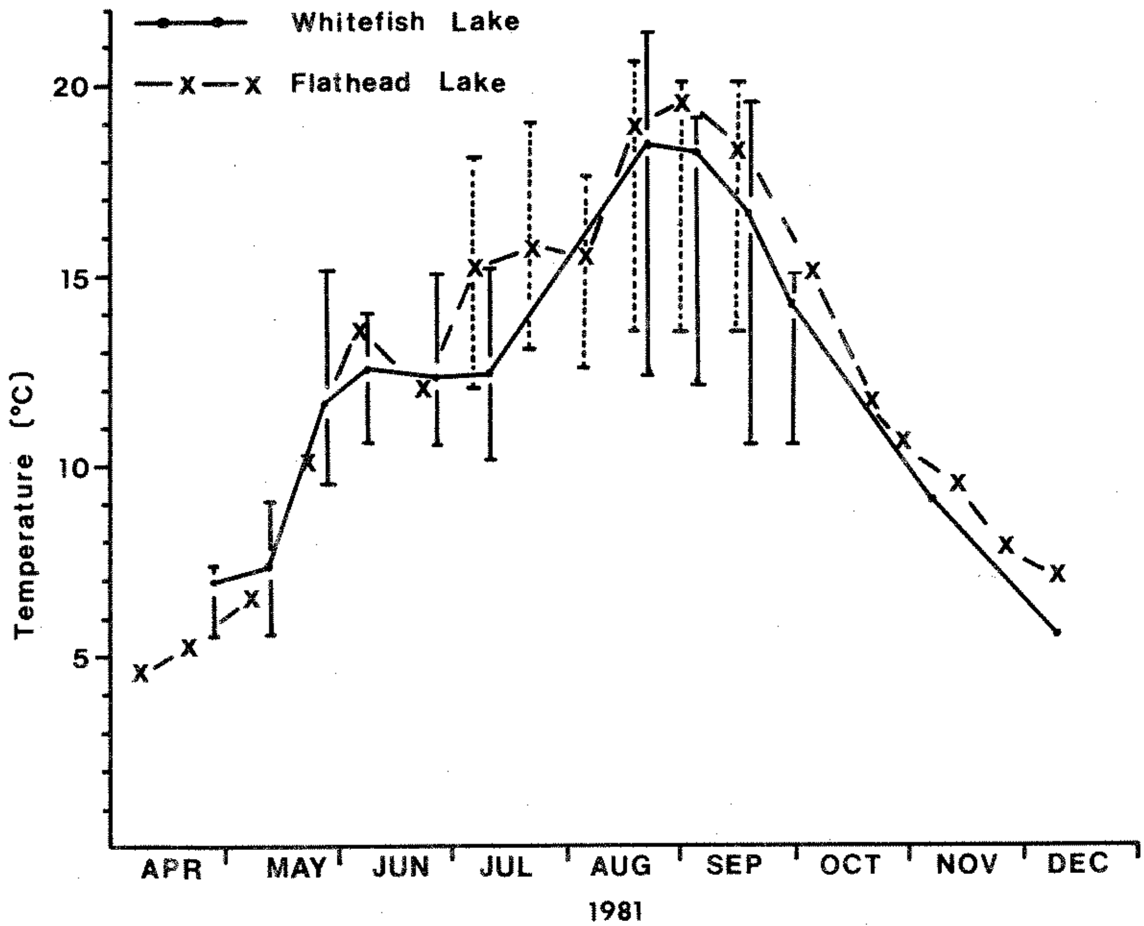


Figure 31. Average water temperature (°C - with ranges plotted) in the upper 15 meters of Whitefish Lake (solid line) and Flathead Lake (broken line) in 1981.

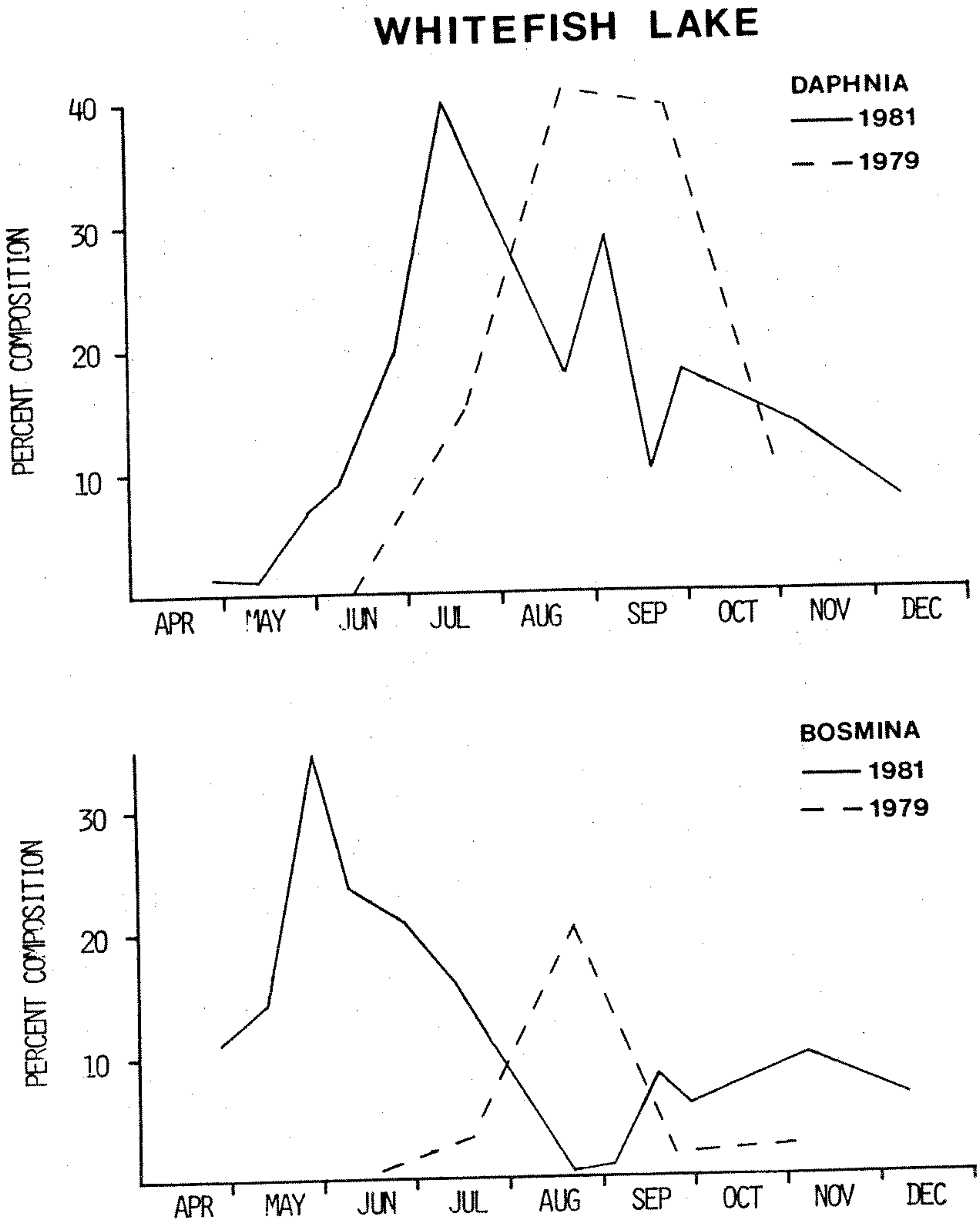


Figure 32. The percent composition of *Daphnia* and *Bosmina* in crustacean zooplankton samples (excluding nauplii) collected from the surface waters (to 15M) of Whitefish Lake during 1979 and 1981.

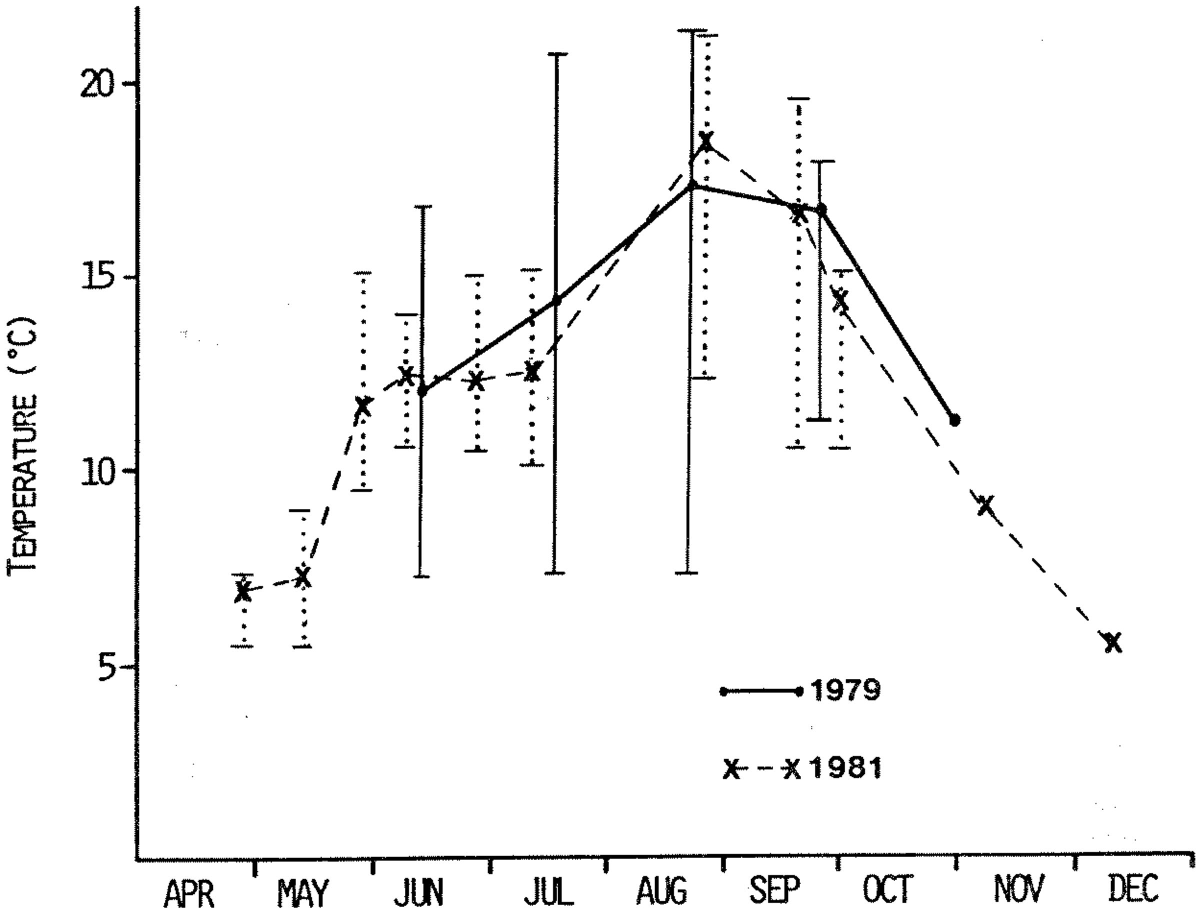


Figure 33. Average water temperatures (with ranges plotted) in the upper 15 meters of Whitefish Lake in 1979 (solid line) and 1981 (broken line).

of impact on plankton populations is variable and likely depends on the density of the *Mysis* population and a number of other factors including lake productivity. Li and Moyle (1981) concluded that the biological communities of oligotrophic lakes are more easily destabilized by the introduction of exotic species than are the communities of more productive lakes. Lake productivity and zooplankton species composition may in part explain the ability for kokanee and mysids to coexist in some lakes.

Although many cause-and-effect kokanee-*Mysis* situations have been observed, researchers have not been able to definitively relate mysid-induced food base changes to kokanee survival. Rieman and Bowler (1980) suggested that the survival of recently emerged fry in Pend Oreille Lake was reduced due to a mysid-induced decrease in the available food supply. However, subsequent studies (Rieman 1981) failed to show increased fry mortality when food availability was limited.

Based on the above mentioned uncertainties, it would be difficult to predict the impact of an established mysid population on the fishery of Flathead Lake. A number of fish species common to Flathead Lake have been known to feed on *Mysis* in other lakes and could possibly benefit from such an introduction. Lake trout utilized *Mysis* in Lake Tahoe, but this did not result in a significant overall improvement in body condition (Morgan et al. 1978). Mysids were believed to have enhanced the growth of small lake trout in Priest Lake. However, the decreasing kokanee population, which was a principal forage species, resulted in declines in condition factors of large lake trout (Rieman and Lukens 1979). This situation could occur in Flathead Lake as well.

Bull trout have been found to feed extensively on mysids in Priest and Kootenay Lakes, but their growth rates have not been enhanced (Rieman and Lukens 1979; Northcote 1972). If mysids were to negatively affect kokanee populations in Flathead Lake, growth rates and condition of large bull trout could decline, similar to that observed for lake trout in Priest Lake. In addition, a decrease in the kokanee population could be accelerated by bull and lake trout predation until the predator population stabilized at a lower level.

Deepwater species such as lake and pygmy whitefish could potentially utilize mysids. However, whitefish species could also be negatively impacted if mysids caused *Daphnia* population reductions since these organisms were an important food item for whitefish in Flathead Lake.

It is possible that kokanee in certain areas of Flathead Lake would be able to utilize mysids as a food source. Flathead Lake is relatively shallow in comparison to other large western lakes such as Lake Tahoe and Pend Oreille Lake. A situation similar to that found in the West Arm of Kootenay Lake could possibly develop at the sill found at the south end of Flathead Lake in the area called "the Narrows". Kokanee could also feed on mysids in shoal areas and bays around the lake. Rieman (1979) suspected that lake basin morphometry was responsible for the appearance of world-record-class kokanee (up to 2.9 kg or 6.5 lb) in the angler catch in Priest Lake after mysid establishment. However, it should be noted that these unusually large kokanee appeared in Priest Lake when the overall kokanee population was on the verge of collapse.

We believe *Mysis* will eventually become established in Flathead Lake, but this process may take five to ten or more years. The direct impact on lake zooplankton and indirect impact on kokanee would likely depend upon the population densities achieved by *Mysis*. The potential impact on kokanee population density in Flathead Lake could be less than observed in some Idaho lakes since the Flathead population is considerably less dense than the pre *Mysis* kokanee population in those lakes.

A reduced availability of *Daphnia* as a spring kokanee food may only affect the growth rate of kokanee, i.e. kokanee may be forced into utilizing more evasive prey species such as *Cyclops* and *Diaptomus* which is less cost-effective in energetic terms. It is also possible that newly hatched fry would be unable to secure food, and thus be more susceptible to starvation or predation.

Potential mysid-induced alterations in kokanee food supply may also vary from year to year in a given lake since *Mysis* populations can exhibit significant annual variation. The *Mysis* population in Whitefish Lake was $50/m^3$, $4/m^3$, and $38/m^3$ in June of 1979, 1981 and 1982, respectively. The size composition of the mysid population is also of importance since small mysids utilize smaller zooplankton prey than do larger *Mysis* (Cooper and Goldman 1980).

The Idaho Department of Fish and Game has resorted to delayed plants of hatchery-reared kokanee fry to bolster sagging populations of wild fish in Pend Oreille Lake (Rieman and Bowler 1980). Hatchery-reared kokanee fry were released into the lake in late July when cladoceran populations became established. Survival of the hatchery reared fry has been much better than wild fry and hatchery fry have continued to comprise an increasing proportion of the total lake population (Bowler 1981). This approach shows good promise but would require extensive hatchery facilities. Bowler (1981) projected that the restoration of the Pend Oreille kokanee population to pre-*Mysis* levels would necessitate the stocking of 20 million mid-summer fry annually.

Research Needs

Population assessment should be conducted on major kokanee producing lakes in northwest Montana (i.e. Flathead, Whitefish, McGregor, Ashley, Swan and Bitterroot) using gear and procedures developed on Flathead Lake. The feeding habits, growth, timing of emergence or stocking, and survival of young-of-the-year kokanee should be monitored annually and related to limnological conditions, zooplankton populations, kokanee year-class strength, and *Mysis* population density.

Laboratory studies with field verification should be initiated to determine the food preference and predation rates of *Mysis* in natural plankton assemblages. The seasonal population dynamics, life history and vertical distribution of mysids should be determined in regional lakes. The coupling of the above information with zooplankton population data (particularly the cladoceran species) would enable a quantitative assessment of the predatory impact of mysids on zooplankton populations.

TROUT AGE AND GROWTH

An understanding of existing age structure and growth rate characteristics of westslope cutthroat trout and bull trout from Flathead Lake is needed as baseline information. Alterations in age structure and growth rates of cutthroat and bull trout populations could result from resource development activities in the upper basin. Age and growth information will also aid in the determination of the ability of the lake to produce trout and in fish life history clarification. Age and growth analysis of other Flathead Lake fish species is being monitored by other Department personnel.

Westslope Cutthroat Trout

Age determinations and scale measurements were made on a total of 573 westslope cutthroat trout collected from Flathead Lake during the years 1962 through 1981. Scales used for age and growth determinations were taken from fish collected by various Department personnel using a variety of sampling techniques (Appendix B1).

Most of the westslope cutthroat trout collected from Flathead Lake were four or five years of age. Four and five year old fish comprised 81 percent of the 1981 gill net catch and 72 percent of the fisherman harvest during the years 1962 through 1981 (Table 17). These same age classes comprised 47, 17 and eight percent, respectively, of the cutthroat trout collected from the Middle Fork, North Fork, and tributaries to these forks of the Flathead River (Fraley et al. 1981). Four and five year old westslope cutthroat trout comprised 68 and 65 percent of the fisherman harvest of this subspecies in Priest and Upper Priest Lakes (Bjornn 1961).

A logarithmic body-scale relationship was used to back calculate fish length at previous annuli. A highly significant relationship was obtained using body length-scale radius information from 2953 cutthroat trout ($r = .95$ and $p<.000$; Table 18). This sample included fish from Flathead Lake, the North and Middle Forks of the Flathead River, tributaries to the North and Middle Forks, and the mainstem Flathead River.

Calculated lengths of westslope cutthroat trout from Flathead Lake (Table 19) were smaller than that found for almost all of the 15 lakes summarized by Carlander (1969). Growth was also slower than that reported for Hungry Horse Reservoir in the Flathead drainage (Huston 1972a) and in Lake Koocanusa in northwestern Montana (May et al. 1979).

Table 17. Age composition (percent) of westslope cutthroat trout from Flathead Lake captured by fishermen (1963-1981) and in gill nets during 1981.

Age	Percent composition	
	In creel	In gill nets
1	---	---
2	<1	2
3	11	12
4	38	42
5	34	39
6	12	4
7	3	1
8	<1	---
Sample size	241	217

Table 18. Equations describing the total body length (in millimeters) to scale radius (millimeters at 67X) relationship for westslope cutthroat trout in the upper Flathead Lake-River system and the total body length to weight (in grams) relationship for westslope cutthroat trout from Flathead Lake.

Equation	Correlation coefficient(r)	p-value	Sample size
log TL = .747 log SR + 1.09	.95	p<.000	2,953
log W = 3.054 log TL - 5.16	.99	p<.000	583

Table 19. Calculated lengths (millimeters) and growth increments for 573 westslope cutthroat trout collected from Flathead Lake during the years 1962 through 1981.

		Length(mm) at annulus							
Age	(n)	I	II	III	IV	V	VI	VII	VIII
1	(0)								
2	(11)	56	120						
3	(77)	63	119	203					
4	(209)	64	123	195	267				
5	(204)	63	117	181	258	311			
6	(60)	66	122	180	252	312	350		
7	(11)	66	118	177	241	307	351	384	
8	(1)	47	103	166	207	256	311	363	410
Grand mean calculated length		64	120	189	261	311	350	382	410
(n)		(573)	(573)	(562)	(485)	(276)	(72)	(12)	(1)
Weighted mean length increment		64	56	69	74	55	39	35	47

Growth of cutthroat trout from Flathead Lake was similar to that reported by Johnson (1963) for lakes and rivers in the Flathead drainage. Comparison with more recent studies in the Flathead drainage has shown that lake fish grew more rapidly than did cutthroat collected from the two forks of the Flathead River and their tributaries (Table 20). Growth of cutthroat from Flathead Lake was quite similar to that observed in the mainstem of the Flathead River (Table 20). This area of the river often harbored migrant cutthroat trout from Flathead Lake for extended periods of time, especially during the winter months (McMullin and Graham 1981).

Age and growth results were very similar for fish collected during the period 1962-1980 and those collected during 1981 in spite of the fact that these groups of scales were analyzed by different personnel. This implies that little variation in cutthroat growth rate occurred during that period of time and that replicability between readers was good. No sex-related growth differences were noted (Leathe and Graham 1980).

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

Migration class was recognizable using scale characteristics for 60 percent of the cutthroat trout collected from Flathead Lake during the years 1962 through 1980 (Leathe and Graham 1981) and for 56 percent of the fish collected during 1981. Difficulties encountered in assigning age at outmigration for many of the cutthroat trout from Flathead Lake may be related to the complex and as yet incompletely understood life cycle of this species in the Flathead drainage. Migrant fish encounter a wide variety of growth environments resulting from differences in tributary, river and lake conditions. Migration class was more easily recognized on scales from mature cutthroat trout captured during spawning migrations into tributaries emptying directly into Hungry Horse Reservoir and Lake Koocanusa than in Flathead Lake where outmigrating juveniles were subject to intermediate growth environments in riverine habitats (J. Huston and B. May, Montana Department of Fish, Wildlife and Parks, personal communication).

Approximately 91 percent of the westslope cutthroat trout from Flathead Lake for which migration class could be determined had spent two or three years in tributary streams (Table 21). This is considered to be typical of adfluvial westslope cutthroat trout populations. Fish trapping results from tributaries to the North Fork of the Flathead River and a tributary to Lake Koocanusa, Montana indicated that most emigrating juvenile cutthroat were two and three years of age (Graham et al. 1980; May and Huston 1974).

Table 20. Calculated mean length (millimeters) at annuli for westslope cutthroat trout collected from various areas in the upper Flathead River Basin.

Area	(n)	Length (mm) at annulus I	II	III	IV	V	VI	VII	VIII
Flathead Lake (1962-1981)	(573)	64	120	189	261	311	350	382	410
Mainstem Flathead River[a/]	(250)	55	103	157	242	305	336	381	
North Fork Flathead River[b/]	(127)	64	108	150	180	213			
Middle Fork Flathead River[b/]	(184)	50	99	156	217	269			
North Fork tributaries[b/]	(730)	54	96	135	166	202			
Middle Fork tributaries[b/]	(377)	51	95	139	193	251			

a/ McMullin and Graham (1981)
b/ Fraley et al. (1981)

Table 21. Percent composition of migration classes in fluvial and adfluvial westslope cutthroat trout populations in various lakes and rivers in Montana and Idaho. Subscripts refer to number of years spent in tributary streams.

Migration class	Flathead Lake	Priest Lake a/	Upper Priest Lake a/	Lower Flathead River b/	Middle Fork River c/	North Fork River c/	Hungry Horse Reservoir d/	St. Joe River e/
X_1	4%	---	6%	6%	22%	21%	6%	26%
X_2	42%	38%	35%	57%	33%	33%	74%	67%
X_3	49%	57%	58%	34%	42%	39%	19%	7%
X_4	5%	5%	---	3%	3%	6%	1%	---

a/ Bjornn (1961)
b/ McMullin and Graham (1981)
c/ Fraley et al. (1981)
d/ Huston (1972)
e/ Averett and MacPhee (1971)

As would be expected, cutthroat trout that left tributary streams at an early age attained larger sizes earlier in life than did those fish that resided in streams for longer periods of time (Table 22; Appendix B2 through B6). Backcalculated tributary growth of adfluvial westslope cutthroat trout collected from Flathead Lake was also generally faster than was observed for fish collected in tributaries to the North and Middle Forks of the Flathead River (Table 23). Scale collections from tributaries probably included a large number of slower-growing stream resident and fluvial (migratory between streams and rivers) fish. Backcalculated tributary growth of mature adfluvial cutthroat trout in the St. Joe River-Coeur d'Alene Lake system was significantly faster than was observed for fish collected from tributaries located at the upper end of the St. Joe River drainage (Averett and MacPhee 1971). These upper drainage tributaries were suspected to support mostly resident and fluvial subpopulations.

Migrant westslope cutthroat trout grew an average of 91 to 99 millimeters in total body length during the first full growing season in Flathead Lake (Table 24). These growth increments were similar to those observed for mainstem Flathead River fish (99 to 119 mm; McMullin and Graham 1981). First-year lake growth increments were 106 to 132 mm in Hungry Horse Reservoir, Montana (Huston 1972), 89 to 127 mm in Priest and Upper Priest Lakes, Idaho (Bjornn 1961), and 168 to 200 mm in Lake Koocanusa, Montana (May et al. 1979). Average growth increments were largest during the third and fourth growing season for fish that spent an undetermined number of years in Flathead tributary streams (Table 24). This suggests that most of these fish outmigrated at age two and three.

The minimum size at maturity of westslope cutthroat trout captured in gill nets from Flathead Lake during this study was 349 millimeters total length. Fish of this size would have averaged four to six years old, depending upon the number of years spent in tributaries (Table 22). Spawned-out adfluvial cutthroat trout captured in downstream traps placed in tributaries to the North Fork of the Flathead River ranged between 351 and 391 millimeters total length (Graham et al. 1980).

The mean condition factor was 0.93 for cutthroat trout collected from Flathead Lake. Condition factors of cutthroat trout from the upper Flathead River system were larger and ranged between 0.95 and 1.09 (Fraley et al. 1981). Condition factors for lake fish ranged from low values of 0.90 to 0.93 in the winter and spring months to high values of approximately 0.98 in the late summer and during the fall. Condition factors varied little between sexes or size classes of cutthroat trout from Flathead Lake.

The first annulus was found to be missing on scales from 43 percent of the westslope cutthroat trout collected from Flathead Lake. Scales collected during the period 1962-1980 (n=318) and during 1981 (n=255) were examined by different personnel, but the percentage of fish missing the first annulus was similar.

Table 22. Mean calculated total length (millimeters) of cutthroat trout that entered Flathead Lake after spending one to four (or undetermined) years in tributary streams. Fish were collected during the years 1962 through 1981.

Years in tributary	(n)	Length (mm) at annulus I	II	III	IV	V	VI	VII
1	(15)	56	154	232	287	360	406	---
2	(148)	65	122	221	284	329	363	---
3	(170)	61	110	160	255	311	350	393
4	(15)	64	117	165	213	304	354	---
Undetermined	(225)	66	125	191	255	305	344	379

Table 23. Comparisons of stream growth attained by westslope cutthroat trout collected in tributary streams of the upper Flathead River drainage versus fish collected from Flathead Lake. Migration class (X_n) subscripts refer to years spent in rearing streams.

	(n)	Total length (mm) at annulus I	II	III	IV
Fish from North and[a/] Middle Fork tributaries	(1107)	53	96	136	174
Fish from Flathead Lake:					
X_1	(15)	56			
X_2	(148)	65	122		
X_3	(170)	61	110	160	
X_4	(15)	64	117	165	213

a/ From Fraley et al. (1981)

Table 24. Mean calculated total length growth increments (millimeters) for westslope cutthroat trout that entered Flathead Lake after spending one to four (or undetermined) years in tributary streams. Fish were collected during the years 1962 through 1982.

Years in tributary	(n)	Length increments (mm) between annuli						
		I	II	III	IV	V	VI	VII
1	(15)	56	98	76	55	61	39	---
2	(148)	65	56	99	63	46	33	---
3	(170)	61	49	50	95	55	39	39
4	(15)	64	53	47	49	91	44	---
Undesignated	(225)	66	59	66	65	54	41	33

The missing first annulus phenomenon is related to short growing season length and was observed in 61 and 29 percent of cutthroat trout collected from the upper Flathead River system and mainstem Flathead River, respectively (Fraley et al. 1981; McMullin and Graham 1981). The first annulus was absent in 35-50 percent of cutthroat trout from Yellowstone Lake (Laakso and Cope 1956).

Age was determined using scales and otoliths from the same fish for a sample of 188 fish collected during 1980 and 1981. Scale age and otolith age agreed in 58 percent of the cases. Scale age exceeded otolith age by one year in 58 percent of the cases where scale and otolith ages did not agree. Scale and otolith ages disagreed by two years in only five instances and no consistent bias was noted. Scale and otolith age agreement was 72 percent for a sample of westslope cutthroat trout collected from tributaries to the North and Middle Forks of the Flathead River (Fraley et al. 1981). These fish were younger than Flathead Lake fish and mostly ranged between one and three years of age.

Based on experience gained during scale-otolith aging comparison efforts, it was concluded that scales were more useful for cutthroat trout age and growth analysis than were otoliths. Very few scales were considered to be unreadable. However, otoliths from approximately ten percent of the fish were considered to be unreadable due to over-calcification, erosion or fracture. Age assignments based on scale examination were usually made with more confidence than were age assignments based on otoliths.

Bull Trout

Age determinations were made on scales from 155, 232, 145 and 396 bull trout collected from Flathead Lake during the years 1963, 1968, 1980 and 1981, respectively. Scales collected during 1963 were gathered during creel census activities. The remaining scales were taken almost entirely from fish caught in gill nets except that scales from 30 fish were obtained by creel census during 1981.

The age structure of bull trout captured in gill nets in Flathead Lake during 1968 and during 1980 and 1981 was similar (Table 25). Mature-aged fish (age six and older) comprised 19 and 23 percent of the 1968 and 1980-81 catches, respectively, indicating that little change has occurred during that timespan.

The age structure of bull trout harvested by fishermen during 1963 and 1981 was quite different (Table 25). This may be related to the small sample size for 1981, the manner in which the 1963 sample was collected, or may reflect a larger percentage of large fish in the 1963 population.

The percentages of mature aged bull trout (age six and older) caught in gill nets in Flathead Lake were 24 and 36 percent in the winter (January) and spring (April) compared to 11 and 15 percent in the summer (August)

Table 25. Age composition of bull trout harvested by fishermen and captured in gill nets in selected years during the period 1963 through 1981.

Age (years)	Percent composition: Creel census 1963	Creel census 1981	Gill netting 1968	Gill netting 1980&1981
1	--	--	--	--
2	--	--	--	1
3	--	12	18	6
4	5	52	39	28
5	19	32	24	42
6	39	4	15	17
7	23	--	4	5
8	13	--	0	1
9	1	--	<1	<1
No. aged	155	25	232	542

Table 26. Seasonal age structure (percent) of bull trout captured in gill nets in Flathead Lake during 1981.

Age (years)	Winter 1981	Spring 1981	Summer 1981	Fall 1981
1	--	--	--	--
2	--	--	--	3
3	6	2	9	7
4	20	12	45	37
5	50	50	35	38
6	22	26	9	11
7	2	8	1	4
8	--	2	1	--
No. aged	46	107	114	102

and fall (October-November). Seasonal gonadal enlargement for bull trout was not nearly as apparent as it was for cutthroat trout, hence the percentage of the population considered to be in spawning condition was not determined. Age six and older fish comprised most of the spawning run into tributaries to the North and Middle Forks of the Flathead River (Fraley et al. 1981; Block 1955).

Observed reductions in the percentage of mature aged fish in the Flathead Lake bull trout population during the summer and fall suggests that between 38 and 69 percent of these fish left the lake on an annual spawning migration. Mature fish comprised an average of 30 percent of the winter-spring and 13 percent of the summer-fall lake population (Table 26). From this it was calculated that an average of 57 percent of the mature-aged fish were missing from the summer-fall lake population and were presumably on a spawning migration in the river system. These rough calculations indicate that at least one-third of the mature aged Flathead Lake bull trout population did not spawn during 1981 although the frequency of repeat spawning has not been determined and may vary with age and sex.

A highly significant logarithmic total body length to scale radius relationship was noted for bull trout collected from the Flathead drainage (Table 27). This relationship was constructed using more than 900 fish from Flathead Lake and about 450 juvenile bull trout collected mostly from tributaries to the North and Middle Forks of the Flathead River by other Department personnel.

Calculated lengths of Flathead Lake bull trout as determined in this study (Table 28) were as much as 18 to 25 percent smaller than was found in previous studies of Flathead Lake (Table 29). Bull trout scales were difficult to interpret as was evidenced by comparing our results for fish collected during 1980 with the results for the 1981 collection (Appendix B8 and B11). The two scale collections were examined by different personnel but the results were analyzed similarly. The backcalculated lengths for 1981 fish were five to 15 percent larger than for the 1980 fish. We feel that this reflects reader-bias rather than actual growth differences. The results for the pooled 1963-1981 sample were most similar to bull trout from Lake Koocanusa, Montana; Upper Priest Lake, Idaho; Hungry Horse Reservoir, Montana; and adfluvial spawners captured in the Middle Fork of the Flathead River and its tributaries (Table 29).

Backcalculated first year growth for bull trout collected from Flathead Lake was similar to growth of juvenile fish collected from tributaries in the upper Flathead drainage (Table 29). Growth patterns diverged after age I, probably as a result of the emigration of some juveniles from rearing streams to the more favorable growth environments of the Flathead Rivers or Lake. Most juvenile bull trout emigrating from North Fork Flathead River tributaries were two or three years old and 102 to 175 millimeters long (Graham et al. 1980). Annual growth increments for Flathead Lake fish increased after age two and remained approximately constant after age four (Table 28). This was typical for other Flathead

Table 27. Equations describing the relationship between total body length (millimeters) and scale radius (millimeters at 67X magnification) for bull trout collected in the upper Flathead River Basin, and the body length (millimeters) to weight (grams) relationship for bull trout collected from Flathead Lake during the years 1963 through 1981.

Equation	Correlation coefficient(r)	p-value	Sample size
$\log TL = 1.020 \log SR + .751$	0.97	$p < .000$	1397
$\log W = 3.321 \log L - 5.910$	0.99	$p < .000$	984

Table 28. Calculated total lengths (millimeters) and growth increments for bull trout collected from Flathead Lake during the years 1963, 1968, 1980 and 1981.

		Length (mm) at annulus								
Age	(n)	I	II	III	IV	V	VI	VII	VIII	IX
1	(0)									
2	(3)	76	149							
3	(75)	69	131	200						
4	(250)	68	130	206	291					
5	(311)	69	131	207	297	387				
6	(188)	67	128	201	288	381	472			
7	(74)	67	127	199	285	381	473	566		
8	(24)	65	127	195	280	378	474	572	661	
9	(4)	51	99	180	259	332	437	549	641	731
Grand mean calculated length		68	130	204	292	384	472	567	658	731
(n)		(929)	(929)	(926)	(851)	(601)	(290)	(102)	(28)	(4)
Length increment		68	62	74	88	92	88	95	91	73

Table 29. Bull trout growth (millimeters) in various waters.

		Total length (mm) at annulus								
		I	II	III	IV	V	VI	VII	VIII	IX
Flathead Lake										
This study	mm	68	130	204	292	384	472	567	658	731
(1963-1981)	(n)	(929)	(929)	(926)	(851)	(601)	(290)	(102)	(28)	(4)
Block (1955)	mm	76	150	234	335	457	566	691	780	---
	(n)	(80)	(51)	(44)	(43)	(41)	(31)	(15)	(1)	---
Rahrer (1963)	mm	71	140	208	323	452	594	724	876	---
	(n)	(289)	(289)	(289)	(245)	(203)	(80)	(14)	(1)	
North and Middle Fork Flathead tributaries[a]	mm	72	108	140						
	(n)	(196)	(97)	(16)						
Middle Fork Flathead[a] River	mm	48	97	174	286	389	484	575	636	---
	(n)	(122)	(83)	(41)	(31)	(31)	(29)	(14)	(3)	
Hungry Horse[b] Reservoir, 1953&1972	mm	72	144	225	324	429	513	594	671	---
	(n)	(212)	(212)	(185)	(130)	(60)	(28)	(5)	(3)	
Lake Koocanusa[c]	mm	67	123	212	309	390	482	518	---	---
	(n)	(162)	(162)	(157)	(96)	(37)	(11)	(1)		
Priest Lake[d]	mm	71	114	183	310	424	516	605	---	---
	(n)	(61)								
Upper Priest Lake[d]	mm	66	102	155	239	358	462	546	612	---
	(n)	(41)								

a/ Fraley et al. 1981
b/ Huston 1974
c/ May et al. (1979)
d/ Bjornn 1961

Lake studies (Rahrer 1963; Block 1955) and studies on other lakes (Bjornn 1961; May et al. 1979; Huston 1974).

Comparisons of annual variations in Flathead Lake bull trout growth have been made previously (Leathe and Graham 1980; and Appendix B8 through B11). It appeared as though fish collected in 1963 grew better than fish collected in either 1968 or 1980. These fish were generally four to eight percent larger than 1968 fish and six to 17 percent longer than 1980 fish. Sex related growth differences were slight. Females were estimated to be five to 18 millimeters longer than males at ages four through six (Leathe and Graham 1981).

A significant positive relationship ($r = 0.49$, $p = .000$) was observed between bull trout length and condition factor (Figure 34). This type of relationship has been observed for many lake trout populations (Carlander 1969).

Comparisons were made between scale and otolith age determinations on the same fish for 122 bull trout collected during 1980 and 289 bull trout collected during 1981. Scale and otolith age estimates agreed in 52 percent of the 1980 and 48 percent of the 1981 fish. These percentages were quite similar even though the two collections were not analyzed by the same person. Overall, scale age exceeded otolith age in 54 percent of the cases where scale age and otolith age did not agree for an individual fish. Scale age and otolith age differed by two or more years in about seven percent of the scale-otolith pairs examined. Comparisons between scale age and otolith age for the same fish on a sample of 40 juvenile bull trout from Flathead River drainage tributaries resulted in 100 percent agreement (Fraley et al. 1981). These fish were much younger (0 to 3 years old) than Flathead Lake fish (3 to 8 years old).

As was true for cutthroat trout, more confidence was placed in bull trout age estimates based on scales than on otoliths. Otoliths from about 22 percent of the bull trout were considered to be unreadable due to over-calcification, erosion, or breakage. Scales from approximately nine percent of the bull trout were not read due to regeneration or poor readability.

PURSE SEINING

A total of 13 purse seine hauls were made in Flathead Lake during 1981 (Table 30). Kokanee dominated the catch and comprised about 75 percent of all fish collected. Mountain and lake whitefish were the second and third most numerous species and comprised 13 and 11 percent of the total catch. Five westslope cutthroat trout and one bull trout were the only other fish captured during 1981.

The average daily kokanee catch ranged between eight and 87.5 fish per haul during late June and early July when lake surface waters were relatively cool and turbid (Table 30). Fewer kokanee were captured in mid and late summer when turbidity decreased and the lake became thermally

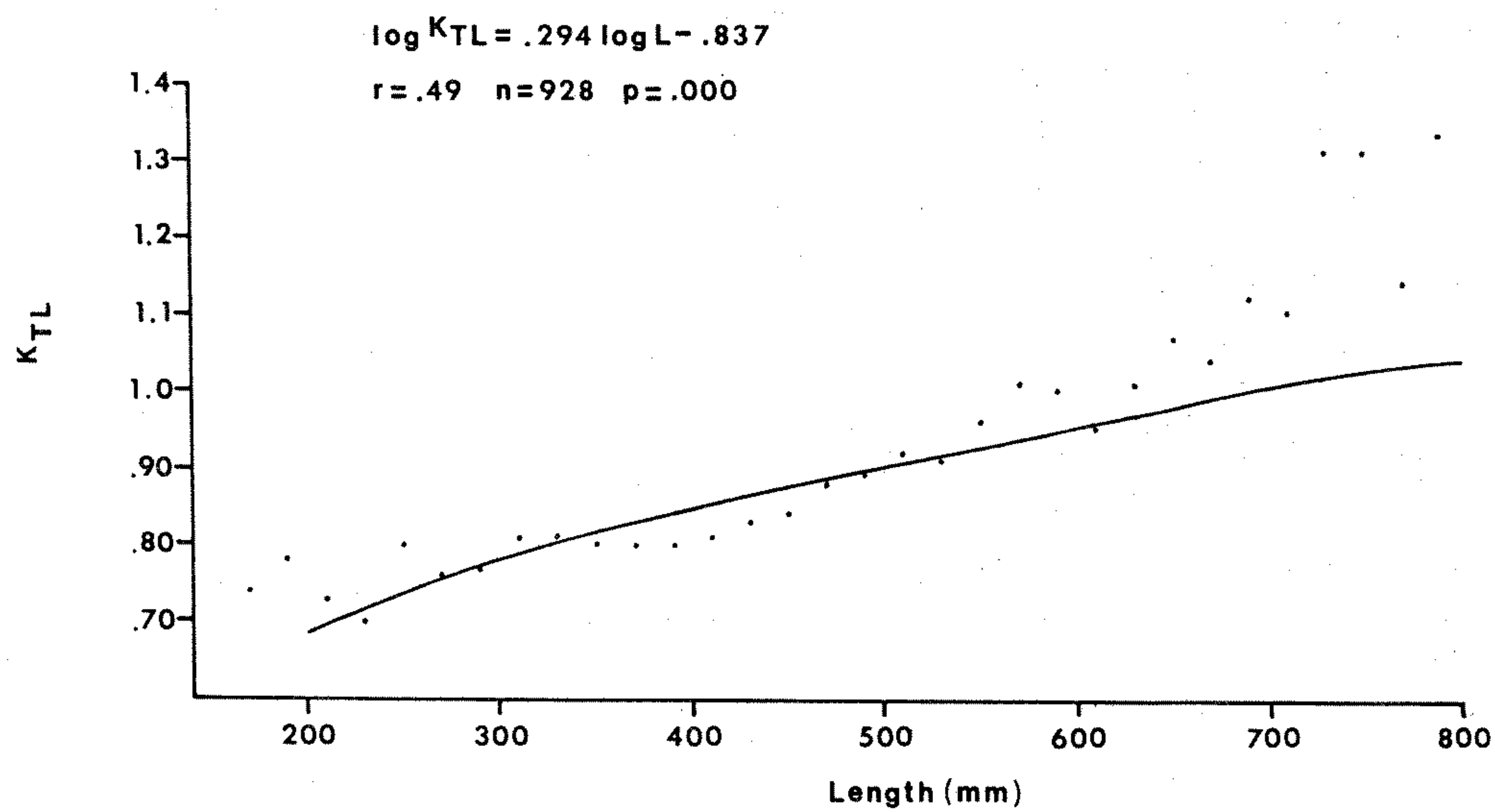


Figure 34. Relationship between condition factor and fish length for 928 bull trout collected from Flathead Lake during the years 1963-1981. Plotted points represent mean condition factors for 20 millimeter length groups.

Table 30. Summary of purse seine catches from Flathead Lake during 1981.

Date	No. hauls	Catch per haul KOK	LWF	MWF	WCT	DV
Jun 22	1	32	3	1	0	1
Jun 24	2	22	6	4.5	1	0
Jun 29	1	8	2	2	0	0
Jun 30	2	87.5	5.5	7	0	0
Jul 1	1	57	3	1	0	0
Aug 4	4	5.5	4.5	4.3	0.8	0
Sep 15	2	0	0	8	0	0

Table 31. Approximate age composition of kokanee captured in purse seine hauls made in Flathead Lake during 1981.

Date	Total kokanee catch	Percent of catch by age class I	II	III and older
Jun 22	32	0	25	75
Jun 24	44	11	11	78
Jun 29	8	0	25	75
Jun 30	175	47	27	26
Jul 1	57	0	47	53
Aug 4	22	0	27	73

stratified. Hanzel (1974a) observed similar declines in purse seine kokanee catches in Flathead Lake during August presumably because kokanee schools frequented deeper waters as surface water temperatures increased.

Most of the kokanee captured in purse seine hauls during 1981 were two and three or more years old (Table 31). More than 90 percent of the yearling kokanee collected during 1981 were taken in a single seine haul on 30 June. This strongly suggests that these fish schooled independently of other kokanee age groups at that time.

MIDWATER TRAWLING

Catches of kokanee in midwater trawl hauls made in the surface waters of Flathead Lake during 1980 and 1981 ranged between zero and one fish per unit of effort (Table 32). All kokanee captured were yearling or young-of-the-year fish.

Large numbers of small yellow perch (10-30 mm) were captured in surface trawls made in Area 1 after dark during the summer of 1981 (Table 32). These fish appeared as a dense layer near the surface on 1981 echo sounder charts but were not detected during sounding runs or midwater trawling activities during 1980. The origin of these perch fry is unknown since, as will be discussed later, perch comprised an insignificant portion of gill net catches throughout the lake. No perch were collected in surface tows made in September and October of 1981 which may indicate that these fish moved into littoral habitats as was found in Oneida Lake, New York (Mills and Forney 1981).

Relatively large numbers of small lake whitefish were captured in surface trawls made in Area 1 during June of 1981 (Table 32). This was the only timespan in which lake whitefish of this size (31-56 mm) were captured during the study.

Kokanee catches were consistently larger in trawl hauls made in deeper waters than in surface hauls (Table 33). Very few large kokanee (age II and older) were collected which indicates that the midwater trawl was inefficient for larger fish (i.e. larger than 200 mm). Pygmy whitefish catches were also substantially greater in deep hauls as compared to surface hauls. Largest catches of pygmy whitefish were obtained in trawls made in close proximity to the bottom (within five meters) in deeper waters (greater than 20 meters). Small numbers of lake whitefish, mountain whitefish, bull trout, northern squawfish, peamouth, longnose suckers, slimy sculpins, and redside shiners were also captured in deep trawls (Table 33).

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 provided specimens for age and growth and food habits analysis. Gill net catches also provided information on the vertical and horizontal fish distribution in the lake.

Table 32. Catch per unit effort (five minutes of towing time) for midwater trawl hauls made in the surface waters (to 10 m) of Flathead Lake during 1980 and 1981.

		Catch per five minutes						Other	
		Kokanee				WF			
Date	No. hauls	0+	I+	II and older	PWF	fry	YP	Total no.	Species
1980									
1 Jul	(3)	---	---	---	---	1.8	---	---	
2 Jul	(1)	1.0	---	---	---	---	---	---	
7 Jul	(1)	0.5	0.5	---	---	---	---	---	
20 Aug	(1)	0.3	0.3	---	---	---	---	---	
1981									
2 Jun	(2)	0.3	0.3	---	---	---	1.8	5	Lk. whitefish
3 Jun	(5)	0.1	0.1	---	0.4	1.4	2.5	18	Lk. whitefish
								1	Reds shiner
5 Jun	(3)	0.2	---	---	0.5	---	0.7	19	Lk. whitefish
9 Jun	(4)	---	---	---	---	---	0.1	28	Lk. whitefish
10 Jun	(3)	---	---	---	---	0.7	15.5	---	
11 Jun	(5)	0.2	0.4	---	---	0.1	0.4	---	
28 Jul	(3)	---	---	---	---	---	0.2	---	
29 Jul	(1)	---	---	---	---	---	106.5	---	

Table 33. Catch per unit effort (five minutes of towing time) for midwater trawl hauls made in deeper waters (10 m to 26 m) of Flathead Lake during 1980 and 1981.

Date	No. hauls	Catch per five minutes: Kokanee 0+	Kokanee I+	Kokanee II and older	PWF	WF fry	YP	Other: Total no.	Species
1980									
2 Jul	(1)	3.0	0.5	---	---	3.0	---	---	
7 Jul	(3)	3.1	4.8	0.2	23.1	---	---	3	Sculpin
17 Jul	(2)	2.8	5.3	---	2.8	---	---	---	
19 Aug	(1)	0.5	0.5	---	2.5	---	---	---	
20 Aug	(7)	1.4	0.8	0.1	2.7	---	---	1	Lk. whitefish
								1	Reds. shiner
10 Sep	(1)	---	---	---	50.0	---	---	---	
25 Sep	(4)	2.8	---	---	0.6	---	---	---	
6 Oct	(3)	1.3	---	---	18.7	---	---	6	Lk. whitefish
								1	Squawfish
								2	Long. sucker
3 Dec	(3)	1.2	---	---	4.8	---	---	1	Lk. whitefish
								1	Mtn. whitefish
1981									
9 Jun	(1)	1.0	---	---	---	---	---	---	
10 Jun	(3)	0.5	---	---	0.2	0.1	1.5	4	Lk. whitefish
29 Jul	(6)	0.9	0.1	0.1	7.4	---	2.7	3	Lk. whitefish
								2	Bull trout
								1	Sculpin
9 Sep	(2)	3.0	---	---	7.8	---	---	---	
10 Sep	(4)	2.6	---	---	0.2	---	---	1	Sculpin
19 Oct	(5)	13.8	0.1	---	0.9	---	---	---	
21 Oct	(4)	3.5	---	---	0.5	---	---	2	Peamouth
23 Nov	(4)	1.4	---	---	3.7	---	---	---	

Catch Composition

More than 5,000 fish were captured in gill nets during the course of the study (Table 34). About 70 percent of these were taken in sinking nets. Peamouth, lake whitefish, and northern squawfish together comprised 74 percent of the total sinking gill net catch. The floating gill net catch consisted mostly of peamouth, kokanee salmon, and northern squawfish which together comprised 80 percent of the catch.

The species composition of our sinking gill net catch differed somewhat from that reported by Hanzel (1970) for Flathead Lake (Table 34). The most apparent differences included the higher percentages of peamouth and squawfish and lower percentages of lake whitefish and kokanee in the 1980-81 catch as compared to 1967-69 catch. This is probably related to the types of gill nets employed as well as depths fished. It is likely that the 1980-81 sets were made in shallower waters where peamouth and squawfish were more numerous. The 1967-69 netting series was conducted using the *Dolly Varden*, a large vessel which could only be safely operated over deeper waters. The 1980-81 netting series was conducted using a 14 foot boat powered by an outboard motor.

Bull Trout

The seasonal bull trout catch in standard sinking gill nets set in Flathead Lake during 1980 and 1981 was fairly stable and ranged between 2.2 and 2.9 fish per net (Table 35). These catch rates were similar to those reported for Lake Koocanusa, Montana (0.6 to 3.2 per net; May et al. 1979), but were lower than those obtained in Hungry Horse Reservoir, Montana (4.8 to 6.0 per net; Huston 1972b, 1974b and 1975). The Hungry Horse and Lake Koocanusa studies utilized identical nets set in areas similar to those selected in this study.

The seasonal bull trout catches in standard floating gill nets set along the shoreline of Flathead Lake during 1980 and 1981 were less than the sinking net catches and ranged between zero and 0.8 fish per net (Table 35). Huston (1975) observed similar reductions in floating net versus sinking net catches in Hungry Horse Reservoir.

Bull trout comprised seven to 16 percent of the seasonal sinking net catch and less than one to 11 percent of the floating net catch in Flathead Lake (Table 36). Hanzel (1970) reported that bull trout comprised 12 to 16 percent of the seasonal sinking net catch in Flathead Lake during the years 1967 through 1969. Bull trout catches were generally largest in Areas 1 and 2 at the north end of the lake during 1980 and 1981 (Figure 35) which agreed with the findings of Hanzel (1970).

The average size of bull trout captured in sinking gill nets in Flathead Lake during 1980 and 1981 was 24 millimeters larger than was found during the period 1967 through 1970 (Table 37). The percentage of legal-sized fish (457 mm and larger) in the 1980-81 netting was also

Table 34. Percent composition by species and net type of combined spring, summer, fall and winter gill net catch on Flathead Lake 1980-81.

Species	Abbreviation	Percent of catch		Total catch
		Sinking nets	Floating nets	
Cutthroat	(WCT)	0.1 (0.8)[a/]	12.8	219
Bull trout	(DV)	10.3 (14.8)	3.4	469
Lake trout	(LT)	1.5 (1.5)	0.2	63
Kokanee	(KOK)	2.3 (10.9)	23.0	479
Lake whitefish	(LWF)	27.0 (44.8)	1.3	1,105
Mountain whitefish	(MWF)	5.9 (1.4)	1.5	260
Suckers	(SU)	4.8 (2.2)	0.4	197
Northern squawfish	(NSQ)	18.2 (10.4)	20.3	1,072
Peamouth	(PM)	28.9 (5.0)	36.5	1,771
Yellow perch	(YP)	0.7 (1.0)	0.4	34
Rainbow trout	(RB)	0 (0)	0.1	1
Northern squawfish X Peamouth	(NSQXPM)	0.5 (-)	0.1	22
Eastern brook trout	(EB)	0 (-)	0.1	1
TOTAL CATCH		4,011	1,682	5,693

a/ Catch composition during the period November 1967 through August 1969 (from Hanzel 1970).

Table 35. Seasonal average catch per standard gill net for principal fish species captured in floating and sinking gill nets set overnight in Flathead Lake during 1980 and 1981.

Species	Floating nets				Sinking nets			
	Winter	Spring	Summer	Fall	Winter	Spring	Summer	Fall
Bull trout	0.1	0.8	0.1	0.5	2.2	2.9	2.9	2.4
Cutthroat trout	1.1	3.3	0.2	1.2	0	0.1	0	0
Lake trout	0	0	0	0.1	0	0	0.1	1.1
Kokanee salmon	0	0.2	0	6.3	0	0.8	0.1	1.2
Lake whitefish	0.2	0.1	0	0.2	6.1	3.2	9.0	6.9
Mountain whitefish	0	0.7	0	0.1	0.4	1.1	3.0	1.0
Northern squawfish	0	1.1	4.6	1.5	1.9	3.0	3.6	7.7
Peamouth	0.3	1.4	6.5	4.7	6.1	7.4	1.6	13.9
Yellow perch	0	0	0.1	0	0	0.4	0	0.3
Longnose sucker	0	0	0	0	0.8	1.1	1.1	1.0
Largescale sucker	0	0	0.1	0.1	0.1	0.3	0	0.4
TOTAL	1.6	7.6	11.6	14.8	17.6	20.3	21.4	35.9

Table 36. Seasonal composition (percent) of principal fish species captured in floating and sinking gill nets set overnight in Flathead Lake during 1980 and 1981.

Species	Floating nets				Sinking nets			
	Winter	Spring	Summer	Fall	Winter	Spring	Summer	Fall
Bull trout	3	11	1	3	13	16	13	7
Cutthroat trout	59	42	1	8	--	1	--	--
Lake trout	--	--	--	1	--	<1	<1	3
Kokanee salmon	3	3	--	41	<1	4	1	3
Lake whitefish	11	2	--	1	36	17	44	19
Mountain whitefish	2	9	--	1	2	6	14	3
Northern squawfish	5	15	42	11	10	15	18	21
Peamouth	15	18	54	30	32	32	8	39
Yellow perch	2	<1	1	--	<1	2	--	1
Longnose sucker	--	--	--	--	5	6	<1	3
Largescale sucker	--	--	1	4	1	1	<1	1

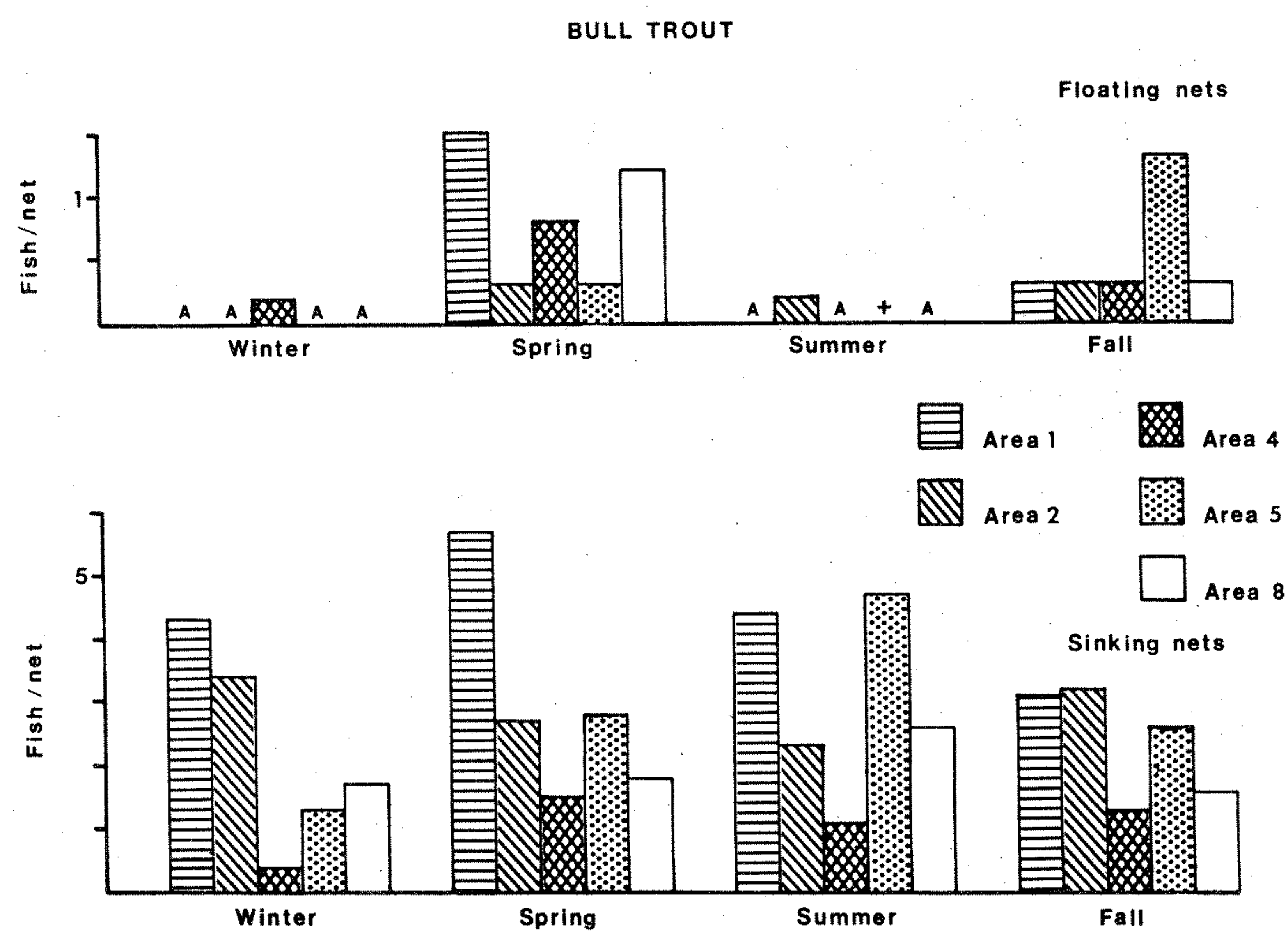


Figure 35. Seasonal catch rates for bull trout captured in floating and sinking gill nets set in five areas of Flathead Lake during 1980 and 1981. A = absent from catch, + = area not sampled.

Table 37. Size composition of the 1980-81 Flathead Lake bull trout gill net catch as compared to previous gill netting conducted by Montana Department of Fish, Wildlife and Parks personnel during the years 1967 through 1970.

Timespan	No. fish	Mean length(mm)	Length range	Percent >457 mm (18 inches)	Percent >634 mm (25 inches)
1967-1970	842	388	165-869	26%	5%
1980-1981	588	412	177-764	42%	4%

Table 38. Sex composition and percentage of fish expected to spawn for westslope cutthroat trout captured in floating gill nets in Flathead Lake during 1980 and 1981.

Season	No. fish sexed	Ratio ♂:♀	Percent of fish expected to spawn
Fall 1980 & 1981	71	1:1.7	15%
Winter (Jan 1981)	40	1:2.5	3%
Spring 1981	102	1:2.5	2%

larger than was observed during previous netting, but the percentage of trophy-sized fish (>634 mm or 25 inches) was similar between periods. Seasonal length frequencies for bull trout captured in gill nets during 1980 and 1981 are presented in Appendix C1 and C2.

The analysis of historical trends in bull trout abundance in Flathead Lake was complicated by variations in net types used and sampling depth selection. Hanzel (1970) used a gang of sinking nets (termed the "Flathead Net") which consisted of a 100 foot fine meshed net (to collect pygmy whitefish), a 250 x 8 foot experimental meshed net, and a 250 x 24 foot experimental meshed net. Re-analysis of the 1967-70 data resulted in estimated bull trout catches ranging between 1.2 and 2.1 fish per standard (125 foot) gill net. This was somewhat less than 1980-81 estimates of 2.2 to 2.9 fish per net (Table 35) and could be related to the possibility that 1967-70 nets were set in deeper waters than 1980-81 nets. Bull trout catches were largest in relatively shallow waters during the spring and summer of 1981 (Figure 46 and 47).

Westslope Cutthroat Trout

Almost all the westslope cutthroat trout captured in gill nets during this study were taken in floating nets (Table 35). Hanzel (1970) reported that all cutthroat trout captured in gill nets in Flathead Lake in 1967-1970 were taken either in floating nets or in sinking nets set in shallow (less than 30 feet deep) water.

The 1980-81 floating gill net catch varied between seasons and ranged from a maximum of 3.3 fish per net in the spring to a minimum of 0.2 fish per net during the summer (Table 35). Shoreline floating gill net catches of westslope cutthroat trout ranged between 1.3 per net in the summer and 4.9 per net in the winter in Lake Koocanusa (McMullin 1979). Westslope cutthroat catches averaged 0.8 per net in shoreline sinking nets and 5.8 per net in shoreline floating nets in Hungry Horse Reservoir, Montana (Huston 1975).

Westslope cutthroat trout were the dominant species in floating nets set in Flathead Lake during the winter and spring of 1980 and 1981 (Table 36). Catches were highest in Area 2 (the northeast portion of the lake near Bigfork) during the winter and spring (Figure 36). Seasonal length frequency diagrams are presented in Appendix C3.

Westslope cutthroat trout in Flathead Lake that would spawn in the spring were easily recognized in the previous fall and winter by the degree of gonadal development. McMullin (1979) also found that gonad development of maturing westslope cutthroat began in the late summer of the year prior to spawning.

Based on gonadal examination, it was found that 15 percent of the cutthroat captured in Flathead Lake during the fall would spawn the following spring, but this percentage decreased to only three and two percent of

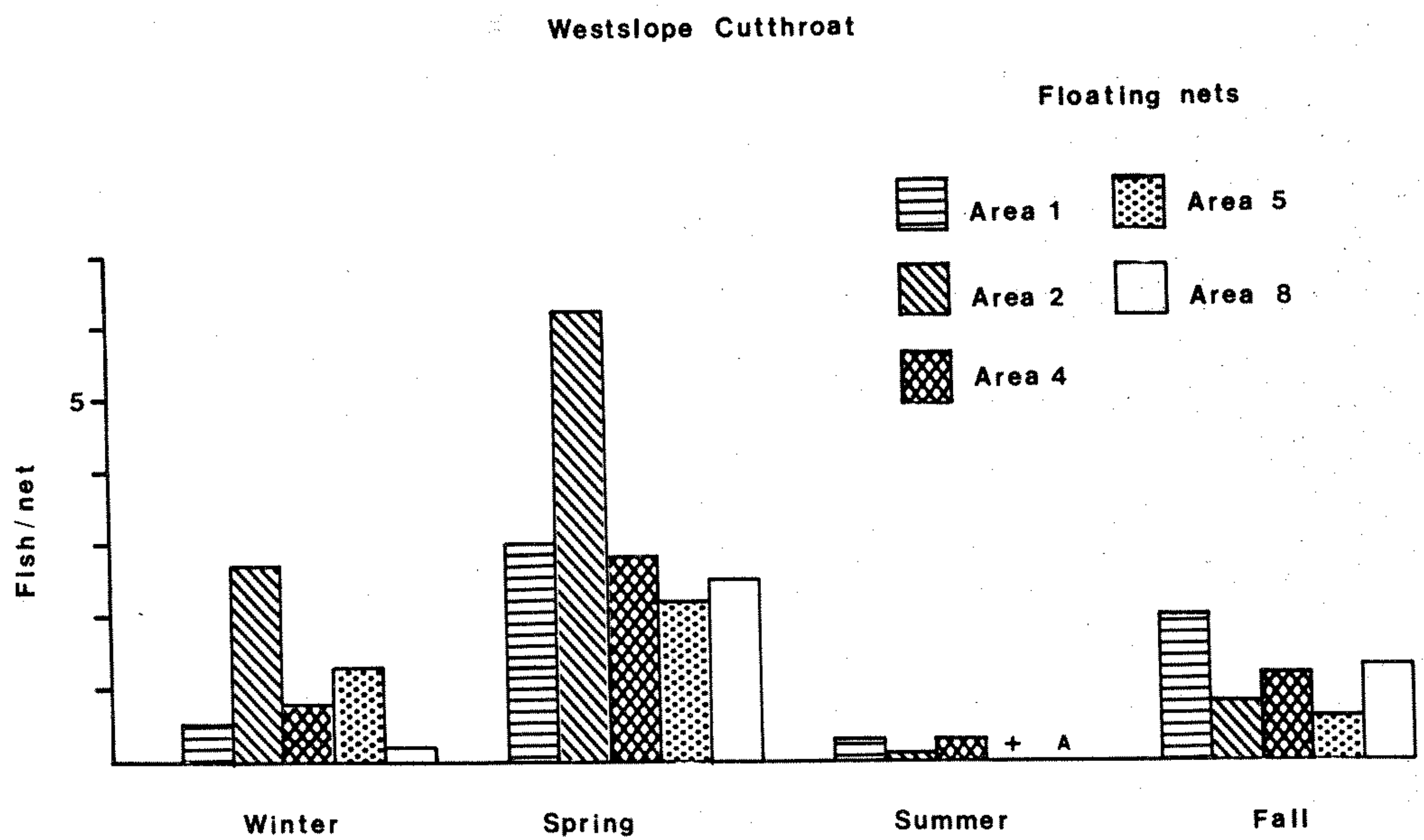


Figure 36. Seasonal catch rates for westslope cutthroat trout captured in floating gill nets set in five areas of Flathead Lake during 1980 and 1981. A = absent from catch, + = area not sampled.

the winter and spring samples (Table 38). This data supports the hypothesis that a large percentage of the spawning cutthroat trout population left Flathead Lake and entered the lower portion of the mainstem Flathead River during the late fall and early winter in preparation for the upstream spring spawning migration (McMullin and Graham 1981). This premature spawning movement was believed to be cued by discharges of relatively warm waters into the mainstem Flathead River from Hungry Horse Reservoir which is located on the South Fork of the Flathead River.

The ratio of males to females for all cutthroat trout netted from Flathead Lake during 1980 and 1981 was 1:2, while the male to female ratio for suspected spawners was 1:3.3. The smallest suspected spawners were 350 and 349 millimeters total length for males and females, respectively. A maximum of 31 percent of the mature-sized cutthroat trout in the lake (observed in the fall) were expected to spawn the following spring. This suggested that alternate-year spawning was prevalent.

A similar reproductive analysis was not performed for bull trout collected during the study. Gonadal maturation for this species apparently occurred after these fish entered the river system on their annual spawning migration.

Other Species

Lake trout were seldom captured in our gill nets except during the fall (Tables 35 and 36). Most of these fish were longer than 500 millimeters (Appendix C4) and were in spawning condition. Largest catches were obtained in sinking nets set in Area 5 (Figure 37) which was located on the west side of the lake near the town of Rollins. These fish apparently spawned in shoreline areas.

Kokanee were also seldom captured in our nets in seasons other than the fall (Figure 38). This species was the most common constituent of the floating net catch during the fall (Table 36) when catches averaged 6.3 fish per net (Table 35). Nearly all the kokanee captured at this time were sexually mature and ranged between 340 and 420 millimeters in length (Appendix C5). Immature fish were seldom captured except during the spring in Area 4 (Figure 38) which was located on the east shore a short distance north of Yellow Bay.

Lake whitefish comprised up to 44 percent of the seasonal sinking gill net catch (Table 36) and catches ranged between 9.0 per net in the summer and 3.2 per net in the spring (Table 35). Relatively few lake whitefish were taken in floating nets. Catch rates were variable between seasons and areas (Figure 39). The largest numbers of small fish (180 to 220 millimeters) were taken during the summer (Appendix C6).

The largest catches of mountain whitefish (up to 3.0 fish per net) were obtained in sinking gill nets during the summer (Figure 40; Table 35). The catch averaged 1.4 fish per sinking net and 0.2 fish per net in floating nets throughout the study period. This species comprised a maximum of nine percent of the floating net catch (in the spring) and

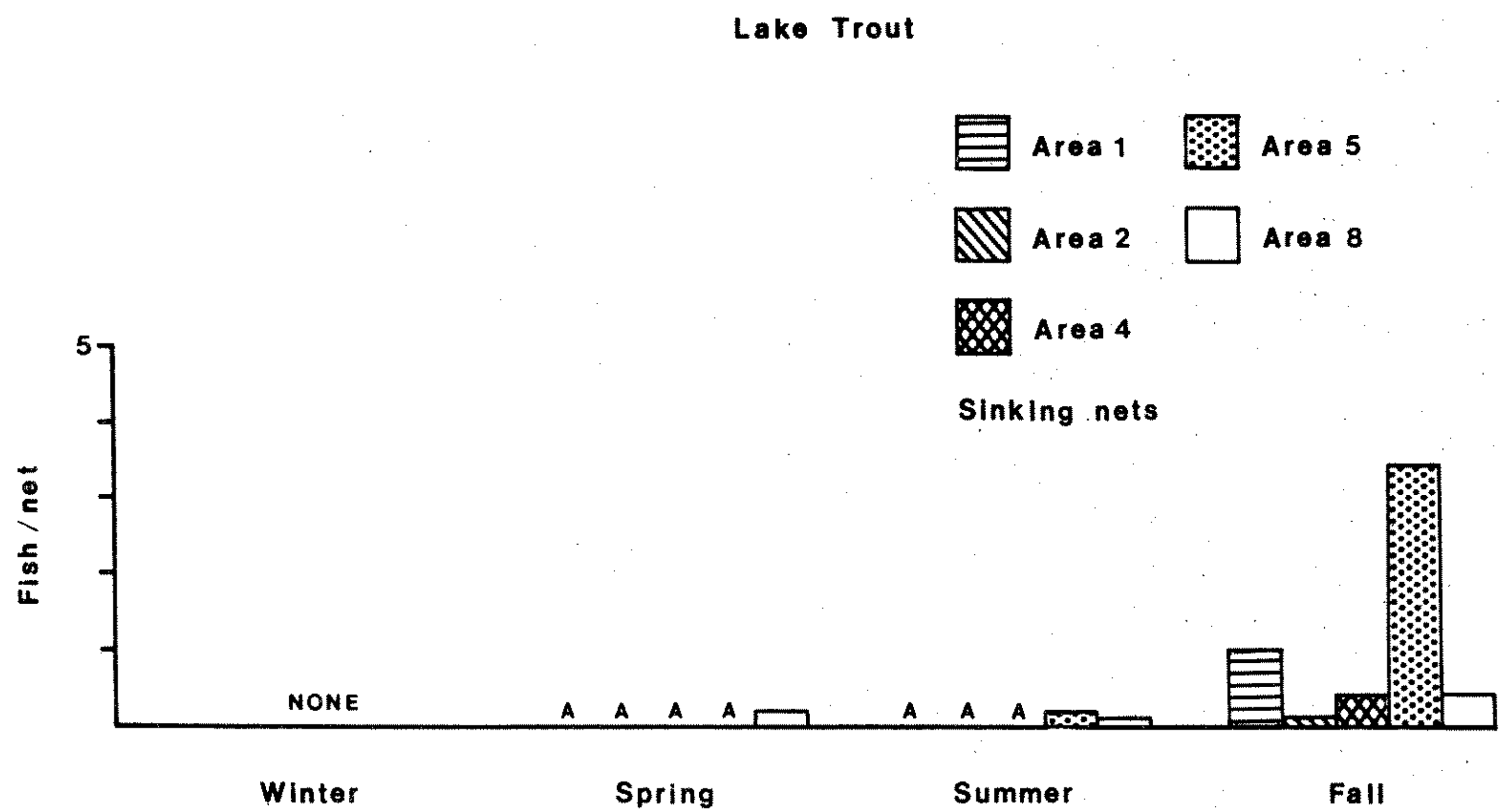


Figure 37. Seasonal catch rates for lake trout captured in sinking gill nets set in five areas of Flathead Lake during 1980 and 1981. A = absent from catch.

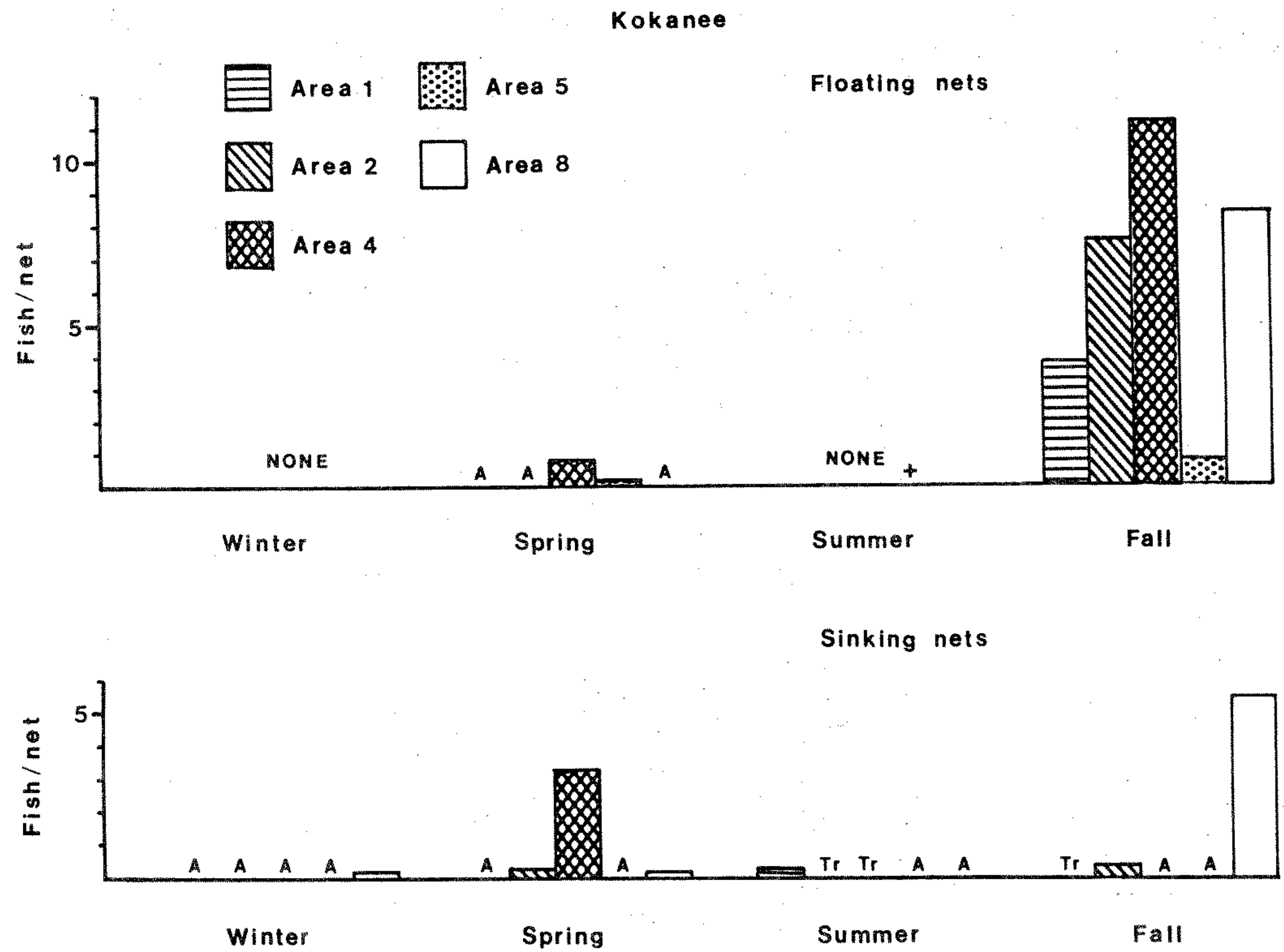


Figure 38. Seasonal catch rates for kokanee captured in floating and sinking gill nets set in five areas of Flathead Lake during 1980 and 1981. A = absent from catch, + = area not sampled, Tr = less than 0.1 per net.

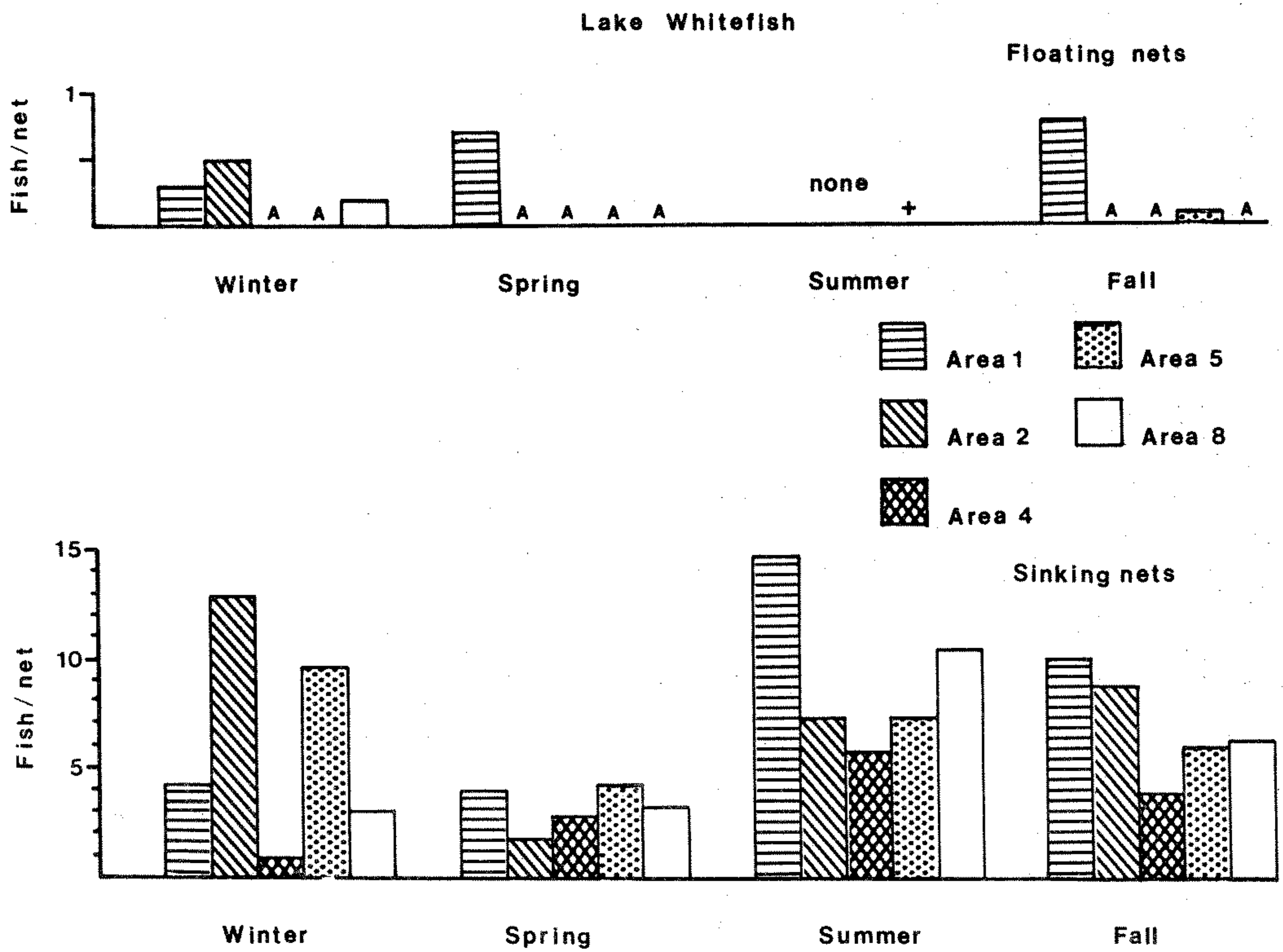


Figure 39. Seasonal catch rates for lake whitefish captured in floating and sinking gill nets set in five areas of Flathead Lake during 1980 and 1981. A = absent from catch, + = area not sampled.

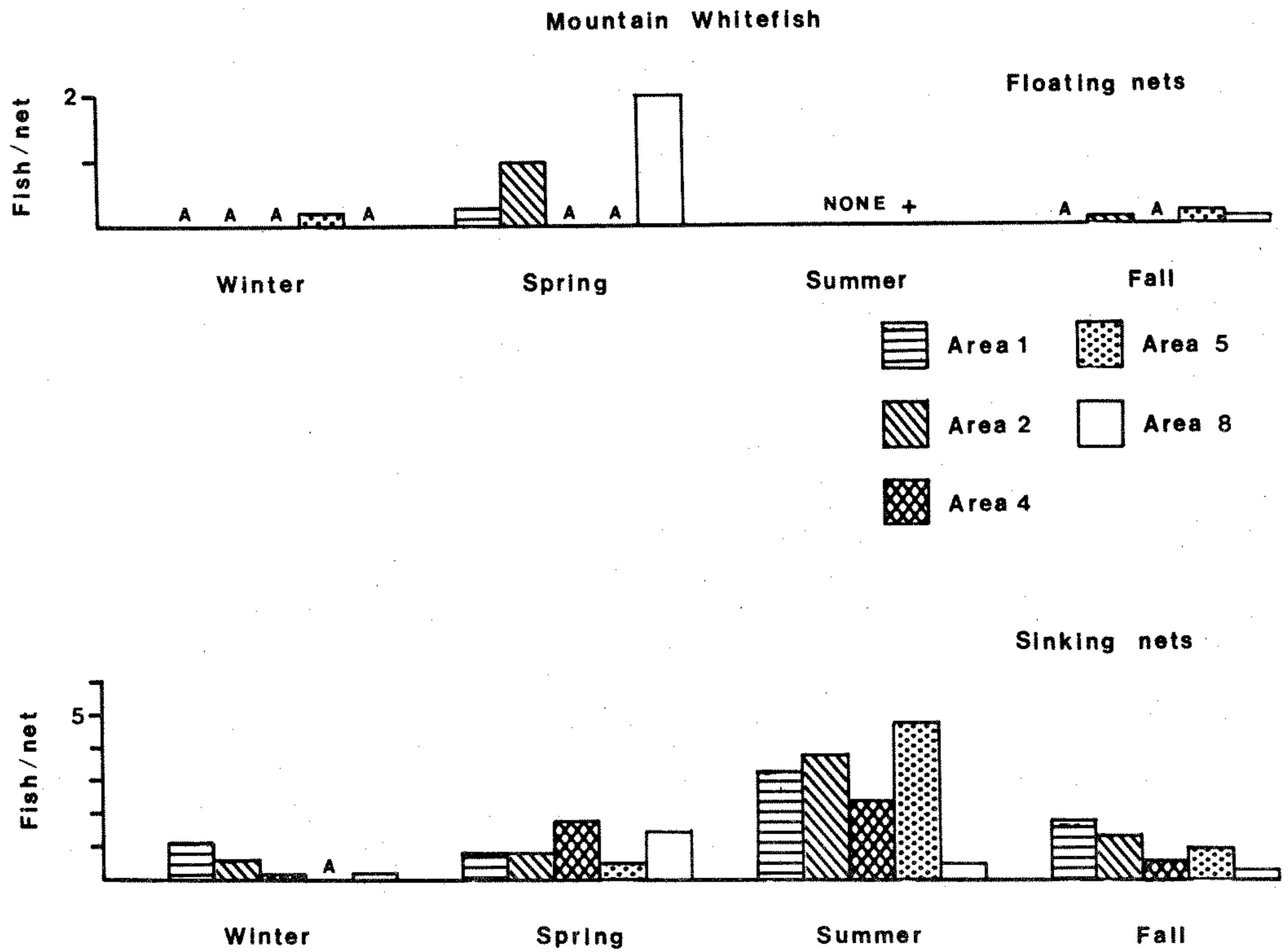


Figure 40. Seasonal catch rates for mountain whitefish captured in floating and sinking gill nets set in Flathead Lake during 1980 and 1981. A = absent from catch, + = area not sampled.

14 percent of the sinking net catch (in the fall; Table 36). The catch rate was similar between areas during most seasons (Figure 40). The largest number of small fish (160 to 210 mm) was taken during the summer (Appendix C7).

Seasonal catches of northern squawfish in floating nets ranged between zero and 4.6 fish per net and averaged 1.8 fish per net (Table 35). Sinking net catches ranged between 1.9 and 7.7 fish per net and averaged 4.1 per net. This species comprised up to 42 percent of the floating net catch (in the summer) and 21 percent of the sinking net catch (in the fall; Table 36). Seasonal catches varied between areas (Figure 41). Exceptionally large catches were obtained in floating nets set in Areas 1 and 2 during the summer months. Seasonal length frequencies appear in Appendix C8.

Seasonal catches of peamouth in floating nets ranged between 0.3 and 6.5 fish per net and averaged 3.2 fish per net (Table 35). Sinking net catches ranged between 1.6 and 13.9 fish per net and averaged 7.3 per net. Peamouth were the predominant species in the summer floating net catch when they comprised 54 percent of the total catch (Table 36). This species dominated the spring and fall sinking net catch when it comprised 32 and 39 percent of the total catches, respectively. Peamouth catches were frequently largest in floating and sinking nets set in Area 1 (Figure 42). Seasonal length frequency diagrams appear in Appendix C9.

Yellow perch were infrequently captured in either floating or sinking gill nets. Catches were always less than 0.5 fish per net for either net type (Table 35) and this species never comprised more than two percent of any seasonal catch (Table 36). Length frequency diagrams were not prepared due to small sample size.

In spite of their limited appearance in gill net catches, yellow perch were a preferred bull trout food item. It is likely that yellow perch abundance is much greater in isolated weedy bays scattered along the margin of the lake and especially in Polson Bay. Sampling during this study was limited to exposed shoreline areas. Yellow perch catch rates were highest in Area 5 which had a more protected shoreline than the other sampling areas (Figures 43 and 3).

Longnose suckers were not collected in floating gill nets, but seasonal sinking net catches were consistent and ranged between 0.8 and 1.1 fish per net (Table 35). This species comprised up to six percent of the seasonal sinking net catch (Table 36). Catch rates were similar between areas in most seasons (Figure 44). Seasonal length frequency diagrams are presented in Appendix C10.

Largescale suckers were captured in both floating and sinking nets although catch rates were low and never exceeded 0.4 fish per net (Table 35) or four percent of any seasonal catch (Table 36). A length frequency diagram for 24 fish collected in the fall is presented in Appendix C4.

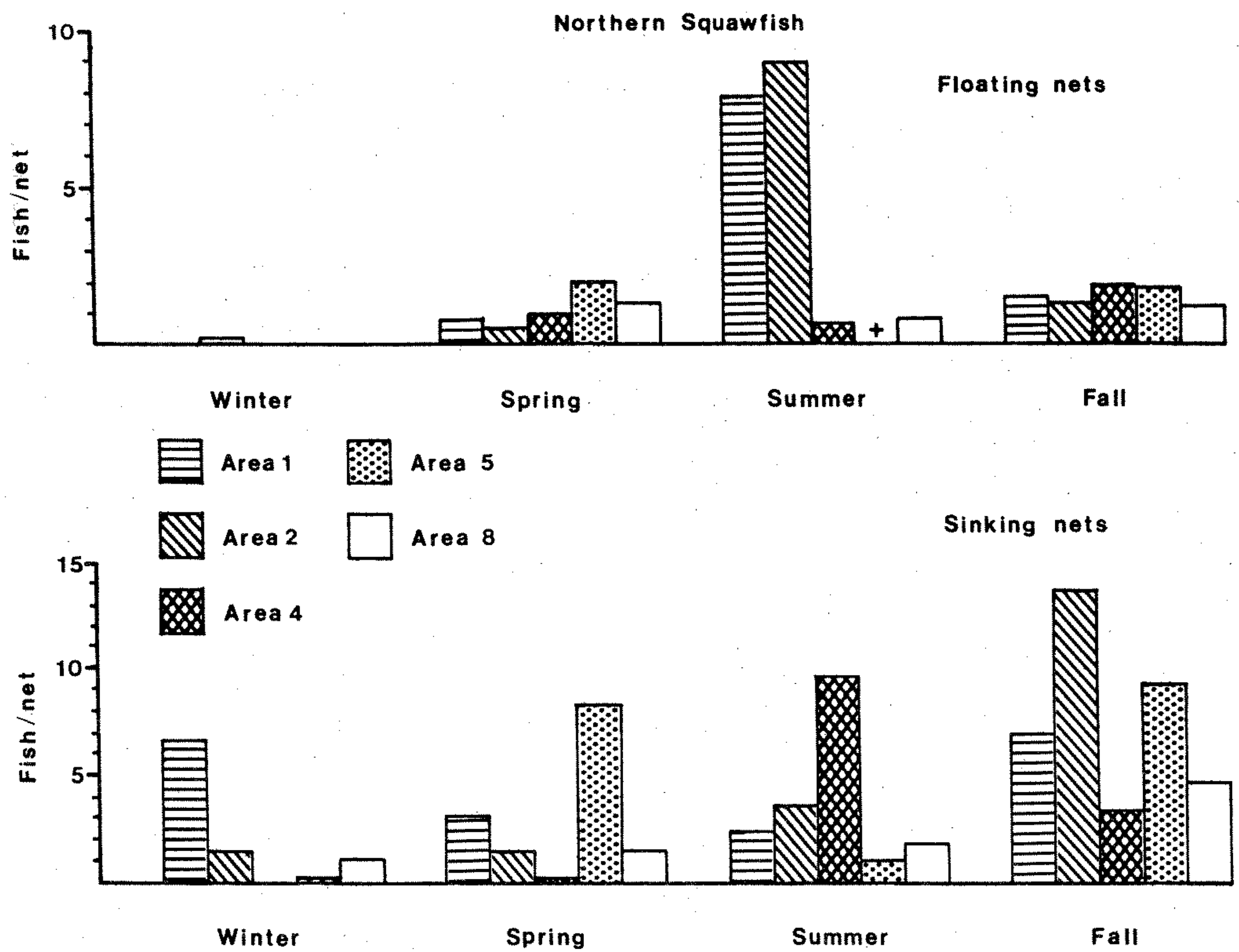


Figure 41. Seasonal catch rates for northern squawfish captured in floating and sinking gill nets set in five areas of Flathead Lake during 1980 and 1981. + = area not sampled.

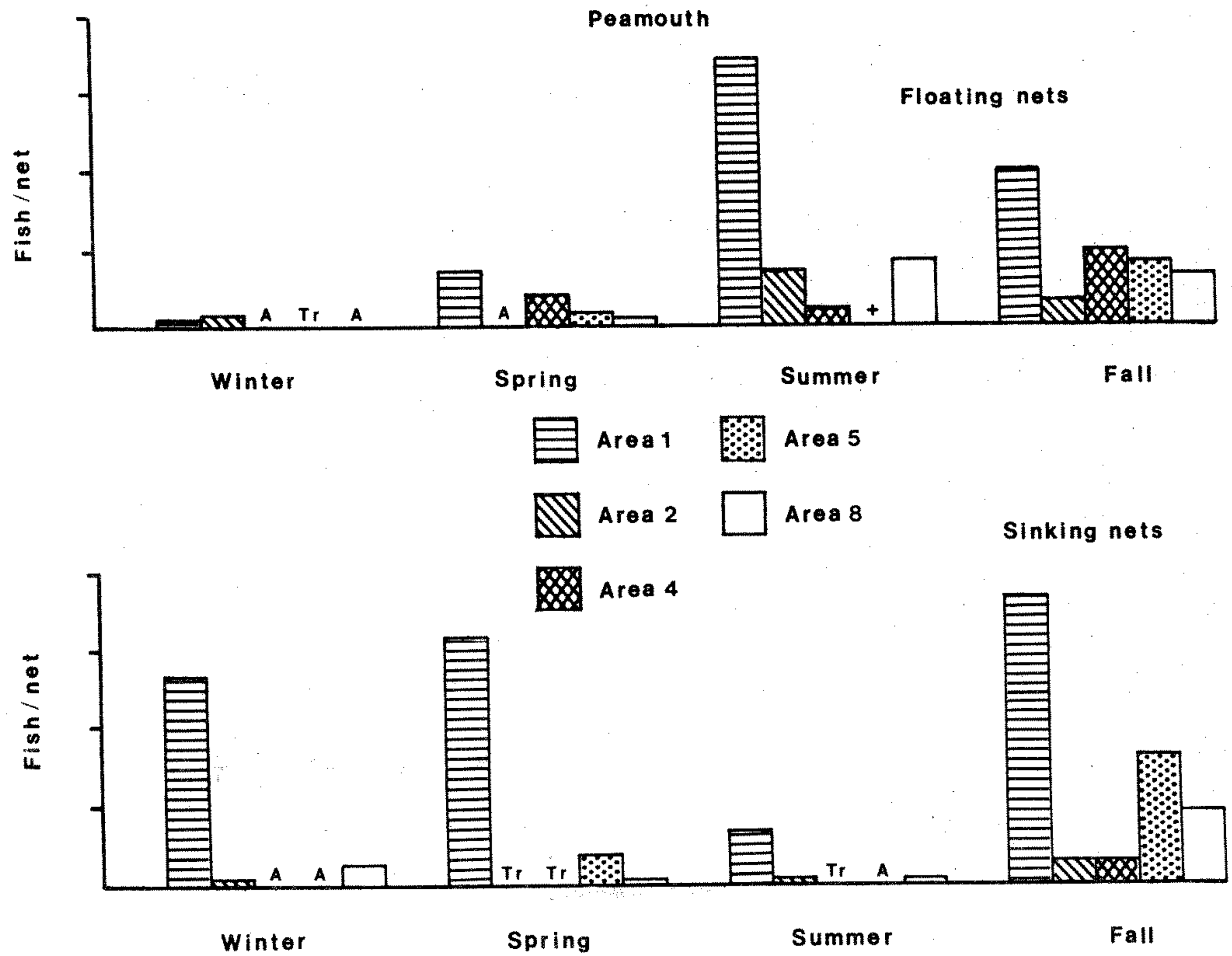


Figure 42. Seasonal catch rates for peamouth captured in floating and sinking gill nets set in five areas of Flathead Lake during 1980 and 1981. A = absent from catch, + = area not sampled, Tr = less than 0.1 per net.

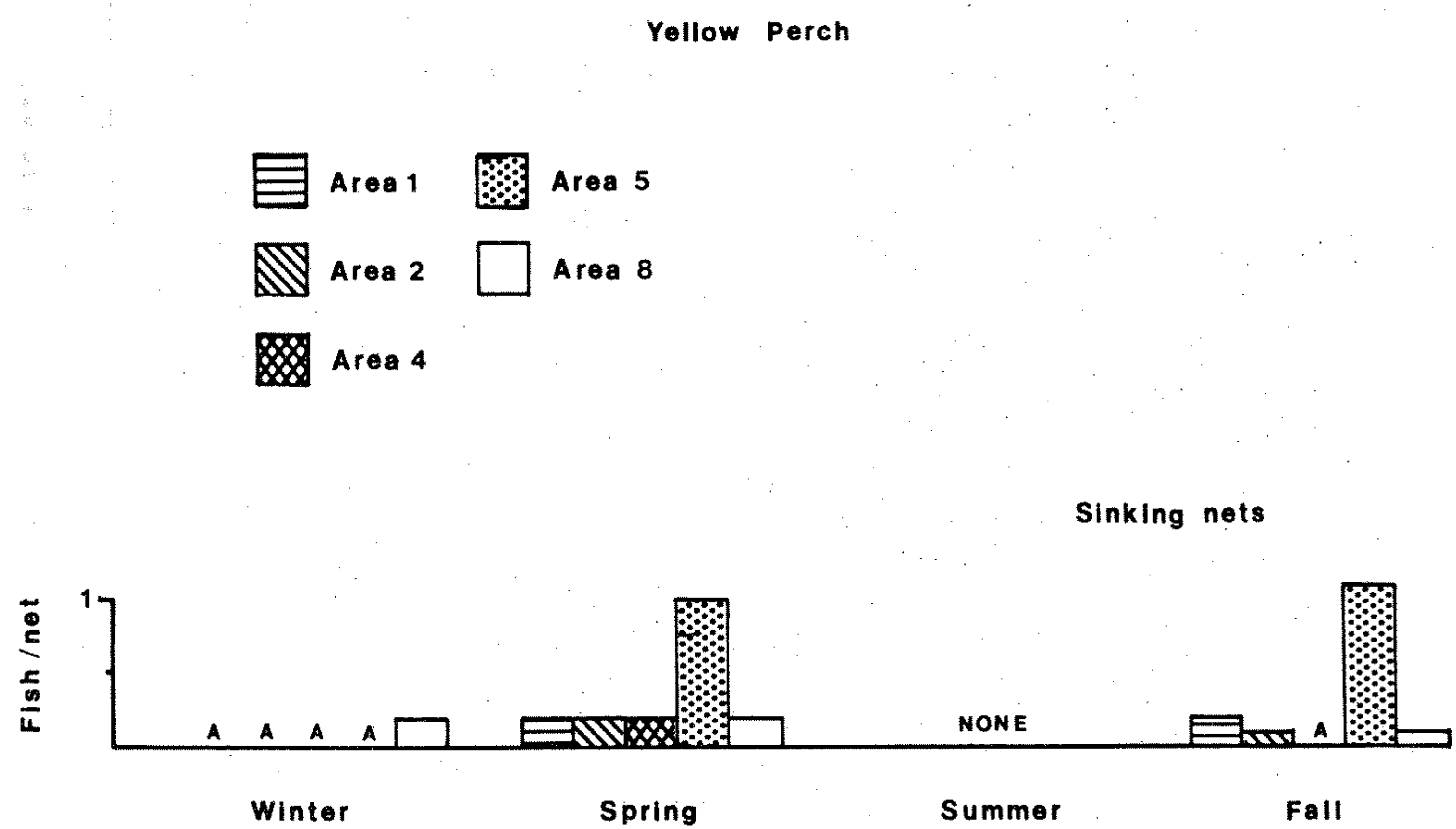


Figure 43. Seasonal catch rates for yellow perch collected in sinking gill nets set in five areas of Flathead Lake during 1980 and 1981. A = absent from catch.

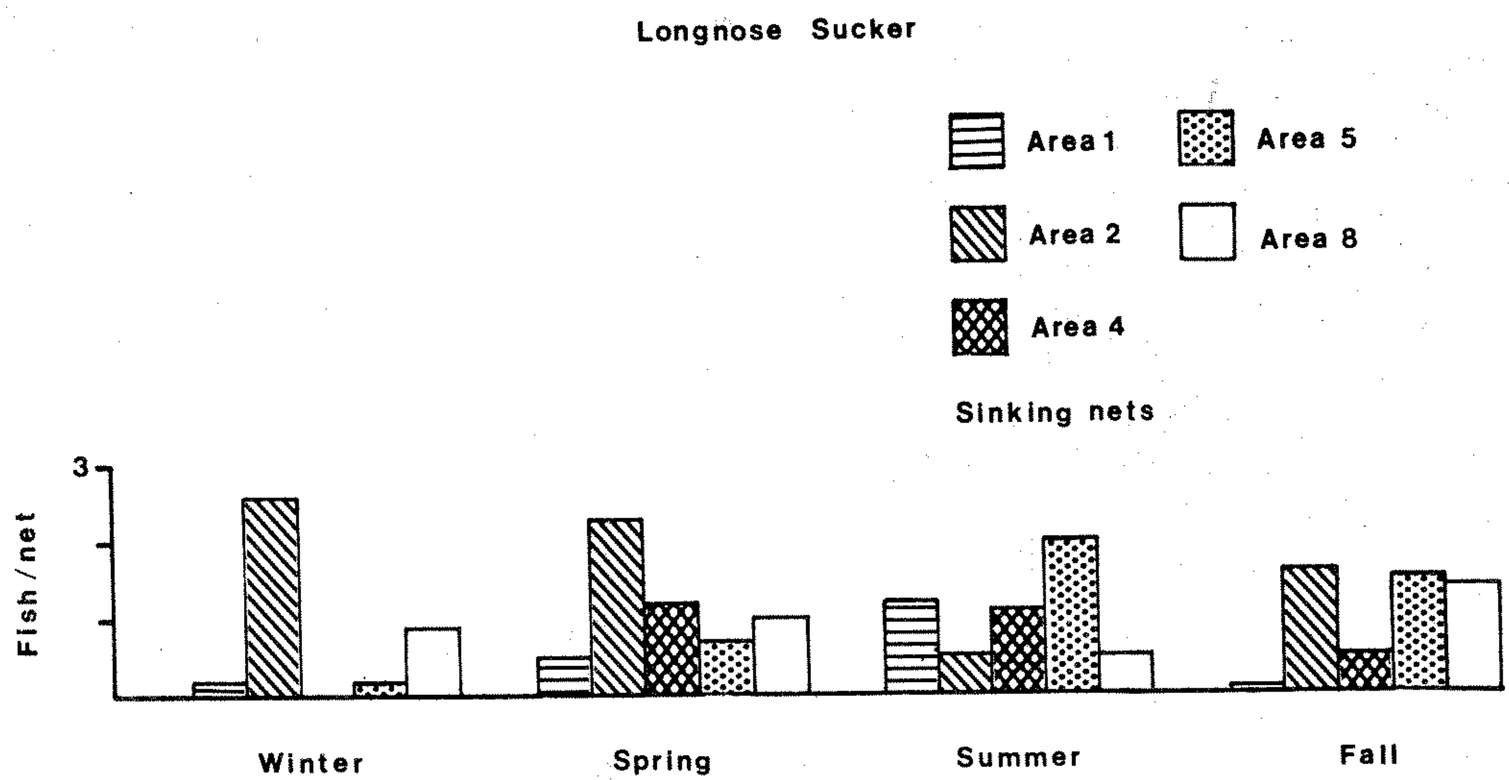


Figure 44. Seasonal catch rates for longnose suckers captured in sinking gill nets set in five areas of Flathead Lake during 1980 and 1981.

Small numbers of northern squawfish-peamouth hybrids were captured in gill nets during the course of the study (Table 34). Catches of this hybrid fish may have been larger than reported due to difficulties experienced in identifying these fish. A single rainbow trout and one brook trout were collected, which indicated that these species comprised an extremely small percentage of the Flathead Lake fish community.

Redside shiners and slimy sculpins were not collected in gill nets although these species were commonly observed in shoreline netting areas. Approximately fifteen sculpins were collected along the shoreline of Yellow Bay during January of 1982. These specimens were identified as slimy sculpins (identification by Dr. William Gould, Montana Cooperative Fishery Research Unit, Montana State University, Bozeman).

Verticial Fish Distribution

Seasonal gill net data collected during the spring, summer and fall of 1981 was analyzed to determine depth distribution of the principal fish species in Flathead Lake. This information was useful in interpreting seasonal variations in gill net catches and could be used to design a gill netting program to monitor annual changes in populations of fish species of particular interest.

The lake was isothermal at about 5°C (41°F) during the spring netting series (Figure 45). At this time, westslope cutthroat trout were the predominant species in the floating net catch (Figure 46). Few or no cutthroat were captured in sinking nets. Bull trout catches were larger in shallow and deep sinking nets than in floating nets. Catches of most other species were largest in sinking nets as well.

Thermal stratification of the lake waters was pronounced during August (Figure 45). This high degree of stratification strongly influenced vertical fish distribution (Figure 47). Few westslope cutthroat trout were captured during this period which indicated that these fish avoided shoreline areas when surface water temperatures were high (>20°C). Few cutthroat were captured in floating nets set over deep waters in offshore areas as well during the summer months. McMullin (1979) observed that westslope cutthroat trout preferred water temperatures less than 18°C.

Bull trout catches during August were largest in sinking nets set in deeper waters, i.e. those greater than 14 meters deep (Figure 47). These waters were at the lower end of the thermocline and had temperatures of about 15°C (59°F) or less (Figure 47). Mountain whitefish were found mostly at shallow and intermediate depths whereas lake whitefish were found in significant numbers at all depths except the surface. Northern squawfish and peamouth were confined almost exclusively to shallow depths (to 14 m or 45 feet) where water temperatures exceeded 15°C.

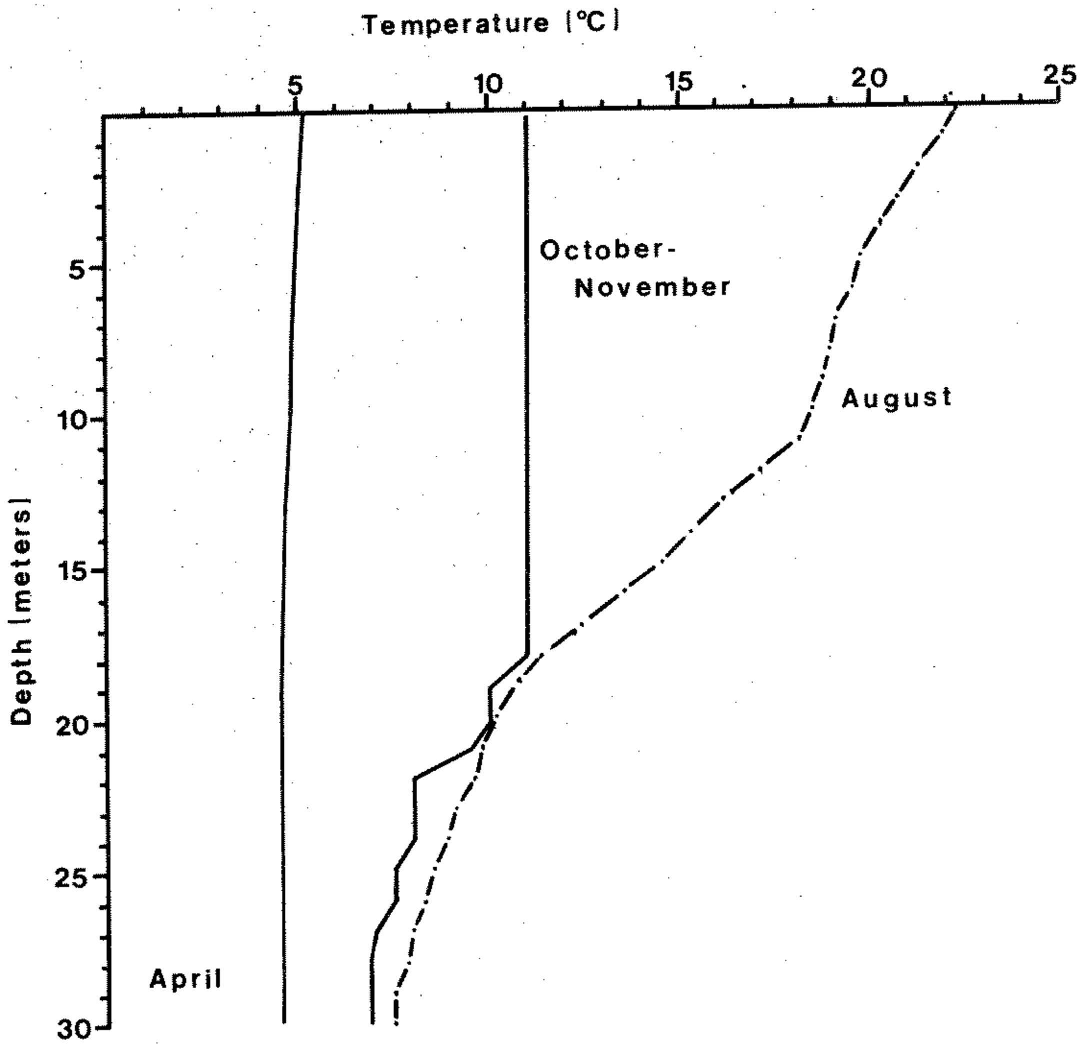


Figure 45. Average temperature profiles for Flathead Lake during gill netting series conducted in the spring, summer and fall of 1981.

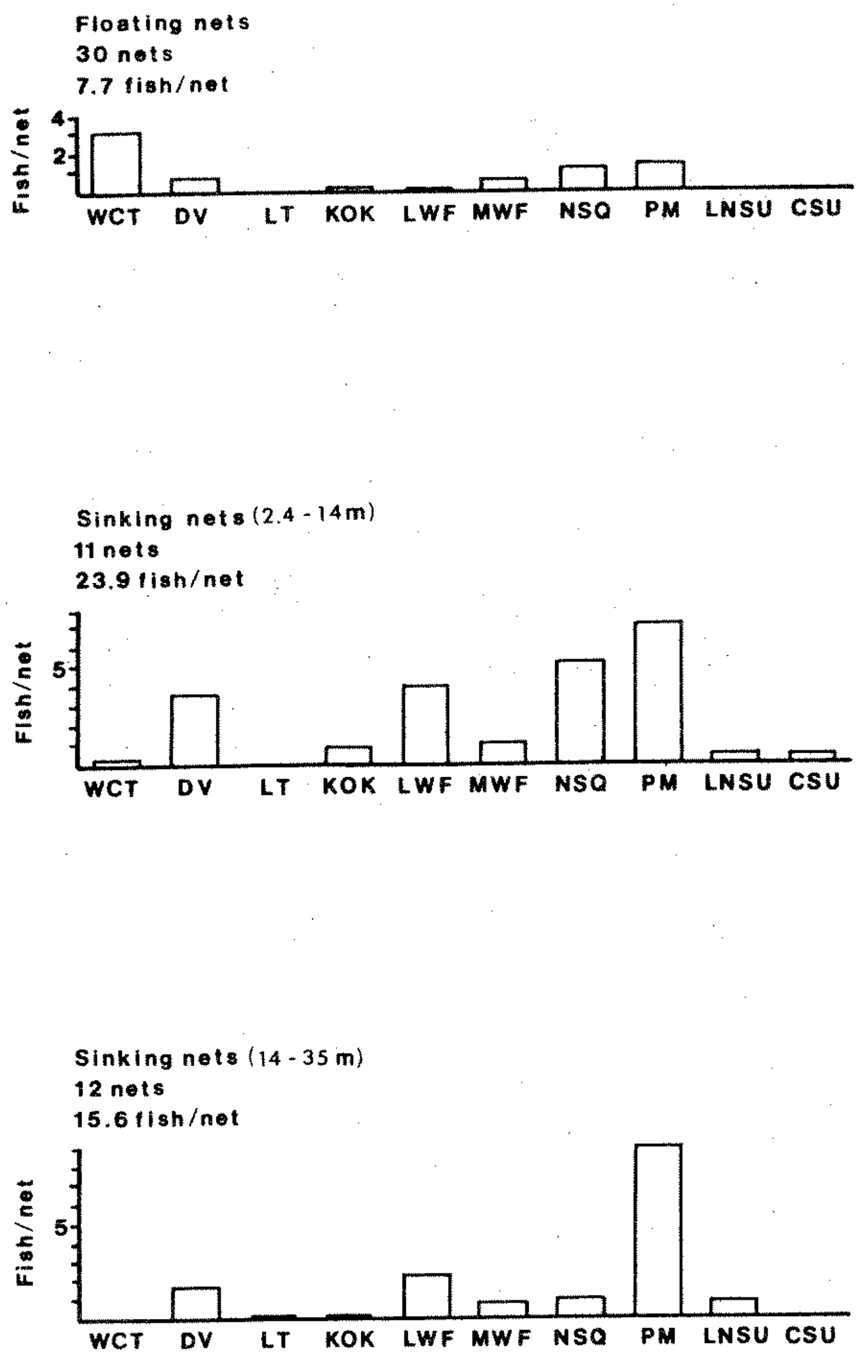


Figure 46. Catch rates (fish per net) of the principal fish species captured in gill nets set at various depths in Flathead Lake during April of 1981.

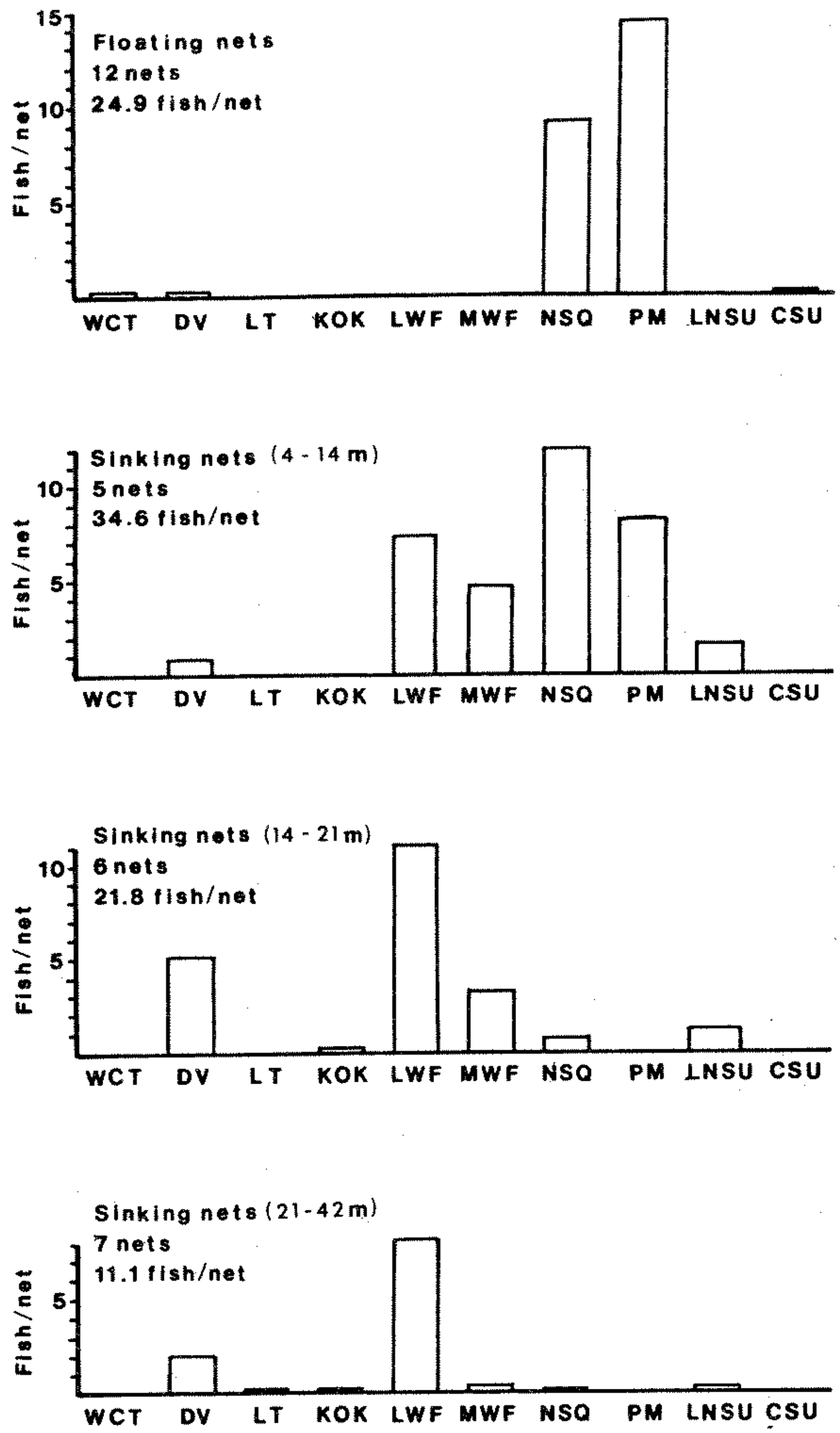


Figure 47. Catch rates (fish per net) of the principal fish species captured in gill nets set at various depths in Flathead Lake during August of 1981.

Cutthroat trout were again captured in significant numbers in floating nets during the fall when surface water temperatures had dropped to 11°C (52°F; Figures 45 and 48). The top of the thermocline was located at 18 meters during this period which was quite deep relative to the August thermocline.

Bull trout distribution was more uniform during the fall and maximum catches were obtained in sinking nets (Figure 48). Large numbers of mature kokanee salmon were captured in shoreline floating nets which reflected a movement to shoreline spawning areas. Lake whitefish were most numerous in mid and deep water areas and mountain whitefish showed a preference for intermediate depths as was noted during August. Squawfish and peamouth apparently dispersed from shallow waters (less than 14 m) during the fall. Large catches of these species were obtained in nets set in deep water (14 to 35 m) during the fall (Figure 48) whereas very few were taken at such depths during August (Figure 47).

Relationships between seasonal bull trout food habits and predator-prey depth associations were inconsistent. Kokanee were the principal food item of bull trout during the spring. Bull trout apprently selected strongly for this prey species at that time since kokanee densities (as indicated by net catches) were much smaller than densities of alternate prey at all depths (Figure 46).

Prey preference of bull trout during the summer corresponded closely with vertical prey distribution. Bull trout fed most heavily on whitefish species at this time and whitefish were the most numerous forage species available at depths where bull trout catches were largest (Figure 47). This relationship did not hold true during the fall however. Peamouth and squawfish were usually the most numerous forage group available in depth zones having largest numbers of bull trout (Figure 48), yet whitefish were by far the most important forage species.

RECOMMENDATIONS

The Department's review of the Stage II Environmental Assessment concerning the proposed Cabin-Howell Creek coal mine highlighted potential increases in sediment production, nutrient loading, and acidity as major threats to the fishery resource of the Flathead system. In light of these threats, we feel a program should be established to monitor long-term fluctuations in fish and zooplankton populations in Flathead Lake on a limited basis. Such a program would enable the recognition of potential adverse conditions resulting from upstream development and would allow for timely implementation of remedial measures.

Kokanee populations in Flathead Lake are currently being monitored by other Department personnel using hydroacoustical techniques. However, populations of cutthroat trout, bull trout and whitefish cannot presently be assessed with this technique. Hence, it is suggested that a limited version of the gill netting program developed during this study be continued on an annual basis.

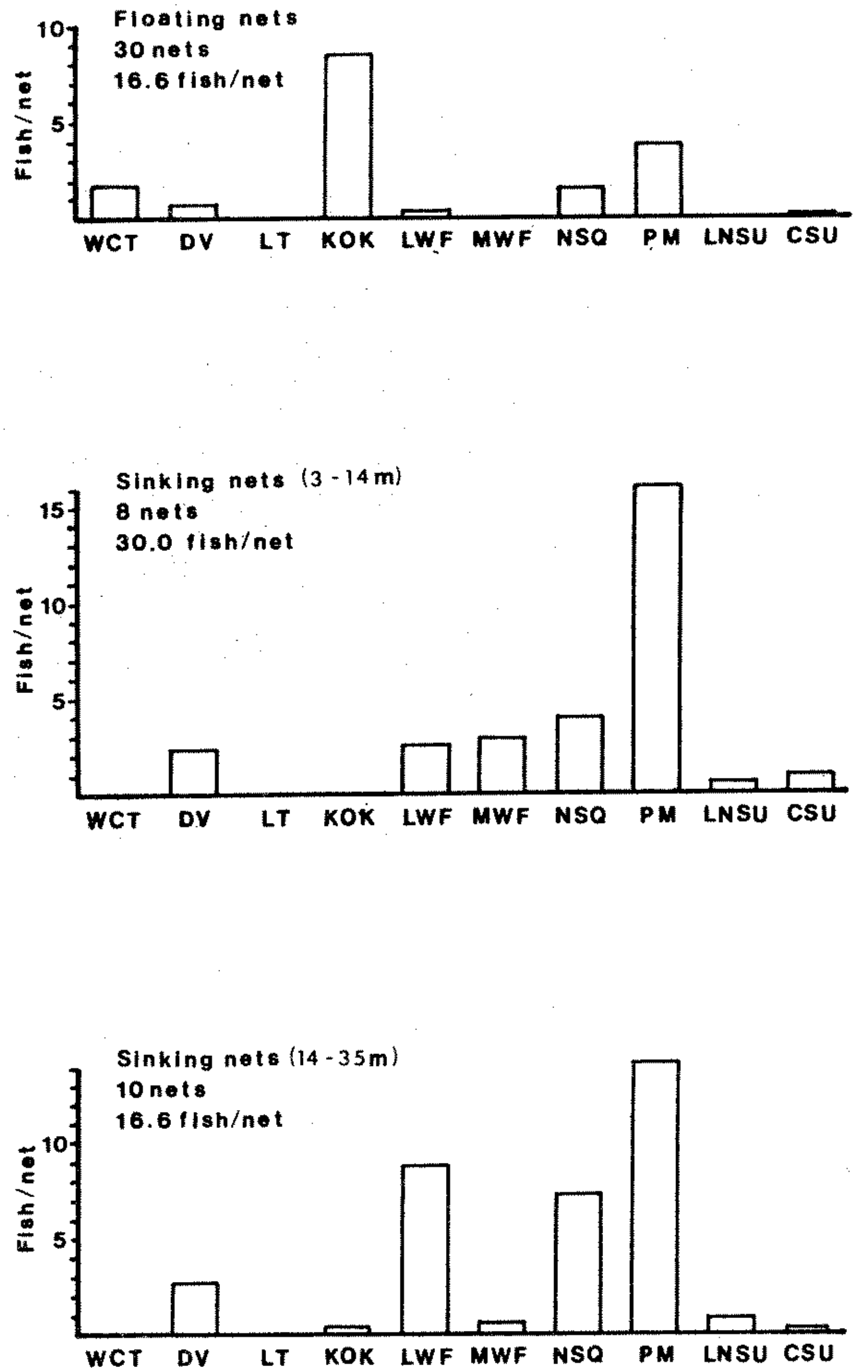


Figure 48. Catch rates (fish per net) of the principal fish species captured in gill nets set at various depths in Flathead Lake during the period 27 October - 10 November, 1981 in Flathead Lake.

In order to maximize catches of westslope cutthroat trout (Table 35) and minimize year-to-year variations in limnological conditions, it is recommended that gill netting be conducted during the spring. Netting should be conducted in established locations using the same equipment and procedures employed in this study. The series should be conducted during early spring (April) prior to runoff when the lake is isothermal at four to five degrees celsius. It is recognized that populations of mature adfluvial cutthroat may not be fully monitored due to the entry of a portion of this group of fish into the Flathead River during the winter months. Gonadal condition of all netted cutthroat should be conducted to determine reproductive status. All segments of the bull trout population should be adequately monitored at this time since the upstream spawning migration appears to commence with the onset of spring runoff. Bull trout catch rates displayed little seasonal variation.

Zooplankton populations should be monitored because these organisms constitute an important food source for many fish species in the lake and can be directly influenced by alterations in water quality described above. The results of our zooplankton work indicate that the use of short surface plankton tows (0-15 m) would adequately represent populations of crustacean zooplankton in Flathead Lake. All of the important summer food organisms (*Daphnia thorata*, adult *Epischura*, and *Leptodora*) in the diets of planktivorous gamefish concentrate in these waters during the period July through October. Maximum densities of the other less preferred food species (excluding copepod nauplii) are also found in this stratum on most dates. In addition, 15 m tows can be rapidly performed and Wisconsin net efficiency is satisfactory for these short tows.

A plankton monitoring system should consist of duplicate 15 m tows collected biweekly from mid-April through mid-October with optional monthly samples collected from November through March. Since few interstation differences in zooplankton density have been noted, it is suggested that any deep-water (30 m or deeper) location be selected for monitoring, preferably Bigfork (Station 2:4) or midlake off Yellow Bay (Station 8:7) due to the existence of previous data. Station 6:3 (Big Arm) could be added to the sampling program if desired since significant differences between this location and other stations were noted for *Cyclops* in 1980 and *Daphnia longiremis* in 1981.

Kokanee feeding habits should be monitored on a monthly basis during the summer months (June through September). This is important because of the almost total dependence of these fish on crustacean zooplankton as a food source plus the fact that they are the dominant fish in the Flathead Lake sport fishery. Monthly samples of stomachs from 10 to 20 fish should be obtained from fishermen and later pooled and subsampled for laboratory analysis.

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APPENDIX A

Fish Food Habits Information

Appendix A1. Summary of stomach collections for age 0+ kokanee (25-108 mm) from Flathead Lake during 1980 and 1981.

Date	Area	No. stomachs	Collection* method	Date	Area	No. stomachs	Collection* method
1980				1981			
2 Jul	3	8	MT	5 Jun	1	1	MT
7 Jul	1	18	MT	9 Jun	3	2	MT
17 Jul	1	9	MT	10 Jun	1	5	MT
20 Aug	3	19	MT	11 Jun	1	4	MT
25 Sep	2	24	MT	29 Jul	1	13	MT
6 Oct	1	12	MT	9-11 Sep	1 & 3	18	MT
3 Dec	1	12	MT	20 Oct	1	15	MT
				23 Nov	1	10	MT

* Collection methods:

PS = Purse seine
MT = Midwater trawl
FG = Exp. floating gill net
SG = Exp. sinking gill net
MG = 250' x 25' monofilament gill net
CC = Creel census

Appendix A2. Summary of food habits data for age 0+ kokanee (25-108 mm) collected from Flathead Lake during 1980 and 1981.

Date	No. stomachs		*Daphnia thorata*	*Daphnia longiremis*	*Bosmina*	*Diaptomus*	*Cyclops*	*Epischura*	*Leptodora*	Diptera	Terrestrial insects
1980											
2 Jul	8	No./fish	57	6.4	0.1	0.2	2.4	10	0.1	0.1	0.1
		% of biomass	71.6	8.2	<.1	<.1	0.5	18.8	0.5	0.5	<.1
7 Jul	18	No./fish	53					22		0.3	
		% of biomass	62.7					36.4		0.9	
17 Jul	9	No./fish	91			1.9	9.4	15			
		% of biomass	78.9			0.3	2.0	18.7			
20 Aug	19	No./fish	142			5.5	5.5	5.5	2.7		
		% of biomass	88.3			1.0	0.7	4.8	5.3		
25 Sep	24	No./fish	279			3.3	6.6	96		<.1	
		% of biomass	66.7			0.2	0.4	32.8		<.1	
6 Oct	12	No./fish	400					11			
		% of biomass	96.3					3.7			
3 Dec	12	No./fish	534					84			
		% of biomass	81.7					18.4			
1981											
5-11 Jun	12	No./fish	21		0.1	0.6	0.8	5.5		0.5	
		% of biomass	68.9		<.1	0.5	0.6	25.6		4.4	
29 Jul	13	No./fish	127					70	2.4		
		% of biomass	54.4					42.4	3.1		
9-11 Sep	18	No./fish	417			6.7	29	16			
		% of biomass	93.0			0.4	1.5	5.0			
20 Oct	15	No./fish	903			15	4.2	8.5			
		% of biomass	98.1			0.5	0.1	1.3			
23 Nov	10	No./fish	651		14			56			
		% of biomass	89.0		0.2			10.9			

Appendix A3. Summary of stomach collections for age I+ kokanee (94-178 mm) from Flathead Lake during 1980 and 1981.

Date	Area	No. stomachs	Collection* method	Date	Area	No. stomachs	Collection* method
1980				1981			
2 Jul	3	1	MT	11 Jun	1	6	MT
7 Jul	1	29	MT	24 Jun	1	5	PS
17 Jul	1	20	MT	30 Jun	1	11	PS
20 Aug	3	12	MT				

* For explanation of collection methods see Appendix Table A1.

Appendix A4. Summary of stomach collections for age II+ kokanee (205-286 mm) from Flathead Lake during 1980 and 1981.

Date	Area	No. stomachs	Collection* method	Date	Area	No. stomachs	Collection* method
1980				1981			
8 Jul	2	2	CC	2 Jun	4	2	CC
9 Jul	1	2	CC	6 Jun	4	3	CC
15 Aug	2	3	CC	8 Jun	9	2	CC
29 Aug	2	2	CC	22 Jun	1	6	PS
29 Aug	1	5	CC	24 Jun	1	5	PS
8 Sep	8	2	MT	30 Jun	1	18	PS
18 Sep	2	2	CC	1 Jul	3	11	PS
22 Sep	5	1	CC	4 Aug	1	5	PS
6 Oct	1	2	MG	15 Dec	9	10	MG

* For explanation of collection methods see Appendix Table A1.

Appendix A5. Summary of stomach collections for age III and older kokanee (242-387 mm) from Flathead Lake during 1980, 1981 and 1982.

Date	Area	No. stomachs	Collection method*	Date	Area	No. stomachs	Collection method*	Date	Area	No. stomachs	Collection method*
1980				1981				1982			
3 Jul	5	17	CC	13 Jan	9	14	CC	3 Jan	9	22	CC
7 Jul	1	5	CC	20 Jan	9	5	CC				
8 Jul	2	23	CC	3 Mar	9	15	CC				
9 Jul	1	5	CC	18 Apr	4 & 8	21	FG & SG				
30 Jul	8	2	CC	16&21 Apr	8	6	CC				
15 Aug	2	10	CC	15 May	8	4	CC				
29 Aug	2	6	CC	19 May	8	3	CC				
29 Aug	1	9	CC	24 May	6	5	CC				
18 Sep	2	9	CC	31 May	7	6	CC				
22 Sep	5	2	CC	2 Jun	4	5	CC				
6 Oct	1	4	MG	8 Jun	9	5	CC				
				9 Jun	2	5	CC				
				14 Jun	7	8	CC				
				18 Jun	2	7	CC				
				21 Jun	2	3	CC				
				22 Jun	4	7	CC				
				29 Jun	1	8	PS				
				30 Jun	1	16	PS				
				1 Jul	3	11	PS				
				4 Aug	1	11	PS				
				19-27 Aug	2&3	15	CC				
				16 Sep	1	10	MG				
				15 Dec	9	10	MG				

* For explanation of collection methods see Appendix Table A1.

Appendix A6. Summary of food habits data for age III and older kokanee (242-387 mm) collected from Flathead Lake during 1980, 1981.

Date	No. stomachs		*Daphnia thorata*	*Daphnia longiremis*	*Bosmina*	*Diaptomus*	*Cyclops*	*Epischura*	*Leptodora*	Diptera	Terrestrial insects
1980											
3 Jul	17	No./fish	1427					403	11		
		% of biomass	70.2					28.2	1.7		
7 Jul	5	No./fish	3127	46							
		% of biomass	98.6	1.5							
8 Jul	23	No./fish	1362					15	77		
		% of biomass	84.1					1.4	14.5		
9 Jul	5	No./fish	1629					37	150		
		% of biomass	76					2.5	21.5		
30 Jul	2	No./fish	1454				32		388		
		% of biomass	54.8				0.3		45		
15 Aug	10	No./fish	2981		22		66		373		
		% of biomass	71.9		<.1		0.4		27.7		
29 Aug	15	No./fish	3445				16	192	169		
		% of biomass	81.2				0.1	6.5	12.2		
18 Sep	9	No./fish	4087					23	68		
		% of biomass	94.4					0.8	4.8		
22 Sep	1	No./fish	3410	235							
		% of biomass	93.5	6.5							
22 Sep	1	No./fish	6973						147		
		% of biomass	93.9						6.1		
6 Oct	4	No./fish	3792						26		
		% of biomass	97.9						2.1		
1981											
13 Jan	14	No./fish	316			941		117		0.7	
		% of biomass	42.6			34.1		22.4		0.8	

Appendix A6. (Continued)

Date	No. stomachs		*Daphnia thorata*	*Daphnia longiremis*	*Bosmina*	*Diaptomus*	*Cyclops*	*Epischura*	*Leptodora*	Diptera	Terrestrial insects
20 Jan	5	No./fish				1245	31				
		% of biomass				98.0	2.0				
3 Mar	12	No./fish		95	7.9	2625	173				
		% of biomass		11.2	0.1	83.9	4.8				
3 Mar	3	No./fish				329	36			0.7	
		% of biomass				91.0	8.3			0.8	
16&21 Apr	21	No./fish		37		7121	101			56	0.3
		% of biomass		1.7		89.9	1.1			6.8	0.5
19 Apr	6	No./fish		58		3067	145				
		% of biomass		6.3		90.0	3.7				
15 May	4	No./fish	1067		11	11	11				
		% of biomass	99.4		0.1	0.3	0.3				
19 May	3	No./fish	3744								
		% of biomass	100.0								
24 May	5	No./fish	800	62	12						
		% of biomass	92.7	7.1	0.1						
31 May	6	No./fish	447	318	12			94			0.3
		% of biomass	49.7	35.3	0.1			14.9			0.1
2 Jun	5	No./fish	2346					17			
		% of biomass	99.0					1.0			
8 Jun	5	No./fish	775			20					
		% of biomass	99.3			0.7					
9 Jun	5	No./fish	1013					669			
		% of biomass	51.6					48.4			
14 Jun	5	No./fish	680	94				469			
		% of biomass	47.2	6.5				46.3			
14 Jun	3	No./fish	810	88						1.0	
		% of biomass	89.9	9.8						0.3	
18 Jun	7	No./fish	1220					312		1.1	
		% of biomass	73.3					26.7		0.1	

Appendix A6. (Continued)

Date	No. stomachs		*Daphnia thorata*	*Daphnia longiremis*	*Bosmina*	*Diaptomus*	*Cyclops*	*Epischura*	*Leptodora*	Diptera	Terrestrial insects
21 Jun	3	No./fish	1355					2625		3.3	
		% of biomass	26.6					73.3		0.2	
22 Jun	3	No./fish	1583	36		36		564			
		% of biomass	65.1	1.5		0.4		33.0			
22 Jun	2	No./fish	2761					23			
		% of biomass	98.8					1.2			
22 Jun	2	No./fish	321					1890			
		% of biomass	10.6					89.4			
22 Jun	10	No./fish	293			15		2633		1.0	
		% of biomass	7.2			0.1		92.6		0.1	
29 Jun	5	No./fish	4341			27		135		1.4	0.2
		% of biomass	95.5			0.2		4.2		0.1	<.1
29 Jun	3	No./fish	94					4289		0.3	
		% of biomass	1.5					98.5		<.1	
30 Jun	10	No./fish	3703			42		85		0.1	
		% of biomass	96.6			0.3		3.1		<.1	
30 Jun	6	No./fish	1612			37		3004		12	
		% of biomass	27.1			0.2		71.9		0.9	
1 Jul	11	No./fish	3926							0.2	0.2
		% of biomass	99.9							<.1	<.1
4 Aug	11	No./fish	1939						175	0.2	
		% of biomass	78.3						21.7	<.1	
19-27 Aug	15	No./fish	2495						233		
		% of biomass	77.7						22.3		
16 Sep	10	No./fish	4728			18					
		% of biomass	99.9			0.1					
15 Dec	10	No./fish	444			15	7.4	104			
		% of biomass	57.8			0.5	0.3	41.5			
1982											
3 Jan	22	No./fish	491			174	4.5	116			
		% of biomass	69.7			6.7	0.2	23.5			

Appendix A7. Summary of food habits data for age I+ kokanee (94-178 mm) collected from Flathead Lake during 1980 and 1981.

Date	No. stomachs		*Daphnia thorata*	*Daphnia longiremis*	*Bosmina*	*Diaptomus*	*Cyclops*	*Epischura*	*Leptodora*	Diptera	Terrestrial insects
1980											
2 Jul	1	No./fish	1091			12	12	99	12		
		% of biomass	85.5			0.3	0.2	11.1	0.2		
7 Jul	29	No./fish	825		5.6	5.6		117	11		
		% of biomass	80.3		<.1	0.2		16.2	3.3		
17 Jul	20	No./fish	2826		18		18	35			
		% of biomass	98,0		0.1		0.2	1.7			
20 Aug	12	No./fish	1561		31		15		15	0.1	2.1
		% of biomass	87.6		0.1		0.2		2.7	<.1	9.4
1981											
11 Jun	6	No./fish	1115	19				57		2.0	0.2
		% of biomass	91.0	1.6				6.7		0.7	0.1
24 Jun	5	No./fish	1310	31					0.2	0.6	
		% of biomass	97.5	2.3					0.1	0.1	
30 Jun	11	No./fish	1277			50		12			
		% of biomass	97.6			1.0		1.4			

Appendix A8. Summary of food habits data for age II+ kokanee (205-286 mm) collected from Flathead Lake during 1980 and 1981.

Date	stomachs		*Daphnia thorata*	*Daphnia longiremis*	*Bosmina*	*Diaptomus*	*Cyclops*	*Epischura*	*Leptodora*	Diptera
1980										
8 Jul	2	No./fish	1514						20	
		% of biomass	96.0						4.0	
9 Jul	2	No./fish	2232		36		72			
		% of biomass	99.2		0.1		0.7			
15 Aug	3	No./fish	3009				49		73	
		% of biomass	92.7				0.3		7.0	
29 Aug	5	No./fish	2900						109	
		% of biomass	89.6						10.0	
29 Aug	5	No./fish	2352					8.0	8.0	
		% of biomass	98.5					0.5	1.0	
8 Sep	2	No./fish	6233			40		40	40	
		% of biomass	97.0			0.2		0.9	1.9	
18 Sep	2	No./fish	3863						141	
		% of biomass	89.9						10.1	
22 Sep	1	No./fish	6243							
		% of biomass	100.0							
6 Oct	2	No./fish	2932							
		% of biomass	100.0							
1981										
2 Jun	2	No./fish	2115	191	16	32		111		
		% of biomass	85.5	7.7	0.1	0.3		6.4		
6 Jun	3	No./fish	591			12		12		
		% of biomass	96.6			0.6		2.8		
8 Jun	2	No./fish	2306							
		% of biomass	100.0							

Appendix A8. (Continued).

Date	No. stomachs		*Daphnia thorata*	*Daphnia longiremis*	*Bosmina*	*Diaptomus*	*Cyclops*	*Epischura*	*Leptodora*	Diptera
22 Jun	6	No./fish	377			20		1944		3.3
		% of biomass	11.9			0.2		87.6		0.3
24 Jun	3	No./fish	1844					3339		0.3
		% of biomass	28.7					71.3		<.1
24 Jun	2	No./fish	6761		38		38	38		
		% of biomass	99.0		0.1		0.1	0.8		
30 Jun	16	No./fish	3070					26		0.1
		% of biomass	98.8					1.2		<.1
30 Jun	2	No./fish	4257			95		1372		2.5
		% of biomass	68.2			0.4		31.3		0.1
1 Jul	11	No./fish	3205			16	16			
		% of biomass	99.7			0.1	0.1			
4 Aug	5	No./fish	1759						153	
		% of biomass	78.9						21.1	
15 Dec	10	No./fish	945			20		322		
		% of biomass	67.1			0.4		32.5		

Appendix A9. Composition by number, weight and frequency of occurrence and calculated index of relative importance (IRI) for food items in the stomachs of 61 cutthroat trout collected between 27 March and 22 April, 1981 in Flathead Lake.

Item	Number	(%)	Wet weight -g.	(%)	Frequency	(%)	IRI
Fish	1	(<.1)	.03	(0.1)	1	(1.6)	0.6
Hymenoptera	1,546	(6.1)	3.45	(13.3)	33	(54.1)	24.5
Plecoptera	4	(<.1)	.035	(0.1)	4	(6.6)	2.2
Coleoptera	696	(2.7)	5.58	(21.5)	37	(60.7)	28.3
Hemiptera	539	(2.1)	3.24	(12.5)	25	(41.0)	18.5
Hirudinea	2	(<.1)	.24	(0.9)	1	(1.6)	0.8
Homoptera	201	(0.8)	.39	(1.5)	17	(27.9)	10.1
Trichoptera	13	(<.1)	.34	(1.3)	7	(11.5)	4.3
Neuroptera	1	(<.1)	.01	(0.4)	1	(1.6)	0.7
Diptera (adults)	324	(1.3)	1.98	(7.6)	28	(45.9)	18.3
Diptera (pupae)	21,251	(83.1)	7.79	(30.0)	55	(90.2)	67.8
Diptera (larvae)	127	(0.5)	.04	(0.2)	19	(31.2)	10.6
Lepidoptera	14	(<.1)	.21	(0.8)	7	(11.5)	4.1
Odonata	2	(<.1)	.05	(0.2)	1	(1.6)	0.6
Ephemeroptera	191	(0.8)	.72	(2.8)	20	(32.8)	12.1
Amphipods	93	(0.4)	.76	(2.9)	18	(29.5)	10.9
Gastropods	5	(0.2)	.29	(1.1)	4	(6.6)	2.6
Arachnids	189	(0.7)	.75	(2.9)	26	(42.6)	15.4
Daphnia	361	(1.4)	.05	(0.2)	1	(1.6)	1.1
Leptodora	1	(<.1)	.00	(<.1)	1	(1.6)	0.5
Total	25,561		25.95		61		
Insect parts*			14.38		48		
Debris*			.45		28		

* Not included in totals.

Appendix A10. Composition by number, weight and frequency of occurrence and calculated index of relative importance (IRI) for food items in the stomachs of 49 cutthroat trout collected between 19 May and 6 August, 1980 and 1981 in Flathead Lake.

Item	Number	(%)	Wet weight -g.	(%)	Frequency	(%)	IRI
Fish	3	(<.1)	1.01	(2.1)	3	(6.1)	2.7
Hymenoptera	3,698	(32.0)	18.01	(37.3)	38	(77.6)	49.0
Orthoptera	31	(0.3)	8.38	(17.3)	9	(18.4)	12.0
Coleoptera	703	(6.1)	8.15	(16.9)	34	(69.4)	30.8
Hemiptera	199	(1.7)	1.2	(2.5)	31	(63.3)	22.5
Odonata	120	(1.0)	.84	(1.7)	1	(2.0)	1.6
Homoptera	511	(4.4)	1.25	(2.6)	28	(57.0)	21.3
Trichoptera	271	(2.3)	.62	(1.3)	24	(49.0)	17.5
Neuroptera	48	(0.4)	.22	(0.5)	15	(30.6)	10.5
Diptera (adult)	397	(3.4)	1.43	(3.0)	31	(63.3)	23.2
Diptera (pupae)	2,600	(22.5)	2.01	(4.2)	34	(69.4)	32.0
Diptera (larvae)	130	(1.1)	.27	(0.6)	17	(34.7)	12.1
Lepidoptera	25	(0.2)	.68	(1.4)	7	(14.3)	5.3
Ephemeroptera	258	(2.2)	2.29	(4.7)	11	(22.4)	9.8
Amphipods	4	(<.1)	.01	(<.1)	3	(6.1)	2.0
Corn	7	(0.1)	.43	(0.9)	2	(4.1)	1.7
Arachnids	51	(0.4)	.18	(0.4)	17	(34.7)	11.8
Epischura	1,531	(13.2)	.57	(1.2)	13	(26.5)	13.6
Leptodora	984	(8.5)	.79	(1.6)	12	(24.5)	11.5
Total	11,571		48.34		49		
Insect parts*			28.89				
Debris*			2.31		25		

* Not included in totals

Appendix A11. Composition by number, weight and frequency of occurrence and calculated index of relative importance (IRI) for food items in the stomachs of 70 cutthroat trout collected between 9 October and 25 November, 1981 in Flathead Lake.

Item	Number	(%)	Wet weight -g.	(%)	Frequency	(%)	IRI
Hymenoptera	664	(4.1)	2.15	(6.7)	56	(80.0)	30.3
Odonata	5	(<.1)	.03	(0.1)	3	(4.3)	1.5
Millipedes	4	(<.1)	.03	(0.1)	2	(2.9)	1.0
Coleoptera	1,575	(9.8)	6.19	(19.4)	64	(91.4)	40.2
Hemiptera	1,271	(7.9)	11.07	(34.7)	54	(77.1)	39.9
Homoptera	7,376	(46.0)	3.93	(12.3)	56	(80.0)	46.1
Trichoptera	18	(0.1)	.10	(0.3)	9	(12.9)	4.4
Neuroptera	207	(1.3)	.69	(2.2)	35	(50.0)	17.8
Diptera (adults)	3,486	(21.7)	4.61	(14.4)	61	(87.1)	41.1
Diptera (pupae)	74	(0.5)	.04	(0.1)	2	(2.9)	1.2
Lepidoptera	12	(0.1)	.17	(0.5)	9	(12.9)	4.5
Ephemeroptera	5	(0.1)	.115	(0.4)	2	(2.9)	1.1
Amphipods	195	(1.2)	.76	(2.4)	6	(8.6)	4.1
Hirudinea	1	(<.1)	.02	(0.1)	1	(1.4)	0.5
Arachnids	466	(2.9)	.94	(2.9)	52	(74.3)	26.7
Daphnia	63	(0.4)	.02	(0.1)	11	(15.7)	5.4
Eipschura	533	(3.3)	.20	(0.6)	23	(32.9)	12.3
Leptodora	97	(0.6)	.88	(2.8)	9	(12.9)	5.4
Total	16,052		31.95		70		
Insect parts*			24.95		54		
Debris*			.27		12		

*Not included in totals.

Appendix A12. Composition by number, weight and frequency of occurrence and calculated index of relative importance (IRI) for food items in the stomachs of 14 cutthroat trout collected between 20 October and 21 November 1981 in the lower Flathead River from the Salmon Hole downstream.

Item	Number	(%)	Wet weight -g.	(%)	Frequency	(%)	IRI
Fish	1	(0.1)	1.28	(22.8)	1	(7.1)	10.0
Hymenoptera	18	(2.4)	.29	(5.2)	7	(50.0)	19.2
Plecoptera	8	(1.1)	.06	(1.1)	5	(35.7)	12.6
Coleoptera	308	(41.0)	2.86	(50.9)	10	(71.4)	54.4
Hemiptera	142	(18.9)	.48	(8.5)	9	(64.3)	30.6
Homoptera	82	(10.9)	.05	(0.9)	4	(28.6)	13.5
Trichoptera	7	(0.9)	.24	(4.3)	5	(35.7)	13.6
Neuroptera	1	(0.1)	.005	(0.1)	1	(7.1)	2.4
Diptera (adults)	39	(5.2)	.05	(0.9)	4	(28.6)	11.6
Diptera (pupae)	123	(16.4)	.05	(0.9)	4	(28.6)	15.3
Ephemeroptera (nymphs)	3	(0.4)	.01	(0.2)	1	(7.1)	2.6
Amphipods	3	(0.4)	.005	(0.1)	1	(7.1)	2.5
Gastropods	1	(0.1)	.22	(3.9)	1	(7.1)	3.7
Arachnids	14	(1.9)	.02	(0.4)	3	(21.4)	7.9
Unid. Cladoceran	1	(0.1)	---	----	1	(7.1)	---
Total	751		5.62		14		
Insect parts*			4.68		12		
Debris*			.69		8		

* Not included in totals.

Appendix A13. Composition by number, weight and frequency of occurrence and calculated index of relative importance (IRI) for food items in the stomachs of 16 cutthroat trout collected between 25 November 1980 and 21 January 1981 in Flathead Lake.

Item	Number	(%)	Wet weight -g.	(%)	Frequency	(%)	IRI
Plecoptera	5	(0.5)	.005	(0.7)	2	(12.5)	4.6
Trichoptera	2	(0.2)	.01	(1.5)	2	(12.5)	4.7
Diptera (adults)	2	(0.2)	.01	(1.5)	1	(6.3)	2.7
Diptera (pupae)	1	(0.1)	.005	(0.7)	1	(6.3)	2.4
Diptera (larvae)	2	(0.2)	.01	(1.5)	2	(12.5)	4.7
Ephemeroptera	2	(0.2)	.01	(1.5)	2	(12.5)	4.7
Amphipods	38	(4.1)	.49	(72.1)	2	(12.5)	29.6
Parasitic nematodes	1	(0.1)	.005	(0.7)	1	(6.3)	2.4
Arachnids	1	(0.1)	.005	(0.7)	1	(6.3)	2.4
Daphnia	805	(87.0)	.11	(16.2)	7	(43.8)	49.0
Epischura	8	(0.9)	.005	(0.7)	4	(25.0)	8.9
Leptodora	21	(2.3)	.01	(1.5)	1	(6.3)	3.4
Eurycercus	37	(4.0)	.01	(1.5)	1	(6.3)	3.9
Total	925		.69		16		
Insect parts*			.10		5		
Debris*			.20		5		

* Not included in total.

Appendix A14. Composition by number, weight, and frequency of occurrence and calculated index of relative importance (IRI) for food items in the stomachs of eight cutthroat trout collected on 26 January 1981 in the Salmon Hole of the Flathead River.

Item	Number	(%)	Wet weight -g.	(%)	Frequency	(%)	IRI
Plecoptera	1,218	(91.4)	3.68	(87.4)	7	(87.5)	88.8
Hemiptera	2	(0.2)	.06	(1.4)	2	(25.0)	8.9
Trichoptera	4	(0.3)	.12	(2.9)	3	(37.5)	13.6
Diptera (adults)	69	(5.2)	.08	(1.9)	5	(62.5)	23.2
Diptera (pupae)	1	(0.1	.01	(0.2)	1	(12.5)	4.2
Diptera (larvae)	6	(0.5)	.005	(0.1)	3	(37.5)	12.7
Ephemeroptera	30	(2.3)	.24	(5.8)	6	(75.0)	27.7
Collembola	1	(0.1)	.005	(0.1)	1	(12.5)	4.2
Parasitic Nematodes	1	(0.1)	.005	(0.1)	1	(12.5)	4.2
Total	1,332		4.21				
Insect parts*			.47		7		
Debris*			.20		4		

* Not included in totals.

Appendix A15. The seasonal and overall importance (Index of Relative Importance) of various forage fish species in the diet of 367 bull trout collected from Flathead Lake during the period 1979-1981.

	Spring (March & April)	Summer (May - Aug)	Fall (Sep & Oct)	Winter (Nov - Feb)	Overall
No. stomachs	95	71	120	95	367
		INDEX OF RELATIVE IMPORTANCE			
FORAGE SPECIES					
Pygmy whitefish	2	4	4	3	4
Lake whitefish		9	17	4	9
Mountain whitefish	4	17	9	4	9
Unid. whitefish	3	5	11	15	7
Total whitefish	*8*	*34*	*40*	*24*	*29*
Kokanee salmon	26	5	14	4	10
Bull trout	1		1		<1
Unid. trout/salmon	1	2	2	2	1
Total trout/salmon	*28*	*6*	*16*	*5*	*12*
Sculpin	4	4	2	2	3
Redside shiner	6	2	1	2	3
Peamouth	3	4	1	1	2
Squawfish		3			1
Sucker		4		4	2
Yellow perch	11	8	5	25	13
Unid. cyprinids	1	1			1
Total non-game	*21*	*26*	*8*	*31*	*23*
Unid. fish	42	39	40	41	39

Appendix A16. Composition by number, weight and frequency of occurrence and calculated index of relative importance (IRI) for major food items in the stomachs of 120 bull trout collected between 22 May and 18 August, 1980 and 1981 in Flathead Lake.

Item	Number	(%)	Wet weight -g.	(%)	Frequency	(%)	IRI
Pygmy whitefish	14	(5.8)	73.7	(3.7)	4	(3.3)	4.3
Lake whitefish	8	(3.3)	345.0	(17.2)	7	(5.8)	8.8
Mountain whitefish	12	(4.9)	704.7	(35.1)	12	(10.0)	16.7
Unid. whitefish	10	(4.1)	84.7	(4.2)	9	(7.5)	5.3
Total whitefish	*44*	*(18.1)*	*1,208.1*	*(60.2)*	*29*	*(24.2)*	*34.2*
Kokanee salmon	7	(2.9)	112.3	(5.6)	6	(5.0)	4.5
Unid. trout/salmon	3	(1.2)	23.6	(1.2)	3	(2.5)	1.6
Total trout/salmon	*10*	*(4.1)*	*135.9*	*(6.8)*	*9*	*(7.5)*	*6.1*
Sculpin	12	(4.9)	10.3	(0.5)	9	(7.5)	4.3
Redside shiner	6	(2.5)	21.9	(1.1)	4	(3.3)	2.3
Peamouth	5	(2.1)	107.3	(5.4)	4	(3.3)	3.6
Squawfish	2	(0.8)	152.4	(7.6)	2	(1.7)	3.4
Sucker	5	(2.1)	153.9	(7.7)	3	(2.5)	4.1
Yellow perch	49	(20.2)	3.4	(0.2)	4	(3.3)	7.9
Unid. cyprinids	2	(0.8)	1.6	(0.1)	2	(1.7)	0.9
Total non-game	*81*	*(33.3)*	*450.8*	*(22.5)*	*28*	*(23.3)*	*26.4*
Unid. fish	108	(44.4)	210.7	(10.5)	76	(63.3)	39.4

Appendix A17. Composition by number, weight and frequency of occurrence and calculated index of relative importance (IRI) for major food items in the stomachs of 81 bull trout collected between 4 September and 29 October, 1980 and 1981 in Flathead Lake.

Item	Number	(%)	Wet weight -g.	(%)	Frequency	(%)	IRI
Pygmy whitefish	5	(4.6)	34.3	(1.4)	4	(4.9)	3.6
Lake whitefish	10	(9.3)	781.0	(31.7)	8	(9.9)	17.0
Mountain whitefish	5	(4.6)	414.6	(16.8)	5	(6.2)	9.2
Unid. whitefish	11	(10.2)	242.0	(9.8)	10	(12.3)	10.8
Total whitefish	*31*	*(28.7)*	*1,471.9*	*(59.8)*	*25*	*(30.9)*	*39.8*
Kokanee salmon	7	(6.5)	668.1	(27.1)	6	(7.4)	13.6
Bull trout	1	(0.9)	10.4	(0.4)	1	(1.2)	0.8
Unid. trout/salmon	2	(1.9)	5.7	(0.2)	2	(2.5)	1.5
Total trout/salmon	*10*	*(9.3)*	*684.2*	*(27.8)*	*9*	*(11.1)*	*16.1*
Sculpin	2	(1.9)	2.8	(0.1)	2	(2.5)	1.5
Redside shiner	1	(0.9)	2.8	(0.1)	1	(1.2)	0.7
Peamouth	1	(0.9)	7.0	(0.3)	1	(1.2)	0.8
Yellow perch	9	(8.3)	6.9	(0.3)	5	(6.2)	4.9
Total non-game	*13*	*(12.0)*	*19.5*	*(0.8)*	*9*	*(11.1)*	*8.0*
Unid. fish	54	(50.0)	286.9	(11.7)	46	(56.8)	39.5

Appendix A18. Composition by number, weight, and frequency of occurrence and calculated index of relative important (IRI) for major food items in the stomachs of ten bull trout collected between 20 October and 30 November, 1981 in the lower Flathead River at or below the Salmon Hole.

Item	Number	(%)	Wet weight -g.	(%)	Frequency	(%)	IRI
Pygmy whitefish	18	(60.0)	154.6	(58.0)	4	(40.0)	52.7
Unid. whitefish	1	(3.3)	67.0	(25.1)	1	(10.0)	12.8
Total whitefish	*19*	*(63.3)*	*221.6*	*(83.1)*	5	*(50.0)*	*65.5*
Unid. fish	11	(36.6)	45.2	(16.9)	6	(60.0)	37.8

Appendix A19. Composition by number, weight, and frequency of occurrence and calculated index of relative importance (IRI) for major food items in the stomachs of 95 bull trout collected between 3 November and 21 January, 1979, 1980 and 1981 in Flathead Lake.

Item	Number	(%)	Wet weight -g.	(%)	Frequency	(%)	IRI
Pygmy whitefish	5	(2.4)	37.0	(4.0)	3	(3.2)	3.2
Lake whitefish	1	(0.5)	104.1	(11.2)	1	(1.1)	4.3
Mountain whitefish	1	(0.5)	24.3	(2.6)	1	(1.1)	4.4
Unid. whitefish	11	(5.3)	281.2	(30.3)	9	(9.5)	15.0
Total whitefish	*18*	*(8.7)*	*446.6*	*(48.1)*	*13*	*(13.7)*	*23.5*
Kokanee salmon	2	(1.0)	82.8	(8.9)	2	(2.1)	4.0
Unid. trout/salmon	2	(1.0)	13.2	(1.4)	2	(2.1)	1.5
Total trout/salmon	*4*	*(1.9)*	*96.0*	*(10.3)*	*3*	*(3.2)*	*5.1*
Sculpin	3	(1.5)	7.6	(0.8)	3	(3.2)	1.8
Redside shiner	5	(2.4)	15.0	(1.6)	2	(2.1)	2.0
Peamouth	1	(0.5)	3.6	(0.4)	1	(1.1)	0.7
Sucker	2	(1.0)	74.4	(8.0)	2	(2.1)	3.7
Yellow perch	83	(40.3)	105.1	(11.3)	21	(22.1)	24.6
Total non-game	*94*	*(45.6)*	*205.7*	*(22.1)*	*24*	*(25.3)*	*31.0*
Unid. fish	90	(43.7)	181.1	(19.5)	58	(61.1)	41.4

Appendix A20. Composition by number, weight, and frequency of occurrence and calculated index of relative importance (IRI) for major food items in the stomachs of 71 bull trout collected between 27 March and 23 April, 1981 in Flathead Lake.

Item	Number	(%)	Wet weight -g.	(%)	Frequency	(%)	IRI
Pygmy whitefish	2	(2.2)	5.6	(0.7)	2	(2.8)	1.9
Mountain whitefish	1	(1.1)	67.8	(8.4)	1	(1.4)	3.6
Unid. whitefish	2	(2.2)	20.8	(2.6)	2	(2.8)	2.5
Total whitefish	5	(5.5)	*94.2*	*(11.6)*	*4*	(5.6)	*7.6*
Kokanee salmon	8	(8.8)	476.6	(58.9)	7	(9.9)	25.9
Bull trout	1	(1.1)	2.0	(0.3)	1	(1.4)	0.9
Unid. trout/salmon	1	(1.1)	.8	(0.1)	1	(1.4)	0.9
Total trout/salmon	*10*	*(11.0)*	*479.4*	*(59.2)*	*9*	*(12.7)*	*27.6*
Sculpin	4	(4.4)	4.5	(0.6)	4	(5.6)	3.5
Redside shiner	7	(7.7)	18.9	(2.3)	6	(8.5)	6.2
Peamouth	2	(2.2)	28.2	(3.5)	2	(2.8)	2.8
Yellow perch	8	(8.8)	105.8	(13.1)	7	(9.9)	10.6
Unid. Cyprinids	1	(1.1)	.2	(<.1)	1	(1.4)	0.8
Total non-game	*22*	*(24.2)*	*157.6*	*(19.5)*	*14*	*(19.7)*	*21.1*
Unid. fish	54	(59.3)	78.7	(9.7)	41	(57.8)	42.3

Appendix A21. Percent of biomass for food items found in the stomachs of lake whitefish collected from Flathead Lake during 1981.

	April	June & July	August & September	October & November	Total Sample
No. stomachs	23	30	56	22	131
No. dates	4	8	7	5	24
Length range(mm)	288-532	178-361	208-536	163-485	163-536
Mean length (mm)	403	259	354	368	343
			Percent of Biomass		
ZOOPLANKTON					
Daphnia thorata		54	59	37	39
Daphnia longiremis				<1	<1
Leptodora		2	4	5	2
Epischura		43	2	1	8
Diaptomus			<1		<1
Copepod nauplii				<1	<1
NON-ZOOPLANKTON					
Algae					
Bryozoa	4		10	41	12
Gastropoda	28		12	1	13
Pelecypoda	3	2	2	<1	2
Hirudinea	2		1		1
Ostracoda	<1		<1	<1	<1
Amphipoda	<1		<1		<1
Hydracarina	2		<1	<1	1
Chironomid larvae	2	<1	2	<1	1
Diptera pupae	1	<1	<1		<1
Diptera adults		<1			<1
Other aq. insects	<1	<1			<1
Terrestrial insects	<1		<1		<1
Insect parts	4		<1	<1	1
Unid. fish	2		<1		1
Organic debris	46		4	10	15
Gravel	6		4	5	4
Biomass per fish (mg. dry wt.)	942	962	561	561	606

Appendix A22. Percent of biomass for food items found in the stomachs of lake whitefish collected from Flathead Lake during 1981.

Date	Apr 14	Apr 16	Apr 21	Apr 23	Jun 22	Jun 24	Jun 24	Jun 29
Area	2	4	8	5	5	1	1	1
Collection method*	FG	SG	SG	SG	PS	PS	PS	PS
No. stomachs	5	7	5	6	3	4	6	2
Length range(mm)	288-426	363-532	373-437	373-475	373-475	178-275	231-285	262-274
Mean length(mm)	344	441	400	410	256	248	263	268
				Percent of Biomass				
ZOOPLANKTON								
Daphnia thorata					5	83	24	69
Daphnia longiremis								
Leptodora						4		
Epischura					95	4	76	32
Diaptomus								
Nauplii								
NON-ZOOPLANKTON								
Bryozoa		<1	32					
Gastropoda		44	<1	2				
Pelecypoda	1	1	3	10		9		
Hirudinea				1				
Ostracoda	<1							
Amphipoda		<1	<1	1				
Hydracarina	1	1	2	5				
Chironomid larvae	2	1	<1	8				
Diptera pupae	1	1	1	<1	<1	<1	<1	<1
Diptera adults								
Other aq. insects		<1						
Terrestrial insects			<1	<1				
Insect parts	94	1	1	<1				
Unid. fish		4						
Organic debris	2	45	42	57				
Gravel		1	18	17				
Biomass per fish(mg)	160	1954	531	454	452	638	669	867

Appendix A22. (Continued).

Date	Jun 30	Jun 30	Jul 1	Jul 29	Aug 4	Aug 12	Aug 13	Aug 14	Aug 18
Area	1	1	3	1	1	2	4	8	5
Collection method*	PS	PS	PS	MT	PS	SG	SG	SG	SG
No. stomachs	3	5	3	3	10	5	11	10	11
Length range(mm)	262-288	258-361	301-355	197-215	276-372	282-417	208-536	353-432	211-427
Mean length(mm)	278	290	328	205	312	357	355	401	310
	Percent of Biomass								
ZOOPLANKTON									
Daphnia thorata	45	100	83		96	27	29	100	47
Daphnia longiremis									
Leptodora				92	3	11	4		20
Epischura	54		17			10	3		8
Diaptomus						<1			
Nauplii									
NON-ZOOPLANKTON									
Bryozoa							45		
Gastropoda						5	1	<1	<1
Pelecypoda				2	1	2	<1		4
Hirudinea									
Ostracoda									<1
Amphipoda									
Hydracarina						<1	<1		<1
Chironomid larvae			<1			6	<1	<1	4
Diptera pupae	1	<1		6		<1	<1		1
Diptera adults	<1								
Other aq. insects			<1						
Terrestrial insects	<1					2	1		
Insect parts						<1			1
Unid. fish						10			
Organic debris						<1	2		14
Gravel						28	14		2
Biomass per fish(mg)	378	222	611	45	786	136	650	749	157

Appendix A22. (Continued).

Date	Sep 15	Sep 16	Oct 23	Nov 3	Nov 5	Nov 10	Nov 19
Area	1	1	1	4	8	5	1
Collection method*	MG	MG	MG	SG	SG	SG	MG
No. stomachs	3	6	7	4	6	2	3
Length range(mm)	271-470	380-442	320-430	375-485	340-480	311-443	163-253
Mean length(mm)	379	410	363	429	406	377	215
			Percent of Biomass				
ZOOPLANKTON							
Daphnia thorata	5	16	93	2	34		98
Daphnia longiremis							2
Leptodora	2	<1		11	2		
Epischura	1	1	4				
Diaptomus							
Nauplii			<1				
NON-ZOOPLANKTON							
Bryozoa		2		81	2	77	
Gastropoda	75			<1	5	<1	
Pelecypoda	<1	29	1	1		<1	
Hirudinea	6						
Ostracoda	<1			<1			
Amphipoda	1						
Hydracarina	<1			<1	<1	1	
Chironomid larvae	<1	30	1	<1	<1	<1	
Diptera pupae		7					
Diptera adults							
Other aq. insects							
Terrestrial insects							
Insect parts		<1		<1	<1		
Unid. fish				1			
Organic debris	10	16	1	<1	40	17	
Gravel				3	16	5	
Biomass per fish(mg)	1659	254	298	1159	380	801	585

* For explanation of collection methods see Appendix Table A1.

Appendix A23. Percent of biomass for food items found in the stomachs of mountain whitefish collected from Flathead Lake during 1980-81.

	April	June	August & September	October & November	Total Sample
No. stomachs	13	22	46	10	91
No. dates	3	5	5	4	17
Length range (mm)	203-291	235-288	177-344	250-322	177-344
Mean length (mm)	267	265	257	278	263
		Percent of Biomass			
ZOOPLANKTON					
Daphnia thorata		100	72	88	77
NON-ZOOPLANKTON					
Algae	28				1
Fish eggs				10	1
Gastropoda			3	2	2
Trichoptera			22		15
Hirudinea	1				<1
Ostracoda			<1		<1
Amphipoda	2				<1
Tipulidae larvae	1				<1
Chironomid larvae	6		<1		<1
Diptera pupae	3	<1	<1		<1
Other aq. insects			<1		<1
Terrestrial insects	1				<1
Insect parts	48		<1		1
Organic debris	9		2	<1	2
Gravel	1		<1	1	<1
Biomass per fish (mg. dry wt.)	69	256	539	534	403

Appendix A24. Percent of biomass for food items found in the stomachs of mountain whitefish collected from Flathead Lake during 1980 and 1981.

Date	Nov 19	Apr 16	Jun 29	Aug 4	Aug 12	Aug 18	Sep 15	Nov 5
Area	1	2&8	1&3	1	2&4	5	1	4,8 & 5
Collection method*	MG	FG&SG	PS	PS	SG	SG	PS	SG
No. stomachs	3	13	22	11	15	10	10	7
Length range (mm)	260-284	203-291	235-288	262-299	177-344	183-265	205-293	250-322
Mean length (mm)	269	267	265	277	256	230	265	282
	Percent of Biomass							
ZOOPLANKTON								
Daphnia thorata	95		100	100	46	75	100	83
Daphnia longiremis								
Leptodora								
Epischura								
Diaptomus								
Nauplii								
NON-ZOOPLANKTON								
Algae		28						
Fish eggs								16
Gastropoda	5				<1	17		
Trichoptera					50			
Hirudinea		1						
Ostracoda					<1			
Amphipoda		2						
Tipulidae larvae								
Chironomid larvae		6			<1	<1		
Diptera pupae		3	<1	<1	<1	<1		
Diptera adults								
Other aq. insects					1	1		
Terrestrial insects		1						
Insect parts		48		<1	<1	<1		
Unid. fish								
Organic debris	<1			<1	3	7		<1
Gravel					<1	1		1
Biomass per fish (mg)	691	69	256	304	735	375	663	466

*For explanation of collection method see Appendix Table A1.

Appendix A25. Percent of biomass for food items found in the stomachs of pygmy whitefish collected from Flathead Lake during 1980 and 1981.

	July 1980&1981	August & September 1980&1981	October & November 1980	December 1980	Total Sample
No. stomachs	61	41	17	16	135
No. dates	6	5	3	2	16
Length range (mm)	55-139	32-138	54-138	65-149	32-149
Mean length (mm)	104	77	99	97	94
		Percent of Biomass			
ZOOPLANKTON					
Daphnia thorata	36	66	49	97	70
Daphnia longiremis				2	1
Leptodora		1			<1
Epischura	25	21	21	<1	13
Diaptomus		<1	2		<1
Cyclops		1		<1	<1
NON-ZOOPLANKTON					
Pelecypoda	<1				<1
Chironomid larvae	10	9	12		6
Dipteran pupae	<1	1			<1
Other aq. insects			<1		<1
Terrestrial insects	<1		<1		<1
Insect parts	<1	1	<1	<1	<1
Ostracods	<1	1	<1	<1	<1
Organic debris	28		16		10
Biomass per fish (mg. dry wt.)	25	22	48	169	44

Appendix A26. Percent of biomass for food items found in the stomach of pygmy whitefish collected from Flathead Lake during 1980-81.

Date	Jul 7	Jul 7	Jul 7	Jul 17	Aug 19	Sep 10	Sep 25	Dec. 3
Area	1-5	1-5	1-5	1-5	1-5	3-13	2-3	1-12
Collection method*	MT	MT	MT	MT	MT	MT	MT	MT
No. stomachs	11	15	14	11	17	10	4	6
Length range (mm)	55-72	122-139	84-110	94-139	38-138	60-69	32-38	112-149
Mean length (mm)	63	132	96	118	101	64	35	127
				Percent of Biomass				
ZOOPLANKTON								
Daphnia thorata	2			75	57	94		97
Daphnia longiremis								3
Leptodora								
Epischura	93			17	23		97	
Diaptomus								
Cyclops						4		
NON-ZOOPLANKTON								
Pelecypoda				<1				
Ostracods				<1	4			
Chironomid larvae	3	13	13	8	16	1		<1
Diptera pupae	1			4	1		1	
Other aq. insects								
Insect parts	1	1		<1		1	1	
Organic debris	1	86	87					
Biomass per fish (mg)	17.9	17.2	11.5	66.2	30.2	7.8	7.2	317.3

Appendix A26. (Continued).

Date	Dec 3	Jul 29	Jul 29	Sep 9	Oct 19	Nov 23	Nov 23
Area	1-12	1-12	1-12	1-5	2-6	1-1	1-1
Collection method*	MT	MT	MT	MT	MT	MT	MT
No. stomachs	10	5	5	10	7	5	5
Length range (mm)	65-86	68-86	128-137	62-70	54-135	75-92	121-138
Mean length (mm)	79	73	132	66	88	84	129
			Percent of Biomass				
ZOOPLANKTON							
Daphnia thorata	60	6		79	91	10	40
Daphnia longiremis							
Leptodora				5			
Epischura	20	85		14		86	
Diaptomus				<1	5		
Cyclops	10			1			
NON-ZOOPLANKTON							
Pelecypoda			1				
Ostracods	3	4	1		<1		<1
Chironomid larvae	3	4	26	<1	<1	4	26
Diptera pupae			1				
Other aq. insects					<1		
Terrestrial insects			1		<1		
Insect parts	3	1	1	<1	<1	<1	
Organic debris			70		3		34
Biomass per fish (mg)	3.0	18.2	19.7	27.8	38.2	38.7	70.0

* For explanation of collection methods see Appendix Table A1.

Appendix A27. Site and age-specific feeding habits of kokanee salmon, lake whitefish and mountain whitefish (caught in purse seine hauls) in relation to prey densities in the northwest quadrant of Flathead Lake during the period 22 June to 1 July, 1981.

							Percent of total biomass in stomachs		Density in lake plankton	
Date	Area	Haul	Species	Age/size group	No. of stomachs	Fish per hectare	*Daphnia thorata*	Adult *Epischura*	*Daphnia thorata* (no./L)	Adult *Epischura* (No./m³)
Jun 22	1:1	PS1	KOK	II+	6	26	12%	88%	1.63	78
				≥III+	10	113	7%	93%		
			LWF	254-258mm	3	13	5%	95%		
Jun 29	1:5	PS1	KOK	≥III+	8	35	53%	47%	1.81	124
			LWF	262&277mm	2	9	69%	31%		
			MWF	246&250mm	2	9	100%	0%		
Jun 30	1:1	PS1	KOK	II+	16	170	99%	1%	2.38	128
				>III+	10	191	97%	3%		
			LWF	258-361mm	5	35	100%	0%		
			MWF	267-288mm	5	30	100%	0%		
Jun 30	1:5	PS2	KOK	I+	11	361	98%	1%	1.81	59
				II+	2	9	68%	31%		
				≥III+	6	26	27%	72%		
			LWF	262-288mm	3	13	45%	54%		
			MWF	235-286mm	5	30	100%	0%		
Jul 1	3:8	PS1	KOK	II+	11	96	100%	0%	2.81	135
				>III+	11	152	100%	0%		
			LWF	301-355mm	3	13	83%	17%		
			MWF	285mm	1	4	100%	0%		

APPENDIX B

Trout Age and Growth Information

Appendix B1. Yearly summary by collection method for cutthroat trout collected from Flathead Lake during the period 1962-1981.

Year	No. aged	Collection method: Creel census No. (%)	Gill nets No. (%)	Purse seine 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)	
1981	255	33 (13)	219 (86)	3 (1)
TOTAL	574	244 (42)	313 (55)	17 (3)

Appendix B2. Calculated lengths and growth increments (millimeters) for westslope cutthroat trout that spent one year in tributaries prior to entering Flathead lake. Fish were collected from Flathead Lake during the period 1962 through 1981.

Age	(n)	Length (mm) at annulus I	II	III	IV	V	VI
1	(0)						
2	(1)	34	127				
3	(0)						
4	(10)	59	156	233	282		
5	(3)	55	155	230	300	357	
6	(1)	54	164	227	295	367	406
Grand mean calculated length		56	154	232	287	360	406
(n)		(15)	(15)	(14)	(14)	(4)	(1)
Weighted mean length increment		56	98	76	55	61	39

Appendix B3. Calculated lengths and growth increments (millimeters) for westslope cutthroat trout that spent two years in tributaries prior to entering Flathead Lake. Fish were collected from Flathead Lake during the period 1962 through 1981.

Age	(n)	Length (mm) at annulus I	II	III	IV	V	VI
1	(0)						
2	(2)	61	103				
3	(38)	63	117	219			
4	(62)	67	124	224	285		
5	(38)	64	121	217	283	329	
6	(8)	68	130	217	282	330	363
Grand mean calculated length		65	122	221	284	329	363
(n)		(148)	(148)	(146)	(108)	(46)	(8)
Weighted mean length increment		65	56	99	63	46	33

Appendix B4. Calculated lengths and growth increments (millimeters) for westslope cutthroat trout that spent three years in tributaries prior to entering Flathead Lake. Fish were collected from Flathead Lake during the period 1962 through 1981.

Age	(n)	Length (mm) at annulus I	II	III	IV	V	VI	VII
1	(0)							
2	(0)							
3	(5)	52	99	152				
4	(65)	60	110	160	255			
5	(75)	60	109	159	256	311		
6	(22)	66	115	163	255	311	349	
7	(3)	64	105	152	243	306	354	393
Grand mean calculated length		61	110	160	255	311	350	393
(n)		(170)	(170)	(170)	(165)	(100)	(25)	(3)
Weighted mean length increment		61	49	50	95	55	39	39

Appendix B5. Calculated lengths and growth increments (millimeters) for westslope cutthroat trout that spent four years in tributaries prior to entering Flathead Lake. Fish were collected from Flathead Lake during the period 1962 through 1981.

Age	(n)	Length (mm) at annulus I	II	III	IV	V	VI
1	(0)						
2	(0)						
3	(0)						
4	(0)						
5	(9)	60	111	156	207	300	
6	(6)	70	127	178	223	310	354
Grand mean calculated length		64	117	165	213	304	354
(n)		(15)	(15)	(15)	(15)	(15)	(6)
Weighted mean length increment		64	53	47	49	91	44

Appendix B6. Calculated lengths and growth increments (millimeters) for westslope cutthroat trout that spent an undetermined number of years in tributaries prior to entering Flathead Lake. Fish were collected from Flathead Lake during the period 1962 through 1981.

		Length (mm) at annulus							
Age	(n)	I	II	III	IV	V	VI	VII	VIII
1	(0)								
2	(8)	58	123						
3	(34)	64	124	193					
4	(72)	67	129	197	261				
5	(79)	68	123	187	255	306			
6	(23)	65	122	182	244	303	343		
7	(8)	67	123	187	240	307	350	381	
8	(1)	47	103	166	207	256	311	363	410
Grand mean calculated length		66	125	191	255	305	344	379	410
(n)		(225)	(225)	(217)	(183)	(111)	(32)	(9)	(1)
Length increment		66	59	66	65	54	41	33	47

Appendix B7. Calculated total lengths (millimeters) and growth increments for bull trout collected from Flathead Lake during the years 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)	69	127	195						
4	(135)	63	121	188	259					
5	(141)	66	127	197	275	356				
6	(120)	66	127	194	277	367	459			
7	(59)	66	126	195	279	372	463	556		
8	(21)	63	124	191	273	371	467	566	657	
9	(4)	51	99	180	259	332	437	549	641	731
Grand mean calculated length		65	125	193	271	363	461	558	654	731
(n)		(533)	(533)	(533)	(480)	(345)	(204)	(84)	(25)	(4)
Length increment		65	60	68	78	92	98	97	76	77

Appendix B8. Calculated total lengths (millimeters) and growth increments for bull trout collected from Flathead Lake during 1981.

Age	(n)	Length (mm) at annulus I	II	III	IV	V	VI	VII	VIII
1	(0)								
2	(3)	76	149						
3	(22)	69	139	212					
4	(115)	74	141	226	329				
5	(170)	71	135	216	315	412			
6	(68)	69	130	214	307	406	496		
7	(15)	72	132	214	305	417	511	606	
8	(3)	79	148	222	332	432	522	612	690
Grand mean calculated length		72	136	218	318	411	500	607	690
(n)		(396)	(396)	(393)	(371)	(256)	(86)	(18)	(3)
Length increment		72	64	82	100	93	89	107	83

Appendix B9. Calculated total lengths (millimeters) and growth increments for bull trout collected from Flathead Lake 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)	69	137	219	313					
5	(29)	70	128	206	291	379				
6	(60)	68	131	200	283	378	474			
7	(36)	69	133	207	299	399	499	589		
8	(20)	65	126	194	277	378	475	575	665	
9	(2)	49	82	151	226	294	410	524	621	726
Grand mean calculated length		68	130	202	288	382	481	582	661	726
(n)		(155)	(155)	(155)	(155)	(147)	(118)	(58)	(22)	(2)
Length increment		68	62	72	86	94	99	101	79	65

Appendix B10. Calculated total lengths (millimeters) and growth increments for bull trout collected from Flathead Lake during 1968.

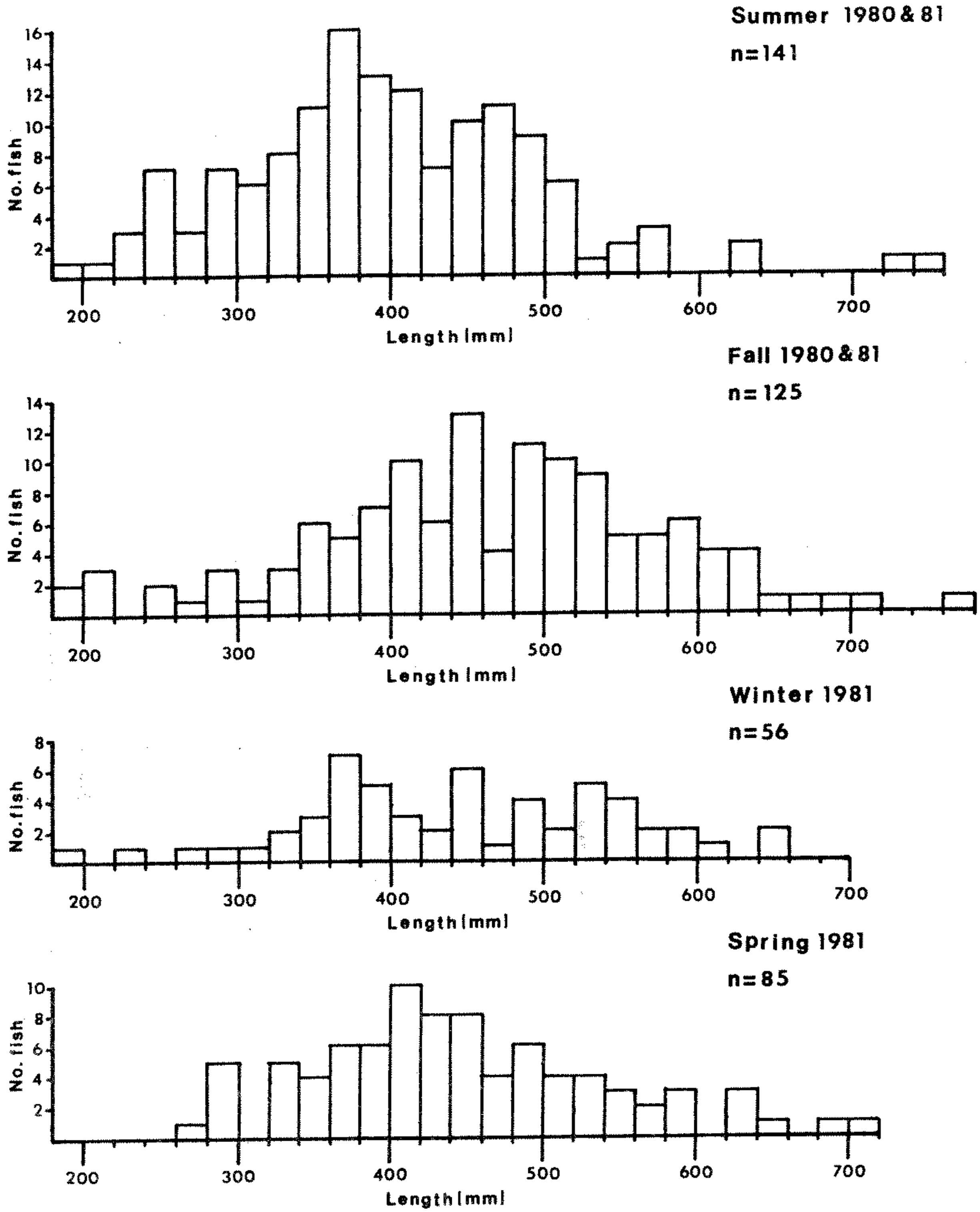
Age	(n)	Length (mm) at annulus								
		I	II	III	IV	V	VI	VII	VIII	IX
1	(0)									
2	(0)									
3	(42)	70	129	195						
4	(89)	66	120	186	252					
5	(55)	69	129	195	272	349				
6	(35)	68	129	200	291	376	461			
7	(10)	66	124	184	252	345	426	524		
8	(0)	--	---	---	---	---	---	---	---	
9	(1)	59	120	237	327	404	502	629	707	785
Grand mean calculated length		68	125	192	265	359	454	534	707	785
(n)		(232)	(232)	(232)	(190)	(101)	(46)	(11)	(1)	(1)
Length increment		68	57	67	73	94	95	80	173	78

Appendix B11. Calculated total lengths (millimeters) and growth increments for bull trout collected from Flathead Lake during 1980.

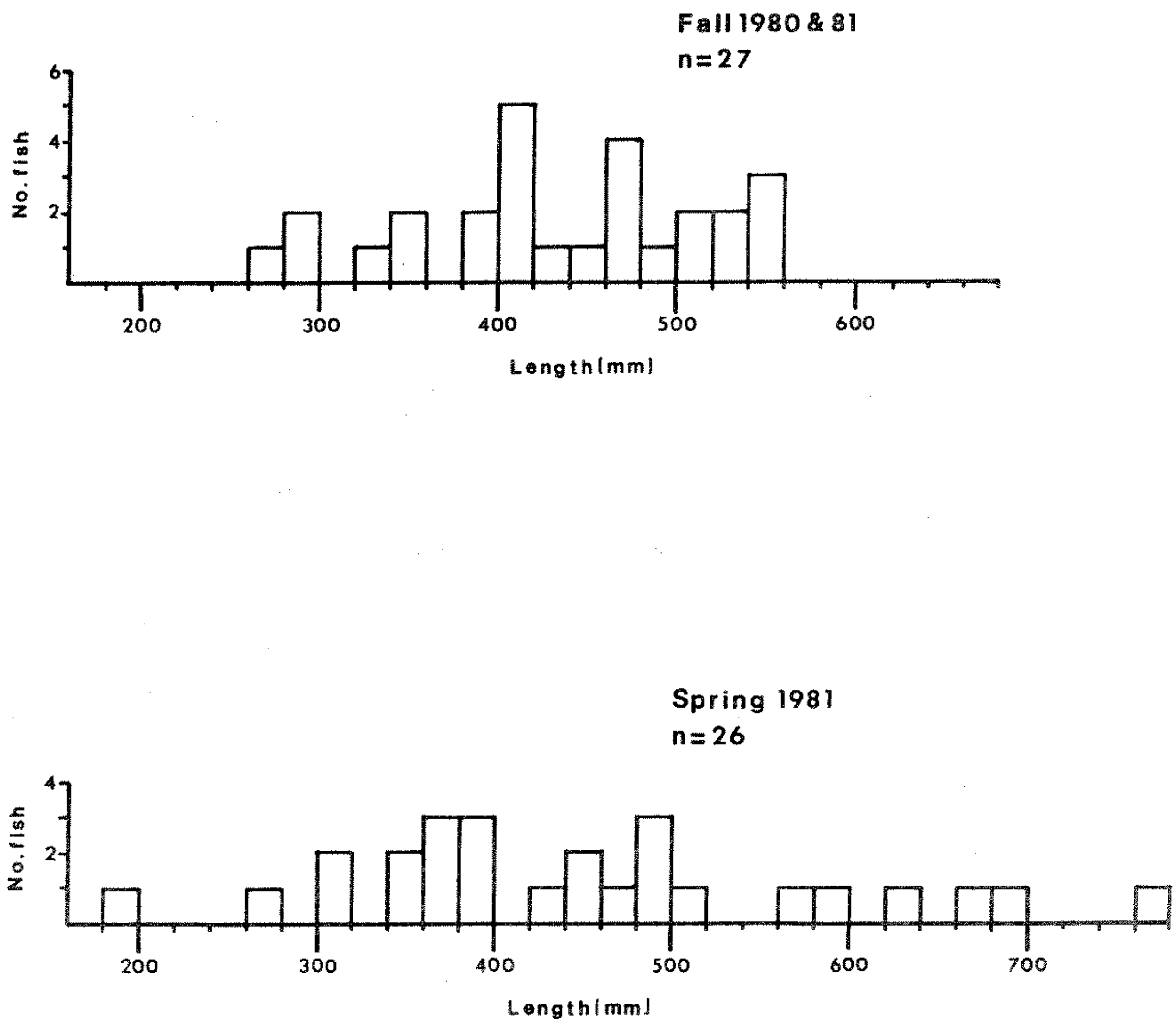
		Length (mm) at annulus								
Age	(n)	I	II	III	IV	V	VI	VII	VIII	IX
1	(0)									
2	(0)									
3	(11)	65	123	197						
4	(38)	56	119	188	266					
5	(57)	62	124	194	271	352				
6	(25)	57	113	172	244	330	418			
7	(13)	56	109	171	245	316	395	488		
8	(1)	30	92	134	182	219	310	391	494	
9	(1)	46	110	180	256	338	426	520	614	686
Grand mean calculated length		59	119	186	261	340	408	484	554	686
(n)		(146)	(146)	(146)	(135)	(97)	(40)	(15)	(2)	(1)
Length increment		59	60	67	75	79	68	76	70	132

APPENDIX C

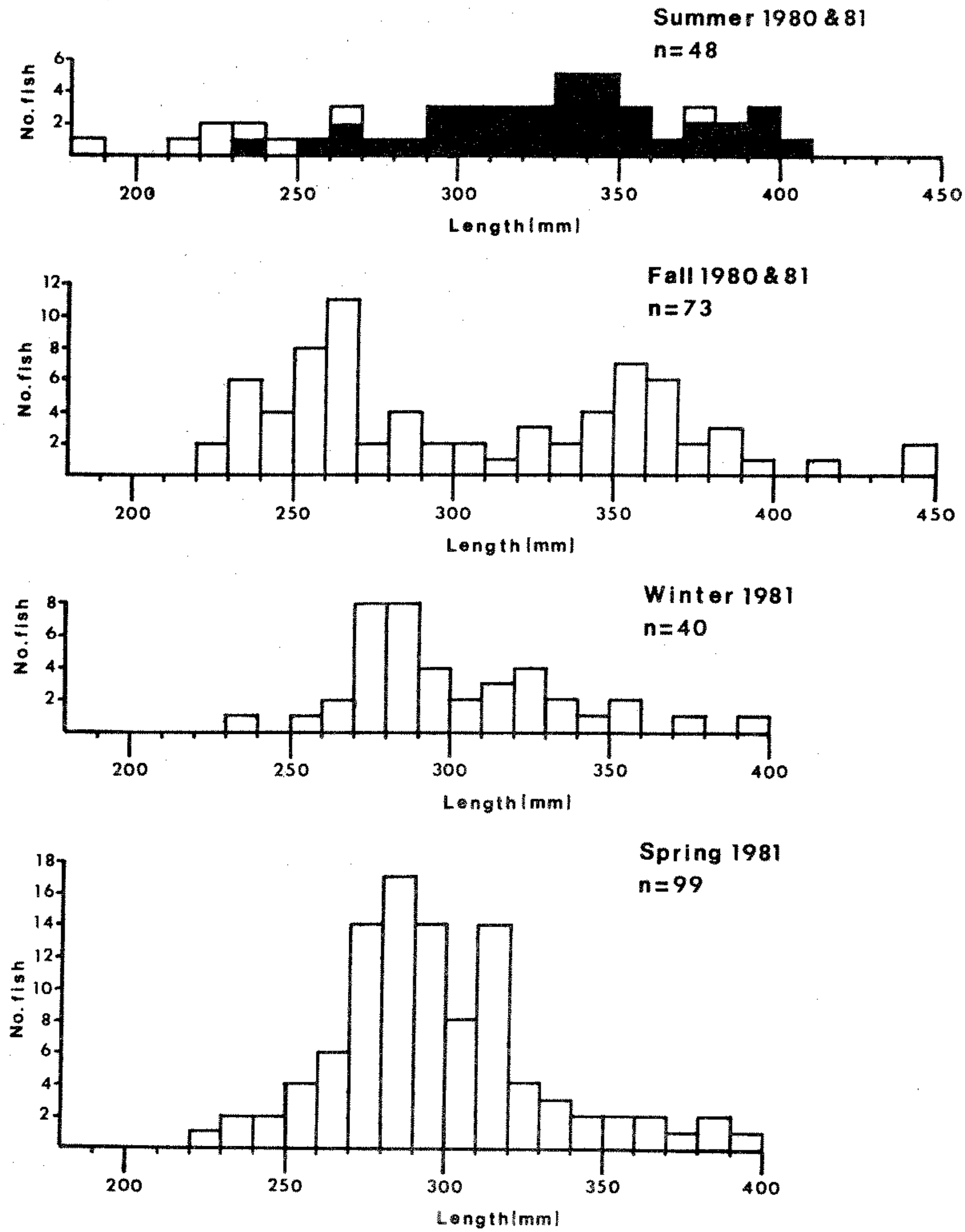
Length Frequency Diagrams for Fish Captured in Gill Nets



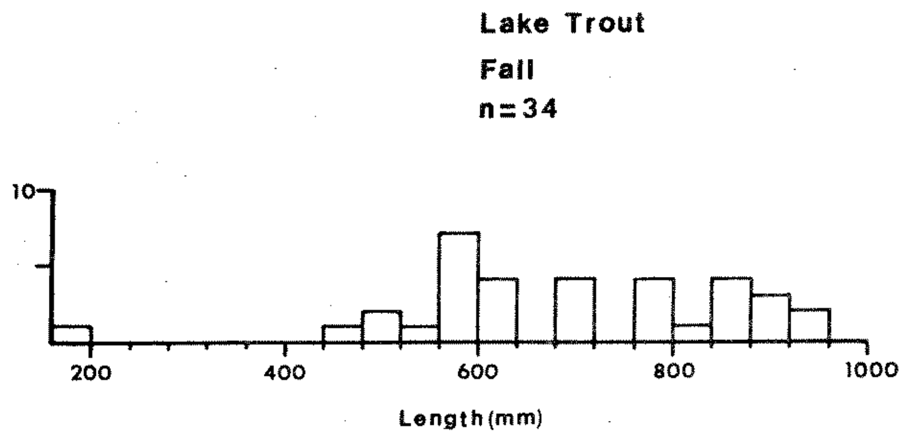
Appendix C1. Seasonal length frequency diagrams for bull trout captured in sinking gill nets set in Flathead Lake during 1980 and 1981.

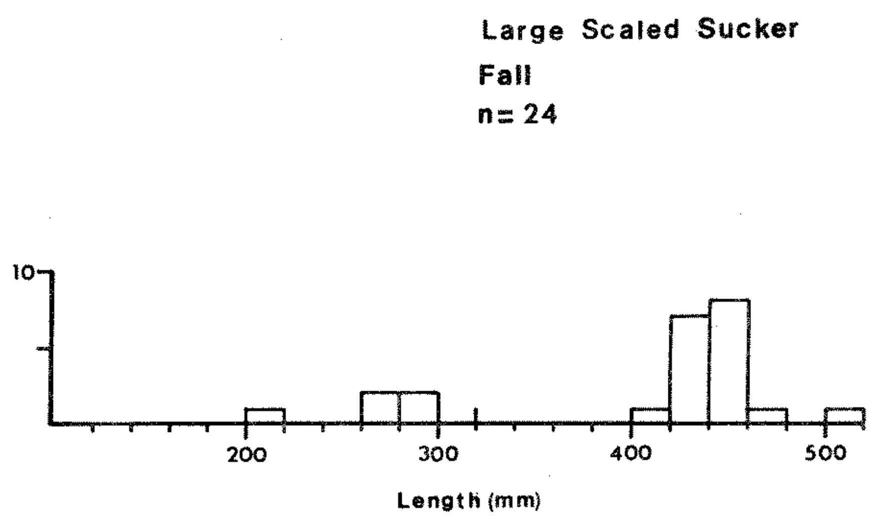


Appendix C2. Seasonal length frequency diagrams for bull trout captured in floating gill nets set in Flathead Lake during 1980 and 1981.

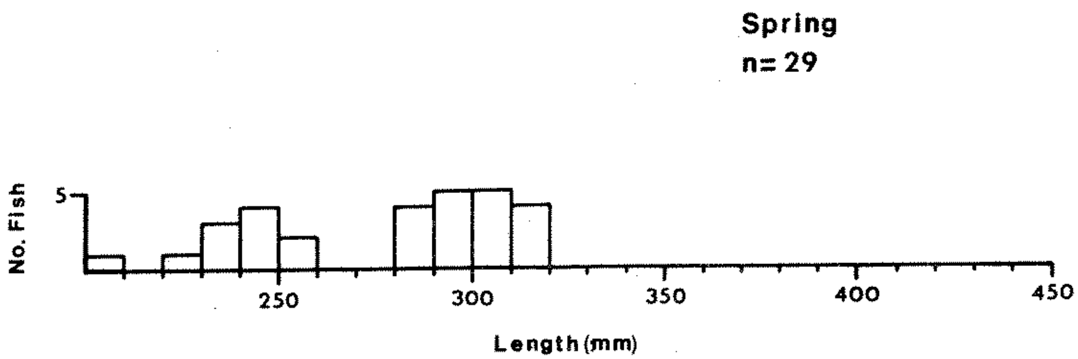


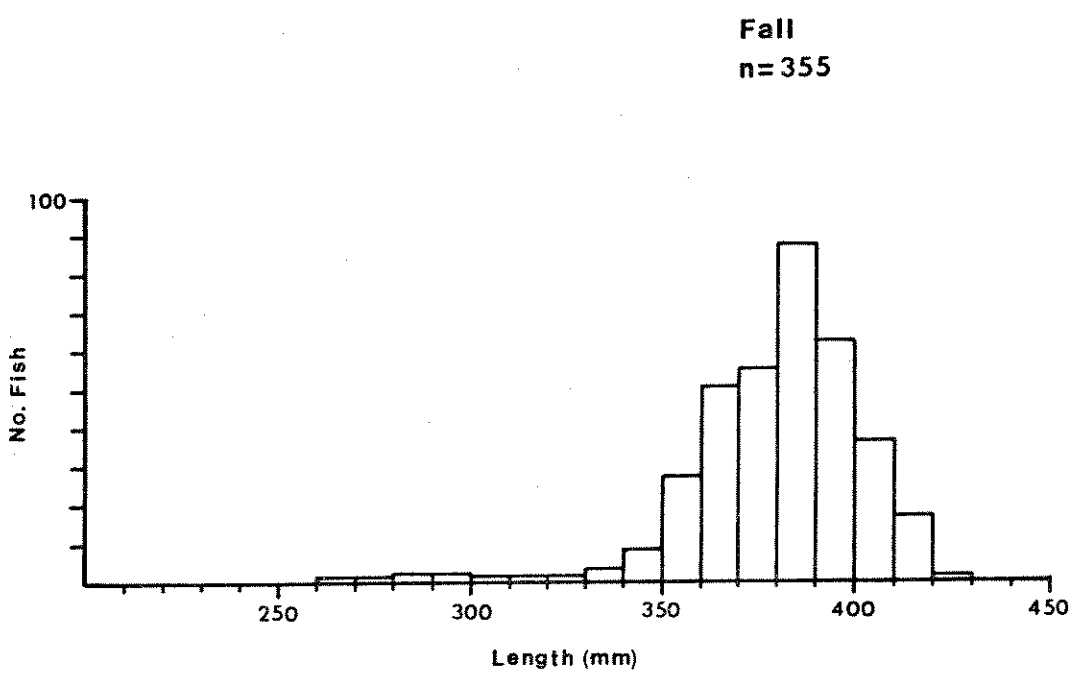
Appendix C3. Seasonal length frequency diagrams for westslope cutthroat trout captured in floating gill nets set in Flathead Lake during 1980 and 1981. Shaded portion of uppermost graph indicates fish checked during creel census.



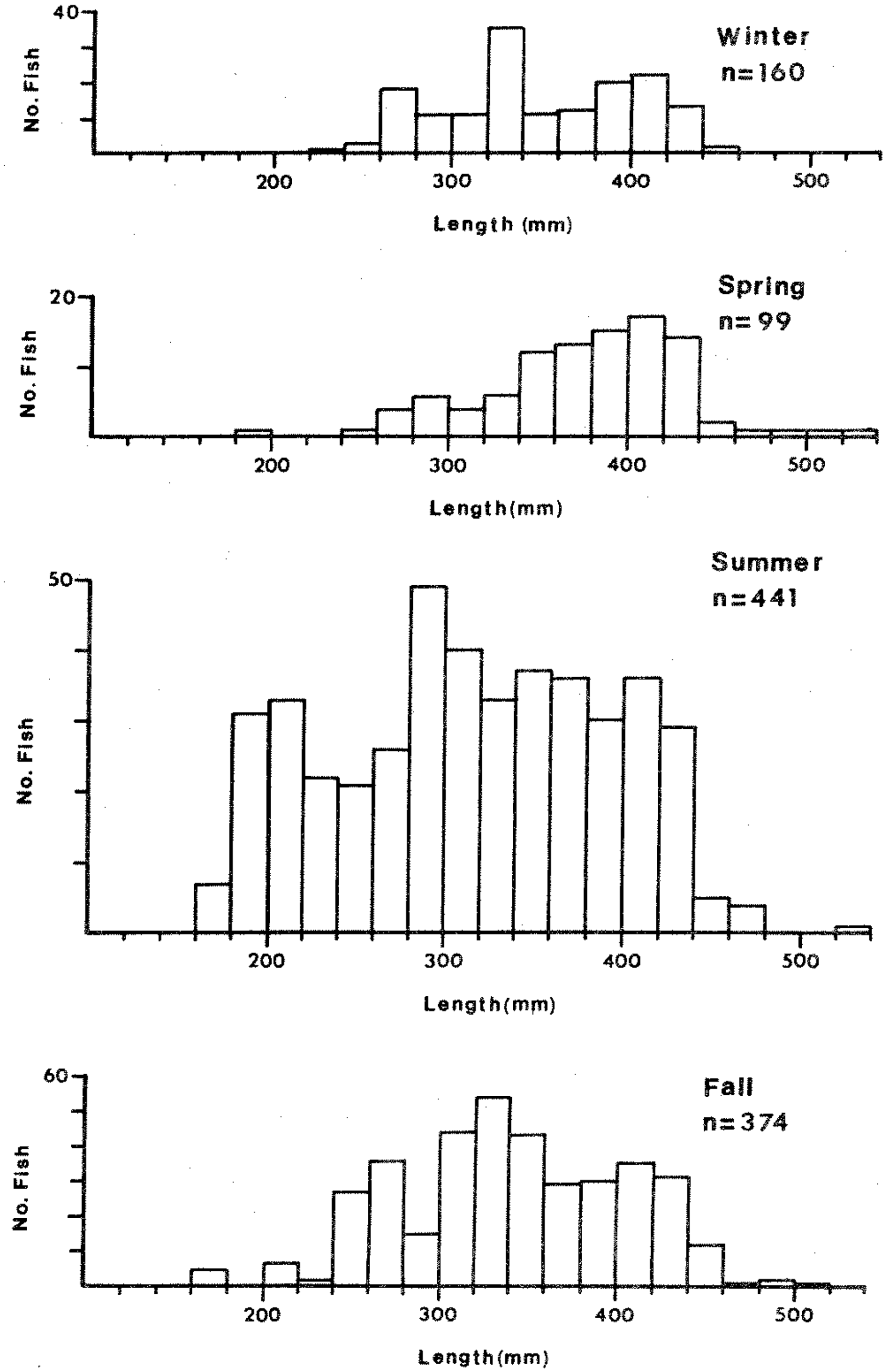


Appendix C4. Length frequency diagrams for lake trout (*Upper figure*) and large scaled suckers (*Lower figure*) captured in floating and sinking gill nets set in Flathead Lake during the fall months of 1980 and 1981.

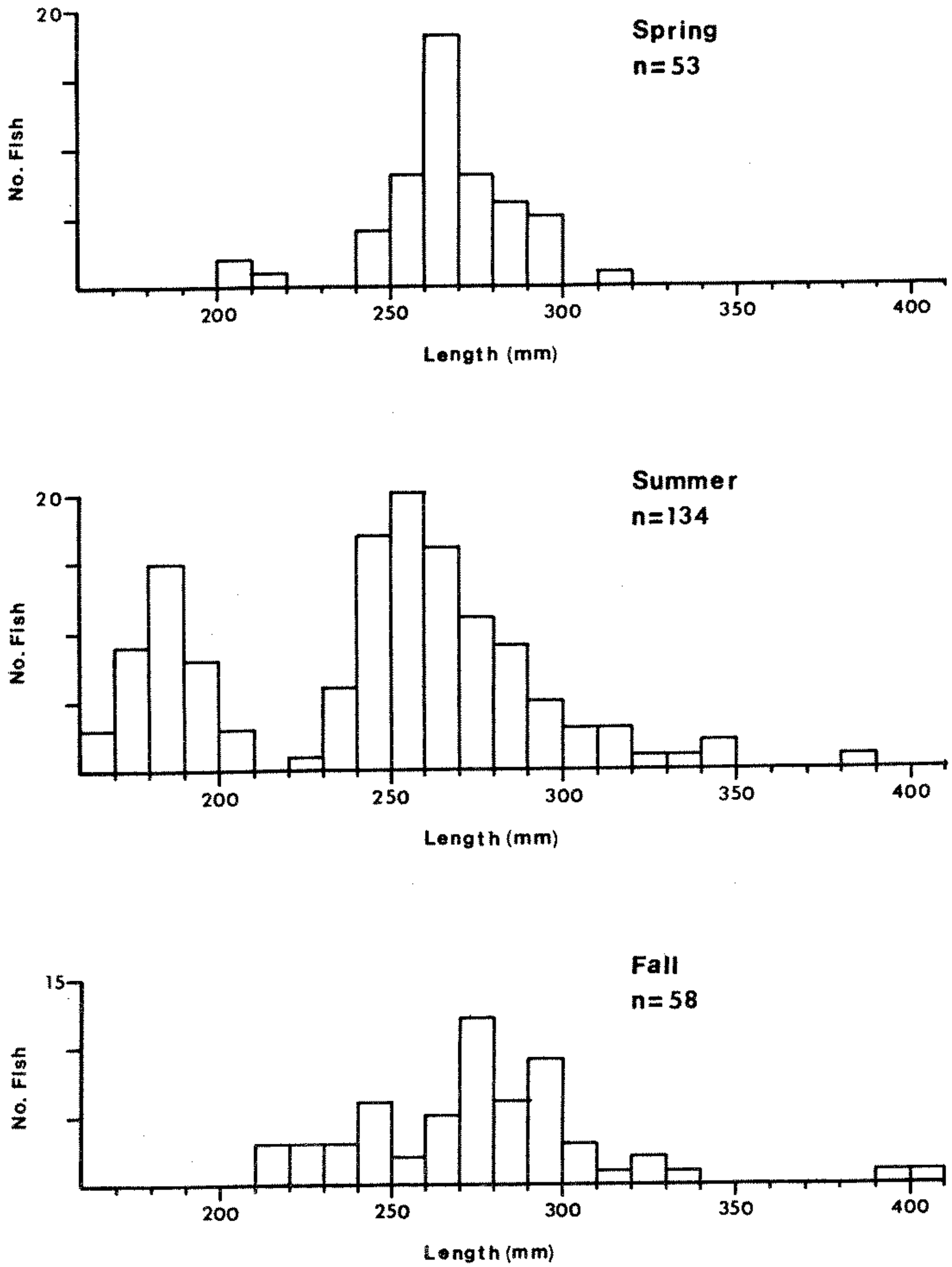




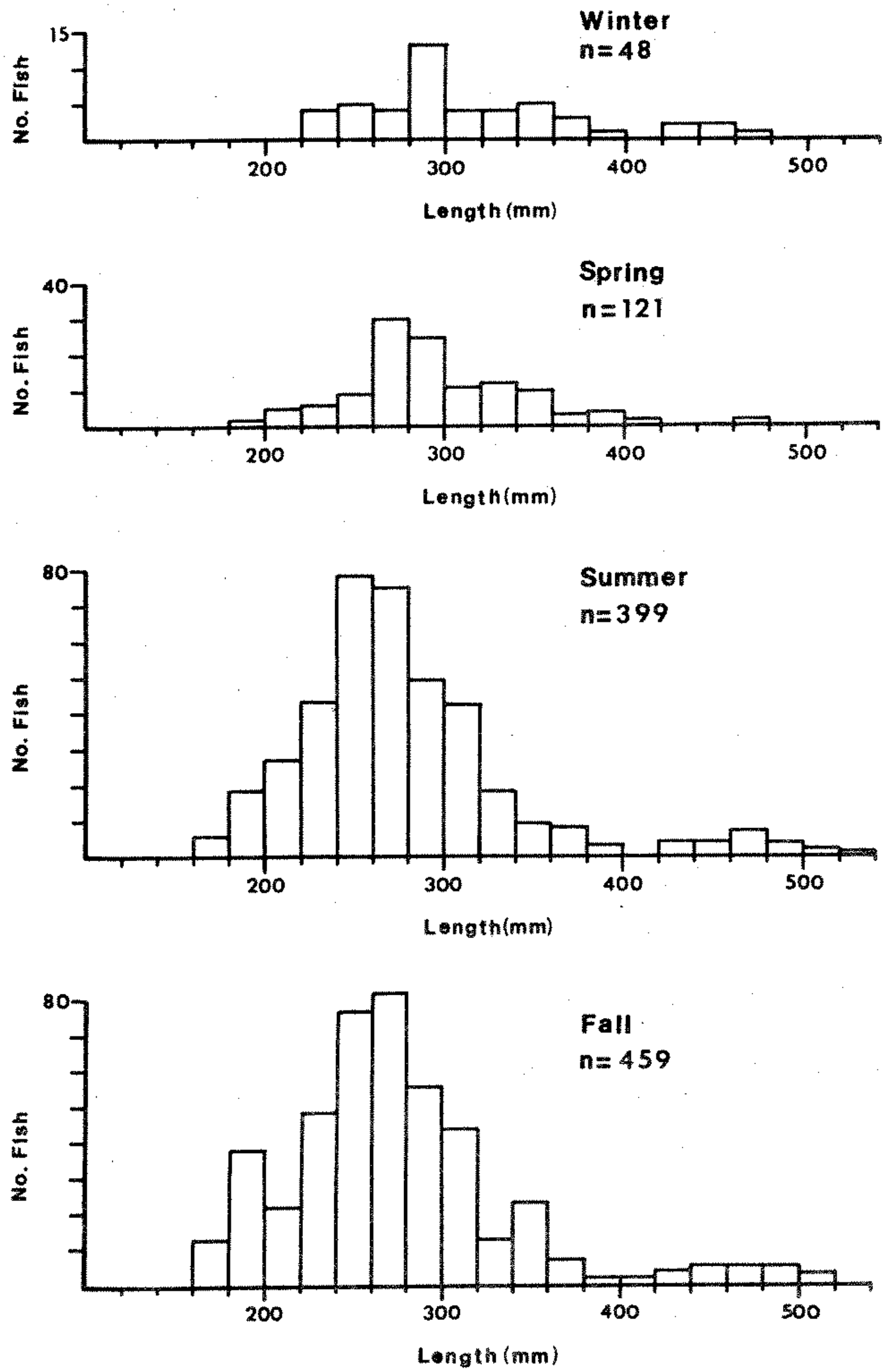
Appendix C5. Length frequency diagrams for kokanee salmon captured in floating and sinking gill nets set in Flathead Lake during the spring of 1981 and the fall of 1980 and 1981.



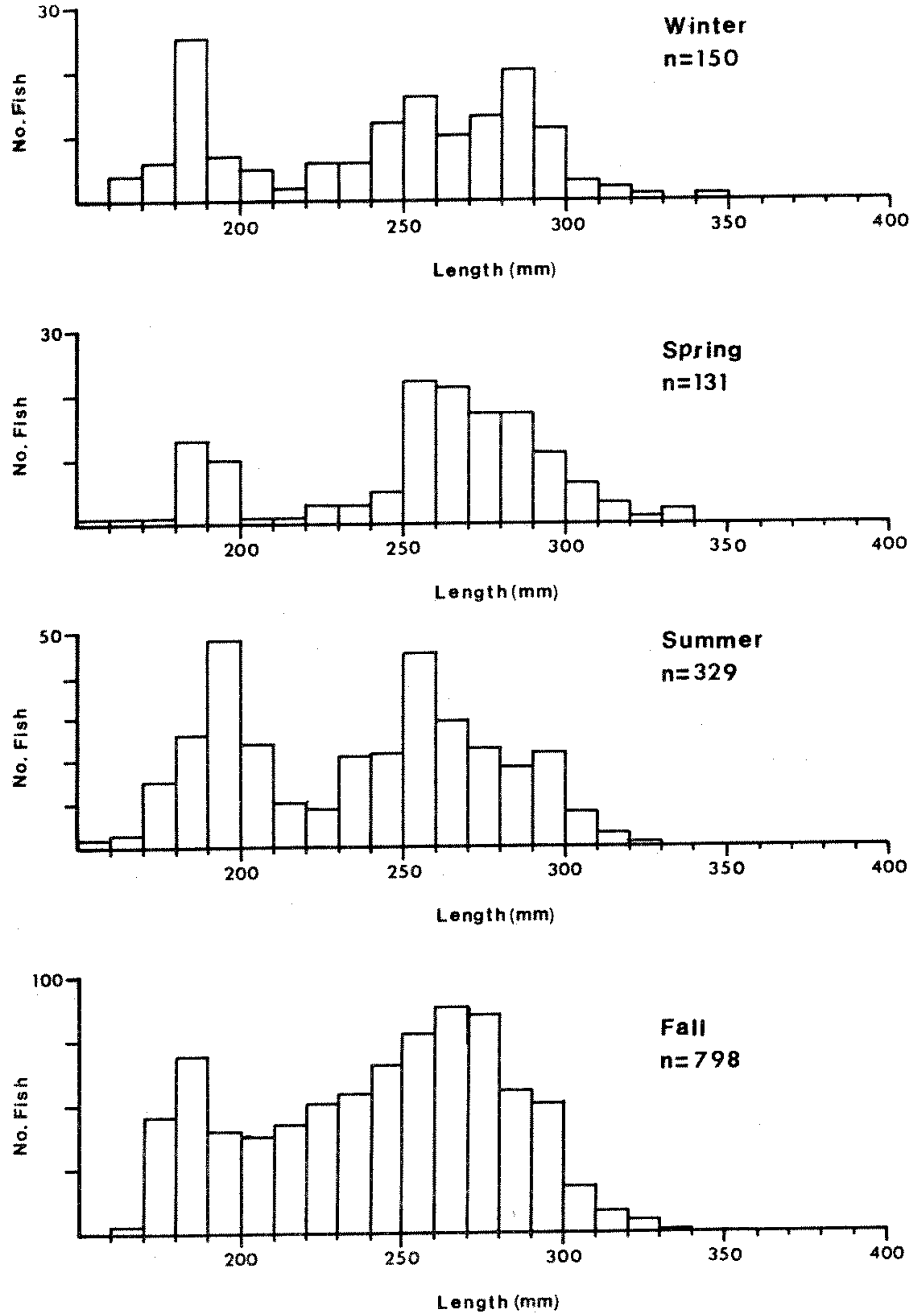
Appendix C6. Seasonal length frequency diagrams for lake whitefish captured in floating and sinking gill nets set in Flathead Lake during 1980 and 1981.



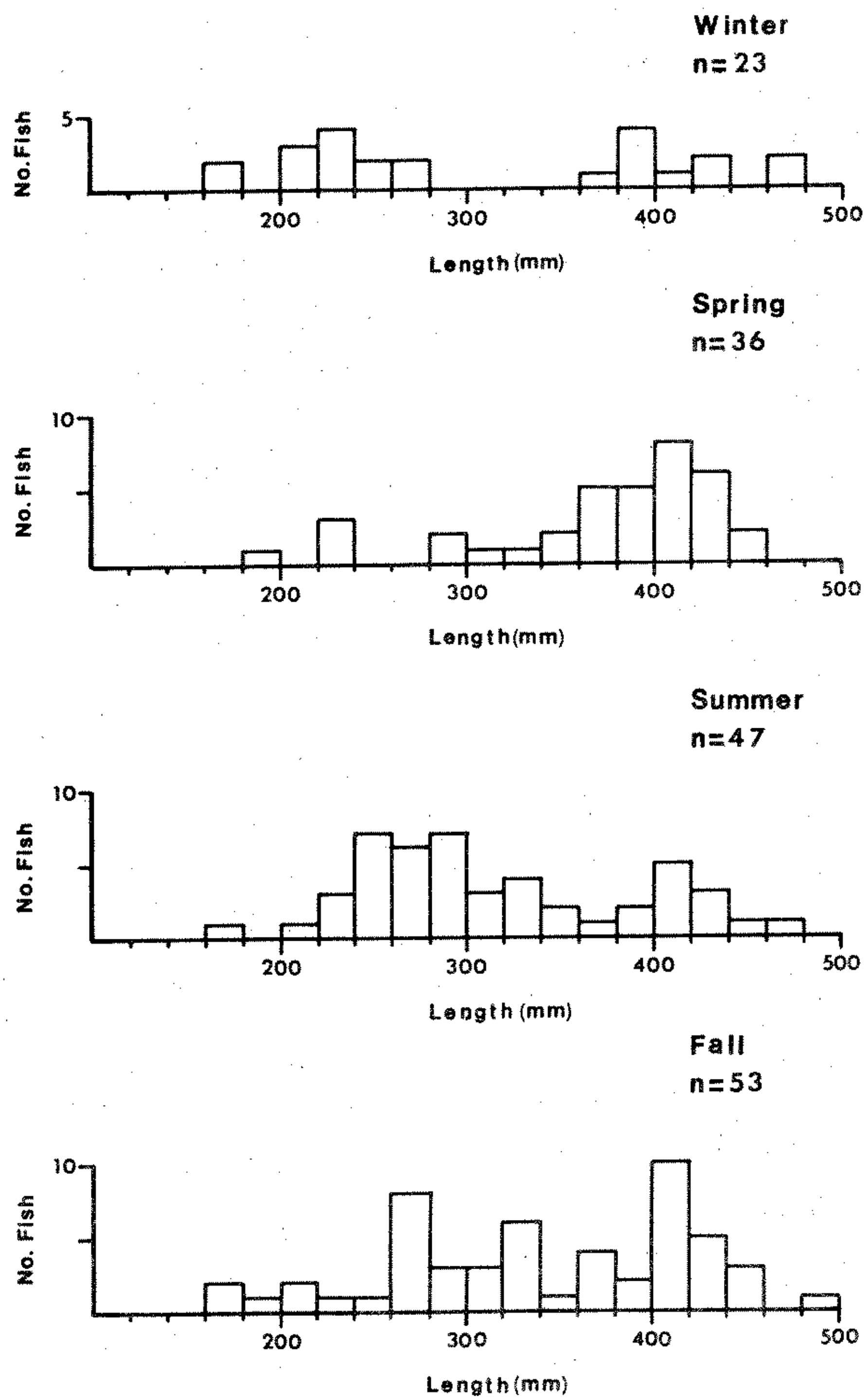
Appendix C7. Seasonal length frequency diagrams for mountain whitefish captured in floating and sinking gill nets set in Flathead Lake during 1980 and 1981.



Appendix C8. Seasonal length frequency diagrams for northern squawfish captured in floating and sinking gill nets set in Falthead Lake during 1980 and 1981.



Appendix C9. Seasonal length frequency diagrams for peamouth captured in floating and sinking gill nets set in Flathead Lake during 1980 and 1981.



Appendix C10. Seasonal length frequency diagrams for longnose suckers captured in floating and sinking gill ents set in Flathead Lake during 1980 and 1981.